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Ecosystem Restoration Program Plan Vol. 1 - Ecological Attributes of the San Francisco Bay-Delta Watershed. Programmatic EIS/EIR Technical Appendix

CalFed Bay-Delta Program

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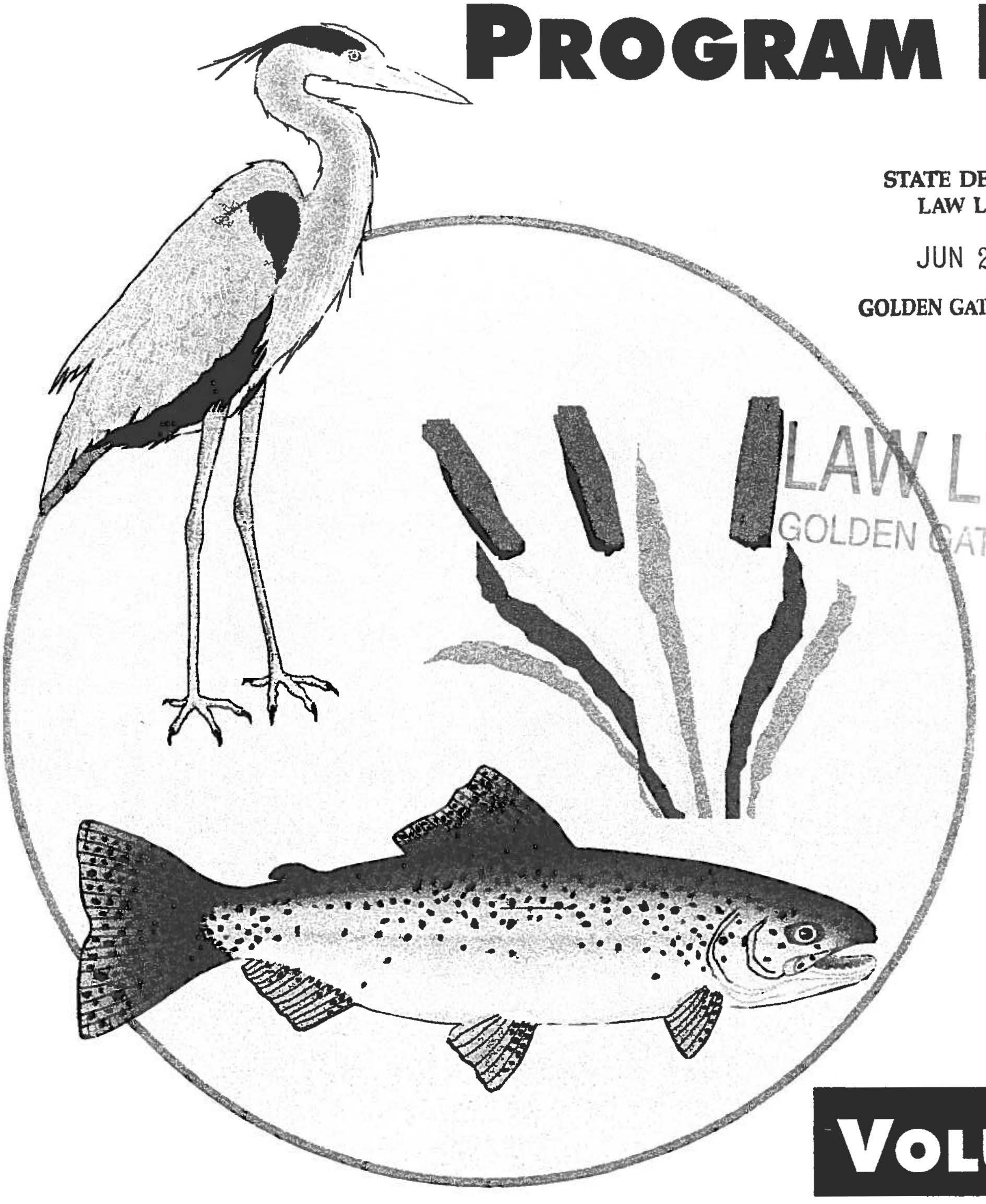
PROGRAM

Ecosystem Restoration Program Plan
Vol 1 - Ecological Attributes of the San Francisco Bay-Delta Watershed

Draft Programmatic EIS/EIR Technical Appendix
June 1999

ECOSYSTEM RESTORATION PROGRAM PLAN



VOLUME I

ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED

CALFED
BAY-DELTA
PROGRAM

June 1999

CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN
VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED

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ENVIRONMENTAL DOCUMENTATION

The CALFED Bay-Delta Program (Program) is currently in what is referred to as Phase II, in which the CALFED agencies are developing a Preferred Program Alternative that will be subject to a comprehensive programmatic environmental review. This report describes both the long-term programmatic actions that are assessed in the June 1999 Draft Programmatic EIS/EIR, as well as certain more specific actions that may be carried out during implementation of the Program. The programmatic actions in a long-term program of this scope necessarily are described generally and without detailed site-specific information. More detailed information will be analyzed as the Program is refined in its next phase.

Implementation of Phase III is expected to begin in 2000, after the Programmatic EIS/EIR is finalized and adopted. Because of the size and complexity of the alternatives, the Program likely will be implemented over a period of 20-30 years. Program actions will be refined as implementation proceeds, initially focusing on the first 7 years (Stage I). Subsequent site-specific proposals that involve potentially significant environmental impacts will require site-specific environmental review that tiers off the Programmatic EIS/EIR. Some actions, such as recreation of shallow water habitats in the Delta and Suisun Marsh, also will be subject to permit approval from regulatory agencies.

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.

Ecosystem goals presented in the ***Strategic Plan for Ecosystem Restoration*** will guide the Ecosystem Restoration Program (ERP) during its implementation phase. Strategic Goals include the following:

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

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

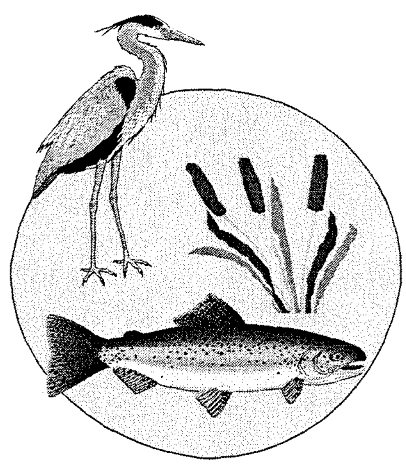
3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.

4. Protect or restore functional habitat types throughout the watershed for public values, such as recreation, scientific research, and aesthetics.

5. Prevent establishment of additional non-native species and reduce the negative biological and economic impacts of established non-native species.

6. Improve and maintain water and sediment quality to eliminate, to the extent possible, toxic impacts to organisms in the system, including humans.

The ERP addresses these goals by restoration of ecological processes 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.



ORGANIZATION OF THE PLAN

The ERP is comprised of a Strategic Plan and the two volume restoration plan:

- Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed

- Volume II: Ecological Management Zone Visions.

STRATEGIC PLAN FOR ECOSYSTEM RESTORATION provides the ERP 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 staging and implementation of the ERP over time. (Note: The CALFED Strategic Plan is derived from the Strategic Plan for the Ecosystem Restoration Program (1998) to reflect the needs of the CALFED Bay-Delta Program and the Ecosystem Restoration Program. Formerly, this was to be Volume III.).

VOLUME I: ECOLOGICAL ATTRIBUTES OF THE SAN FRANCISCO BAY-DELTA WATERSHED 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 ERP and display how the many ecosystem elements relate to one another and establish a basis for actions which are presented in Volume II.

VOLUME II: ECOLOGICAL MANAGEMENT ZONE VISIONS presents the visions for the 14 ecological management zones and their respective ecological management units. Each individual ecological management zone vision contains a brief description of the management 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 strategic objectives, targets, and programmatic actions which describe the ERP approach to improving the ecological health of the zone and its contribution to the health of the Delta. Rationales are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

INTRODUCTION TO VOLUME I

Volume I contains information related to problems, theory, and concepts linked to the Central Valley ecosystem and includes descriptions of important ecological processes and functions, habitats, species, and stressors which impair or otherwise adversely effect the other ecosystem elements (Figure 1). Individually and cumulatively, the visions for the ecosystem elements establish the foundation and scientific basis of the ERP.

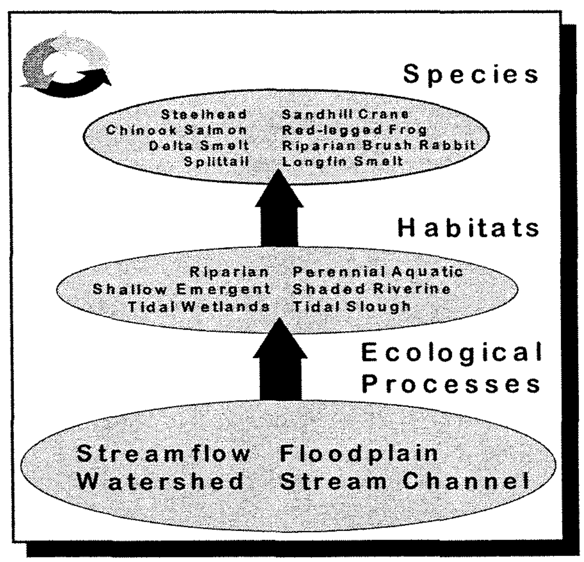


Figure 1. Relationship of ecological, processes, habitats, and species in the Ecosystem Restoration Program Plan.

Each section follows the same format and begins with introductory information regarding the ecosystem elements. Three introductory tables summarize the strategic objectives, basis for selection as an ecosystem element, and the distribution of ecosystem elements by ecological zone.

Individual visions begin with an introduction followed by a description of the relevant process, habitats, species, or stressors. These are followed by the ERP vision for the element, how restoration of the process, habitat, or species, or reduction or elimination of the stressor integrates with other ongoing restoration or management programs. The relationship or linkage of the ecosystem elements to other elements is then discussed followed by a presentation of the strategic objective, targets, and summary of programmatic actions.

PERSPECTIVE

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERP 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 ERP 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. We do not know the balance needed between restoration efforts in the Delta and Bay and restoration efforts upstream. However, aquatic species cannot be the sole driving force for ecosystem restoration. Ecosystem restoration must involve the integration of the needs of terrestrial and aquatic species and plant communities.

The ERP, 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 have been evaluated as sets of programs and projects and broad benefits and impacts have been identified. In the implementation 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 further developing and adhering to the *Strategic Plan for Ecosystem Restoration*. A major effort toward reaching target levels will be emphasized during the first 7 years of the implementation program. Special effort will be directed to 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 ERP 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.

Natural systems are dynamic; i.e., they are characterized by response to cycles of change and episodic catastrophes that are driven by natural or human 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 (spatial) scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay (Note: These ecological zones are more fully described in the section on Key Ecological Attributes of the San Francisco-Bay Delta Watershed which follows this section). The geographic scope defines the locations where actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes of others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats. The values also include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

CALFED is developing a Multi-Species Conservation Strategy to serve as the platform for compliance with the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and the State's Natural Community Conservation Planning Act (NCCPA). The Conservation Strategy has identified a subset of species which are federally and State listed, proposed, or candidate species, other species identified by CALFED that may be affected by and for which the CALFED Program and the ERP have responsibility related to (1) recover the species, (2) contributing to their recovery, or (3) maintaining existing populations. The "recover species" depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, for example, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

Secondarily, the ERP addresses, at a broader, programmatic level, Central and South San Francisco Bay and their local watersheds (Note: The primary geographic focus area for the ERP can be divided into 14 management zones, each characterized by a predominant physical habitat type and species assemblage, Figure 2). These 14 ecological management 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 and watershed planning, management and restoration. The CALFED Coordinated Watershed Management Program addresses the coordination of planning and restoration actions in the upper watershed regions.

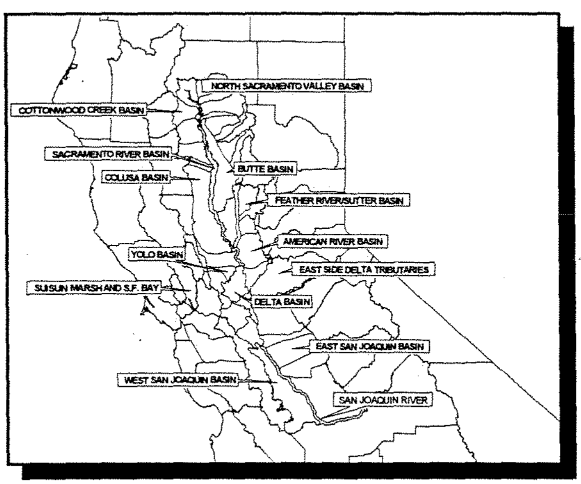


Figure 2. Location Map of the 14 Ecosystem Restoration Program Ecological Management Zones.

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 ERP 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 ERP. 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 use 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. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

DIRECTED 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. (Note: A Comprehensive Monitoring, Assessment, and Research Program is being developed. A description of that program is presented later in this section.)

STAGED IMPLEMENTATION 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.

Stage I implementation is defined as the first 7 year phase of the program and 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. Later implementation phases will be shaped through adaptive management by the results of restoration actions in the first 7 years of the program.

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

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

2. **CREATE AN ECOSYSTEM SCIENCE PROGRAM** to provide ongoing scientific evaluation of the ERP. The Science Program will be a collaborative effort among local and national, independent stakeholder and agency scientists and technical experts convened to address outstanding scientific issues and review the ERP.

3. **PREPARE CONCEPTUAL MODELS** to describe the Bay-Delta ecosystem and the proposed actions of the ERP. Restoration or rehabilitation programs for complex ecosystems must be based on clear concepts about how the system is believed to function, how it has been altered or degraded, and how various actions might improve conditions in the system. Conceptual models can provide a basis for quantitative modeling or identify critical information needs for research or monitoring. In ecosystem restoration, they can be used to link human activities or management actions to outcomes important to society. In adaptive management, the most

important uses of conceptual models are for: linking human activities to valued outcomes, highlighting key uncertainties where research or adaptive probing might be necessary, and identifying monitoring needs.

4. **DEVELOP TESTABLE HYPOTHESES** for proposed ERP actions. The hypotheses underlying the ERP will be tested through experiments using the conceptual models and on-the-ground research. The results from these experiments will feed back into the adaptive management process and will support proposed actions, suggest revisions to actions, and identify needs for further research.

5. **CONDUCT IMMEDIATE DIRECTED RESEARCH** to improve understanding of the ecosystem and the causes of problems identified in the conceptual models and testable hypotheses. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERP targets, actions, and implementation schedule.

6. **DEVELOP AND BEGIN A STAGED IMPLEMENTATION PROGRAM** that entails:

   - short-term implementation of ecosystem restoration demonstration projects (e.g., through Restoration Coordination 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 ERP 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 ERP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

COMPREHENSIVE MONITORING, ASSESSMENT, AND RESEARCH PROGRAM

Many institutions, both within and outside of the CALFED partnership, are involved in monitoring and applied research that can contribute to the design and assessment of environmental rehabilitation programs. The scope, coverage, and coordination of existing monitoring and applied research, however, are admittedly fragmentary. When viewed together, these programs do not provide a coherent, overall picture of what is being monitored, how the environment is changing over large spatial scales, or a clear sense of how the monitoring data might be used by resource managers and decision makers. The ability to provide coordinated and complete monitoring coverage is especially difficult because of the complex system structure, and the complexities of the associated physical and ecological processes. These programs, however, provide information essential to our understanding and management of the system. These existing programs will figure prominently in the development of a Comprehensive Monitoring, Assessment and Research Program (CMARP) (CMARP Steering Committee 1998).

Monitoring, assessment, and research are important steps in an iterative process to understand and manage a natural resource system. Monitoring involves measuring and sampling physical, chemical, and biological attributes of the resources and can include social and economic attributes of associated human activities. Assessment involves developing correlations among monitored data, for example correlations between the abundance of a fish species and a factor such as river flow that might affect abundance. Research involves analysis or experiments to establish mechanisms that explain observed correlations, such as documenting fish distributions and mortalities for different flows. The information generated from monitoring, assessment, and research provides resource managers with understanding needed to design actions and to detect responses to their actions.

CALFED needs a monitoring and research program for at least four reasons. First, CALFED needs monitoring data and information to implement the preferred program alternative and to carry out its related programs, and this need is increased by CALFED's adoption of an adaptive management strategy. Second, CALFED needs to satisfy the Congressional mandate for indicators and performance measures with which to judge the success of restoration efforts. Third, CALFED needs data and information with which to assure stakeholders that the actions being taken are having desired results. Finally, CALFED needs to reduce the scientific uncertainty regarding the management and protection of valued natural resources.

Thus, the purpose of CMARP is to provide those new facts and scientific interpretations necessary for CALFED to implement fully its preferred program alternative and related programs and for the public and government to evaluate the success of CALFED actions.

TERMS USED IN THE ERPP

The following terms are used in the ERP:

ECOSYSTEM-BASED MANAGEMENT: Ecosystem-based management is a resource management concept of achieving species management objectives by sustaining and enhancing the fundamental ecological structures and processes that contribute to the well being of the species. A basic tenent of CALFED's implementation of ecosystem-based management is, to the extent feasible, to restore or rehabilitate the natural processes that create and maintain the important elements of ecosystem structure. Ecosystem-based management differs fundamentally from the more traditional approach of species-based management, which seeks to manipulate specific environmental factors (e.g., direct removal of predators from the environment to reduce predation levels on the target species) thought to be limiting target species populations at levels below management objectives.

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.

ECOSYSTEM REHABILITATION: Within CALFED's concept of ecosystem restoration, the ERP will largely focus on ecosystem rehabilitation. In the context of CALFED, ecosystem rehabilitation is defined as the process by which resource managers reestablish or refurbish key elements of ecological structure and function within the Bay-Delta ecosystem to a level necessary to achieve ERP goals and objectives.

ECOSYSTEM RESTORATION: Ecosystem restoration is a term sometimes used to imply the process of recreating the structural and functional configurations of an ecosystem to that present at some agreed to time in the past. Because the structure and function of many elements of the Bay-Delta ecosystem have been severely disrupted and cannot be feasibley restored to a specified historic condition, within the context of CALFED, ecosystem restoration is more realistically defined as the process by which resource managers ensure that the capacity of the ecosystem to provide ecological outcomes valued by society is maintained, enhanced, or restored.

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.

LONG- AND SHORT-TERM OBJECTIVES: Objectives can be both short-term and long-term. Short-term objectives should be clearly feasible, relatively easy to measure, and achievable in reasonable length of time (usually <25 years). The time period is not the same as Stage I of the CALFED process. Long-term objectives may be more difficult to determine and require additional resources and knowledge to achieve.

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 Management Unit.

STRATEGIC OBJECTIVES: Strategic objectives are a more detailed delineation of the Strategic Goal components and provide a framework to develop and organize targets and programmatic actions. A strategic objective is the most specific and detailed description of what the ERP strives to maintain or achieve for an ecosystem element. The objectives are stated primarily in terms of management actions designed to have a favorable impact on the Bay-Delta system, however, some are also stated in terms of studies that will teach us how the ecosystem behaves so that principles of adaptive management can be better employed.

SPECIES AND SPECIES GROUPS: Certain species or groups of species are given particular attention in the ERP. This focus is based on three criteria that might be met by a species (including fish, wildlife, and plants): 1) is it a formally listed threatened or endangered species (e.g., winter-run chinook salmon, delta smelt), or is it a species proposed for listing; 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass, signal crayfish); 3) is it a native species or species community that is presently not listed by which could be if population abundance or distribution declines, or 4) it is an important prey species (e.g., Pacific herring).

STAGE 1 EXPECTATIONS: Stage 1 expectations are meant to be measures of the progress towards meeting short-term objectives in the first 7 years of implementation program. These expectations have two basic components: improvements in information to allow better management of the ecosystem and improvements in physical and biological properties of the Bay-Delta ecosystem and watershed.

STRATEGIC GOAL: Strategic goals are the broad statements that define the scope and purposes of the ERP. Strategic goals provide guidance in the development and evaluation of proposed restoration actions.

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.

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.

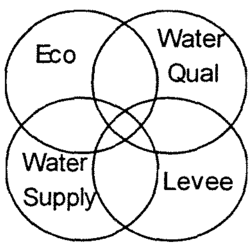
The intent of the ERP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and staged implementation; (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.

Examples of targets for tidal perennial aquatic habitat are to restore 1,500 acres of shallow-water habitat in the Suisun Marsh/North San Francisco Bay Ecological Management Zone, and restore 2,000 acres of shallow-water habitat in the South Delta Ecological Management Unit.

VISION: A vision is what the ERP 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 ERP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERP: 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.

Relationship of Other CALFED Common Programs to Ecosystem Restoration

There are many linkages among the objectives in the four resource areas and among the actions that might be taken to achieve these objectives. Most actions that are taken to meet Program objectives, if carefully developed and implemented, will make simultaneous improvements in two, three, or even four resource areas.



The actions can be grouped into categories of water use efficiency, water transfers, water storage, Delta conveyance modifications, levee system improvements, ecosystem restoration, water quality improvements, watershed coordination, and financing. Specific actions range from physical restoration of habitat in the Delta to water conservation measures. The actions in our problem-solving "toolbox" are described below, along with examples of the problems that can be solved and the multiple benefits that can be gained from each type of action. Complete descriptions of program elements are contained in various technical appendices to the draft programmatic EIS/EIR.

Water Use Efficiency Interrelationships: Water use efficiency measures include conservation of water used in urban areas, in agricultural areas, and on wildlife refuges, as well as water recycling. Efficiency measures reduce water demand, thereby reducing the mismatch between supply and demand. Efficiency measures provide other benefits as well. Reduced demand can mean reduced diversion of water from the Bay-Delta system and reduced diversion impacts associated with the entrainment of fish. Efficient use can also yield water quality benefits. Careful application of water to gardens, lawns and farm fields can result in less runoff of herbicides, pesticides, fertilizers, and salts back into water bodies that provide drinking water sources and aquatic habitats. Regardless, the issues related to water use efficiency are unresolved.

Water Transfers Interrelationships: A water transfer is a voluntary transaction in which a person or entity that possesses the right to use water can sell the use of the water for a period of time to another person or entity. Transfers reduce the mismatch between supply and demand by satisfying the strongest demands for water and compensating others for reducing their use of that supply. A water transfer that moves water from upstream of the Delta to Delta export (water diversion from the Delta used for purposes outside the Delta) regions may provide ecosystem benefits by increasing flow into the Delta or modifying the timing of flows in ways that may benefit the ecosystem. Transfers of water between two users in Delta export areas may reduce the need to pump water from the Delta and reduce the environmental impacts of that Delta pumping. Transfers can reduce the need for new or expanded reservoirs. In some cases, conserved water can be transferred so the ability to transfer water offers an economic incentive to conserve. Finally, water can be transferred from diverters to instream uses, restoring beneficial timing of flows and increasing Delta outflow during critical periods.

Water Storage Interrelationships: CALFED is evaluating additional storage as one approach to increasing water supply reliability and providing instream flow benefits during periods of greater ecosystem need. Storage can be used to improve water supply reliability, provide water for the environment at times when it is needed most, provide flows timed to maintain water quality, and protect levees through coordinated operation with existing flood control reservoirs.

Decisions to construct storage will be predicated upon complying with all program linkages including: completion of the Integrated Storage Investigation which includes and assessment of groundwater storage, surface storage, re-operation of power facilities and a fish barrier assessment; demonstrated progress in meeting the Program's water use efficiency, water reclamation and water transfer program targets; implementation of groundwater monitoring and modeling programs; and compliance with all environmental review and permitting requirements.

New storage will be developed and constructed, together with aggressive implementation of water conservation, recycling and a protective water transfer market, as appropriate to meet CALFED Program goals. During Stage 1, CALFED will evaluate and determine the appropriate mix of surface water and groundwater storage, identify acceptable projects and initiate permitting of construction if program linkages and conditions are satisfied.

DELTA CONVEYANCE MODIFICATIONS INTERRELATIONSHIPS: CALFED has examined three broad choices for conveyance through the Delta: minor physical modifications coupled with operational changes, increases in the capacity of certain Delta channels to facilitate conveyance through the Delta, and a dual system that increases the capacity of certain channels and includes a new isolated channel to convey water from the Sacramento River around the Delta to water export pumps in the south Delta. To varying degrees, all three decrease the detrimental effects on the ecosystem and Delta water users of using the Delta for water conveyance, while improving the effectiveness of the Delta as a conveyance hub.

Conveyance modifications can enable drinking water to be moved through the Delta with less risk of contamination by seawater or naturally occurring organic material found in the Delta. The conveyance modifications can also reduce the detrimental effects on fish of moving water through the Delta by reducing unnatural flow patterns, screening diversions, and providing alternative diversion points.

DELTA LEVEE IMPROVEMENTS INTERRELATIONSHIPS: Delta levee improvements reduce the risk that levees will fail during flood periods or as a result of earthquakes or gradual deterioration. This can protect not only lives and property of those who would otherwise have been flooded, but can also protect wildlife habitat from inundation. Strong levees also protect water quality for all who use Delta water. The land surface of Delta islands is often below the level of the water in surrounding channels because the organic peat soils have subsided over time. When a levee fails, water rushes onto the island and draws salty water up into the Delta from the Bay. This salty water in the Delta channels may be unsuitable for irrigation of crops on lands that are not flooded, and may be unsuitable as a drinking water source for urban areas that get their water from the Delta. Regaining a suitable supply may not be possible in the short-term or the long-term.

Improvements to Delta levees can be made in ways that accommodate habitat restoration, so that levees can simultaneously protect land uses, protect water quality, and support a variety of wetland, aquatic, and riparian habitats.

SUISUN LEVEE IMPROVEMENTS INTERRELATIONSHIPS: Suisun Marsh levee improvements reduce the risk that levees will fail during flood periods. This can protect property and wildlife habitat from inundation. Widespread levee failure in the Suisun Marsh pose a risk to maintaining Delta water quality. Improvements to Suisun Marsh levees can be made in a way that avoids significant impacts to fish and wildlife, results in protection for areas being retained as managed wetlands, and minimizes the expenditure of funds on levees that, in the short-term, may be allow for restored tidal actions consistent with the goals and objectives of the ERP.

WATER QUALITY INTERRELATIONSHIPS: Program actions to improve water quality focus on source control: improving the quality of water that flows through the Bay-Delta system by addressing water quality concerns at their source. In some cases this may involve cleanup of abandoned mines that leach toxic heavy metals from mine tailings. In other cases, water quality may be improved by conserving water on a farm or an urban landscape, reducing the amount of runoff that finds its way back into streams. Modifications to Delta conveyance can improve water quality in the Delta by reducing salinity. This in turn can improve water supply reliability: high quality Delta water can be blended with lower quality water from other sources to stretch water supplies. Water quality improvements can also facilitate water recycling. When water is used, it becomes saltier. Recycling this water may produce water with unacceptable salinity levels if source water is too salty to begin with.

WATERSHED MANAGEMENT COORDINATION INTERRELATIONSHIPS: The watershed management coordination element of the Program consists of engaging local watershed organizations in planning and implementing the CALFED Program and coordinating among these organizations to more efficiently and effectively implement the CALFED Program. In the lower watershed, the focus will be on ecosystem restoration and water quality actions. In the upper watersheds, the immediate focus will be on partnership projects with local entities in the upper watershed to improve water quality and habitat, decrease erosion, and increase base flows in the tributaries to the Delta. This coordinated approach to improving the condition of watersheds can increase the reliability of predictable amounts of water flowing into the Delta during dry seasons by slowing down the rate at which water leaves the upper watershed.

REFERENCES

CMARP Steering Committee. 1998. A proposal for the development of a comprehensive monitoring assessment and research program. Developed for CALFED by the CMARP Steering Committee. Final Report. April 24, 1998. 50 pp.

Costanza, R. and H. Daly. 1992. Natural capital and sustainable development. Conservation biology 1:31-45.

Ecological Society of America. 1995. The scientific basis for ecosystem management. Ad Hoc Committee on Ecosystem Management. Washington, DC.

Healey, M. 1998. Paradigms, policies and prognostication about watershed ecosystems and their management. To appear in R. J. Naiman and R. E. Bilby (eds.), Ecology and management of streams and rives in the Pacific Northwest Coastal Ecoregion. Springer-Verlag. New York, NY.

Hennessey, T.M. 1997. Ecosystem management: the governance dimension. Western Social Sciences Association Symposium. Albuquerque, April 23-16, 1997.

Richardson, J.S., and M. Healey. 1996. A healthy Fraser River? How will we know when we achieve this state? Journal of Aquatic Ecosystem Health 5:107-115.

Strategic Plan for the Ecosystem Restoration Program. 1998. Prepared by the Strategic Plan Core Team for the CALFED Bay-Delta Program. September 30, 1998.

World Commission on Environment and Development. 1987. Our common future. Report of the World Commission on Environment and Development. Oxford University Press. Oxford England.

◆ Key Ecological Attributes of the San Francisco Bay-Delta Watershed

Note: The following section is a summary of information provided by the Indicators Workgroup (1998).

RATIONALE

Understanding the structure, function and organization of ecosystems is necessary for planning and implementing environmental restoration, rehabilitation and protection projects. Such understanding enables managers to assess, during planning phases of a program, the degree to which prospective restoration sites diverge from a "healthy" or "natural" condition, as well as to evaluate, after actions have been undertaken, project progress and effectiveness. In a management context, perhaps the most practical means of summarizing the most relevant existing information on ecosystems is to develop, over an appropriate hierarchy of spatial and ecological scales, a list of key system attributes - those fundamental natural ecological characteristics that together define and distinguish these systems, their status, and/or their interrelationships. Such lists of attributes may serve as a convenient and necessary "check list" of environmental factors that might be addressed in an ecological restoration/rehabilitation context. At sites for which comprehensive restoration is the goal, a full suite of applicable attributes would presumably be addressed. More commonly, at sites where partial restoration (rehabilitation) is the goal, actions and efforts would be focused upon an appropriate subset of attributes.

Some individual system attributes - such as water temperature - may be evaluated directly. Others, such as "habitat continuity," are more nebulous, and must be evaluated by developing appropriate "indicators" - measurable parameters that provide a means to objectively (preferably quantitatively) evaluate individual attributes that in themselves are not readily measured. The term indicator is also used in a broader context to refer to a *subset* of system attributes (or their measurable parameters) that are derived and used *as a group* to provide a convenient way to evaluate *overall* system status. Thus, the term "indicator" is commonly used in two somewhat different ecosystem management/restoration contexts, representing two differing scales of resolution: that of *individual* attributes, or alternately, that of *groups* of attributes. In either case, "indicators" are simply a convenient way of measuring or evaluating that which is of primary concern - system attributes. An additional, and most useful tool in understanding and describing fundamental characteristics of complex systems is the use of conceptual models that integrate and diagrammatically represent the three basic *kinds* of system components: elements (attributes), their states, and the relationships that affect attribute states.

This document presents a provisional list of natural ecological attributes and indicator of the ecosystems of this watershed for use in the context summarized above.

ECOSYSTEM TYPOLOGY

The ERP study area is divided into four ecological zones, based on similarities and differences in their respective attributes. The ecological zone designations follow:

- Upland River-Floodplain Ecological Zone
- Alluvial River-Floodplain Ecological Zone
- Delta Ecological Zone
- Greater San Francisco Bay Ecological Zone

The following tables display the attributes and indicators related to each ecological zone.

Table 1: Ecological Zone: Upland River-Floodplain Ecosystem.

Ecosystem Typology: Upland river-floodplain ecosystems are defined as rivers, streams, and associated riparian corridors that extend from headwaters elevations in the Coast Ranges, Cascade Range, and Sierra Nevada to the point near the floor of the Central Valley where they merge with alluvial river-floodplain ecosystems (in most cases near the 300 foot (91.4 m) elevation contour). The Sacramento River above Red Bluff is included in the upland river-riparian ecosystem. Most rivers and streams in this ecosystem correspond with the A2410 (fishless low-order tributaries) to A2430 (salmon-steelhead streams) series in the habitat classification system of Moyle and Ellison (1991) and Moyle (1996).

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Variable streamflows	■ Minimum base flows ■ Seasonal shifts in stream level ■ Measures of variability
	Floods	■ Minimum surface area of floodplain inundated at least once every 2 years ■ Flood duration (mean and variability)
	Ground water	■ Depth of water table ■ Soil moisture levels, laterally from banks. ■ Characteristic plant communities ■ Width of riparian corridor
Geomorphic	Dynamic Channels	■ Bedload movement ■ Sediment particle size and distribution ■ Pool-to-riffle ratio ■ Inter-annual comparison of fluvial geomorphic features
	Sediment budget	■ Net change in depth per unit time of unconsolidated sediment
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of native and migratory fish species ■ Length of river channel obstructed by artificial barriers ■ Length of riparian corridor unobstructed by artificial barriers

	Water/sediment quality	■ Toxicity
		    ■ Concentrations in water and sediment
		    ■ Tissue concentrations
		    ■ Bioassays
		    ■ Biomarkers
		    ■ Bioindicators
		    ■ Contaminant loading
		■ Dissolved oxygen
		■ Turbidity-suspended solids
		■ Temperature
		■ Nutrients (N, P, C)

Table 1: Ecological Zone: Upland River-Floodplain Ecosystem.		
Habitat (continued)	Instream habitat complexity	■ Pool-to-riffle ratio ■ Abundance, distribution, and recruitment rate of large woody debris ■ Shaded riverine aquatic habitat ■ Diversity of flow velocity

Biological Communities	Community Structure	■ Trends in the abundance, diversity, composition, and distribution of riparian insect assemblages, by functional group
		■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages, by functional group
		■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds
		■ Trends in the abundance, diversity, composition, and distribution of native mammals
		■ Trends in distribution, diversity, and structural complexity of native plant associations
		■ Trends in abundance, diversity, composition, distribution and trophic structure of natives fishes
		■ Invasive introduced species
		    ■ Measures of new invasions
		    ■ Abundance, spatial extent and distribution of selected species
		    ■ Number of selected species eradicated or exhibiting no net increase in distribution
		■ Population trends of selected listed species
		■ Fish and wildlife health

Community Energetics/ Nutrient Cycling	Nutrient loading	■ Nutrients from salmon carcasses ■ Organic input from grazing animals ■ Ratios of natural to anthropogenic sources of nutrients

Table 2: Ecological Zone: Alluvial River-Floodplain Ecosystem.		
Ecosystem Typology: Lowland rivers, as defined herein, constitute those waterways and their floodplains that traverse the alluvial deposits of the Central Valley. The actual geomorphic "dividing line" between "upland" and "lowland" river-floodplain systems (as defined in this document) generally occurs at about the 300 ft. elevation contour. Lowland river-floodplain systems of the Central Valley are distributed across a vast area, covering thousands of square miles. This does not include the Redding Basin, which is considered part of the upland mountain river-floodplain ecosystem described in the previous section.		
INDICATOR TYPE	**ATTRIBUTE**	**INDICATORS**
Hydrologic/ Hydrodynamic	Variable streamflows	■ Minimum base flows ■ Seasonal shifts in river level ■ Measures of variability ■ Geographic distribution of flows
	Floods	■ Minimum surface area of floodplain inundated at least once every 2 years and every 10 years ■ Flood duration (mean and variability) ■ Mean annual frequency
	Ground water	■ Depth of water table ■ Soil moisture levels, laterally from banks. ■ Characteristic plant communities ■ Width of riparian corridor
Geomorphic	Topography	■ Mean width of available meander corridor ■ Percent of river length not constrained by constructed levees ■ Distribution and extent of floodplain habitats ■ Distribution and extent of littoral zone
	River meander	■ Percent of river miles exhibiting naturalistic meandering
	Sediment supply, delivery, and movement processes	■ Net change in depth per unit time of unconsolidated sediment ■ Amount of coarse sediment delivered (as a proportion of pre-dam) ■ Lateral exchange: river to floodplain ■ Inter-annual comparison of fluvial geomorphic features ■ Sediment particle size and distribution ■ Pool-to-riffle ratio
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport

Table 2: Ecological Zone: Alluvial River-Floodplain Ecosystem.		

Habitat (continued)	Water/sediment quality	■ Toxicity
		  ■ Concentrations in water and sediment
		  ■ Tissue concentrations
		  ■ Bioassays
		  ■ Biomarkers
		  ■ Bioindicators
		  ■ Contaminant loading
		■ Dissolved oxygen
		■ Turbidity-suspended solids
		■ Temperature
		■ Nutrients (N, P, C)

Biological Communities	Community Structure	■ Trends in the abundance, diversity, composition, and distribution of riparian insect assemblages, by functional group
		■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages by functional group
		■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds
		■ Trends in the abundance, diversity, composition, and distribution of native mammals
		■ Trends in distribution, diversity, and structural complexity of native plant associations
		■ Trends in abundance, diversity, composition, distribution and trophic structure of natives fishes
		■ Invasive introduced species
		  ■ Measures of new invasions
		  ■ Abundance, spatial extent and distribution of selected species
		  ■ Number of selected species eradicated or exhibiting no net increase in distribution
		■ Population trends of selected listed species
		■ Fish and wildlife health

Community Energetics/ Nutrient Cycling	Nutrient and energy supply	■ Ratio of floodplain to river production ■ Export of organic materials from floodplain to river channel ■ Percent increase in dissolved N and P after overbank flows ■ Concentrations of dissolved N and P in groundwater at selected sites

Table 3. Ecological Zone: Delta		
Ecosystem Typology: The Delta is the easternmost (upstream) portion of the estuary, and today is clearly delimited by a legal boundary that includes areas that historically were intertidal, along with supra-tidal portions of the floodplains of the Sacramento and San Joaquin Rivers. Today's legal Delta extends between the upper extent of the tidewater (near the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River) and Chipps Island to the west, and encompasses the lower portions of the Sacramento and San Joaquin river-floodplain systems as well as those of some lesser tributaries (Mokelumne, Calaveras Rivers). The Sacramento and San Joaquin Rivers enter the Delta from the north and south respectively, where they join and together discharge their contents near the western margin of the Delta.		
INDICATOR TYPE	**ATTRIBUTE**	**INDICATORS**
Hydrologic/ Hydrodynamic	Positive seaward flow	■ Delta outflow
	Spatial and temporal salinity patterns	■ Salinity at selected locations throughout the Delta

	Water circulation	■ Composite measures
		  ■ Freshwater flow rates
		  ■ Water residence time
		  ■ Flow direction for selected channels
		■ Flows of tributaries mimic pattern of unimpaired flow

Geomorphic	Flat topography	■ Difference in percent of area flooded during MHHW versus MLLW
	Dendritic distributary channel patterns	■ Linear distance of channels per unit area ■ Proportion of first, second, and third order channels per unit area
	Channel morphology	■ Bank slope
	Physical connectivity	■ Connectivity of riverine channels to wetlands
	Sediment production and acquisition	■ Marsh plain elevation relative to sea level ■ Change in area of Delta islands and islets
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport

	Water/sediment quality	■ Toxicity
		■ Concentrations in water and sediment
		  ■ Tissue concentrations
		  ■ Bioassays
		  ■ Biomarkers
		  ■ Bioindicators

Table 3. Ecological Zone: Delta

Habitat (continued)		■ Contaminant loading ■ Dissolved oxygen ■ Turbidity-suspended solids ■ Temperature ■ Nutrients (N, P, C) ■ Salinity/TDS
Biological Communities	Community Structure	■ Trends in abundance, diversity, composition, and distribution of native phytoplankton and zooplankton assemblages ■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages ■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds ■ Trends in the abundance, diversity, composition, and distribution of native mammals ■ Trends in distribution, diversity, and structural complexity of native plant associations ■ Trends in abundance, diversity, composition, distribution and trophic structure of native resident and anadromous fishes ■ Cohort replacement and survival rates of selected life stages of certain fish ■ Invasive introduced species ■ Measures of new invasions ■ Abundance, spatial extent and distribution of selected species ■ Number of selected species eradicated or exhibiting no net increase in distribution ■ Population trends of selected listed species ■ Fish and wildlife health
Community Energetics/ Nutrient Cycling	Plankton productivity	■ Primary production rates ■ Abundance of zooplankton
	Benthic invertebrate production	■ Secondary production of zoobenthos
	Net transport/export of detrital organic matter from marshes to other habitats	■ Flux of detrital organic matter
	Variable sources of nutrient loading to the Bay	■ Nutrient loading

Table 4. Ecological Zone: Greater San Francisco Bay.

Ecosystem Typology: Greater San Francisco Bay, as defined here, is that part of the estuary between Chipps Island and the Golden Gate. It includes four major embayments: Suisun Bay and Marsh, San Pablo Bay, and central and south San Francisco Bay.

INDICATOR TYPE	ATTRIBUTE	INDICATORS
Hydrologic/ Hydrodynamic	Freshwater inflow	■ X2 location ■ Salinity at selected locations throughout Bay
	Spatial and temporal salinity patterns	■ Salinity at selected locations throughout Bay ■ X2 location
	Hydrodynamics	■ Water movement and vertical mixing at select locations throughout Bay
Geomorphic	Sediment supply	■ Net sediment accretion rate relative to rate of sea-level rise at subtidal and intertidal sites ■ Elevation at appropriate fixed sites in marshes and mudflats throughout Bay. Compare to sea level
Habitat	Habitat mosaic and connectivity	■ Extent and distribution of patches of all natural habitat types ■ presence and distribution of species requiring multiple habitats ■ Presence and distribution of migratory fish species ■ Number of unnatural barriers interfering with natural movements of native species, water flow, sediment transport and supply, and nutrient transport

	Water/sediment quality	■ Toxicity
		    ■ Concentrations in water and sediment
		    ■ Tissue concentrations
		    ■ Bioassays
		    ■ Biomarkers
		    ■ Bioindicators
		    ■ Contaminant loading
		■ Dissolved oxygen
		■ Turbidity-suspended solids
		■ Nutrients (N, P, C)
		■ Salinity/TDS

Table 4. Ecological Zone: Greater San Francisco Bay.		

Biological Communities	Community Structure	■ Trends in abundance, diversity, composition, and distribution of native phytoplankton and zooplankton assemblages
		■ Trends in the abundance, diversity, composition, and distribution of benthic invertebrate assemblages
		■ Trends in abundance, reproductive success, diversity, composition, and distribution of native resident and migratory birds
		■ Trends in distribution, diversity, and structural complexity of native plant associations
		■ Trends in abundance, diversity, composition, distribution and trophic structure of native resident and anadromous fishes
		■ Invasive introduced species
		  ■ Measures of new invasions
		  ■ Abundance, spatial extent and distribution of selected species
		  ■ Number of selected species eradicated or exhibiting no net increase in distribution
		■ Population trends of selected listed species
		■ Fish and wildlife health

Community Energetics/ Nutrient Cycling	Plankton productivity	■ Phytoplankton productivity ■ Zooplankton productivity
	Benthic invertebrate production	■ Benthic invertebrate productivity
	Net transport/export of detrital organic matter from marshes to other habitats	■ Flux of detrital organic matter

References

Indicators Workgroup. 1998. Framework process for CALFED ecosystem restoration program ecological indicators development. Draft, August 27, 1998. 40 pp + appendix.

Moyle, P. B. 1996. Status of aquatic habitat types. Chapter 32, pages 945 - 952, *in*: Sierra Nevada Ecosystem Project, Final Report to Congress, vol. II, Assessments and Scientific Basis for Management Options. Davis: University of California, Centers for Water and Wildland Resources, 1996.

Moyle, P. B. and J. P. Ellison. 1991. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77:161-180.

◆ Visions for Ecosystem Elements

The Strategic Plan for Ecosystem Restoration provides the scientific and practical framework for restoring the Bay-Delta watershed. The Strategic Plan guides the planning by providing 6 Strategic Goals which bound the scope of ecosystem restoration and numerous Strategic Objectives which provide more detailed direction and a basis by which to determine whether or not progress is being made toward achieving the respective goal. The majority of the goals are presented in terms of management or restoration actions designed to have a favorable impact on the Bay-Delta ecosystem and watershed.

This section provides the ERP vision for each of the ecosystem elements (ecological processes, habitats, species, and stressors). Each vision is a snapshot of what the ERP intends to accomplish during the long-term implementation program.

Table 5. Summary of Visions for Ecosystem Elements.

Ecosystem Element	Vision Summary
Ecosystem Processes	
Hydrology and Hydraulics	
Central Valley Streamflows	The vision for Central Valley streamflows is to protect and enhance the ecological functions that are achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas in order to contribute to the recovery of species and the overall health of the Bay-Delta.
Bay-Delta Hydraulics	The vision for hydraulic processes in the Sacramento-San Joaquin Delta is to restore channel hydraulics to conditions more like those that occurred during the mid-1960s. Historical hydraulic conditions provided migratory cues for aquatic species; transport flows for eggs, larvae, and juvenile fish; and transport of sediments and nutrients.
Channel Forming Processes	
Stream Meander	The vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible, by implementing stream conservation programs, setting levees back, and reestablishing natural sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities.
Natural Floodplains and Flood Processes	The vision for natural floodplains and flood processes is to conserve existing intact floodplains and modify or remove barriers to overbank flooding to reestablish aquatic, wetland, and riparian floodplain habitats.

Ecosystem Element	Vision Summary
Coarse Sediment Supply	The vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to riverine bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions. This would contribute to habitat structure, function, and foodweb production throughout the ecosystem.
Cycling and Transport of Nutrients, Detritus, and Organisms	
Bay-Delta Aquatic Foodweb	The vision for the Bay-Delta aquatic foodweb is to restore primary and secondary production to levels comparable to those during the 1960s and early 1970s. Restoring the Bay-Delta foodweb would require enhancing productivity and reducing loss of productivity as a result of water exports from the system, and in seeking to reduce or eliminate the adverse effects of introduced aquatic species.
Water Quality	
Central Valley Stream Temperatures	The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature.
Habitats	
Tidal Perennial Aquatic Habitat	The vision for tidal perennial aquatic habitats is to increase the area and improve the quality of existing connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes. Achieving this vision will assist in the recovery of special-status fish and plant populations and provide high-quality aquatic habitat for other fish, wildlife, and plant communities dependent on the Bay-Delta. Restoring tidal perennial aquatic habitat would also result in higher water quality and increase the amount of shallow-water and mudflat habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish.
Nontidal Perennial Aquatic Habitat	The vision for nontidal perennial aquatic habitat is to increase the area and improve the quality of existing open-water areas to provide high-quality habitat for waterfowl and other water birds. This vision can be achieved as a component of saline and freshwater emergent wetland restorations.
Delta Sloughs	The vision for Delta sloughs is to increase the area and improve the quality of interconnected dead-end and open-ended Delta sloughs. Achieving this vision will assist in the recovery of special-status fish and wildlife populations, provide shallow-water habitats for fish spawning and rearing, and provide aquatic, wetland, and riparian habitat for wildlife. Existing sloughs would be protected and enhanced and the area of tidal slough habitat would be increased.

Ecosystem Element	Vision Summary
Midchannel Islands and Shoals	The vision for midchannel islands and shoals is to increase and enhance the area and protect the quality of existing habitat for fish and wildlife dependent on the Bay-Delta.
Saline Emergent Wetland	The vision is to increase the area and protect the quality of existing saline emergent wetlands from degradation or loss. Wetland habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Fresh Emergent Wetland	The vision is to increase the area and improve the quality of existing fresh emergent wetlands from degradation or loss and increase wetland habitat. Achieving this vision will assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Seasonal Wetlands	The vision is to increase the area and improve the quality of seasonal wetlands by restoring ecosystem processes that sustain them and reduce the effect of stressors that can degrade the quality of seasonal wetlands in order to assist in the recovery of special-status plant and animal populations and provide high-quality habitat for waterfowl, water birds, and other wildlife dependent on the Bay-Delta.
Riparian and Riverine Aquatic Habitats	The vision for riparian and riverine aquatic habitats is to increase their area and protect and improve their quality. Achieving this vision will assist in the recovery of special-status fish and wildlife populations and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta. The vision includes restoring native riparian communities ranging from valley oak woodland associated with higher, less frequently inundated floodplain elevations to willow scrub associated with low, frequently inundated floodplain elevation sites such as streambanks, point bars, and inchannel bars.
Freshwater Fish Habitats	The vision for freshwater fish habitats is to protect existing habitat from degradation or loss, to restore degraded habitats, and restore areas to a more natural state. Freshwater fish habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.
Essential Fish Habitats	The vision for essential fish habitats is to maintain and improve the quality of existing habitats and to restore former habitats in order to support self-sustaining populations of chinook salmon.
Inland Dune Scrub Habitat	The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas. Achieving this vision will provide high-quality habitat for associated special-status plant and animal populations.

Ecosystem Element	Vision Summary
Perennial Grassland	The vision is to protect and improve existing perennial grasslands and increase perennial grassland area. This vision is a component of restoring wetland and riparian habitats. Achieving this vision will provide high-quality habitat for special-status plant and wildlife populations and other wildlife dependent on the Bay-Delta.
Agricultural Lands	The vision for agricultural lands is to improve associated wildlife habitat values to support special-status wildlife populations and other wildlife dependent on the Bay-Delta. Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.
Species and Species Groups	
Priority Group I: At-risk native species dependent on the Bay-Delta system, most of them listed under the State or federal Endangered Species Acts (ESA) or proposed for listing, whose management for restoration will require substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of the year).	
Species	Vision Summary (Conservation Strategy designation in parentheses, designations are described at the end of this section.)
Fish Species	
Delta Smelt	The vision for delta smelt is to recover this State- and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta. Achieving this vision will reduce the conflict between protection for this species and other beneficial water uses in the Bay-Delta. Increases in the population and distribution of delta smelt can be realized through habitat restoration accompanied by reductions in stressors. **(Conservation Strategy Designation: Recover)**
Longfin Smelt	The vision for longfin smelt is to recover this California species of special concern and restore population distribution and abundance in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb. **(Conservation Strategy Designation: Recover)**

Ecosystem Element	Vision Summary
Green Sturgeon	The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels. Restoration of this species would contribute to overall species richness and diversity, and reduce conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Splittail	The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of water in the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Chinook Salmon	The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley. **(Conservation Strategy Designation: Recover)**
Winter-run Chinook Salmon	The vision for winter-run chinook salmon is to recover this State and Federally listed endangered species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully uses existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley. **(Conservation Strategy Designation: Recover)**
Spring-run Chinook Salmon	The vision for spring-run chinook salmon is to recover this stock which is proposed for listing as endangered under the ESA and listed as a threatened species under CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley. **(Conservation Strategy Designation: Recover)**

Ecosystem Element	Vision Summary
Late-fall-run Chinook Salmon	The vision for late-fall-run chinook salmon is to recover this stock which is presently proposed for listing under the ESA (it is included in the fall-run chinook salmon evolutionarily significant unit), achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley. **(Conservation Strategy Designation: Recover)**
Fall-run Chinook Salmon	The vision for the fall-run chinook salmon evolutionarily significant unit is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley. **(Conservation Strategy Designation: Recover)**
Steelhead Trout	The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully uses existing and restored habitat areas. **(Conservation Strategy Designation: Recover)**
Priority Group II: At-risk native species dependent on the Bay-Delta whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).	
Fish Species	
Anadromous Lampreys	The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability. **(Conservation Strategy Designation: Not Covered)**
Mammal Species	
Salt Marsh Harvest Mouse	The vision for the salt marsh harvest mouse is to contribute to the recovery of this State- and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes. **(Conservation Strategy Designation: Contribute to Recovery)**

Ecosystem Element	Vision Summary
San Pablo California Vole	The vision for the San Pablo California vole is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Suisun Ornate Shrew	The vision for the Suisun ornate shrew is to recover this California species of special concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Bird Species	
Swainson's Hawk	The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
California Clapper Rail	The vision for the California clapper rail is to contribute to the recovery of this State- and federally listed endangered species to contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
California Black Rail	The vision for the California black rail is to contribute to the recovery of this State-listed threatened species and contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Suisun Song Sparrow	The vision for the Suisun song sparrow is to recover this California species of special concern in Suisun Marsh and the western Delta and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Alameda Song Sparrow	The vision for the Alameda song sparrow is to restore this California species of special concern in the southern San Francisco Bay region. **(Conservation Strategy Designation: Not Covered)**

Ecosystem Element	Vision Summary
Invertebrate Species	
Valley Elderberry Longhorn Beetle	The vision for the valley elderberry longhorn beetle is to recover this federally listed threatened species by increasing their populations and abundance through habitat restoration. **(Conservation Strategy Designation: Recover)**
Special Status Plant Species	
Mason's Lilaeopsis	The vision for Mason's lilaeopsis is to recover this State listed rare plant by protecting and preserving important habitat sites within the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Suisun Marsh Aster	The vision for Suisun Marsh aster is to recover this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Recover)**
Bristly Sedge	The vision for bristly sedge is to contribute to the recovery of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Contribute to Recovery)**
Suisun Thistle	The vision for Suisun thistle is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Soft Bird's Beak	The vision for soft bird's beak is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta. **(Conservation Strategy Designation: Recover)**
Delta Tule Pea	The vision for Delta tule pea is to contribute to the recovery of this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Contribute to Recovery)**
Delta Mudwort	The vision for Delta mudwort is to contribute to the recovery of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Contribute to Recovery)**
Alkali Milkvetch	The vision for alkali milkvetch is to contribute to the recovery of this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Contribute to Recovery)**
Priority Group III: At-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.	
Mammal Species	
Riparian Brush Rabbit	The vision for the riparian brush rabbit is to contribute to the recovery of this federally proposed and State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat. **(Conservation Strategy Designation: Contribute to Recovery)**

Ecosystem Element	Vision Summary
San Joaquin Valley Woodrat	The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally proposed endangered species through improvement in its habitat to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Fish Species	
Sacramento Perch	The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Bird Species	
Greater Sandhill Crane	The vision for the greater sandhill crane is to contribute to the recovery of this State-listed threatened species in the Bay-Delta. Recovery of the greater sandhill cane would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Western Yellow-Billed Cuckoo	The vision for the western yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. Recovery of this species would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Bank Swallow	The vision for the bank swallow is to contribute to the recovery of this State-listed threatened species. Recovery of the bank swallow would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Western Least Bittern	The vision for the Western least bittern is to contribute to the recovery of this California species of special concern to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**

Ecosystem Element	Vision Summary
Least Bell's Vireo	The vision for the Least Bell's vireo is to contribute to the recovery of this State and federally listed endangered species to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
California Yellow Warbler	The vision for the California yellow warbler is to contribute to the recovery of this California species of special concern. **(Conservation Strategy Designation: Contribute to Recovery)**
Little Willow Flycatcher	The vision for the little willow flycatcher is to contribute to the recovery of this State-listed endangered species. Recovery of the little willow flycatcher would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
Reptile and Amphibian Species	
Giant Garter Snake	The vision for the giant garter snake is to contribute to the recovery of this State- and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Contribute to Recovery)**
California Tiger Salamander	The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Achieving this vision will 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. **(Conservation Strategy Designation: Maintain)**
Western Spadefoot Toad	The vision for the western spadefoot toad is to maintain this California species of special concern in the Bay-Delta. Achieving this vision will 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. **(Conservation Strategy Designation: Maintain)**
California Red-Legged Frog	The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Maintain)**

Ecosystem Element	Vision Summary
Native Anuran Amphibians	The vision for native anuran amphibians is to contribute to their restoration. Note: western spadefoot and California red-legged frog are discussed individually. **(Conservation Strategy Designation: foothill yellow-legged frog = maintain, other species = not covered)**
Western Pond Turtle	The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: Maintain)**
Invertebrate Species	
Delta Green Ground Beetle	The vision for the delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration. **(Conservation Strategy Designation: Contribute to Recovery)**
Lange's Metalmark Butterfly	The vision for the Lange's metalmark butterfly is to recover this federally listed endangered species by increasing the existing Lange's metalmark population distribution and by increasing its abundance. **(Conservation Strategy Designation: Recover)**
California Freshwater Shrimp	The vision for the California freshwater shrimp is to maintain populations of this federally listed endangered species by maintaining its existing distribution and abundance. **(Conservation Strategy Designation: Maintain)**
Plant Species	
Fragrant Fritillary	The vision for fragrant fritillary is to maintain populations of this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Not Covered)**
Recurved Larkspur	The vision for recurved larkspur is to maintain populations of this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Maintain)**
Mad-dog Skullcap	The vision for mad-dog skullcap is to maintain populations of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Maintain)**
Rose-mallow	The vision for rose-mallow is to maintain populations of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Maintain)**

Ecosystem Element	Vision Summary
Eel-grass Pondweed	The vision for eel-grass pondweed is to maintain populations of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Maintain)**
Colusa Grass	The vision for Colusa grass is to maintain populations of this federally listed threatened and State-listed endangered species. **(Conservation Strategy Designation: Maintain)**
Boggs Lake Hedge-hyssop	The vision for Boggs Lake hedge-hyssop is to maintain populations of this State-listed endangered species. **(Conservation Strategy Designation: Maintain)**
Contra Costa Goldfields	The vision for Contra Costs goldfields is to maintain populations of this federally listed endangered species. **(Conservation Strategy Designation: Maintain)**
Legenere	The vision for legenere is to maintain populations of this California Native Plant Society List 1B plant species. **(Conservation Strategy Designation: Maintain)**
Dwarf Downingia	The vision for dwarf downingia is to maintain populations of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Not Covered)**
Crampton's Tuctoria	The vision for Crampton's tuctoria is to contribute to the recovery of this federally and State-listed endangered species. **(Conservation Strategy Designation: Contribute to Recovery)**
Heartscale	The vision for heartscale is to maintain populations of this California Native Plant Society List 2 plant species. **(Conservation Strategy Designation: Maintain)**
Antioch Dunes Evening-primrose	The vision for Antioch Dunes evening-primrose is to recover this federally and State-listed endangered species. **(Conservation Strategy Designation: Recover)**
Contra Costa Wallflower	The vision for Contra Costa wallflower is to recover this federally and State-listed endangered species. **(Conservation Strategy Designation: Recover)**

Ecosystem Element	Vision Summary
Priority Group IV: Native species in the estuary and watershed that are not yet at risk of extinction that have the potential to achieve that status if steps are not taken to reverse their declines or keep populations at present levels. Their rehabilitation either does not depend on conditions in the Bay-Delta system or depends on unknown factors.	
Fish Species	
Native Resident Fish Species	The vision for resident fish species is to maintain and restore the distribution and abundance of native species, such as Sacramento blackfish, hardhead, and tule perch to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. **(Conservation Strategy Designation: hardhead = maintain, other species = Not Covered)**
Invertebrate Species	
Bay-Delta Aquatic Foodweb Organisms	The vision for the Bay-Delta aquatic foodweb organisms is to maintain and restore the Bay-Delta estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton communities. **(Conservation Strategy Designation: Not Covered)**
Bird Species	
Shorebird and Wading Bird Guild	The vision for the shorebird and wading bird guild is to maintain and restore healthy populations of shorebirds and wading birds through habitat protection and restoration and reduction in stressors. **(Conservation Strategy Designation: Not Covered)**
Migratory Waterfowl	The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl management Plan. **(Conservation Strategy Designation: Not Covered)**
Neotropical Migratory Bird Guild	The vision for the neotropical migratory bird guild is to maintain and restore healthy populations of neotropical migratory birds through restoring habitats on which they depend. Note: several neotropical species are discussed individually. **(Conservation Strategy Designation: Not Covered)**
Upland Game	The vision for upland game is to maintain and restore healthy populations of native upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors. **(Conservation Strategy Designation: Not Covered)**

Ecosystem Element	Vision Summary
Plant Species	
Plant Community Groups	The vision for plant community groups is to maintain and restore existing and rehabilitate degraded habitats that support the diverse assemblages of plants in the Bay-Delta. **(Conservation Strategy Designation: Not Covered)**
Species covered by Strategic Goal 3: Maintain and enhance populations of selected species for sustainable commercial and recreational harvest.	
Fish Species	
Striped Bass	The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission's striped bass policy. This will support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. **(Conservation Strategy Designation: Not Covered)**
White Sturgeon	The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Restoration would support a sport fishery for white sturgeon, and contribute to overall species richness and diversity and reduce conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta. **(Conservation Strategy Designation: Not Covered)**
American Shad	The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Achieving this vision will reduce the conflict between protection of this species and other beneficial uses of water in the Bay-Delta. **(Conservation Strategy Designation: Not Covered)**
Non-native Warmwater Gamefish	The vision for non-native warmwater gamefish is to maintain self-sustaining populations in order to provide opportunities for consumptive use such as fishing. **(Conservation Strategy Designation: Not Covered)**
Pacific Herring	The vision for Pacific herring is to maintain self-sustaining populations in order to support commercial fishing. **(Conservation Strategy Designation: Not Covered)**
Invertebrate Species	
Signal Crayfish	The vision for signal crayfish is to maintain self-sustaining populations in order to support recreational and commercial fishing. **(Conservation Strategy Designation: Not Covered)**
Grass Shrimp	The vision for grass shrimp is to maintain self-sustaining populations in order to support existing commercial fisheries. **(Conservation Strategy Designation: Not Covered)**

Ecosystem Element	Vision Summary
Stressors	
Water Diversions	The vision for water diversions is to reduce the adverse effects of water diversions, including entrainment of all life stages of aquatic species, by installing fish screens, consolidating or moving diversions to less sensitive locations, removing diversions, or reducing the volume of water diverted. Achieving this vision will assist in the recovery of State- and federally listed fish species, improve important sport fisheries, and improve the Bay-Delta aquatic foodweb.
Dams and Other Structures	The vision for dams and other structures is to reduce their adverse effects by improving fish passage and enhancing downstream fish habitat. Reducing these adverse effects will assist in the recovery of State- and federally listed fish species and contribute to sustainable sport and commercial fisheries.
Levees, Bridges, and Bank Protection	The vision for levees, bridges, and bank protection is to reduce the adverse effects of these structures in order to improve riverine and floodplain habitat conditions to assist in the recovery of State- and federally listed fish species, and other fish and wildlife.
Dredging and Sediment Disposal	The vision for dredging and sediment disposal in the Bay-Delta is to maintain adequate channel depth for navigation, flood control, and water conveyance while reducing the adverse effects of dredging activities on the Bay-Delta ecosystem. Dredged material disposal would be environmentally sound and the use of nontoxic dredged material would be promoted as a resource for restoring tidal wetlands and other habitats, reversing Delta island subsidence, and improving dikes and levees.
Gravel Mining	The vision for gravel mining is to improve gravel transport and cleansing by reducing the adverse effects of instream gravel mining. Achieving this vision would help to maintain or restore flood, floodplain, and streamflow processes that govern gravel supply to improve fish spawning and floodplain habitats.
Invasive Aquatic Plants	The vision for invasive aquatic plants is to reduce their adverse effects on native species and ecological processes, water quality and conveyance systems, and major rivers and their tributaries.
Invasive Aquatic Organisms	The vision for invasive aquatic organisms is to reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation. This vision can be accomplished through enforcement of State laws regulating ballast water dumping and other measures designed to reduce the number of new, potentially harmful species introduced accidentally into the Bay-Delta estuary. Habitat changes or direct control measures may reduce their effects in specific cases.

Ecosystem Element	Vision Summary
Invasive Riparian and Marsh Plants	The vision for invasive riparian and salt marsh plant species is to reduce their adverse effects on native species and ecological processes, water quality and water conveyance systems, and major rivers and their tributaries.
Zebra Mussel	The vison for zebra mussel is to establish procedures to prevent or delay their introduction and to set up protocols to swiftly treat and eliminate any introduction.
Non-Native Wildlife	The vision for non-native wildlife species is to implement a program to reduce the numbers of harmful non-native wildlife species (i.e., those that threaten the diversity or abundance of native species or the ecological stability of an area).
Predation and Competition	The vision for predation and competition is to reduce unnatural levels to restore fish populations by removing, redesigning, or reoperating inwater structures, diversion dams, and hatchery practices.
Contaminants	The vision for contaminants is to ensure that all waters of mainstem rivers and tributaries entering the Bay-Delta, and all waters of the Bay-Delta, are free of deleterious concentrations of toxic substances. The vision includes preventing, controlling, or reducing damaging levels of high-priority contaminants by remediating mine wastes, minimizing boat discharges and dredging effects, managing flows, restoring habitat, managing watersheds, and supporting existing programs for controlling agricultural and urban point and nonpoint sources.
Fish and Wildlife Harvest	The vision for fish and wildlife harvest is to support strategies that maintain a sustainable commercial and recreational chinook salmon fishery in a manner consistent with the recovery of individual stocks; steelhead trout harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks; the continued legal harvest of striped bass and reduction of illegal harvest; and the present white sturgeon harvest strategy, which protects the species from overexploitation while providing a sustainable trophy fishery.
Artificial Fish Propagation	The vision for the artificial propagation of fish is to modify existing hatcheries and hatchery practices in ways to augment salmon and steelhead populations without having detrimental effects on naturally spawning populations of salmon and steelhead.
Stranding	The vision for stranding is to reduce the magnitude of the number of aquatic organisms lost when rivers recede or overflow into flood bypasses and to reconnect areas that become isolated with flowing water and to reduce the frequency by which low-lying areas are inundated.
Disturbance	The vision for disturbance is to reduce the adverse effects of boating and other recreational activities, temporary habitat disturbances, and other human activities on wildlife and their habitats in the Bay-Delta.

CONSERVATION STRATEGY SPECIES DESIGNATIONS

The Multi-species Conservation Strategy (MSCS) addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term "evaluated species" is used to refer to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (bound separately) for more information and for a complete list of evaluated species.

RECOVERY "R": For those species designated "R" the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of "Recovery" was generally assigned to those species whose range is entirely or nearly entirely within the area affected by the CALFED Program and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recovery the species. The term "recover" generally means the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured. In the case of most species listed under the Federal ESA, recovery is equivalent, at a minimum, to the requirements of delisting. For certain species, such as anadromous fish, with threats outside the geographic scope or purview of the CALFED Program, CALFED may not be capable of completely recovering the species, but will implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED may choose a goal that aims to achieve more than would be required for delisting (e.g., restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "Recovery" may be highly variable between species. In sum, a goal of "Recovery" implies that CALFED will undertake all actions within the ERP Ecological Management Zones and program scope necessary to recover the species.

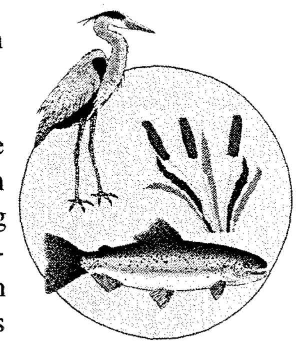
CONTRIBUTE TO RECOVERY ("r"): For those species designated "r," the CALFED Program will make specific contributions toward the recovery of the species. The goal "Contribute to Recovery" was generally assigned to those species for which CALFED Program actions affect only a limited portion of the species range and/or CALFED Program actions have limited effects on the species. In the case of a species with a recovery plan, this may mean implementing some of the measures identified in the plan. For species without a recovery plan, this would mean implementing specific measures that would benefit the species. In sum, a goal of contributing to a species' recovery implies that CALFED will undertake some of the actions within its geographic scope necessary to recovery the species.

MAINTAIN ("M"): For those species designated "m," the CALFED Program will undertake actions to maintain the species (this category is less rigorous than Contribute to Recovery). The goal "Maintain" was generally assigned to species expected to be minimally affected by CALFED actions. For this category, CALFED will ensure that any adverse effects to the species are addressed commensurate with the level of effect on the species; thus, actions may not actually contribute to the recovery of the species, but would be expected, at a minimum, to not contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also maximize beneficial effects on these species to the extent practicable.

◆ Ecological Process Visions

Introduction

This section presents visions for ecological processes. 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. Physical and biological processes addressed are those that have a strong effect in shaping and influencing the Bay-Delta ecosystem. These processes can also be managed to improve the health of the Bay-Delta ecosystem and its resources. Table 6 identifies important ecological processes and the related Strategic Plan objective. Table 7 presents the basis for their selection as an ecosystem element.



Visions describe the role and importance of each process in maintaining the health of the Bay-Delta, and a description of how the process currently operates in the ecosystem, stressors and changes to other processes that have altered how they operate in the ecosystem. The Strategic Plan objectives, targets, and programmatic actions are presented here and more fully described in Volume II: Ecological Management Zone Visions. Table 8 presents the ecological management zone in which Strategic Plan objectives, targets, and programmatic actions have been proposed to accomplish each ecological process vision.

Table 6. Strategic Plan Goal and Objectives for Ecological Processes.

<table>
<tr><td colspan="2">Goal 2. Rehabilitate natural processes in the Bay-Delta estuary and its watershed to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities.</td></tr>
<tr><th>Ecological Process</th><th>Strategic Plan Objective</th></tr>
<tr><td rowspan="3">Central Valley Streamflows
and
Central Valley Stream Temperatures</td><td>Manage the hydrologic regime for the Bay-Delta system in ways that favor native species, desirable non-native species, and natural habitats.</td></tr>
<tr><td>Make sure that high flows occur frequently enough in regulated streams to maintain channel and sediment conditions favorable to native aquatic and riparian organisms.</td></tr>
<tr><td>Create flow and temperature regimes in regulated rivers that favor native aquatic species.</td></tr>
</table>

Goal 2. Rehabilitate natural processes in the Bay-Delta estuary and its watershed to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities.	
Ecological Process	**Strategic Plan Objective**
Coarse Sediment Supply	Restore coarse sediment supply to sediment-starved rivers downstream of reservoirs.
Stream Meander	Increase the extent of freely meandering reaches and other pre-1850 river channel forms.
Natural Floodplains and Flood Processes	Re-establish frequent inundation of floodplains by removing, breaching, or setting back levees and, in regulated rivers, by providing flow releases capable of inundating floodplains
Bay-Delta Hydraulics	Establish and manage a hydrodynamic regime for the Bay-Delta estuary that favors native species, desirable non-native species, and natural habitats by providing species needs such as migratory cues, transport, food web support, and rearing habitat, and restoring and maintaining important aquatic and terrestrial habitats.
Bay-Delta Aquatic Foodweb	Increase estuarine productivity.

Table 7. Basis for Selection of Ecological Process Ecosystem Elements.

Ecological Process	Basis for Selection as an Ecosystem Element
Central Valley Streamflows and Central Valley Stream Temperatures	Virtually all streams in the region are regulated to a greater or lesser degree and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns and increasing flows during summer months. Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional experimentation with flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow/habitat conditions for native organisms, as part of the short term goal. Part of the studies should be to determine if the objective can be achieved without 'new' water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. These findings can then be applied opportunistically to achieve the long-term goal. Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year to year variability. Frequent (annual or biannual) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high flow releases (commonly termed 'flushing flows') lends itself well to adaptive management, because the flows can easily be adjusted to determine the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, which requires that monitoring be long-term. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular intervals; artificial high flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one, but differs in its focus on high flow events that are likely to be higher than those needed to maintain most native fish species but important for maintaining in-channel and riparian habitats for other species (invertebrates, birds, mammals, etc.).

Ecological Process	Basis for Selection as an Ecosystem Element
Coarse Sediment Supply	One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing 'armoring' of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. Accomplishing this objective can be done by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50 percent of estimated bedload supply or less (or levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.
Stream Meander	Freely migrating rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to maintain. Flood plain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch flood waters).
Natural Floodplains and Flood Processes	Frequent (usually annual or biannual) flood plain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) limits shear stress exerted on the bed, reducing channel incision, (2) acts as a "pressure relief valve," permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores flood water (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to re-establish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since the severe floods of the Mississippi River and its tributaries in 1993.

Ecological Process	Basis for Selection as an Ecosystem Element
Bay-Delta Hydraulics	Bay-Delta hydraulics refers to the direction and velocity of flows in the Bay-Delta channels on a temporal, tidal, and seasonal basis for a given hydrologic condition. The direction and velocity of flows and their distribution in time and location help define the extent to which the Bay-Delta can support important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Human activities such as reduced Delta inflow, exports from the Delta, and conversion of tidal wetlands have had a large influence on the natural hydraulic regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydraulic regime that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta.
Bay-Delta Aquatic Foodweb	The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal or seasonally flooded marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

Table 8. Ecological Management Zones for Which Targets, and Programmatic Actions Are Proposed for Ecological Processes.

[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding targets and programmatic actions.]

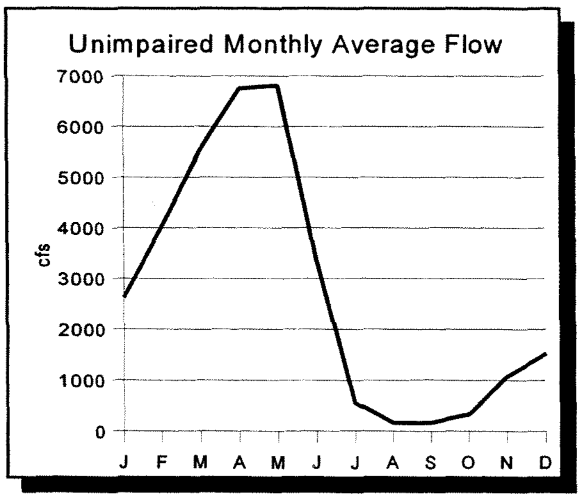
Ecological Process Vision	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Central Valley Streamflows and Temperatures	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Coarse Sediment Supply	●	●	●	●	●	●	●	●	●	●	●	●	●	
Stream Meander			●	●	●		●	●	●			●	●	
Natural Floodplains and Flood Processes	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Bay-Delta Hydraulics	●	●												
Bay-Delta Aquatic Foodweb	●	●												

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

◆ CENTRAL VALLEY STREAMFLOWS

INTRODUCTION

Streamflow refers to the amount of fresh water flowing in rivers and Bay-Delta channels. Central Valley streamflows are a combination of natural discharges from surface water and groundwater and managed releases from reservoirs. Streamflow varies seasonally and annually with rainfall, run-off, and water-supply management. The volume and distribution of water in the Bay-Delta and its watersheds support important ecological processes and functions. Human activities have had a significant influence on the natural streamflow pattern of the Bay-Delta and its watershed.



Unimpaired Median Monthly Average Flow in the American River below Nimbus Dam, 1962-1992

RESOURCE DESCRIPTION

California is divided into hydrologic regions which reflect runoff and drainage basins. Three major hydrologic regions are contained within the ERPP Study Area: Sacramento River, San Joaquin River, and San Francisco Bay

The Sacramento River Region contains the entire drainage of the Sacramento Valley and its adjacent watersheds and extends from Collinsville in the Sacramento-San Joaquin Delta almost 300 upstream to the Oregon border.

Characteristics of the Sacramento River Region

Average annual precipitation: 36 inches
Average annual runoff: 22,389,700 AF
Land area: 26,960 square miles
Population: 2,208,900

(Source: DWR 1994)

The San Joaquin River Region is located in the heart of California and is bordered by the Sierra Nevada on the east and the coastal range on the west.

Characteristics of the San Joaquin River Region

Average annual precipitation: 13 inches
Average annual runoff: 7,933,300 AF
Land area: 15,950 square miles
Population: 1,430,200

(Source: DWR 1994)

The San Francisco Bay Region extends from Pescadero Creek in southern San Mateo County to the mouth of Tomales Bay in the north and inland to the confluence of the Sacramento and San Joaquin rivers near Collinsville.

Characteristics of the San Francisco Bay Region

Average annual precipitation: 31 inches
Average annual runoff: 1,245,500 AF
Land area: 4,400 square miles
Population: 5,484,000

(Source: DWR 1994)

The total streamflow that would occur without upstream reservoirs and diversions is called the unimpaired flow. Data on unimpaired flows provide a record of natural streamflow patterns and a benchmark for judging the effects of water management and allocation of the available runoff. Unimpaired streamflows are also influenced by the condition of the upper watersheds and their ability to moderate or intensify runoff patterns.

Streamflows in Central Valley watersheds are extremely variable. Total annual unimpaired streamflow into and through the Central Valley varies from a low of about 5 million acre-feet (MAF) to a high of about 38 MAF. Most of the flow occurs December through June. A large part of the total flow volume occurs during relatively short periods of time, caused either by rainfall or snowmelt.

Construction and operation of dams on major rivers and streams has reduced peak winter and spring flows and increased summer and fall flows. Dry year flows are higher in some streams from release of carryover storage from reservoirs. In other streams, flow may be lower because of water diversions.

Winter and spring peak flows and summer and fall base flows are important to maintain ecological processes such as sediment transport, stream meandering, and riparian habitat regeneration. Native fish and wildlife species evolved with these flow patterns. Spawning and migrating fish depend on the natural streamflow patterns. For example, Sacramento splittail spawn in winter in flooded areas provided by high flows.

The ability to restore natural streamflows is limited. Constraints include water management practices, upper watershed conditions, and previous water supply allocation (water rights and contracts). Emulating natural runoff patterns will provide the greatest potential for improving the ecological functions that are dependent on streamflow.

ECOLOGICAL FUNCTIONS OF STREAMFLOW

Streamflow can be thought of as the life-blood of the tributary watersheds that link together to form the Sacramento and San Joaquin rivers. Groundwater and surface runoff generate flows into the stream networks in each tributary basin. Streamflow provides the geomorphic forces (energy and materials) needed to create and maintain stream channels and riparian corridors (floodplains). Streamflow controls the erosion, transport, and deposition of sediment in the stream channel and floodplain. Streamflow also transports and cleanses river gravels that support invertebrate production and fish spawning.

Natural flow patterns maintain natural sediment erosion, deposition, transport, and cleansing patterns, and thus natural stream channel and floodplain configurations. Reduced streamflow can lead to excessive sediment deposition in gravelbeds and armoring the channel with cobble.

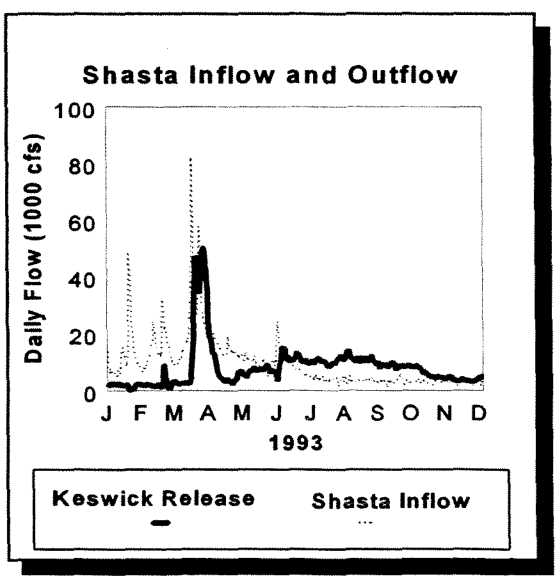
Streamflow transports nutrients as well as dissolved and particulate organic material from rivers upstream to the Delta and estuary. These materials are important to planktonic and benthic foodweb organisms. Streamflows maintain soil moisture and transport seeds which contribute to the regeneration of riparian and riverine aquatic habitats.

Streamflow is needed to flood stream channel pools and riffles and riparian wetlands that provide habitat for fish and other wildlife. Flows transport fish eggs and larvae (e.g., striped bass, delta smelt) from spawning to nursery areas and may assist in the movement of juveniles from upstream spawning and rearing areas to the Delta (e.g., young splittail and chinook salmon).

Streamflow through the Delta to San Francisco Bay is referred to as Delta outflow. Delta outflow is simply the net flow at Chipps Island. Conceptually, it is estimated as the sum of Delta inflow and precipitation in the Delta minus water use in the Delta and exports from the Delta. Delta outflow has a major influence on the tidal mixing processes and the amount of saltwater that reaches upstream into the Delta. Delta outflow controls the location of the "entrapment zone" (the area where freshwater mixes with saline water) and transports planktonic organisms, particulate organic materials, and nutrients from the rivers to the Delta and San Francisco Bay.

Following are general ecological processes and functions sustained with natural streamflow patterns:

- Channel-forming processes create and sustain the pools, riffles, meanders, sand and gravel deposits, banks, side channels, and floodplain areas. These elements are the physical framework for the stream, wetland, riparian corridor, and floodplain habitats.
- Streamflow transports nutrients and organic materials to downstream aquatic habitats where they provide the necessary components for primary (plant) and secondary (bacterial and invertebrate) foodweb production. Transport processes also move larval and juvenile fish and other aquatic organisms to downstream rearing habitats.



- Filling and flooding of channel and floodplain areas at high streamflows provide aquatic, wetland, and riparian habitat and sustain botanical processes (i.e., seed dispersal, soil moisture replenishment) within the floodplain, flood bypass, and riparian stream corridor.

HYDROLOGIC VARIATIONS

Water supplies in the Central Valley are categorized by "water-year classes" (wet, above normal, below normal, dry, and critical). This natural year-to-year hydrologic variability is used to establish water management plans. Facility operations are generally estimated using monthly rainfall and natural, unimpaired runoff conditions. Runoff is estimated from measured flows for 1922 to the present.

Seasonal variability results from rainfall events and snowmelt runoff. Rainfall events occur mainly during the "wet" season (between November and June). Substantial runoff from Sierra Nevada snowmelt extends into the summer and fall. This runoff pattern allows substantial diversion of water from Sacramento and San Joaquin River tributaries from May through September.

Central Valley reservoirs have been constructed during the last century to manage seasonal variability. Reservoirs capture winter floods and spring snowmelt (while reserving sufficient flood control storage space and maintaining minimum instream flows). This storage provides an increased water supply during summer and fall for diversions and instream flows.

MULTIPURPOSE WATER MANAGEMENT

Seasonal and annual runoff fluctuation complicates control and allocation of the available water supply. Water is allocated for various beneficial uses including flood control, water supply, power generation, and instream and other environmental flows. Priorities for streamflow management are established according to the available water supply.

Almost all major Central Valley streams are regulated by large multipurpose reservoirs (as well as smaller diversion dams) and confined by flood control levees. Many rules govern the operation of these dams and affect the overall operation of water-management systems. As the effects from these facilities on the natural runoff, sediment transport, and fish migration patterns are observed, an increased understanding of the needs for instream flows is emerging.

Recognition of the importance of streamflows to protect and promote habitat conditions for fish and wildlife populations has created conflicts between existing beneficial uses of water supply, industry, and flood control.

Several agencies may be involved in the operation of each major reservoir or diversion facility. The many rules governing facility operations have an incremental and interdependent effect on overall operation of water management systems.

Water Rights and Instream Flow

California water rights govern streamflow allocation for beneficial uses. Both riparian and appropriative water rights exist in California. These rights are administered and monitored by the State Water Resources Control Board (SWRCB). Riparian rights support specific beneficial uses on lands immediately adjacent to the stream. Appropriative water rights allow direct diversion or storage and may be obtained for beneficial use.

Water rights are incremental, with a specific priority scheme that controls water allocation during periods of shortage. Federal courts have assigned the jurisdiction over several California streams that are used for single-purpose hydropower projects to the Federal Energy Regulatory Commission (FERC). Additional "exchange contracts" between water-rights holders and water districts or government agencies, such as the U.S. Bureau of Reclamation (Reclamation) or California Department of Water Resources (DWR) further complicate the allocation of California water supplies.

Instream flow levels are sometimes required as conditions for water quality standards, water-rights permits, and FERC licenses. Negotiated agreements between water and fisheries agencies govern minimum flows downstream of major water projects. Some streams, such as Butte Creek, are formally managed by the State watermaster agreements.

The SWRCB has included instream spring flow requirements for both Delta outflow (i.e., X2 location objectives) and the San Joaquin River at Vernalis in the 1995 Water Quality Control Plan. Instream flow requirements govern the minimum flows at specific points below diversions and are often dependent on the available water supply (e.g., water-year type). Average annual instream and spring flow requirements are generally a small fraction of natural unimpaired flow and winter releases from storage reservoirs may be much less than unimpaired flows.

Many streams have no instream flow requirements. On some streams, riparian and appropriative water rights diversions may be restricted only by an amount necessary to supply downstream users having a higher priority water right. Some Central Valley streamflows are totally depleted downstream of the major diversions during the irrigation season.

Issues and Opportunities

Natural flow regimes. Restoration of natural flow regimes in regulated rivers has become the new paradigm in stream restoration. It is based on the assumption that desired species of fish (usually salmonids), high aquatic biodiversity, and preferred riparian conditions depend on variable flow regimes that maintain active channels and floodplains and keep non-native species at bay. A completely natural flow regime for a river reach below a dam is not possible, however, (because of human water demand) and may not even be particularly desirable because the pre-dam sediment supply has been cut off. If upstream coldwater habitat is inaccessible, higher summer flows may be needed. Nevertheless, native species are usually favored by flow regimes that at least resemble the historical flow regime in the pattern of natural, seasonal variability, if not in magnitude. The desired conditions below every major dam are likely to be different, suggesting a need for experimental manipulations of flows, including moderate annual floodflows, and habitat to find the right combination of factors that will maximize ecosystem benefits or assist endangered species in ways that are compatible with other uses of water and river corridors (Strategic Plan 1999).

OPPORTUNITIES: Mimic natural flow regimes through innovative methods to manage reservoir releases. There is underutilized potential to modify reservoir operations rules to create more dynamic, natural high-flow regimes in regulated rivers without seriously impinging on the water storage purposes for which the reservoir was constructed. Water release operating rules could be changed to ensure greater variability of flow, provide adequate spring flows for riparian vegetation establishment, simulate effects of natural floods in scouring riverbeds and creating point bars, and increase the frequency and duration of overflow onto adjacent floodplains. In some cases, downstream infrastructure of river floodways may require upgrading to safely accommodate a more desirable natural variability and peak discharge magnitude associated with moderate floodflows (e.g., strengthen or set levees back) (Strategic Plan 1999).

VISION

The vision for Central Valley streamflows is to protect and enhance the ecological functions that are achieved through the physical and biological processes that operate within the stream channel and associated riparian and floodplain areas in order to contribute to the recovery of species and overall health of the Bay-Delta.

To achieve maximum potential ecological functions and benefits from streamflows will require restoring and protecting the stream channel and floodplain process and in developing and implementing watershed management strategies and programs to protect the health of upper watersheds.

Opportunities to protect, enhance, and restore natural streamflow patterns and processes depend on stream channel and floodplain conditions, as well as existing impoundments and diversions.

Opportunities for adjusting seasonal streamflow patterns to benefit fish and wildlife while maintaining other beneficial water uses will be explored. Opportunities may include acquiring water rights from willing sellers or developing supplemental supplies (e.g., recycled water programs). Individual water rights are established according to California law, and this vision does not propose any adjudication or involuntary reallocation of water rights.

Many environmental factors and functions controlled by streamflow dynamics are only partially understood at this time. Therefore, the vision for Central Valley streamflow includes a substantial commitment to continued monitoring and evaluation of physical, chemical, and biological processes and ecological functions that are sustained and governed by streamflow.

Although the historical pattern of natural streamflows can be used as a guideline for establishing streamflow targets, the actual management of flows for each tributary or river segment will require coordination with all agencies and stakeholders. Conflicting interests and priorities will most likely be the rule rather than the exception. Streamflow targets will be developed within the existing multipurpose water resource management framework for each watershed.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The vision for streamflow is intended to complement existing streamflow management programs. Several agencies are directly or indirectly responsible for streamflow management.

Agencies with important streamflow management responsibilities and programs include:

- U.S. Army Corps of Engineers' flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs);
- DWR programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources;
- Reclamation's operation of the Central Valley Project (and several other independent water projects in the Central Valley) to provide for multiple beneficial water uses, including fish and wildlife protection and habitat restoration (e.g., Central Valley Project Improvement Act);
- FERC regulation of minimum flows below hydropower projects;
- SWRCB administration of water rights for storage and diversions, including decisions about required instream flows for fish, water quality, and public trust resource protection;
- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirements for fish protection and propagation in streams and at hatcheries;
- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species, including the Anadromous Fish Restoration Program and the Water Management Program; and
- U.S. Geological Survey water resources division programs to measure streamflow and water quality, providing the information necessary for adaptive management of streamflows. Their monitoring and modeling activities for Central Valley groundwater and Bay-Delta hydrodynamics are also important contributions to water resources management.

Streamflows in Central Valley streams are being addressed under the Central Valley Improvement Act (CVPIA) subsection 3406(b)(2) and (b)(3) programs being administered by the USFWS. Under 3406(b)(2) 800 TAF of CVP water is to be allocated for fish and wildlife purposes. Under 3406(b)(3) additional water is to be acquired from willing sellers. The combined sources of water are to be managed under a Water Management Plan being developed for selected individual rivers under FERC licensing requirements, negotiated settlements between stakeholders and agencies, State Water Resources Control Board water rights and water quality plans, and court ordered settlements such as that for the American River (Water Forum).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Streamflow being a primary ecosystem process is integrally linked with other processes, habitats, and species. In addition, the effects of many ecological stressors are influenced by streamflow.

In all cases, the ecological value of streamflows will be incorporated into a comprehensive adaptive management program. (The Strategic Plan for the Ecosystem Restoration Program, 1999, contains additional information regarding CALFED's approach to adaptive management.) This program for Central Valley streamflows will necessarily focus on the relationship of flow to the health of closely related ecological processes, habitats, and species.

Processes influenced by streamflow include:

- Central Valley water temperatures,
- sediment supply,
- stream meander corridors,
- Bay-Delta aquatic foodweb,
- floodplain and flood processes,
- groundwater/surface water interactions, and
- dilution of contaminants.

Habitats that depend on streamflow include:

- riparian,
- aquatic, and
- wetlands.

Species directly linked to streamflow include:

- anadromous fish,
- delta smelt,
- resident fish,
- riparian species,
- shorebirds, and
- waterfowl.

Each of these processes, habitats, and species is adversely affected by stressors which restrict their full function, extent, distribution, or survival. Therefore, the full ecological benefit to be derived from streamflows also depends on reduction or elimination of stressors which impair other closely related ecosystem elements. Streamflow is an important ingredient for ecological health, but cannot provide full benefit without improvement in other areas.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

One important Strategic Objective for streamflow is to make sure that high flows occur frequently enough in regulated streams to maintain channel and sediment conditions favorable to native aquatic and riparian organisms.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective focuses on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

A second Strategic Objective for streamflow is to create flow and temperature regimes in regulated rivers that favor native aquatic species.

LONG-TERM OBJECTIVE: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

SHORT-TERM OBJECTIVE: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

RATIONALE: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

STAGE 1 EXPECTATIONS: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should evaluate and consider flow regimes favorable for native fishes.

The general target for streams with large water storage reservoirs is to provide a spring flow event that emulates natural spring pulse flows in dry and normal years. For all streams provide sufficient year-round base flows to sustain important ecological processes, habitats, and species.

Actions that will contribute to restoring the ecological values of stream flow include maintaining spring flows and sustaining summer-fall base flows are the two major streamflow restoration activities considered in this vision. The following three programmatic actions will help to achieve streamflow objectives:

- Provide sufficient high flows during spring (March-May) to sustain high-flow dependent ecological functions. This can be accomplished by allowing a portion of the natural inflow to pass through large Central Valley reservoirs in spring of all but the driest years. In extreme cases, this may be accompanied by reductions in high summer storage releases.

- Maintain sufficient year round base flows to sustain aquatic streamflow dependent ecological processes, habitat, and species.

- Provide sufficient flow during the first yearly significant rain event to sustain habitat and species dependent on such flow. This can be accomplished by allowing a portion of the natural inflow to pass through large Central Valley reservoirs in all but the driest years.

REFERENCES

DWR 1994. California Department of Water Resources. California Water Plan Update: Volume 2. Bulletin 160-93, October 1994.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ CENTRAL VALLEY STREAM TEMPERATURES

INTRODUCTION

Water temperatures in Central Valley rivers and streams and in the Bay-Delta are determined by the natural heating and cooling process of water bodies. Water temperature is controlled by water source (i.e., dam releases, runoff, and discharges), surface water and groundwater inflow, geomorphology (e.g., depth), tides, riparian shading, water clarity, and, most often, air temperature. Water temperature is a major factor in habitat suitability for aquatic organisms. Unnaturally high water temperature can become a stressor to many aquatic organisms.

Major factors that limit water temperature contributions to the health of the Bay-Delta are disruption of historical streamflow patterns, loss of riparian vegetation, stored water releases from reservoirs, and discharges from agricultural drains.

RESOURCE DESCRIPTION

Natural biochemical processes, as well as aquatic organism physiology and behavior (e.g., respiration, feeding, growth), are partially controlled by water temperatures. Many native aquatic organisms, such as chinook salmon, depend on cool water for spawning, rearing, and migrating. For example, adult salmon migrating upstream through the Delta and into the rivers are stressed when water temperatures reach into the 58 to 65° Fahrenheit (F) range, which may delay migration and spawning, which in turn may affect egg quality and potential production of juvenile salmon.

High fall water temperatures in the Delta may delay upstream migration of fall-run chinook salmon from the Bay into and through the Delta. High spring water temperatures in the rivers and Delta may stress young chinook salmon migrating downstream to the ocean. High summer water temperatures in the Sacramento River near Redding may stress the eggs and fry of winter-run chinook salmon. Unusually high water temperatures in periods of drought were primary factors in historical declines of salmon and other fish species.

Although stream temperatures fluctuate daily, seasonally and in response to meteorological conditions (e.g., air temperature and the amount of sunshine), many important ecological functions are dependent on a relatively narrow temperature range. For example, salmon and steelhead require 54°F to 57°F to spawn and egg development requires water temperatures below 57°F. Growth of young salmon and steelhead is generally optimal in the 50-60°F range.

Stream temperatures regulate important ecosystem functions including:

- Algae blooms,
- Aquatic invertebrate reproduction and growth,
- Fish migration,
- Fish spawning,
- Fish development and growth,
- General well-being of aquatic organisms,
- Metabolism and behavioral cues of aquatic organisms,
- The amount of dissolved oxygen (DO) available in the water body, and

- Rates of organic material decay and nutrient recycling in aquatic habitats.

The ability to control water temperature in rivers and the Delta is limited because water temperature is most strongly influenced by air temperature. Some temperature regulation is available through control over streamflows, discharges of warm water into rivers and the Delta, and the extent of inundation and shading of floodplains. Temperature can be controlled to some extent below major Central Valley reservoirs by the selective release of warm or cold water from different depths behind the dams.

Construction and operation of Shasta Dam dramatically altered the flow regime and thermal characteristics of the Sacramento River (Hallock 1987). Hallock observed that water released in the spring was often too cold for rapid growth of juvenile fall- and late-fall-run chinook salmon, and that water released in August and September was often too warm for successful spawning and incubation of spring- and winter-run chinook salmon eggs and alevins.

The Shasta Dam Temperature Control Device allows operators to release water from different depths or combinations of depths to regulate the temperature in upper portions of the lower Sacramento River. Intake shutters on Folsom Dam allow water to be released from three different layers into the lower American River. Most large reservoirs have only one deep water intake in the cold water zone of the reservoir. The amount of cold water that can be released from Central Valley reservoirs is limited, especially in drought years.

Temperatures in Central Valley streams follow a seasonal pattern. Water temperatures are controlled primarily by meteorological conditions (indicated by air temperature fluctuations). Although Central Valley air temperatures range from 30°F to over 100°F, stream temperatures generally range from about 40°F to 80°F. Coolwater fish generally require stream temperatures lower than 65°F. Lower temperatures are easily achieved in high mountain streams but are more difficult to maintain in streams at lower elevations and along the valley floor. Releases from major reservoirs and groundwater (e.g., springs) are two important seasonal sources of cool water.

Maintaining cool water below reservoirs is especially important because salmon and steelhead are blocked from reaching their historic spawning and rearing grounds in headwaters in these rivers.

The water from many Central Valley streams is impounded by large multipurpose reservoirs (as well as by smaller diversion dams) that limit the upstream migration of anadromous fish into higher elevation tributaries historically used for spawning and rearing. The operations of these reservoirs can be used to maintain adequate stream temperatures in the segments immediately downstream of the reservoirs, but these temperature control operations must be integrated with other water management objectives.

Stream temperature is a major habitat condition that exerts a strong influence on many biochemical processes. Temperature controls the maximum concentration of dissolved oxygen (DO) in water. Fish and other aquatic organisms require adequate amounts of DO in water to survive. The maximum DO concentration is higher at 50°F than at 70°F. Higher temperatures also increase the decay of oxygen-consuming organic materials further reducing total DO concentration.

Many fish behavioral and physiological functions, such as spawning, are controlled in part by temperature. Fall-run salmon begin to spawn when stream temperatures fall to 60°F. Salmon-egg survival is a strong function of temperature, declining to near zero at temperatures greater than 62°F. Successful holding of adult winter-run and spring-run salmon until spawning requires temperatures below about 60°F. Temperatures below 65°F are considered necessary for successful steelhead rearing.

The Sacramento River Winter-run Chinook Salmon Recovery Team reported that water temperatures in the upper Sacramento River result from the complex interactions of: (1) ambient air temperature, (2) volume of water, (3) water temperature at release from Shasta and Trinity dams, (4) total reservoir storage, (5) location of reservoir thermocline, (6) ratio of Spring Creek Powerplant releases to Shasta Dam release, and (7) tributary inflows (NMFS 1997).

Wang (1986) reported that delta smelt spawn in fresh water at temperatures of 44 to 59°F. In recent years, ripe delta smelt and recently hatched larvae have been collected at temperatures of 59 to 72°F, so it is likely that spawning can take place over the entire 44 to 72°F range (U.S. Fish and Wildlife Service 1996).

Splittail trawl catches in Suisun Marsh are highest in summer when salinities are 6 to 10 parts per thousand and water temperatures are 59 to 73 °F (U.S. Fish and Wildlife Service 1996).

Cool temperatures also affect the growth rate of fish. For example, at 50°F, about 100 days are needed for rearing juvenile fall-run salmon to reach a size suitable for outmigration (3 inches). Rearing at 45°F would require about 140 days; rearing at 55°F would shorten the growth period to about 80 days. Fish spawning in different streams with differing temperature regimes will, therefore, have different timing and duration for spawning, growth, and migration.

Hatchery temperature objectives are often targeted to provide maximum growth without increasing mortality from excessive rates of respiration and diseases that are more prevalent at higher temperatures. Coldwater virus disease (IHN) is often a substantial problem at temperatures below 50°F. Salmonid temperature objectives in hatcheries are therefore generally within the 50-60°F range, which is much lower than the full range of Central Valley water temperatures.

VISION

The vision for Central Valley stream temperatures is to restore natural seasonal patterns of water temperature in streams, rivers, and the Delta to benefit aquatic species by protecting and improving ecological processes that regulate water temperature and reducing stressors that change water temperature. Appropriate water temperatures will provide suitable fish spawning, holding, and rearing habitat conditions and contribute to the recovery of species and overall health of the Bay-Delta.

Natural temperature conditions in Central Valley streams vary along a continuum on a "longitudinal gradient" from the mountain headwaters to meandering lowland rivers, and on to the Delta. Therefore, restoration needs for stream temperatures vary for different streams and stream segments. These needs will vary by stream and stream segment, depending on existing conditions. The needs and opportunities to protect and manage Central Valley stream temperatures will depend on the conditions of the stream channel and riparian corridor, as well as the existing water supply (i.e., reservoir storage) of each tributary stream.

A primary restoration need will be to maintain relatively low water temperatures in summer and fall for anadromous fish populations in the upstream portion of each major tributary to the Delta, especially those tributaries with larger foothill reservoirs and impassable dams. These low water temperatures are particularly important for the survival of juvenile steelhead. In relatively wet years, with full reservoirs and high reservoir releases for downstream diversions, water temperatures below the major Central Valley reservoirs are maintained within the 50-60°F target range. However, as available water supply declines (i.e., in drier years), the ability to maintain sufficient carryover storage to sustain the release of cool water and to release sufficient flows to control downstream temperatures for salmon and steelhead rearing is substantially reduced. Sustaining adequate temperatures below reservoirs and power diversion dams is needed to provide coolwater anadromous fish habitat within the existing Central Valley multipurpose water resources management framework. Flexibility in managing stream temperatures will be an important ingredient in the successful restoration of Central Valley natural resources.

Particular attention has been given to water temperatures below Keswick Dam because this area is the only remaining spawning habitat on the Sacramento River for winter-run chinook salmon. Extremely warm water in 1976 and 1977 was likely a major cause of the decline in winter-run chinook salmon. Red Bluff Diversion Dam likely contributed to the sustained low population of winter-run chinook throughout the period following the 1976-77 drought, even when water temperature impacts were moderated. Only very low populations of winter-run salmon have been maintained since this drought event, when Shasta Reservoir storage declined to less than 1 million acre-feet. The California Department of Fish and Game (DFG) and the Anadromous Fish Restoration Program (AFRP) suggest that Shasta Reservoir carryover storage should not drop below 1.9 million acre-feet to ensure an adequate supply of cold water for release in summer and fall. The Temperature Control Device, completed in 1997, provides additional flexibility in temperature control and conserving cooler reservoir waters through the summer and fall.

The State Water Resources Control Board (SWRCB) has added water temperature requirements below Keswick Dam (and in the Trinity River below Lewiston Dam) to the water rights for Shasta and Clair Engle Reservoirs. A multiagency Sacramento River Temperature Task Force is responsible for the adaptive management of Sacramento River water temperatures. It reports to SWRCB on the effects of its temperature management and the resulting winter-run chinook spawning and rearing success each year. These water management decisions are more difficult in years with limited water supply.

Whiskeytown Reservoir releases of water into Clear Creek, a tributary to the Sacramento River, are sufficiently cool to support salmon and steelhead. However, since 1965, insufficient streamflows and fish-passage problems have prevented this potential habitat from supporting many fish. Low-level outlets can be used for releases to Clear Creek. Efforts to manage temperatures in Clear Creek could be implemented as on the Sacramento River.

The temperature of Lake Oroville releases to the Feather River is controlled (e.g., temperature control panels) for the Feather River Hatchery and the "low-flow" channel. The objective is to maintain temperature for natural spawning and holding of spring-run salmon and steelhead. Carryover storage, sufficient to maintain low fall water temperatures, is limited during droughts. The California Department of Water Resources (DWR) is exploring operations of the Oroville-Thermalito complex to determine whether improved stream temperature controls can be achieved. As at Shasta Dam, additional means for controlling temperature are needed for these adaptive management efforts to provide optimal water temperatures within the overall water management framework. One such means would be additional storage water dedicated to temperature control in the Feather River below Lake Oroville and Thermalito Reservoir.

Yuba River water temperatures are considered well suited for salmon and steelhead below Englebright Dam (the first impassable dam), but flows and riparian vegetation have been insufficient to maintain target temperatures below the Daguerre Dam, the major water diversion dam on the lower Yuba below Englebright Dam. The Yuba County Water Agency is evaluating the temperature control potential of New Bullards Bar Reservoir (a major storage reservoir upstream of

Englebright Lake on the North Fork of the Yuba River) and is working with AFRP and DFG to develop an adaptive management strategy for Yuba River flows and temperatures. Again, like at Shasta and Oroville, additional storage dedicated to water temperature control and possibly the addition of temperature control devices on major storage reservoirs could improve the water temperature conditions on the lower Yuba River.

Many of the upper Sacramento River tributaries are largely nonregulated. Water temperatures on these stream and in the Sacramento River at their confluence could be improved by managing water diversions and improving riparian vegetation.

The U.S. Bureau of Reclamation (Reclamation) has recently modified the Folsom Dam temperature control panels to provide some additional temperature management potential; however, the relatively low storage capacity of Folsom Reservoir limits the ability to control temperatures at the Nimbus Hatchery and in the lower American River. Additional storage dedicated for water temperature and potential improvements to temperature controls at Nimbus Dam could improve water temperatures in the lower American River.

Temperatures in the San Joaquin River tributaries (Mokelumne, Stanislaus, Tuolumne, and Merced rivers) are controlled by a combination of cold-water reservoir releases and streamflow management. Although initial efforts to monitor and control water temperatures on these rivers have begun, the upstream segment of each may require additional reservoir and flow management actions. Actions similar to those described above for Shasta, Oroville, New Bullards Bar, and Folsom Dams could be implemented. Long-term agreements to adaptively manage reservoirs on these San Joaquin River tributaries are needed to provide the best possible flow and temperature conditions for fish habitat while also protecting the other existing beneficial water uses.

Another primary restoration need will be to maintain cool temperatures through the spring and again in the fall in the Delta and lower rivers to provide for upstream migrating adult and downstream migrating and rearing juvenile anadromous fish. Low flows either naturally occurring or caused by water storage or diversions are the problem in these areas. Although control of water temperature is limited in the lower rivers and the Delta, restoring natural flows, riparian vegetation, connecting marsh-sloughs, and reducing warm water discharges should benefit water temperatures in small but significant ways. Shallow water habitats with adequate shade will not locally warm to intolerable levels for species dependent on them. Dead-end sloughs will maintain slightly lower water temperatures with adequate shading. Minimizing discharges of warm water such as agricultural drains into rivers and Delta will help sustain cooler temperatures further into the spring and earlier into the fall. Although water temperature changes would be small, possibly less than an degree or two, such changes are significant when overall water temperatures are stressful or approach lethal levels for some species.

Although historical stream temperatures can be used as a guideline for establishing stream temperature targets, the actual management of temperatures for each tributary or river segment will require coordination with all agencies and stakeholders. Therefore, stream temperature targets should be developed within the existing multipurpose water resource management framework for each watershed. The relative ecological value of streamflow and temperature should be estimated for each tributary stream. Streamflow and temperature should be accurately monitored and rapidly evaluated for both short-term and long-term management decisions. This basic streamflow information will then allow for flexible management of streamflows. Flexible management will allow temperatures to become a major element in the restoration of ecological functions and benefits throughout the Sacramento and San Joaquin River basins.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Water temperature in Central Valley streams is being addressed under the Central Valley Improvement Act (CVPIA) subsection 3406(b) programs being administered by the USFWS. Water temperature is also addressed in various biological opinions and recovery plans (e.g., winter-run chinook salmon) for threatened and endangered species. Water temperature is also a common criteria in water quality standards for various rivers and the Delta.

There are several important ongoing programs that attempt to improve the multipurpose water management of Central Valley streamflows and temperature conditions. The vision for stream temperature management is to complement and coordinate (where conflicts exist) these existing streamflow and temperature management programs. Several agencies are directly or indirectly responsible for stream temperature management. ERPP supports the policies and decisions of these individual agencies and could provide resources to implement stream-temperature management actions and mediate conflicts between water management goals of individual agencies.

Important stream-temperature management responsibilities and programs of agencies include:

- DWR's operation of Lake Oroville to satisfy DFG hatchery and stream temperature objectives;
- Reclamation's operation of Central Valley Project reservoirs to achieve specific temperature criteria or objectives for salmon and steelhead habitat conditions;
- Federal Energy Regulatory Commission's regulation of minimum flows below hydropower projects throughout California (e.g., Butte Creek temperatures below Centerville Diversion Dam);
- SWRCB's administration of water rights and water quality objectives (in coordination with Regional Water Quality Control Boards) necessary for beneficial uses and for fish protection below reservoirs and dams;
- DFG's responsibility to study and recommend stream temperature requirements for fish protection and propagation in streams and at hatcheries;
- USFWS's and the National Marine Fisheries Service's programs to recommend temperatures needed for mitigation of impacts from federal projects (e.g., hatcheries) and protection of endangered species (the biological opinion for winter-run chinook salmon and the AFRP each have specific temperature recommendations and requirements); and
- USGS's water resources division programs to measure streamflow and temperature to provide the information necessary for adaptive management of stream temperatures.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Water temperature is a primary ecological process closely linked with other processes, habitats, and species. Water temperatures are dependent on streamflow and riparian vegetation. Stressors including water diversions and agricultural drainage discharges affect water temperature.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective for Central Valley stream temperature is to create flow and temperature regimes in regulated rivers that favor native aquatic species.

Long-Term Objective: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

Short-Term Objective: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

Rationale: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

Stage 1 Expectations: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should evaluate and consider flow regimes favorable for native fishes.

General targets to achieve healthy Central Valley stream temperatures include:

- Maintaining water temperature at or below 56°F in salmon and steelhead spawning areas during spawning and incubation seasons below major dams on rivers. The ability of meeting this broad target will be influenced by in some drainages by the quantity and quality of coldwater stored behind the larger dams.
- Maintaining water temperature below 58°F for rearing and out-migrating salmon and steelhead from late winter through late spring.
- Maintaining water temperature below 60°F in oversummering areas of salmon and steelhead to the extent possible. When temperature control at this level is not possible, temperatures should be maintained below 65°F to avoid significant adverse impacts.

- Maintaining water temperature below 68°F in migratory routes of anadromous fish in spring and fall. Meeting this target in the lower Sacramento River, lower San Joaquin River, and in the Delta may be difficult in many years as there is no practical, short-term means by which to reduce water temperatures.

Several stream temperature actions should be implemented immediately. There is general agreement that these actions will improve stream temperatures without having significant impacts on water supply or energy resources. Many of these actions have been recommended by DFG and by AFRP but have not been implemented because of limited financial resources. They include:

- Increasing coldwater releases from Whiskeytown Lake to Clear Creek to allow restoration of the habitat along this 18-mile stream segment for salmon and steelhead spawning and rearing; Whiskeytown Lake could be coordinated with the operation of Shasta Dam to minimize impacts on the water supply;

- Developing a long-term agreement with Pacific Gas and Electric Company (to provide appropriate compensation for energy losses) to monitor temperatures and provide bypass flows in the lower North Fork and South Fork segments of Battle Creek to maintain suitable temperatures for holding, spawning, and rearing habitat for spring-run and winter-run chinook salmon and steelhead;

- Restoring stream temperature monitoring capability at several U.S. Geological Survey stream gages and other strategic locations of Central Valley streams, combined with improving fish sampling and counting devices to provide a solid basis for adaptive stream temperature management decisions; and

- Increasing Feather River flows in the "low-flow" channel to a maximum of 2,500 cubic feet per second (cfs) and reducing the flows through Thermalito Forebay and Afterbay released to the Feather River. Thermalito releases can have a major effect on down-stream temperatures; only water needed for irrigation diversions and peaking power generation should be diverted (energy from the Thermalito power plant would be reduced).

Because temperatures are an important habitat condition and can vary with changes in other factors, there should be a substantial commitment to continued monitoring and evaluation of the physical, chemical, and biological processes and ecological functions that are governed by stream temperature.

Many stream-temperature management actions will require a slightly longer implementation period because additional information is needed for careful planning decisions, or because detailed designs for new or modified facilities are required. Nevertheless, the necessary planning studies and engineering design work can be initiated on the following longer term actions:

- Establish coordinated stream-temperature management teams for each major stream. Coordinated teams could follow the approach used by the Sacramento River Water Temperature Task Force to help Reclamation allocate and schedule releases for Sacramento River temperature control. This cooperative management approach attempts to maximize streamflow and temperature benefits while maintaining other beneficial uses of water. The choice between carryover storage and increased releases for temperature control can best be made by this type of adaptive management team. Potential conflicts between different fish populations and other water uses can also be addressed using this strategy.

- Restore blocks of riparian habitat that are sufficiently large (>50-100 acres) to create air convection currents, which will cool adjacent river water temperatures.

- Restore and protect the stream channels and riparian corridors (i.e., pools, gravelbeds, and vegetation). Minimizing warming along the stream gradient and providing habitat features will allow fish to use cool water areas in deep pools and springs.

- Develop a comprehensive series of reservoir and stream temperature models. The models would be used to investigate the effects of possible modifications to reservoir facilities and stream channel and riparian corridor conditions. These calibrated models can form the basis for adaptive management of Central Valley streamflows and temperatures within the overall framework of multipurpose water management objectives and constraints.

To protect and improve Central Valley stream temperatures, a responsible balance must be achieved between water management for temperature controls and other beneficial uses of the available water supply.

To be implemented, these measures may require that water from willing sellers be purchased or water exchanges negotiated and alternative supplies explored. There are two general programmatic actions:

- Provide sufficient carryover storage and selective withdrawal facilities in major reservoirs. These measures would help optimize summer and fall release temperatures to allow spawning and rearing of winter-run and fall-run salmon. A target temperature of 56°F during spawning and egg incubation is appropriate because salmon eggs have increasingly high mortality rates as temperatures rise above 56°F and total mortality above 68 percent. The Shasta Reservoir temperature device is being constructed to allow warmer water to be released in spring and early summer to reserve more of the cooler water (at greater depth) for summer and fall releases. Because some carryover storage must be maintained to provide desirable temperatures downstream, specific reservoir releases for water supply may be reduced in some dry years.

- Provide sufficient summer and fall streamflows to maintain adequate holding and rearing temperatures for spring-run, fall-run, and winter-run salmon of less that 60°F and steelhead trout of less that 65°F in streams supporting these populations. This may require limiting hydropower diversions or providing higher reservoir releases than would otherwise be required for downstream diversions.

References

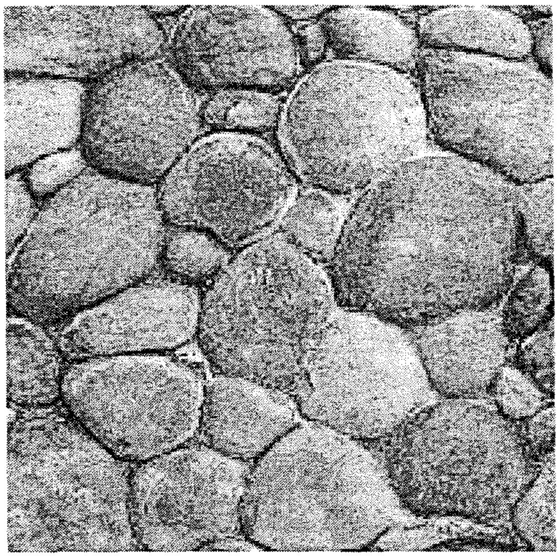
Hallock, R.J. 1987. Sacramento River system salmon and steelhead problems and enhancement opportunities. A report to the California Advisory Committee on Salmon and Steelhead Trout. June 22, 1987. 92 pp.

NMFS. 1997. NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon. National Marine Fisheries Service, Southwest Region, Long Beach, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, Oregon. 195 pp.

Wang. J.C. 1986. Fishes of the Sacramento-San Joaquin estuary and adjacent waters, California: A guide to the early life histories. Interagency Ecological Study Program for the Sacramento-San Joaquin estuary. Technical Report 9.



INTRODUCTION

Natural sediments of streams, rivers, and estuaries consist of mineral and organic silts, sands, gravel, cobble, and woody debris. These materials naturally enter, deposit, erode, and are transported through the Bay-Delta and its watershed. Sediment, like water, is one of the natural building blocks of the ecosystem. Many other ecological processes and functions, and habitats and species require specific types and amounts of sediment and the habitats sediments create. Gravel, for example, is important for maintaining spawning habitat for salmon and steelhead, and as habitat for stream invertebrates. Finer sediments are important in the natural development of riparian and wetland habitats. Major factors that influence the sediment supply in the Bay-Delta and its watersheds include many human activities such as dams, levees, and other structures, dredging, and gravel and sand mining.

River-transported sediments are an essential component of the physical structure and nutrient base of the Bay-Delta ecosystem and its riverine and tidal arteries. The size, volume, and seasonal timing of sediments entering the riverine and estuarine systems should be compatible with both natural and altered flow regimes. Sediment transport should match channel and floodplain characteristics of individual rivers, streams, and tidal sloughs. A specific sediment management objective is to redistribute sediment in the watersheds and valley components of the ecosystem. An appropriate level, rate, and size of sediment should be redistributed to match specific habitat requirements and ecological functions.

RESOURCE DESCRIPTION

The coarse sediment supply is highly variable between the streams and tidal sloughs of the Sacramento and San Joaquin Rivers and Bay-Delta ecosystems. Part of the reason is differences in soils and geofluvial morphology of the watersheds. Other factors include difference in runoff patterns and watershed characteristics. Human activities and development may be important factors. Large dams deprive most of the major rivers entering the Sacramento-San Joaquin Valley of their primary source of sediment from the upper watersheds. Upper watershed sediment supplies have been altered by increased human use and habitation in areas previously only influenced by natural processes of fire, flood, and mass wasting.

Alluvial sediment is stored in the valley floodplains along rivers, but much of this natural supply is no longer available to rivers and streams because of extensive hardening of banks (e.g., rip-rap) to protect stream-side levees, orchards, and cropland. Some individual streams have an excess of fine sediment, such as the lower Feather River that is still affected by an oversupply of sand from the hydraulic mining era. Within the Delta, rivers and sloughs appear to suffer from a net loss of channel sediment resulting in the reduction or disappearance of midchannel islands and shallow shoal habitats. This is believed to be caused by a combination of reduced sediment supply from rivers, historic loss of Delta floodplains (reclamation of formerly extensive tule islands for agricultural uses), high velocity tidal currents, wind wave and boat wake erosion of unprotected, artificially steep banks, and channel dredging to maintain shipping routes and floodway capacity.

Land use has also altered natural sediment supplies in Central Valley watersheds. During the gold rush, natural sediment supplies in the Central Valley were greatly altered by extensive hydraulic and dredge mining on the western Sierra Nevada streams (especially the Yuba, Feather, American, lower Sacramento, and San Joaquin rivers and their tributary watersheds). Sediment from mining in the late 19th Century greatly exceeded the amounts that rivers were able to transport. Rivers became overloaded with sediment, causing deposition and flooding in valley towns and farms. Fine sediments pulsed quickly through the river systems, but the coarser sediments moved more gradually. By the late 20th Century, most riverbeds had returned to pre-Gold Rush elevations because riverflows had cut through the old placer mining debris deposits stored along the banks. Some rivers and creek valleys still contain "debris dams" (e.g., Daguerre Point Dam on the Yuba River) built a century ago in an attempt to keep placer mining sediment from spreading into streambeds of the valley and causing flooding of cities and farmlands.

Natural sediment recruitment and transport in the Central Valley are tied to streamflow. Most sediment is transported and deposited during winter and spring runoff events. Typically, bars, shoals, and braided deltas form or expand as floodwaters decline and stabilize during the dry season. Flowing water rearranges and sorts sediment (sand, silt, and clay particles) and bedload (cobble and gravel) to create the structural support for many important habitats, including fish spawning gravels, growth medium (substrate) in which riparian forests germinate and establish, and loamy floodplains that support oak woodland and grasslands. Transporting heavier cobble and gravel helps rivers dissipate stream energy, and the formation of heavy cobble bars shields the riverbed from excessive erosion and incision.

Shallow shoals of fresh sediment form along Bay-Delta rivers and sloughs by replacing sediment lost to wave action and tidal currents. The fresh sediment creates new substrate for tule marsh and sustains shallow-aquatic and tidal-mudflat habitats. Fine organic particles and suspended mineral sediment also provide essential nutrients (e.g., carbon, nitrogen, phosphorus, and iron) that support algae and phytoplankton at the base of the foodweb. High concentration of suspended sediment (high turbidity) limits growth of aquatic plants and algae by reducing sunlight penetration.

Constructed features and disturbance factors that eliminate, reduce, or alter the amount, distribution, and timing of natural sediment sources include:

- reservoirs behind medium and large dams that capture the sediment supply from the watershed;
- levees that prevent deposition of fine sediments in the floodplain alongside rivers and increase sediment scour and transport within the river channel by forcing deeper, more erosive floodflows;
- sand and gravel mining in channels and active lower floodplains of rivers and smaller tributaries that deplete the natural supply to downstream sites;
- bank protection and channelization that alters sediment transport, reduce natural bar and riffle formation, and prevent natural bank erosion and gravel and sediment releases to the river; and

- dam-regulated reduction of the magnitude and duration of average peak flows during winter and spring that reduce the ability of a river to transport bedload entering the river from tributary sources.

Sediment transport and deposition processes of the ecosystem have been significantly modified. Construction of the Sacramento River, San Joaquin River, and Delta levees and bypass systems in the early 20th century allowed Central Valley settlements and California agriculture to expand. The original levee system of the Sacramento River was built to bypass excessive floodflows, maintain sufficient channel depth for river navigation, and carry the heavy loads of sediments deposited into the Central Valley by hydraulic gold mining in the mountains and foothills.

The levees isolated rivers from their natural floodplains and separated the Bay-Delta from the extensive freshwater and saline emergent wetlands and secondary sloughs that became the agricultural "islands" we know today. River flows have sufficiently sluiced most of the sediment past the river floodplains and Delta and out to San Francisco Bay. Some of the sluiced sediment was deposited in deeper channels that now require dredging.

The natural supply of gravels and sediments entering the rivers and dams and reservoirs severely reduced streams. Construction of the State and federal dam system occurred between the 1930s (e.g., Shasta Dam) and 1970s (e.g., New Melones and New Don Pedro Dams). Although dams provide water supply and flood control benefits, they drastically reduced the natural sediment supply to Central Valley river floodplains and the Bay-Delta. Dams captured all the bedload and most of the finer sediment. Many smaller dams have filled to capacity with sediment.

The absence of sediment below dams and the confinement of rivers into narrow, leveed corridors triggered channel incision and bank erosion. Incision and erosion threatened the integrity of the levee system, leading to ongoing efforts to armor riverbanks and levees with rock riprap. Implementation of these actions further reduces the natural sediment supply of rivers.

Confining rivers and hardening banks removes the major remaining supply of gravel and sediment below dams. The lack of gravel and sediment inhibits bank erosion. Preventing or reducing bank erosion also reduces the establishment of instream woody cover (a component of shaded riverine aquatic cover) because the erosion required to topple trees into the channel no longer occurs.

The sediment deficit and high transport efficiency of the primary Delta channels, combined with wave-wash erosion, are causing the progressive disappearance of remnant tule and willow midchannel islands and shoals. These conditions prevent the replenishment of deposits that support mudflat, emergent wetlands, and willow scrub habitats. Lack of sediment and high velocities are also undermining the submerged toe of levees along Delta islands.

Immediately downstream of dams, where water temperature is often cool enough to support spawning fish populations, the release or uncontrolled spills of "clean, hungry" dam water removes the spawning gravels from the channel, armors the channelbed with more resilient cobble and boulders, and erodes the fine sediment that would normally support riparian trees and shrubs along the banks. Scoured and armored river beds lack spawning habitat for salmon and steelhead forced to spawn and rear below dams that have cut them off from natural upstream habitats.

Further downstream, natural sediment and erosion patterns of the floodplain have been altered by river channelization. Only the Butte basin flood overflow area and the Sutter and Yolo Bypasses support physical sedimentation processes that roughly approximate a natural floodplain. However, flood conveyance capacity, intensive farming in the bypasses, and flood easement restrictions do not allow the remnant floodplains to support natural habitats. Floodplain habitats such as emergent marsh, cottonwood-willow riparian forest, or valley oak woodland thrive in the fine-textured alluvial deposits. A few notable natural habitats do exist. These include Sutter National Wildlife Refuge, the new Yolo Basin Wildlife Management Area, and some large privately managed waterfowl habitats in the Butte basin.

Gravel mining in Central Valley river channels has also interrupted natural sediment supplies of the rivers. In-channel sand and gravel mining reduces downstream physical habitat and triggers incision of the channelbed both upstream and downstream. Large in-channel and low-floodplain pits are often excavated to a depth lower than the stream channel, such as occurs on the eastside tributaries of the San Joaquin River. These pits often "capture" the river. This creates additional ecosystem disturbances by trapping bedload gravel, causing the river alignment to suddenly shift, exposing outmigrating juvenile salmon and steelhead to increased predation, and stranding of outmigrating juvenile salmon and steelhead in isolated backwater ponds when the river recedes.

Issues and Opportunities

Channel dynamics, sediment transport, and riparian vegetation. There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated.

Opportunities: Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well providing access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for coarse sediment supply is to provide a sustained supply of alluvial sediments that are transported by rivers and streams and distributed to riverine bed deposits, floodplains, channel bars, riffles, shallow shoals, and mudflats, throughout the Sacramento-San Joaquin Valley, Delta, and Bay regions. This would contribute to habitat structure, function, and foodweb production throughout the ecosystem. Where supplies are adequate they should be protected. Where inadequate, natural supplies should be restored where possible. Where supplies cannot be restored naturally, a feasibility analysis of artificially maintaining sediment supplies will be conducted.

In specific cases natural sediment supply can be restored by removing barriers to sediment transport. A common barrier to sediment transport in Central Valley rivers are diversion dams (e.g., Daguerre Dam on the Yuba River). In some tributary streams, small dams that no longer serve a purpose can be modified, or possibly decommissioned and removed. Dam removal allows a larger fraction of gravel to pass downstream.

Studies will be conducted to determine whether smaller reservoirs could be modified or re-operated to allow some sediment from upstream sources to pass through to the dam outlet. Sediment deposits in the upper ends of reservoirs are potential sources of sediments for introductions below dams.

In some river reaches, bank armoring could be reduced or avoided by creating unimpeded channel meander corridors using special conservation zones (e.g., erosion easements), landowner incentive programs, and strategic levee setbacks where feasible. A natural river meandering process provides much of the sediment needs of rivers.

Where channel hardening occurs downstream of major dams, sediments stored in armored banks, bars, and upper terraces can be moved into the active streambed to replace natural sediments blocked by the dams. Where bank and floodplain deposits along rivers below dams have become inactive from controlled flows, additional sediment can be recruited by restoring episodic floodflows. These floodflows must be of sufficient duration and magnitude (e.g., peak flows that occur every 1.5 to 2 years) to mobilize channel-bed, bank, and bar sediments. This strategy would apply only to river systems that have an excess of stored channel deposits because of limited flood duration and magnitude below the dam. Such actions would be coordinated with project operations and aquatic species life-cycle requirements.

Wherever possible, the future sediment supply from the remaining nondammed tributaries should be declared a protected ecological resource of the river and Bay-Delta ecosystem. (Cottonwood Creek is a prime example of a nondammed tributary of the Sacramento River that contributes a significant proportion of the present natural sediment supply to the river). Effects on sediment supplies will be considered in evaluating potential new water supply and flood storage facilities as part of the Bay-Delta solution.

Further natural sediment supplies can be restored by expanding river access to historical floodplains during high flows. Floodplains provide fine particulate organic matter and small food particles. These particles will reenter the Delta and main rivers from overland flows that pass over and through crop stubble, grasslands, and riparian woodlands.

Levee setbacks, partial historical floodplain restoration (e.g., breaching diked tidelands) and selected Delta island levee removal strategies would provide new sources of sediment to the Central Valley floodplain. These measures, combined with increased channel roughness from marsh and riparian restoration projects, will increase the sediment-trapping efficiency of the Delta in sloughs and channels that are not essential for commercial ship and barge navigation.

Increasing the extent of the high-water floodplain of the Delta will reduce the potential for channel erosion, thereby reducing the rate of sediment loss from midchannel tule islands and shallow shoals. Larger floodplain areas along rivers would allow additional riparian vegetation to grow along the river floodways and would enhance the formation of bank and bar deposit habitats.

Appropriate reaches of the Sacramento, San Joaquin, Merced, Mokelumne, Cosumnes, Feather, and Yuba rivers and other suitable streams, such as Cottonwood and Cache creeks, will be evaluated and, where feasible, designated for eligibility as river erosion and deposition zones, or "meander belts." Meander belts will provide an area where natural erosion and sedimentation processes can occur unimpeded (within reasonable limits) to sustain a diversity of sediment-driven habitats.

In these meander belt conservation zones, some types of agricultural production could continue. Older alluvial floodplains, unlikely to be within the eroding pathway of the river within the next 20-50 years, are ideal farming lands. Farmed areas within the estimated 20-year riverbank migration corridor could be targeted for special erosion and river floodplain easements and incentive programs. Orchardists could be compensated for loss of fruit and nut trees caused by natural bank erosion, or for permanent acquisition as river floodplain conservation areas.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Protection and enhancement of sediment supplies in the rivers and Delta will involve coordination with other programs including:

- the Upper Sacramento River Fisheries and Riparian Habitat Council's efforts under the SB 1086 Program to preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River between Redding and Colusa,
- river corridor management plans,
- the U.S. Army Corps of Engineers Sacramento River Flood Control and Bank Protection Projects,
- San Joaquin River Riparian Habitat Restoration Program to develop and implement a plan for restoration of a continuous riparian corridor,
- gravel mine reclamation programs being initiated under the Surface Mining and Reclamation Act by the California Department of Conservation,
- the Anadromous Fish Restoration Program's gravel replenishment program (CVPIA Subsection 3406 b13),
- small dam removal and fish ladder rehabilitation projects, and
- local bank protection and levee construction projects.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of natural sediment supplies in the rivers, Delta, and San Francisco Bay is closely linked to the following:

- streamflow,
- floodplain processes,
- stream meander processes,
- riparian, wetland, and aquatic habitats,

and many stressors including:

- dams,
- levees,
- bank protection,
- dredging, and
- gravel and sand mining in the floodplain.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

Two Strategic Objectives apply to coarse sediment supply. The first objective for coarse sediment supply is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correction existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

The second Strategic Objective for coarse sediment supply is to make sure that high flows occur frequently enough in regulated streams to maintain channel and sediment conditions favorable to native aquatic and riparian organisms.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

The general targets are to conserve and augment the natural sediment supply by increasing the availability of upstream sediment sources on select streams, increasing the availability of sediment stored in banks and riverside floodplains, increasing the extent of natural stream bank erosion and channel migration, increasing the transport of sediment to the Delta and to spawning reaches of streams, increasing the deposition and stability of sediment within the Delta, and increasing the extent and distribution of shallow water habitats and tule-willow islands in the Delta.

In most cases the supply necessary to sustain functions and habitats for specific watersheds is not known. Preliminary targets for cubic yards of gravel needed below dams have been prescribed for selected rivers.

The following general approach includes actions that will sustain existing natural sediment sources and restore natural sources that no longer contribute to the sediment supply of rivers and the Delta.

- Protect existing natural sediment sources in river floodplains from disturbances such as bank protection, gravel mining, levees, dams, changes in streamflow, and changes to natural stream meanders.

- Artificially maintain sediment supplies below dams that block natural sediments in rivers.

- Increase the availability of sediment stored in banks and riverside floodplains by removing bank protection.

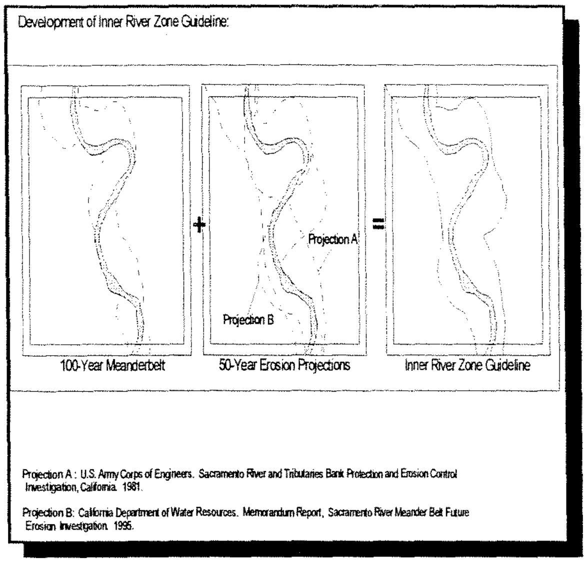
- Enhance and restore natural stream bank erosion and stream meander processes.

REFERENCES

California Department of Water Resources. 1992. Data base. Division of Safety of Dams. Sacramento, CA.

California State Lands Commission. 1993. California's rivers. A public trust report. February. Second Edition. Sacramento, CA.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

A "stream meander" is a dynamic natural process, and is also a term used to describe the shape of the river as a sinuous or bending wave form. Rivers with active stream channel meander zones generally support a greater diversity of aquatic and terrestrial habitat types.

Major factors that limit natural stream channel migration include construction of levees, bank riprap, channelization, upstream sediment loss from dams and levees, instream gravel mining, vegetation removal for increased floodway capacity or for reclamation of the river floodplain for agricultural uses and the storage of water and release pattern from State Water Project, Central Valley Project, and other large water development projects within the Central Valley.

Approaches to restoring more natural stream meander corridors include conserving existing river migration zones, expanding stream meander corridors, conserving upstream and bank sediment supply, and incorporating simulated flood peaks into dam water release schedules during wet years.

RESOURCE DESCRIPTION

The width and habitat patch size of riparian forest on meandering streams tend to be large and connected. The forest is always being replenished by new territory colonized by cottonwood and willow trees on recently formed point bars and floodplain deposits.

The flow velocity in meandering streams varies greatly, causing sediment and organic debris to be sorted into different sizes at different locations within the channel along a velocity gradient. Other habitat benefits from meandering streams include formation of oxbows, sloughs, and side channels that create a highly productive interaction between aquatic and terrestrial communities, (e.g., canopy shading and leaf and insect drop over the riverine aquatic bed). Therefore, many species of fish, amphibians, and insects can find suitable habitat in stream meander landscapes.

Rivers that flow through their own valley alluvium (i.e., gravel, sand, and silt deposited earlier in time) have the potential to shift position. Rivers shift position when banks erode and sediment is deposited. Bank erosion and sediment deposition, form bars that block or redirect river flow. The bars also stimulate additional erosion as the river channel migrates away from the bar.

The following characteristics of a river increase the probability that it will change course during winter/spring flows:

- high average sediment or bedload source, erodible bank and bed deposits (e.g., sand and gravel);
- potential for extreme flood peaks, and
- a low density of mature vegetation along the channel.

Meandering streams typically support a wider corridor of natural habitats than channelized rivers. River flora and fauna are adapted to the changing, unstable nature of alluvial streams. They tolerate their stems being buried by deposits of river sediment and disperse seeds by wind and water to locations where new bars have formed. Meandering streams typically form the pool-riffle sequence that supports a range of fish habitats. The leading edge of the eroding side of the bend generates new sediment and gravel from the bank and topples riparian trees into the channel. These processes create high-quality aquatic cover and provide food and substrate for aquatic insects on which fish feed. Sediment lost at the eroding bank is transported downstream and redeposited on point bars. This process initiates the habitat colonization and bank renewal process. When pronounced bends are formed, an unimpeded river will eventually cut off the bend by eroding a "shortcut" across the inside bend during high flows. Through this process, backwater swales and oxbow lakes are formed, providing important juvenile fish rearing areas and sources of foodweb production.

Rivers with armored banks (rock riprap) or naturally stable stream channels are more likely to have urban or agricultural land use encroach into the riparian floodplain and forest. This encroachment often leaves room for only a narrow band of trees or shrubs along the bank and results in low habitat quality for fish and wildlife. Alluvial rivers with artificially hardened banks and static channels suffer a general loss of diversity and quality at the interface of aquatic and terrestrial habitats. Unfortunately, making rivers more predictable has led to a decline in river ecosystem quality because the species and habitats that evolved on rivers are dependent on the changing, natural disturbance cycles of meandering streams.

All Central Valley streams have been affected by stressors that diminish stream meandering and associated aquatic and riparian habitats. However, significant reaches of several large rivers still support full or partial characteristics of a dynamic stream meander pattern. The best example in California is the Sacramento River between Red Bluff and Butte City. Other important examples include the San Joaquin River (from Mossdale to Merced River); the Merced, Tuolumne, Cosumnes, Feather, and Yuba rivers; and Cottonwood, Stony, and Cache creeks.

Natural meander belts tend to be the least affected where there are no major levees or where levees are set back several hundred feet from the main channel bank; on rivers that have high flow stage during frequent flood peaks, thereby discouraging land conversion to urban or agricultural uses; and on rivers with floodplain soils that are not conducive to high-yield crops or orchards (e.g., saline hardpan soils along the lower San Joaquin River or gravelly, barren floodplains along the Yuba River).

To support a natural, dynamic stream meander system, the following important characteristics are needed, and identified stressors must be overcome or compensated for:

- A supply of gravel and sediment that matches the net transport and displacement of channel sediment and bedload. Dams interfere with the natural sediment supply from upstream, while levees, instream gravel mining, and bank protection projects deplete channel and floodplain sediment supplies. Most of the major tributaries of the Sacramento and San Joaquin Rivers have large dams above an elevation of 300 feet. Most of the length of these rivers in the valley floor are being mined or have been mined for gravel, and all are confined by leveed and incised channels along substantial portions upstream of the Delta.

- A series of periodic flood peaks sufficient magnitude and duration to remobilize and rearrange gravel and cobble deposits, transport sand and fine sediment to form new or expanded point bars, and erode banks or low bars on outside bends. Dam releases typically tame flows or eliminate flood peaks in dry or normal years. Tamed flows reduce bedload transport capacity while increasing base flows during summer. Channelization and levee confinement cause high flows to become deeper to compensate for less floodplain width, resulting in artificially increased sediment transport capacity. This reduced capacity prevents sediment capture in the off-channel floodplains and removes sediment from shallow shoal and bar deposits. The absence of frequent high-energy flows also prevents the scour of riparian vegetation, reducing the rate of natural sediment and cottonwood regeneration.

- Dense vegetation occupying the channelbanks and adjacent low floodplains to stabilize the river planform (i.e., modulate the annual rate of bank migration), reduce river flow velocities to cause new sediment to aggrade on bars, build topsoil in higher floodplains, and provide shade and instream woody cover to the aquatic zone. Narrow channels created by levees set too close to the low-flow shoreline separate the river from its floodplain and leave little room for riparian vegetation. Bank protection eliminates or reduces vegetation on outside bends. Channel hardening discourages both erosion and point bar formation, resulting in a static, similarly-aged stand of riparian forest and a narrowing or discontinuity of the riparian cover. Artificially narrowed channels may require periodic vegetation removal to maintain minimum floodflow capacity and are more likely to require expensive bank riprap to protect the vulnerable levees during high flows.

- Adequate floodplain width to absorb and pass out-of-bank flows (i.e., the natural flood stage), capture fine sediments, store and filter woody debris, and, most importantly, make room for the progressive meander migration of the river channel within its floodplain. Loss of river floodplain functions has converted dynamic riverine ecosystems to static conveyance facilities for the transport of irrigation and drinking water and floodflow management. Urban encroachment in floodplains and meander belts usually follows river confinement and bank hardening.

- Development of innovative means to meet local or riparian water supplies without the need to install bank protection for diversion points. Creation of these hard points to protect diversions also impairs natural stream migration. In general, diversions situated within designated stream meander zones should be modular and designed to be removable to accommodate stream meander.

In general, the loss of river meander potential and functions in the Central Valley has resulted in more sterile river ecosystems upstream of the Delta. Supports less habitat for anadromous and resident fish and provides less nutrients and food to the Delta.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION: There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated.

OPPORTUNITIES: Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for stream meander is to conserve and reestablish areas of active stream meander, where feasible, by implementing stream conservation programs, setting levees back, and reestablishing natural sediment supply to restore riverine and floodplain habitats for fish, wildlife, and plant communities.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Ecosystem Restoration Program Plan (ERPP) efforts may involve cooperation with other programs and organizations. These include:

- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB 1086) group efforts and river corridor management plans implemented for the Sacramento River (Resources Agency 1989);
- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River Flood Control Project and ongoing Bank Protection Project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- Proposed riparian habitat restoration and floodplain management studies for the San Joaquin River, including potential new flood

bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service (USFWS);

- Anadromous Fish Restoration Program gravel replenishment programs and plans and small dam removal and/or fish ladder rehabilitation projects;

- The Nature Conservancy's ongoing Sacramento Valley conservation planning; expansion plans being made for the Sacramento River National Wildlife Refuge (USFWS) and California Department of Fish and Game's Sacramento River Wildlife Management Area;

- The Cosumnes River Preserve which is a joint project of The Nature Conservancy, Department of Interior, Department of Water Resources, Department of Fish and Game, Wildlife Conservation Board, and others.

- Plans for the San Joaquin River Parkway; plans being put into effect for all county-sponsored instream mining and reclamation ordinances and river and stream management plans; and reclamation planning assistance programs being initiated under the Surface Mining and Reclamation Act by the California Department of Conservation.

- The Riparian Habitat Joint Venture which promotes the coordinated development of riparian restoration plans with the primary purpose of conserving migrant land birds.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Health stream meander corridors are dependent on the following ecological processes:

- Central Valley streamflows,
- Natural sediment supplies, and
- Natural floodplains and flood processes.

Habitat supported by healthy stream meander corridors are primarily related to riparian and riverine aquatic habitats.

Many fish, wildlife, plant species, and plant communities are dependent on the riparian zone associated with stream meander corridors.

Stressors that impair the health of stream meander corridors include:

- Dams, reservoirs, weirs, and other human-made structures;
- Levees, bridges, and bank protection;
- Gravel mining;
- Invasive riparian plants; and
- Wildfires in the riparian zone.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to increase the extent of freely meandering reaches and other pre-1850 river channel forms.

LONG-TERM OBJECTIVE: Reestablish active meander belts on all formerly meandering alluvial reaches in the Central Valley except those densely urbanized or with infrastructure whose relocation would have a high cost-to-benefit ratio.

SHORT-TERM OBJECTIVES: Inventory (at 1:1,200 scale or better) along all major river reaches bank conditions and land uses on adjacent floodplains. Prioritize for acquisition land or easements in rural areas with high potential for urbanization, especially around meander bends. Begin an acquisition program.

RATIONALE: Freely meandering rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to aquatic biota. Floodplain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch floodwaters).

STAGE 1 EXPECTATIONS: Plans for meander belts will have been developed for all major river corridors and priorities for land acquisition and easements established. Development of a meander belt will have begun on at least one river.

The general targets and actions which will contribute to restoring healthy stream meander corridors include the following.

EXISTING RIVER MIGRATION ZONES

Appropriate reaches of the Sacramento and San Joaquin Rivers and their major alluvial tributaries will be evaluated. Suitable portions will be designated as important river migration and floodplain deposition zones, or "meander belts." In these zones, natural erosion and sedimentation processes occur or could potentially occur unimpeded (within reasonable limits), sustaining a diversity of sediment-driven habitats.

These river reaches and potential meander zones will be eligible for river conservation programs and appropriate landowner incentives once they have been evaluated and ranked according to ecological process and function characteristics. Remaining Central Valley stream reaches where natural meander processes occur will be mapped and ranked according to the level of meander-system functions, the quality of dependent habitats, and the contribution to Delta species and important physical processes.

STREAM MEANDER CORRIDORS

Levees and floodplains along rivers of the Sacramento and San Joaquin Valleys will be evaluated to determine if some levees can be set back to create new meander corridors or nodes of expanded floodplains and wider riparian forest. This approach also benefits flood safety and reduces flood protection maintenance costs by repositioning levees outside the primary bank migration pathway of alluvial streams, reducing the need for expensive rock riprap, and reducing the potential for levee breaches. Enlarging inadequate floodplains will increase the volume of safe floodflow, while allowing additional riparian vegetation within the channel to close gaps in the forest canopy. Riparian vegetation will tend to naturally recolonize stream meanders in areas where the channel is widened because point bar development and sediment capture will be enhanced. Vegetation removal practices, required in confined channels, are reduced with levee setbacks. The Sacramento River between Chico Landing and Colusa is an example of a partial levee setback that benefits both flood safety and habitat quality while reducing levee and channel maintenance costs.

In other areas, land use changes and land management costs in floodplains outside existing levees may no longer justify continual levee upkeep and future bank protection costs. These areas present additional potential for expanded river meander zones. Levees could be removed, breached in key locations, or allowed to gradually erode from river migration processes. An example is the floodplain of the lower San Joaquin River near Los Banos, where former livestock pasture has been acquired for wildlife management as part of the San Luis National Wildlife Refuge. Another example is north Delta islands, where land subsidence and frequent levee failures have diminished the value of farmed land.

UPSTREAM AND BANK SEDIMENT SUPPLY

The first step in restoring upstream and bank sediment supply is to identify and rank the sediment contribution of remaining non-dammed tributaries of alluvial rivers. These tributaries help support the dynamic equilibrium of meandering stream corridors and spawning gravel areas. River reaches where bank and floodplain gravels and sediment deposits are, or could reasonably be made, available to meandering rivers through natural erosion processes must also be identified. A variety of approaches will be needed to ensure that these remaining river sediment supply sources are conserved.

The potential ecosystem benefits of county mining ordinances which incorporate incentives and policies that promote replacing instream gravel mines with off-channel mines in high terrace deposits, abandoned dredger tailings, and reservoir Delta deposits should be evaluated. The objective is to phase out instream gravel extraction that disrupts natural meander geomorphology and depletes annual sediment supply.

DAM RELEASE SCHEDULES DURING WET YEARS

The potential for modifying reservoir storage management during wet years will be investigated. Releases during wet years could simulate the seasonal pattern of natural, short-duration flood peaks. The magnitude and duration of major natural flood peaks cannot be restored in rivers below large reservoirs, but even short duration high flows can contribute significantly to the physical forces that support meander formation. This was demonstrated by the experimental flows released on the Colorado River below Glen Canyon Dam, which redistributed channel sediments from tributaries to create new fish habitat and substrate for riparian vegetation. Dam releases can be combined with non-regulated tributary inflow below the reservoirs to create flow spikes of sufficient magnitude to mobilize bed and bank sediments, clean spawning gravels, and form new river corridor landforms.

REFERENCES

California State Lands Commission. 1994. California's river's. A public trust report. Second edition. February. Sacramento, CA.

Resources Agency. 1989. Upper Sacramento River fisheries and riparian habitat management plan. The Resources Agency, January 1989. 158 p.

Resources Agency. 1998. Draft Sacramento River Conservation Area Handbook. Prepared by the Sacramento River Advisory Council under the SB 1086 Program.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ NATURAL FLOODPLAINS AND FLOOD PROCESSES

INTRODUCTION

Floodplains and flood processes provide important seasonal habitat for fish and wildlife, and provide sediment and nutrients to both the flooded lands and aquatic habitats of the rivers and Bay-Delta. Flooding also shapes the associated plant and animal communities. Major factors that reduce floodplain and flood processes contributions to the health of the Central Valley rivers and the Bay-Delta include construction of levees that constrict the floodplain, dams and reservoir operations that moderate flows, and activities that maintain flow capacity in major flood bypasses.

Before reclamation, Central Valley rivers and the Bay-Delta were comprised primarily of tidal and riverine floodplains in the form of vast tule islands, perennial grasslands, and riparian fringe corridors, intersected by permanent open water channels and secondary sloughs. Today only the primary open water channels remain, bordered by narrow, steep-sided floodplains sandwiched between the channel and the levee. Floodplains of the Bay-Delta provided a matrix for the interaction of secondary channel shorelines with tule marsh, riparian scrub, grasslands, and intertidal community types. Floodplains are essential to a balanced sediment budget by providing an area having lower velocity than the main channel, thereby capturing fine sediment and organic debris, and providing a more stable substrate for many vegetation types to flourish. During winter and spring flood events, floodplains provide important velocity refugia for resident and anadromous fish.

Floodplains reduce flood stages by slowing flow velocities, moderate channel incision and scour by providing a wide area for bank overflow, contribute to species diversity by creating the landforms that support different communities, contribute to the aquatic foodweb when overbank floodflows collect and transport organic matter from the floodplain back to channels and eventually the Bay-Delta estuary, provide low-velocity refuge for fish and other aquatic organisms during floods, and provide spawning habitat for fish species dependent on the Bay-Delta. Major factors that have disrupted floodplains and flood processes in the Delta and its tributaries include construction of levees that constrict the floodplain, dams and reservoir operations that moderate flow and block sediment, and activities that maintain flow capacity in major flood bypasses. Approaches to restoring more natural floodplains and flood processes include conserving existing natural floodplains and expanding confined floodplains.

RESOURCE DESCRIPTION

A natural floodplain is an important component of rivers and estuaries that allows many essential ecological functions to occur. Healthy floodplains are morphologically complex, including backwaters, wetlands, sloughs, and distributaries that carry ans store floodwater. Floodplain areas can constitute islands of biodiversity within semi-arid landscapes, especially during dry seasons and extended droughts. The term *floodplain* as used here means the generally flat area adjoining rivers and sloughs that is flooded by peak flows every 1.5-2 years and exceed the capacity of the channel ("bankfull discharge"). Peak flows in winter and spring that happen every 1.5-2 years are considered by river geomorphologists to be the "dominant discharge" that contributes the most to defining the shape and size of the channel and the distribution of sediment, bar, and bed materials. Larger flood events can cause major changes to occur, but they do not happen often enough to be the decisive factor in river geomorphology.

A more common use of the term *floodplain* refers to the 100-year floodplain as determined and mapped by the U.S. Army Corps of Engineers (Corps) and Federal Emergency Management Agency (FEMA). This definition is used to prepare land-use and flood-management plans.

Active floodplains provide many ecological benefits by:

- Slowing flow velocities
- Moderating channel incision and scour by providing area for bank overflow
- Contributing to species diversity by creating landforms that support different communities
- Contributing to the aquatic foodweb by collecting and transporting organic matter from the floodplain back to channels and eventually the Bay-Delta estuary
- Providing low-velocity refuge for fish and other aquatic organisms during floods
- Providing spawning habitat for fish species dependent on the Bay-Delta
- Providing habitats for wildlife such as shorebirds and dabbling ducks, and in high rainfall years, diving ducks.

One benefit of levees and flood control reservoirs is reducing the extent of and hazards within the 100-year floodplain and similar high-magnitude, low-probability storm events, as experienced in the January 1997 flood. The 100-year floodplain is related to a natural river floodplain but does not apply to the following discussion of ecosystem functions as supported by flood processes. A predicted 100-year floodplain covers a much larger area than a natural floodplain of a river, slough, or stream at bankfull discharge.

At higher flow, water spills out of the channel and flows over the flat-lying land near the river. River channels are not large enough to accommodate higher discharges without overflowing. This process of out-of-bank flow is a common but little recognized attribute of rivers and their floodplain.

Levees placed close to riverbanks have allowed human encroachment on river floodplains. Human encroachment on the floodplains of rivers accounts for the predominance of flood-related damage. Central Valley rivers that have little or no remaining natural floodplain, typically have the lowest ecological values and present the greatest risk of flood damage to adjacent lands. Large-scale reclamation and separation of low-lying land alongside rivers, streams, and estuaries have eliminated major habitat areas including riparian forests, marshes, and upper tidal zones.

On many tributaries, large reservoirs and diversions have also reduced the size of natural floodplains. Reservoirs and diversions reduce the frequency and duration of bankfull discharge and restrict channel flow to the low-flow channel most of the time, including during the wet season. In this case, a stream no longer comes into contact with its floodplain except during high-magnitude, low-frequency flood events. These types of streams may experience channel straightening and incision. The reduction of flood frequency on the lower floodplain often encourages encroachment of agricultural land uses and even recreational development on the area that once supported diverse floodplain habitats.

Floodplains reduce flood stages in the Delta, rivers, and streams by increasing the cross-sectional area of the channel and slowing flow velocities. Under overbank flow conditions, the river merges with its floodplain, increasing the capacity of the river to move and temporarily store large volumes of storm flow. Slow-moving water covering large riverine floodplains and adjacent basins naturally detains the volume of floodwaters entering the Delta and leveed reaches of the lower Sacramento and San Joaquin Rivers. Temporary floodplain storage thereby reduces the peak stage of flood events in the Delta region and other sectors of the levee system, and gradually releases the storm water as flood waters recede. The prolonged inundation of floodplains, such as can be observed in the Yolo and Sutter bypasses and Stone Lakes basin, is highly compatible with the natural flood tolerance of seasonal wetland and riparian vegetation and animal life.

Floodplains capture and store sediment, build soil, and reduce the need for dredging channels downstream and in the Delta. The overbank flow across a floodplain is wider and more shallow than in the channel. The flow often encounters more resistance from vegetation along the outer banks, which causes the river to lose energy in the floodplain areas and, in turn, causes sand and fine sediment to be deposited. Natural levee mounds parallel the channel banks are created by the deposited sediment. The sediment also builds soil to support forests and grasslands. Natural floodplains are thus able to capture and store enormous volumes of fine sediment spread over large areas, balancing the river's sediment budget and preventing the clogging of channels and estuaries downstream.

Floodplain overflow moderates channel incision and bank scour. The term *stream power* refers to the ability of riverflow to erode the bed and bank by the shear stress created by deep, high-velocity, turbulent water. Rivers and streams confined to a narrow channel by bedrock canyon walls or constructed levees have greater stream power than alluvial rivers with unconfined adjoining floodplains. Energy and flood volume diverted into the overbank floodplain regulate the stream power acting on the channelbed and banks and, in concert with the binding effect of shoreline vegetation, prevent channel instability. Stream meander moderates the rate of change. Although many rivers and streams tend to experience some bed incision during high winter flows, the floodplain overflow capacity moderates stage increases and channel velocities that would otherwise cause excessive channel incision and widespread loss of riparian vegetation and riverine bed habitats during major storm events. Wide floodplains also reduce the scour effects on levees and bridge piers during high flows.

Floodplains contribute to habitat, and therefore, species diversity. During bankfull discharge, a flow/energy gradient exists from the channelbanks to the outermost extent of the natural floodplain. The flow/energy gradient results in a corresponding gradient from larger to smaller particle deposition and greater to lesser frequency of inundation. Scour effects are also greatest nearest the channel banks. The build-up of natural levee mounds and ridges may trap floodwaters in shallow, marshy basins formed between the outermost high ground and the sediment ridge deposited alongside the channel. These physical processes combine to create highly variable vegetation community types and age classes over the floodplain surface. The variation in plant species and community structure provides a wide array of habitat types and interfaces, resulting in the notably high wildlife species diversity found in riverine and estuarine corridors.

Floodplains are a major source of nutrients and organic matter for the aquatic zone. Floodwater passing over flat-lying lands captures organic material, carbon and nutrient-rich soil particles, insects, and fallen trees. These materials are transported at high flow stage to backwater basins, estuaries, and secondary channels that may then return the organic "cargo" to the river and Delta aquatic zone. These organic components provide microhabitats, prey items, and nutrients that sustain zooplankton, aquatic invertebrates, and small fish in the rivers and Delta.

Organic debris and dislodged trees may be captured by the filtering effect of the floodplain during one year, forming debris piles as floodwaters recede, and then be resuspended or swept away by a subsequent inundation of the floodplain. Without a floodplain to cycle buoyant matter conveyed by rivers and streams at high flow, most of the organic matter generated would be flushed through the system without being fully used. By detaining floodwaters longer than in the main channels, floodplains increase the residence time of nutrients, phytoplankton, and zooplankton, which promotes greater energy use and higher productivity of the foodweb entering the Delta.

Floodplains provide safe haven and spawning areas for native Delta and valley fish species. Fish, especially juveniles, seek lower velocity refuge from turbid, turbulent floodflows in rivers and streams. Vegetated floodplains adjoining channels provide ideal velocity refuge and overhead and instream cover during high-flow events. Here, small juvenile salmon, steelhead, and resident native fish can avoid excessive predation and weather the inhospitable stormflows in the main channel. Some fish species important to the Delta, such as splittail, will disperse from the rivers and sloughs into shallow, vegetated floodplains to spawn. Splittail recruitment is highest during wet years when the floodplains of the Delta and rivers, such as the lower Yolo basin, are flooded for a long time. In some areas, or under specific hydrologic events, poor drainage from floodplain and flood overflow areas can pose a hazard to aquatic organisms, primarily adult and juvenile fish, by contributing to stranding. Reconnecting rivers to their floodplains will be accomplished in ways sensitive to this risk and provide measures to reduce or eliminate it.

Floodplain function is affected by a number of common and widespread stressors, including levees and dams. Levees restrict the width and extent of floodplains in rivers and the Bay-Delta. In some areas, levees are only slightly wider than the channel at low flow, such as along the Sacramento River downstream of Colusa. Restricted floodplains typically cause deeper flow and faster channel velocity during high stage. They also restrict the amount and width of allowable or potential riparian vegetation, and have a low ratio of shallow-water habitats to deep, open water. Channels in these areas typically have a trapezoidal section, rather than a more natural compound channel with low bank angles and one or more flat-lying floodplain surfaces. Under these conditions, channels typically have a high depth-to-width ratio which is inherently unstable during high flows that can remobilize deep layers of channel bed materials. The physical processes necessary to sustain floodplain habitats may be absent or diminished. Within the Delta and Suisun and San Pablo Bays, levees restrict the extent of tidal floodplains inundated by higher high tides and storm flow surges passing through Delta sloughs and rivers.

Narrow floodplains along streams limit natural floodplain vegetation. Along rivers and streams contained within levee systems, the width of the floodplain is restricted, and much of the remaining floodplain surface has been reclaimed for orchard and cropland. Floodplain narrowing and conversion to cropland provides less inundation of vegetated areas during normal high water events, thereby reducing the input of critical nutrients and organic materials that typically come from a natural wide floodplain, and limiting rearing and spawning habitat for native fish such as splittail. In other cases, riparian vegetation is removed from the floodplain to optimize flood conveyance capacity if it is assumed that the predicted 100-year flood or "design flow"event will exceed the capacity of the channel.

Dams and reservoir operations reduce the natural peaks of a typical flood flow pattern, thereby reducing inundation of the natural floodplain. Large reservoirs on most of the Sacramento and San Joaquin Rivers tributaries capture the 1.5- to 2-year bankfull discharge. Water releases from reservoirs limit the magnitude, frequency, and duration of higher channel-forming flows that would otherwise spread into the lower floodplain areas adjoining rivers. Reservoirs also capture most of the incoming fine sediment that is needed to build soil on the floodplain. The net effect is to convert rivers and streams below dams into much smaller versions of the original channel and floodplain.

Managed reservoir releases may not be sufficient to interact with the remaining patches of floodplain except during higher magnitude stormflows. This is especially true on rivers such as the American River, where there are no major nondammed tributaries downstream of Folsom and Nimbus Dams. Channel incision that often follows dam construction and associated loss of the natural sediment supply further exacerbates the shrinkage of the floodplain alongside the lowered channel.

Flood management programs and policies affecting the Sutter and Yolo Bypasses discourage vegetation in the floodplain. Although the Yolo and Sutter Bypasses provide some of the physical functions of natural flooding and floodplain benefits, the full ecological potential of the floodplain is not realized because of the artificially uniform grade and generally sterile, nonvegetated condition of most of the bypass system. As recently as 1960, there were still hundreds of acres of natural grassland and valley oak woodland in the bypass system, most of which have been removed to improve floodway conveyance and make way for more intensive cropping patterns.

ISSUES AND OPPORTUNITIES

FLOOD MANAGEMENT AS ECOSYSTEM TOOL: The current approach is to control floods using dams, levees, bypass channels, and channel clearing. This approach is maintenance intensive, and the underlying cause of much of the habitat decline in the Bay-Delta system since 1850. Not only has flood control directly affected ecological resources, but confining flows between closely spaced levees also concentrates flow and increases flood problems downstream. Without continued maintenance or improvement of flood control infrastructure, further levee failures are likely. Emergency flood repairs are stressful to local communities and resources and often result in degraded habitat conditions. An alternative approach is to manage floods, recognizing that they will occur, they cannot be controlled entirely, and have many ecological benefits. Allowing rivers access to more of their floodplains actually reduces the danger of levee failure because it provides more flood storage and relieves pressure on remaining levees. Valley-wide solutions for comprehensive flood management are essential to ensure public safety and to restore natural, ecological functioning of river channels and floodplains. Integrating ecosystem restoration with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management can help redesign flood control infrastructure to accommodate more capacity for habitat while reducing the risks of flood damage (Strategic Plan 1999).

BYPASSES AS HABITAT: The Yolo and Sutter Bypasses along the Sacramento River are remarkably successful in reducing flooding in urban areas. They are also important areas for farming. The realization of their relatively low-cost benefits to flood control is leading to the consideration of additional bypasses, especially in the San Joaquin Valley. There is also a growing realization that bypasses can be important habitat for waterfowl, for fish spawning and rearing, and possibly as a sources of food and nutrients for estuarine foodwebs. For example, when the Yolo Bypass is flooded, it effectively doubles the wetted surface area of the Delta, mostly in shallow-water habitat. Managing the bypasses for the benefit of fish and wildlife, however, may conflict with their use for flood control and farming. Therefore, there is a major need to evaluate existing bypasses as habitat to reduce management conflicts. New or expanded bypasses and managed flood basins should also be designed with the needs of fish and wildlife in mind (Strategic Plan 1999).

OPPORTUNITIES: Undertake floodplain restoration on a broad scale, where land or easements can be acquired and where the river hydrology includes (or can be made to include) sufficiently high flows to inundate floodplain surfaces. Restoration of floodplain function can produce many benefits, such as reducing stress on remaining levees, reducing excessive channel scour, and encouraging establishment of riparian vegetation over a larger area within the adjacent floodplain. A range of possible measures will need to be employed to fit local conditions, such as widening flood bypasses or creating new ones; setting levees back, creating backup levee systems, or deauthorizing specific levee reaches; constructing armored notch weirs in levees and purchasing flood easements to restore flood basin storage functions; or implementing measures described in item two above to increase the frequency and duration of overbank flow onto existing floodplains. Reactivating the historical floodplain can provide effective reliable, and cost effective flood storage while restoring important ecological processes (Strategic Plan 1999).

VISION

The vision for natural floodplains and flood processes is to conserve existing intact floodplains and modifying or removing barriers to overbank flooding to reestablish aquatic, wetland, and riparian floodplain habitats.

Measures for conserving and enhancing natural floodplains and flood processes are complimented by the visions for natural sediment supply, natural fluvial geomorphology, and stream meander corridors. If the floodplain, meander width, sediment supply, and natural or simulated flood peaks are in place, the river will respond by creating natural landforms. These natural landforms will support self-sustaining vegetation communities and aquatic and terrestrial habitats. Even partial restoration or simulation of natural physical processes and floodplains will enhance channel characteristics and resultant habitats.

Conservation and management of natural existing floodplains should be promoted. Cooperative efforts with the U.S. Army Corps of Engineers and California Department of Water Resources (DWR) should be developed to map and describe the hydrologic characteristics and conditions of all remaining natural riverine and estuarine floodplains not separated from channels by levees or irreversible stream incision. Remaining floodplains that interact with bankfull discharge and higher high tides should be maintained as active floodplains because of their ecological functions and habitat potential, as well as their flood management benefits.

Flood processes and floodplain functions can be restored to many rivers, streams, and estuaries where levees are no longer essential for flood safety or where agricultural uses are marginal or problematic because of poor drainage, high maintenance costs, or frequent sand deposition.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for natural floodplains and flood processes will involve coordination with other programs and organizations, including:

- Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB1086 group) efforts and river corridor management plans implemented for the Sacramento River;
- studies underway by the state Reclamation Board and DWR to evaluate the aftermath of the January 1997 flood damage, levee stability, and future floodplain risk assessment;
- the U.S. Army Corps of Engineers and the Reclamation Board's Sacramento and San Joaquin River Basins Comprehensive Study, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- proposed riparian habitat restoration and floodplain management studies for the San Joaquin River and its major tributaries, under supervision of the State Reclamation Board and Corps of Engineers, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service (USFWS);

- the San Joaquin River Parkway Plan;
- various plans for the restoration of tidelands (i.e., tidal floodplains) in the north San Pablo Bay and Suisun Bay; and
- multiagency plans or studies to breach levees and reopen floodplains of islands of the north Delta, including Liberty and Prospect Islands, and Little Holland Tract.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of natural floodplain and flood processes in the rivers and Delta is closely linked with stream flow, sediment supply, and stream meander processes, riparian, wetland, and aquatic habitats, and many stressors including dams, levees, bank protection, dredging, and gravel and sand mining in the floodplain.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for natural floodplains and flood processes is to re-establish frequent inundation of floodplains by removing, breaching, or setting back levees and, in regulated rivers, by providing flow releases capable of inundating floodplains.

LONG-TERM OBJECTIVE: Reestablish active inundation of floodplains with area targets and inundation frequencies (1-5 years) to be set for each major alluvial river (where feasible) based on probable pre-1850 floodplain inundation regimes and on existing opportunities to modify existing land uses.

SHORT-TERM OBJECTIVE: Reestablish active inundation of at least half of all remaining unurbanized floodplains in the Central Valley, where feasible.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to reestablish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

STAGE 1 EXPECTATIONS: All existing unurbanized floodplains in the Central Valley will have been identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics will have been developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects will be used to increase understanding of channel-floodplain interactions and the potential for restoration of processes.

General targets to restore health to floodplains and flood processes include:

- conserving and expanding floodplains of Central Valley rivers and Bay-Delta by augmenting the natural flood processes including increasing the average floodplain width and linear extent of low areas beyond channel banks subject to bankfull discharge;
- promoting flood detention in flood basins and, where appropriate, encouraging wetland formation,
- increasing the frequency of inundation of vegetated floodplains connected to rivers and tidal channels; increasing the extent of tidal inundation at or above mean high tide; and
- reducing the extent of trapezoidal channels within levees and floodways; and increasing the acreage and connectivity of natural habitat areas within active floodplains of rivers and estuaries.

Floodplain expansion can be implemented in one of the following ways:

- Set back levees along channels and tidal sloughs to expand the width of the river's floodplain within the levee system. This approach should be evaluated on many rivers and tributaries as part of the overall reevaluation of the valley's flood control infrastructure and floodplain management policies.
- Acquire flood easements on agricultural and natural lands to allow a greater frequency and extent of floodplain inundation.
- Breach or remove levees from channels that are confined by narrow levee corridors, where feasible. In farmed areas, much of the land could continue to be farmed, if desirable, because most flooding would occur in limited areas and only during the non-growing season. This approach may have wide applicability to the low-lying plains of the San Joaquin River and lower tributaries and should be studied together with levee upgrades.
- Modify bypass and channel vegetation management policies to allow greater vegetative cover on existing floodplains. Where needed, compensate for increased channel roughness by implementing other flood control projects upstream that reduce peak flood water surface elevations.
- Expand floodplains and bypasses and add additional flood relief structures to reduce maximum flood stage in the channels. Expanded floodplains will allow for more vegetation and habitat within the channels, as well as the potential to provide greater flood protection. The Corps of Engineers and the Governor's Flood Control Task Force will be evaluating the need for new flood relief structures for the Sacramento and Feather Rivers along the Colusa Basin and Sutter Basin and for the San Joaquin River and lower tributaries along the extensive historic river plains.
- Breach or remove levees along Delta sloughs and former diked tidelands of the Bay.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

INTRODUCTION

The Delta of today is greatly altered from its historical condition. Historically, a complex, dendritic array of channels drained extensive marsh plains. Now, theses channels have been replaced by a greatly simplified network of uniform channels.

The Delta waterways generally contain fresh water, with brief incursions of slightly brackish water into the northern and western Delta. This incursion is more pronounced during the spring and early summers of very dry years when the discharges from the Sacramento and San Joaquin rivers are low. This differs from the natural pattern in which brackish water intrusion naturally occurred in late summer and early fall.

Beginning in the mid 1800s, the Delta has been subject to the effects of alteration of the natural seasonal patterns of river discharge, Delta morphology, and tidal prism. These factors interact to determine water movement patterns and salinity distribution in the Delta. Salinity levels in Delta waters is primarily a result of tidal prism and stage, and net Delta outflow. It is also influenced by prevailing wind direction and velocity. Daily tidal cycles result in flows in the lower San Joaquin River of up to 300,000 to 400,000 cfs, and the spring-neap cycle alters water surface elevations and salinity levels on a monthly basis.

Other factors that now contribute to alteration or moderation of historic flow patterns in Delta waterways and channels include operation of the CVP/SWP pumping plants in the south Delta, the Suisun Marsh Salinity Control Structure, the Delta Cross Channel (DCC), and a temporary flow barrier on the San Joaquin River at the head of Old River. The DCC and Old River Barrier affect flow rates, direction, and water surface elevations. At times, these factors contribute to the creation of unnatural flow patterns which is particularly evident in the channels of the southern and central Delta.

Hydraulic processes are an extremely important aspect of the Bay-Delta system and refers to the seasonal and daily direction and velocity of flows in Bay-Delta channels. The direction and velocity of flow and their distribution in time and location are important factors in habitat preferences of Bay-Delta organisms, erosion and sedimentation processes, migratory cues for organisms, and many other ecological processes and functions in the Bay-Delta. Major factors that affect hydrodynamics of Bay-Delta channels include streamflow, sediment composition, and channel configuration.

Flow conditions in Delta channels affect foodweb production, transport of organisms through the Delta, and vulnerability to south Delta pumping plant diversions. The Bay-Delta estuary provides important fish spawning, rearing, and migrating habitats. The Bay-Delta also serves as an important link in nutrient cycling and provides for high levels of primary (plant) productivity that supplies the aquatic foodweb.

RESOURCE DESCRIPTION

Nonimpeded tidal action into tidal wetlands affects sediment and nutrient supplies into those wetlands and complements natural marsh successional processes. Tidal action associated with flows out of tidal wetlands transports nutrients and organic carbon into aquatic habitats of the Bay-Delta.

Hydrodynamic patterns in the Delta are important to the survival of delta smelt, longfin smelt, striped bass, chinook salmon, and other fish dependent on the Sacramento-San Joaquin Delta. Unfavorable hydrodynamic conditions, such as net flow moving south to Delta export facilities instead of moving west toward Suisun Bay, reduce fish survival.

Improved hydrodynamic patterns will increase residence times of Delta water; provide more natural downstream flows; and improve rearing and spawning habitat, nutrient cycling, and foodweb integrity.

Delta hydrodynamics are determined by a combination of flow parameters including Delta inflow, Delta diversions, tidal flows, and facility operations (e.g., operation of the DCC gates). Cross-Delta water flow to the south Delta pumping plants reduces residence time of water in the Delta and alters flow direction and magnitude.

Unfavorable hydrodynamic conditions decrease juvenile chinook salmon survival as they migrate from the Sacramento River through the Delta. With a high rate of north-to-south flow from the Sacramento River through the DCC and Georgiana Slough into the central Delta, young salmon may become lost or delayed within the Delta, or may become more susceptible to being drawn to the south Delta pumping plants.

Favorable hydrodynamic conditions are important for chinook salmon because the Delta is a migration corridor and also provides rearing habitat. Juvenile chinook salmon rearing in the Delta are exposed to adverse hydrodynamic conditions for approximately 1-3 months until they are ready to migrate to the ocean.

Other species, including striped bass and delta smelt, are also subject to being drawn south across the Delta to the pumping plants. Because the water has a short residence time, the food supply is generally poor for those fish drawn into or residing in the central and southern Delta.

VISION

The vision for hydraulic processes in the Sacramento-San Joaquin Delta is to restore channel hydraulics to conditions more like those that occurred during the mid-1960s. Historical hydraulic conditions provided migratory cues for aquatic species; transport flows for eggs, larvae, and juvenile fish; and transport of sediments and nutrients.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The objective of one current program, the Temporary Barriers Program in the south Delta, is to improve the quantity and quality of irrigation water to agricultural users in the south Delta. A secondary objective is to provide a physical barrier in spring at the head of Old River at its junction with the San Joaquin River to reroute outmigrating San Joaquin fall-run chinook salmon downstream and away from the export facilities. In fall, a partial rock barrier modifies channel hydrodynamics to reduce the risk of dissolved oxygen blocks near Stockton and to ensure that a greater percentage of attraction water from natal streams reaches the Central and West Delta Ecological Unit.

The DCC gates are required to be closed under the terms of the National Marine Fisheries Service's biological opinion on winter-run chinook salmon and the 1995 Water Quality Control Plan to reduce impacts on salmon migrating down the Sacramento River. The gates can be closed at the request of the California Department of Fish and Game for half of November, December, and January. The DCC gates are then closed from February 1 through May 15.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Bay-Delta hydrodynamics are closely linked to the health of aquatic habitats in the Bay-Delta and the aquatic resources that depend on these health habitats. These include:

- Tidal perennial aquatic habitat,
- Delta sloughs, and
- Midchannel islands and shoals.

Species and species groups that are dependent on healthy hydrodynamic conditions in the Bay-Delta include:

- Delta smelt,
- Longfin smelt,
- Striped bass,
- Chinook salmon, and
- Many other estuarine and resident aquatic species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for Bay-Delta hydrodynamics is establish and maintain a hydrodynamic regime for the Bay and Delta that favors native species, desirable non-native species, and natural habitats by providing species needs such as migratory cues, transport, food web support, and rearing habitat and restoring and maintaining important aquatic and terrestrial habitats.

LONG-TERM OBJECTIVE: Have a hydrodynamic regime in the Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay that is favorable to maintenance of large, self-sustaining populations of species and habitats treated separately under goals 1, 3 and 4.

SHORT-TERM OBJECTIVE: Develop a more favorable hydrodynamic regime during key spawning and rearing times for native species and desirable non-native species. Select and implement water project operations measures to the extent feasible to support this hydrodynamic regime. Evaluate other measures and actions designed to create favorable conditions for depleted species and implement them where feasible.

RATIONALE: The restoration to abundance of most, if not all, of the native species and habitats in the Sacramento-San Joaquin estuary depends on the restoration and maintenance of a Bay-Delta hydrodynamic regime that supports important ecological functions such as sustaining a productive food web, providing spawning, rearing, and feeding habitat for estuarine and anadromous fish, and supporting migration of adult and juvenile fish. Human activities such as reduced Delta inflow, exports from the Delta and conversion of tidal wetlands have had a large influence on the natural hydrodynamic regime of the Bay-Delta. There are opportunities to restore or simulate, where and when appropriate, a more natural hydrodynamic regime, particularly in the February through June period, that sustains ecological functions and meets the life requirements of the fish and wildlife in or dependent on the Bay-Delta. As more is learned about the hydrodynamics of the estuary, direct and indirect modifications of estuarine processes (in an adaptive management context) should continue.

STAGE 1 EXPECTATIONS: Implementation of actions to restore or simulate a more natural hydrodynamic regime in the February through June period will be underway. Actions will include modifications to Delta inflow patterns and export operations during that period as well as restoration of tidal action to areas within the Bay-Delta. Studies on the factors affecting the abundance of key organisms should be ongoing, And a basic understanding of how effective the water operations measures have been for the at-risk species with continued exports from the south

Delta should be developed and used to assess the need for a dual conveyance facility and to implement other strategies for their recovery.

The general target for restoring and maintaining healthy Bay-Delta hydrodynamics is to focus on restoring hydrodynamic patterns typical of those exhibited when the ecosystem was functioning in a healthy state (e.g., 1960s).

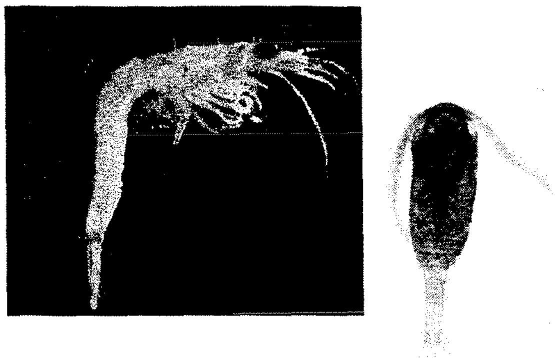
The general approach to attain the target include the following:

- The effects of water exports and lower riverflows can be reduced by altering Delta channel configurations to improve system hydrodynamics. The two ecological units that have the greatest need for improved hydrodynamics are the South Delta and Central and West Delta Ecological Units.
- Modify Delta inflow patterns and export operations during the February through June period to more closely mimic hydrodynamic conditions that would have occurred under conditions in the mid-1960s.
- The greatest opportunities to restore hydrodynamic processes to reference levels that occurred when the estuary was healthier are linked to the water and storage alternatives. The potential for restoration is limited by a water storage and transport component that has its only export facilities located in the South Delta Ecological Unit. Under that condition, increased storage upstream or downstream of the Delta could reduce exports in portions of some months and improve hydrodynamics during those times. Other more limited opportunities exist that are associated with storing water in the Delta, using physical barriers in strategic locations in the Delta, broadening specific sloughs to increase their flow-bearing capacity while reducing water velocities, and restoring large acreages of tidal wetlands and tidal channels to increase the tidal volume of the estuary.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ BAY-DELTA AQUATIC FOODWEB



INTRODUCTION

The aquatic foodweb of the Bay-Delta ecosystem is the web of organisms through which energy transfers up through the different trophic levels from the lower level that includes the plants to the highest level that includes the fish, water birds, and marine mammals. Each level in the web receives energy from the lower levels. The lower or primary producer level gets energy from photosynthesis or basic forms of dissolved organic compounds in the water. The second level is generally the primary consumers or herbivores (e.g., bacteria and algae-eating zooplankton) that feed on the plants or plant products. Secondary and tertiary consumers are further up the foodweb.

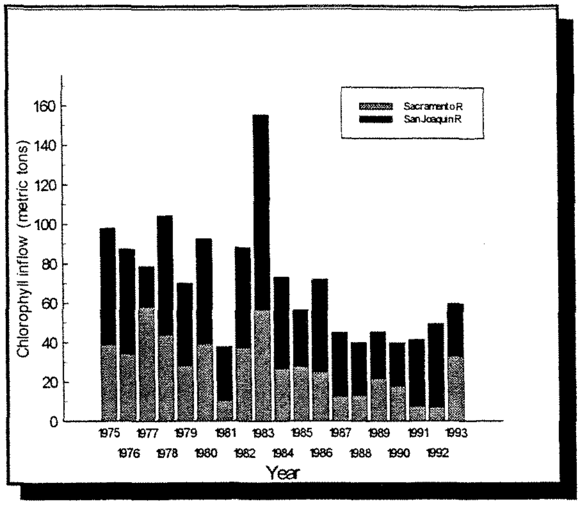
Total productivity of the Bay-Delta estuary is dependent primarily on the amount of plant biomass produced and the efficiency in which the energy is transferred up through the higher levels of the web. The Bay-Delta aquatic foodweb is derived from energy created by many kinds of plants, some of which are grown in the Bay-Delta waters and adjacent riparian and wetland habitat, while others are from upstream or land production.

RESOURCE DESCRIPTION

Plant contributions to the estuary foodweb consist mostly of benthic algae and phytoplankton produced in the estuary and its watershed. "Benthic" foodweb organisms are bottom dwelling, whereas plankton spend most of their time drifting in the water column. Vascular-plant debris contributed from terrestrial or wetland communities adjacent to the system also contribute to the foodweb. Algae are generally small (diameter <0.1 millimeters [mm]), easily transported, and highly nutritious; whereas most vascular-plant debris begins as coarse particulate organic matter that must be colonized and partially decomposed by bacteria before being usable by invertebrates and fish.

The Bay-Delta foodweb has undergone many changes since the 1960s. Most notably, algal abundance (as measured by chlorophyll concentrations in waters of the estuary) has declined in important fish nursery areas of Suisun Bay and the western Delta. Lowered algal abundance in Suisun Bay coincides with very low Delta outflow during drier years, particularly in the drought years, such as 1977 and 1987-1992, and with very wet years, such as 1983 and 1995. However, many species of zooplankton underwent their largest declines between 1970 and 1980, well in advance of the 1987-1992 drought (Obreski et al. 1992). Chlorophyll levels greater than 20 micrograms-per-liter (μg/l) represent in Suisun Bay only twice since 1986.

Over the past three decades, chlorophyll concentrations upstream in the western Delta have been similar to those in Suisun Bay. As in Suisun Bay, concentrations are lower in dry years and very wet years. Such levels have been achieved in only two years since 1986.



May-October Chlorophyll Inflow to Delta, 1975-1993

pattern of very low chlorophyll levels in Suisun Bay and the western Delta beginning in 1987 has caused concern among many scientists. These low levels may be the result of high densities of Asian clams (*Potamocorbula amurensis*) which colonized the Bay after being accidentally introduced from the ballast waters of ships. Large numbers of the clams colonized this area of the estuary during the drought period from 1987 to 1992.

Some of the plant production appearing in the Delta and Suisun Bay is washed down from south Delta channels and the San Joaquin River. Chlorophyll levels in these channels reached an average of more than 100 μg/l in spring and summer of some years in the early 1970s. In the past two decades, productivity in these channels, although remaining relatively high, has declined. Levels in 1993, 1995, and 1996 were low, possibly because of high flows (as in 1982, 1983, and 1986); however, lower than expected levels in recent dry years are a concern.

In wet years, some algae and other plant material in Suisun Bay and the Delta are transported tidally downstream into the wider expanses of San Pablo Bay and other portions of San Francisco Bay. Spring and summer chlorophyll levels in San Pablo Bay are generally low compared with those in Suisun Bay and the Delta. Peak concentrations in the past three decades in San Pablo Bay occurred in wet years (1980, 1982, 1983, 1984, 1986, and 1995).

Aquatic invertebrate population trends have varied significantly over the past three decades. Species that once dominated the aquatic invertebrate community have become relatively scarce such as *Eurytemora* and *Neomysis*, while some others have increased in relative abundance. Many native species have become less abundant or more narrowly distributed, while dozens of new non-native species have become well established and widely dispersed. Overall, the abundance of invertebrate plankton has declined, while most notably populations of Asian clams, have increased. This transition has been most evident in Suisun Bay and other traditionally important fish-rearing areas such as the western Delta and Montezuma Slough in Suisun Marsh. Also in these areas, populations of rotifers, copepods, and other relatively small species have declined substantially since monitoring began in the 1960s. This pattern is perhaps most dramatic for the mysid shrimp, which has declined to less than one-tenth of its former abundance, particularly since 1986. The continued decline from 1993 to 1995, despite the return of higher flows, is of particular concern. These declines in zooplankton abundance have roughly coincided with the decline in algae, one of the main food sources for the zooplankton.

The deterioration of the zooplankton community and its algal food supply in key habitat areas of the Bay-Delta is a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early life. Limited research indicates that survival and growth of fish larvae may improve with increased concentration of zooplankton. Declines in the production of juveniles of these fish species appear to coincide with the declines in algae and zooplankton.

Modifying the Bay-Delta ecosystem in ways that will lead to increased algae and zooplankton abundance, such as increasing the residence time of water in the Delta, may be critical to restoring Bay-Delta fish populations and improving the health of its ecosystem.

Much of the plant biomass and other forms of fine particulate organic matter consumed by zooplankton in the Bay-Delta is transported from the Sacramento and San Joaquin rivers and accumulates in the western Delta and Suisun Bay. Some organic matter also comes from the lower mainstem rivers and from side channels, side sloughs, and floodplain lakes. Large amounts of organic matter and associated bacterial biomass enter the rivers, Bay, and Delta as crop residue, leaf litter, dead tule stems, and other organic debris from riparian corridors, floodplains, or other areas subject to periodic flooding by tides and high flows. Historically, considerable organic material entered the rivers and Bay-Delta from sewage and food-processing plants. These point source loadings have since been reduced as part of an overall effort to improve water quality.

The San Joaquin River contributes a disproportionately high percentage of the food resources supplied to the Delta. The river's chlorophyll levels are among the highest recorded for temperate rivers anywhere in the world. San Joaquin River water has a relatively long hydraulic residence time and high phosphorus and nitrogen levels. Under these circumstances, algae have an abundant supply of nutrients and enough time to process them before being swept downstream into the Delta. The Sacramento River, by contrast, has relatively low nutrient levels throughout most of its length and a comparatively short residence time and, therefore, low productivity.

These differences between the San Joaquin and Sacramento Rivers are partly a result of natural differences in regional soils and hydrologic conditions, but are also a function of how the two rivers have been engineered and operated to meet water supply needs. The San Joaquin River is fertile and sluggish from May to October because it consists primarily of agricultural return flows. In contrast, the Sacramento River consists primarily of reservoir releases that are relatively nutrient poor. Although the San Joaquin River accounts for only 17% of Delta water inflow from May through October, it contributes 60% of the plant material flowing into the Delta.

From May through October, the amount of plant material flowing out of the Delta exceeds the amount transported in from the rivers by an average of 44%. This difference results from production of algae within the Delta. Most of the plant material transported to or produced within the Delta flows out of the Delta, either through the main channel connecting the Delta with Suisun Bay or by way of the project pumps in the southern Delta. Of the total outflow of water and plant material from the Delta (i.e., project exports plus "net Delta outflow" to Suisun Bay), on average two-thirds goes to Suisun Bay and one-third is exported by the pumps.

The proportion of the organic material in the Delta that reaches Suisun Bay varies considerably from year to year and depends, in part, on prevailing flow conditions. At higher flows, much of the organic material brought in by the rivers will travel to Suisun Bay or farther to San Pablo Bay or central San Francisco Bay. At low flows, a greater proportion remains in the Delta or is exported from the south Delta pumping plants.

In addition to serving as a critical habitat area for food production and accumulation, Suisun Bay is an area of intense food consumption. Before the prolonged drought that began in the mid-1980s, high densities of copepods, young mysid shrimp, and other planktonic grazers usually accompanied relatively high chlorophyll levels in Suisun Bay. Dozens of species of filter-feeding clams and other benthic grazers joined in the intense food consumption. Since the drought ended in 1993, however, chlorophyll concentrations have remained low in Suisun Bay.

The Asian clam is likely responsible for this lack of plankton recovery. This non-native marine bivalve was first detected in Carquinez Strait in 1986. Since then, it has become very abundant throughout San Pablo Bay and Suisun Bay and, in dry years, extends upstream into the western Delta. It is estimated that the clam can effectively filter the entire water column within 24 hours. Therefore, some scientists believe that these clams are effectively removing algae and other fine organic materials from the water column of Suisun Bay almost as fast as the Delta can supply it. The Asian clam is, therefore, considered an important "stressor" that will likely hamper efforts to restore the Bay-Delta foodweb; however, clam densities and the extent of their upstream distribution in the estuary have declined since 1993 with the onset of higher freshwater winter and spring inflows associated with wet years in 1993, 1995, and 1996.

The decline of plankton populations and chlorophyll concentration in the Bay-Delta may be a result, at least in part, of the effects of heavy metals, herbicides, pesticides, and other toxic substances. Low concentrations of these substances in the water column may act individually or in combination to reduce productivity of plant and animal plankton. Laboratory tests of Delta water on sensitive organisms indicate periodic toxicity of Delta water.

ISSUES AND OPPORTUNITIES

DECLINE IN PRODUCTIVITY: Productivity at the base of the foodweb has declined throughout the Delta and northern San Francisco Bay. Although some of this decline can be attributed to the introduced clam Potamocorbula amurensis, or Asia clam, not all of the decline is explained. The decline at the base of the foodweb has been accompanied by declines in several (but not all) species and trophic groups, including mysids and longfin smelt. The long-term implications of this seem to be a reduction in the capacity of the system to support higher trophic levels. This implies a limit on the extent to which Bay-Delta fish populations can be restored unless creative solutions can be found to increase foodweb productivity (Strategic Plan 1999).

OPPORTUNITIES: Initiate targeted research on major restoration issues, such as: (1) how to control problem invasive species such as the Asia clam (*Potamocorbula amurensis*), which has a negative effect on foodweb dynamics in the estuary; (2) factors limiting the abundance of high-priority endangered species; and (3) design of habitats for shallow-water tidal marsh and bypasses. Use such research to begin addressing issues raised in "Twelve Important Issues" above. Ultimately, the limited funds available for restoration will be much more effectively spent if there is a clear understanding of the relative seriousness of the diverse problems facing the estuarine and riverine ecosystems and of the ability to solve those problems. Where the research can be linked to pilot or large-scale restoration projects, the benefits will be multiplied (Strategic Plan 1999).

VISION

The vision for the Bay-Delta aquatic foodweb is to restore primary and secondary production to levels comparable to those during the 1960s and early 1970s. Restoring the Bay-Delta foodweb would require enhancing productivity and reducing loss of productivity as a result of water exports from the system, and in seeking to reduce or eliminate the adverse effects of introduced aquatic species.

Although zooplankton abundance has declined in Suisun Bay, herbivore productivity (i.e., productivity of Potamocorbula) in Suisun Bay is still very high. Thus, in Suisun Bay, energy from primary production flows mainly to the benthos instead of to zooplankton in the water column. The vision is also in evaluate means by which to restore primary and secondary production and increasing zooplankton biomass.

There are several means to enhance Bay-Delta productivity. One way to maintain or increase productivity is to reduce the loss of nutrients, plants, and animal plankton to water diversions. Additional improvements can be gained by increasing shallow-water habitat and tidal wetlands in the Bay and Delta, which would result in more plant production. Increasing the acreage of floodplain lakes, sloughs, and other backwaters in the Sacramento and San Joaquin Rivers will further increase organic matter inputs to the Delta. Reducing the amount of toxic substances entering the system will reduce loss of primary and secondary production. Other means of increasing productivity of the aquatic foodweb include opening leveed lands to tidal or seasonal floodflows; increasing the array of sloughs in the Delta; protecting and restoring shallows, shoals, and channel islands in the Delta; and providing for a more natural floodplain and meander belt along the rivers.

Restoring tidal action to leveed lands in San Pablo Bay, Suisun Marsh, and the Delta enhances productivity by allowing Bay-Delta waters to capture their plant production. The Yolo and Sutter bypasses offer potential opportunities to produce more permanent slough, riparian, and wetland habitats in the Sacramento River floodplain. Setback levees or improved riparian and shallow-water habitat along leveed reaches of the rivers and Delta offer additional opportunities to increase productivity of the Bay and Delta. These actions will promote aquatic and riparian plant production, which should improve the plant material base of the foodweb. With greater plant material available, the productivity of consumers like zooplankton will be greater, which in turn will increase the productivity of many important fish and wildlife species in the Bay-Delta.

There are several ways to ensure that increased plant material transported to or produced in the Delta is transported to Suisun Bay. Changes in the timing and magnitude of flows through the Delta and exports from south Delta pumping plants may increase transport of organic materials to the Bay from the Delta. Spring flow pulses in drier years from the rivers will enhance productivity in the rivers, Bay, and Delta and ensure that a greater amount of this productivity is transported through the Delta to the Bay. More of the organic material transported to or produced within the Delta would be retained in the Delta or transported to the Bay if the south Delta export pumps were relocated to the northern Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore the productivity of the Bay-Delta foodweb would involve the cooperation and support from established programs underway to restore habitat and fish populations in the Bay-Delta including the following:

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes calls for improving flows, reducing diversions, and increasing habitat.

- The Salt Marsh Ecosystem Recovery Plan calls for improving a wetland habitat in the Bay.

- The Recovery Plan for Winter Run Chinook Salmon (NMFS) includes recommendations for habitat and foodweb restoration in the Bay-Delta and Sacramento River.

- The Recovery Plan for the Salt Marsh Harvest Mouse and California Clapper Rail includes provisions for protection and restoration of wetland habitats in the Bay.

- The Central Valley Project Improvement Act (PL 102-575) and its associated Anadromous Fish Restoration Plan includes provisions to reduce losses of organisms into water diversions, to restore aquatic habitat, to improve water quality, to improve freshwater flows, and to restore wetland and riparian habitats in the rivers and Bay-Delta.

- The Steelhead Trout, and Anadromous Fisheries Program Act of 1988 includes elements to improve freshwater flows and riparian habitats in the Sacramento and San Joaquin Rivers and their tributaries.

- The Delta Wildlife Habitat Protection and Restoration Plan include protection and improvements to riparian and wetland habitats of the Bay-Delta.

- Central Valley Habitat Joint Venture includes restoration of riparian and wetlands of the rivers, Delta, and Suisun Marsh.

- US Army Corps of Engineers Yolo Basin Wetlands Creation and Restoration Project will increase wetland acreage in the Yolo Bypass.

- California Senate Concurrent Resolution 28 has set a goal of doubling wetland acreage by the year 2000.

- San Francisco Estuary Project planning for wetland protection and restoration, and water quality protection and improvement.

- San Joaquin River Management Plan is a plan to restore riparian and wetland habitats and improve water quality in the San Joaquin River and its tributaries.

- SWRCB and RWQCB efforts to restore wetlands and improve water quality of the rivers and Bay-Delta.

- Suisun Resource Conservation District is developing wetlands restoration and management plans.

- The San Francisco Bay Joint Venture is a public/private partnership working to protect, restore, enhance and increase wetlands of all types throughout the San Francisco Bay region to benefit fish and wildlife using a non-regulatory approach.

- Riparian Habitat Joint Venture will restore riparian habitats.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Improvement of the aquatic foodweb of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, water quality (contaminants) improvement, and Central Valley streamflow improvements.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for the Bay-Delta aquatic foodweb is to increase estuarine productivity.

LONG-TERM OBJECTIVE: Using knowledge gained in the shorter term, raise the level of ecosystem productivity to lift limits on production of desirable species of fish and invertebrates.

SHORT-TERM OBJECTIVES: Determine the limits on productivity and the major sources of organic carbon contributing to the estuarine ecosystem. Evaluate large-scale restoration projects associated with the restoration of tidal emergent, seasonal, and nontidal perennial wetlands, generate hypotheses as to the actions that might be effective at increasing productivity, and conduct pilot studies based on those findings.

RATIONALE: The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding, so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

STAGE 1 EXPECTATIONS: Studies of large-scale restoration projects associated with the restoration of tidal emergent, seasonal, and nontidal perennial wetlands will have been undertaken to assess organic carbon sources and cycling to generate and test hypotheses as to factors limiting their availability. These hypotheses (and findings generated from testing them) will be considered in setting priorities for restoration actions taken in future stages.

The general targets for a healthy Bay-Delta aquatic foodweb include:

- Restore chlorophyll "a" abundance in San Pablo and Suisun Bays, and in the Delta to levels that occurred in the 1960's and early 1970's.

- Restore abundance of important zooplankton species in San Pablo and Suisun bays, and in the Delta to levels that occurred in the 1960's and early 1970's.

General programmatic actions to contribute to attaining targets include:

- Increase the residence time of water in the Delta.

- Restore tidal action to diked wetlands.

- Reduce concentrations and loadings of trace metals, herbicides, and other toxic substances in sediments and waters of the Central Valley.

- Reduce losses to diversions by modifying the structure and operation of Delta conveyance and pumping facilities.

- Increasing the amount and diversity of organic matter input from the Bay-Delta watershed by restoring aquatic, riparian, and wetland habitats.

REFERENCES

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

INTRODUCTION

This section presents visions for habitat ecosystem elements. Habitats are areas occupied by plants, fish, and wildlife that provide specific conditions essential to the needs of plant and animal communities. There are no fixed boundaries for habitats, just as there are no fixed boundaries for environments, communities, or ecosystems (Goals Project 1999). Habitats will benefit markedly from restoration activities related to ecological processes and stressors. In some cases, direct action may be necessary to restore important habitats. Habitat types that are included are those that have a strong effect on an ecological process or a species that is dependent on the Bay-Delta and can be restored and managed to improve the health of the Bay-Delta ecosystem and its resources.

Many habitat classification systems have been developed to allow researchers to inventory and report abundance, distribution, and other related data for scientific, educational, or administrative purposes. For example, the classification system developed by Cowardin (1979) was designed by wetland ecologists to allow researchers to develop standard information which could be compared over large areas of the United States.

The Delta Wildlife Habitat Protection and Restoration Plan (Madrone Associates 1980) modified the habitat classifications of Cowardin (1979) to provide descriptions of habitat in the Sacramento-San Joaquin Delta. The Goals Project (1999) developed a habitat typology (hierarchical classification) in which habitat components of one level are nested within the next higher level. The Bay Institute (1998) broadly described historic habitat and changes in its ecological history of the San Francisco Bay-Delta watershed using a classification system similar to Cowardin (1979). Moyle and Ellison (1991) contributed by developing a hierarchical classification system for the inland waters of California. This system is based largely on fish distribution and endemism.

Table 9 identifies important habitat ecosystem elements and the related ERPP Strategic Objective. Strategic objectives are fixed and will not change through time. Table 10 presents the basis for their consideration.

Visions describe the role and importance of each habitat type to dependent plants, fish, wildlife, and other organisms, a description of the current condition of habitats, stressors and changes to ecological processes that have altered habitat condition, and approaches for restoring habitats and their functions to improve the health of the Bay-Delta and its biological resources. The Ecosystem Restoration Program Plan (ERPP) implementation objectives, targets, and actions for each habitat type are described in Volume II: Ecological Management Zone Visions. Table 11 presents the ecological management zone in which targets, and programmatic actions have been proposed to accomplish each habitat vision.

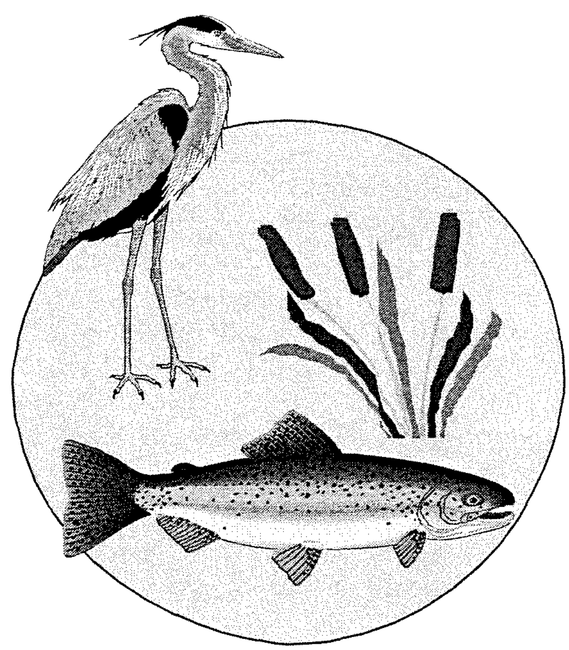


Table 9. Habitat Ecosystem Elements and Strategic Goal, Objectives, and Subobjectives.

Goal 4: Protect or restore functional habitat types throughout the watershed for public values, such as recreation, scientific research, and aesthetics.

Note: There are five Strategic Objectives for habitat:

Objective 1: Restore large expanses of all major habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

Objective 2: Restore large expanses of all aquatic, wetland, and riparian habitats in the Central Valley and its rivers.

Objective 3: Increase the area of tidal marsh (freshwater, brackish, salt) by removing or breaching levees (opening them to tidal action) and by increasing the elevation of subsided, leveed former marshes.

Objective 4: Halt as much as is possible the conversion of agricultural land to urban and suburban uses in areas adjacent to restored aquatic, riparian, and wetland habitats and manage these lands in ways that are favorable to birds and other wildlife.

Objective 5: Manage the Yolo and Sutter bypasses as major areas of seasonal shallow water habitat.

Because there is a need for more specificity in setting objectives for habitats, subobjectives for individual types of habitats have been developed. These subobjectives are subordinate to the five Strategic Objectives.

Ecosystem Habitat Element	Strategic Subobjective
Tidal Perennial Aquatic Habitat	Increase the area of tidal perennial aquatic habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.
Nontidal Perennial Aquatic Habitat	Increase the area of nontidal perennial aquatic habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.
Delta Sloughs	Increase the area and linear extent of Delta sloughs as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.
Midchannel Islands and Shoals	Increase the area of midchannel island and shoal habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.
Saline Emergent Wetland	Increase the area of saline emergent wetland habitat (both brackish and salt) as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

Ecosystem Habitat Element	Strategic Subobjective
Fresh Emergent Wetland	Increase the area of fresh emergent wetlands as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.
Seasonal Wetlands	Protect existing and restore and increase the area of seasonal wetland habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley and its rivers.
Riparian and Riverine Aquatic Habitats	Increase the area of riparian and riverine aquatic habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley and its rivers.
Freshwater Fish Habitats	Protect existing and restore and increase the quality of freshwater fish habitat as an integral component of restoring large expanses of all major historical habitat types in the Central Valley and its rivers.
Essential Fish Habitat	Protect existing and restore and increase the quality of essential fish habitat as an integral component of restoring large expanses of all major historical habitat types in the Central Valley and its rivers.
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 enhanced wildlife forage and resting area habitat for wintering and migrating waterfowl, shorebirds, and other associated wildlife in the Delta.

Table 10. Basis for Selection of Habitat Ecosystem Elements.

Ecosystem Habitat Element	Basis for Selection as an Ecosystem Element
Tidal Perennial Aquatic Habitat	Tidal perennial aquatic habitats, particularly areas less than 9 feet deep at mean high tide, are important habitat use areas for many species of fish and wildlife in the Delta. The substantial loss of historic shallow-water areas, primarily as a result of reclamation of tidally influenced habitat and channel dredging, has reduced the available habitat area for associated fish and wildlife. Loss of shallow-water areas has also caused a reduction in primary and secondary productivity which contributed to changing the historic foodweb of the Delta.
Nontidal Perennial Aquatic Habitat	Nontidal perennial aquatic habitats, particularly areas less than 6 feet deep, are important habitat-use areas for many species of fish and wildlife in the ERPP focus area. The substantial loss or degradation of nontidal perennial aquatic habitats, primarily as a result of reclamation of wetlands and alteration of streamflows, has reduced the available habitat area for associated fish and wildlife.
Delta Sloughs (Dead-end)	Dead-end sloughs provide warmer, highly productive habitat for seasonal spawning, rearing, and foraging of important aquatic organisms, as well as important carbon production for other Bay-Delta habitats. Several smaller branches of tidal slough networks have been severed from the main slough channel by levees. For waterfowl and wildlife, dead-end sloughs have associated marsh and riparian corridors important for breeding, feeding, resting, and roosting.
Delta Sloughs (Open-ended)	Open-ended sloughs provide unique, generally low-velocity habitats and important migratory pathways for many species and important habitat for wildlife and waterfowl along the riparian corridors of the sloughs. Levee construction and channel dredging over many years has converted the gradual sideslopes supporting marsh and tideflat habitat along sloughs to steep-sided, high-velocity channels with narrow or nonexistent shoreline habitat.
Midchannel Islands and Shoals	Midchannel islands and shoals provide unique remnant shallow-water edge habitat in many Delta channels. They typically support willow scrub, tule marsh, and tidal mudflat habitats and associated wildlife and fish. Midchannel islands and shoals have been shrinking or disappearing as a result of progressive erosion. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area.

Table 10. Continued

Ecosystem Habitat Element	Basis for Selection as an Ecosystem Element
Saline Emergent Wetland	Saline emergent wetland habitats, including brackish and saline wetlands, are important habitat-use areas for fish and wildlife dependent on marshes and tidal shallows in the Bay-Delta and support several special-status plant species. The loss or degradation of historic saline emergent wetlands, primarily as a result of reclamation of tidally influenced wetlands for agriculture, has substantially reduced the habitat area available for associated fish and wildlife species. Several plant and animal species closely associated with tidal saline emergent wetlands have been listed as endangered under the State and federal Endangered Species Acts, primarily as a result of the extensive loss of this habitat type. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area.
Fresh Emergent Wetland	Tidal and nontidal fresh emergent wetland habitats are important habitat-use areas for fish and wildlife dependent on marshes and tidal shallows in the ERPP focus area and support several special-status plant species. The loss or degradation of historic fresh emergent wetlands has substantially reduced the habitat area available for associated fish and wildlife species.
Seasonal Wetlands	Seasonal wetland and aquatic habitats are important habitat-use areas for many species of fish and wildlife in the ERPP focus area. Loss or degradation of historic seasonal wetlands, primarily as a result of urban development and reclamation of wetlands for agriculture, has substantially reduced the habitat area available for waterfowl, shorebirds, and other water birds. Loss of vernal pool habitat, in particular, has directly resulted in the listing of several vernal pool-dependent species as threatened or endangered under the federal Endangered Species Act. The loss of seasonal aquatic floodplain habitat, primarily as a result of levee construction and alteration of riverflows, has substantially reduced floodplain refuge habitat for fish and spawning habitat for the Sacramento splittail. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions in the ERPP focus area.
Riparian and Riverine Aquatic Habitats (Shaded riverine aquatic)	Shaded riverine aquatic habitat (SRA) is a major component of the ERPP riparian and riverine aquatic habitat ecosystem element. SRA habitats are important habitat areas for one or more life stages of most fishes that inhabit the ERPP focus area. The loss or degradation of historic riparian vegetation from river and stream channelbanks and alteration of nearshore aquatic habitat have primarily been caused by channelization, stabilization of channelbanks with riprap, and construction of levees. Control of flows and diversion of water have altered the hydrologic conditions that historically supported riparian vegetation. The loss of SRA has directly contributed to declines in populations of associated native fishes and reduced an important source of nutrients and allochthonous material in streams and Delta sloughs.

Table 10. Continued

Ecosystem Habitat Element	Basis for Selection as an Ecosystem Element
Riparian and Riverine Aquatic Habitats (Riparian scrub, woodland, and forest habitat)	Riparian scrub, woodland, and forest habitat is the other major component of the riparian and riverine aquatic habitat ecosystem element. Many species of wildlife, including several species listed as threatened or endangered under the State and federal Endangered Species Acts and several special-status plant species in the ERPP focus area are dependent on or closely associated with riparian habitats. Compared with all other habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced nutrient cycling, and foodweb support functions in the ERPP focus area. Valley oak woodland habitats are important habitat-use areas for many species of wildlife in the ERPP focus area. The loss or degradation of historic stands of valley oak woodland has substantially reduced the valley oak woodland habitat area available for associated wildlife.
Freshwater Fish Habitats	Freshwater fish habitats and native fishes are closely linked in the Central Valley as the health of the native fish populations is largely dependent on the health of their habitats. Generally the fish habitats include standing waters, flowing waters and artificial waters. These habitats have additional utility as this classification scheme assumes that use by fishes also is representative of use by less we-known aquatic organisms such as insects and amphibians.
Essential Fish Habitat	The designation of Essential Fish Habitat is important to allow the systematic protection of chinook salmon habitat and other related elements of biological diversity within distinct regions of the Central Valley.
Inland Dune Scrub Habitat	Coastal scrub is associated with inland sand dunes and is limited in the ERPP focus area to the vicinity of the Antioch Dunes National Wildlife Refuge. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act.
Perennial Grassland	Grasslands are important breeding and foraging habitat areas for many species of wildlife and support several special-status plant species. Historically common throughout most of the Central Valley, most perennial grassland in the ERPP focus area has been lost or has been converted to annual grassland.

Table 10. Continued

Ecosystem Habitat Element	Basis for Selection as an Ecosystem Element
Agricultural Lands (Agricultural wetlands)	Following extensive loss of native wetland habitats in the ERPP focus area, some wetland-associated wildlife species have adapted to the artificial wetland environment created by some agricultural practices and have become dependent on agricultural wetland areas to sustain their populations at current levels. Agricultural wetlands include rice lands; fields flooded for weed, salinity, and pest control; stubble management; and tailwater circulation ponds.
Agricultural Lands (Agricultural uplands)	Following extensive loss of some native upland habitats, upland-associated wildlife species have adapted to the artificial upland environment created by some agricultural land uses and have become dependent on agricultural upland areas and fence line vegetation to sustain their populations at current levels.

Table 11. Ecological Management Zones in Which Habitat Targets, and Programmatic Actions Are Proposed. *[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding specific targets and actions.]*

Habitat Vision	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tidal Perennial Aquatic Habitat	●	●												
Nontidal Perennial Aquatic Habitat	●	●												
Delta Sloughs	●	●												
Midchannel Islands and Shoals	●													
Saline Emergent Wetland		●												
Fresh Emergent Wetland	●													
Seasonal Wetlands	●	●	●	●		●	●	●	●		●	●		●
Riparian and Riverine Aquatic Habitats	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Freshwater Fish Habitats	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Essential Fish Habitat	●	●	●	●	●	●	●	●	●	●	●	●	●	
Inland Dune Scrub Habitat	●													
Perennial Grassland	●	●							●					
Agricultural Lands	●					●	●	●	●	●		●		●

Ecological Management Zones

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

REFERENCES

The Bay Institute. 1998. From the Sierra to the Sea: the ecological history of the San Francisco Delta-Bay watershed.

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Moyle, P.B. and J.P. Ellison. 1991. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77(4):161-180.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Tidal Perennial Aquatic Habitat

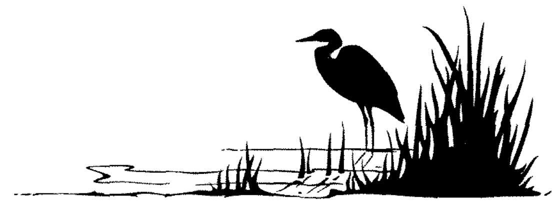
Introduction

Tidal perennial aquatic habitat consists of the estuary's edge waters, mudflats and other transitional areas between open-water habitats and wetlands. Similar habitats are defined by the Goals Project (1999) as elements of tidal baylands which include mudflats, sandflats, and shellflats. These shallow waters are associated with natural wetland and riparian habitats that are important to fish and wildlife of the Bay-Delta. The substantial loss of historic shallow tidal waters, primarily as a result of reclamation and channel dredging and scouring, has led to the decline of many native fish, wildlife, and plant species in the Bay-Delta. Loss of such habitat has also reduced primary (plant) and secondary (invertebrate) productivity in the Bay-Delta estuary, and has changed important characteristics of the natural foodweb of the system.

Resource Description

Tidal perennial aquatic habitat is important for many fish, wildlife, and plants. It also supports many biological functions important to the Bay-Delta system. Many animal and plant species, identified as threatened or endangered under the California and federal Endangered Species Acts (ESAs), rely on tidal perennial aquatic habitat during some portion of their life cycle.

Bay-Delta estuary tidal wetlands and associated perennial aquatic habitat are among the most valuable natural resources in the United States. Restoring tidal perennial aquatic habitats is an important ingredient for successfully restoring the Bay-Delta. Tidal aquatic habitats link wetlands with open-water habitats. Such habitat is used as foraging and resting habitat and escape cover for shorebirds, wading birds, and waterfowl. Resident and migratory fish use tidal perennial aquatic habitats for spawning, rearing, foraging,



and escape cover. Young salmon forage in these productive waters and put on critical weight before entering the ocean. Striped bass, delta smelt, splittail, and many native resident Bay-Delta fish use this habitat, especially as rearing areas.

Tidal perennial aquatic habitat plays a primary role in the formation and maintenance of tidal wetlands. As tidal aquatic habitats accumulate sediment vegetation can increase. Over time this vegetation will become wetland and riparian habitat. As these tidal aquatic habitats accumulate sediment and vegetation, they maintain their structure and function, even with gradual rises in sea level.

Stressors that adversely affect the health of tidal perennial aquatic habitats include urban and industrial development, dredging, levees and associated land conversion, wastewater discharges, and land, urban and agricultural runoff.

Vision

The vision for tidal perennial aquatic habitat is to increase the area and improve the quality of connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes. Achieving this vision will assist in the recovery of special-status fish and plant populations and provide high-quality aquatic habitat for other fish, wildlife, and plant communities dependent on the Bay-Delta. Restoring tidal perennial aquatic habitat would also result in higher water quality and increase the amount of shallow-water and mudflat habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish.

Reducing fragmentation of existing tidal perennial aquatic habitat should be a focus of restoration efforts. Many areas of open water in the Bay-Delta are isolated by levees or deeper open-water habitat. Many open-water areas have been converted to managed marshes, saltponds, or agricultural use. Restoring historic habitats would involve reclaiming former tidal habitat by levee removal.

Initial efforts should focus on protecting existing tidal perennial aquatic habitats. These existing habitats offer functions and values that may not be possible to recreate. Former habitats should be linked with existing healthy habitats to enhance natural habitat restoration. Restored habitats should have natural gradients of open water, shallow water, wetland, riparian, and upland habitats to increase the habitat value for a greater diversity of species.

Many leveed lands in the Bay and Delta have subsided and are too low to support shallow tidal perennial aquatic habitat, and thus cannot be readily restored. The greatest subsidence has occurred in the Central and West Delta Ecological Management Unit. A comprehensive long-term program is needed to reverse subsidence. Changes in land use management, and use of suitable dredged materials or other "natural materials" should be implemented to restore land elevations to suitable ranges.

Restoration efforts should focus on those leveed lands that have not yet been subjected to severe subsidence. Prime candidates are existing managed marshes and salt ponds adjacent to San Pablo and Suisun Bays. Leveed agricultural lands and some industrial lands adjacent to Suisun Bay can be readily restored to tidal aquatic habitat. Some of the habitat would be mudflats, while deeper waters would be shallow productive bays not unlike the very productive Honker and Grizzly Bays of Suisun Bay, and much of northern San Pablo Bay.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Tidal perennial aquatic habitat used here is similar to the Goals Project (1999) descriptions of shallow bay and channel habitat, and tidal flat habitat. It also includes marine and estuarine subtidal areas that are less than 2 m deep at low water and shallow tidally influenced riverine areas (Cowardin 1979).

Many programs and projects aim to protect, restore, and enhance habitats within the San Francisco-San Joaquin Bay-Delta estuary. These include:

- Bay Area Aquatic Habitats Planning Group;
- Cache Creek Corridor Restoration Plan;
- California Wetland Riparian Geographic Information System Project;
- Central Valley Habitat Joint Venture;
- Governor's California Wetland Conservation Policy;
- Inland Wetlands Conservation Program;
- Montezuma Wetlands Project;
- National Estuarine Reserve Research System;
- North American Waterfowl Management Plan;
- North Bay Initiative;
- North Bay Wetlands Protection Program,

- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan;
- San Francisco Estuary Project;
- Suisun Ecological Workgroup of the Interagency Ecological Program;
- Tidal Wetlands Species Recovery Plan;
- Wetlands Reserve Program;
- and Yolo Basin Wetlands Project.

The Ecosystem Restoration Program Plan restoration targets and objectives reflect the goals of many of these programs. For example, the Goals Project (1999) has completed a comprehensive science-based approach to determining where, how much, and what kinds of wetlands should be restored in the Suisun Bay and San Francisco Bay areas. Contributing to each of these program would help to restore critical ecological processes, functions, and habitats and reduce or eliminate stressors.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Tidal perennial aquatic habitat is linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4) stressors.

Related ecological processes include Delta inflow (Central Valley streamflows) which influences the location of X2; natural sediment supply which influences the maintenance of mudflats, shallow shoals, bottom composition throughout the Delta and Bay; Bay-Delta hydraulic patterns which influence flow patterns in channels and sloughs; and Bay-Delta aquatic foodweb which depends on nutrient input, shallow water interactions, and access to tidal perennial habitat.

Habitats which are closely linked to tidal perennial aquatic habitat include tidal sloughs and channels, saline emergent wetlands, midchannel islands and shoals, and perennial grasslands. Tidal perennial aquatic habitat also provide an important ecological connection between open-water areas and shallow-water, emergent wetlands, and riparian habitats.

Species which depend on tidal perennial aquatic habitat include a large assemblage of marine, estuarine, anadromous, and resident fish, wildlife, and plant species and communities.

Stressors which adversely effect tidal perennial aquatic habitat include levee construction, contaminants, and dredging and sediment disposal.

STRATEGIC OBJECTIVE, TARGETS AND PROGRAMMATIC ACTIONS

The Strategic Subobjective to increase the area of tidal perennial aquatic habitat as an integral component of restoring large expanses of all major habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

LONG-TERM OBJECTIVE: Restore tidal perennial aquatic habitats in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of tidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

The general target for restoration of tidal perennial aquatic habitat is to restore 7,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions will help achieve this vision:

- restoring land elevations will allow more leveed lands to be returned to tidal shallow water habitat,
- setting backs levees would add aquatic habitat along potential margins of the Bay and Delta, and
- opening or breaching levees would also open unnaturally isolated lands to tidal flows.

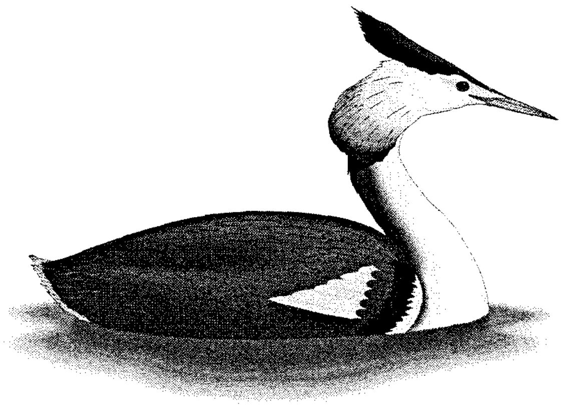
REFERENCES

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ NONTIDAL PERENNIAL AQUATIC HABITAT



INTRODUCTION

Nontidal perennial aquatic habitat in the Bay-Delta estuary is present in certain low-elevation areas. Such areas have permanent open water which is no longer subject to tidal influence. The size, quantity, and quality of existing nontidal perennial habitat do not equal the wildlife habitat values of sloughs and backwaters in the estuary before reclamation.

Nontidal perennial aquatic habitats are important for many species of wildlife in the Delta. In many places within the Delta, nontidal aquatic habitat has replaced the native tidal aquatic habitats. Outside the Delta, the substantial loss or degradation of nontidal aquatic habitats associated with Central Valley wetlands has reduced the available habitat area for many native fish and wildlife species. Land reclamation is the major factor that limits the contribution of nontidal perennial aquatic habitats to the health of the Delta.

RESOURCE DESCRIPTION

Historically, most wetlands in the Bay-Delta estuary were tidal. Nontidal perennial aquatic habitats were largely nonexistent. Some historical nontidal perennial habitat was created naturally. Shifts in river alignments occasionally isolated oxbow lakes, and drainage divide ponds in Bay area tidal wetlands were subjected to limited tidal action. Most of the remaining nontidal perennial aquatic habitat areas were established by constructing dikes and levees.

Isolating these areas allowed their conversion for other uses, primarily agricultural. Perennial aquatic habitats on converted lands are primarily located in large agricultural drains, small farm ponds, industrial ponds, ponds managed for waterfowl and other wildlife, and Delta island blowout ponds (created by levee failures that scour island interiors deeply enough to maintain permanent water through seepage).

Existing nontidal open-water areas generally have poor wildlife value. Nontidal perennial aquatic habitats have insufficient shoreline cover for nesting and protection from predators. Adjacent lands are relatively barren (e.g., farmed fields and land next to industrial ponds) and lack cover needed by nesting waterfowl and other species that require adjacent open-water and upland habitats. A notable exception is the unreclaimed blowout ponds around which native vegetation has been allowed to establish (e.g., ponds on Webb Tract).

The loss of permanent open water within historic tidal wetlands substantially reduced habitat for waterfowl, shorebirds, and other wetland wildlife species in the Bay-Delta system. Important ecosystem processes needed to restore and sustain nontidal perennial aquatic habitat include:

- the geologic and hydrologic condition, stream meander, and tidal function necessary to maintain permanent surface water;
- a range of elevations sufficient to support deep-water (greater than 3 feet in depth) and shallow-water areas; and

- adjacent wetland and riparian (streambank) vegetation.

Land use and human disturbance are stressors on nontidal perennial aquatic habitat. Insufficient buffer areas around open water reduce habitat value for wildlife species. These species require quality upland habitats connected to the aquatic habitat and increasing levels of human disturbance that adversely affects wildlife using open-water areas.

The value of open-water habitat to wildlife greatly increases if emergent vegetation is present along shorelines and in shallow-water areas. Adjacent dense upland herbaceous vegetation and riparian woodland further increase the value to wildlife.

VISION

The vision for nontidal perennial aquatic habitat is to increase the area and improve the quality of existing open-water areas to provide high-quality habitat for waterfowl and other water birds. This vision can be achieved as a component of saline and freshwater emergent wetland restorations.

Permanent open-water areas could be restored as a component of nontidal saltwater, and fresh emergent wetland habitat areas. The bottom slope ranges of restored wetland areas will provide the water flow patterns necessary to create a wide variety of permanent open-water areas. Waterfowl brood ponds can be constructed on agricultural lands next to suitable waterfowl nesting habitats.

Restoring nontidal perennial aquatic habitat would improve ecological process and functions of other habitats and wildlife. Adjacent wetland and upland habitats would then have increased ecological value. The open shallow water would provide resting and foraging habitat for waterfowl and other water birds. Wading and shore birds would feed in the open shallow water habitat. These restored habitats may improve the quantity and quality of nesting habitat. Increased nesting habitat would increase the production of waterfowl and other water birds in the estuary.

Restoring nontidal perennial aquatic habitat in sufficient quantity and quality will require reestablishing associated ecosystem processes. Restoring these processes will establish and maintain habitat, reduce or remove stressors, and help restore adjacent habitats.

Restoration efforts should be accomplished through landowners, conservation groups, and land management agencies. The focus of these efforts should be to restore open-water habitats on Delta islands and other former tidelands of the Bay-Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Nontidal perennial aquatic habitat used here is similar to the Goals Project (1999) description of diked marsh, salt pond, and storage/treatment pond.

Efforts to restore nontidal perennial aquatic habitat would involve cooperation with other wetland restoration and management programs. These include:

- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- Natural Resources Conservation Service's Wetland Reserve Program,
- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,

- Central Valley Habitat Joint Venture and North American Waterfowl Management Plan,

- the Suisun Marsh Protection Plan,

- and ongoing management of State and federal wildlife refuges and private duck clubs.

Cooperation will also be sought from agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including California Department of Fish and Game, California Department of Water Resources, U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Nontidal perennial aquatic habitat is linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4)stressors.

Related ecological processes include:

- natural geologic and hydrologic conditions,

- stream meander corridor,

- and tidal actions that maintain permanent water.

Other areas which are closely linked to nontidal perennial aquatic habitat include:

- adjacent wetlands and upland habitats,

- and riparian and riverine aquatic habitat.

Species which depend on nontidal perennial aquatic habitat include:

- resident fish and wildlife,

- migratory birds,

- and plant species and communities.

Stressors which adversely effect nontidal perennial aquatic habitat and wildlife use include:

- levee construction,

- land use,

- loss of edge vegetation,

- and human disturbance.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to increase the area of nontidal perennial aquatic habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

LONG-TERM OBJECTIVE: Restore nontidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their presettlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of nontidal perennial aquatic habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San

Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Pablo Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

The general target for restoring nontidal perennial aquatic habitat is to provide 2,600 acres in the Sacramento-San Joaquin Delta Ecological Management Zone, 1,600 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone, and 1,000 acres in the West San Joaquin Ecological Management Zone.

The following actions would help to achieve targets for nontidal perennial aquatic habitat restoration:

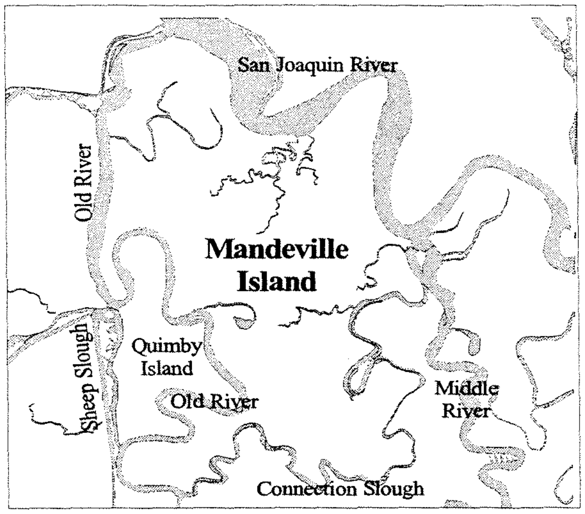
- Restore nontidal perennial aquatic habitat in concert with restoration of fresh emergent wetland habitats.

- Restore permanent open-water areas by establishing elevation gradients sufficient to maintain surface water through natural groundwater or surface-water recharge, or by pumping water into lowland areas.

REFERENCE

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, California and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Sloughs are a small remaining part of natural Delta habitats. Sloughs are tidal channels of the Delta that once connected rivers to the Bay through Delta marshes. These low-velocity, natural tributaries of Delta rivers vary in depth and width, have gently sloped, vegetated sides, and are connected to the Delta.

Most of the Delta sloughs were lost when the islands were reclaimed by construction of the levees. Many smaller Delta sloughs were lost in the past several decades when levees severed them from main channels. Levee construction and maintenance along sloughs has reduced the habitat value of many natural sloughs in the Delta. Boat traffic has also lead to shoreline erosion and loss of shallow water, marsh, and riparian habitat along many sloughs.

Sloughs provide warmer, highly productive habitat for seasonal spawning, rearing, and foraging for many aquatic organisms, as well as important organic carbon productivity for all habitats of the Bay-Delta. Sloughs provide shallow, low-velocity refuge habitat for many native fishes. Slough habitat also includes associated marsh and riparian corridors that are important for breeding, feeding, resting, and roosting waterfowl. Several resident species of Delta fish live in sloughs, and splittail and delta smelt may use them for spawning. Unlike leveed river channels, sloughs have marsh and riparian fringes with shallow water and natural shaded riverine aquatic habitat.

RESOURCE DESCRIPTION

Delta sloughs provide various beneficial habitats. They offer protection to plants, fish, and wildlife from wind and high-velocity flows. Delta sloughs support floating aquatic plant communities, which are otherwise found only in small, sheltered pockets along open channels. The seasonal succession of native floating plants in sloughs is a valuable link in the estuary's food chain. First to appear is duckweed, which provides primary food production for insect larvae, crustaceans, and waterfowl and other birds. The duckweed community creates conditions favorable to water fern establishment. The water fern's pores contain a bacterium that photosynthesizes and "fixes" (stores) nitrogen, which allows the water ferns to establish in nitrogen-deficient waters. Aquatic plants in sloughs provide protective cover for fish; habitat for insects, fish, and birds; and an abundance of food organisms. Wildlife use varies with the amount of open water and marsh, the extent and type of vegetation present, and surrounding land uses.

Delta sloughs provide habitat for biological functions necessary for the survival of resident and migratory fish species. These species need Delta slough's warm, highly productive habitat for seasonal spawning, rearing, and foraging. Organic carbon created by the sloughs helps other Bay-Delta habitats.

Adjacent marsh and riparian corridors provide breeding, feeding, resting, and roosting habitat for waterfowl and wildlife. Delta sloughs and their riparian scrub, riparian forest, and open-water habitats provide the complex habitat needed by some State- and federally listed species such as the giant garter snake, splittail, and delta smelt.

Dead-end sloughs include Beaver, Hog, and Sycamore sloughs. These quiet backwaters provide essential habitat for native resident fish. Open-ended sloughs provide unique, generally low-velocity habitats and migratory pathways for many species. In addition, the adjacent riparian corridors provide habitat for wildlife and waterfowl.

Sloughs provide valuable transitional zones that link upland terrestrial habitats with open-water habitats. Historically, these transitional areas provided foraging, resting, and escape cover for shore and wading birds and other waterfowl. Resident and migratory fish use sloughs for rearing, foraging, and escape cover.

The ability of most sloughs to provide these functions has been severely degraded. Urban and industrial development has moved into areas adjacent to sloughs, destroying historic riparian habitat. Other factors that have contributed to degradation of habitat values include invasion and spread of non-native aquatic plants, such as water hyacinth, reduced water quality, and reduced freshwater outflows. In addition, levee construction and channel dredging have converted gradual sideslopes that once supported marsh and tidal flat habitat into steep-sided, high-velocity channels with narrow strips of emergent shoreline habitat.

VISION

The vision for Delta sloughs is to increase the area and improve the quality of interconnected dead-end and open-ended Delta sloughs. Achieving this vision will assist in the recovery of special-status fish and wildlife populations, provide shallow-water habitats for fish spawning and rearing, and provide aquatic, wetland, and riparian habitat for wildlife. Existing sloughs would be protected and enhanced and the area of tidal slough habitat would be increased.

Existing natural sloughs require protection and habitat improvement. Additional restoration efforts would be identified by developing a thorough understanding of site-specific sediment transport, tides, hydrogeomorphology (landscape forms created by moving water), and Delta channel hydraulics (water flow patterns). Restoration of a variety of slough and adjacent terrestrial and aquatic areas would provide a wide range of complex habitats that would benefit many aquatic and terrestrial species.

Changes in tidal flows through sloughs and decreased human disturbance (e.g., reduced wake erosion) could improve slough habitat. Removing invasive, non-native aquatic plants would help restore many smaller sloughs to their natural function.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Delta sloughs as described here are related to the tidal riverine classification in Cowardin (1979), the slough and backwater designation in Moyle and Ellison (1991), and the channels and open water habitat and lakes and dead-end channels descriptions in Madrone Associates (1980).

Many projects associated with wetlands would benefit open-ended and dead-end sloughs. Some of these are sponsored by:

- San Francisco Estuary Project, Bay Area Wetlands Planning Group,
- California Wetland Riparian Geographic Information System Project,

- Governor's California Wetland Conservation Policy,

- Canal Ranch Project to develop tidally influenced areas and riparian zones in conjunction with existing agricultural practices,

- Inland Wetlands Conservation Program,

- North Bay Wetlands Protection Program,

- San Francisco Estuary Project,

- and Wetlands Reserve Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Delta sloughs are linked to the following ecosystem elements: (1) ecological processes, (2) habitats, (3) species, and (4) stressors. For example sloughs are an important element in Delta channel hydraulics, provide a range of aquatic habitats from deep water to tidal emergent vegetation, and support riparian vegetation. Many resident fish species, invertebrates, reptiles, and amphibians utilize these habitats, as well as resident and neotropical migratory birds, and waterfowl.

Maintenance and restoration of Delta and other tidal slough are dependent on channel hydraulics, natural sediment supply, sediment transport, erosion, deposition, and tides.

Other habitats that are interconnected to Delta and other tidal sloughs include open water areas, tidal perennial aquatic habitat, mainstem rivers, emergent wetlands, mudflats, seasonal floodplains, and riparian and riverine aquatic habitats.

Stressors to the health and quality of slough habitats include levee and channel island erosion, increased water velocities, and the removal of overhanging vegetation.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to increase the area and linear extent of Delta sloughs as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

LONG-TERM OBJECTIVE: Restore slough habitats in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of slough habitat in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Pablo Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

The general target for restoration of Delta sloughs it to restore 160 miles in the Sacramento-San Joaquin Delta Ecological Management Zone and 30 miles of tidal sloughs in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The restoration of Delta sloughs will, in many instances, be closely linked to the restoration of tidal perennial habitat, and fresh and saline emergent marshes. In developing the approach to habitat restoration, a mosaic of habitats is very desirable, including provisions for increasing the overall linear mileage of Delta sloughs.

Actions that could be taken to improve slough habitat in the Delta include the following:

- Protect existing dead-end and open-ended sloughs from possible future degradation through cooperative agreements with land management agencies or conservation easements or purchase from willing sellers.

- Restore hydrologic conditions necessary for establishing Delta sloughs by constructing setback levees, removing dikes, constricting slough openings, and managing flows through Delta channels.

- Where consistent with flood control objectives, modify vegetation management practices along levees adjacent to sloughs to allow wetland vegetation to reestablish naturally.

- Identify and implement solutions to levee and channel island erosion that do not remove shallow-water habitat, increase water velocities, or remove overhanging vegetation.

- Reduce the adverse effects of boat wakes in sensitive habitat areas by excluding boats from certain areas at certain times and establishing maximum speed limits.

- Restore connectivity between high-quality habitats through cooperative agreements with land management agencies or through conservation easements or purchase from willing sellers.

- Where possible create new slough habitat where tidal saline and freshwater emergent wetlands are created in the Bay and Delta.

REFERENCES

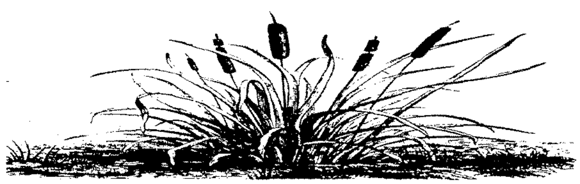
Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Moyle, P.B. and J.P. Ellison. 1991. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77(4):161-180.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ MIDCHANNEL ISLANDS AND SHOALS



INTRODUCTION

Midchannel islands and shoals provide unique remnant shallow-water habitat in many Delta channels. They typically support tule marsh, and to a lesser extent willow scrub, tidal mudflat habitats and associated wildlife and fish. Some midchannel islands have small, remaining riparian woodlands with oaks, cottonwoods, alders, and willows.

Midchannel islands and shoals have been shrinking or disappearing as a result of progressive erosion of the remaining habitat. Loss of islands and shoals affects fish and wildlife habitat, and foodweb productivity. Major factors contributing to the loss of midchannel islands and shoals are gradual erosion from channels conveying water across the Delta to south Delta pumping plants, boat wakes, and dredging within the Delta or on adjacent waters.

RESOURCE DESCRIPTION

Midchannel islands and adjacent shoals provide shallow-water edge, riparian scrub, and emergent marsh habitats in selected Delta channels. The midchannel islands in some Delta locations retain many of these qualities because of their relative isolation. In other channels, high water velocities, heavy use for boating, and associated wave-induced erosion have degraded these islands. Many of the Delta channels and their midchannel islands and shoals are changing rapidly because of increased wakes from boats and changes in water velocities.

Midchannel islands vary in size, shape, and elevation, creating a diversity of habitat types and associated wildlife benefits. Protecting midchannel islands and shoals will help improve the overall quality and diversity of Bay-Delta aquatic habitats. Improving the productivity of the Bay-Delta aquatic habitat foodweb is needed to support the sustainable production and survival of fish.

The Delta formerly supported broad expanses of tule marshes, riparian forests, and shallow-water habitats. Today, most of these habitats have been replaced by intensive agricultural production on levee-bounded islands. Delta islands are separated by steep-banked waterways, which provide few shallow-water areas where natural vegetation can take root. Natural vegetation is generally limited to midchannel islands and a narrow band along levee edges. In many areas, even this remaining band of vegetation has been displaced by bank protection. Cumulative loss of natural vegetation has a detrimental impact on the Delta's fish and wildlife populations.

Midchannel islands and shoals in the Delta are the remnants of naturally occurring islands that existed prior to reclamation or are remnants of natural or old levees. The islands are the surviving examples of an expansive tule marsh with largely shallow and diffuse channels separating the stands. Early efforts to convert the Delta islands into agricultural lands included dredging in the vicinity of these islands for material to form levees. At first, dredging was simple because most of the excavated land was intertidal marsh. While converting the marsh to agriculture lands, naturally meandering channels were straightened, resulting in the creation of tule islands. In other areas, the distance between levees was wide and marsh was left between the levees. The sizes of these remainders varied considerably.

Midchannel islands and their adjacent shoals present a wide array of physiographic types and include a wide variety of habitats. Island habitats range from small tule islands that are essentially freshwater marshlands to large upland sites with riparian woodland, dredge spoils, brushland, ponds, and a variety of marsh types.

An important attribute of these islands is their isolation from mainland activities. Isolation turns these islands into wildlife refuges during spring and summer months when recreational use of the Delta is at its peak.

Midchannel islands and shoals provide valuable riverine-edge and shallow-water habitat within main channels. Actual descriptions of midchannel islands would have to be made on a site-by-site basis, since their physical features depend on parameters such as elevation, size, location, and amount of human disturbance. The island's isolation from human disturbance and the amount of disturbance to the terrestrial-aquatic interface determine the value of midchannel islands to wildlife, especially listed species.

Midchannel islands and shoals are important components of the landscape and contribute to the health of the Bay-Delta. Other important ecological functions influencing Bay-Delta health include natural sediment supply, aquatic habitat, nutrient input, and areas of primary and secondary production. Various life stages and species of fish require a variety of habitats and the ability to move between habitat patches. Habitat variations and access are important for the reproduction and survival of fish in flowing water ecosystems. Shallow water habitat in the Delta is predominantly found along levees, islands, and shoals. The terrestrial-aquatic interface provides habitat diversity, a large supply of organic matter, and shallow habitats with few aquatic predators. Most Delta-spawning fish spawn in shallow water.

Human activities on stream ecosystems are typically concentrated at the terrestrial-aquatic interface. Shallow water land uses decrease the diversity and connectivity of physical habitats. The result of these alterations is a reduction in fish diversity, a shift in fish trophic structure, and an increase in temporal variability of fish abundance in water ecosystems.

The terrestrial-aquatic interface experiences extreme physical-chemical variability when hydraulic conditions fluctuate. Floodflows are confined by levees and bank protection structures. Fluvial energy increases flows that scour and cut into the midchannel islands and shoals.

The main concern regarding midchannel islands is the rate at which they are eroding. Midchannel islands are built up by sediment deposition and reduced by erosion. Reduction of flow or sediments reduces or halts the rate of midchannel island formation. Some waterways within the Delta lack sufficient sediment, while in other areas, erosion exceeds deposition. Lack of sediment supply to the Delta causes midchannel islands and shoals to erode, decreasing both the quality and quantity of island and shoal habitat. Dredging the shoals immediately adjacent to channel islands undermines the structural stability of the islands and subjects them to slumping and increased erosion. Boat wakes and boat-related recreational activities play a large role in the increased rate of erosion.

VISION

The vision for mid-channel islands and shoals is to increase and enhance the area and protect the quality of existing habitat for fish and wildlife dependent on the Bay-Delta.

Restoring midchannel islands is dependent on local hydrologic conditions (e.g., water depth, water velocity, and wave action). Depositing sediment necessary for establishing and maintaining shoals and terrestrial-aquatic interfaces will help rebuild the islands and reduce harmful erosion. Preserving midchannel island isolation will protect the islands and shoals from further damage and allow for natural habitat restoration.

Direct restoration of midchannel islands and shoals will be the primary approach to achieving this vision. The primary method of restoring midchannel islands would be to protect and improve existing channel islands. Restoration should include reconstructing the natural flows and velocities that provided consistent and predictable flows and sediments. Consequently, sediment supply must be restored to that which formed islands, shoals, and habitat for native fish and wildlife.

Reducing erosion rates and offsetting erosion losses would reduce the effects of major stressors on these islands. Reducing boat wakes and excessive channel velocities will allow deposits and wetlands to establish.

Integration with Other Restoration Programs

Midchannel islands as described here is very similar to the channel island designation in Madrone Associates (1980).

The U.S. Army Corps of Engineers and U.S. Fish and Wildlife Service Deep Water Ship Channel Monitoring Program provided information to successfully design and create wetland habitats in the Delta. The project deposited dredged spoils to create new shallow-water, wetland, and upland habitats within two flooded islands in the Sacramento-San Joaquin Delta. The Levee Subvention Program demonstration projects for erosion control and habitat establishment is another related effort.

The San Francisco Estuary Project's Delta In-Channel Island Work Group has reviewed and researched a number of candidate islands for restoration and investigated available biotechnical techniques for erosion control, land restoration, and revegetation. The Group is presently funded to conduct demonstration restoration projects on Little Tinsley and Webb Tract islands.

Linkage with Other Ecosystem Elements

Midchannel islands and shoals are linked to other ecosystem elements including ecological processes, habitat, species, and stressors.

Ecological processes include contribution to the Bay-Delta aquatic foodweb and natural sediment supply which helps to maintain channel islands.

Midchannel islands and shoals provide riverine-edge habitat, shallow-water habitat, escape cover for young fish and wildlife, riparian and riverine aquatic habitat, and mudflats. Numerous aquatic and terrestrial fish, wildlife, and plant species rely on the complex array of habitats provided by this type of habitat.

Erosion seems to be the major stressor that is impairing the ecological health of this resource. This erosion is a result of wind-driven and boat wake wave erosion and high channel water velocities.

Strategic Objectives, Targets, and Programmatic Actions

Midchannel islands and shoals are addressed by two Strategic Objectives. One objective addresses habitat and the other addresses the physical processes necessary to maintain channel islands.

The Strategic Subobjective is to increase the area of midchannel island and shoal habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

LONG-TERM OBJECTIVE: Restore midchannel islands and shoals in the Delta to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for restoring large and significant examples of midchannel islands and shoals in the Delta.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

STAGE 1 EXPECTATIONS: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

A second Strategic Objective is to manage channels in the Delta and Suisun Marsh in ways that favor the maintenance of islands and shallow water habitat.

LONG-TERM OBJECTIVE: Have large expanses of shallow water habitat, both on the edges of channels and on small channel islands, maintained by natural processes.

SHORT-TERM OBJECTIVE: Set priorities for channels in terms their importance for shallow water habitat; develop and implement protection strategies for existing and restored shallow water habitat in those channels; investigate the value of shallow-water habitat in supporting and increasing abundances of desirable species.

RATIONALE: There is widespread agreement that more shallow water habitat needs to be created in the Delta and that existing shallow water habitat needs to be maintained. However, opinions differ on whether creating more habitat will actually increase abundance of desirable species. Ecosystem-based restoration is predicated on this assumption, but adaptive management demands that it be rigorously tested. Staged implementation will allow an increase in confidence in whether or not habitat restoration in the estuary will result in higher abundance of desirable species. Ultimately much of this shallow water habitat will be along Delta and Suisun Marsh channels (recreating some of the original channel-marsh system) or on small islands in the channels. The desirable physical and biotic characteristics of these habitats may be created artificially at first, but the expectation is that they will be maintained by natural processes (e.g., tidal flux, sediment inputs from upstream). This will require restrictions on human activities in these channels that have negative impacts on the habitats, such as boating at speeds that generate erosive wakes or channel dredging.

STAGE 1 EXPECTATIONS: Channels or channel reaches most suited for restoration and protection of shallow water habitats should be identified and given priorities for restoration activities. Detrimental human activities in these channels should be eliminated through a phased program associated with restoration activities. Major studies of the use of shallow water habitats by native and non-native species should be undertaken to test the assumption that shallow water habitat is indeed the key to restoring many of the native species.

The general restoration target for midchannel islands and shoals is to restore and maintain 50-200 acres of high quality midchannel islands and shoals.

The following actions would help to protect and restore channel islands and shoals:

- Implement restoration projects currently proposed in the Delta by resource and cooperating agencies.

- Develop and implement an inventory and assessment of the existing midchannel Delta islands. Use this information to develop long-term actions to protect and enhance the islands.

- Install structures, such as floating booms, to weaken the force of waves to reduce midchannel erosion in sensitive areas.

- Reduce boat traffic near high quality midchannel islands.

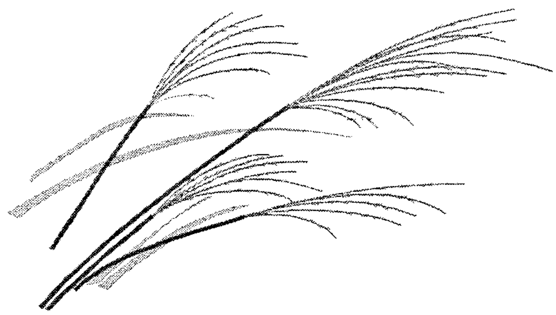
Mid-channel islands are important habitat, but restoration cost will be a consideration in designing and implementing restoration actions. To most effectively link the restoration of mid-channel islands with adaptive management, a Delta-wide understanding of the value of natural flows, water velocities, and sediment transport processes need to be well understood. This can be facilitated by developing conceptual models based on our present understanding of the processes that create, maintain, or erode channel islands. Locating areas where sediment accretion is occurring naturally is vital to restoring channel islands. Projects in these areas may be cost-effective.

REFERENCES

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Saline Emergent Wetland



INTRODUCTION

Saline emergent wetland habitats are located on the western edge of the Delta and in Suisun Marsh on the Bay. Saline emergent wetland habitats, including brackish and saline wetlands, are important habitats for fish and wildlife that are dependent on marshes and tidal shallows. This designation is similar to the Goals Project (1999) descriptions of tidal marsh which includes tidal salt marsh and tidal brackish marsh.

The loss or degradation of historic saline emergent wetlands has substantially reduced the habitat area available for associated or dependent fish and wildlife species. Several plant and animal species closely associated with tidal saline emergent wetlands have been listed as endangered under the State and federal Endangered Species Acts, primarily as a result of the extensive loss of this habitat type. Major factors that limit this resource's contribution to the health of the Delta are related to harmful effects of saline emergent wetlands conversion for agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

Saline emergent wetlands were once continuous from San Francisco Bay into the western Delta. Saline emergent habitat also is found in low-elevation areas of the Central Valley where salts have accumulated and groundwater is near the surface. Most remnant tidal saline emergent wetlands are narrow bands along the margins of San Pablo Bay and Suisun Marsh and Bay. Extensive relict tidal marshes are associated with Cutoff Slough and eastern Hill Slough flank the Potrero Hills in the north central Suisun Marsh and are especially unique in that there is a wetland continuum from tidal slough through low, middle, and high marsh zones and into adjacent uplands which are rich with associated vernal pools.

Land use changes over the past century have reduced the amount of saline emergent wetland habitat and fragmented what was once nearly contiguous habitat. In particular, diking of historic wetlands has substantially reduced the amount of tidally influenced saline emergent wetlands. Large areas of nontidal wetlands that were created largely by diking for reclamation are present in the Suisun Marsh and Bay areas.

Saltwater flowing into the Delta was reduced by water management in California's Central Valley. Before the development of California's reservoir system, saltwater intruded far into the upper Delta during summer months. This saltwater intrusion created a seasonally wide range of salinity over a large portion of the estuary. Reservoir operations and other water management practices have reduced saltwater intrusion into the Delta by retaining water during winter and releasing water during summer. Consequently, the area that can support brackish wetlands has been reduced, and the area that can support fresh emergent wetlands has increased. Complex water control systems are now required in Suisun Marsh to preserve the largest single area of saline emergent wetland habitat in California.

Saline emergent wetland area and quality have decreased because of historical conversion to other uses, and reduced land subject to tidal flooding. This habitat has a reduced potential to maintain populations of many native plant and wildlife species. A number of plant species that depend on saline emergent wetlands, including Ferris's milkvetch, soft bird's beak, palmate bird's beak, narrow-leaf gumplant, Suisun Marsh thistle, heartscale, San Joaquin spearscale, crownscale, brittlescale, Delta button celery, and hairy bird's beak, have been given special status because of their reduced populations.

More than 25 species of birds and mammals use saline emergent wetlands in the estuary. Populations of some wildlife species that are heavily dependent on saline emergent wetlands, such as the endangered clapper rail and salt marsh harvest mouse, have been substantially reduced in the Bay-Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have adapted to foraging on some types of croplands.

Saline emergent wetland also serves as an important transitional habitat between open water and uplands. Wildlife species that use tidally influenced areas, such as the salt marsh harvest mouse, have adapted to moving during high tides to seasonal wetlands and uplands above the saline emergent wetlands. Loss of adjacent seasonal wetlands and uplands has prevented species associated with these intertidal habitat areas from finding refuge in the higher tidal zone elevations.

Since the turn of the century, an estimated 70,000 acres of saline emergent wetland have been lost in the Suisun Marsh and Bay and the west Delta. The primary factor causing this loss has been wetlands conversion to agricultural and other land uses.

Diking has isolated most of the remaining saline emergent wetlands from tidal flows. Loss of tidal flows into and out of the wetlands has substantially reduced the exchange of nutrients between these wetlands and tidal aquatic communities. Wetlands receiving tidal flows are highly productive, supporting large numbers of important foodweb microorganisms, and maintaining rearing areas for many fish species. Consequently, loss of tidal exchange has greatly reduced the contribution of saline emergent wetlands to the Bay-Delta aquatic ecosystem.

The loss of tidal exchange can also affect the biochemical balance in the soil-water interface. Excessive accumulation of salt in some soils has created conditions unsuitable for plant growth. Agricultural and other land uses have allowed undesirable non-native plant species to become established in remaining wetlands. Non-native plants compete with native plants and change the structure and diversity of the saline emergent plant community from historical conditions.

Tidal exchange is the primary process that supports healthy saline emergent wetlands in the Bay-Delta. Tides flush the wetland system, replacing nutrients and balancing salinity concentrations. Changes in the tidal flux and the accompanying daily and seasonal salinity changes are critical to habitat functioning. Saline emergent wetlands are recognized for their high productivity, which results from the complex interactions of dissolved nutrients with the saline or brackish water. The process of mixing estuarine freshwater with tide-driven saltwater is critical for the biochemical transformations (i.e., carbon and nitrogen cycles) which support the entire estuarine ecosystem.

Human-made stressors negatively affect the health of saline emergent wetlands. Controls placed on seasonal inflow of fresh water to the Delta affect the salinity gradient of the estuary. Land use practices, primarily those associated with agriculture, result in the establishment of weedy plants that displace native, saline-adapted plant species. An associated stressor is the loss of adjacent native upland habitats, which are used by some wildlife species as a temporary refuge when escaping high tides. Collectively, these stressors have substantially reduced the habitat quality of remaining saline emergent wetlands. The combined effect of these actions could eventually be the elimination of much of the remaining habitat.

VISION

The vision for this habitat type is to increase the area and protect the quality of existing saline emergent wetlands from degradation or loss. Wetland habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

Restoration of saline emergent wetlands would focus on protecting and improving important existing wetlands and restoring wetlands in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Restoring saline emergent wetland is dependent on restoring tidal flows, establishing and maintaining healthy estuarine salinity gradients and reestablishing elevation gradients from open water to uplands.

Enhancing and increasing saline emergent wetland habitat would also help to increase water quality. Areas restored to tidal flow will contribute to the aquatic foodweb of the Bay-Delta and provide fish rearing habitat. Restoring saline emergent wetland would improve the ecological value of adjacent associated habitats, including tidal aquatic habitats, and will provide an important transitional zone between open water and uplands.

Other habitat restoration efforts will be directed toward reestablishing native plant species, controlling competitive weedy plants, increasing the quality of adjacent upland habitats to provide refuge for wildlife during high tides, and modifying land use practices that are incompatible with maintaining healthy wetlands. Restoring saline emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. For example, saline emergent wetland greatly increases wildlife habitat quality of deep and shallow open-water areas and adjacent grasslands.

These protection and restoration needs could be met by establishing cooperative efforts between government and private agencies. This effort would coordinate implementation of existing restoration strategies and plans; develop and implement alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery; provide incentives to private landowners to implement desirable land use practices; establish additional incentive programs to encourage landowners to create and maintain saline emergent wetlands; and protect existing habitat areas from future degradation through acquisition of conservation easements or purchase from willing sellers.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The use of saline emergent wetland habitat here is similar to the Goals Project (1999) designation of tidal salt marsh and tidal brackish marsh, and Cowardin's (1979) emergent wetland classification.

Efforts to restore fresh emergent wetland habitat would involve cooperation with other wetland restoration and management programs. These include:

- Suisun Marsh Preservation Agreement,
- Natural Resources Conservation Service's Wetland Reserve Program,
- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- ongoing management of State and federal wildlife refuges and private duck clubs,

- and the San Francisco Bay Area Wetlands Ecosystem Goals Project.

Proposed ERPP targets are intended to be consistent with wetland habitat goals identified by the San Francisco Bay Area Wetlands Ecosystem Goals Project. Agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats will be asked to cooperate. These include:

- U.S. Bureau of Reclamation,
- California Department of Water Resources,
- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- California Coastal Conservancy,
- San Francisco Bay Area Conservancy Program,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- and the Delta Protection Commission,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Saline emergent wetlands are linked to other ecological elements in the Bay. Tidal exchange is an important ecological function that restores the proper salinity and nutrient balance and mixed fresh and estuarine waters.

Saline emergent wetlands are closely linked to open water areas and upland habitats. The value of each habitat is increase by the presence and quality of the adjacent types of habitats. A variety of aquatic and terrestrial fish, wildlife and plant communities depend on healthy saline emergent wetlands. These include numerous plant species and the salt marsh harvest mouse.

Saline emergent wetland are impaired by reduced seasonal inflow of fresh water, land use and loss of upland habitat, and introduction and proliferation of invasive salt marsh plant species.

STRATEGIC OBJECTIVE, TARGETS AND PROGRAMMATIC ACTIONS

Saline emergent wetland habitat is addressed in two strategic objectives. One addresses freshwater marshes and the other address restoring large expanses of all major habitats in the Delta, in Suisun Bay, Suisun Marsh, and San Francisco Bay.

The Strategic Subobjective is to increase the area of tidal saline emergent wetland habitat (both brackish and salt) as an integrated component of restoring large expanses of all major historical habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

LONG-TERM OBJECTIVE: Restore saline emergent wetlands in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their presettlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Inventory and prioritize for restoration diked former tidal marsh sites, develop techniques for restoration through implementation of pilot restoration projects, and begin implementation of large-scale manipulations of high priority areas, especially in the Suisun Marsh.

RATIONALE: Tidal wetlands are a diverse group of habitats included under Objective 1 and 2 in this series. However, they merit additional attention beyond those objectives because their restoration is urgently needed for the benefit of many species. They also represent, by acreage, some of the largest restoration projects that are likely to be attempted in the system. Restoration of tidal marshes in the Suisun Marsh and San Pablo Bay in particular will require innovation and a concerted and collaborative effort with existing landowners, because restoration of tidal action to one parcel may result in special levee rehabilitation needs on adjacent lands and because successful restoration of natural marsh building processes requires careful consideration of any potential site's elevation, topography, and geomorphology. Therefore, restoration will initially require pilot projects to ensure the success of larger scale tidal restoration projects.

STAGE 1 EXPECTATIONS: Ongoing efforts to restore large expanses of tidal marsh should continue and experimental pilot projects to restore tidal marshes to areas in the Suisun Marsh and San Pablo Bay should be undertaken.

A second Strategic Objective is to increase the area of tidal marsh (freshwater, brackish, salt) by removing or breaching levees (opening them to tidal action) and by increasing the elevation of subsided, leveed former marsh.

LONG-TERM OBJECTIVE: Restore the amount and diversity of tidal wetlands to the level that existed in 1906 or similar reference date.

SHORT-TERM OBJECTIVES: Inventory and prioritize for restoration diked, former marsh sites and develop techniques for restoration through large-scale manipulations of high-priority areas, especially on Delta islands.

RATIONALE: Tidal wetlands are a diverse group of habitats included under Objectives 1 and 2 in this series. However, they merit additional attention beyond those objectives because their restoration is urgently needed for the benefit of many species. They also represent, by acreage, some of the largest restoration projects that are likely to be attempted in the system. Restoration of tidal marshes in the Delta in particular will require major effort and innovation, because so many of the islands that could be restored to tidal marsh now have elevations considerably below sea level. If flooded, they will be too deep for marsh restoration at present. Therefore, restoration will require large-scale pilot projects to find ways to restore marsh lands to such islands.

STAGE 1 EXPECTATIONS: Ongoing efforts to restore large expanses of tidal marsh should continue and experimental pilot projects to restore tidal marshes to Delta islands should be undertaken.

The general target for saline emergent wetland is to restore 7,000 to 11,000 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help achieve saline emergent wetlands restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;
- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to control seasonal freshwater inflows to the Delta;
- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the needs of other habitats; and

- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plant species, including special-status species, that are adapted to different elevations and provide a broader range of habitats for wildlife.

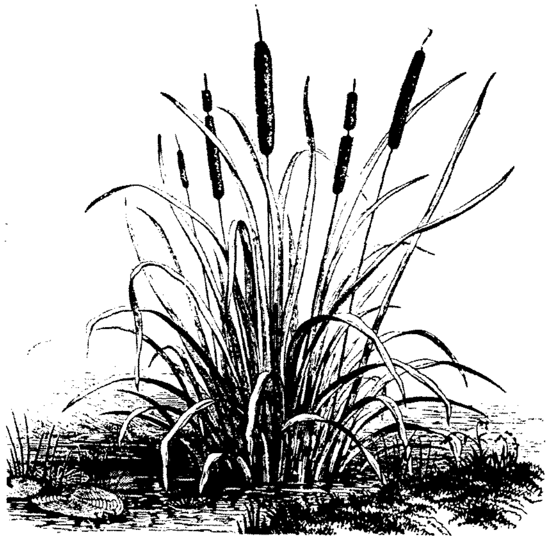
REFERENCES

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ FRESH EMERGENT WETLAND



INTRODUCTION

Most fresh emergent wetlands in the Delta occur as narrow, fragmented bands. These fragmented wetlands appear along island levees, channel islands, shorelines and levee blowout ponds. Small areas of nontidal fresh emergent wetlands exist on Delta islands. These Delta island wetlands are primarily associated with agricultural infrastructure (e.g., drainage ditches), levee blowout ponds, and areas managed for wetlands (e.g., duck clubs).

Tidal and nontidal fresh emergent wetland habitats are important habitat areas for fish and wildlife dependent on marshes and tidal shallows and support several special-status plant species. The loss or degradation of historic fresh emergent wetlands has substantially reduced the habitat area available for associated fish and wildlife species. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of wetlands conversion to agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

Over the past 150 years, more than 300,000 acres of fresh emergent wetlands have been lost in the Sacramento-San Joaquin Delta Ecological Management Zone. Less than 15,000 acres remain.

Prior to the mid-1800s, extensive areas of fresh emergent habitat occurred throughout the Central Valley, particularly in the Delta. A complex network of rivers, sloughs, and channels connected low islands and basins that supported a diverse and dense variety of freshwater emergent vegetation. This freshwater emergent vegetation supported a diversity of fish and wildlife species and ecological functions.

Vast areas of the Sacramento-San Joaquin Valley were commonly flooded in winter by a slow-moving blanket of silt-laden water. Flood control activities and land settlements in the late 1800s and early 1900s led to the development of leveed Delta islands. Levees and other land uses led to the loss of fresh emergent wetlands in the Delta. Loss of wetlands has substantially reduced habitat for wetland wildlife species in the Bay-Delta system. Fresh emergent wetland losses have also substantially reduced the area available for the biological conversion of nutrients in the Delta. The Delta contains insufficient wetland area to provide adequate levels of nutrient transformation, which results in lower quality water in San Francisco Bay.

The loss of fresh emergent wetlands has substantially reduced the habitat of several plant and wildlife species. Some species being designated as California or federal special-status and threatened with local extermination. At least eight plant species, Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap, are endemic to the Delta. Most of these plants are adapted to a complex tidal cycle and are typically found with more common vegetation such as tule, cattails, common reed, and a great diversity of other herbaceous plant species. Changes in habitat conditions have allowed the invasion of hundreds of non-native weedy plant species. Some of these species, such as water hyacinth, now clog waterways and irrigation ditches and reduce overall habitat quality for native plants and wildlife.

Over 50 species of birds, mammals, reptiles, and amphibians use fresh emergent wetlands in the Delta. Populations of some wildlife species that are closely dependent on fresh emergent wetlands, such as the California black rail, giant garter snake, and western pond turtle, have been substantially reduced in the Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have successfully adapted to foraging on some types of Delta croplands converted from historic wetland areas.

Isolating wetlands from tidal flows and removing Delta island fresh emergent wetlands changed the ecological processes that support wetlands. Removing the perennial water and vegetation from the organic soils of Delta islands resulted in soil oxidation and, subsequently, the subsidence of the interior islands. Loss of these tidal flow to islands has reduced habitat for native species of fish, plants, and wildlife; reduced water quality; and decreased the area available for floodwater dispersion and suspended silt deposition.

High water velocities in confined Delta channels continue to erode remaining fresh emergent wetland at a greater rate than habitat formation. Continued erosion reduces the amount of fresh emergent habitat changes the elevation of the land. Elevation affects the types of plant species that can grow depending on a species' ability to tolerate flooding. Flood protection and levee maintenance continue to impair wetland vegetation and prevent the natural reestablishment of fresh emergent wetlands in some locations.

Wind, boat-wake waves, and high water velocities in confined channels actively erode the soil needed to support remnant fresh emergent wetlands. Continued erosion of existing habitat, such as midchannel islands and levees and levee berms, is currently the primary cause of habitat loss in the Delta.

VISION

The vision is to increase the area and improve the quality of existing fresh emergent wetlands from degradation or loss and increase wetland habitat. Achieving this vision will assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

Restoration of fresh emergent wetlands would focus on protecting and improving important existing wetlands, such as channel islands, and restoring wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

To prevent further loss of existing fresh emergent wetlands erosion rates must be reduced. Inchannel islands and levee berms are of particular concern. Erosion losses could be offset by allowing deposition and wetland establishment. Wetlands erosion could be reduced by reducing boat speeds where wetlands are subject to boat-wake-induced erosion (e.g., Snodgrass Slough). Constructing protective structures around eroding channel islands would weaken wave action (e.g., wave barriers and riprap groins) in a way that retains habitat value for fish and wildlife. Protecting inchannel islands from further erosion and connecting with larger islands would provide greater protection for this unique habitat.

Restoring fresh emergent wetland is dependent on local hydrological conditions (e.g., water depth, water velocity, and wave action); land elevation and slope; and the types and patterns of sediment deposition. The approach to restoring fresh emergent wetlands would include:

- reestablishing the hydraulic, hydrologic, and depositional processes that sustain fresh emergent wetlands and inchannel islands;
- restoring a full spectrum of wetland elevations to allow the establishment of a greater diversity of plant species, including special-status species adapted to different elevations within the tidal or water (nontidal sites) column; and
- providing a broader range of habitats for wildlife.

Restoration of fresh emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. Restoration would also include reestablishment of the full diversity of fresh emergent wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Protecting and restoring fresh emergent wetlands could be accomplished by implementing elements of existing restoration plans such as Central Valley Habitat Joint Venture; expanding State and federal wildlife areas to create additional wetland complexes; improving management of existing and restoring additional fresh emergent wetlands on private lands; and reestablishing connectivity between the Delta and Delta islands, and between channels with their historic floodplains.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Fresh emergent wetland habitat use here is similar to the Goals Project (1999) designation of managed marsh, Madrone Associates (1980) description of freshwater marshes, Moyle and Ellison's (1991) description of valley marsh, and Cowardin's (1979) designation of emergent wetland.

Efforts to restore fresh emergent wetland habitat would involve cooperating with other wetland restoration and management programs. These include:

- Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- and ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts would be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- and the Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Fresh emergent wetlands are linked to other ecological elements in the ERPP study area. This type of habitat contributes to the aquatic foodweb by supporting nutrient transformation. Fresh emergent wetland also provides habitat for many wildlife and plant species. Some of these are designated California or federal special status species.

Stressors that have reduced the extent of fresh emergent wetlands include flood protection practices, levee construction, and the loss of tidal flow. Increased water velocities in Delta channels causes erosion of wetlands and changes the elevation of the land. Wind and boat wake erosion also contribute to the loss of soil needed to support fresh emergent wetlands in areas where midchannel islands and levee berms are present.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to increase the area of tidal fresh emergent wetland habitat as an integral component of restoring large expanses of all major historical habitats in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay.

Long-Term Objective: Restore fresh emergent wetlands in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

Short-Term Objective: Inventory and prioritize for restoration diked former tidal marsh sites, develop techniques for restoration through implementation of pilot restoration projects, and begin implementation of large-scale manipulations of high-priority areas, especially on Delta islands.

Rationale: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

Stage 1 Expectations: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

The overall target for fresh emergent wetlands is to restore or recreate 30,000- to 45,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone.

Actions that would help restore fresh emergent wetlands include:

- Setbacks or breaches of island levees to allow water flows to reestablish wetlands with improved but limited ecological functions.
- Increase land elevations in the interior of Delta islands where subsidence has lowered land elevations below tidal emergent wetlands
- Use substrate materials to create levee berms at elevations necessary for fresh emergent vegetation
- Modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally reestablish.
- Reintroduce native wetland plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;
- establishing additional incentive programs to encourage landowners to establish and maintain fresh emergent wetlands; and
- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of fresh emergent wetlands elsewhere in the Central Valley.

REFERENCES

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board. Oakland, California.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Moyle, P.B. and J.P. Ellison. 1991. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77(4):161-180.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

INTRODUCTION

Bay-Delta seasonal wetlands include vernal pools, wet meadows or pastures, lands that are seasonally flooded, federal refuges, privately owned waterfowl hunting clubs, and private environmental refuge lands, and seasonally flooded areas within a stream course or its floodplain. Historically, seasonal wetlands occurred throughout the Central Valley. Vernal pools and wet meadows are probably best described as specialized components of terrestrial habitats. The remaining seasonal wetland types are flooded for periods that are too long to support characteristic upland vegetation.

Seasonal wetlands and aquatic habitats are important habitat areas for many species of fish and wildlife. Loss or degradation of historic seasonal wetlands has substantially reduced the habitat area available for waterfowl, shorebirds, and other wildlife. The loss of seasonal aquatic floodplain habitat has substantially reduced refuge habitat for fish and spawning habitat for the Sacramento splittail. Loss of vernal pools seasonally flooded shallow areas, in particular, has directly resulted in the listing of several species as threatened or endangered under the federal Endangered Species Act.

Major factors that limit the contribution of this habitat type to the health of the Bay-Delta are related to adverse effects of land conversion, and substantial reductions in seasonal overbank flooding.

RESOURCE DESCRIPTION

Vernal pools and wet meadows are associated with soils (basalt flow, claypan, hardpan, volcanic ash-flow, volcanic mudflow, mesa, and plateau) that maintain standing water after winter and spring rains. In some areas of the Central Valley, high spring flows from the rivers and creeks saturate soils. Seasonal wetlands are created when puddles or small ponds form in depressions or standing water remains in low-lying grass fields after river flows recede. Although aquatic plants can establish in areas that are frequently flooded, upland plants cannot survive.

Wet meadows are grassy areas with saturated soils and standing water of varying depths that remain after winter and spring rains end. This habitat is conducive to the production of invertebrates. Invertebrates are the main food source of migrating waterfowl and other birds that periodically forage in these fields. Sandhill cranes forage and roost, and many ducks, geese, and shorebirds also commonly forage in wet meadows throughout the valley. During the dry seasons, many ground-nesting birds, such as pheasants and meadowlarks, nest in meadow grasses. Most wet meadow habitat remaining in the Central Valley, now composed almost entirely of non-native grasses, is used as pasture for livestock.

Vernal pools are often referred to as hog wallows or ponds. These pools are common in grasslands in northern Central Valley where the natural geomorphology remains relatively unchanged. Many State- and federally listed plants (including vernal pool plants), invertebrates, and wildlife, including the western spadefoot toad, California tiger salamander, and various fairy shrimp, are native to or associated with vernal pools. In addition, a variety of birds, including migrating waterfowl, shorebirds, and ground-nesting birds such as meadowlarks, commonly use seasonal wetlands habitat.

Seasonal wetlands play a vital role in the natural succession of plant communities. Seasonal wetlands that maintain surface water for long periods may support cattails, bulrushes, and sedges. Historically, these emergent plant species were probably prevalent along natural stream courses where long-standing water reduced the ability of upland species to establish. These types of wetlands provide the essential building blocks for the future establishment of riparian scrub and eventually riparian woodland. Beyond the normal river flows, wetlands probably formed where rains and high flows left areas too wet for terrestrial plants to establish. These wetland areas provided high-quality habitat for waterfowl, other migratory birds, shorebirds, red-legged frogs, giant garter snakes, tricolored blackbirds, and many other wildlife species.

The continued existence of these seasonal wetland types is closely linked to overall ecosystem integrity and health. Although many species that use seasonal wetlands are migratory (e.g., waterfowl and sandhill cranes), many others have evolved (e.g., spadefoot toad, fairy shrimp, and many specialized plants) and adapted to seasonal wetlands.

The extent and quality of seasonal wetlands has declined because of cumulative effects of many factors, including:

- modification of natural geomorphology such as ground leveling for agriculture and development,
- adverse effects of overgrazing,
- contamination from herbicides,
- establishment of non-native species that have an adverse effect on native wetland plants and wildlife,
- flood control and water supply infrastructure that reduces overbank flooding and floodplain size, and
- reduction of the natural underground water table that supported wetlands.

Existing wetland regulations have been in effect for several years in an attempt to prevent the further loss of wetlands. The protected status of wetlands has resulted in an extensive permitting process for construction in wetland areas. Mitigation measures have been developed to offset loss of existing wetlands as a result of construction activities. These efforts have slowed the rate of wetland loss in many areas. Large-scale efforts in areas such as the Suisun Marsh, Grasslands Resource Conservation District, Yolo Bypass, and Butte Sink have been successful in maintaining and restoring seasonal wetlands.

VISION

The vision is to increase the area and improve the quality of seasonal wetlands by restoring ecosystem processes that sustain them and reduce the effect of stressors that can degrade the quality of seasonal wetlands in order to assist in the recovery of special-status plant and animal populations and provide high-quality habitat for waterfowl, water birds, and other wildlife dependent on the Bay-Delta.

Restoration of seasonal wetlands will focus on protecting and improving important existing wetlands, reestablishing vernal pools within and adjacent to existing ecological reserves, and restoring seasonal wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Seasonal wetland restoration will be coordinated with restoration of other habitats, including shallow-water and riparian woodland and scrub.

Restoration would include reestablishment of the full diversity of seasonal wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore seasonal wetlands would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- The Nature Conservancy,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan, and
- Central Valley Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The description of seasonal wetland here is similar to the Goals Project (1999) description of grassland/vernal pool complex, Moyle and Ellison's (1991) floodplain pool and vernal pool classifications, Madrone Associates (1980) description of vernal pools, and Cowardin's (1979) classifications for seasonally flooded and intermittently flooded wetlands.

Seasonal wetlands are linked to other ecosystem elements in the ERP Study Area. Seasonal wetlands include wet meadows or seasonally flooded pastures, vernal pools, and federal, State, and privately owned refuges and hunting clubs. This habitat supports many species and communities of wildlife and plants.

The health and extent of seasonal wetlands is adversely influenced by land use, herbicide application, proliferation of non-native plant species, flood control practices, and lowering of ground water tables.

STRATEGIC OBJECTIVES, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to protect existing and restore and increase the area of seasonal wetland habitat as an integrated component of restoring large expanses of all major historical habitat types in the Delta, in Suisun Bay, Suisun Marsh, and San Francisco Bay and other areas of the Central Valley.

LONG-TERM OBJECTIVE: Restore, protect and manage, throughout the watershed, multiple large areas of seasonal wetlands in association with other aquatic, wetlands, and riparian habitat types in the Central Valley and its rivers to a point where the wintering needs of waterfowl and shorebirds are met and all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVE: Conserve the best examples of seasonal wetlands, particularly in the Bay-Delta, begin implementation of action plans for restoring significant, large areas of seasonal wetland.

RATIONALE: Restoring seasonal wetlands in combination with other wetland habitat types will help restore and maintain the ecological health of aquatic and terrestrial resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Seasonal wetlands will provide high quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds. Restoration of seasonal wetlands will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Furthermore, restoring other wetland habitats in the Delta, such as tidal emergent wetland and tidal perennial aquatic habitat, can reduce habitat values for species such as waterfowl and the State listed greater sandhill crane. Increasing seasonal wetlands in the Delta will ensure that any adverse impacts associated with those habitat losses will be fully mitigated.

Each habitat, including seasonal wetlands, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large seasonal wetland projects will be initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring seasonal wetlands in heavily subsided areas where land elevations are too low to support actions to restore aquatic habitat.

The general target for seasonal wetland habitat is to restore 30,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,000-1,500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help protect and restore seasonal wetlands:

- implement existing restoration plans;
- expand State and federal wildlife areas to create additional wetland complexes;
- improve management of existing wetlands and restore seasonal wetlands on private lands; and
- reconnect channelized streams and rivers with their historic floodplains.

The following actions would help implement protection and restoration strategies:

- establish cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- develop and implement alternative land use practices that will protect grasslands containing vernal pools and wet meadows and allow existing, compatible land uses, such as grazing, to continue;
- develop and implement alternative land management practices on public lands to improve seasonal wetland habitat quality or

promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;

- establish additional incentive programs to encourage landowners to establish and maintain seasonal wetlands;

- protect existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers; and

- set back or breach levees and dikes to create the hydrologic conditions necessary for establishing seasonal wetland vegetation.

Restoration of stream meander belts and the process of overbank flooding along major Bay-Delta tributaries proposed in the ERP in other ecological management zones will also create the conditions necessary for the natural reestablishment of seasonal wetlands elsewhere in the Central Valley.

REFERENCES

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Moyle, P.B. and J.P. Ellison. 1991. A conservation-oriented classification system for the inland waters of California. California Fish and Game 77(4):161-180.

Strategic Plan for Ecosystem Restoration 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement/ Environmental Impact Report. June 1999.

◆ RIPARIAN AND RIVERINE AQUATIC HABITATS

INTRODUCTION

Habitats associated with shorelines of rivers and the Delta include riparian and shaded riverine aquatic habitat. Riparian vegetation includes scrub, woodland, and forest habitats that support a great diversity of wildlife species. Riverine aquatic habitat shaded by riparian vegetation, is important habitat for many species of fish, waterfowl, and wildlife.

Major factors that limit these habitats' contribution to the health of the Bay-Delta include historic riparian vegetation loss or degradation and near-shore aquatic habitat alteration from channelization, stabilization of channel banks with riprap, construction of levees, and control of flows.

Restoring riparian and riverine aquatic habitats will involve reactivating or improving natural physical processes. Natural streamflows, stream meanders, and sediment transport create and sustain these habitats and increase the complexity and structural diversity of the habitat. Natural streamflow patterns help sculpt healthy riparian and riverine aquatic habitats. High winter and spring flows trigger seed dispersal and germination, move sediment, stimulate stream meander, and flood and scour riparian and riverine habitat.

Natural stream channel meanders (often termed "meander belts") provide healthy, high-quality riparian and riverine aquatic habitats. Channelizing rivers (e.g., constructing levees), protecting banks (e.g., adding riprap), and channel dredging hinder natural stream meander and natural river channel morphology.

Natural sources of gravel and other sediments along rivers and floodplains provide materials needed to create and sustain healthy riparian and riverine aquatic habitats. Where improvement to physical processes do not adequately restore riparian and riverine habitats, direct modification may be necessary to restore habitats to their target acreage and quality.

A major increase in floodplain riparian habitat will contribute sediment and nutrient to the rivers and estuaries. It will also improve the foodweb, and provide critical habitat for threatened and endangered terrestrial wildlife species, such as the yellow-billed cuckoo and Swainson's hawk. More extensive and continuous riparian forest canopy on the banks of estuaries and rivers will stabilize channels; help to shape submerged aquatic habitat structure; benefit the aquatic environment by contributing shade, overhead canopy, and instream cover for fish; and reduce river water temperature. More extensive and continuous shoreline vegetation associated with woody debris (branches and root wads) and leaf and insect drop in shallow aquatic habitats will increase the survival and health of juvenile salmonids, resident Delta native fishes, and introduced resident fishes. Achieving this objective will also greatly enhance the scenic quality and recreational experience of our Delta and riverine waterways.

Resource Description

Riparian habitats include the trees, shrubs, vines, herbaceous undergrowth, and organic material and snags along estuaries. These habitat elements combine to create the complex variety of species mixes, age classes, and distribution patterns common to shoreline vegetation. The landforms and changing fluvial streamflow patterns processes that create and interact with riparian vegetation are also an important but often overlooked part of the habitat.

Historically, the Central Valley floor had approximately 922,000 acres of riparian vegetation (Katibah 1984) supported by a watershed of more than 40,000 square miles. Today, approximately 100,000 acres of riparian forest remain. About half of this riparian habitat is in a highly degraded condition, representing a decline of 90% (Katibah 1984). The Sacramento River once supported 500,000 acres of riparian forest; it now supports 10,000-15,000 acres, or just 2-3% of historic levels (McGill 1979, 1987). From about 1850 to the turn of the century, most of the forest was destroyed for fuel as a result of the Gold Rush and river navigation, and by large-scale agricultural clearing.

Additional clearing in early and mid 1900s coincided with the aftermath of flood control reservoir and levee projects. These projects allowed ongoing clearing of floodplain riparian stands for orchards, crops, flood bypasses, levee construction, and urban areas. Similar patterns occurred along the San Joaquin River, which was also greatly affected when major portions of the river were dried up following construction of Friant Dam and other large reservoirs in the San Joaquin Basin. Resulting major changes in river flow conditions and sediment deposits triggered channel instability, and downcutting of rivers and streams that caused additional riparian and riverine habitat loss and fragmentation.

Riverine aquatic habitats comprise the relatively shallow submerged and seasonally flooded areas in estuary and river channel beds. Channel beds contain gravel beds, bars, and riffles; transient sandy shoals; waterlogged woody debris piles; and the shaded riverine aquatic habitat zone. The shaded riverine aquatic habitat is located where the river meets the riparian canopy. Riverine aquatic zones provide spawning substrate, rearing and escape cover, feeding sites, and refuge from turbulent stormflows for fish and other aquatic organisms.

The condition of riverine aquatic and nearshore habitats is not well documented for most of Central Valley and Delta estuaries, rivers, and streams. The condition of these habitats has been degraded by channel straightening; channel incising; channel dredging and clearing; instream gravel mining; riparian zone grazing; flow modifications; removal and fragmentation of shoreline riparian vegetation; and the loss of sediment, bedload, and woody debris from watershed sources upstream of dams.

Riparian and riverine aquatic habitats are created and sustained by natural fluvial processes associated with rivers. Fluvial dynamics are affected by the presence and pattern of riparian vegetation. Vegetation patterns define and contribute to riparian and riverine aquatic ecosystem structure and functions.

In general, riparian and riverine aquatic habitats are healthiest where ecosystem processes are in the most unaffected natural state. These sites are also the most resilient to human and natural disturbance. Ecosystem processes that are integral components of riparian and riverine aquatic habitats are described in greater detail in the ecosystem restoration visions for stream meander corridors, floodplains, natural geomorphology and sediment supply.

Sediment transport, deposition, and scour support, succession, and regeneration of riparian vegetation. These secondary processes require frequent high flow events in winter and spring. These frequent high flows redistribute sediment and bedload. After new vegetation is established on sediment bars and freshly deposited floodplains, the primary physical factors that sustain riparian vegetation are adequate streamflow, winter inundation of the floodplain, and shallow groundwater during the dry season.

Sediment transport and deposition, are also the processes that create and replenish riverine aquatic habitats. A high-quality aquatic habitat requires a continuous supply of sediment. Riverflows must periodically be high enough and of sufficient duration to move streambed materials.

Sediment deposits are shaped, in part, by riparian vegetation. Riparian vegetation resists flow and causes fine sediment to aggrade within the dense stems. Riparian vegetation also redirects flows and causes the channel water to scour the bed. Scouring action forms pools, riffles, and bar patterns. Away from high-energy estuary channels, tidal mudflats form in broad, low-velocity areas when shoals of organic-rich fines are deposited.

Riparian vegetation serves many important ecological functions. Riparian vegetation absorbs nutrients and produces primary and secondary biomass at very high rates. This biomass feeds numerous fish and wildlife species. Birds and small mammals nest and take cover in the protective canopy foliage of trees. Trees also shade and cool floodplains and channels. Channel velocities are slowed by riparian foliage, allowing sediment to settle and create new landforms. Riparian foliage also stabilizes channels and banks, thereby rendering the characteristic geomorphology of estuaries, rivers, and streams.

Primary stressors affecting riparian habitats include:

- channel straightening and clearing;
- levee construction and bank hardening to protect bridge abutments and diversion structures (e.g., with riprap);
- instream gravel mining and riparian zone grazing;
- flow modifications affecting sediment transport and spring germination;
- removal, burning, and fragmentation of mature riparian vegetation; and
- loss of sediment and bedload from watershed sources upstream of dams.

Other stressors increasing in importance and magnitude include:

- displacement by invasive non-native trees and shrubs (e.g., tamarisk and giant reed),
- new expansion of orchards and vineyards into the riparian floodplain,
- human-set fires along river parkways,
- unusually high summer stage in rivers that supply increasing demand for downstream water diversions,
- groundwater lowered below the root zone, and
- expanded clearing of channel vegetation in response to recent flood events that called into question the capacity of levee-confined rivers and streams.

Most stressors have an indirect but lasting effect on the physical structure and post-disturbance recovery of streambed habitat. Collectively, these stressors have substantially reduced the quality and resilience of riverine aquatic habitats, thereby diminishing their effectiveness in providing for the life cycle requirements of fishes of the Delta and Sacramento and San Joaquin rivers and their tributaries.

VISION

The vision for riparian and riverine aquatic habitats is to increase their area and protect and improve their quality. Achieving this vision will assist in the recovery of special-status fish and wildlife populations and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta. The vision includes restoring native riparian communities ranging from valley oak woodland associated with higher, less frequently inundated floodplain elevations to willow scrub associated with low, frequently inundated floodplain elevation sites such as streambanks, point bars, and inchannel bars.

The simple preservation of remaining natural riparian areas and riverine aquatic zones will not ensure the diversity, and resilience of these habitats. Preservation alone is not adequate because of the scarcity, degradation, and fragmentation of existing river and estuary systems. Most riparian restoration projects in the Central Valley have been implemented on a relatively small scale, primarily as mitigation for project impacts or infill of existing protected preserves. The National Research Council (1992) has recommended a national strategy for restoring rivers and aquatic ecosystems through integrated restoration of large landscape units.

If the floodplain, meander width, sediment supply, and natural spring flows are in place, the river will respond by creating natural landforms. These landforms will support self-sustaining vegetation communities and streambed habitats. Even partial restoration or simulation of natural physical processes and floodplains will amplify ecosystem characteristics and resultant habitat quality. Rivers and Delta estuaries where natural fluvial processes and landforms are relatively intact need to be identified and highlighted as potential reserves of riparian and riverine habitat. Complete restoration on many segments may be limited by unalterable levee confinement and bridge crossings.

Restoring riparian and riverine aquatic habitat depends on recovery or simulation of natural fluvial processes and landforms. Revegetating and artificially altering stream channels will be considered only where overwhelming limitations prevent natural recovery of these physical processes and ecosystem functions.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to achieve the vision for riparian and riverine aquatic habitats may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;

- SB1086 Advisory Council efforts and river corridor management plan for the Sacramento River;

- the San Joaquin River Parkway and Management plans;

- proposed riparian habitat restoration and floodplain management and riparian restoration studies for the San Joaquin River, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by State and federal agencies and land trusts;

- ongoing Sacramento Valley conservation planning by The Nature Conservancy and other private nonprofit conservation organizations;

- expansion plans and conservation easements underway for the Sacramento River National Wildlife Refuge and California Department of Fish and Game's Sacramento River Wildlife Management Area;

- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture;

- all county-sponsored instream mining and reclamation ordinances and river and stream management plans;

- and the California Department of Conservation reclamation planning assistance programs under the Surface Mining and Reclamation Act.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Riparian and riverine aquatic habitat used here is similar to the Goals Project (1999) description of riparian forest, willow grove, oak woodland, and mixed evergreen forest, Madrone Associates (1980) designations of riparian habitats including riparian woodland, riparian shrub-brush, brushy riprap, and herbaceous banks, and Cowardin's (1979) classifications of scrub/shrub wetland and forested wetland.

Riparian and riverine aquatic habitats are closely linked to the ecological health of many Ecological Management Zones and Units. This type of habitat is important to many fish, wildlife, and plants species and communities. It is adversely affected by many stressors that include levee construction, gravel mining, flow patterns, fragmentation of existing stands of riparian vegetation, competition and displacement by non-native plant species, land use and conversions, fires, lowered groundwater levels, and removal to increase flood control channel capacity.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to increase the area of riparian and riverine aquatic habitat as an integrated component of restoring large expanses of all major historical habitats in the Central Valley and its rivers.

LONG-TERM OBJECTIVE: Restore, protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers to a substantial fraction of their pre-settlement areas or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVES: Systematically identify and locate the best remaining areas containing the aquatic, wetland, and riparian habitat types, and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Moyle and Ellison (1991) and Moyle (1996) developed a scheme for classifying the aquatic habitats of California for the purposes of conservation. Other classification schemes of aquatic habitats also exist, as do schemes for classifying riparian and wetland habitats. Whatever the system, it is obvious that the diversity of aquatic habitats is declining in Central Valley watersheds, especially in lowland areas. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic protection of examples of the entire array of habitats in the region provides some assurances that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: A classification system for riverine and riparian habitats that can be used as a basis for conservation actions will have been developed. Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

General restoration targets for riparian and riverine aquatic habitat include acquisition of easements or in-fee title to 16,000 to 24,000 acres of riparian lands in the stream meander zone along the Sacramento River between Red Bluff and Colusa and the acquisition or protection of riparian corridors along most of the streams and rivers throughout the ERP Study Area.

Recovery and simulation of natural fluvial processes and landforms will be accomplished using the following integrated steps:

- locating setback levees to expand potential riparian floodplain;
- expanding the storage, detention, and bypass capacity of the Sacramento and San Joaquin River flood control project to allow natural expansion of riparian vegetation within levees and the Sutter and Yolo bypasses; and
- designating, acquiring title or easements for, and deliberately managing river corridor meander zones on appropriate rivers and stream throughout the Central Valley.

The following actions would restore or enhance sediment supply to rivers and streams:

- reduce bank hardening by creating meander zones and widening floodplains;
- analyze alternative approaches for water diversions and associated intake and screening facilities on the mainstem river to avoid hardening the bank in some sections of the river;
- remove small, nonessential dams on gravel-rich streams;
- eliminate mining in streams and on low floodplains near channels; and
- widen bridges to broaden out-of-bank flow and eliminate the need to riprap vulnerable bridge abutments.
- breach or remove nonessential levees restricting former tidelands that would capture sediment needed to create tidal mudflats and estuary landforms.

These measures will significantly increase the extent and distribution of shallow-water and nearshore habitats. These habitats are productive generators of the Delta foodweb and provide essential new rearing habitat for juvenile Delta and anadromous fish. Where Delta land elevations are suitable, levee systems can be set back or altered to allow out-of-bank shallow flooding during high flood stage. Floodplain inundation will also provide additional flood storage and moderation of peak flows to decrease the risk of flooding elsewhere in the Delta. Foodweb support, spawning and rearing habitat for native fish (e.g., splittail), would be further enhanced by altering levees.

Opportunities for reducing riparian habitat stressors include:

- phasing out instream gravel mining;
- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow greater natural recolonization;

- designing biotechnical slope protection measures that allow riparian vegetation to be established within levees;

- phasing out or reducing livestock grazing in riparian zones;

- establishing conservation easements for purchase of land or using other incentives to reduce or eliminate cropland conversion of riparian forest;

- eliminating or modifying programs which remove large woody debris from stream channels and rivers;

- identifying levee-confined channels and banks where routine vegetation removal by local reclamation districts can be safely discontinued; and

- establishing weed control programs to suppress the expansion of tamarisk, giant reed, locust, and other invasive non-native plants degrading habitat quality and native flora.

Opportunities for reducing stressors affecting riverine aquatic habitat include:

- phasing out instream gravel mining, especially downstream of dams and on streams that support salmon and steelhead spawning;

- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow natural meander patterns;

- designing slope protection measures that allow shoreline riparian vegetation to be established within levees;

- phasing out or reducing livestock grazing in riparian and aquatic zones, especially on tributary streams that support salmon and steelhead spawning; and

- identifying levee-confined channels and banks where routine channel clearing and grading can be safely discontinued.

Reservoir operations will be evaluated to determine whether winter and spring releases can be augmented with flood simulation spikes every 1-10 years. Simulated flood spikes would mobilize bed and bank deposits to redistribute, sort, and clean spawning gravels and scour deep pools between riffles.

Restoring riparian and riverine aquatic habitat should be accomplished by eliminating the stressors and recovering or simulating the physical processes and fluvial landforms described above. Habitat restored in this way will be more resilient to future disturbances; require little or no long-term maintenance; be self-sustaining; and be more compatible with flood control requirements.

However, habitat fragmentation and severe limitations of the physical environment will not allow ecosystem processes and functions to fully recover on many segments of valley streams and Delta estuaries. In these situations, some large-scale stream channel sculpting, gravel additions, and riparian replanting may be necessary. For example, the lower Sacramento River has abandoned river floodplains and sediment is in short supply. Naturally reactivating these habitats would be nearly impossible. Restoring these habitats would require human intervention. Revegetation projects should be contemplated only where native trees and grasses may no longer germinate naturally but have a high probability of unaided survival and vigorous growth following 1-5 years of artificial irrigation.

REFERENCES

Cowardin, M.L., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior. FWS/OBS-79/31. December 1979. 131 pp.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Katibah. 1984. A brief history of riparian forest in the Central Valley of California. in R. E. Warner and K. M. Hendrix (eds.), California riparian systems: ecology, conservation and productive management. University of California Press. Berkeley, CA.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

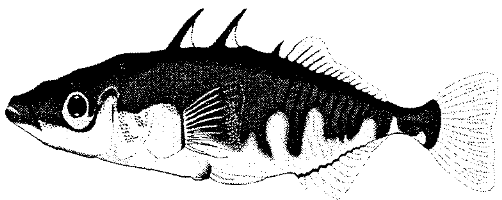
McGill, R. R. 1979. Land use changes in the Sacramento River riparian zone, Redding to Colusa: an update (first update). California Department of Water Resources. Sacramento, CA.

__________. 1987. Land use changes in the Sacramento River riparian zone, Redding to Colusa: an update (third update). California Department of Water Resources. Sacramento, CA.

National Research Council. 1992. Restoration of aquatic ecosystems: science, technology, and public policy. National Academy Press. Washington, DC.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ FRESHWATER FISH HABITATS



INTRODUCTION

Freshwater fish habitats and native fishes are closely linked in the Central Valley as the health of native fish populations is largely dependent on the health of their habitats. The Sacramento-San Joaquin drainage system's large size, diversity of aquatic habitats, and isolation from other systems have provided a basis for freshwater fish speciation (Moyle 1976). Seventeen fish species evolved and live in the system. In addition, the diversity of habitats present in the Central Valley support a variety of native resident fish species, native anadromous species, native marine species, and an ever increasing number of introduced species.

The diversity of habitats include clear headwater streams that support rainbow trout, small warm tributaries and larger streams that flow through open foothill oak woodlands and support California roach, streams with average summer flows of 300 cfs or more and support squawfish, suckers, and hardheads, sluggish river channels, oxbow and floodplain lakes, and sloughs that support or supported Sacramento perch, hitch, and tule perch (Moyle 1976).

The designation of these habitats is important to allow the systematic protection of biological diversity within distinct geographic regions. The application of such a conservation-oriented classification system is of particular importance in the Central Valley where a rapidly growing human population and large tracts of irrigated agriculture compete with aquatic organisms for water (Moyle and Ellison 1991).

RESOURCE DESCRIPTION

Freshwater fish habitats complement the other habitats described in this volume. In general, the proposed freshwater fish habitat designations are based on a hierarchical classification system (Moyle and Ellison 1991) developed to provide a structure for conservation efforts and is based on fish distribution and endemism.

This classification system has additional utility as it assumes that observations of fishes are representative of less well-known aquatic organisms such as insects and amphibians.

Major habitat classifications for the Central Valley include standing waters, flowing waters, and artificial habitats.

STANDING WATERS

This classification included ephemeral waters such as floodplain and vernal pools, and permanent waters such as lakes, sloughs, oxbow lakes, and backwaters. Floodplain pools are shallow pools and ponds resulting from receding floodwaters of the Sacramento and San Joaquin rivers and their major tributaries. These waters often support fish and other aquatic organisms early in the season but can become detrimental as they gradually become too warm to support fish and typically evaporate by late summer.

Vernal pools in the Central Valley are northern claypan pools. They are shallow, temporary pools formed in depressions that hold winter and spring rainfall. These pools support a rich variety of invertebrates and flowering plants. The larger pools may support tiger salamander and spadefoot larvae.

Permanent waters supporting fish are found throughout the Central Valley. These areas resulted from the meandering of the Sacramento and San Joaquin rivers which created oxbow lakes, backwater areas, and sloughs.

FLOWING WATERS

Flowing water fish habitats include the following classifications: resident trout streams, salmon-steelhead streams, and low elevation streams.

Resident trout streams include resident rainbow trout streams and rainbow trout/cyprinid streams. Resident rainbow trout streams are low order, cold, high gradient streams dominated by rainbow trout and riffle sculpins. Rainbow trout/cyprinid streams are small streams of moderate gradient supporting rainbow trout and one or more species of native minnows such as California roach or Sacramento sucker.

Salmon-steelhead streams include spring chinook streams and steelhead streams. Spring chinook streams are third to fifth order streams at elevations of 500-1500 m with deep canyons containing deep, cold pools that can sustain spring-run chinook salmon through the summer. Steelhead streams are second to fourth order streams used by steelhead for spawning and are dominated by juvenile steelhead.

Low elevation streams include valley floor rivers, fall chinook spawning stream, hardhead/squawfish streams, hitch streams, and California roach streams. Valley floor rivers include the main channels of the Sacramento and San Joaquin rivers, and the lower reaches of their tributary streams. Much of the flow is sluggish in summer and considerable cover is provided by woody debris and shaded riverine aquatic habitat. These low elevation streams flood seasonally and support a wide variety of fishes. Fall chinook salmon spawning streams are low elevation, low gradient tributaries to major rivers that dry up in summer but are used for spawning by both anadromous and resident fish species. Hardhead/squawfish stream are low- to mid-elevation streams characterized by deep, bedrock pools, clear water, and cool temperatures. The typical assemblage of fish include hardhead, Sacramento squawfish, and Sacramento sucker. Hitch streams are warm, low-elevation streams with low to moderate current and long reaches with sandy bottoms. Typical fish assemblages include hitch and Sacramento blackfish, although Sacramento squawfish and Sacramento sucker and other species may be present. California roach streams are small, clear, mid-elevation second, third, or fourth order streams that typically contain deep pools in canyons and are often intermittent in flow by late summer. The dominant species is California roach but juveniles of Sacramento squawfish and Sacramento sucker may be present.

ARTIFICIAL HABITATS

Artificial habitats include ephemeral water, permanent waters and flowing waters. Given the high development within the Central Valley and the development of water resources, it is not surprising that artificial habitats provide a significant amount of habitat.

Ephemeral water include rice paddies, wildlife refuges, drainage and evaporation ponds, and seasonally irrigated lands. Permanent waters include cold water ponds, warm water ponds, ornamental ponds, cold water reservoirs, cool water stratified reservoirs, warm water reservoirs, run-of-river reservoirs, forebays, and flooded pit lakes such as gravel and rock quarries. Flowing waters include aqueducts, drainage ditches, irrigations ditches, and flood control canals and bypasses such as the Yolo Bypass.

VISION

The vision for freshwater fish habitats is to protect existing habitat from degradation or loss, to restore degraded habitats, and restore areas to a more natural state. Freshwater fish habitat will be increased to assist in the recovery of special-status plant, fish, and wildlife populations. Restoration will provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

Freshwater Fish Habitats

Standing Waters

- ephemeral waters
  - floodplain pools
  - vernal pools
- permanent waters
  - lakes
  - sloughs
  - oxbow lakes
  - backwaters

Flowing Waters

- resident trout streams
  - resident rainbow trout streams
  - rainbow trout/cyprinid streams
- salmon-steelhead streams
  - spring chinook streams
  - steelhead streams
- low elevation streams
  - valley floor rivers
  - fall chinook spawning streams
  - hardhead/squawfish streams
  - hitch streams
  - California roach streams

Artificial Habitats

- ephemeral waters
  - rice paddies
  - wildlife refuges
  - drainage and evaporation ponds
  - seasonally irrigated lands
- permanent waters
  - cold water ponds
  - warm water ponds
  - ornamental ponds
  - cold water reservoirs
  - cool water stratified reservoirs
  - warm water reservoirs
  - run-of-river reservoirs
  - forebays
  - flooded pit lakes
- flowing waters
  - aqueducts
  - drainage ditches
  - irrigation ditches
  - flood control bypasses

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore freshwater fish habitat would involve cooperation with other restoration and management programs. These include:

- Central Valley Project Improvement Act including the Anadromous Fish Restoration Program,

- Department of Water Resources programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources,

- U.S. Army Corps of Engineers flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs),

- U.S. Bureau of Reclamation operation of the federal Central Valley Project to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration,

- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species,

- Other independent water projects in the Central Valley to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration (e.g., Yuba County Water Agency, East Bay Municipal Utilities District, Pacific Gas and Electric Company(,

- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirement for fish protection and propagation is streams,
- FERC regulations of minimum flow below hydropower projects, and
- State Water Resources Control Board administration of water rights for diversion and storage including decisions regarding instream flows for fish, water quality, and public trust resource protection.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Freshwater fish habitats are linked to other ecological elements in the Bay-Delta watershed. These important habitats are linked to our visions for:

- Central Valley streamflows,
- Central Valley stream temperatures,
- natural sediment supply,
- stream meander,
- natural floodplain and flood processes,
- Delta sloughs,
- riparian and riverine aquatic habitat,
- water diversions,
- dams, reservoirs, weirs, and other structures,
- levees, bridges, and bank protection,
- dredging and sediment disposal,
- gravel mining,
- invasive species,
- predation and competition, and
- fish and wildlife harvest.

STRATEGIC OBJECTIVE, TARGETS AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to protect existing and restore and increase the quality of freshwater fish habitat as an integral component of restoring large expanses of all major historical habitat types in the Central Valley and its rivers.

LONG-TERM OBJECTIVE: Restore, protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers to a substantial fraction of their pre-settlement areas or to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVES: Systematically identify and locate the best remaining areas containing the aquatic, wetland, and riparian habitat types, and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Moyle and Ellison (1991) and Moyle (1996) developed a scheme for classifying the aquatic habitats of California for the purposes of conservation. Other classification schemes of aquatic habitats also exist, as do schemes for classifying riparian and wetland habitats. Whatever the system, it is obvious that the diversity of aquatic habitats is declining in Central Valley watersheds, especially in lowland areas.

Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic protection of examples of the entire array of habitats in the region provides some assurances that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: A classification system for riverine and riparian habitats that can be used as a basis for conservation actions will have been developed. Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

The general targets for freshwater fish habitat are:

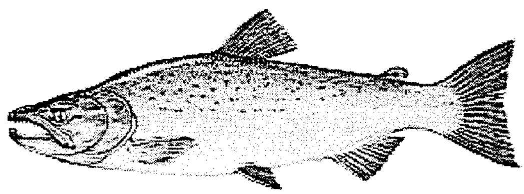
- protect and rehabilitate floodplain pools, sloughs, backwaters and oxbow lakes,
- improve the quality and extent of flowing water habitats,
- establish and protect a variety of functional habitats for biodiversity, scientific research (e.g., for resident trout streams, salmon-steelhead streams, etc),
- improve the quality of artificial habitats in the Central Valley to better support native fish species.

REFERENCES

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

Moyle. P.B., and J.P. Ellison. 1991. A conservation-oriented classifications system for the inland waters of California. California Fish and Game 77(4):161-180.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Essential Fish Habitat (EFH) is the aquatic habitat necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem. The salmon fishery EFH includes all those streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon. In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments to 60 km offshore. Salmon EFH excludes areas upstream of longstanding naturally impassible barriers (i.e., natural waterfalls in existence for several hundred years) (National Marine Fisheries Service 1998a).

The designation of these habitats is important to allow the systematic protection of biological diversity within distinct geographic regions. The application of such a conservation-oriented classification system is of particular importance in the Central Valley where a rapidly growing human population and large tracts of irrigated agriculture compete with aquatic organisms for water (Moyle and Ellison 1991).

RESOURCE DESCRIPTION

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act to establish new requirements for "Essential Fish Habitat" description in federal Fishery Management Plans (FMPs) and to require federal agencies to consult with the National Marine Fisheries Service on activities that may adversely affect EFH. The amended act requires the National Marine Fisheries Service to assist the Pacific Fisheries Management Council in the description and identification of EFH for each managed fishery and to provide the Pacific Fishery Management Council with proposed recommendations for EFH (National Marine Fisheries Service 1998a).

ESSENTIAL HABITATS FEATURES

Habitat and biological associations examined in the development of proposed EFH included:

- Eggs and spawning requirements
- Larvae and alevins requirements
- Juveniles in freshwater
- Juveniles in estuarine waters
- Juveniles in marine waters, and
- Adults requirements.

The National Marine Fisheries Service will assume a holistic approach toward implementation of EFH, and prefers not to subdivide by life stage or habitat type. The intent is to provide habitat conditions that support all life-cycle stages of chinook salmon: an approach fundamentally consistent with the ERP's emphasis on ecosystem management.

In summary, EFH is an integration of two major subdivisions: freshwater essential habitat and marine essential habitat.

Important features of essential habitat for spawning, rearing and migration include adequate:

(1) substrate composition; (2) freshwater water quality (e.g., dissolved oxygen, nutrients, temperature); (3) freshwater water quantity, depth and velocity; (4) channel gradient and stability; (5) food; (6) freshwater cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation); (7) space, (8) access and passage; (9) floodplain and habitat connectivity; (10) adequate marine water quality; (11) adequate marine water temperature; (12) adequate marine prey species and forage base; and (13) adequate depth, cover, marine vegetation, and algae in estuarine and near-shore habitats.

VISION

The vision for essential fish habitats is to maintain and improve the quality of existing habitats and to restore former habitats in order to support self-sustaining populations of chinook salmon.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore freshwater fish habitat would involve cooperation with other restoration and management programs. These include:

- Central Valley Project Improvement Act including the Anadromous Fish Restoration Program,
- Department of Water Resources programs to provide water supplies (State Water Project), flood protection facilities, water quality monitoring, and multipurpose management of California water resources,
- U.S. Army Corps of Engineers flood control operations of reservoirs and management of flood control facilities (e.g., levees, overflow channels and bypass weirs),
- U.S. Bureau of Reclamation operation of the federal Central Valley Project to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration,
- U.S. Fish and Wildlife Service and National Marine Fisheries Service programs to recommend flows and other measures needed for mitigating impacts from federal projects and protecting endangered species,
- Other independent water projects in the Central Valley to provide for multiple beneficial uses of water including fish and wildlife protection and habitat restoration (e.g., Yuba County Water Agency, East Bay Municipal Utilities District, Pacific Gas and Electric Company),
- California Department of Fish and Game responsibility to study and recommend streamflows and temperature requirement for fish protection and propagation is streams,
- FERC regulations of minimum flow below hydropower projects, and
- State Water Resources Control Board administration of water rights for diversion and storage including decisions regarding instream flows for fish, water quality, and public trust resource protection.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Essential Fish Habitats are linked to other ecological elements in the Bay-Delta watershed. These important habitats are linked to our visions for:

- Central Valley streamflows,
- Central Valley stream temperatures,

- natural sediment supply,
- stream meander,
- natural floodplain and flood processes,
- Delta sloughs,
- riparian and riverine aquatic habitat,
- water diversions,
- dams, reservoirs, weirs, and other structures,
- levees, bridges, and bank protection,
- dredging and sediment disposal,
- gravel mining, and
- invasive species.

STRATEGIC OBJECTIVE, TARGETS AND PROGRAMMATIC ACTIONS

Essential fish habitat is addressed by Strategic Plan Goals related to restoring aquatic, wetland, and riparian habitats in the Central Valley and its rivers, in the Delta, and in Suisun Bay, Suisun Marsh, and San Francisco Bay.

The Strategic Subobjective is to protect existing and restore and increase the quality of essential fish habitat as an integrated component of restoring large expanses of all major historical habitat types in the Central Valley and its rivers. (including the Delta, and Suisun and San Francisco Bay).

LONG-TERM OBJECTIVE: Protect and manage, on a self-sustaining basis throughout the watershed, multiple large areas containing all aquatic, wetland, and riparian habitat types in the Central Valley and its rivers (including the Delta and Suisun and San Francisco Bays) to a point where all at-risk species that depend on the habitats are no longer at risk.

SHORT-TERM OBJECTIVE: Systematically identify and locate the best examples of essential fish habitats and prioritize them for conservation. Develop and begin implementation of action plans for restoring significant examples of each habitat type.

RATIONALE: Declines in the abundance of chinook salmon have been well-documented throughout the southern portion of their range. Concern over coast wide declines from southeastern Alaska to the Pacific Northwest was a major factor leading to the signing of the Pacific Salmon Treaty between the United States and Canada in 1985. Naturally spawning chinook salmon populations have been extirpated from large portions of their historic range in a number of watersheds in California and all Evolutionarily Significant Units have been proposed for listing by the National Marine Fisheries Service (1998b).

Habitat degradation is the major cause for extinction of populations and many extinctions are related to dam construction and operation. Urbanization, agricultural land use, water diversion, and logging are also factors contributing to habitat degradation and the decline of chinook salmon (Nehlsen 1991). The development of large-scale hatchery programs have, to some degree, mitigated the decline in abundance of chinook in some areas. However, the genetic and ecological interactions of hatchery and wild fish have also been identified as risk factors for wild populations, and high harvest rated directed at hatchery fish may cause over-exploitation of co-mingled wild stocks (Reisenbichler 1997).

STAGE 1 EXPECTATIONS: Inventory of habitat types should be completed and areas prioritized for conservation actions. Restoration actions should be evaluated and initiated where feasible.

REFERENCES

Moyle. P.B., and J.P. Ellison. 1991. A conservation-oriented classifications system for the inland waters of California. California Fish and Game 77(4):161-180.

National Marine Fisheries Service. 1998a. Proposed recommendations for Amendment 14 to the Pacific Coast Salmon Plan for Essential Fish Habitat (Draft). March 26, 1998. 256 pp.

National Marine Fisheries Service. 1998b. Endangered and threatened species; proposed endangered status for two chinook salmon ESUs and proposed threatened status for five chinook salmon ESUs; proposed redefinition, threatened status, and revision of critical habitat for one chinook salmon ESU, proposed designation of chinook salmon critical habitat in California, Oregon, Washington, and Idaho. Federal Register 63(45):11481-11520.

Nehlsen, W. 1991. Pacific Salmon Status and Trends. A coast wide perspective, in Pacific salmon and their ecosystems: status and future options. D. Stouder, P. Bisson, and R. Naiman editors. Chapman and Hall, New York.

Reisenbichler, R. 1997. Genetic factors contributing to declines of anadromous salmonids in the Pacific Northwest, in Pacific salmon and their ecosystems: status and future options. D. Stouder, P. Bisson, and R. Naiman editors. Chapman and Hall, New York.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ INLAND DUNE SCRUB HABITAT

INTRODUCTION

Inland dune scrub is associated with inland sand dunes and is limited in the ERPP focus area to the vicinity of the Antioch Dunes National Wildlife Refuge. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants.

RESOURCE DESCRIPTION

Historic dunes within the Sacramento-San Joaquin Delta Ecological Management Zone may have covered 15,560 acres, based on soil surveys, including 8,510 acres of Delhi series, 5,810 acres of Piper series in Contra Costa County, and 1,300 acres of Tinnin series in Sacramento County. The Delhi series was a large area of dunes in the Antioch-Oakley area, of which the Antioch Dunes National Wildlife Refuge is a tiny remnant. The Piper series were small areas of remnant dunes within the organic soils of the Delta marshes, remnants of larger areas of dunes that existed prior to the rise in sea level at the end of the last ice age. The Tinnin series were small isolated dunes on the eastern edge of the Delta.

Remaining habitat areas are being protected. Recent land-use changes help this habitat support several special-status plant and wildlife species. Most protected inland dune scrub is located within the Antioch Dunes National Wildlife Refuge and Brannan Island State Park. Most of the inland dune scrub habitat outside these two areas are protected to various degrees.

Two special-status plant species, the Antioch Dunes evening primrose and the Antioch Dunes wallflower, are found with inland dune scrub. The Lange's metalmark, a butterfly listed as endangered under the federal Endangered Species Act (ESA), is known only from the Antioch Dunes, where it feeds on naked buckwheat. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes. The dunes represent a localized habitat that does not support other types of upland vegetation.

As in other dune ecosystems, such as coastal dunes and desert sand dunes, wind is the major process that shapes dunes and dune structures. The presence of the wind-modified, river-deposited sands, in combination with the Delta wind patterns, maintain a natural disturbance threshold that favors the establishment of the plant species that are characteristic of dunes and prevents the establishment of species less tolerant of these conditions.

Direct and indirect disturbances are reducing the extent and health of inland dune scrub habitat and its associated plants and animals. Sand mining directly removes habitat. Urban development has moved onto historical dune habitat and changed wind-flow patterns. Excessive foot traffic, off road vehicle traffic, and grazing disturb dune surfaces, which makes dunes more susceptible to erosion. Application of herbicides, pesticides, and fertilizers change ecological processes that may encourage or support non-native species.

Structures or activities that reduce or accelerate winds, wind-disturbances, or barriers to wind-driven sand movement, disrupt the processes that sustain dunes. Wind patterns blow river-deposited sand into shifting dunes. Shifting sand offers little stability for establishing plant root systems. Plant species characteristic of dunes survive within a disturbance threshold. Direct disturbances inhibit the ability of dune-associated plants to establish and result in loss of plant vigor or mortality. Sand movement barriers create conditions unfavorable for establishing native dune vegetation. These types of disturbances create site conditions conducive to establishing invasive weedy plants. Non-native weeds compete with native dune plants and reduce overall habitat quality. Continued disturbance of potentially restorable adjacent habitat could interfere with protecting and restoring additional areas of high-quality habitat by affecting dune structure and destroying buckwheat, Antioch evening primrose, and Antioch Dunes wallflower plants.

VISION

The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas. Achieving this vision will provide high-quality habitat for associated special-status plant and animal populations.

Restoration of inland dune scrub would focus on protecting and improving important existing habitat areas. Historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Management Zone would be reestablished. Protecting and restoring inland dune scrub habitat would begin by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat would be protected and restored.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore inland dune habitats will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- and the Delta Protection Commission,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Inland dune scrub habitat is limited to the area near the Antioch Dunes Ecological Reserve, Brannan Island State Park and a few other localities. This type of habitat is important for two plant and one butterfly species listed as endangered under the federal Endangered Species Act.

It is adversely affected by human caused actions that contribute to erosion and spread of non-native species. One important linkage in maintaining this habitat is maintenance of river flows which deposit sediments including sand which feed the dune formation process.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to protect and restore inland dune scrub habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta.

LONG-TERM OBJECTIVE: Restore inland dune scrub habitat in the Delta to a substantial fraction of its presettlement areas, or to a point where all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVE: Develop and begin implementation of action plans for significant examples of inland dune scrub habitat in the Delta.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub.

In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

General restoration targets for inland dune scrub habitat are directed at protecting and restoring 50 to 100 acres of low- to moderate-quality Antioch inland dune scrub habitat within or adjacent to existing ecological preserves in the Central and West Delta Ecological Management Unit.

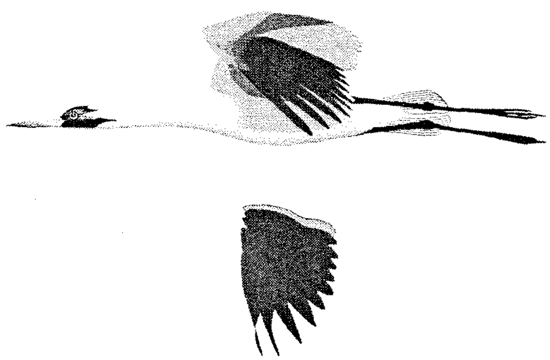
Managing protected areas could include reducing disturbance of dunes and dune vegetation. This could be accomplished by reducing vehicle and pedestrian access to dune areas. Protective structures, such as small boardwalks could be built. These actions would reduce habitat disturbance while maintaining recreational access. The following actions would help restore inland dunes:

- remove barriers to wind-driven sand-dune movement to increase the area that would be available for natural expansion of the sand-dune base;
- import sands from areas being developed or clean sand dredged from Bay-Delta channels to increase restoration potential and dune area;
- control non-native weeds to recreate conditions suitable to reestablishing native dune plants; and
- reduce the use of herbicides, pesticides, and fertilizers that adversely effect native dune vegetation and animals.

Dune habitat protection and restoration strategies could be implemented through cooperative efforts with existing ecological reserves. Restoration efforts should focus on implementing existing protection and restoration programs, establishing cooperative agreements with land management agencies, and establishing conservation easements or purchasing land from willing sellers.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Perennial grasslands provide important breeding and foraging habitat areas for many wildlife species and support several special-status plant species. Perennial grassland was historically common throughout the Central Valley. Most perennial grassland has been lost or converted into annual grassland. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to the adverse effects of grasslands conversion for agricultural, urban, and industrial uses, and continuing land use practices that maintain non-native annual grasses dominance in historic perennial grassland habitat.

RESOURCE DESCRIPTION

Perennial grassland provides habitat for many plant and wildlife populations and are important for maintenance of vernal pools and their associated plant and animal species.

In addition to supporting vernal pools, perennial grasslands provide valuable habitat for many wildlife species. Common grassland species include deer, San Joaquin kit fox, ground squirrels, kangaroo rats, and blunt-nosed leopard lizards, and nesting waterfowl. Where grassland still occurs, it also provides an extremely valuable transition zone and support area for adjacent habitats.

Perennial grasslands and associated vernal pools historically were present at drier, higher elevations in the Delta. Grasslands developed adjacent to wetland and riparian habitats that occupied wetter, lower elevation. Much of the perennial grasslands have been converted for other uses. Most remaining grasslands are now dominated by non-native annual grasses. Annual grasses out competed and replaced perennial bunch grasses over most of the Central Valley.

Extent and health of perennial grasslands in the Bay-Delta estuary are declining. Large areas of historic perennial grassland has been converted for agriculture, urban, and industrial uses. Remaining grasslands have been invaded by non-native annul grass. Many of the annual grass species out-compete native grasses. Fire-resistant, non-native species have been given an additional competitive edge from current fire suppression techniques. For example, native bunch grasses are fire resistant and adapted to relatively frequent fires because their perennating buds are near the ground and protected by the rest of the plant. Present fire suppression activities may favor non-native annuals which, because of infrequent catastrophic fires, destroy the bunch grasses when very hot fires burn the thatch which has built up over time. Fires promote plant succession and have aided in the intrusion of non-native fire-tolerant plants; and continuation of land use practices that maintain the dominance of non-native annual grasses.

VISION

The vision is to protect and improve existing perennial grasslands and increase perennial grassland area. This vision is a component of restoring wetland and riparian habitats. Achieving this vision will provide high-quality habitat for special-status plant and wildlife populations and other wildlife dependent on the Bay-Delta.

Restoration of perennial grassland would focus on reestablishing historic grasslands and protecting and improving important existing grassland areas in the Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, and Yolo Basin Ecological Management Zones. Grasslands would be restored as a component of wetland and riparian habitat restoration. Combining these restoration efforts increases overall habitat value for species that require multiple habitats. The proximity of habitats to each other (e.g., grasslands adjacent to wetlands provides nesting habitat for several species of ducks and refuge habitat for small mammals during flooding) and provides a protecting buffer from potential adverse effects of adjacent land uses.

Reducing land use changes and the introduction of non-native species will decrease the major stressors affecting perennial grasslands and vernal pools. The promotion of fire as a natural method for succession would aid in managing fire-sensitive non-native plants. Alternatives to the use of herbicides and other contaminants to control vegetation should be encouraged to promote more natural revegetation.

Increasing the quantity and quality of grasslands habitat conditions would help increase special-status plant and wildlife populations. Habitat improvements would also maintain or increase populations of other species that are dependent on grasslands in the estuary.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Perennial grasslands as used here is similar to the upland designation in Madrone Associates (1980) and the Goals Project (1999) description of grasslands.

Protecting and restoring perennial grasslands are objectives of agencies and organizations that operate many protected habitat areas. These include:

- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- Jepson Prairie Preserve,
- Putah Creek South Fork Preserve,
- Stone Lakes National Wildlife Refuge,
- and Woodbridge Ecological Reserve.

Restoring perennial grassland is also an objective of the Cache Creek Corridor Restoration Plan and Yolo County Habitat Conservation Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Perennial grasslands are an important component of the Bay-Delta ecosystem and provide habitat for many plant and wildlife populations. Common species dependent on perennial grasslands include deer, San Joaquin kit fox, blunt-nosed leopard lizards, kangaroo rats and nesting waterfowl. Grassland also provide an important transition habitat between adjacent habitat areas. In addition, health grasslands provide contributions to flood control function by slowing and extending storm events and by reducing erosion.

This type of habitat is adversely affected by land use, land conversion, and proliferation of non-native plant and grass species. Control of exotic plant species is a significant stressor and control programs need to be developed for protecting and restoring perennial grasslands.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Subobjective is to protect existing and increase the area of perennial grassland habitat as an integral component of restoring large expanses of all major historical habitat types in the Delta, in Suisun Bay, Suisun Marsh, and San Francisco Bay and other areas of the Central Valley.

Long-Term Objective: Restore perennial grasslands in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley to a substantial fraction of their pre-settlement areas, or to a point where all at-risk species that depend on the habitats are no longer at risk.

Short-Term Objective: Develop and begin implementation of action plans for restoring large and significant examples of perennial grasslands in the Delta, Suisun Bay, Suisun Marsh, San Francisco Bay, and other areas of the Central Valley.

Rationale: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. This reversal will require a large number of diverse and localized actions, from levee setbacks to land acquisition to better management of existing sites. The major habitat types to be restored include tidal shallow water habitat, freshwater emergent wetland, channel islands and associated habitats, tidal sloughs, nontidal freshwater emergent wetlands, seasonal upland wetlands, vernal pools and surrounding uplands, riparian forests and associated upland areas, perennial grassland, and inland dune scrub. In order to make restoration actions systematic and cost-effective, specific objectives need to be established for each of the habitat types, as well as subsets of them that have distinctive biological characteristics, and then priorities set within each objective for protection and restoration activities.

Stage 1 Expectations: A classification system for Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay habitats that can be used as a basis for conservation actions will have been developed. Specific, numeric objectives should be formulated for each habitat type, with restoration objectives based on clearly stated conceptual models. Within and among habitat types, conservation and restoration activities should be prioritized. Work should begin on those projects given highest priority within a year of adoption of the strategic plan.

The general target for perennial grassland is to protect and restore 4,000-6,000 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 1,000 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

Restoring, protecting, and improving grasslands could be achieved through:

- purchasing land or conservation easements or from willing landowners to protect important existing habitat areas from potential future degradation,
- establishing incentive programs to encourage landowners to establish and maintain perennial grasslands,

- implementing an intensive management program to control non-native vegetation and enhance native grasses and other plant species, and

- developing and implementing alternatives to land management practices on public lands that continue to degrade habitat quality or inhibit habitat recovery.

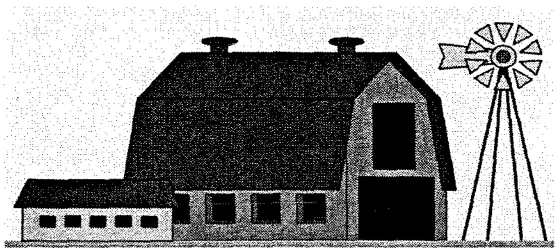
Restoring other ecological processes and habitats proposed by the Ecosystem Restoration Program Plan (ERPP) would also create opportunities for the managed reestablishment of grasslands elsewhere in the Central Valley.

REFERENCES

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Estuary Baylands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Bay Regional Water Quality Control Board, Oakland, California.

Madrone Associates. 1980. Delta wildlife habitat protection and restoration plan. Prepared for the California Department of Fish and Game and the U.S. Fish and Wildlife Service.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Following extensive native habitats loss in the Central Valley to agricultural and urban lands, some wildlife species have adapted to the artificial wetland and upland environments created by some agricultural practices. Once adapted, species became dependent on these agricultural areas to sustain their populations.

A major factor that limits this resource's contribution to the health of the Bay-Delta is related to adverse effects of some agricultural practices. Clean farming practices reduce the availability and quantity of forage and fence-line vegetation. Converting production from crops that provide relatively high-values for wildlife to relatively low-value crop types, displaces or insufficiently supports species that have adapted to the habitat. Converting agricultural lands for urban or industrial uses, also reduces or eliminates available habitat.

RESOURCE DESCRIPTION

Agricultural lands are located throughout the Central Valley. These lands comprise many different types of agricultural land uses ranging from non-irrigated grazing land to drip-irrigated vineyard. The type of crops grown on any particular parcel are usually dictated by soil type, topography, and availability of water. Intensively managed agricultural lands or croplands are located on flat or slightly rolling terrain. Flat cropland is usually the product of extensive surveying and laser land-leveling activities. Flat croplands provide more efficient use of water, less soil erosion, and higher crop yields. A variety of fragmented habitats that support various resident and migratory wildlife species are closely associated with these agricultural lands and includes naturally occurring wetland types (creeks, vernal pools, and gullies).

Agricultural lands being managed for certain crops and following certain agricultural practices create wetland-like benefits for certain wildlife. These lands can provide significant habitat for some wildlife species. Crop type and cultivation practices determine the quality of habitats. For example, rice lands support millions of wintering waterfowl using the Central Valley. Lands where wheat and corn have been harvested, particularly if they have been shallowly flooded after harvest, also support large populations of wintering waterfowl and the State-listed greater sandhill crane.

Major stressors that determine the wildlife values provided by agricultural lands include activities such as water quantity and quality management, crop type conversion from relatively high-wildlife-value crops to relatively low-wildlife-value crops (e.g., conversion from pastureland rowcrops to vineyards), the use of "clean farming techniques," deep postharvest discing, practices that reduce crop and grain residue within the field, cropland management with varied pesticide application, and the timing of these activities. Implementing appropriate land use management techniques accompanied by reimbursement programs to the agricultural stakeholder can reduce the adverse impacts of stressors on diverse agricultural habitat.

VISION

The vision for agricultural lands is to improve associated wildlife habitat values to support special-status wildlife populations and other wildlife dependent on the Bay-Delta. Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Protecting and enhancing agricultural lands for wildlife would focus on encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Vegetation management of agricultural lands could provide wildlife habitat at many locations, including rice checks, irrigation ditches, lowlands, ponds, fallow lands, fence rows, and other areas unsuitable for agricultural land use. Agricultural crop types that present excellent opportunities for enhancement include rice, alfalfa and pasture, corn and grain, and certain rowcrops. Enhancing agricultural lands adjacent to existing wildlife habitat areas, such as refuges, would be particularly beneficial. The value of enhanced land could be increased if nearby nonfarmed or fallow lands were managed to provide other habitats required by wildlife that use agricultural lands.

In some situations, altering common management practices can greatly increase wildlife habitat value with little or no change in crop production.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Numerous agricultural habitat improvement projects involving a number of project proponents are proposed and in various stages of development throughout the ecological management zones. Some of the more notable projects are:

- Stones Lakes National Wildlife Refuge, Cosumnes River Preserve, and
- Yolo Bypass Wildlife Management Area.

There are also many voluntary landowner incentive programs that involve various agricultural habitat improvements in the ecological management zones. These include:

- Wetland Reserve Program,
- Agricultural Conservation Program,
- Water Bank Program,
- Partners for Wildlife,
- California Waterfowl Habitat Program,
- Inland Wetland Conservation Program,
- Conservation Reserve Program,
- Agricultural-Wildlife Incentive Program (CVPIA), and
- Permanent Wetland Easement Program.

Governmental and private agencies and agricultural stakeholders involved in current agricultural land enhancement and management include:

- California Department of Fish and Game,
- Delta Protection Commission
- California Department of Water Resources,
- California Department of Transportation,
- U.S. Fish and Wildlife Service,
- U.S. Bureau of Land Management,
- U.S. Bureau of Reclamation,
- U.S. Natural Resources Conservation Service,
- Ducks Unlimited
- Valley Care (Ducks Unlimited),
- Central Valley Habitat Joint Venture,
- The Nature Conservancy,
- resource conservation districts,
- farm bureaus,
- county agricultural commissions,
- and various county land planning agencies.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Agricultural lands are an important habitat for many migratory wildlife species, particularly for wintering waterfowl and the State-listed greater sandhill crane.

Wildlife values of agricultural lands are adversely affected by water quantity and quality, type of agricultural crop produced, farming techniques, and application of pesticides.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Subobjective is to co-manage agricultural uplands and wetland habitat to provide enhanced wildlife forage and resting habitat for wintering and migrating waterfowl, shorebirds, and other associated wildlife in the Delta.

LONG-TERM OBJECTIVE: Prevent agricultural land near or adjacent to restored habitats from being converted to urban and suburban uses likely to have a negative effect on natural areas, while encouraging agricultural practices that favor birds and other wildlife and that minimize run-off of contaminants into nearby waterways.

SHORT-TERM OBJECTIVES: Identify agricultural lands in the region that are likely to have strong interactions with nearby wetlands, riparian areas, or aquatic habitats or that are important as habitat for waterfowl and other birds. Acquire conservation easements on high priority lands and provide incentives to farmers to use farming methods and crops that are favorable to wildlife.

RATIONALE: The Bay-Delta watershed is one of the most productive agricultural areas in the world, so agricultural lands and practices will always have a big influence on natural habitats in the area. The agricultural land is important as winter feeding grounds for sandhill cranes, various species of geese, and many ducks. It is also frequently important for foraging raptors, such as Swainson's hawk, and other birds. These benefits are lost if the land becomes urbanized and intense land use disturbs or alters adjacent wetlands or aquatic systems. The negative aspects of modern agriculture from an ecological perspective include its heavy use of pesticides, its efficiency of crop harvest (leaving little for wildlife), its capacity to change land use quickly (e.g., from row crops to vineyards) and its ability to use every scrap of available land. Thus, ideally, there should be a buffer zone of agricultural land that is farmed in environmentally friendly ways between the natural habitats and more industrial agriculture lands or urban areas.

Managing significant areas of agricultural lands in the Delta in a wildlife friendly manner will help offset some of the effects of other restoration actions which will convert other agricultural lands in the Delta to tidal wetlands thus reducing their value to species such as the greater sandhill crane or the Swainson's hawk.

STAGE 1 EXPECTATIONS: High priority agricultural lands should be identified and the process begun to acquire easements from willing sellers; incentive programs should be developed and implemented to encourage the planting of crops favored by wildlife and to farm in ways that minimize environmental damage to adjacent areas.

The general target for agricultural land is to cooperatively manage 40,000-75,000 acres for agriculture and wildlife in the Sacramento-San Joaquin Delta Ecological Management Zone.

Actions that would help increase wildlife quality include:

- deferring fall tillage until later in the year can increase the quantity of forage on cornfields for waterfowl and greater sandhill cranes,
- shallow flooding of seasonal croplands in fall/winter can greatly increase the availability of forage for wintering waterfowl
- retaining a percentage of the unharvested crop in the agricultural field would enhance the value of flooding.

Incidental benefits to agricultural stakeholders from improving conditions for wildlife would be:

- groundwater recharge to aquifers used for summer irrigation,
- leaching salts from soils,
- biological decomposition of crop residue,
- reduction in soil erosion, and
- create an opportunity for cash income from hunting and increase esthetic values, both of which may increase property values.

Protecting and enhancing agricultural lands would be achieved through participation and cooperation with agricultural stakeholders, including farmers, ranchers, and other landowners and lessees. Mechanisms to protect and enhance agricultural lands include various multi year agreements, conservation easements, and purchases through specific payment programs between resource agencies and willing participants.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ SPECIES AND SPECIES GROUP VISIONS

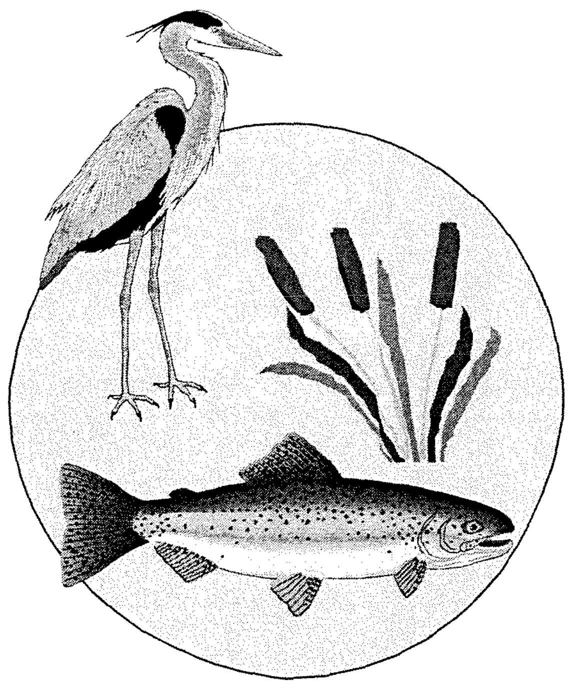
INTRODUCTION

This section presents visions for species and species group ecosystem elements. Species and species groups included occur in or are dependent on the Bay-Delta. Many of these species are listed or candidate species for listing as threatened or endangered under the California Endangered Species Act (CESA), listed or proposed for listing under the federal Endangered Species Act (ESA), or designated as a species of special concern by the California Department of Fish and Game (DFG), or the U.S. Fish and Wildlife Service (USFWS). Visions were also created for important recreational or commercial species. Table 12 identifies important fish and wildlife species and species groups and associated strategic objectives. Table 13 presents the basis for selecting each species or species group as an ecosystem element. Species are grouped by the following Strategic Plan Goals:

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

- ***GOAL 3: Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the previous goal.***

Visions describe what the Ecosystem Restoration Program hopes to achieve for each species and species group, how the vision is to be achieved through restoring ecological processes and habitats and reducing the effects of stressors.



Proposed population targets and programmatic actions to help achieve targets are also included in visions. "Ecosystem Restoration Program Plan, Volume II: Ecological Management Zone Visions" contains more specific objectives, targets, and programmatic actions for each species by specific geographic zone. Table 14 identifies which ecological management zone(s) in which the species are treated in more detail.

Consistent with the Strategic Plan, this section is divided into five sections which correspond with the classification system used for Strategic Objectives. Four of the classes fall under Strategic Goal 1, and the remaining class is linked to Goal 3. The divisions follow:

- **HIGH PRIORITY AT-RISK SPECIES** (Priority Group I): These are at-risk species, most of which are listed or proposed for listing under the State or federal ESA, and whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of the year).

- **AT-RISK NATIVE SPECIES** (Priority Group II): These are at-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed (e.g., brackish water plants).

- **AT-RISK UPSTREAM NATIVE SPECIES** (Priority Group III): These are at-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.

- **DECLINING NATIVE SPECIES** (Priority Group IV): These are native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not takes to reverse their declines or keep populations at present levels. Their rehabilitation either does not depend on conditions in the Bay-Delta system or depends on unknown factors.

- **HARVESTED SPECIES:** These are species that support recreational and commercial harvest not already covered by the previous classes.

LINKAGE TO CONSERVATION STRATEGY

The Multi-Species Conservation Strategy addresses all federally and State listed, proposed, and candidate species that may be affected by the CALFED Program; other species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the Strategy. The term "covered species" is used to refer to all of the species addressed by the Conservation Strategy.

Not all covered species are within the ERP focus area and thus are not reflected in the ERP. For example, the giant kangaroo rat is a covered species but classed a species which occurs in areas that would not be affected by CALFED actions. It is included in the Conservation Strategy because it is federally or State-listed as an endangered, threatened, rare, or fully protected species.

The ERP includes species whose range is entirely or nearly entirely with the Study Area such as delta smelt, species for which CALFED actions affect only a limited portion of their range such as little willow flycatcher, and species expected to be minimally affected by CALFED actions such as the California freshwater shrimp.

Conservation Strategy species designations of recover (R), contribute to recovery (r), and maintain (m) are described earlier in this volume (Page 39).

The reader should refer to the Multi-Species Conservation Strategy report and appendices for complete information regarding the basis, scope, and content of the Strategy.

Table 12. Strategic Plan Goals, Objectives and Multispecies Conservation Strategy (CS) Designation for Ecosystem Restoration Program Species and Species Groups.

Strategic Plan Goal 1.
Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

Priority Group I. ***At-risk species, most of which are listed or proposed for listing under the State or federal ESA, and whose management for restoration implies substantial manipulations of the ecosystem.***

Species	CS[1]	Strategic Plan Objective
Delta Smelt	R	Restore delta smelt to the Delta and Suisun Bay
Longfin Smelt	R	Restore longfin smelt to the Delta and Suisun Bay.
Green Sturgeon	R	Restore green sturgeon to the Delta and Suisun Bay.
Splittail	R	Restore splittail to the Delta, Suisun Bay, and the Central Valley.
Sacramento Winter-run Chinook Salmon	R	Restore winter-run chinook salmon to the Sacramento River and the Bay-Delta estuary.
Sacramento Spring-run Chinook Salmon	R	Restore spring-run chinook salmon to Central Valley streams and the Bay-Delta estuary.
Sacramento Late-fall-run Chinook Salmon	R	Restore late-fall-run chinook salmon to Central Valley streams and the Bay-Delta estuary.
Fall-run Chinook Salmon	R	Restore self-sustaining fall-run chinook salmon to Central Valley streams and the Bay-Delta estuary.
Steelhead Trout	R	Restore self-sustaining Central Valley steelhead to Central Valley streams and the Bay-Delta estuary.
Priority Group II: ***At-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed***		
Lamprey Family	NC	Restore anadromous lampreys dependent on the Delta and Suisun Bay.
California Clapper Rail	r	Restore California clapper rail.
California Black Rail	r	Restore a self-sustaining population of California black rail within its historical range.
Swainson's Hawk	r	Restore Swainson's hawk populations.

Species	CS[1]	Strategic Plan Objective
Suisun Song Sparrow	R	Restore the population of Suisun song sparrow to representative habitats within its range.
Alameda Song Sparrow	NC	Increase habitat for Alameda song sparrow in the southern San Francisco Bay region.
Salt Marsh Harvest Mouse	r	Restore salt marsh harvest mouse populations to tidal marsh within its historical range.
Suisun Ornate Shrew	R	Restore Suisun ornate shrew to representative habitats within its historical range.
San Pablo California Vole	r	Maintain current San Pablo California vole population and conduct further research into vole genetics.
Perennial Grassland Special Status Plant Species ■ Fragrant fritillary ■ Recuvred larskspur	NC	Preserve and restore perennial grassland habitat in conjunction with restoration of wetland and riparian habitats.
Tidal Brackish and Freshwater Marsh Special Status Plant Species ■ Mason's lilaeopsis ■ Suisun Marsh aster ■ Bristly sedge ■ Mad-dog skullcap ■ Suisun thistle ■ Soft bird's beak ■ Rose-mallow ■ Delta tule pea ■ Delta mudwort	 R R r m R R m r r	Restore at-risk endemic tidal brackish and freshwater tidal marsh plants.
Aquatic Habitat Special Status Plant Species ■ Eel-grass pondweed	 m	Maintain eel-grass pondweed in nontidal perennial aquatic habitats in the Bay-Delta estuary.

Species	CS[1]	Strategic Plan Objective
Vernal Pool Special Status Plant Species ■ Colusa grass ■ Boggs Lake hedge-hyssop ■ Contra Costa Goldfields ■ Legenere ■ Alkali milkvetch ■ Dwarf downingia ■ Crampton's tuctoria ■ Heartscale	 m m m m r NC r m	Maintain or contribute to the recovery of at-risk endemic vernal pool species.
Inland Dune Special Status Plan Species ■ Antioch Dunes evening-primrose ■ Contra Costa wallflower	 R R	Recover at-risk inland dune special status plants.
Valley Elderberry Longhorn Beetle	R	Increase and maintain habitat to recover valley elderberry longhorn beetle.
Priority Group III:		***At-risk species that primarily live upstream of the estuary or in local watersheds of San Francisco Bay.***
Sacramento Perch	r	Restore Sacramento perch within its native range.
Riparian Brush Rabbit	r	Restore riparian brush rabbit throughout its historical range.
San Joaquin Valley Woodrat	r	Restore the San Joaquin Valley woodrat to the full extent of its habitat.
Greater Sandhill Crane	r	Increase the greater sandhill crane populations in the Central Valley.
Western Least Bittern	m	Restore wintering populations of western least bittern in the Central Valley to historic levels.
Least Bell's Vireo	r	Restore Least Bell's vireo to representative habitats throughout its former range.
California Yellow Warbler	r	Restore and protect habitats used by neotropical migrant birds for breeding and forage in the Central Valley.
Western Yellow-Billed Cuckoo	r	Restore populations of yellow-billed cuckoo throughout its historical range in the Central Valley.
Bank Swallow	r	Increase the number of breeding colonies of bank swallow in the Central Valley.

Species	CS[1]	Strategic Plan Objective
Little Willow Flycatcher	r	Restore little willow flycatcher populations to habitats throughout its former range in Central California.
Native Anuran Amphibians		Restore native anuran amphibians throughout the Central Valley.
California Red-legged Frog	m	Restore California red-legged frog to representative habitats throughout its former range.
California Tiger Salamander	m	Restore California tiger salamander to representative habitats throughout its range.
Giant Garter Snake	r	Restore populations of giant garter snake to its historical range.
Western Pond Turtle	m	Restore self-sustaining populations of western pond turtle to habitats throughout the Central Valley.
Delta Green Ground Beetle	r	Restore Delta green ground beetle to multiple populations within its presumed natural range.
Lange's Metalmark Butterfly	m	Restore Lange's metalmark butterfly to multiple populations within its natural range.
California Freshwater Shrimp	m	Restore populations of California freshwater shrimp throughout its former range.
***Priority Group IV:** Native species in the estuary and watershed not yet at risk of extinction that have the potential to achieve that status if steps are not takes to reverse their declines or keep populations at present levels.*		
Native Resident Fish Species ▪ hardhead ▪ other species	 r NC	Reverse the decline of native resident fishes.
Migratory Waterfowl	NC	Enhance populations of waterfowl for harvest by hunting and for non-consumptive recreation.
Upland Game	NC	Maintain healthy populations and restore habitats that promote the expansion of populations at levels that can support both consumptive and nonconsumptive uses and provide additional opportunities for those uses.
Shorebird Guild	NC	Ensure that members of the shorebird guild continue to be abundant, diverse, and important members of the local fauna.
Wading Bird Guild	NC	Maintain or expand populations of bird species that are members of the wading bird guild.

Species	CS[1]	Strategic Plan Objective
Neotropical Migratory Birds	NC	Restore and protect habitats used by neotropical migrant birds for breeding and forage in the Bay-Delta watershed.
Western Spadefoot Toad	m	Restore spadefoot toad populations to representative habitats throughout its range.
Planktonic Organisms	NC	Restore assemblages of planktonic organisms in the Delta and Suisun Bay to states of increased abundance and greater predictability in composition.
Aquatic Habitat Plant Community Group	NC	Increase the amount of aquatic habitat plant communities in the Delta to provide habitat for pondweeds with floating and submerged leaves.
Tidal Brackish and Freshwater Marsh Habitat Plant Community Group	NC	Protect and enhance existing tidal brackish and freshwater marsh habitat plant communities by restoring tidally influenced marsh areas in the Delta.
Seasonal Wetland Habitat Plant Community Group	NC	Restore and manage seasonal wetland habitat plant communities in the Delta.
Inland Dune Habitat Plant Community Group	NC	Improve low- to moderate-quality inland dune habitat to support special-status plant and animal species and other associated plant and wildlife species.
Tidal Riparian Habitat Plant Community Group	NC	Restore and enhance tidal riparian vegetation along largely non-vegetated, riprapped banks of Delta island levees, the Sacramento and San Joaquin rivers, and their major tributaries.
Strategic Plan Goal 3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest consistent with the previous goal.		
White Sturgeon	NC	Enhance fisheries for white sturgeon.
Striped Bass	NC	Maintain fisheries for striped bass.
American Shad	NC	Maintain fisheries for American shad.
Non-native Warmwater Gamefish	NC	Maintain fisheries for non-native warmwater gamefishes.
Pacific Herring	NC	Enhance fisheries for Pacific herring.
Grass Shrimp	NC	Maintain fisheries for grass shrimp in the San Francisco Bay.
Signal Crayfish	NC	Maintain fisheries for signal crayfish in the Delta.

1. CS = Conservation Strategy, R = Recover, r = contribute to recovery, m = maintain, NC = Not Covered.

Table 13. Basis for Selection of Species and Species Group Ecosystem Elements.

Species and Species Groups	Basis for Selection as an Ecosystem Element
Delta Smelt	The delta smelt is a native estuarine resident fish that has been listed as threatened under the California and federal Endangered Species Acts.
Longfin Smelt	The longfin smelt is a native estuarine resident species and is designated as a species of special concern by DFG and a species of concern by USFWS.
Green Sturgeon	The green sturgeon is designated as a species of special concern by DFG and a species of concern by USFWS.
Splittail	The splittail is a native resident fish that is listed under the federal Endangered Species Act and a candidate for listing under the California Endangered Species Act. The splittail also supports a small winter sport fishery in the lower Sacramento River.
Sacramento Winter-run Chinook Salmon	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The winter-run race is listed as endangered under the California and federal Endangered Species Acts.
Sacramento Spring-run Chinook Salmon	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The spring-run race on the Sacramento River is listed as a threatened species under CESA and proposed for listing under the ESA.
Fall-run Chinook Salmon	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The fall-run race is the largest population of chinook salmon on the Sacramento River. It is proposed for listing under the ESA.
Sacramento Late-fall-run Chinook Salmon	The chinook salmon is an important native anadromous sport and commercial fish with important ecological value. The late-fall-run race on the Sacramento River is proposed for listing under the ESA.
Steelhead Trout	The steelhead is an important native anadromous sport fish of high recreational and ecological value. The Central Valley Steelhead Evolutionarily Significant Unit is listed as threatened under the ESA.
Lamprey Family	Anadromous lamprey is an important native anadromous fish of high ecological value. The status, abundance, and distribution of anadromous lamprey is unknown.
California Clapper Rail	The California clapper rail is listed as endangered under the California and federal ESAs.
California Black Rail	The California black rail is listed as threatened under the California ESA.
Swainson's Hawk	The Swainson's hawk is listed as threatened under the California ESA.
Suisun Song Sparrow	The Suisun song sparrow is a species of special concern.

Species and Species Groups	Basis for Selection as an Ecosystem Element
Alameda Song Sparrow	The Alameda song sparrow is a California species of special concern.
Salt Marsh Harvest Mouse	The salt marsh harvest mouse is listed as endangered under the California and federal ESAs.
Suisun Ornate Shrew	The Suisun ornate shrew is a species of special concern.
San Pablo California Vole	The San Pablo California vole is a California species of concern.
Special-status Plant Species	Special-status plant species include plants associated with a wide variety of habitats including perennial grasslands (fragrant fritillary, recurved larkspur), tidal brackish and freshwater marsh complexes (Mason's lilaeopsis, Suisun Marsh aster, bristly sedge, mad-dog skullcap, Suisun thistle, soft bird'- beak, rose-mallow, Delta tule pea and Delta mudwort), aquatic habitat associated with shorelines of rivers and the Delta (eel-grass pondweed), vernal pools (Colusa grass, Boggs Lake hedge-hyssop, Contra Costs goldfields, alkali milk-vetch, dwarf downingia, Crampton's tuctoria, and heartscale), and inland dunes (Antioch Dunes evening primrose, Contra Costa wallflower). Protection, enhancing, or restoring these special-status plant species will necessarily rely on protecting, enhancing, and restoring the appropriate type of habitat.
Valley Elderberry Longhorn Beetle	The valley elderberry longhorn beetle listed as threatened under the federal ESA.
Sacramento Perch	The Sacramento perch is a California species of special concern.
Riparian Brush Rabbit	The riparian brush rabbit is listed as endangered under the California ESA.
San Joaquin Valley Woodrat	The San Joaquin Valley woodrat is proposed for endangered status under the ESA and is a California species of special concern.
Greater Sandhill Crane	The greater sandhill crane is listed as a threatened species under CESA.
Western Least Bittern	The western least bittern is a California species of special concern.
Least Bell's Vireo	Least Bell's vireo is listed as endangered under ESA and CESA.
California Yellow Warbler	The California yellow warbler is a California species of special concern.
Western Yellow-billed Cuckoo	The western yellow-billed cuckoo is listed as endangered under the CESA.

Species and Species Groups	Basis for Selection as an Ecosystem Element
Bank Swallow	The bank swallow is listed as threatened under the CESA.
Little Willow Flycatcher	The little willow flycatcher is listed as an endangered species under CESA.
Western Spadefoot Toad	The western spadefoot toad is an amphibian designated as species of special concern.
California Red-legged Frog	The California red-legged frog is listed as a threatened species under the federal ESA.
California Tiger Salamander	The California tiger salamander is an amphibians designated as species of special concern.
Giant Garter Snake	The giant garter snake is listed as threatened under the California and federal ESAs.
Western Pond Turtle	The western pond turtle is designated as a species of special concern and a species of concern by DFG and USFWS, respectively.
Delta Green Ground Beetle	The delta green ground beetle is listed as endangered under the federal ESA.
Lange's Metalmark Butterfly	The Lange's metalmark is listed as endangered under the federal ESA.
California Freshwater Shrimp	The California freshwater shrimp is listed as an endangered species under ESA.
Native Resident Fishes	Resident fish species of the Delta include native and non-native species and are important ecologically and as indicators of ecosystem health. Some native species are important elements of the foodweb; others are important predators. Native resident fish have been in decline as a percentage of total fish species abundance in tributaries of the Bay-Delta/Central Valley watershed. Some non-native species are considered beneficial as prey species for other fish or as sport fish. Other species are considered undesirable because they compete with or are predators on native fish. Wakasagi is a close relative to delta smelt and could threaten the delta smelt population by interbreeding or by competing for habitat.
Bay-Delta Foodweb Organisms	Foodweb organisms are essential for the survival and productivity of fish, shorebirds, and other higher order animal populations in the Bay-Estuary.

Species and Species Groups	Basis for Selection as an Ecosystem Element
Shorebird and Wading Bird Guild	Many species of shorebirds and wading birds migrate through, winter, or breed in the Bay-Delta. These species are significant components of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures.
Migratory Waterfowl	Many species of waterfowl migrate through, winter, or breed in the Bay-Delta. Waterfowl are significant components of the ecosystem, are of high interest to recreational hunters and bird watchers, and contribute to California's economy through the sale of hunting and related equipment.
Neotropical Migratory Birds	Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are significant components of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures.
Upland Game	Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and expenditures.
Plant Community Groups	Plant community groups include aquatic habitat plant communities (pondweeds with floating and submerged leaves), tidal brackish and freshwater marsh plant communities (pickleweed series, saltgrass series, bulrush series, cattail series, and common reed series), seasonal wetland plant communities (northern claypan vernal pool communities, northern hardpan vernal pool communities, inland dune plant communities (Antioch Dunes plant community), and tidal riparian habitat plant communities (black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series).
White Sturgeon	The white sturgeon is an important native anadromous sport fish with high recreational and ecological value.
Striped Bass	The striped bass is an important non-native anadromous sport fish with high recreational value. It also plays an important role as a top predator in the aquatic system.
American Shad	The American shad is an important non-native anadromous sport fish with high recreational value.
Non-native Warmwater Gamefish	Non-native warmwater gamefishes provide abundant opportunities for recreational angling.
Pacific Herring	Pacific herring support the most valuable commercial fishery in San Francisco Bay.
Grass Shrimp	Grass shrimp support bait fisheries in the Bay.
Signal Crayfish	The signal crayfish is an introduced species that supports a small commercial fishery, as well as a sport fishery, in the Delta.

Table 14. Ecological Management Zones in Which Programmatic Actions Are Proposed That Will Assist in the Recovery of Species and Species Groups.

[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding specific targets and actions.]

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Delta Smelt	●	●												
Longfin Smelt	●	●												
Green Sturgeon	●	●	●					●				●		
Splittail	●	●	●			●		●	●	●	●	●		
Winter-run Chinook Salmon	●	●	●	●	●									
Spring-run Chinook Salmon	●	●	●			●	●						●	
Fall-run Chinook Salmon (including late-fall-run)	●	●	●	●	●	●	●	●	●	●	●	●	●	
Steelhead Trout	●	●	●	●	●		●	●	●	●	●	●	●	
Lamprey	●	●	●	●	●		●	●	●	●	●	●	●	●
California Clapper Rail		●												
California Black Rail	●	●												
Swainson's Hawk	●	●							●	●	●	●	●	
Suisun Song Sparrow		●												
Alameda Song Sparrow		●												
Salt Marsh Harvest Mouse		●												
Suisun Ornate Shrew		●												

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
San Pablo California Vole		●												
Special-status Plant Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Valley Elderberry Longhorn Beetle	●	●	●	●	●									
Riparian Brush Rabbit	●											●	●	
San Joaquin Valley Woodrat	●											●	●	
Sacramento Perch	●	●	●	●							●	●	●	●
Greater Sandhill Crane	●													
Western Yellow-Billed Cuckoo	●		●									●	●	
Bank Swallow				●										
Western Least Bittern	●	●	●	●								●		
Least Bell's Vireo	●	●	●	●								●		
California Yellow Warbler	●	●	●	●	●	●	●	●	●	●	●	●	●	
Little Willow Flycatcher				●					●		●	●	●	
Giant Garter Snake	●	●				●	●		●		●	●	●	
California Tiger Salamander	●													
Western Spadefoot Toad	●													

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
California Red-Legged Frog	●					●	●		●		●	●	●	●
Native Anuran Amphibians	●	●				●	●		●		●	●	●	●
Western Pond Turtle	●	●				●	●		●		●	●	●	
Delta Green Ground Beetle	●	●												
Lange's Metalmark Butterfly	●	●												
California Freshwater Shrimp		●												
Native Resident Fish Species	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Bay-Delta Foodweb Organisms	●	●												
Shorebird and Wading Bird Guild	●	●											●	
Waterfowl	●	●				●	●	●	●		●	●	●	●
Neotropical Migratory Bird Guild	●	●	●	●						●	●	●	●	●
Upland Game	●		●							●	●	●	●	●
Plant Community Groups	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Striped Bass	●	●	●					●	●			●		
White Sturgeon	●	●	●					●				●		

Species and Species Group Visions	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
American Shad	●	●	●					●	●			●		
Non-native Warmwater Gamefish	●	●	●							●	●	●	●	●
Pacific Herring		●												
Signal Crayfish	●		●											
Grass Shrimp		●												

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin

◆ High Priority At-risk Species

Introduction

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. The first Strategic Goal focuses on at-risk species:

> ***GOAL 1: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.***

Because there are so many species covered under this goal, they have been divided into four groups in terms of priority for CALFED attention. Many are "at-risk" species, which are in danger of extinction if present trends continue.

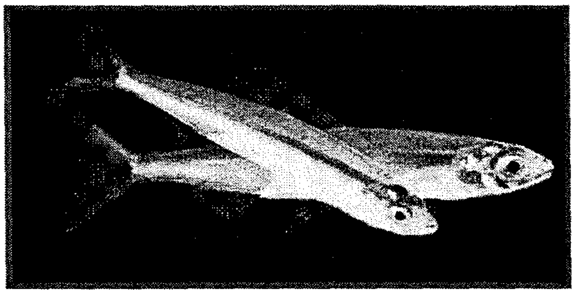
First Priority Species are at-risk fishes, most of them listed under the ESA or proposed for listing, whose management for restoration is likely to have large-scale effects on ecosystem functioning (e.g., requiring large amounts of freshwater at certain times of year). First priority species are species for which CALFED takes major responsibility for their recovery and removing them from the threat of extinction, *at a minimum*.

The objectives and expectations for this goal are narrowly aimed, for the most part, on actions that benefit individual at-risk species. In the short run, this is appropriate because ecosystem restoration requires that we keep all the pieces around for the rebuilding process.

High Priority At-risk Species (Priority Group I): These are at-risk species, most of which are listed or proposed for listing under the State or federal ESA, and whose management for restoration implies substantial manipulations of the ecosystem (e.g., requiring large amounts of fresh water at certain times of the year).

Species in the Priority 1 group include:

- Delta smelt
- Longfin smelt
- Green sturgeon
- Splittail
- Sacramento winter-run chinook salmon
- Central Valley spring-run chinook salmon
- Late-fall-run chinook salmon
- Fall-run chinook salmon
- Central Valley steelhead.



INTRODUCTION

The delta smelt is a native estuarine resident fish. Delta smelt are found mainly in the waters of the Sacramento-San Joaquin Delta and in Suisun and San Pablo Bays. They are found only in the Sacramento-San Joaquin Estuary. Delta smelt are most abundant in Montezuma Slough, Suisun Bay, and the western Delta, but beginning in December and continuing through perhaps June 30, migrate upstream and are more abundant in the Delta. They have been found as for upstream as the mouth of the American River on the Sacramento River as Mossdale on the San Joaquin River. Human-caused adverse habitat modifications reduced delta smelt populations resulting in its listing as threatened under State and federal Endangered Species Acts

Major factors that limit this species' contribution to the health of the Delta are adverse effects of low Delta outflow, poor foodweb productivity, reduced low-salinity habitat, losses to water diversions, poor spawning habitat, and potentially higher concentrations of toxins.

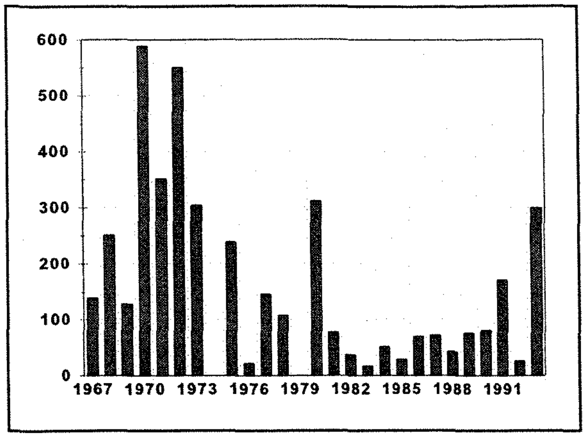
RESOURCE DESCRIPTION

Delta smelt are native to the Sacramento-San Joaquin Delta estuary and represent an important component of the historic native fish fauna and Bay-Delta foodweb (i.e., as a prey species for species such as chinook salmon). Delta smelt's 1-year life span and relatively low reproductive rate make its population abundance sensitive to short-term habitat changes. As a consequence, the population abundance of delta smelt is characterized by sharp declines followed by dramatic recovery. Low abundance through the drought years (1987-1992) indicated need for actions to restore the delta smelt population. Delta smelt are considered environmentally sensitive because the have a one year life cycle, unusually low fecundity, a limited diet, and reside primarily within the interface between salt and freshwater.

During the late winter to early summer, delta smelt migrate to freshwater to spawn. Females only produce between 1,000 and 2,600 eggs which sink to the bottom and attach to the substrate. Spawning habitat includes shallow freshwater sloughs and edge waters with firm substrate, submerged vegetation, and woody debris. Rearing habitat includes shallow freshwater and low salinity (less than 6-8 ppt salinity) habitats that provides a protective, food-rich environment. Such habitats include shallow bays, tidal sloughs, shoals, shorelines, and marsh channels.

Land reclamations in the Bay-Delta have diminished the quality and quantity of shallow-water, marsh-slough habitat. Remaining shallow-water, low-salinity habitat is further reduced in dry-water years because of extensive water diversions from the Delta.

Population abundance during 1993 and 1995 (relative to abundance during the 1987-1992 drought) suggests that recovery potential may be high. Sharp population decline during drought conditions (as in 1994), however, illustrates the potential threat of poor conditions to the species' survival under existing habitat and stressor



Abundance Data for Delta Smelt from DFG September and October Fall Mid Water Trawl Survey (USFWS 1996)

conditions. A preliminary low abundance index in 1996, a wet year, is further cause for concern. The fall mid water trawl (FMWT) is best measure of delta smelt abundance (Sweetnam and Stevens 1993) as it measures the abundance of pre-spawning adults. September and October abundances of adults were chosen as they represent the months most continuously samples during the last 30 years. It includes cumulative data for 35 sampling stations.

Delta smelt tolerate a wide range of salinity but are most abundant in the Bay-Delta estuary, where salinity is around 2 parts per thousand (ppt). Spawning occurs in freshwater in the upstream areas of the Delta. Construction of levees in the 1800s created narrow channels and eliminated vast areas of marshes and interconnecting sloughs. Marshes and adjoining sloughs are very productive and support an abundance of zooplankton, on which delta smelt feed, and are important as spawning and rearing habitat for the species.

Reduced freshwater outflow during the late winter and spring of dry years allows saltwater to move farther upstream in the estuary than during wet years. This reduces the amount of low-salinity habitat for delta smelt. The increased upstream saltwater movement changes the location of habitat that meets the salinity needs of the delta smelt, similar to effects on other Delta fish species such as striped bass, longfin smelt, and Sacramento splittail. Habitat location is shifted upstream from the relatively shallow, productive bays, marshes, and sloughs of Suisun Bay and into the narrow, deeper, and less-productive channels of the Delta.

The upstream shift also increases exposure to Delta water diversions. Water is drawn from the Delta by hundreds of small agricultural diversions, Central Valley Project (CVP) and State Water Project (SWP) South Delta export pumps, and Pacific Gas & Electric (PG&E) power generation facilities. During most years, large numbers of delta smelt are lost to Delta diversions.

Food availability, toxic substances, competition and predation (particularly from non-native species), and loss of genetic integrity through hybridization with the introduced Japanese pond smelt (wagasaki) also are other factors believed to influence smelt abundance.

Overall, the threats to the population, in decreasing order of importance, are:

- reduction in outflow from the Estuary,
- entrainment to water diversions,
- extremely high outflow,
- changes in food organisms,
- toxic substances,
- disease, competition, and predation, and
- loss of genetic integrity by hybridization with introduced wagasaki.

VISION

The vision for delta smelt is to recover this State- and federally listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta. Achieving this vision will reduce the conflict between protection for this species and other beneficial water uses in the Bay-Delta. Increases in the population and distribution of delta smelt can be realized through habitat restoration accompanied by reductions in stressors.

Delta smelt would benefit from the many expected improvements in ecosystem processes and habitats, and reductions in stressors. These improvements will result from the wide variety of actions proposed for the Delta and Suisun Bay. Improvements in streamflow (Delta inflow and outflow) would better attract adults to spawning habitat, ensure transport or movement of larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Additional freshwater flow could be provided reservoir releases during spring to maintain salinity requirements of delta smelt in areas that are good nurseries of delta smelt, such as Suisun Bay and Marsh.

Delta smelt would benefit from spawning and rearing habitat restoration. Habitat restoration may be achieved by adding and modifying physical habitat and creating additional freshwater flow during critical periods. More habitat can be created by breaching levees to inundate lands once part of the Bay and Delta, setting levees back to increase shallow-water habitat along existing channels, protecting existing shallow-water habitat from erosion, and filling relatively deep water areas with sediments to create shallow-water habitat.

Reducing stressors is a major component of delta smelt restoration. Reducing delta smelt losses to diversions is of primary concern.

RECOVERY GOALS

The basic strategy for the recovery of delta smelt is to manage the estuary is such a way that it is a better habitat for native fish in general and delta smelt in particular (U.S. Fish and Wildlife Service 1996). Improved habitat will allow delta smelt to be widely distributed throughout the Delta and Suisun Bay. Recovery of delta smelt will occur in two phases, restoration and delisting. Restoration is defined as a return of the population to pre-decline levels, but delisting is not recommended until the population has been tested by extreme outflows. Delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period.

RECOVERY CRITERIA: Restoration of delta smelt will be evaluated on distributional and abundance criteria. Distributional criteria include:

- catches of delta smelt in all zones during 2 of 5 consecutive years.
- in at least two zones in 1 of the remaining 3 years, and
- in at least one zone for the remaining 2 years.

Abundance criteria include:

- delta smelt numbers or total catch must equal or exceed 239 for 2 out of 5 years, and
- not fall below 84 for more that two consecutive years.

If abundance and distributional criteria are met for a five-year period the species will be considered restored. Delta smelt will meet the remaining recovery criteria and be considered for delisting when abundance and distribution criteria are met for a five-year period that includes two successive extreme outflow years, with one year dry or critical.

Integration with Other Restoration Programs

Efforts to restore delta smelt involve cooperation and support of other established programs that are protecting and improving conditions for delta smelt and other species in the Bay and Delta.

- The Recovery Plan for the Sacramento/San Joaquin Delta native fishes (U.S. Fish and Wildlife Service 1996) would be considered in developing actions.

- The Central Valley Project Improvement Act will implement actions that will benefit delta smelt, including changing the timing of diversions, restoring habitat, and dedicating flow during critical periods (U.S. Fish and Wildlife Service 1997).

- Federal ESA requirements (biological opinions and habitat conservation plans) will ensure maintenance of existing habitat conditions and implement recovery actions.

- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat conditions for delta smelt, chinook salmon, striped bass, and other species.

Linkage with Other Ecosystem Elements

Successful restoration of delta smelt will be closely tied with improving late winter and spring Delta outflow, increasing shallow water and wetland-slough habitat, improving the productivity of the aquatic foodweb, reducing the effects of Delta water diversions, and reducing the level of contaminants in Bay-Delta waters. Restoration actions are similar to those prescribed for other native resident and anadromous fish including longfin smelt and striped bass.

Maintenance of rearing habitat is extremely important for the recovery of delta smelt and other native Delta species. Successful restoration of delta smelt will also be closely tied with improving Delta outflow that maintains the X2 location in Suisun Bay for rearing delta smelt and prevents adverse influence of the CVP/SWP export facilities in the southern Delta.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore delta smelt to the Delta and Suisun Bay.

Long-term Objective: To restore delta smelt abundance to levels that existed in the 1960s and 1970s, as measured over a period of at least 10 years.

Short-term Objective: Achieve the recovery goals for delta smelt identified in the Delta Native Fishes Recovery Plan.

Rationale: The annual life cycle of delta smelt contributes to wide interannual variation in abundance, necessitating multiple sample years to discern a trend in abundance. Delta smelt were extremely abundant in the system when the "standard" trawling program in the Delta began in the 1960s. This period is used as a standard simply because that is when the data available for comparative purposes begin. Conditions in the estuary were clearly favorable for the species in that period. Achieving the long-term objective may be impeded by the presence of several introduced species, notably the clam, *Potamocorbula amurensis*, inland silversides, and wakasagi. If future investigations determine that substantial reductions in Delta smelt are attributable to the introduced species already established, the long-term population abundance objective may need to be lowered.

STAGE 1 EXPECTATIONS: In 7-10 years, the delta smelt population indices should be within the same range as during 1990-1998. The basic factors limiting delta smelt distribution and abundance should be determined (e.g., reduced food supply, interactions with non-native species, negative effects of diversions) and, where feasible, overcome through habitat and ecosystem process restoration.

The targets for delta smelt include exceeding a fall midwater trawl catch index of 240 in dry water-year types and a wider distribution of delta smelt in the trawl survey.

The following actions would contribute to improving the delta smelt population:

- Improve Delta outflow during the late winter and spring to improve foodweb productivity and to disperse larvae and juveniles to downstream rearing habitat in Suisun Bay.

- Maintain Delta outflow once larvae and juveniles have reached downstream rearing habitat to keep them beyond the "zone of influence" of the CVP/SWP and agricultural diversions.

- Increase the residence time of X2 at key locations in Suisun Bay (e.g., Roe Island, Chipps Island, and Collinsville).

- Reduce adverse effects of CVP and SWP diversions during the period when larvae, juveniles, or adult life stages appear in the Delta.

- Increase the amount of shallow-water habitat in areas critical to spawning and rearing.

- Construct and improve fish facilities for Delta diversions, including agricultural diversions and CVP and SWP diversions, and improve handling and salvage practices at diversions.

- Develop and implement a program to reduce the adverse effects of introduced aquatic species and the potential for future introductions.

- Implement restoration actions identified in the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes Recovery Plan.

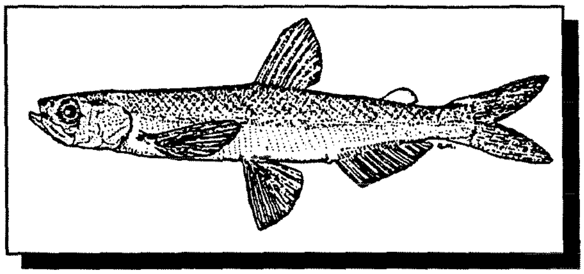
REFERENCES

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Sweetnam, D.A., and D.E. Stevens. 1993. A status of the delta smelt (Hypomesus transpacificus) in California. Report to the Fish and Game Commission. Candidate Species Report 93-DS. 98 pp.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, OR.

____________. 1997. Revised draft anadromous fish restoration plan. U.S. Fish and Wildlife Service, Sacramento, CA.



INTRODUCTION

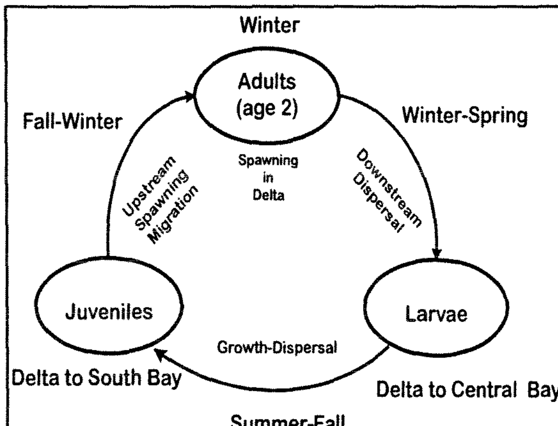
Longfin smelt are small native fish that live in the brackish waters of San Francisco Bay and the Delta. They can be found in water ranging from sea water to completely fresh water (Moyle 1976). They are an important element of the Bay-Delta foodweb as prey for chinook salmon, striped bass, and other predatory fish species. Because their abundance dropped sharply during dry periods over the past several decades, they are designated by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service (USFWS) as a species of special concern. Longfin smelt abundance was especially low during the 1987-1992 drought and showed signs of recovery only in 1995.

Major factors that limit this species' contribution to the health of the Delta are related to the adverse effects of low Delta outflow and include associated poor foodweb productivity, greater effects of water diversions, poorer larval transport and habitat conditions (i.e., poor dispersal is related to poor survival), and potentially higher concentrations of toxins that may limit its survival and production during droughts.

RESOURCE DESCRIPTION

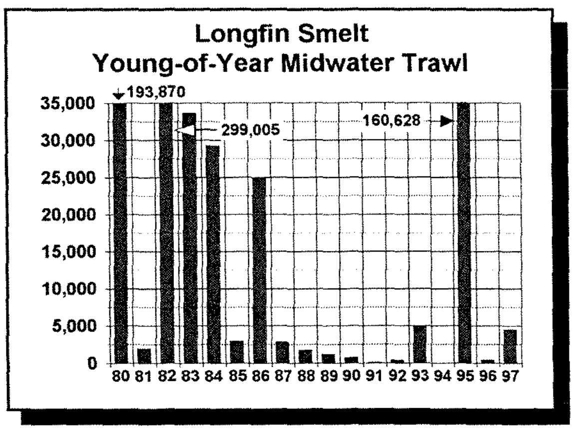
The largest, southernmost populations of longfin smelt in California inhabits San Francisco Bay and the Delta. Elsewhere in California, the longfin smelt is known from the Eel River, Humboldt Bay, and the Klamath River estuary, but none have been collected at these locations since the early 1990s. Longfin smelt migrate upstream into the Delta to spawn. Longfin smelt are well-adapted to the Bay-Delta estuary and are also found in other west-coast estuaries from northern California to southern Alaska.

In the Bay-Delta estuary, longfin smelt is anadromous. Adults, fish approaching their second year of age, migrate in winter from saltwater portions of the Bay and open coast to spawn in freshwater portions of the upper Bay and Delta. Spawning occurs in habitats with hard-bottom or plant substrates such as tidal wetlands and channels. Most spawning takes place from late December through April. High winter and early spring flows transport and disperse buoyant, newly hatched larvae downstream into Suisun and San Pablo Bays, where the plankton food supply is characteristically abundant and necessary for high survival of longfin smelt larvae and juveniles. Flows of the magnitude to accomplish this increase the area and shifts the location of intermediate salinity (1.1 - 18.5 ppt) habitat downstream reducing competition and predation from marine and freshwater fishes.

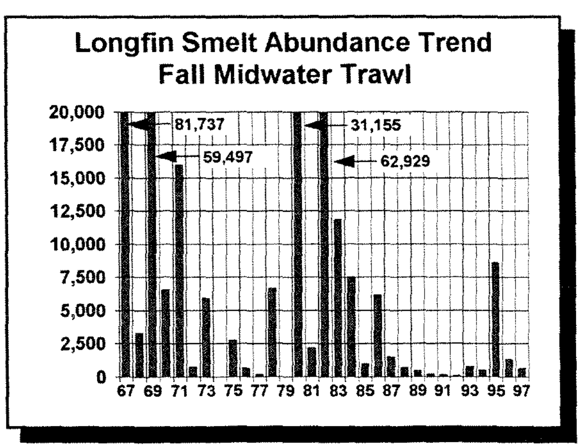


Longfin Smelt Life Cycle. California Department of Fish and Game, 1992.

Since longfin smelt spawn primarily as age 2 fish, they tend to maintain strong even-year or odd-year cohorts, depending upon the sequence of wet and dry years. 1978 broke the drought and established the even-year cohort as dominant in the 1980s, until the next drought broke in 1993 and allowed the odd-year cohort a recruitment advantage. Abundance is a function of both outflow and habitat conditions and adult population size which is related to fecundity. Peak abundance index levels are not reached until favorable flow conditions persist for 2-3 generations.

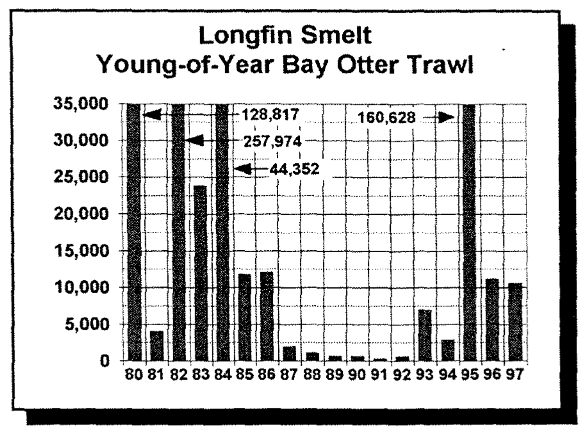


Longfin smelt abundance has been monitored by DFG in the Bay and Delta each fall since 1967. Population rates have fluctuated sharply, with greatest abundance in wetter years in wet-year sequences (1967, 1969, and 1971 from 1967-1971; and 1980, 1982, and 1983 from 1980-1983).



Abundance has been very poor in drought periods (1976-1977 and 1987-1992). Low abundance in 1993, the first wet year following the drought from 1987 to 1992, may reflect a greatly reduced spawning population resulting from drought conditions. Improved abundance in 1995 indicates that they may be recovering from the effects of the drought.

A similar pattern of population abundance is evident since 1980 in DFG's Bay trawling survey and the University of California, Davis' trawl survey in Suisun Marsh. Abundance was high from 1980 through 1984, but declined to very low levels through the 1987-1992 drought and has recovered only slightly since 1995.



The decline in the longfin smelt population has coincided with a number of changes in the estuary. Related stressors believed to contribute to this decline are listed below.

Low flows in late winter and spring into and through the Delta may reduce survival of eggs and larval longfin smelt spawned in the Delta. Low Delta outflow limits transport of larval and juvenile longfin smelt downstream into quality nursery grounds of Suisun and San Pablo Bays. Low flows are a consequence of climatic conditions (low rainfall and more precipitation as winter rains rather than snow) and upstream reservoir storage of winter and spring runoff in dry and normal years.

Reduced freshwater flows through the Delta and into Suisun Bay may limit production of foodweb organisms during the critical early life stages of longfin smelt. Poor recruitment in drier years reduces the number of adults two years later, thus reducing the future spawning run. Water exports from the Delta during drier years entrain both prespawning adults and planktonic larvae, further reducing their population size. Such entrainment is greatly reduced or absent in wetter years.

The number of adults making the upstream spawning run has dropped to such low levels in recent years that they no longer spawn sufficient numbers of eggs to bring about quick recovery in wet years. This may explain why production in 1993 was lower than expected.

Water diversion practices, especially in drier years, reduce larvae (about 5-15 millimeters long) and adult populations and lower reproduction rates. In drier years, the percentage of freshwater diverted is sharply higher than in wetter years.

In dry years, many larval and juvenile longfin smelt rearing in the Delta are drawn south across the Delta toward the south Delta pumping plants by the net southward flow caused by water exports at the pumping plants. Many probably perish before reaching the pumps as a result of poor food supply, poor water quality (mainly high water temperature), and predation in the central and south Delta channels, and intake forebays and structures of the pumping plants. Of those reaching the pumping plants, some are recovered in fish salvage facilities and returned to the Bay, while others are lost in water exported.

Power plants at Pittsburg and Antioch with the largest diversions (up to 3,000 cubic feet per second) operate in the prime nursery area of the western Delta and Suisun Bay. The power plants operate longer in winter and spring of dry years (when less hydroelectric power is produced) to meet regional electricity demands.

Similarly, Delta agricultural diversions are generally confined to late spring through fall; however, spring diversions are generally greater in drier years, when irrigation needs are higher. Although larvae losses to south Delta Central Valley Project and State Water Project pumping plants are generally much lower than losses to more northern and western Delta diversions, they are higher in drier years when Delta outflow is insufficient to move larval longfin smelt out of the Delta into the Bay.

Contaminants in the Delta water may also reduce the survival of longfin smelt. The effect may be indirect through reduced planktonic food supply or direct from toxin-induced egg, larval, or juvenile stress or mortality.

Other more speculative causes of the decline and low abundance of longfin smelt include competition or predation. Recently established non-native fishes, such as gobies introduced from the ballast water of ships from Asia, compete with longfin smelt. Predation in dry years may also be a problem, although it is difficult to quantify the potential adverse effects. Management programs that should be evaluated for potential adverse influence on longfin smelt and other native fish populations include the juvenile striped bass stocking program and salmon hatchery release programs. The striped bass stocking program has released over 11 million juvenile striped bass from 1985 through 1990 into San Pablo and Suisun Bays and Central Valley salmon hatcheries have released millions of hatchery-reared salmon smolts into San Pablo Bay in spring each year. Changes in plankton abundance and community species composition of the Bay and Delta caused by the introductions of non-native species of zooplankton and Asian clams may also have contributed to the decline of longfin smelt by affecting their food supply.

Overall, the longfin smelt are affected by the following factors in approximate order of importance (U.S. Fish and Wildlife Service 1996);

- reductions in Delta outflows,

- entrainment losses at water diversions,
- climatic variations (droughts and extreme floods),
- toxic substances,
- predation, and
- adverse effects of introduced species.

VISION

The vision for longfin smelt is to recover this California species of special concern and restore population distribution and abundance in the Bay-Delta estuary so that it resumes its historical levels of abundance and its role as an important prey species in the Bay-Delta aquatic foodweb.

Achieving consistently high production of longfin smelt in normal and wetter years, which historically produced more abundant juvenile populations (year classes), will be critical to the recovery of longfin smelt. Good wet-year production would be ensured by (1) not allowing production to fall too low in drier years such that numbers of adult spawners in subsequent wet years remains low, (2) maintaining and improving spawning and rearing habitat, and (3) minimizing stressors in wetter years.

Longfin smelt recovery efforts will also focus on enhancing freshwater outflow in dry and normal water year types during winter spawning and early rearing periods. Natural Delta outflows in dry and below- and above- normal water-year types have been reduced, particularly in late winter and spring, and such reductions coincide with the longfin smelt decline. The 1995 Water Quality Control Plan for the Delta provided interim provisions for increasing February-through-June Delta outflows. Additional improvements in late-winter and spring outflows would:

- improve transport of larvae and juveniles from Delta spawning areas to Bay rearing areas,

- limit the extent of total southerly flows toward the south Delta pumps where larvae and juveniles are subject to being exported,

- improve survival and production of longfin smelt by stimulating foodweb productivity, and

- dilute concentrations of contaminants that may be detrimental to longfin smelt or their food supply.

Although deterioration of habitat is not considered a major factor in the decline of longfin smelt, protecting, improving, and restoring shallow-water habitat in the Bay-Delta would help to increase survival and production of longfin smelt. Increasing shallow water habitat would increase brackish water habitat and overall habitat complexity which may be directly related to longfin smelt survival. Freshwater pushes out most marine larvae and most freshwater species are adapted to avoid being advected downstream by spawning later in the year or in backwater areas.

Other than striped bass and salmonids, few predators exploit pelagic, brackish water habitats, especially when the habitat is shifted downstream geographically between low and high outflow years. Increasing habitat complexity through increasing shallow water habitats (including side channels, etc.) and riparian zone width could assist longfin smelt larval dispersal. Presently, many appear to spawn in main channels and larvae are transported in dense pulses down the main channels and are dispersed into the shallows of Suisun and San Pablo bays. Increasing channel "roughness" may act to retain and spread larval pulses and reduce intra-specific competition.

Improved habitat would provide spawning and rearing habitat and increasing foodweb production. The increased spawning area and improved food supply may help to overcome other factors that have little potential for change (e.g., competition and predation from non-native species). Increases in tidal wetlands will provide tidal channels that are important spawning and rearing habitat. Improving and restoring shallow waters and riparian vegetation along levees and channel islands in the Delta will also provide additional important spawning habitat. Habitat improvements are expected to also increase the abundance of plankton, on which longfin smelt feed, and lead to improved survival of larvae and juveniles.

The Recovery Plan for Native Resident Fishes of the Sacramento-San Joaquin Bay-Delta Estuary (Recovery Plan) recommends restoring spawning and rearing habitat in shallow Delta islands (i.e., Prospect Island, Hastings Tract, Liberty Island, New Hope Tract, Brack Tract, and Terminous Tract) (U.S. Fish and Wildlife Service 1996). The Recovery Plan also recommends restoring tidal shallow-water habitat in Suisun Marsh by reclaiming leveed lands.

In addition to improving Delta outflow and habitats, reducing stressors will be important in restoring longfin smelt populations. Water diversions remove many longfin smelt and their food supply from the Bay and Delta, particularly during drier years. Losses to diversions should be reduced.

RESTORATION GOALS

The basic strategy for the restoration of longfin smelt is to manage the estuary is such a way that it is a better habitat for native fish in general (U.S. Fish and Wildlife Service 1996). Longfin smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period. This period was chosen because it includes the earliest continuous data on longfin smelt abundances and was a period during which populations stayed reasonably high in most years.

RESTORATION CRITERIA: Restoration of longfin smelt will be achieved when the species satisfies distributional and abundance criteria. Distributional criteria include:

- longfin smelt must be captured in all zones 5 of 10 years,
- in two zones for an additional year, and
- at least one zone for 3 of the 4 remaining years, with no failure to meet site criteria in consecutive years.

Abundance criteria:

- Abundance must be equal or greater than predicted abundance for 5 of 10 years.

Distributional and abundance criteria can be met in different years. If abundance and distributional criteria are met for a ten-year period, the species will be considered restored.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoring longfin smelt in the Central Valley is will involve cooperation with the following programs.

- Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1995a): Its purpose under the federal Endangered Species Act is to provide a strategy for the conservation and restoration of Delta native fishes. Longfin smelt are identified in this plan as requiring prompt restoration actions. The basic objective of this plan is to establish self-sustaining populations of the species of concern, including longfin smelt, that will persist indefinitely. The vision for longfin smelt includes facilitating implementation of the Recovery Plan.
- The Central Valley Project Improvement Act (PL 102-575): It calls for the doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon, and American shad) by 2002 (U.S. Fish and Wildlife Service 1995b). This program

involves actions that may indirectly benefit longfin smelt.

- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988: DFG is required under State legislation to restore numbers of anadromous fish in the Central Valley (California Department of Fish and Game 1993). Actions include restoring the food supply of anadromous fish; that food supply includes longfin smelt.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Successful restoration of longfin smelt will be closely tied with improving late winter and spring Delta outflow, increasing shallow water and wetland-slough habitat, reducing the effects of Bay-Delta water diversions, and reducing the level of contaminants in Bay-Delta waters. Restoration actions are similar to those prescribed for other native resident and anadromous fish including delta smelt and striped bass.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore longfin smelt to the Delta and Suisun Bay.

LONG-TERM OBJECTIVE: Restore longfin smelt abundance to levels that existed in the 1960s and 1970s, as measured over a period of at least 10 years.

SHORT-TERM OBJECTIVE: Achieve the recovery goals for longfin smelt identified in the Delta Native Fishes Recovery Plan.

RATIONALE: The longfin smelt is arguably one of the most endangered fishes in the estuary although the petition for listing it as an endangered species was declined (largely for genetic reasons). Longfin smelt were extremely abundant in the estuary when the fall midwater trawling program began in the 1960s. This period is used as a standard simply because it was during this period that the data available for comparative purposes begin, and the period covers a series of wet and extremely dry years. Evidence suggests that longfin smelt were abundant enough in the 19th century to support a fishery. Because longfin smelt abundance has a strong relationship to X2, future abundance may be tied closely to available fresh water and the ability to manipulate outflows to favor the species. Achieving the long-term objective may be impeded by the presence of several introduced species, notably the clam *Potamocorbula amurensis*. If future investigations determine that substantial reductions in longfin smelt are attributable to the introduced species currently established, then the long-term population abundance objective may need to be scaled back.

STAGE 1 EXPECTATIONS: In 7-10 years, the longfin smelt population indices should stay within the same range that they have been in during the period 1990-1998 unless there is an exceptionally long period of drought. The basic factors limiting their distribution and abundance should be determined.

The following actions would improve the longfin smelt population:

- Improve Delta outflow in late winter and spring to improve foodweb productivity and to dispense larvae and juvenile longfin smelt to downstream rearing habitat in Suisun and San Pablo Bays.

- Increase the amount of shallow water spawning habitat in the Delta and rearing habitat in Suisun and San Pablo Bays.

- Relocate or add diversion options for the south Delta pumping plants to (1) alleviate net southerly flows in the Delta in drier years, (2) improve transport of young longfin smelt to the Bay and away from the south Delta pumping plants and Delta agriculture diversions, and (3) increase the foodweb productivity.

- Evaluate and implement options to reduce PG&E power plant diversions from January through July in drier years. Options include limiting power operations during critical periods; improving screening facilities to reduce entrainment of larval and early juvenile longfin smelt, life stages that are presently most vulnerable to the intakes; or retrofitting plants with alternative cooling technologies (e.g., cooling towers).

- Evaluate the need to alter the timing and location for stocking striped bass and hatchery-reared chinook salmon in spring and early summer to avoid important longfin smelt juvenile rearing areas in Suisun and San Pablo Bays.

- Develop and implement a program to reduce the introduction of non-native species to the estuary from released ballast water would help minimize increases in predation and competition.

- Develop and implement a program to reduce contaminant inputs to the Bay-Delta would indirectly improve production of longfin smelt.

ADDITIONAL CONSIDERATIONS

The restoration criteria for longfin smelt needs to be reevaluated. The equation used to predict longfin smelt abundance from outflow in the Delta Native Fishes Recovery Plan (U.S. Fish and Wildlife Service 1996) is in error. In addition, the restoration criteria implicitly requires relatively frequent (one of every four years) uncontrolled flows to attain and maintain restoration based on distribution criteria. The required frequency to attain restoration may actually be higher. It may be necessary to concentrate on the lower end of the outflow/abundance relationship and attempt to maintain sufficient outflow for the dominant cohort (i.e., odd year or even year cohort). It might also provide beneficial to consider a January through May period for the increased flow. Based on the dominant cohort, attempt to provide an average February through May outflow of about 12,000 cfs while favoring higher flow of 15,000 or greater in February and possibly in January. If minimum outflows could be provided every other year, sufficient numbers of adults should be present to respond to favorable flow conditions.

REFERENCES

Baxter, R. 1998. Splittail and longfin smelt. Interagency Ecological Program Newsletter. Volume 11, No. 2.

California Department of Fish and Game. 1992. Estuary dependent species. Exhibit WRINT-DFG-#6. State Water quality Control Board, 1992, Water Quality Rights Proceeding on the San Francisco Bay Sacramento-San Joaquin Delta. 97 pp.

Moyle, P.B. Inland Fishes of California. University of California Press, Berkeley. 405 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, OR.

INTRODUCTION

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

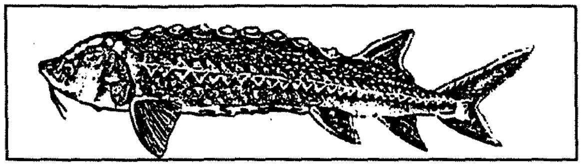
The green sturgeon is designated as a species of special concern by the California Department of Fish and Game (DFG) and U. S. Fish and Wildlife Service (USFWS).

Major factors that limit sturgeon populations in the Bay-Delta are adequate streamflows for attracting adults to spawning areas in rivers and transporting young to nursery areas, illegal and legal harvest, and entrainment into water diversions.

RESOURCE DESCRIPTION

Green sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay-Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate. Sturgeon are long-lived species. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

Green sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Habitat requirements of green sturgeon are poorly known, but spawning and larval ecology probably are similar to that of white sturgeon which is better known (U.S. Fish and



Wildlife Service 1996). Spawning is thought to occur in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g. levee construction) may affect sturgeon use and spawning success.

Losses of sturgeon young into water diversions reduces sturgeon productivity. However, relative to other species, the percentage of the sturgeon population caught in diversions is low.

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

VISION

The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historical levels. Restoration of this species would contribute to overall species richness and diversity, and reduce conflict between the need for protection for these species and other beneficial uses of water in the Bay-Delta.

Green sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Ecosystem processes that need improvement include streamflows, stream and channel configurations, and migration barriers (e.g. dams). Additional streamflow during late winter and spring would attract sturgeon to rivers and maintain spawning flow requirements.

Green sturgeon would benefit from restoring spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and increasing freshwater flow during critical periods. Juvenile sturgeon frequent Delta sloughs and may benefit from increases in slough habitat. Spawning habitat includes upstream river reaches that contain appropriate substrate (e.g., gravel, rock). Rearing habitat includes areas in the Sacramento and San Joaquin Rivers and the Delta that provide protective, food-rich habitats such as the shallow shoals and bays of the Bay-Delta.

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

RESTORATION GOALS

The primary restoration objective for green sturgeon is to maintain a minimum population of 1,000 fish over 1 meter total length each year, including 500 females over 1.3 meters total length (minimum size at maturity), during the period (presumably March-July) when spawners are present in the estuary and the Sacramento River (U.S. Fish and Wildlife Service 1996). The restoration of green sturgeon should not be a the expense of other native fishes, including white sturgeon. The 1,000 number was determined as being near the median number of green sturgeon estimated to be in the estuary during the 1980s. The total size of the adult green sturgeon population that uses the estuary may be larger than 1,000 because non-spawning adults may be in the ocean.

RESTORATION CRITERIA: Green sturgeon will be considered restored in the Sacramento-San Joaquin estuary once the median population of mature individuals has reached 1,000 individuals, including 500 females over 1.3 meters over a 50-year period or for five generations (10 years of age is the minimum age of sexual maturity). If population estimates are fewer than 1,000 fish for more than three consecutive years the restoration period will be restarted. This definition will be revised as better information becomes available.

Restoration will be measured by determining population sizes from tagging programs or other suitable means. The present sturgeon tagging and recovery program, which focus on white sturgeon, are inadequate for determining accurately the abundance of green sturgeon. Thus, the first restoration criterion will be establishment of an adequate monitoring program so that accurate population estimation can be conducted on a more regular basis.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore green sturgeon in the Central Valley would involve cooperation and support from other programs underway to restore sturgeon and other important fish.

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

- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.

- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds and actions to DFG for sturgeon restoration.

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for green sturgeon.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of green sturgeon populations are integrally linked with restoration of river floodplain and stream meander habitat, improvements in Central Valley streamflows, improvements in habitat, and reductions in losses to water diversions and illegal harvest.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore green sturgeon to the Delta and Suisun Bay.

LONG-TERM OBJECTIVE: Increase the population of green sturgeon utilizing the Sacramento-San Joaquin estuary and its tributaries so that the recreational fishery benefits.

SHORT-TERM OBJECTIVE: Continue the efforts established under Stage 1 Expectations and implement findings of habitat needs.

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

STAGE 1 EXPECTATIONS: A better understanding will have been developed about the life history and usage of the Sacramento-San Joaquin estuary and its watershed as spawning and rearing habitats. In addition, a program will have been implemented to monitor the ocean migration and its usage in the life history of the species.

General targets for sturgeon populations are:

- Restore population to levels of the 1960s,
- Improve flow in Sacramento River in spring,
- Reduce the rate of illegal harvest,
- Reduce the percentage lost of sturgeon to water diversions to that of the 1960s,

The general approach for programmatic actions are:

- Improve the aquatic foodweb,
- Improve spring flows in Sacramento River and major tributaries,
- Restore natural meander belts and add gravel substrates in upstream spawning areas,

- Increase Delta outflow in spring of dry and normal years,
- Improve water quality of Bay-Delta,
- Provide greater enforcement to reduce poaching,
- Reduce losses of eggs, larvae, and juvenile sturgeon at water diversions,
- Upgrade fish protection facilities at diversion facilities in the Delta,
- Restore tidally influenced Delta and estuarine habitat such as tidal perennial aquatic habitat and sloughs.

REFERENCES

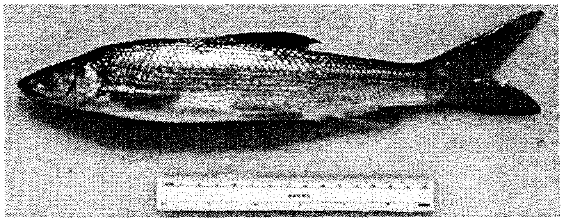
California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. Sacramento, CA.

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, OR.

____________. 1997. Revised draft anadromous fish restoration plan. U.S. Fish and Wildlife Service, Sacramento, CA.



INTRODUCTION

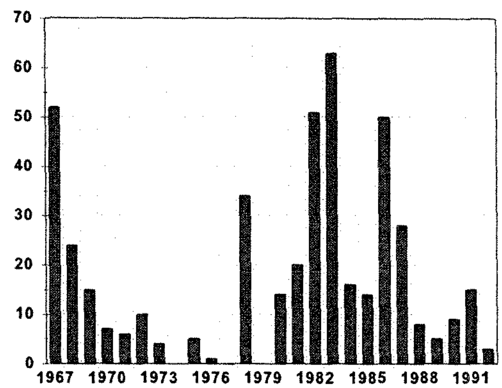
The splittail is a native resident fish of the lower reaches of the Sacramento and San Joaquin Rivers. It has been listed recently under the federal Endangered Species Act and a candidate for listing under the California Endangered Species Act. The splittail also supports a small winter sport fishery in the lower Sacramento River.

Major factors that limit its contribution to the health of the Bay-Delta include loss of floodplain spawning and rearing habitat, and low streamflows that limit floodplain inundation and transport young to downstream nursery areas. Recent information suggests that losses to water diversions do not have an important effect on the population (Sommer et al. 1997).

RESOURCE DESCRIPTION

Splittail are endemic to the Sacramento-San Joaquin Delta estuary and to the lower reaches of the Sacramento and San Joaquin Rivers. Splittail represent an important component of the historical native fish fauna. Splittail tolerate a wide range of salinity, but are most abundant in shallow areas where salinity is less than 10 parts per thousand (ppt). Spawning occurs in fresh water, primarily in floodplain areas upstream of the Delta including the Mokelumne, Feather and American rivers, and downstream of the Delta in the Napa and Petaluma rivers (Sommer et al. 1997). Spawning habitat includes shallow edgewaters and seasonally flooded riparian zones and flood bypass areas that provide spawning substrate (e.g., submerged vegetation). Rearing habitat includes shallow- fresh- and brackish water (less than 10 ppt salinity) habitat that provide a protective, food-rich environment.

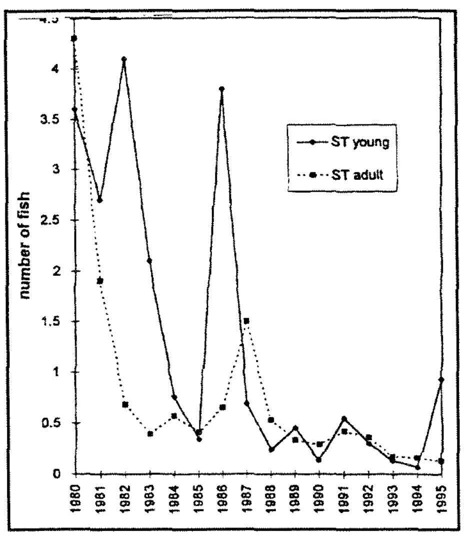
The population abundance of splittail is highly variable. Year-class abundance varies greatly. Low year-class success occurred throughout the 1987-1992 drought years. Age-0 abundance declined in the estuary during the 6 year drought and typically declines in dry years (Sommer et al. 1997).



Abundance Data for Splittail from DFG Fall Mid Water Trawl Survey (USFWS 1996)

Floodplain inundation is a significant element required to maintain strong year classes (Sommer et al. 1997). Access to habitat throughout the geographic range of splittail has been greatly diminished by human-caused actions. Restrictions to the floodplain, loss of marshes, and reduced winter-spring river flows from flood control and water supply development have reduced the species' range and abundance. In addition, water quality (e.g., high temperature and dissolved solids) reduce the use of the lower San Joaquin River by splittail.

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



Index of Adult and Juvenile Splittail
in Suisun Marsh Trawl Survey

Levee construction in the 1800s created narrow channels and eliminated vast areas of fluvial marsh and seasonal wetlands that are important as spawning and rearing habitat for splittail.

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

VISION

The vision for splittail is to recover this federally listed threatened species in order to contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of water in the Bay-Delta.

Splittail would benefit from improvements in spawning and rearing habitat, and late winter and spring river flows. Increases in the frequency of floodplain inundation, improved access to floodplain areas, and increased freshwater flows would contribute most to their recovery. Additional freshwater flow could be provided during late winter and spring to inundate floodplains and attract adults to upstream spawning areas, transport young to downstream nursery areas in the Bay-Delta, and maintain low salinity habitat in the western Delta and Suisun Bay.

Restoring splittail will require restoring seasonally flooded spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and additional freshwater flow during critical periods. Actions include breaching levees to inundate existing islands, setting levees back to increase shallow-water habitat along existing channels, protecting existing shallow-water habitat from erosion, and filling deep water areas with sediments to create shallow-water habitat.

Splittail have a high fecundity, which when combined with years of high flows, allows the population to benefit from high recruitment rates.

RECOVERY GOALS

RESTORATION CRITERIA: Splittail will be considered restored when they meet two out of three possible restoration criteria, developed from three independent surveys. The three possible criteria are:

1) FMWT numbers must be 19 or greater for 7 of 15 years;

2) Suisun Marsh catch per trawl must be 3.8 or greater AND catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years, and

3) Bay Study otter trawls must be 18 or greater AND catch of young-of-year must exceed 14 for 3 out of 15 years.

Within each survey, if target criteria are not met at least once in 5 consecutive years, the restoration period for the failed survey will be restarted. Criteria depend on data collected by three independent surveys, two conducted by DFG (FMWT and Bay Study otter trawl) and one conducted by UCD (Suisun Marsh otter trawl). These studies were chosen because they sample most of the splittail range and contain the earliest continuous data on splittail abundance. When any two out of three criteria are reached, splittail will be considered restored.

Integration with Other Restoration Programs

Efforts to restore splittail would involve cooperation and support from other established programs that are protecting and improving conditions for delta smelt, striped bass, and other species.

- Recovery Plan for the Sacramento/San Joaquin Delta native fishes (U.S. Fish and Wildlife Service 1996) will be considered in developing program actions.

- Central Valley Project Improvement Act (CVPIA) will implement actions that will benefit splittail, including changing timing of diversion, restoring habitat, and dedicating flow during critical periods for co-occurring species.

- State Water Resources Control Board (SWRCB) will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat conditions for splittail, chinook salmon, striped bass, and other species.

Linkage with Other Ecosystem Elements

Successful restoration of splittail will be closely tied with improving freshwater inflow, improved access to floodplain spawning and rearing habitats, floodplain inundation, and wetland restoration. Restoration actions are similar to those prescribed for other native resident fishes including delta smelt.

Strategic Objectives, Targets, and Programmatic Actions

The Strategic Objective is to restore Sacramento splittail to the Delta, Suisun Bay, and the Central Valley.

LONG-TERM OBJECTIVE: Restore the splittail so that it is one of the most abundant fish species in the Sacramento-San Joaquin estuary and its tributaries.

SHORT-TERM OBJECTIVE: Achieve the recovery goals for splittail identified in the Delta Native Fishes Recovery Plan.

RATIONALE: The splittail was once widespread in lowland waters of the Central Valley but is today largely confined to the estuary, except during wet years. The splittail population dropped to a low point in the estuary during the drought of the 1980s but rebounded to high levels in the estuary during wet years of the 1990s. It is likely that reproductive success of this species is tied to the timing and duration of flooding of the Yolo and Sutter Bypasses and to flooding of riparian zones along the major rivers of the Central Valley, so a return to its former abundance and distribution will require special management of these areas.

STAGE 1 EXPECTATIONS: At least one additional strong year class should have developed to maintain splittail populations, while factors limiting splittail spawning and recruitment success are determined and accounted for in a management plan.

The targets for splittail include achieving a fall mid-water trawl index consistently of 20 units or higher, and a Suisun Marsh trawl index consistently of 4 units or higher.

The following actions would improve the splittail population:

- improve late winter and spring freshwater flows,
- increase flooded and shallow water spawning habitat in rivers and Bay-Delta,
- reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin,
- prevent introduction of non-native species,
- High water temperatures and dissolved solids also reduce splittail use of the lower San Joaquin River.

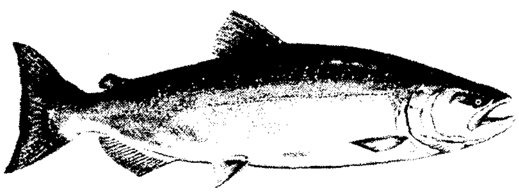
REFERENCES

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126:961-976, 1997.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, Oregon.

◆ CHINOOK SALMON



INTRODUCTION

Chinook salmon are medium- to large-bodied fish that spawn in freshwater, migrate to the ocean as juveniles, achieve significant growth, and return to freshwater at varying degrees of sexual maturity. Four runs of chinook salmon are present in the Central Valley, distinguished by their timing of reentry to fresh water: fall, late-fall, winter, and spring (Boydstun et al. 1992). Winter-run chinook salmon were formally listed as an endangered species under the California Endangered Species Act in 1989, and as endangered under the federal Endangered Species Act in 1994 (National Marine Fisheries Service [NMFS] 1996). The NMFS is reviewing the status of the other Central Valley chinook salmon runs and considering the potential needs for additional listings under the ESA. Listing of the winter-run chinook population reflected poor ecological health of the Bay-Delta watershed including the Sacramento River and placed additional regulatory controls on water management operations in the Central Valley. Water management regulations for winter-run chinook salmon affect the magnitude of flow by season in the Sacramento River and the volume of carryover storage in Shasta Reservoir for temperature control in the upper Sacramento River. The regulations also constrain the timing of water diversions at various location in the Sacramento River.

Listing status of Central Valley chinook salmon populations.

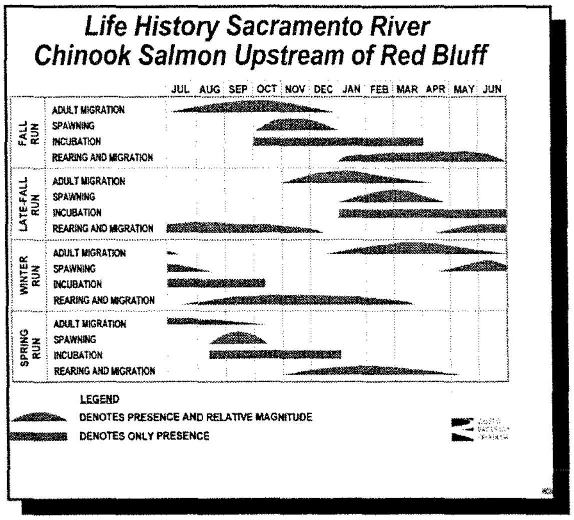
Chinook Stock	Listing Status
Winter-run	Endangered - ESA Endangered - CESA
Spring-run	Proposed - ESA Threatened - CESA
Late-fall-run and fall-run	Proposed - ESA

The key to improving chinook salmon populations will be maintaining populations through periods of drought by improving streamflow magnitude, timing, and duration; reducing the effects of the CVP/SWP export pumps in the southern Delta which alter Delta hydrodynamics, juvenile rearing and migration patterns, and cause entrainment at the facilities, and reducing stressors such as unscreened water diversions, high water temperatures, and harvest of naturally spawned salmon. The overall nature of habitats, flows, and stressors varies greatly throughout the range of chinook salmon in the Central Valley and is influenced by which specific run of salmon is present, its life stage (egg, fry, juvenile, adult), and the season.

RESOURCE DESCRIPTION

Chinook salmon represent a highly valued biological resource and a significant biological legacy in the Central Valley of California. Central Valley chinook salmon comprise numerous individual stocks, including the Sacramento fall-run, late-fall-run, spring-run, winter-run, and San Joaquin fall-run. The continued existence of

Central Valley chinook salmon is closely linked to overall ecosystem integrity and health.



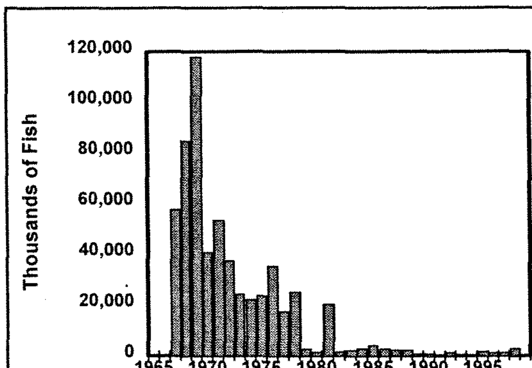
Because of their life cycle, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Human-caused actions (stressors) have diminished the quality and accessibility of habitats used by chinook salmon. These habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon. However, the restoration approach must fully consider the problems and opportunities within each individual watershed and must be fine-tuned to meet the requirements of locally adapted stocks.

The chinook salmon resources of the Central Valley include:

- Sacramento River winter-run chinook
- Central Valley spring-run chinook
- Sacramento Basin fall-run chinook
- San Joaquin Basin fall-run chinook
- late-fall-run chinook

The National Marine Fisheries Service (1998), in its status review of west coast chinook stocks, identified major chinook grouping based on preliminary data regarding ecological, geographical, and genetic differences among chinook stocks. These major groups included the Sacramento River winter-run evolutionarily significant unit (ESU), Central Valley spring-run ESU, and the Central Valley fall-run ESU. The fall-run ESU includes Sacramento and San Joaquin fall-run chinook, as well as late-fall-run chinook.

SACRAMENTO RIVER WINTER-RUN ESU. During the listing process for winter-run chinook, both the California Department of Fish and Game and NMFS cited a list of factors considered important to the decline of winter-run chinook. NMFS cited the loss of juveniles to entrainment at poorly or unscreened diversions including loss to the state and Federal water project pumps in the Delta. Impacts at other State and Federal water project facilities such as Red Bluff Diversion Dam, and Keswick and Shasta dam operation were considered major factors.

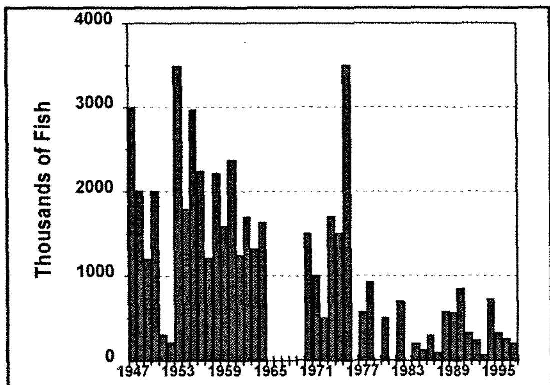


Annual return estimates for the endangered winter-run chinook salmon.

This ESU includes chinook salmon entering the Sacramento River from November to June, an entry pattern not shared with any other chinook population. Winter-run spawn from late-April to mid-August, with a peak in May and June. In general, winter-run exhibit an ocean-type life-history strategy, with smolts migrating to the ocean after five to nine months of residence in freshwater (Johnson et al. 1992). DNA analysis indicates substantial genetic differences between winter-run and other chinook salmon in the Sacramento River.

Historically, winter-run populations existed in the upper Sacramento, Pit, McCloud, and Calaveras Rivers. The spawning habitat for these stocks was primarily located in the Sierra Nevada Ecoregion (Omernik 1987). Construction of dams on these rivers in the 1940s led to the elimination of populations in the San Joaquin Basin and displaced the Sacramento River population to areas below Shasta Dam. There is also data to suggest that winter-run inhabited Battle Creek prior to its development for hydropower production.

CENTRAL VALLEY SPRING-RUN ESU. Spring-run chinook were the dominant run in the Sacramento and San Joaquin river systems prior to the construction of dams and water development projects. Spring-run chinook have been eliminated

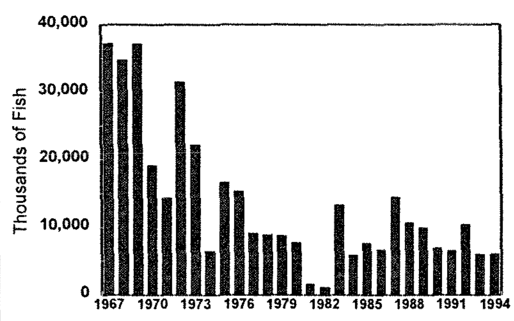


Estimated returns of spring-run chinook salmon to Mill Creek.

from the San Joaquin Basin but are still present in some of the tributary streams of the Sacramento River. Mill, Deer, and Butte creeks consistently support spawning populations of spring-run chinook salmon. Several other tributaries occasionally have spring run present. These include Big Chico, Antelope, and Beegum creeks. There may be some spring run in the Feather River, but these fish have likely interbred with fall-run chinook. The status of spring-run chinook in the Yuba River is uncertain, but a small population may exist (California Department of Fish and Game 1998).

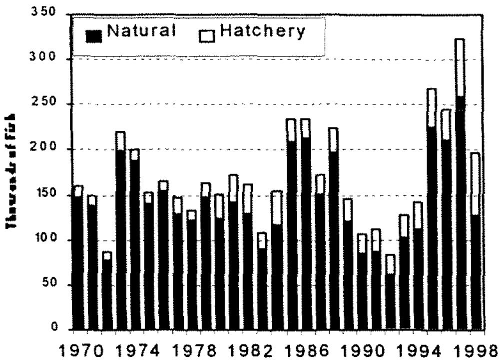
This ESU includes chinook salmon entering the Sacramento River from March to July and spawning from late August through early October, with a peak of spawning in September. Spring-run chinook exhibit and ocean-type life history, and emigrate from their natal streams as fry, subyearlings, and yearlings (National Marine Fisheries Service 1998).

CENTRAL VALLEY FALL-RUN ESU. Fish in this ESU enter freshwater from July through April and spawn from October through February. Both runs are ocean-type chinook, emigrating predominantly as fry and subyearlings.



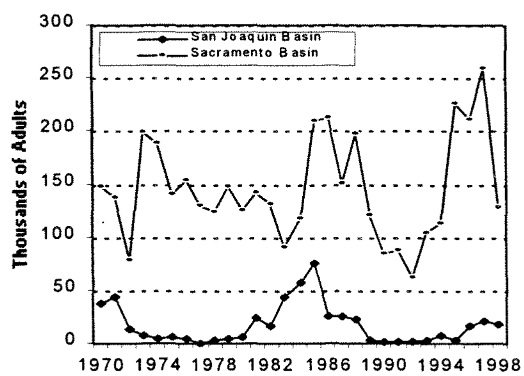
Estimated returns of late-fall run chinook salmon, 1967-1994.

Fall-run are the most abundant run in the Central Valley and populations are supported by an extensive State and Federal hatchery propagation program. Cumulatively, fall-run chinook maintain strong ocean sport and commercial troll fisheries as well as inland fisheries.



Sacramento River fall-run chinook salmon escapements, 1970-1998 (PFMC 1999).

Overall, the abundances of stocks have varied annually since 1970 and exhibited depressions in run size (escapement) during and following the 1976-1977 and 1987-1992 droughts (Mills and Fisher 1994). Low flows and reservoir storage levels during droughts caused high water temperatures, poor spawning and rearing habitat conditions, high predation rates, high diversion losses, and increased harvest, which in turn reduce salmon survival.



Comparison of the escapement trends of adult fall-run chinook salmon in the Sacramento and San Joaquin Basins (PFMC 1999).

Chinook salmon are found in virtually all 14 ecological zones that comprise the ERPP Study Area and many of their respective ecological units. Overall, the decline of the chinook salmon population resulted from the cumulative effects of degrading spawning, rearing, and migration habitats in the Sacramento and San Joaquin basins and the Sacramento-San Joaquin Delta. Specifically, the decline was most likely caused by a combination of factors that reduced or eliminated important ecological processes and functions, such as:

- excessively warm water temperatures during the prespawning, incubation, and early rearing periods of juvenile chinook;
- interrupting or blocking the free passage of juveniles and adults at diversion and water storage dams;
- loss of natural emigration cues when flow regimes are altered as a result of the export of water from large diversions in the south Delta;
- heavy metal contamination from sources such as Iron Mountain Mine;
- entrainment in a large number of unscreened and poorly screened diversions; and
- degradation and loss of woody debris, shaded riverine aquatic (SRA) habitat, riparian corridors and forests, and floodplain functions and habitats from such factors such as channelization, levee construction, and land use.

Climatic events and human activity have exacerbated these habitat problems. Lengthy droughts have led to low flows and higher temperatures. Periodic El Niño conditions in the Pacific Ocean have reduced salmon survival by altering ocean current patterns. Ocean and inland recreational and commercial salmon fisheries have probably impaired efforts to rebuild salmon stocks.

Human activities have also contributed to the decline of the chinook, although perhaps to a lesser degree. These activities include:

- construction and operation of various smaller water manipulation facilities and dams;
- levee construction and marshland reclamation causing extensive loss of rearing habitats in the lower Sacramento River, San Joaquin River, and Sacramento-San Joaquin Delta;
- and the introduction of predatory species.

Existing regulatory efforts have not adequately maintained some chinook stocks as healthy populations. As a result, the winter-run population was protected under the State and federal ESAs to save it from extinction. Since its listing, some significant habitat improvements have been made to help preserve this and other chinook populations. These include improved water temperatures and flow management for spawning, incubation, and rearing; improved passage of juveniles and adults at diversions and dams on the upper Sacramento River; reduced diversions during periods when juveniles are most susceptible to entrainment; and the positive-barrier fish screens installed on the larger water diversions along the Sacramento River. However, additional measures that focus on reactivating or improving ecological processes and functions that create and maintain habitats will be necessary for recovery of the various chinook salmon stocks in the Central Valley.

Rebuilding chinook populations to a healthy state will require a coordinated approach to restoring ecosystem processes and functions, restoring habitat, reducing or eliminating stressors on a site-specific basis, and improving management and operation of the five salmon hatcheries in the Central Valley.

VISION

The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under the ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. This vision will contribute to the overall species diversity and richness of the Bay-Delta system and reduce conflict between protection for this species and other beneficial uses of water and land in the Central Valley.

This vision is consistent with restoring the Sacramento River winter-run chinook salmon to levels that will allow it to be removed from the State and federal endangered species lists; increasing populations of other chinook stocks to levels that eliminate any future need for protection under the State and federal Endangered Species Acts (ESAs); and providing population levels for all chinook stocks that sustain recreational and commercial fisheries and other scientific, educational, and nonconsumptive use of these valuable resources.

Within the broad context of ecosystem restoration, salmon restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are not specific to chinook salmon. For example, restoring riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetational/successional processes. These factors will be extremely important in providing SRA habitat, woody debris, and other necessary habitats required by food organisms and juvenile and adult salmon populations.

Another example is to reactivate tidal flows into fresh and brackish (somewhat salty) marshes. Reactivating the tidal exchange in marshes will increase the production of lower trophic organisms, thereby improving the foodweb. Reactivating tidal exchange will also substantially increase the complexity of nearshore habitats in the lower mainstem rivers, the Delta, and the Bay, which will be valuable habitats for juvenile salmon.

Operating the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including chinook salmon.

Harvest management will play an important role in restoring healthy salmon populations. The Ecosystem Restoration Program Plan (ERPP) anticipates a highly compatible relationship between restoring ecological processes and harvest management recommendations. Ecological processes selected for restoration include those that create and maintain critical habitat elements. Harvest management recommendations focus on rebuilding naturally spawning stocks.

Lack of adequate corridors between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of some stocks such as spring-run chinook salmon. Unscreened diversions are widespread in the Central Valley and are a known source of mortality to chinook salmon.

Many action-oriented activities are underway in the Central Valley that will assist in achieving the vision for chinook salmon. Some are short-term actions and some are long-term evaluations. All are designed to eliminate stressors and improve ecological processes and habitats.

RECOVERY GOALS

All stocks of Central Valley chinook salmon are considered in the development of actions to ensure the recovery of endangered species. This includes formally listed stocks such as winter-run chinook, the State-listed threatened spring-run chinook salmon, and stocks proposed for listing under the ESA including spring-run, late-fall-run, and fall-run chinook.

WINTER-RUN CHINOOK SALMON

The National Marine Fisheries Service (1997) has proposed recovery goals for the endangered winter-run chinook salmon. The recovery goals include delisting criteria based on population criteria. The population criteria are:

- The mean annual spawning abundance over any 13 consecutive years shall be 10,000 females (because the specified spawning abundance is in terms of females, the total spawning run will be more than twice the female spawning abundance). The geometric mean of the cohort replacement rate over those same 13 years shall be greater than 1.0. Estimates of these criteria shall be based on natural production alone and shall not include hatchery-produced fish. The variability in cohort replacement rate is assumed to be the same as or less than the current variability.

- There must be a system in place for estimating spawning run abundance with a standard error less than 25% of the estimate, on which to base the calculation of the population criteria. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the cohort replacement rate is estimated must be increased by one additional year for each 10% of additional error above 25%.

In addition to the population criteria, NMFS has specified recovery actions for winter-run chinook that are linked to one of the following goals.

RECOVERY GOALS FOR SACRAMENTO RIVER WINTER-RUN CHINOOK SALMON (NMFS 1997).	
Goal	Description
1	Protect and restore spawning and rearing habitat
2	Improve survival of downstream migrants
3	Improve adult upstream passage
4	Prevent extinction through artificial propagation
5	Reduce harvest and incidental take in commercial and recreational fisheries
6	Reduce impacts of fish and wildlife management programs
7	Improve understanding of life history and habitat requirements

SPRING-RUN CHINOOK SALMON

Spring-run chinook salmon are proposed as a threatened species under the ESA and are a threatened species under CESA. The Department of Fish and Game's recovery objectives for the Sacramento River spring-run chinook salmon are:

- protect and enhance existing populations;
- re-establish additional, viable native populations; and
- restore and protect natal, rearing, and migratory streams within the Sacramento River Basin (California Department of Fish and Game 1998).

In addition the Department of Fish and Game will develop specific recovery goals and delisting criteria based on the best scientific information. In developing the recovery goals, the Department of Fish and Game will consider the following criteria developed by the U.S. Fish and Wildlife Service (1996).

RESTORATION CRITERIA

Sacramento spring chinook will be regarded as restored when:

- self-sustaining populations in excess of 500 spawners each are present in both Deer and Mill creeks;
- the number of wild spawners in Sacramento River tributaries reaches a mean number of 8,000 fish and does not drop below 5,000 fish, for 15 years, three of which are dry or critical dry years, and
- when the smolt survival rates between Sacramento and Chipps Island approach pre-project levels when the number of adults in the tributary streams is fewer than 5,000.

Restoration will be measured by three interacting criteria:

1) presence of self-sustaining spawning populations in Deer and Mill creeks,

2) total number of spawners in Mill, Deer, Antelope, Butte, Big Chico, Begum, South Fork Cottonwood, and Clear creeks, and

3) smolt survival rates through the Delta.

The number of spawners can be estimated by carcass and redd counts and counting from weirs at dams on Deer and Mill creeks, but smolt survival cannot yet be satisfactorily estimated. These restoration goals can be achieved only if there is simultaneous improvement in conditions in spawning and rearing streams, in the Delta for passage of juveniles and adults, and improved management of the fishery to allow for increased survivorship of adults during periods of low population size.

LATE-FALL-RUN CHINOOK SALMON

Late-fall-run chinook salmon are included in the Central Valley fall-run Evolutionarily Significant Unit (ESU) and are proposed for listing as a threatened species under the ESA.

RESTORATION CRITERIA

Sacramento late-fall chinook salmon will be regarded as recovered when:

1) the number of wild spawners in the Sacramento River reaches a mean number of 22,000 fish and does not drop below 15,000 fish, for 15 years, three of which are dry or critical dry and

2) when the juvenile survival rates approach pre-project levels following years when the adult populations are fewer than 15,000 fish in the Sacramento River.

The number of spawners can be estimated by carcass and redd counts or enumerated through dam counts, while smolt survival cannot yet be satisfactorily estimated. It is recognized that these restoration goals can be achieved only if there is simultaneous improvement in conditions in spawning and rearing streams, in the Delta for passage of juveniles, and improved management of the fishery to allow for increased survivorship of adults.

SAN JOAQUIN FALL-RUN CHINOOK SALMON

San Joaquin fall-run chinook salmon are included in the Central Valley fall-run Evolutionarily Significant Unit (ESU) and are proposed for listing as a threatened species under the ESA.

RESTORATION CRITERIA

San Joaquin fall-run chinook salmon will be regarded as restored when:

1) the number of naturally spawning fish in the Stanislaus, Tuolumne, and Merced rivers reaches a median number of 20,000 fish and the three-year running average does not drop below 3,000 fish, for 15 years, three of which are dry or critically dry and

2) when the smolt survival rates approach pre-project levels when adult numbers decline to fewer than 3,000 naturally spawning fish.

The number of spawners can be estimated by carcass and redd counts. A model has been developed for estimating smolt survival through the Delta. The smolt survival index is a calculated variable base upon on-going tagging studies, that is presumed to have a strong positive relationship to actual smolt survival rates. The model relies on the relationship between (1) salmon smolt survival and flows in the San Joaquin River, (2) rates of diversion into Old River, and (3) export rates at the CVP and SWP pumps.

These restoration goals can be achieved only if there is simultaneous (1) improvement in conditions in the spawning and rearing streams, (2) improvements in conditions in the lower San Joaquin River and in the Delta, and (3) improved management of the fishery to allow for increased survivorship of adults during periods of low population size. Salmon taken by hatcheries for artificial propagation will not be counted toward meeting criteria.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are three major programs to restore chinook salmon populations in the Central Valley.

- Central Valley Project Improvement Act: The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (U.S. Fish and Wildlife Service 1995).

- Endangered Species Recovery Plan: The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996).

- Salmon, Steelhead Trout and Anadromous Fisheries Program Act: The California Department of Fish and Game (DFG) is required under State legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).

- California Endangered Species Act which can provide specific criteria for downlisting, delisting, and recovery of listed species.

Each of the major chinook salmon restoration/recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and reducing or eliminating stressors.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Chinook salmon are closely dependent on ecological processes and habitats and adversely affected by a variety of stressors.

Important ecological processes the directly influence the health of chinook salmon or its habitat include:

- Central Valley streamflows,
- Natural sediment supply,
- Stream meander,
- Natural floodplain and flood processes,
- Central Valley stream temperatures,
- Bay-Delta hydraulics, and
- Bay-Delta aquatic foodweb.

Habitats used by chinook salmon during their juvenile or adult life stages include:

- Tidal perennial aquatic habitat,
- Delta sloughs,
- Midchannel islands and shoals,
- Saline and fresh emergent wetlands, and
- Riparian and riverine aquatic habitats.

Stressors that adversely affect chinook salmon or its habitats include:

- Water diversions,
- Dams, reservoirs, weirs, and other human-made structures,
- Levees, bridges, and bank protection,
- Dredging and sediment disposal,
- Gravel mining,
- Predation and competition,

- Contaminants,
- Harvest,
- Some aspects of artificial propagation programs, and
- Disturbance.

STRATEGIC OBJECTIVES, TARGETS, AND PROGRAMMATIC ACTIONS

The strategic objectives for chinook salmon include discreet strategies for winter-run chinook, spring-run chinook, and fall- and late-fall chinook salmon. The objectives follow.

WINTER-RUN CHINOOK SALMON

The Strategic Objective is to restore winter-run chinook salmon to the Sacramento River and the Bay-Delta estuary.

LONG-TERM OBJECTIVE: Create self-sustaining populations of winter-run chinook salmon in both the mainstem Sacramento River and in Battle Creek at abundance levels equal to or greater than those identified in the National Marine Fisheries Service (NMFS) proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon (NMFS 1997).

SHORT-TERM OBJECTIVE: Achieve recovery as defined in the NMFS proposed Recovery Plan for Sacramento River Winter-run Chinook Salmon.

RATIONALE: Winter-run chinook salmon are unique to the Sacramento River and are adapted to spawn in the cold, spring-fed rivers now located above Shasta Dam. They are presently maintained in artificial cold-water habitat below Keswick Dam in the Sacramento River and in a special hatchery program. Because they are so vulnerable to disasters (e.g., a toxic spill from Iron Mountain mine, just upstream), at least one other naturally reproducing population needs to be established to reduce the probability of extinction. Battle Creek, a cold-water stream to which winter-run chinook have been deliberately denied access in the past, is the best and probably only site available for such restoration. It is unlikely, however, that winter-run chinook salmon will ever be much more abundant than specified in the recovery plan goals because available habitat is so limited.

STAGE 1 EXPECTATIONS: The cohort replacement rate (the number of future spawners produced by each spawner) in 7-10 years should continue to exceed 1.7 (as it has in recent years), and average abundance should increase. Battle Creek restoration should have proceeded to a point where a determination can be made regarding the benefits of re-introducing winter-run chinook. The determination will be based on genetic considerations. The probability of extinction of winter-run chinook will have been recalculated using assumptions regarding the establishment of an additional self-sustaining winter-run chinook population.

SPRING-RUN CHINOOK SALMON

The Strategic Objective is to restore spring-run chinook salmon to Central Valley streams and the Bay-Delta estuary.

LONG-TERM OBJECTIVE: Restore wild, naturally reproducing populations of spring-run chinook salmon to numbers or spawning densities in the Sacramento River system equal to those that existed in the 1940s (average of 70,000-80,000 per year), as measured over a period of at least 25 years.

SHORT-TERM OBJECTIVE: Achieve recovery as defined by the Delta Native Fishes Recovery Plan and the California Department of Fish and Game or in a federal recovery plan developed if they are formally listed as a threatened or endangered species.

RATIONALE: Spring-run chinook salmon were historically the most abundant run of salmon in central California. Unfortunately, they spawned primarily in stream reaches that are now above major dams. The biggest declines in their abundance occurred after Shasta and Friant dams were built (1944 and 1942, respectively). A run of 50,000 spring-run chinook salmon alone was stranded when Friant Dam shut off San Joaquin River flows. Attempts to rear spring-run chinook salmon in hatcheries have largely failed, and both hatchery and wild populations in the Sacramento River proper are hybridized with fall-run chinook. The only streams maintaining small runs of wild, unhybridized spring-run chinook salmon are Deer, Mill, Butte and Big Chico Creeks. Spring-run chinook have been listed as threatened by the California Fish and Game Commission (September 1998) and were proposed for federal listing as endangered in 1997. It is uncertain whether additional subpopulations can be reestablished in other Sacramento River basin streams or in the San Joaquin River basin, but the possibilities need to be investigated. If establishing additional subpopulations is impossible, the long-term objective may have to be modified downward.

STAGE 1 EXPECTATIONS: Better methods for estimating population sizes should be developed. Populations in Deer, Mill, and Butte creeks should remain within numbers found in the streams in 1990-1998, with a cohort replacement rate greater than 1. Factors limiting survival of out-migrating smolts should be determined. The ability of Big Chico Creek to sustain a spring-run chinook population should be evaluated and measures taken to improve its capacity to support salmon. The potential for other streams, including Battle Creek, to support runs of spring-run chinook salmon should be evaluated. The potential for using artificial propagation as a tool to expedite reintroduction to former habitat will have been evaluated and, if deemed appropriate by the resource agencies, a propagation program should be implemented.

LATE-FALL-RUN CHINOOK SALMON

The Strategic Objective is to restore late fall-run chinook salmon to Central Valley streams and the Bay-Delta estuary.

LONG-TERM OBJECTIVE: Restore wild, naturally reproducing populations of late-fall-run chinook salmon to numbers or spawning densities in the Sacramento River equal to those that existed in 1967-1976, as measured over a period of at least 25 years, and reestablish a self-sustaining population in the San Joaquin River drainage.

SHORT-TERM OBJECTIVE: Achieve recovery, as defined by the Delta Native Fishes Recovery Plan or in a federal recovery plan developed if the species is formally listed as threatened.

RATIONALE: Late-fall-run chinook salmon have long been recognized as a distinct run in the Sacramento River and, formerly, in the San Joaquin River. Their numbers in the Sacramento River were not quantified until Red Bluff Diversion Dam was completed in 1967. The dam was a major factor contributing to their most recent decline. The NMFS does not distinguish late-fall-run from fall-run chinook salmon in its listing proposal (Myers et al. 1998), but the two forms represent distinct life history patterns in the Sacramento River and therefore need to be managed separately. Late-fall-run chinook were mainstem spawners and probably were separated from their principal spawning grounds by Shasta and Friant dams. Restoration may be possible in rivers that have had their flow regimes adjusted to accommodate the oversummering of juveniles (e.g., Tuolumne River).

STAGE 1 EXPECTATIONS: Late-fall-run chinook salmon numbers should not fall lower than they have been in the 1990s. Factors limiting their abundance should be determined, and methods to determine their abundance should be developed.

FALL-RUN CHINOOK SALMON

The Strategic Objective is to restore self-sustaining fall-run chinook salmon to Central Valley streams and the Bay-Delta estuary.

LONG-TERM OBJECTIVE: Restore self-sustaining populations of fall-run chinook salmon to all their native streams, except those above Shasta Reservoir, with numbers of fish of wild origin equal to or exceeding the average numbers of fish of both hatchery and wild origin from 1980-1998.

SHORT-TERM OBJECTIVE: Recover San Joaquin fall-run chinook salmon to levels identified in the Delta Native Fishes Recovery Plan, and in the Sacramento River, have wild salmon spawners number 75,000-100,000 fish each year, assuming that salmon of wild origin make up 50% of the fall run.

RATIONALE: When Shasta and Friant dams were built, implicit promises were made that fisheries for salmon would not decline. It was assumed that hatcheries and habitat improvements would make up for any losses caused by the dams. The hatchery system has been at best a partial success even though it has focused heavily on fall-run chinook salmon. Because of the hatcheries, the status of wild populations in the Central Valley is uncertain, and concerns exist about genetic and other effects of hatchery programs on the wild-spawning stocks.

Much of the habitat previously available for wild-spawning fish is permanently disconnected from the migration corridors. However, the remaining habitat or the "new" habitat in the tailwaters of large dams should be usable for spawning at densities (fish per unit of habitat, either area or distance) as great as those that existed before the construction of Shasta, Friant, and other dams. The objective, therefore, is to restore the spawning densities of fall-run chinook salmon to values existing before Shasta and Friant Dams were built. The restoration of salmon to pre-dam densities using primarily currently available habitat depends on assumptions about habitat quality and the biology of the fish that need to be tested.

STAGE 1 EXPECTATIONS: Numbers of wild fall-run chinook salmon should not fall lower than they have been in the 1990s. Factors limiting their abundance in each major river should be determined, including the impact of hatchery fish. Programs (e.g., mass marking of hatchery juveniles) should be instituted to allow hatchery fish to be distinguished from wild fish, and surveys should be made to determine the contribution of hatchery fish to natural spawning. The overall target for chinook salmon is presented as a strategy to increase the survival and return of each generation. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0. In practical application, management and restoration goals need to be developed on a stream-specific basis and include all runs of chinook salmon.

The strategy for achieving the chinook salmon vision includes protecting existing populations, restoring ecological processes, improving habitats, and reducing stressors. The following actions would improve chinook salmon populations:

- Restore ecological processes in the Central Valley. Chinook salmon are dependent on adequate streamflows; gravel recruitment, transport, and cleansing; low water temperatures; and channel configurations.

- Maintain adequate streamflows to improve gravel recruitment, transport, and cleansing; water temperatures; and channel conditions. Improved streamflow would also provide attraction flows for adult salmon migrating upstream to spawning grounds through the Bay, Delta, and lower rivers. Flows also support downstream transport for juvenile salmon migrating to the ocean and minimize losses to diversions and predators. Short-term improvements in flows may be possible with existing supplies. Necessary changes in streamflows may require long-term water supply improvements.

- Restore habitats required by chinook salmon. Where ecological processes cannot restore habitats to the desired level, habitats can be improved using direct measures. Important habitat components for chinook salmon include spawning gravel, water temperatures, and access to spawning habitats. In the short term, gravel can be introduced to rivers where needed. Fish passage facilities can be upgraded where deficient. Generally, habitat quality and availability along the lower reaches of the major rivers and in the Delta have been greatly diminished by the construction of levees; construction of levees that isolated rivers from their floodplains; and removal or other loss of riparian, shaded riverine, and woody debris habitats. A major long-term commitment will be required to restore the habitats in these areas.

- Protect existing populations in the Central Valley. The ERPP focuses on supporting efforts to protect existing natural populations of chinook salmon by limiting harvest of naturally spawned fish while emphasizing the harvest of hatchery-produced fish. A short-term action would be to evaluate mass marking of all hatchery-produced chinook salmon and limiting harvest to only marked salmon. Another short-term action would be to promote hatchery practices that embody the concepts of genetic conservation.

- Eliminate stressors that cause direct or indirect mortality of chinook salmon. Important stressors on chinook salmon include insufficient streamflow, high water temperatures, blockages at diversion dams, predation near human-constructed structures, contaminants, unscreened diversions, and harvest. ERPP focuses on reducing each of these stressors in the short term and eliminating the conditions that bring about the stress factors in the long term by restoring natural processes and eliminating stressors where feasible.

REFERENCES

Boydstun, L.B., R.J. Hallock, and T.J. Mills. 1992. Salmon in: California's living marine Resources and their utilization. W.S. Leets, C.M. DeWees, and C.W. Haugen eds. Sea Grant Publication UCSGEP-92-12. 257 p.

California Department of Fish and Game. 1998. Report to the Fish and Game Commission: A status review of the spring-run chinook salmon (Oncorhynchys tshawytscha) in the Sacramento River Drainage. June 1998.

Johnson, R., D. Weigand, and F. Fisher. 1992. Use of growth data to determine the spatial and temporal distribution of four runs of juvenile chinook salmon in the Sacramento River, California. U.S. Fish and Wildlife Service: AFF1/FRO-92-15.

Mills, T.J., D.R. McEwan, and M.R. Jennings. 1996. California salmon and steelhead: beyond the crossroads, p. 91-111. *In* D.

Stouder, P. Bisson, and R. Naiman, (eds.), Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York.

Mills, T.J. and F. Fisher. 1994. Central Valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. California Department of Fish and Game, Inland Fisheries Technical Report, Revised August 1994. 70 p.

National Marine Fisheries Service. 1997. NMFS proposed recovery plan for the Sacramento River winter-run chinook salmon. National Marine Fisheries Service, Long Beach, CA. March 6, 1996. 233 p.

National Marine Fisheries Service. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-95. 443 pp.

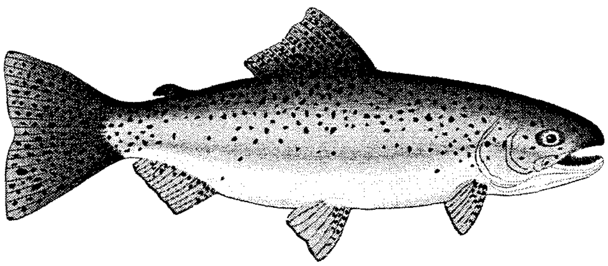
Pacific Fishery Management Council. 1999. Review of the 1998 Ocean salmon fisheries. Pacific Fishery Management Council, Portland, Or.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, OR.

____________ 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997. 112 p.



INTRODUCTION

Steelhead trouts are an anadromous form of rainbow trout. This species spawns in freshwater, its juveniles rear in cool water for a year or more before migrating to the ocean. Steelhead spend one to three years in the ocean before maturing and returning to fresh water to spawn. While they rear in fresh water, young steelhead are susceptible to mortality resulting from elevated water temperatures and a variety of other adverse environmental and habitat factors.

Steelhead is one of the listed species for which actions are developed to achieve its recovery.

The California Fish and Wildlife Plan estimated that there were 40,000 adult steelhead in the Central Valley drainages in the late 1950s, and Hallock et al. (1961) estimated that the average annual steelhead run size was 20,540 adults in the Sacramento River system above the mouth of the Feather River. In the early 1960s, It is estimated that 30,000 adult steelhead returned to Central Valley rivers and streams (Mills et al. 1996, Mills and Fisher 1994).

In the early 1990s, the total (hatchery and wild) annual run size for the entire system was roughly estimated to be no greater than 10,000 adult fish (McEwan and Jackson 1996). A more reliable indicator of the magnitude of the decline of Central Valley hatchery and wild stocks is the trend reflected in the Red Bluff Diversion Dam (RBDD) counts: numbers declined from an average annual count of 11,187 adults for the ten-year period beginning in 1967, to 2,202 adults annually in the early 1990s. The average escapement estimates for wild (natural spawners) above RBDD for the same time periods was 6,819 and 893, respectively (McEwan and Jackson 1996).

Hallock et al. (1961) reported that the composition of naturally produced steelhead in the population estimates for the 1953-54 through 1958-59 seasons averaged 88%. This is probably not reflective of present composition in the Central Valley system, due to the large-scale loss of spawning and rearing habitat and increases in hatchery production. During the time period of the Hallock et al. study, only Coleman and Nimbus hatcheries were in operation. Today, four Central Valley steelhead hatcheries (Mokelumne River, Feather River, Coleman and Nimbus hatcheries) collectively produce approximately 1.5 million steelhead yearlings annually.

Historically, steelhead ranged throughout the Sacramento River system (including both east- and west-side tributaries) and the San Joaquin River system. Historical documentation exists that show steelhead to have been widespread throughout the San Joaquin River system, At present, naturally spawning populations of steelhead are known to occur in the upper Sacramento River and tributaries, Mill, Deer, and Butte creeks, and the Feather, Yuba, American, and Stanislaus rivers. However, the presence of naturally spawning populations appears to correlate well with the presence of fish monitoring programs, and recent implementation of monitoring programs has found steelhead in streams previously thought not to contain a population, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs (IEP Steelhead Project Work Team 1999).

RESOURCE DESCRIPTION

Rainbow trout exhibit one of the most complex life histories of any salmonid species. Those that exhibit anadromy (i.e., migrate as juveniles from fresh water to the ocean and then return to spawn in fresh water as adults) are called steelhead. Rainbow trout populations appear to be structured around several key life-history traits and a continuum of migratory behaviors, the two extremes being anadromy (strongly migratory) and residency (non-migratory). Within these extremes are potamodromous (river migratory), and possibly estuarine and coastal forms. All of the life-history forms within a particular stream comprise a single, interbreeding population.

This complexity of life history forms can also be found in individual behaviors. A rainbow trout can mature in fresh water and spawn, then migrate to the ocean and return to spawn in subsequent years as a steelhead. More importantly, there is evidence that progeny can exhibit a different life-history strategy than that of their parents (e.g., offspring of steelhead can adopt a resident lifestyle and the offspring of resident trout can migrate to the ocean and become steelhead) (IEP Steelhead Project Work Team 1999).

A complex structure and flexibility in reproductive strategies among a single population may be necessary for the long-term persistence of the population in environments that are frequently suboptimal and not conducive to consistent, annual recruitment of migrants to the ocean. It was not uncommon, even under unimpaired conditions, for the lower reaches of many Central Valley streams to become intermittent during the dry season (and longer), isolating individuals in the perennial headwaters, and these conditions may have persisted for years.

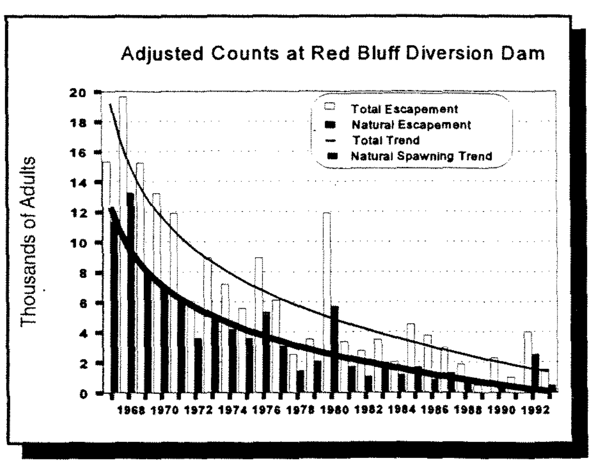
Having several different life-history strategies among a single population effects "bet-hedging" against extinction. If ecological conditions are not conducive for a particular life history form to survive and reproduce, the population would be sustained by other life history forms that could successfully reproduce (usually the resident fish). However, for this mechanism to be effective in sustaining the population, the ecological linkages between the various life-history forms, and the habitat linkages between the lower river reaches and the headwaters, must be maintained. The large-scale disruption of this linkage that has occurred in the Central Valley through the placement of impassable dams on many streams may go a long way in explaining the significant decline of Central Valley steelhead stocks.

Generally, juvenile steelhead typically migrate to ocean waters after spending 1-3 years in fresh water. Most Central Valley steelhead migrate to the ocean after spending two years in fresh water (Hallock et al. 1961). They reside in marine waters for typically 2 or 3 years before returning to their natal stream to spawn as 3- to 5-year-old fish. Unlike Pacific salmon, steelhead are iteroparous (i.e., they are capable of spawning more than once before they die). However, post-spawning survival rates are generally low, thus the percentage of adults in the population that spawn more than once is low.

Biologically, steelhead can be categorized into two reproductive ecotypes according to their state of sexual maturity at the time of river entry, the duration of their spawning migration, and behavior. These two ecotypes are termed *stream maturing* and *ocean maturing* (also known as *summer steelhead* and *winter steelhead*, respectively). Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean-maturing steelhead enter fresh water with well-developed gonads and spawn shortly thereafter. Central Valley steelhead stocks are of the ocean-maturing type and are called winter steelhead. Some evidence suggests that summer steelhead were once present but that construction of large dams on major tributaries, which would have blocked adults from reaching the deep pools they need to oversummer, most likely eliminated these populations.

The National Marine Fisheries Service (NMFS) has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU). ESUs are defined using a variety of physical and biological data, including the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); life history traits (age at smolting, age at spawning, river entry timing, spawning timing); and genetic uniqueness.

The Central Valley steelhead ESU comprises the Sacramento River and its tributaries and the San Joaquin River and its tributaries downstream of the confluence with the Merced River (including the Merced River). Recent data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California (Busby et al. 1996; NMFS 1997).



In reviewing the status of steelhead, NMFS (1996a) concluded that the Central Valley ESU is in danger of extinction due to the following:

- water diversion and extraction
- mining
- agriculture
- urbanization
- habitat blockages
- logging
- harvest
- hydropower development, and
- hatchery introgression.

Steelhead are somewhat unique in that they depend on essentially all habitats of a river system. Steelhead use the estuary for rearing and adapting to saltwater. The main channel is used for migrating between the ocean and upstream spawning and rearing areas. The tributaries are used for spawning and rearing. They are, therefore, found in virtually all ecological management zones and many of their respective ecological management units.

Overall, the decline of the steelhead trout population resulted from the cumulative effects of degrading habitats and environmental processes and functions. These factors include constructing dams on the larger rivers and streams which eliminated access to critical habitat for adults and juveniles; excessively warm water temperatures during the rearing period of juvenile steelhead; interrupting or blocking the free passage of juveniles and adults at diversion dams; loss of natural emigration cues due to altered flow regimes resulting from the export of water from large diversions in the south Delta; unscreened and poorly screened diversions which entrain fish as they are migrating; and channelization, levee construction, and land use which have led to degradation and loss of woody debris, shaded riverine aquatic, riparian corridors and forests, and floodplain functions and habitats. The single, most limiting factor for the decline of Central Valley steelhead is elimination of access to an estimated 82% to 95% of historical spawning and rearing habitat (Reynolds et al. 1993; Yoshiyama et al. 1996).

A host of other factors has also contributed to the decline of the steelhead trout, but perhaps to a lesser degree. These include the various smaller water diversion facilities and dams; extensive loss of rearing habitats in the lower Sacramento River, San Joaquin River, and Sacramento-San Joaquin estuary through levee construction and marshland reclamation; and the interaction with and predation by non-native species.

VISION

The vision for Central Valley steelhead trout is to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully uses existing and restored habitat areas. Achieving this vision will primarily require restoring degraded spawning and rearing habitats and enhancing fish passage to historical habitat. Reestablishing the ecological linkage between headwaters and lower reaches by restoring steelhead access to historical habitats above dams is the most important element to achieve the vision.

This vision is consistent with restoring populations of steelhead to levels that eliminate the need for any future protection under the State and federal Endangered Species Acts (ESAs). To achieve this vision, ecological functions and processes that create and sustain steelhead habitats would be maintained and restored and stressors and known sources of mortality would be reduced or eliminated.

The strategy for attaining this vision is to restore degraded spawning and rearing habitat in tributaries; restore access to historical habitat that is partially or completely blocked; dedicate more water in storage to provide adequate tailwater habitat conditions (primarily water temperature) year-round below dams; support angling regulations consistent with restoring ecosystem processes and functions; support additional research to address large deficiencies in information regarding steelhead freshwater and ocean life history, behavior, habitat requirements, and other aspects of steelhead biology; and provide opportunities for angling and nonconsumptive uses.

In addition, the strategy includes operating Central Valley hatcheries to protect and maintain the existing genetic diversity of naturally spawning populations and provide hatchery-produced fish for a healthy recreational fishery.

NMFS has recommended general conservation measures for steelhead throughout their Pacific coast range. These conservation measures, when applied to the Central Valley, include the following:

- Implement land management practices that protect and restore habitat. Existing practices that may affect steelhead include timber harvest, road building, agriculture, livestock grazing, and urban development.
- Review existing harvest regulations to identify any changes that would further protect Central Valley steelhead.
- Incorporate practices to minimize impacts on native populations of steelhead into hatchery programs.
- Make provisions at existing dams to allow the upstream passage of adult steelhead.
- Provide adequate headgate and staff gage structures at water diversions to control and effectively monitor water usage, and enforce water rights.
- Screen irrigation diversions affecting downstream migrating steelhead.

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are not specific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the Central Valley water storage and conveyance systems for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout.

Inadequate connectivity between upstream holding, spawning, and rearing habitat in certain tributary streams has impaired or reduced the reproductive potential of most steelhead stocks. Providing stream flows, improving fish ladders, and removing dams will contribute greatly to efforts to rebuild steelhead populations.

One critical effort will be to conduct the necessary evaluations and analyses to determine the potential benefits and consequences of reintroducing certain steelhead stocks above major dams to provide access to historic spawning and rearing areas. The potential transfer of adult fish above the dams may be straightforward, but the successful emigration downstream by juveniles cannot be ensured. Juvenile salmonid passage at large dams in the Columbia River basin has had little success and the viability of this option to protect and restore naturally spawning steelhead trout in the Central Valley is unknown.

RECOVERY GOALS

The National Marine Fisheries Service has not developed a proposed recovery goal for the Central Valley steelhead ESU.

The U.S. Fish and Wildlife Service developed a target production level for steelhead spawning upstream of Red Bluff Diversion Dam in conjunction with their development of the Anadromous Fish Restoration Program (USFWS 1997). The target production level is 13,000 adult steelhead. The Service was constrained from developing additional target production levels for streams elsewhere in the Central Valley due to a lack of abundance data for other populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Two major programs to restore steelhead trout populations exist within the Central Valley. The U.S. Fish and Wildlife Service's goal, as established by the Central Valley Project Improvement Act, is to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to attempt to double the numbers of steelhead estimated to have been present in the Central Valley in 1988 (McEwan and Jackson 1996, Reynolds et al. 1993, and McEwan and Nelson 1991).

Each of these steelhead trout restoration programs has developed specific restoration goals for Central Valley steelhead trout stocks. Implementation of the steelhead vision strategy will contribute to each agency's program through the restoration of critical ecological processes and functions, restoration of habitats, and reduction or elimination of stressors.

Linkage with Other Ecosystem Elements

Steelhead trout are closely dependent on ecological processes and habitats and adversely affected by a variety of stressors. Many of the stressors affecting abundance, persistence, and recovery of steelhead were initially identified as stressors that constrain Central Valley chinook salmon populations, and were applied secondarily to steelhead because they are an anadromous fish with a generally similar life history. For the most part, stressors that affect chinook salmon also affect steelhead. However, because of the focus on chinook salmon, it is often assumed that steelhead have been affected by the identified stressors *to the same degree* as chinook salmon, hence it is a common misconception that alleviation of the stressor to the level that it no longer impacts a chinook salmon population will result in steelhead population increases. In reality, some stressors cause greater impacts on steelhead populations than they do on chinook salmon populations. For example, high water temperatures affect juvenile steelhead to a greater degree than juvenile fall-run chinook salmon because most fall-run chinook have emigrated to the ocean by early summer before high water temperatures occur, and steelhead must rear through summer and fall when water temperatures are more likely to become critical.

Important ecological processes the directly influence the health of steelhead trout or its habitat include:

- Central Valley streamflows,
- Coarse sediment supply,
- Stream meander corridors,
- Natural floodplain and flood processes,
- Central Valley stream temperatures,
- Bay-Delta hydraulics, and
- Bay-Delta aquatic foodweb.

Habitats used by steelhead trout during their juvenile or adult life stages include:

- Tidal perennial aquatic habitat,
- Delta sloughs,
- Midchannel islands and shoals,
- Saline and fresh emergent wetlands,
- Riparian and riverine aquatic habitats, and
- Freshwater Fish Habitats.

Stressors that adversely affect steelhead trout or its habitats include:

- Water diversions,
- Dams and other structures,
- Levees, bridges, and bank protection,
- Dredging and sediment disposal,
- Gravel mining,
- Predation and competition,
- Non-native wildlife,
- Contaminants,
- Harvest, and
- Artificial propagation programs.

Strategic Objective, Targets and Programmatic Actions

The Strategic Objective is to restore self-sustaining Central Valley steelhead to Central Valley streams and the Bay-Delta estuary.

Long-Term Objective: Restore self-sustaining populations of steelhead to all streams that historically supported steelhead populations and contain suitable habitat, or could contain suitable habitat with the implementation of reasonable restoration and protection measures. Numbers of fish of natural origin should exceed in most years the estimated population level in the early 1960s: 40,000 adult spawners annually.

Short-Term Objective: Determine the abundance, distribution, and structure of existing steelhead populations, and develop and implement restoration measures and protections that have a relatively high degree of certainty of increasing number and size of naturally spawning populations.

RATIONALE: Because dams have been constructed at low elevations on all major tributaries of the Sacramento and San Joaquin rivers, steelhead have been denied access to most of their historical spawning and rearing habitats in upstream areas. It was generally assumed that hatchery production would make up for any losses caused by the dams; however, hatchery production of steelhead has been limited by numerous problems. For example, one major hatchery (Nimbus) raises steelhead derived from fish imported from the Eel River and other sources because native steelhead were in short supply). Because of the hatcheries and changes to the rivers, the exact status of wild populations in the Central Valley is unclear, but the populations are certainly at low levels. The largest remaining populations of wild steelhead appear to be in the upper Sacramento River and its tributaries, but the status of these runs is unknown. Because of the severe decline of Central Valley steelhead, the NMFS has listed them as threatened under the federal Endangered Species Act. The objective, therefore, is designed to restore the numbers and spawning densities of wild steelhead to a point where the species can remain viable and can sustain a substantial sport fishery. The restoration of steelhead to reasonably high numbers and densities in currently available habitat depends on assumptions about habitat quality and the biology of the fish that need to be tested. It is likely that restoration of this fish will require providing it with access to upstream areas now blocked by dams.

STAGE 1 EXPECTATIONS: Central Valley steelhead numbers should not fall lower than they have been in the 1990s. Ongoing efforts to provide passage at impassable dams on key tributaries such as Battle, Clear, and Butte creeks should be accelerated. Water operations should provide temperatures adequate for summer rearing in reaches below the major reservoirs. Now that a hatchery marking program has been implemented so that hatchery and wild fish can be differentiated, information on the status of natural stocks can be obtained. Chinook salmon emigration studies should be augmented so that information regarding steelhead is obtained, and monitoring of adult spawner escapement on all major tributaries should be implemented. Use of the steelhead life-stage assessment protocol (see below) by the anadromous fish monitoring programs will provide valuable information on natural steelhead distribution (IEP Steelhead Project Work Team 1999).

The following actions would help to achieve the short- and long-term restoration of Central Valley steelhead populations:

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

- Provide sufficient flows in lower tributaries for immigration and emigration to improve migration success.

- Reduce losses to unscreened diversions.

- Increase the scope of catch-and-release recreational fisheries for naturally produced steelhead. (Note: The Fish and Game Commission has adopted more stringent angling regulations for the Central Valley, including the elimination of retention of unmarked (wild) steelhead except for a limited area in the upper Sacramento River.)

- Implement programmatic actions proposed in the 14 ecological management zone visions to help achieve steelhead targets by creating and sustaining improved habitat conditions and reducing sources of mortality.

OTHER ISSUES AND INFORMATION NEEDS

The Comprehensive Monitoring, Assessment, and Research Program (CMARP - see Overview section) identifies six major knowledge gaps and monitoring needs for steelhead (CMARP Steering Committee 1999). In addition, a conceptual model was developed for Central Valley steelhead and has been incorporated into the CMARP plan as a technical appendix (IEP Steelhead Project Work Team 1999). These documents describe past research and monitoring projects for steelhead, identify what is known about their life history and status, review the adequacy of existing anadromous fish monitoring projects in terms of their ability to obtain steelhead information, and recommend new monitoring and assessment programs or enhancements to ongoing anadromous fish monitoring programs that will address the identified knowledge gaps.

The knowledge gaps are the result of institutional and natural constraints to steelhead monitoring and research. Institutional constraints are the result of the narrow focus of most anadromous fish monitoring programs: because chinook salmon are commercially exploited, highly visible, and politically sensitive, they have received the majority of limited monitoring funds and effort. This narrow focus was reinforced by the belief among resource agencies that steelhead suffer from the same level of impacts as do chinook salmon, and assessment of impacts would be similar for steelhead.

Natural constraints result from life-history traits that are common to all Central Valley steelhead that make them difficult to monitor and assess. Adults tend to migrate during high flow periods, which make it difficult to observe them and difficult to maintain counting weirs and other monitoring equipment and structures. Carcass surveys, a reliable method to estimate chinook salmon spawning escapement, is not applicable to steelhead because many survive spawning and most others do not die on the spawning grounds. Although steelhead redds can be discerned from salmon redds, they are difficult to observe because steelhead spawn at higher flows than do chinook salmon. Trap efficiencies are lower for juvenile steelhead because emigrating juveniles can more readily escape trapping because of their larger size, relative to chinook salmon.

In addition to the CMARP documents, NMFS has provided additional information regarding factors influencing the decline of steelhead, ongoing steelhead conservation efforts, and areas where clarification and additional studies are needed to provide better assurances that the actions proposed for steelhead restoration are adequate (National Marine Fisheries Service 1996a and 1996b). Information needs corresponding to the major knowledge gaps identified by the CMARP documents and other issues identified by the NMFS are described below:

■ CURRENT DISTRIBUTION, ABUNDANCE AND LIFE-HISTORY CHARACTERISTICS OF NATURALLY SPAWNING POPULATIONS

Existing monitoring projects have shown that naturally spawning steelhead populations exist in the upper Sacramento River and tributaries, Mill, Deer, and Butte creeks, and the Feather, Yuba, American, and Stanislaus rivers. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs.

From 1967 to 1993, run size estimates were generated for steelhead using counts at the fishway on the Red Bluff Diversion Dam (RBDD). From these counts, estimates of natural spawning escapement for the upper Sacramento River above RBDD were made. Because of impacts to winter-run chinook salmon, the operation of RBDD was changed so that the dam gates were raised earlier in the season, and this eliminated the ability to generate run-size estimates.

Beginning with broodyear 1997, all steelhead produced in Central Valley hatcheries were marked with an adipose fin clip. This program will continue as a permanent hatchery practice at these hatcheries. Marked juvenile fish were captured in smolt emigration studies beginning in 1998 and marked adult steelhead began returning in winter 1999.

The IEP Steelhead Project Work Team has developed a steelhead life-stage assessment protocol that classifies rainbow trout by developmental life stage and includes diagnostics for determining the degree of smoltification using a set of characteristics that is well-established in the scientific literature. Implementation of a standardized protocol to assign individual fish to one of several life-stage categories (yolk-sac fry, fry, parr, silvery parr, or smolt) will yield valuable information regarding when and where naturally-produced steelhead smolts occur and the disposition of juvenile steelhead through time and space. This will be an important tool in determining current distribution of steelhead throughout the Central Valley.

ACTION - More comprehensive monitoring is needed to determine system-wide distribution. In addition to existing monitoring, new projects should be initiated in the mainstem San Joaquin and Cosumnes rivers and Stony, Thomes, Antelope, and Putah creeks. For the Stanislaus, Tuolumne, Merced, and Yuba rivers and Mill and Deer creeks, the existing chinook salmon monitoring projects should be augmented so that steelhead information can be obtained. Index reaches could be established and monitored by electrofishing, beach seining, hook and line, or some other method to document occurrence, assess smolt production, and provide indices of abundance. The adult fish trap in the Daguerre Point Dam fish ladder, which is operated to monitor adult spring run chinook salmon, should be utilized to monitor adult steelhead escapement as well.

Another method of generating run-size estimates for the upper Sacramento River system, or perhaps an index, needs to be developed.

Capture of non-clipped juvenile steelhead in tributary monitoring projects will help elucidate the location of naturally spawning populations. Some existing anadromous fish monitoring projects have begun recording the life stage and the presence or absence of adipose fins on all rainbow trout observed or captured. All monitoring projects should adopt these protocols into their data collection regimen.

■ GENETIC AND POPULATION STRUCTURE

NMFS recently completed a genetic analysis on Central Valley steelhead as part of the west coast steelhead Endangered Species Act status review. This study provided useful information for purposes of delineation of Evolutionarily Significant Units (ESU's), but did not have the resolution necessary to provide meaningful information within ESU's, such as the Central Valley ESU. There is a need to augment this analysis to provide comprehensive information on the relationship of Central Valley steelhead populations to each other and to other populations of coastal rainbow trout. A genetic evaluation of Central Valley steelhead populations is necessary to determine phylogenetic relationships among putative native rainbow trout, naturally spawning steelhead, and hatchery steelhead that were founded from non-native broodstock. This information will be useful in estimating the structure and genetic diversity within and among Central Valley steelhead populations.

A generalized population structure can be inferred from existing knowledge of rainbow trout/steelhead life histories and behaviors, and from more specific studies on other anadromous trout population (e.g., brown and cutthroat trout). However more research into this topic is necessary to fully elucidate the interrelationship of the various life history forms, especially the non-anadromous and anadromous forms. Population ecology theory suggests that the non-anadromous forms are important for population persistence through periods of adverse climatic conditions (e.g., drought) and the anadromous forms are important for recolonizing new and restored habitat after catastrophic events (e.g., wildfires) cause the extirpation of the non-anadromous forms of a local population. This would suggest that all life-history forms of a population may be necessary for long-term persistence of the population.

ACTION - A comprehensive, basin-wide evaluation using analysis of mtDNA and microsatellite DNA structure and allele frequencies could provide information that is essential for designing recovery actions and will provide the context for successful interpretation of genetic relationships of steelhead populations in specific streams. Specific objectives of the evaluation would be:

- Evaluate and describe genetic and population structures and genetic diversity of Central Valley steelhead populations.

- Compare genetic profiles and describe phylogenetic relationship of Central Valley naturally-spawning and hatchery steelhead populations.

- Analyze genotypes of self-sustaining, putative native Central Valley rainbow trout populations that are presently isolated above artificial barriers to determine their phylogenetic relationship to anadromous and stream-dwelling rainbow trout populations and strains.

- Provide genetic information on steelhead populations of specific stream systems.

Determining maturation status of rainbow trout captured in the various monitoring projects will assist in elucidating the population structure of Central Valley steelhead and will provide much-needed information on the extent of the contribution of mature parr to the breeding population. Parr maturation, especially in males, is common in steelhead and other polymorphic salmonid populations. Sexually mature non-anadromous parr can be easily detected when working up samples of juvenile steelhead and can be easily incorporated into the steelhead life-stage assessment protocol (IEP Steelhead Project Work Team 1999). When collected systematically throughout the system in conjunction with life stage and condition, these data will provide information about the relationship of anadromous and non-anadromous forms and developmental variation in steelhead, all of which has direct bearing on population growth and dynamics.

■ INSTREAM FLOW NEEDS AND TEMPERATURE CONTROL

Flow needs for chinook salmon and steelhead often differ in timing; the most important flow needs for steelhead are for cold water during the summer and early fall, while increased flows for chinook typically are scheduled for the spring and mid-fall migration periods. In some cases, such as the temperature criterion for winter-run chinook from Keswick to Red Bluff, flow related actions for chinook provide appropriately timed temperature modulation for steelhead. However, this situation is a rarity. Differences in the timing and amount of flow needed by each species have the potential to lead to difficult management dilemmas in the event of extended drought.

ACTION - Workshops and research designed to contribute to developing flow-assessment protocols should pay equal attention to both steelhead and chinook salmon, and should also specifically address differences in life history between these species that require tradeoffs in flow conditions. This potential conflict should be made explicit for locations where it is most problematic (e.g., Stanislaus, American, Feather, Mokelumne, and Yuba rivers, and Cottonwood Creek). Effects of different flow regimes on habitat attributes important for each species should be evaluated for all water-year types. This information could be used to develop flow-allocation priorities where conflicts exist between the needs of both species.

A set of biological criteria including population abundance, productivity, and location should be established to guide the decision-making process. The objective should be to achieve drought protection for a well distributed set of natural populations that could serve as the source of colonists for populations that may be depleted or extirpated during a prolonged drought. Establishing priorities before a crisis exists should yield a more thoroughly considered and readily implementable course of action.

Locations where a conflict over flow allocation is less likely should also be highlighted (e.g., mainstem Sacramento from Keswick to Red Bluff, Mill, Deer, Antelope, and Butte creeks). Battle, Cow, and Clear creeks

■ ROLE OF INSTREAM HABITAT IN STEELHEAD PROTECTION AND RESTORATION

Temperature regulation below mainstem dams has replaced a host of other ecological and physical functions of flow as the focal point of setting flow criteria. However, maintenance of an adequate temperature regime does not provide other ecological characteristics associated with cold temperatures in upstream habitats, especially the type and availability of food resources and cover, and refugia from predatory fish. Restoration of connectivity among habitats will permit more natural movement patterns and habitat selection by steelhead juveniles and adults.

Steelhead and resident rainbow trout have been shown to utilize seasonal habitats of intermittent streams for spawning and rearing. Also, there is evidence that steelhead populations exist in some small, low elevation Sacramento River tributaries (e.g., Dry and Auburn Ravine creeks) that do not contain suitable habitat year-round, or are limiting in one or more suitable habitat characteristics. Habitat characteristics, the extent of use of these streams by steelhead, and life-history characteristics (spawning and emigration timing, size/age at emigration, etc.) is unknown.

ACTION - Given the intractability of re-creating headwaters ecology below a mainstem dam, restoration priority should be placed on both protection of intact habitats and improving access to these habitats. The second tier of priority should be degraded habitats that have the greatest potential for restoration to the combination of temperature regime and ecological function that approximate conditions in historic headwaters habitats (Pacific Rivers Council 1996).

The extent of steelhead use of intermittent and low elevation streams, habitat characteristics of these streams, and life-history characteristics (spawning and emigration timing, size/age at emigration, etc.) needs to be assessed.

■ Restoration of Access to Historical Habitat Presently Blocked by Dams

Because of the large-scale loss of spawning and rearing habitat that has occurred in the Central Valley, restoring access to historical habitats above impassable dams needs to be considered on some streams. This would not only increase the amount of available habitat for steelhead, but if spawning and rearing is allowed to take place in the upper reaches of a stream where it occurred historically, this may reduce the reliance on the downstream areas below the dam for spawning and rearing, and this could reduce the need to provide adequate flow and temperature conditions in the lower reach. This could have a positive impact on water storage and power generation.

Action - The Yuba River, and Battle and Clear creeks are locations at which evaluating opportunities to provide passage above existing barriers is most needed. Evaluation of habitat capacity above barriers is an essential first step, followed by a engineering feasibility study (Meral and Moyle 1998). In addition to the drainages named above, steelhead restoration above barriers should be pursued in at least one tributary of the San Joaquin.

Removal of barriers provides the highest probability of restoration success. However, the limited number of locations in which barrier removal is feasible, and the limited amount of habitat access provided, may be inadequate to achieve steelhead recovery. Trap, haul, and release approaches to reintroduction should not be dismissed, especially because these approaches will probably be instrumental to effective steelhead restoration in the San Joaquin and American River basins. Furthermore, over the 25 to 30 year course of the ERP, new technologies may enable implementation of trap, haul, and release approaches in locations where they are not currently considered feasible.

■ Assessment of Freshwater Predation Rates

One of the ultimate factors often associated with the evolution of anadromy is escape from high predation rates on egg and juvenile life stages in the ocean environment. The relatively large egg size and low fecundity of steelhead are life-history adaptations that correspond with reduced juvenile mortality. Low freshwater predation rates are associated with headwaters habitats. Large predatory fish are more abundant and more diverse in mainstem rivers than in headwaters streams. Largemouth and smallmouth bass have been identified as important predators on juvenile chinook salmon in the Tuolumne River (EA Engineering 1992). The effect of predation by introduced striped bass is uncertain.

Paired release experiments with chinook salmon have provided information about conditions affecting freshwater survival for this species. Inferring the causative mechanisms responsible for survival patterns is an important research topic for both steelhead and chinook salmon.

Action - Paired release or other types of experiments conducted with steelhead smolts at different sites throughout the Central Valley could provide information on survival rates of migrating juvenile steelhead. These experiments could be incorporated into the ERP adaptive management program. The potential for protecting wild populations by manipulation of the timing and distribution of hatchery releases is one strategy that should be evaluated in these experiments. Red Bluff Diversion Dam, the Hamilton City Pumping Plant, flood bypasses, San Joaquin tributaries and mainstem, and the Delta are locations where predation rates may be high and experiments would be useful (see Gregory and Levings 1998).

Steelhead runs in the American and Feather rivers which are highly supported by hatchery production provide opportunities for using uniquely-marked parr to evaluate survival rates of rearing fish.

■ Magnitude of Inland Recreational Fishery

Large experiments with Coleman fish in 1972-73, estimated that 2.7% of the steelhead released were caught before they reached the Delta (Menchen 1980, cited in McEwan and Jackson 1996). Staley (1976, cited in McEwan and Jackson 1996) found that 51.2% of Nimbus Hatchery yearlings released in the American River were caught. Much lower harvest rates occurred on Nimbus Hatchery fish released in the Sacramento River. Several anecdotal reports suggest that harvest rates on hatchery stocked fish can be high.

Action - Considerable efforts have been made to protect steelhead by modifying recreational fishery regulations and marking all hatchery steelhead. Central Valley steelhead are now listed as threatened under the ESA, and further provisions that minimize incidental take may be necessary. These provisions include:

- Rigorous estimates, with associated error estimates, of the level of potential incidental take,
- Continued marking of hatchery-produced steelhead and retention of only marked fish,
- Specification of time periods and locations of fishing seasons to minimize incidental take,
- Availability of sanctuary areas,
- Availability of effective monitoring efforts,
- Availability of effective enforcement mechanisms and public education programs, and
- Availability of effective implementation agreements.

Given that many anglers target hatchery releases, stocking practices should be designed to avoid overlap with outmigration of wild fish.

■ Influence of Hatchery Practices on Recovery

Natural production of steelhead is emphasized by both State policy and the ESA. Artificial production will be limited to areas where it already occurs, where it is necessary to prevent the extinction of a native run, or where the native population has already become extirpated and the habitat is irrevocably altered (McEwan and Jackson 1996).

The hatchery percentage of total production is currently estimated at 70 to 90 % (F. Fisher, pers. comm., cited in McEwan and Jackson 1996), and this level is considered to be as high as it should get (McEwan and Jackson 1996). From 1953-54 to 1958-59 the estimated average hatchery contribution to total steelhead production was 12% (Hallock et al. 1961).

Nimbus Hatchery broodstock, and naturally spawning fish in the American River exhibit genetic affinity to populations from the Eel River (NMFS 1997), reflecting the origin of this broodstock from the Van Arsdale Fisheries Station (Busby et al. 1996). This broodstock has also been introduced to the Mokelumne River via the Mokelumne River Fish Installation (Cramer et al. 1995).

Recommendations for hatchery operations (Hard et al. 1992, NRC 1996) provide an appropriate framework for evaluation. One important issue for the Central Valley is to link recovery of native populations with decreasing production objectives for the hatchery program.

Action - The objective of complete marking of hatchery fish should continue without exception throughout the duration of the CALFED program.

A plan should be developed by which restoration of natural production is matched by decreases in hatchery production. Hatchery production should not attempt to compensate for poor natural production, but should instead continue or more closely serve in the role of mitigating for the loss of upstream habitat and the loss of resultant fish and not serve to increase the number of naturally spawning fish.

For example, out-of-basin broodstock should be phased out. Replacement broodstock should be developed from wild spawning anadromous steelhead or native non-anadromous rainbow trout that became isolated when the dams were constructed, if sufficient numbers are available to permit take for broodstock. Replacement with another hatchery stock that exhibits genetic association with Central Valley steelhead is preferable to continued propagation of the out of basin stock. The replacement of broodstock by native non-anadromous rainbow trout has much merit, but is premature until certain evaluations are completed. These include identifying native populations isolated above dams (one of the objectives of the comprehensive genetic evaluation is to identify these populations), and demonstrating that anadromous forms can be recreated from these populations.

■ FECUNDITY OF MAIDEN (FIRST-TIME) AND REPEAT SPAWNERS

Fecundity for steelhead in their initial spawning is about half the fecundity of chinook salmon (Hutchings and Morris 1985). Fecundity is positively related to body weight, and the average fecundity of repeat spawners can approximate that of chinook salmon. In addition to increased fecundity, the larger body size of repeat spawners may enable them to make a disproportionate contribution to population productivity due to: 1) ability to dig deeper, more superimposition- and scour-resistant redds, and 2) a propensity to spawn in deeper water, reducing the potential for redd dewatering.

ACTION - Fish passage facilities should be constructed to pass adult steelhead efficiently in both directions. Recreational fisheries for adults should be governed by retention of only marked fish. Success of restoration should include an evaluation of trends in proportion of repeat spawners; an appropriate target would be at least 17% reported by Hallock (1989) for upper Sacramento River samples.

■ ROLE OF REARING HABITAT IMMEDIATELY BELOW LARGE DAMS

Maintaining the longest possible profile of riverine habitat capable of supporting all steelhead life stages is the most desirable objective for restoration. However, numerous constraints and competing interests limit attainment of this objective, especially for juvenile steelhead. Where constraints are severe, habitat enhancement near dams may provide opportunities to improve rearing habitat capacity. Most substrate supplementation that currently occurs in the Central Valley is in the form of spawning gravel for chinook salmon. This gravel can also be used by steelhead for spawning, but it does not contribute to enhancement of steelhead rearing habitat. Juvenile steelhead prefer substrates > 4 inches in diameter (Everest and Chapman 1972, Barnhart 1986). Steelhead parr also favor microhabitat sites adjacent to relatively swift currents that have overhead cover (Fausch 1993). Overhead cover is naturally provided by undercut banks and boulders or large woody debris, but artificial structures can also provide this habitat feature. Sedimentation reduces habitat quality by reducing food production, pool depth, and cover (Barnhart 1986).

ACTION - Adding cobble substrate to areas near dams, and providing shaded riparian aquatic habitat, could increase the suitability of tailwater areas as rearing habitat for steelhead. Because maintenance of adequately cool temperatures for steelhead rearing can be accomplished with less water in the immediate vicinity of dams, this habitat enhancement could permit a reduction in the volume of cold water released by encouraging more complete use of the cool water plume.

■ Drought Period Contingency Plan

Recent history has demonstrated the impact prolonged drought can have on fish populations, and the potential for recurring extended droughts has been documented from tree-ring data (Hunrichs 1991, cited in Mount 1995; USFWS 1995).

Action - An essential function of a long-term restoration plan for Central Valley steelhead is to avert population bottlenecks resulting from drought. Development of a drought contingency plan should begin with an assessment of which basins afford the greatest potential for successful use of economic incentives to maintain ample instream flows during a protracted drought. Other measures should include establishment of a drought fund that is designated for purchase of water from willing sellers and economic compensation for reduced demand in watersheds identified in the assessment phase.

■ Adequacy of Monitoring Program

The recovery criteria found in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (NMFS 1997, Botsford and Brittnacher 1998), and the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (1995) can be viewed as models for recovery planning. Existing recovery plans require a means for measuring natural spawner abundance (fish or redd counts) with an estimated uncertainty level, and consistent application of this monitoring procedure for an extended period. Duration of monitoring is either specified by a function of both uncertainty associated with estimation techniques and consistent attainment of abundance levels that correspond to an acceptably low probability of extinction, or attainment of specified abundance targets for a length of time often calculated as five times generation time. No recovery plan has been developed for steelhead at this time.

The widespread distribution of steelhead in the Central Valley, the relatively small size of populations in each tributary, and fundamental differences in life history and metapopulation dynamics compared to other listed species all suggest that steelhead monitoring will need to be broader in scope, and longer in duration than for other species.

Action - CMARP, in coordination with the IEP Steelhead Project Work Team, has developed a monitoring program for steelhead. Because of the anticipated broad scope and prolonged duration of this program, it should serve as the foundation upon which other monitoring components are built.

The monitoring program (IEP Steelhead Project Work Team 1999), in its base-level application, is designed to keep a pulse on the primary attributes of both existing and potentially-restorable steelhead habitat and associated steelhead populations. The plan is intended for application in tributary streams, mainstem rivers, and the delta and is suitable for addressing the identified specific knowledge gaps concerning Central Valley steelhead populations, collecting baseline information, and gauging the effects of CALFED actions.

The monitoring program has two primary components: habitat monitoring and steelhead population monitoring. The habitat component begins with habitat typing and mapping streams and rivers per the method of Snider et al. (1992). The resultant information on the distribution and abundance of mesohabitats in the stream (e.g., riffles, runs, glides, pools) provides the basis for identifying stream reaches based on stream channel attributes, and a template for allocating study effort (such as the study of juvenile steelhead rearing) per a random-stratified study design.

The steelhead population monitoring component of the plan essentially follows the basic life history of steelhead. The three main life-history compartments are spawning, rearing, and emigration. Within each of these compartments, questions are posed that provide the basis for what will be measured in the monitoring program. Each question is examined, either directly or indirectly, relative to basic habitat conditions being monitored. Thus, the plan is designed to observe population-level responses (in terms of population size and the extent to which a certain activity occurs) to variation in monitored habitat, including variation resulting from management actions implemented under CALFED. In addition, basic biological information will be collected on individual fish to monitor potential responses in the composition and structure of the population to actions taken.

Although monitoring of steelhead spawning will occur on a stream-specific basis, rearing and emigration monitoring will occur not only at that level but also on a linked, system-wide basis. Rearing and emigration monitoring will allow tracking of juvenile steelhead through the system, to the extent possible. This activity will be coupled with marking or tagging of wild fish - in addition to the hatchery marking program - as they are sampled through the system to obtain more specific information about how steelhead use the system as they move toward the ocean, including addressing questions about rearing requirements in downstream areas.

Classifying, prioritizing, and allocating monitoring effort in tributaries can at least be partially guided by considering options for steelhead enhancement and restoration. Monitoring effort and restoration actions should be allocated across a cross-section of these enhancement options so as to maintain the biodiversity of Central Valley steelhead and their associated habitats.

More detailed monitoring of steelhead harvest in Central Valley streams is needed. Continued complete marking of hatchery releases will be essential to the success of this monitoring program.

REFERENCES

Barnhart, R. A. 1986. U.S. Fish and Wildlife Service Biological Report, No. 82(11.60): Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest) -- steelhead. U.S. Army Corps of Engineers, TR EL-82-4, Washington.

Botsford, L. W., and J. G. Brittnacher. 1998. Viability of Sacramento River winter-run chinook salmon. Conservation Biology **12**:65-79.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. National Oceanic and Atmospheric Administration Technical Memorandum, NMFS-NWFSC-27: Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, Seattle.

CMARP Steering Committee. 1999. Recommendations for the Implementation and Continued Refinement of a Comprehensive Monitoring, Assessment, and Research Program.

Cramer, S. P., and 16 others. 1995. The status of steelhead populations in California in regards to the Endangered Species Act. S.P. Cramer & Associates, Inc., Gresham, OR.

EA Engineering, Science, and Technology. 1992. Report of Turlock Irrigation District and Modesto Irrigation District pursuant to Article 39 of the license for the Don Pedro Project. EA Engineering, Science, and Technology, Lafayette, CA.

Everest, F. H., and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada **29**:91-100.

Fausch, K. D. 1993. Experimental analysis of microhabitat selection by juvenile steelhead (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) in a British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences **50**:1198-1207.

Gregory, R. S., and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society **127**:275-285.

Hallock, R. J. 1989. Report to the U.S. Fish and Wildlife Service: Upper Sacramento River steelhead (*Oncorhynchus mykiss*), 1952-1988. California Department of Fish and Game, Sacramento.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. Fisheries Bulletin, No 114: An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. California Department of Fish and Game, Sacramento.

Hard, J.J., R.P. Jones, M.R. Delarm, and R.S. Waples. 1992. Pacific salmon and artificial propagation under the Endangered Species Act. U.S. Department of Commerce. NOAA Technical Memo. NMFS-NWFSC-2, 56 pp.

Hunrichs, R. A. 1991. U.S. Geological Survey Water Supply Paper, W2375: California: Floods and Droughts. U.S. Geological Survey, Washington, D.C.

Hutchings, J. A., and D. W. Morris. 1985. The influence of phylogeny, size and behaviour on patterns of covariation in salmonid life histories. Oikos **45**:118-124.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, Assessment, and Research on Central Valley Steelhead: Status of Knowledge, Review of Existing Programs, and Assessment of Needs. *in* Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. App. VII-11

McEwan, D. And T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game. 234 p.

McEwan, D., J. Nelson. 1991. Steelhead restoration plan for the American River. Department of Fish and Game. 40 p.

Menchen, R. S. 1980. Estimated freshwater sport catch of Coleman Hatchery yearling steelhead, *Salmo gairdnerii* in 1973. California Department of Fish and Game, Anadromous Fisheries Branch, Sacramento.

Meral, G. H., and P. B. Moyle. 1998. Restoring steelhead and spring-run salmon to the American River watershed. Planning and Conservation League Foundation, Sacramento.

Mills, T.J., D.R. McEwan, and M.R. Jennings. 1996. California salmon and steelhead: beyond the crossroads, p. 91-111. *In* D. Stouder, P. Bisson, and R. Naiman, (eds.), Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York.

Mills, T.J. and F. Fisher. 1994. Central Valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. California Department of Fish and Game, Inland Fisheries Technical Report, Revised August 1994. 70 p. draft

Mount, J. F. 1995. California rivers and streams: the conflict between fluvial process and land use. University of California Press, Berkeley.

National Marine Fisheries Service. 1996a. Factors for Decline. A supplement to the notice of determination for West Coast steelhead under the endangered species act. National Marine Fisheries Service. Protected Species Branch. Portland, Oregon. August 1996. 83 pp.

National Marine Fisheries Service. 1996b. Steelhead Conservation Efforts. A supplement to the notice of determination for West Coast steelhead under the endangered species act. National Marine Fisheries Service. Protected Species Branch. Portland, Oregon. August 1996. 29 pp.

National Marine Fisheries Service. 1997. Status review update for deferred and candidate ESUs of west coast steelhead. National Marine Fisheries Service, West Coast Steelhead Biological Review Team.

National Research Council. 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

Pacific Rivers Council. 1996. Healing the watershed: a guide to the restoration of watersheds and native fish in the west. 1st edition. Pacific Rivers Council, Inc. Eugene, Oregon. 220 pp.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

Snider, B., D.B. Christopher, B.L. Jackson, and P.M. Bratovich. 1992. Habitat characterization of the lower American River. Calif. Dept. of Fish and Game and Beak Consultants. 20 pp

Staley, J. R. 1976. Administrative Report, No. 76-2: American River steelhead, *Salmo gairdnerii gairdnerii*, management 1956-1974. California Department of Fish and Game, Anadromous Fisheries Branch, Sacramento.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland.

U.S. Fish and Wildlife Service. 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997. 112 p.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: Final report to Congress, vol. III. Centers for Water and Wildland Resources, Univ. Cal. Davis. pg. 309-361.

◆ At-risk Native Species (Priority Group II)

Introduction

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. The first Strategic Goal focuses on at-risk species:

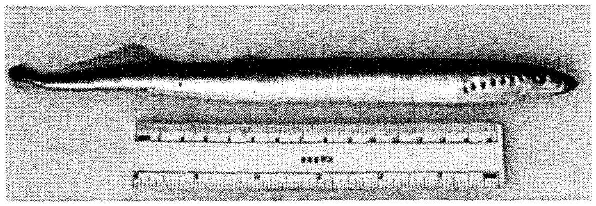
> ***GOAL 1: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.***

Because there are so many species covered under this goal, they have been divided into four groups in terms of priority for CALFED attention. Many are "at-risk" species, which are in danger of extinction if present trends continue.

Group II priority species are those at-risk native species dependent on the Bay-Delta system whose restoration is not likely to require large-scale manipulations of ecosystem processes because they have limited habitat requirements in the estuary and watershed.

Species in Priority Group II include:

- Lamprey
- California clapper rail
- California black rail
- Swainson's hawk
- Suisun song sparrow
- Alameda song sparrow
- Salt marsh harvest mouse
- Suisun ornate shrew
- San Pablo California vole
- Special status plant species
- Valley elderberry longhorn beetle



INTRODUCTION

Like any native species the lamprey is an indicator of ecosystem health. Although the lamprey does not hold any commercial or recreational value in California, its life history is similar to that of other anadromous species (salmonids). Loss of suitable spawning habitat and disturbance by humans has impacted the population of native lampreys. Even though these fish are predaceous in nature, they appear to have little affect on other resident fish species. Some California Native American tribes and European countries consider the lamprey a delicacy.

Factors that will limit the lamprey's ability to contribute to a healthy ecosystem are Delta outflow and spawning habitat in the upper rivers.

Little recent information regarding the abundance and distribution of lampreys in the Central Valley is available. This lack of information needs to be remedied by research into the basic biology of the genus, including life history studies, and data collection regarding abundance and distribution.

RESOURCE DESCRIPTION

The lamprey is the most primitive of all fish species that reside in California waters. Of the four species of lamprey that can be found in California only three have life stages in the Sacramento-San Joaquin system. These are the river lamprey (*Lampetra ayresi*), Pacific lamprey (*Lampetra tridentata*) and the Pacific brook lamprey (*Lampetra pacifica*). Access to spawning grounds has been blocked by dams on both the Sacramento and San Joaquin rivers and their tributaries.

The river lamprey is an anadromous fish that is predaceous on fish in both salt- and fresh-waters. Adults migrate from the ocean and move into smaller tributary streams in April and May to spawn and die shortly afterwards. Juveniles, called ammocoetes, remain in this life stage until they reach about 117 mm standard length (SL) and transform into adults and emigrate to the ocean.

The Pacific lamprey is an anadromous fish that spends its predatory phase in the ocean. Migration occurs between April to late-July with adults moving upstream several month prior to spawning. After spawning, the adults die and the eggs settle and adhere to the substrate. Between 140 mm and 160 mm the ammocoetes begin the transformation into adults and migrate to the ocean.

The Pacific brook lamprey is a relativity small, (when compared to other lampreys) non-predaceous fish that resides in the lower reaches of the Sacramento-San Joaquin rivers. Spawning is believed to occur from July through September in the upper reaches of the San Joaquin River.

The health of lamprey populations is adversely affected by the following general types of activities or conditions:

- urbanization
- agricultural practices
- livestock grazing and dairy farming
- timber harvesting
- gravel mining
- water development
- summer dams
- urban runoff
- wastewater discharge, and
- flood control and bank protection.

VISION

The vision for anadromous lampreys is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Better knowledge of these species and restoration would ensure their long-term population sustainability. A major focus of the efforts would be to improve access to historic spawning grounds within California. Many of the efforts described in the Stage 1 Actions that would benefit anadromous fish species would directly effect all lamprey populations due to their similarities in spawning habitat and flow requirements.

On the Sacramento side of the system efforts to expand access to spawning habitats would need to be accomplished. On the San Joaquin side of the system, efforts would need to be directed towards improving the overall health of the river (water quality) in addition to improving access to historic spawning grounds.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring habitat used by anadromous lamprey include all the programs directed at the restoration of habitat for chinook salmon and steelhead. Although lamprey are not directly targeted by these restoration programs, lamprey will derive benefits directly from programs that address habitat. Lamprey habitat will also improve with the implementation of improved watershed management program. The CALFED Watershed Management Coordination component in not an element of the ERPP.

- Central Valley Project Improvement Act: The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995) by implementing a variety of measures including habitat restoration.

- Salmon, Steelhead Trout and Anadromous Fisheries Program Act: The California Department of Fish and Game (DFG) is required under State legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993). Implementation of this program will increase the suitability of aquatic habitats required by lamprey.

- CALFED Watershed Management Coordination Program: The watershed program is designed to reduce stressors resulting from mining practices, agricultural discharges, excessive runoff and erosion, wildfire, excessive timber harvest, livestock grazing, and damaging land use practices that constrain ecological health of the streams.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the lamprey populations and their habitats will be integrally linked to:

- maintaining essential fish habitats,

- restoration of natural stream meander corridors,

- providing suitable water temperatures for rearing,

- providing flows for migration, and

- reducing or eliminating the adverse effects of stressors such as contaminants, gravel mining, unscreened diversions, and other sources of mortality.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore anadromous lampreys dependent on the Delta and Suisun Bay.

LONG-TERM OBJECTIVE: Restore wild self-sustaining populations of anadromous lampreys to all accessible rivers in which they historically occurred.

SHORT-TERM OBJECTIVE: Evaluate the status and life history requirements of Pacific lamprey and river lamprey in the Central Valley and determine their use of the Delta and Suisun Bay for migration, breeding, and rearing.

RATIONALE: Lampreys are anadromous species that clearly have declined in the Central Valley although the extent of the decline has not been documented. Pacific lamprey probably exist in much of the accessible habitat available today but this is not known. The decline of lampreys is presumably due to the decline of salmonids (major prey species), to deterioration of their spawning and rearing habitat, to entrainment in diversions, and to other factors affecting fish health in the system. As for salmonids, much of the habitat previously available for wild-spawning lampreys is permanently disconnected from the migration corridors. However, the remaining habitat or, the "new" habitat in the tailwaters of large dams, should be useable for spawning. Presumably, restoration of salmonid populations will also benefit lampreys, although this assumption should be regarded as a hypothesis, not a fact. If the assumption is not true, lampreys may have to be treated as Priority Group I species.

STAGE 1 EXPECTATIONS: Surveys will have been conducted to determine the status of lampreys in the Central Valley and a status report should be in place that recommends restoration actions.

The target for lamprey populations would be to double and maintain the population of all lampreys within the Central Valley.

All lamprey populations would benefit from the following restoration activities and actions:

- restoration activities to spawning sites in the upper rivers and tributaries of the Central Valley,
- increased river flows,
- removal of barriers to historic spawning grounds,
- improved water quality in the San Joaquin River System,
- remove existing threats to known populations,
- restore habitat conditions favorable to the survival of lampreys and other native aquatic species, and
- protect and monitor lamprey populations and habitat once the threats have been removed and restoration has been completed.

REFERENCES

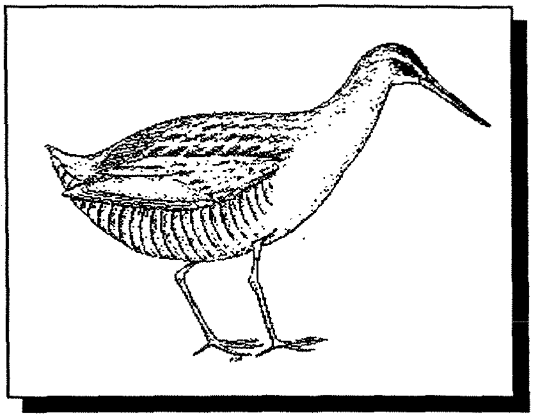
Moyle. P.B. 1976. Inland Fishes of California. University of California Press, Berkeley. 405 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada. Bulletin 184. Ottawa, Canada. 966 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Wang, Johnson, C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. IESP Technical Report 9. pp 1-1.

◆ CALIFORNIA CLAPPER RAIL



INTRODUCTION

The clapper rail is a year-long resident in coastal wetlands and brackish areas around San Francisco Bay. Within the Central Valley, this species is found only in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. The California clapper rail is associated with saline emergent wetlands. The population and distribution of this species have declined substantially, primarily as a result of reclamation of its tidal saltmarsh habitats. The loss of habitat and declining condition of the species' population have warranted its listing as endangered under the State and federal Endangered Species Acts. This species characteristically inhabits the more saline marshes of the Bay. Highest population densities are associated with large tidal marsh areas with well-developed channel systems (Goals Project 1999).

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of historical and current loss or degradation of tidal saltmarshes for agricultural, industrial, and urban uses, and excessive predation on nests and individuals by non-native predators.

RESOURCE DESCRIPTION

Habitat loss is largely a result of reclamation for agricultural, industrial, and urban uses and water management projects. Populations have also been limited due to loss or degradation of tidal saltmarshes for waterfowl hunting and management. The total area of these remaining habitats represents only a small percentage of their historic level. The California clapper rail breeds from February through August. The preferred habitat is saline tidal marshes but are known to use brackish marsh areas with alkali bulrush. It builds a platform nest concealed by a canopy of cordgrasses and pickleweed. It may also use cattails and bulrushes in fresh emergent wetland habitats although these area are not considered suitable foraging and breeding habitat. Adjacent upper wetland or upland habitat with aquatic vegetation are also important because they provide nesting and escape cover during high tides and floodwaters.

Significant loss of saline and brackish emergent wetland habitat and associated upland habitats and high marshes is the primary factor for the decline in this species' populations. These habitat losses have reduced populations sufficiently that predation by non-native species, such as the Norway rat, red fox, and feral cats; swamping of nests by boat wakes; and contaminants, such as selenium, are now also substantial factors affecting the ability of the species to recover.

VISION

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

Protecting existing and restoring additional suitable saline and brackish emergent wetlands and adjacent higher elevation habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California clapper rail. The Suisun Marsh and San Francisco Bay areas once comprised a mosaic of large contiguous blocks of tidal saline emergent wetland in association with adjacent upland habitats. Restoration of saline and brackish emergent wetland and associated upland habitats in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help the recovery of this species by increasing habitat area.

Upland cover could be improved by providing incentives to farmers to allow natural vegetation to reclaim portions of the upland habitat adjacent to tidal wetlands.

Clapper rail habitat utilization in Suisun Marsh and the Napa Marshes suggest that a natural network of small tidal creeks which begin high in the marsh and grade down into large tidal sloughs and bays are essential habitat components for successful breeding populations. Improved habitat would also include water quality levels and other components necessary to support isopods, arthropods, mollusks, and insects on which clapper rails forage. These components could be provided by developing and implementing a program to reduce the level of toxins that adversely affect clapper rail populations in the Bay-Delta. Clapper rail breeding success could be improved by reducing the adverse effects of boat wakes on nests during the February through August breeding period. Restoring high-quality clapper rail habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for rails and less favorable for predators.

Improved habitat would also include water quality levels and other components necessary to support isopods, arthropods, mollusks, and insects on which clapper rails forage. These components could be provided by developing and implementing a program to reduce the level of toxins that adversely affect clapper rail populations in the Bay-Delta. Restoring high-quality clapper rail habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for rails and less favorable for predators.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Wetland restoration and management programs that would improve habitat for the clapper rail include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- implementing recommendations of the Goals Project (1999) regarding restoration of large areas of tidal marsh in all subregions of the Bay,
- protect remaining tidal slough habitats supporting pickleweed, cordgrass, bulrushes, and cattails,
- maintain adjacent higher elevation wetland and upland habitat to provide cover during high tides and floods,
- the Suisun Marsh Protection Plan, and
- ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- the California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service (USFWS),
- California Coastal Conservancy,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Improvement of the population of clapper rail in the Bay is integrally linked with wetland and riparian habitat restoration, and water quality (contaminants) improvement.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore California clapper rail.

LONG-TERM OBJECTIVE: Have self-sustaining populations of California clapper rail located throughout their original native range in tidal marshes of the Bay-Delta system.

SHORT-TERM OBJECTIVE: Protect existing populations of the species and restore habitat to provide sites for expansion of present populations.

RATIONALE: The California clapper rail requires tidal salt marshes for all phases of its life cycle. Its populations have declined as these marshes have been eliminated and fragmented, permitting easier access of non-native predators (e.g., house cats, red fox), people, and other intruders to their nesting and high-tide roosting areas. These birds should recover as tidal salt marshes are allowed to re-expand and as marsh restoration efforts proceed.

STAGE 1 EXPECTATIONS: Substantial progress will have been made in protecting habitat for all existing populations and management plans will be in place to further improve existing habitats for clapper rails. Potential additional restoration sites will have been identified.

The general target is to increase the numbers of breeding pairs of clapper rails in the Bay-Delta. The U.S. Fish and Wildlife Service is currently revising the recovery plan for the clapper rail, which will establish population recovery goals.

The following general programmatic actions will contribute to meeting the target for the California clapper rail:

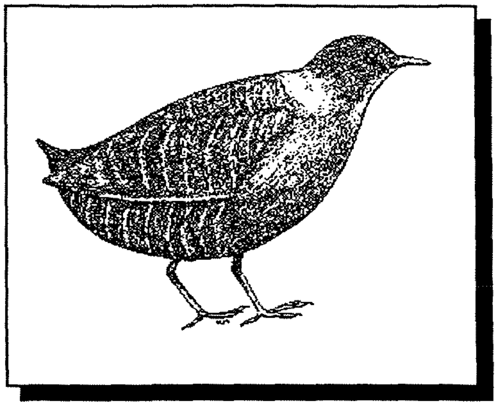
- restore saline and brackish wetland habitat in the Bay,
- protect remaining tidal slough habitats supporting pickleweed, cordgrass, bulrushes, and cattails, especially in areas adjacent to high marsh meadows characterized by pickleweed-saltgrass plant associations,
- improve water quality of Bay marshes,

- reduce the adverse effects of boat wakes on nests during the breeding period,
- develop and implement predator control programs,
- maintain adjacent higher elevation wetland and upland habitat to provide cover during high tides and floods, and
- improve upland cover by providing incentives to farmers to allow natural vegetation to reclaim portions of the upland habitat adjacent to tidal wetlands.

REFERENCES

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

The California black rail is a rarely seen, year-round resident of saline, brackish and fresh emergent wetlands and viable populations of the species are found only in the Suisun Marsh, San Francisco Bay, and the Delta. The California black rail is associated with tidal and nontidal emergent wetlands. The population and distribution of this species have declined substantially primarily as a result of reclamation of its wetland habitats. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the California Endangered Species Act. The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of historical and current loss or degradation of salt, brackish, and freshwater marshes.

RESOURCE DESCRIPTION

Historically, the black rail was a resident of coastal wetlands from Santa Barbara County to San Diego County. Much of the California black rail's marshland habitat in California has been destroyed or modified since the mid-1800s. This decline in marshland has reduced population densities of black rail throughout its range.

Important habitats for the species include tidal perennial and nontidal perennial aquatic, dead-end and open-ended sloughs, seasonal wetland and aquatic, saline and fresh emergent wetland, and midchannel islands and shoals. Many tidal habitats, including those that support pickleweed, bulrushes, and saltgrass, are critical types for this species that need to be protected and currently exist as only a small percentage of their historical extent. In addition, upper wetland or upland areas adjacent to these habitat areas provide nesting and escape cover during high tides and floods. Black rails are especially abundant in undiked tidal marshes of Suisun Marsh. They are most often associated with dense stands of American bulrush (*Scripus americanus*) immediately adjacent to high marsh meadows supporting pickleweed-saltgrass associations. They are often associated with soft bird's-beak, and endangered plant of the high tidal marsh.

Black rail habitat is directly influenced by sediment supply from the upstream portion of the Delta and tidal influences from the Bay. As sediment is deposited in a tidal marsh, the elevation of the marsh changes. Eventually, the marsh may no longer be affected by tidal action or support tidal marsh plants which depend on the interaction of compatible tides and sediment supply regimes. Water quality in habitat areas must be sufficiently high to support the invertebrates and vegetation that sustain black rails. Currently, the condition most hazardous to the black rail's existence in salt marshes is the elevated water level associated with the highest tides and high outflow conditions. High water destroys nests and forces rails to leave the marsh temporarily in search of sufficient cover in uplands. Black rails use corridors between wetland and upland habitats to seek cover during high tides. However, these corridors have been fragmented by the extensive system of Delta levees, which are often devoid of vegetation. This lack of sufficient cover subjects black rails to predation, frequently by non-native species.

These habitats continue to be threatened by sedimentation, water diversions, recreational activities, and land use practices. Insufficient quantity and quality of emergent wetland habitat is the primary factor limiting recovery of the species' population in the estuary. Other factors that can also adversely affect the black rail include disturbance during its breeding period, contaminants, and excessive predation by non-native species.

VISION

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

Restoring suitable fresh, brackish, and saline emergent wetlands and tidal sloughs in the Bay-Delta and adjacent higher elevation habitats is critical to the recovery of the species in the estuary. These restored habitats would provide refuge for the California black rail during high-water periods. Although the black rail's range extends into other ecological zones, the primary focus for habitat restoration will be in the Sacramento-San Joaquin Delta Ecological Management Zone and the Suisun Marshland Ecological Management Unit in the Suisun Marsh/North San Francisco Bay Ecological Management Zone. Efforts outside the Delta and Suisun Marsh to restore natural tidal action to aquatic and wetland habitats within the Suisun Marsh/North San Francisco Bay Ecological Management Zone would also benefit the species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Many programs designed to benefit broader groups of fish and wildlife that use or depend on wetlands, sloughs, or adjacent aquatic systems in the Bay-Delta also benefit the California black rail. Some of these are operated by the following organizations:

- Bay Area Wetlands Planning Group,
- California Coastal Conservancy,
- Delta Native Fishes Recovery Team,
- San Francisco Bay National Wildlife Refuge,
- San Francisco Bay Conservation and Development Commission,
- San Francisco Bay Joint Venture,
- San Francisco Bay Regional Water Quality Control Board,
- U.S. Fish and Wildlife Service San Francisco Bay Program, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and recovery of the California black rail population of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, and water quality (contaminants) improvement.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore California black rail.

LONG-TERM OBJECTIVE: Have self-sustaining populations of California black rail located throughout their original native range in tidal marshes of the Bay-Delta estuary.

SHORT-TERM OBJECTIVE: Restore the population of California black rails to levels necessary to have its status down-graded from a threatened species.

RATIONALE: The California black rail is a state-listed threatened species and is considered a species of concern by the federal government. The leading cause of its decline is the degradation and loss of emergent wetland habitat throughout its range. The California black rail builds nest on the ground and is susceptible to predation by terrestrial species. Non-native species such as the red fox and feral domestic animals (cats and dogs) in some areas have raided nests and contributed to their decline. To develop improve the status of this species, it will be necessary to restore and enhance suitable habitat throughout the wetlands of the estuary. It will also be very important to develop methods to control the non-native predators.

STAGE 1 EXPECTATIONS: Plans should be developed and implemented to restore and protect emergent wetlands within the Napa and Suisun marshes and along San Francisco Bay; develop strategies for controlling problem predators.

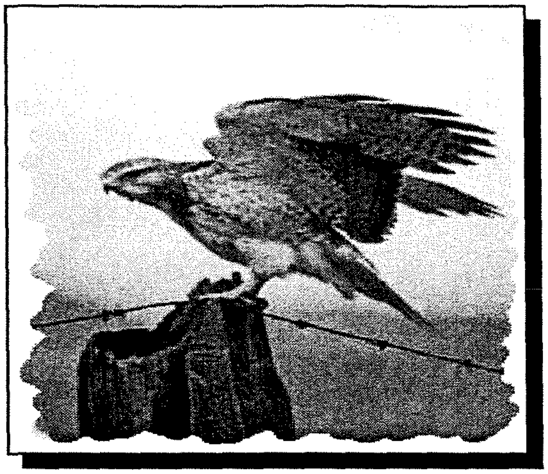
The general target is to increase the number of breeding pairs of black rail in the Bay-Delta. General programmatic actions to achieve the target for the California black rail include:

- restore the natural tidal action of aquatic habitats;
- preserve the remaining populations of black rail, tidal slough habitats that support pickleweed, bulrushes, and saltgrass;
- enhance and restore connectivity between tidal sloughs and adjacent upland refugial habitats;
- improve the connection between wetland and upland habitat areas to reduce predation;
- implement management programs for small water diversions, disturbance, land use changes, and contaminants would improve habitat, reproductive potential, and recruitment for black rails;
- protect tidal sloughs and wetlands from adverse land uses;
- protect nearby unoccupied suitable habitat areas would help ensure natural expansion area is available;
- protect of existing suitable habitats by implementing conservation easement purchasing from willing landowners, or establishing incentive programs to maintain suitable habitat;
- develop and implement alternatives to land management practices on public lands that continue to degrade the quality or inhibit the recovery of black rail habitats; and
- restore, protect, and improve emergent wetlands, tidal sloughs, and adjacent uplands.

REFERENCES

Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco and San Francisco Regional Water Quality Control Board, Oakland, California.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Swainson's hawks occur throughout the Central Valley where riparian forest and oak savanna habitats are present. The nesting population of the Swainson's hawk has declined substantially, primarily as a result of habitat loss and degradation, reduced reproductive success, and high rates of mortality during migration and on South American wintering areas. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the State Endangered Species Act. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of habitat loss and degradation, toxic pesticides accumulated in the foodweb on reproduction, human-associated disturbances at nest sites, and increased competition with other species for nest sites.

RESOURCE DESCRIPTION

The Swainson's hawk was common in the Central Valley at the end of the 19th century. Historical populations were estimated between 4,000 and 17,000 pairs, but declines were documented as early as the 1940s. In 1979, 110 active pairs were observed in the Central Valley with estimates of 375 pairs present throughout the State. Today, the few remaining concentrations of breeding pairs are supported within the Yolo, Sacramento, San Joaquin, Sutter, and Colusa counties, with steadily decreasing numbers to the north and south.

Possible reasons for the Swainson's hawk's decline include

- loss or degradation of habitat on the breeding grounds,
- disturbance on the breeding grounds,
- thin eggshells from pesticide residues,
- increased competition with other species, and
- mortality during migration and on the wintering grounds in South America.

To a large degree, the decline of the Swainson's hawk can be attributed to the long-term, cumulative effects of riparian and wetland habitat conversion and degradation. A combination of changes to Central Valley area ecosystems has added to the problem. These changes include:

- the conversion of perennial grassland to agricultural uses, eliminating foraging habitat;
- urban development adjacent to waterways and nesting areas;
- incompatible land use that disrupts breeding and nesting;
- levees and bank protection that eliminate nesting habitat;
- disturbance from human activities near nest sites; and

- contaminants from agricultural runoff and pesticide use.

Excessive harvest of Swainson's hawk on South American wintering grounds is also thought to be a major factor affecting the decline of the species.

Agricultural crops, such as alfalfa, and dryland pasture provide habitat that supports a continual prey base for the Swainson's hawk. A large number of hawks may congregate near farming activities such as mowing, discing, and irrigation where prey, including some agricultural pests such as grasshoppers, is abundant. Valley oak and riparian woodlands are essential for Swainson's hawk nesting, and 78% of nest trees are located within riparian systems with adjacent foraging habitat. The Swainson's hawk typically returns to the same nest site; therefore, the preservation of nest sites is important to prevent total loss.

VISION

The vision for the Swainson's hawk is to contribute to the recovery of this State-listed threatened species and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Habitat restoration in the Sacramento-San Joaquin Delta Ecological Management Zone will help achieve recovery of the Swainson's hawk by increasing the quality and quantity of its habitats. Limiting land use changes can help to retain foraging and nesting habitat. Because many agricultural practices are compatible with Swainson's hawk foraging, simply improving the timing of farming activities would further improve foraging habitat.

Strategies could be implemented collaboratively with organizations to improve existing preserves that support Swainson's hawk habitat. Cooperative agreements with land management agencies, conservation easements or landowner incentives will improve land management practices for the Swainson's hawk.

Restoration of habitats proposed in other ecological management zones will also allow Swainson's hawk nesting and foraging habitats to develop elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Several organizations have plans that indirectly target the Swainson's hawk for recovery through habitat restoration.

- The Riparian Habitat Joint Venture includes 11 federal, State, and private organizations that signed a cooperative agreement to protect and enhance habitats for native land birds throughout California.
- The Putah Creek - South Fork Preserve, which works to increase fish and wildlife populations dependent on riparian and wetland habitats, including species of special concern, plans to restore 130 acres of riparian habitat.
- The Upper Sacramento River Fisheries and Riparian Habitat Management Plan (SB1086) also targets riparian habitat for restoration that will benefit the Swainson's hawk.
- Restoration and strategies should be coordinated with the Swainson's Hawk Technical Group, a group of agency and non-agency specialists dedicated to restoring the health of this species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the Swainson's hawk population is integrally linked with restoration of riparian, grassland, and agricultural habitat in the Central Valley.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore Swainson's hawk populations.

LONG-TERM OBJECTIVE: Have self-sustaining breeding and wintering populations of Swainson's hawk located throughout their original native range in the Delta and the Central Valley and provide habitat needed to support Swainson's hawks that migrate from overwintering in Argentina.

SHORT-TERM OBJECTIVE: Determine the importance to the species of the small numbers that overwinter in the Delta and determine and develop plans to expand the number of overwintering birds.

RATIONALE: Swainson's hawk is listed as a threatened species by the State of California because its numbers have declined to a small (<2%) percentage of its original population. It nests in riparian areas and forages in upland grasslands and crop lands. The decline has been caused by the combined loss of riparian nesting habitat and foraging habitat and by large mortalities in its overwintering habitat in Argentina. A small number of these hawks overwinter in the Delta rather than migrating, for unknown reasons. If restoration of breeding habitat does not significantly reverse the decline of these birds because of mortality during their long migrations, then there may be a need to find ways to encourage more overwintering in the Delta.

STAGE 1 EXPECTATIONS: A recovery plan for Swainson's hawk in the Central Valley and Delta will have been developed and implemented with key habitats identified and initial protective steps taken.

The general target is to increase the number of breeding pairs of Swainson's hawks in the Central Valley.

General programmatic actions that will contribute to reaching the targets include:

- protect existing and restoring additional suitable valley oak and other riparian habitats and grasslands;
- improve agricultural land management;
- reduce the effect of factors that can suppress breeding success;
- protect known nest sites from loss, degradation, or disturbance during the entire year;
- increase prey populations (e.g., rodents) necessary to support an expanding population;
- establish buffer zones that eliminate human disturbance during nesting; and
- provide habitat to support increased numbers of Swainson's hawks that migrate from overwintering in Argentina.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

INTRODUCTION

Suisun song sparrows live only in and around the Suisun Marsh and Bay. The Suisun song sparrow is associated with saline emergent wetlands. The population and distribution of this species have declined substantially primarily as a result of reclamation of tidal saltmarshes. The loss of habitat and declining condition of this species' population have warranted its inclusion as a species of special concern. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of historical and current loss or degradation of tidal saltmarshes for agricultural, industrial, and urban uses and excessive predation on nests and individuals by non-native predators.

RESOURCE DESCRIPTION

Historically, much of the Suisun Marsh was a brackish tidal marsh. The Suisun song sparrow inhabited areas with suitable brackish marsh vegetation. The total area of historical tidal marsh habitat is estimated to have been about 66,600-73,700 acres. Between 70,000 and 77,000 pairs of Suisun song sparrows are estimated to have used the available marsh habitat annually. Recent estimates indicate that fewer than 6,000 pairs remain in 13 isolated populations, representing 8% of the species' former abundance. The remaining 13 populations number from about 1,300 pairs to about 20 pairs.

Since artificial levees were constructed beginning in the late 1800s, the managed marsh areas on the nontidal side of the levees are flooded seasonally and then drained or allowed to dry. These areas are consistently avoided by Suisun song sparrows. The birds require appropriate vegetation for nesting sites, song perches, and foraging cover. The vegetation must also produce seeds or harbor invertebrates that the birds pick up from the surface of mudflats. Each sparrow's territory must contain permanent water or moisture in the form of tidal ebb and flow. Typically, each territory contains at least one patch of tall, hard-stemmed bulrush that stands above the surrounding vegetation and is used as a singing perch. The birds apparently need these high song perches to establish territory, and the absence of song perches may be a limiting factor in the distribution of pairs.

The Suisun song sparrow is physiologically and behaviorally adapted to this area's naturally occurring brackish tidal conditions. It can drink brackish water and breeds earlier than upland subspecies. Early breeding avoids nest flooding during the highest spring tides. The Suisun song sparrow forages for invertebrates and seeds directly on the surface of mudflats.

The primary threat to the continued existence of the Suisun song sparrow is the continuing loss of habitat and severe fragmentation of brackish tidal marsh habitat in and around Suisun Marsh. The once-vast marsh has been reduced to small areas that are separated by barriers or connected only by narrow strips of vegetation along the banks of tidal sloughs. Interbreeding between populations in these areas is rare. As the southern shore of Suisun Marsh in Contra Costa County becomes increasingly industrialized and developed, habitat will continue to be degraded and, ultimately, the southern population may no longer be viable. Egg and nestling mortality is about 50% in the first 3 weeks after eggs are laid. The primary causes of this mortality are predation on eggs and nestlings by the introduced Norway rat, predation on nestlings by feral house cats, and flooding of nests during periods of high tides. Maintenance of levees, dikes, and other structures during the breeding period may also create sufficient disturbance to cause nesting failure. Levees constructed in the sparrow's habitat are high enough above the surrounding marsh to allow the growth of upland plants that require fresh water. Although Suisun song sparrow territories may include these areas, the species avoids centering its territory in this type of vegetation.

Long-term changes in the salinity gradient of the Bay-Delta may also have an effect on the species' distribution and abundance. The normal brackish condition of Suisun Marsh is directly attributable to the amount of freshwater outflow it receives from the Delta. This fresh water mixes with saltwater transported on incoming tides through Carquinez Strait. The amount of freshwater outflow has been reduced since historical times during water-years that are now considered normal. Suisun song sparrows can withstand short-term alterations in brackish conditions because they can subsist on pure saltwater for several days. The vegetation they occupy in the brackish marsh is similarly adapted. If the water regime changes drastically or for long periods, however, a large-scale change in habitat could result. If salinity decreases, the Suisun song sparrow could face lowered reproductive rates, increased competition, and loss of genetic integrity as a result of breeding with invading upland subspecies that consume fresh water. If the water becomes too salty, saltwater marsh vegetation could displace brackish vegetation; saltwater marsh is not suitable habitat for the species, which is not adapted to consume saltwater for extended periods.

VISION

The vision for the Suisun song sparrow is to recover this California species of special concern in Suisun Marsh and the western Delta and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting and restoring existing and additional suitable tidal saline and fresh emergent wetlands (including brackish marshes) and reducing breeding stressors will be critical to the recovery of the Suisun song sparrow.

Restoration of tidal emergent wetlands in the Suisun Marsh/North San Francisco Bay Ecological Management Zone will help to recover this species by increasing its habitat area. Restoring associated higher elevation uplands would provide escape cover during high tides and flooding. Restoring these habitats would allow the population to increase at existing protected habitat areas and would ensure long-term survival. The restoration of high-quality sparrow habitat would also reduce the adverse effects of predation by non-native species by creating habitat conditions that are more favorable for sparrows and less favorable for predators.

The potential adverse effects of disturbance on breeding success could be reduced by encouraging agencies, organizations, and private landowners, through cooperative agreements and incentive programs, to conduct infrastructure maintenance activities in occupied habitat areas so that tidal brackish marsh vegetation is disturbed as little as possible and adults are not disturbed during the breeding season. The possibility of managing breeding of the species to increase its reproductive success should be investigated (e.g., transferring eggs and/or young between nearby isolated populations to increase genetic interchange between populations). If the species responds favorably to such manipulations, the period for its recovery would be reduced.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs and projects designed to protect, restore, and enhance the Suisun Marsh/North San Francisco Bay Ecological Management Zone to provide direct or incidental benefits to the Suisun song sparrow include:

- San Francisco Estuary Project,

- San Francisco Bay Area Wetlands Ecosystem Goals Project.
- Cache Creek Corridor Restoration Plan,
- California Wetland Riparian Geographic Information System Project,
- Governor's California Wetland Conservation Policy,
- Tidal Wetlands Species Recovery Plan,
- Wetlands Reserve Program,
- Inland Wetlands Conservation Program,
- Montezuma Wetlands Project, and
- National Estuarine Reserve Research System.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the Suisun Song Sparrow is integrally linked with restoring tidal permanent emergent wetlands in Suisun Bay and Marsh and the western Delta. Restoration of adjacent tidal perennial aquatic habitat, particularly mudflats, is also important.

STRATEGIC OBJECTIVE, TARGET, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to increase suitable habitat and restore the population of Suisun song sparrow within its range

LONG-TERM OBJECTIVE: Restore populations of Suisun song sparrow to habitats throughout its native range by creating/restoring enough brackish tidal marsh habitat to support 40,000 nesting pairs.

SHORT-TERM OBJECTIVE: With existing populations, find ways to connect fragmented brackish and freshwater habitats to increase the gene flow among population segments and reduce the likelihood of extirpation of isolated population segments.

RATIONALE: The Suisun song sparrow occurs only in and near Suisun Marsh, in about 13 isolated populations. Populations of this unusual subspecies are declining for a variety of reasons but mainly the degradation of their habitat. Reductions in fresh water outflow from the Sacramento-San Joaquin Rivers and diking and channelization of marsh lands have contributed to their decline. Restoration of their populations is likely to be a good indicator of the success of restoration of brackish tidal marshes in the Suisun Marsh area.

STAGE 1 EXPECTATIONS: All Suisun song sparrow populations will have been identified and protected from further development and habitat alterations; plans will have been developed and implemented to connect isolated populations by means of habitat restoration projects.

The following general targets will assist in meeting the implementation objective:

- Increase the total number of pairs.
- Increase the number of pairs in each of the 13 isolated populations.
- Increase the number of populations.
- Reduce the extent of isolation among the populations.

The following general programmatic actions will assist in meeting the targets:

- Increase the amount of tidal brackish water marshes in Suisun Bay and Marsh and in the western Delta.
- Decrease the extent of isolation of remaining tidal marshes in Suisun Bay and Marsh and the western Delta.
- Increase the amount of grassland habitat adjacent to tidal marshes in Suisun Bay and Marsh and the western Delta.
- Within existing and restored marshes ensure presence of tall, hard-stemmed bulrush stands.
- Increase the area of tidal mudflats in close proximity to existing and restored marshes.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ ALAMEDA SONG SPARROW

INTRODUCTION

The Alameda song sparrow is a subspecies of the song sparrow which inhabits salt marshes along the southern portion of San Francisco Bay. The declining condition of this subspecies' population has warranted a listing by the Federal government as a special concern species and by the Department of Fish and Game as a special concern species. Major factors that have contributed to the decline of the Alameda song sparrow include habitat loss due to reclaiming of land for agricultural, industrial and urban uses, nesting predation, and losses due to the use of pesticides.

RESOURCE DESCRIPTION

Since J. Grinnell studied song sparrows in the early 1900s, the Alameda song sparrow has been identified as a distinct subspecies. Historically its habitat ranged from San Francisco and San Bruno on the west, south to Alviso, Santa Clara County to Stege, Contra Costa County on the north east side of the bay (J. Marshall 1948). In much of the San Francisco Bay area duck clubs, urbanization, and reclamation of lands has changed the tidal marshes. Levees have been built and species that depend on tidal conditions have been adversely affected. Some estimate only about 10% of the Alameda song sparrow's habitat remains. Density measures average about four to six birds per hectare and based on census data it is estimated about 8,250 birds remain (Nur 1997).

Alameda song sparrows have strict habitat requirements for nesting and foraging sites. They are territorial and for the most part sedentary, not moving any great distances. Highly adapted to be able to drink brackish water and live in tidal conditions, they forage for invertebrates and seeds on the mudflats. As conditions change and marshes fill in or tidal action ceases to exist due to levees, song sparrows move out of the area.

VISION

The vision for the Alameda song sparrow is to restore this California species of special concern in the southern San Francisco Bay region.

Protecting and restoring existing and additional suitable tidal saline and fresh emergent wetlands and reducing breeding stressors will be critical to the recovery of the Alameda song sparrow. Restoring these habitats and protecting nesting sites would allow the population to increase and ensure long-term survival of the species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs and projects that are designed to protect and restore salt marshes in the south San Francisco Bay that would have a direct impact on the Alameda song sparrow include:

- San Francisco Estuary Project,
- San Francisco Bay Area Wetlands ecosystem Goals Project,
- California Wetland Riparian Geographic Information System Project,
- Tidal Wetlands Species Recovery Plan,
- Wetlands Reserve Program and,
- National Estuarine Reserve Research System

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the Alameda song sparrow is integrally linked with restoring salt marsh and wetlands in the southern San Francisco Bay.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore the population of Alameda song sparrow to representative habitats within its range.

LONG-TERM OBJECTIVE: Restore populations of Alameda song sparrow to habitats throughout its native range by creating/restoring sufficient salt marsh to increase breeding pairs.

SHORT-TERM OBJECTIVE: With existing populations, connect fragmented habitat to increase gene flow between populations. Conduct genetic studies as well as juvenile dispersal studies to determine effective management of the species.

RATIONALE: Alameda song sparrows are one of the species that uses saltmarsh habitat in the south San Francisco Bay region. By protecting the saltmarsh habitat not only will this species benefit but the other inhabitants of the marsh ecosystem will also benefit. Restoration of this species would be a good indicator to the overall health of the marsh system.

STAGE 1 EXPECTATIONS: All Alameda song sparrow populations will have been identified and protected from further development and habitat alteration. Pilot restoration projects will have been undertaken to develop protocols for habitat restoration efforts.

The following general targets will assist in meeting the implementation objective:

- Increase the amount of tidal saltmarsh
- Increase the total number of breeding pairs

The following general programmatic actions will assist in meeting the targets:

- Increase the amount of tidal marsh in the south San Francisco Bay region.
- Decrease the extent of isolation among salt marshes
- Reduce the degree of stressors including water management and land use practices on existing salt marshes

REFERENCES

Marshall, J.T. 1948a. Ecological races of song sparrows in the San Francisco Bay region Part I: habitat and abundance. Condor, 50:193-215.

_____1948b. Ecological races of song sparrows in the San Francisco Bay region Part II: geographical variation. Condor, 50: 233-256.

Nur, Nadav. 1997 Tidal Songbirds Denizens of Remnant Marshlands of San Francisco Bay. http://www.igc.apc.org/prbo/Observer/Observer110/Tidalbirds.html.

◆ Salt Marsh Harvest Mouse

Salt Marsh Harvest Mouse
Endangered (Federal)
Endangered (State)

Introduction

The salt marsh harvest mouse is associated with saline emergent wetlands. The population and distribution of this species have declined substantially, primarily as a result of reclamation of tidal salt marshes for agriculture, salt production, and urban development. The loss of habitat and declining condition of this species' population have warranted its listing as endangered under the State and federal Endangered Species Acts. The major factors that limit this resource's contribution to the health of the Delta are related to the adverse effects of historical and current loss or degradation of saline tidal wetlands that support the dense stands of pickleweed on which the salt marsh harvest mouse is dependent.

Resource Description

The salt marsh harvest mouse occurs only in saline emergent wetlands associated with San Francisco Bay and its tributaries. Historically, these areas supported extensive tidal wetlands, which sustained dense stands of pickleweed. These plants, in turn, supported the salt marsh harvest mouse.

With the gradual development of the Suisun Marsh and San Francisco Bay areas came the construction of dikes and levees for flood control and protection of lands reclaimed for uses such as for salt ponds and agriculture. These reclaimed areas supported livestock grazing and, in the Suisun Marsh, small grain crops and asparagus. The vegetation growing beyond the limits of high tide supported grazing, and settlers found that if they diked those areas, wetland plants would eventually recede and give way to upland plants favored by livestock. As more and more settlers arrived, development resulted in the loss of large areas of habitat and severe fragmentation of the habitat that remained. Barriers, such as a road or path no more than 10 feet across, isolated the mouse in fragmented habitats because it would not use or travel across areas lacking vegetation. Upland areas consisting of grasslands or salt-tolerant plants that offered refuge during extreme high tides and high outflow periods were adjacent to the saline emergent wetlands. Development altered the landscape and geomorphology in many of these areas, which contributed to the loss of habitat.

Saline emergent wetlands with pickleweed occur only within the Suisun Marsh/North San Francisco Bay Ecological Management Zone of the Ecosystem Restoration Program Plan (ERPP) area. The elimination of much of the salt marsh harvest mouse's habitat is the primary cause of the species' decline. Other factors or "stressors" that have contributed to the decline or potentially could inhibit the recovery of the species include human activities that disturb the species and predation by non-native species. Grazing; water management practices; land use practices; contaminants; and human-made structures, such as dikes and levees, continue to degrade the quality of remaining habitat areas.

VISION

The vision for the salt marsh harvest mouse is to contribute to the recovery of this State- and federally listed endangered species through restoring salt marsh habitat in San Pablo and Suisun bays and adjacent marshes. Existing occupied and unoccupied suitable habitat areas will be protected. Saline emergent wetlands will be restored. Stressors to the population and habitat will be reduced. new populations will be introduced into unoccupied habitat areas.

Protecting existing suitable habitat areas from potential activities that could adversely affect the harvest mouse could be achieved through cooperative agreements with land management agencies, conservation easements, or purchase from willing sellers. Restoration of adjacent upland habitat will help to recover this species by increasing habitat area. Uplands provide the mouse with refuge from flooding.

Reducing factors that contribute to degradation of saline emergent wetland communities would promote natural restoration and maintenance. Increasing the quantity and quality of salt marsh harvest mouse habitat and reducing the adverse effects of stressors would establish conditions necessary to maintain existing populations and allow them to naturally recover. However, introducing the mouse into unoccupied habitat areas within its historic range would speed the recovery of the species by establishing new populations before the species would be expected to naturally expand into these or restored habitat areas.

Many programs are underway to restore the Bay-Delta salt marshes. Successful restoration program implementation will increase the chances of salt marsh harvest mouse recovery. Current land management practices need to be examined and redefined to restore, enhance, and promote salt marsh harvest mouse habitat. Salt marsh harvest mouse management strategies should focus on:

- managing known critical mouse habitat areas;
- providing additional research to identify other factors limiting the population and determine corrective measures; and
- addressing the needs of waterfowl and other migratory birds that also use saline emergent wetlands.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Existing restoration programs that would benefit the salt marsh harvest mouse include:

- Suisun Marsh Recovery Plan,
- San Francisco Bay Joint Venture,
- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- California Coastal Conservancy,
- Delta Native Fishes Recovery Plan,
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program,
- Grizzly Island Wildlife Area,
- National Estuarine Reserve Research System,
- North Bay Wetlands Protection Program,
- San Francisco Bay National Wildlife Refuge, and
- Tidal Wetlands Species Recovery Plan.

Targets and actions will be coordinated through these programs.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of salt marsh harvest mouse is integrally linked with restoration of saline emergent wetlands and adjacent grasslands adjacent to San Pablo and Suisun Bays.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore salt marsh harvest mouse to tidal marsh within their historical range.

LONG-TERM OBJECTIVE: Restore salt marsh harvest mouse to tidal marsh throughout their historical range.

SHORT-TERM OBJECTIVES: Reestablish populations in newly created or restored marshland and protect existing populations as outlined in the salt marsh harvest mouse recovery plan.

RATIONALE: This species is listed as endangered by both state and federal governments and exists in small isolated populations in Bay salt marshes. Historically, about 107,000 acres of habitat suitable for the salt marsh harvest mouse existed. Degradation of habitat due to agricultural practices, diking, and human disturbance has limited greatly what is available today. It is important that this degradation and loss of any more habitat be stopped. Existing habitat is susceptible to flooding and silting in, as well as new building projects. New wetlands have to be created to outweigh disappearing marsh in other areas if the small isolated populations are to be enhanced. Created habitat would also benefit other species that use tidal marsh environments.

STAGE 1 EXPECTATIONS: Key items in the salt marsh harvest mouse recovery plan will have been identified, followed by implementation of those that would have immediate benefits to the species, including stopping population decline and increasing genetic flow between isolated populations. The existing populations will have been studied to determine their size and their habitat requirements. Limit the activities that would further increase erosion of Bay marshes and therefore reduce existing population sizes.

The following general targets will assist in meeting the implementation objective:

- Increase the number of salt marsh harvest mice in San Pablo and Suisun Bay marshes.
- Reduce the extent of isolation among the mouse populations.

The following general programmatic actions will assist in meeting the targets:

- Increase the area of salt marsh adjacent to San Pablo and Suisun Bays.
- Decrease the extent of isolation among remaining salt marshes.
- Increase the amount of adjacent grasslands to the marshes.
- Reduce the degree of stressors including water management and land use practices on existing and restored marshes and adjoining upland habitats.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ SUISUN ORNATE SHREW

INTRODUCTION

The Suisun shrew, a subspecies of the ornate shrew, is a federal species of concern and is also listed as a California Department of Fish and Game Species of Concern. Historically, this species inhabited tidal marshes ranging from San Pablo and Suisun Bays to Grizzly Island and as far west as the mouth of Sonoma Creek, Petaluma River, and Tubbs Island. Most of the shrew's range today exists in the tidal marshes of Suisun Bay.

The primary factor affecting the Suisun shrew is habitat degradation. The shrew prefers tidal wetland to diked or managed wetlands and therefore is limited in its range.

RESOURCE DESCRIPTION

The Suisun shrew typically inhabits tidal salt marsh with adjoining upland areas where they can seek shelter during high tides and flooding. They only occur where dense foliage and driftwood can be used for nesting material and foraging. In addition, the shrew prefers areas where the soil moisture is constant. An upland component to their habitat requirements is necessary to avoid inundation during rising tides. The structure of the vegetation that occurs in their habitat may be more important than species composition. When tides are high and the ground is wet the shrew travels above ground, in the vegetation. Therefore, vegetation needs to be thick enough to provide cover for an escape corridor. The Suisun ornate shrew is an insectivore and additional diet items include crustaceans.

With the development of the Suisun Marsh came the construction of dikes and levees for flood control and protection of lands reclaimed for uses such as agriculture. These reclaimed areas supported livestock grazing, and crops such as asparagus and grain. As more and more lands were converted to agriculture, more and more habitat loss occurred which allowed for severe fragmentation of the habitat that remained. Barriers, such as roads also added to fragmentation of the remaining habitat. Development altered the landscape and geomorphology in many of these areas, which contributed to the loss of habitat.

Tidal marshes occur within the Suisun Marsh/North San Francisco Bay Ecological Management Zone of the ERP area. The elimination of much of Suisun shrew's habitat is the primary cause of the species' decline. Other factors that have contributed to the decline or potentially could inhibit the recovery of the species include human activities that disturb the species and predation by non-native species. Grazing; water management practices; land use practices; contaminants; and human-made structures, such as dikes and levees, continue to degrade the quality of remaining habitat areas.

VISION

The vision for the Suisun ornate shrew is to recover this California species of species concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing suitable habitat areas from potential activities that could adversely affect the Suisun shrew could be achieved through cooperative agreements with land management agencies, conservation easements, or purchase from willing sellers. Restoration of adjacent upland habitat will help to recover this species by increasing habitat area. Uplands provide the shrew with refuge from flooding.

Reducing the factors that contribute to degradation of marshes would promote natural restoration and maintenance. Increasing the quantity and quality of Suisun shrew habitat and reducing the adverse effects of stressors would establish conditions necessary to maintain existing populations and allow them to naturally recover.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Existing restoration programs that could benefit the Suisun shrew are:

- Suisun Marsh Recovery Plan
- San Francisco Bay Joint Venture
- Bay Area Wetlands Planning Group
- California Costal Conservancy
- Delta Native Fishes Recovery Plan
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program
- Grizzly Island Wildlife Area
- National Estuarine Reserve Research System
- North Bay Wetlands Protection Program
- San Francisco Bay National Wildlife Refuge
- Tidal Wetlands Species Recovery Plan, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoring tidal habitat to increase populations of the Suisun shrew would benefit the other species found in this habitat. These species include the salt marsh harvest mouse and wading and shorebirds.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore Suisun ornate shrew to representative habitats within its range.

LONG-TERM OBJECTIVE: Restore Suisun ornate shrew to tidal wetland habitats throughout its native range.

SHORT-TERM OBJECTIVE: Identify the remaining populations of Suisun ornate shrew and develop a conservation plan to stop the decline of this species.

RATIONALE: The Suisun ornate shrew is a listed as a species of special concern by the California Department of Fish and Game, but its limited habitat and distribution indicate it may qualify as a threatened species. Long-term survival of this subspecies is dependent upon tidal wetland, as opposed to diked wetlands, and has to have adequate physical structures and plant communities for survival. Its tidal marsh habitat has to have adjacent upland habitat for survival of the species during periods when the marsh is inundated. The upland habitat has to have relatively low densities of exotic predators. Restoring habitat would not only benefit the Suisun ornate shrew but other species, such as the salt marsh harvest mouse, that also use tidal marsh and upland marsh habitats.

STAGE 1 EXPECTATIONS: All remaining populations of Suisun ornate shrew will have been identified and protection/restoration plans developed and implemented.

REFERENCES

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service, *Status and Trends Report on Wildlife of the San Francisco Estuary, San Francisco Estuary Project*, 1992

Zeiner, David C., William F. Laudenslayer, Jr., Kenneth E. Mayer (ed.), *California's Wildlife Volume III Mammals*, Department of Fish and Game, Sacramento, 1988.

◆ San Pablo California Vole

Introduction

The San Pablo California vole is known to inhabit the salt marshes of San Pablo Bay. This species has declined, primarily as a result of the loss or degradation of its habitat. The loss of habitat has warranted its listing as a California Special Concern Species. The major factor that limits this resource's contribution to the health of the Bay-Delta are related to adverse effects of habitat loss.

Resource Description

The San Pablo California vole is known exclusively from the salt marshes of San Pablo Creek, Contra Costa County, on the south shore of San Pablo Bay.

To a large degree, the decline of the San Pablo California vole can be attributed to the long-term cumulative effects of salt marsh habitat conversion and degradation. A combination of changes to salt marsh ecosystems has added to the problem. These changes include:

- loss of salt marsh habitat,
- agricultural activities such as discing and poisoning, and
- nonnative predators such as the red fox.

Vision

The vision for the San Pablo California vole is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Integration with Other Restoration Programs

Existing restoration programs that would benefit the San Pablo California Vole include:

- San Francisco Bay Joint Venture,
- Bay Area Wetlands Planning Group,
- California Coastal Conservancy,
- California Department of Fish and Game Delta/Bay Enhanced Enforcement Program,
- National Estuarine Reserve Research System,
- North Bay Wetlands Protection Program,
- San Francisco Bay National Wildlife Refuge,
- Tidal Wetlands Species Recovery Plan, and
- San Francisco Bay Area Wetlands Ecosystem Goals Project.

Linkage with Other Ecosystem Elements

Restoration of the San Pablo California Vole is integrally linked with restoration of salt marsh habitat of San Pablo Bay.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to maintain current San Pablo California Vole population and conduct further research into vole genetics.

Long-Term Objective: Restore San Pablo vole to tidal marsh throughout their historical range.

Short-Term Objective: Determine the distribution and taxonomic status of the vole while maintaining existing salt marsh habitat know to contain populations. Undertake wetland restoration projects in and adjacent know populations to increase available habitat.

Rationale: The San Pablo vole is a California Department of Fish and Game Special Concern species. Although little is known about its distribution, biology, or taxonomy, it appears to be a distinct form that is confined to salt marshes and adjoining grasslands in Contra Costa County. To limit the decline of the populations even further, salt marsh and adjoining grassland habitats in Contra Cosa County need to be protected and further degradation and loss of habitat halted. Because present populations appear to be isolated from one another, there is a need to expand salt marsh habitats to maintain populations sizes and increase gene flow between the isolated populations.

Stage 1 Expectations: All known localities for this species will have been protected and a thorough search made for other populations. A restoration plan will have been developed and implemented that includes genetic studies to determine its relationship to the widely distributed California vole.

References

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Williams, Daniel F. 1986. Mammalian Species of Special Concern in California, Wildlife Management Division Administrative Report 86-1. June 1986.

◆ SPECIAL-STATUS PLANT SPECIES

PERENNIAL GRASSLAND SPECIAL-STATUS PLANT SPECIES

INTRODUCTION

Perennial grassland was historically common throughout the Central Valley. Most perennial grassland has been lost or converted into annual grassland dominated by non-native species. Perennial grassland provides important breeding and foraging habitat for many wildlife species and supports several special-status plant species, including fragrant fritillary (*Fritillaria liliacea*) and recurved larkspur (*Delphinium recurvatum*).

SPECIES DESCRIPTIONS

FRAGRANT FRITILLARY (*Fritillaria liliacea*) is a slender, bulb-forming herbaceous perennial of the Lily family (Lileaceae). Its flowers are white and typically have a green or yellow throat. Fragrant fritillary is considered a species of concern by the USFWS and is considered rare, threatened, or endangered by the California Native Plant Society (List 1B). Fragrant fritillary occurs primarily in the outer Coast Ranges from Sonoma County to Monterey County, with disjunct occurrences in Solano County. Many populations occur on public lands, and several occurrences are found on The Nature Conservancy's Jepson Prairie Preserve. The habitat of the species is low elevation grasslands or coastal scrub with clay soils, typically characterized by serpentine. The primary threats to this species include livestock grazing, agriculture, recreational activities, and urban development (NDDB 1996).

RECURVED LARKSPUR (*Delphinium recurvatum*) is a perennial herb with light blue and white flowers in the Buttercup family (Ranunculaceae). It is considered a species of concern by the USFWS and is considered rare, threatened, or endangered by the California Native Plant Society (List 1B). Recurved larkspur inhabits poorly drained, fine, alkaline soils in grassland in the Central Valley and surrounding foothills of the Coast Ranges from Colusa County to Kern County (NDDB 1996). Much of the larkspur's habitat has been converted to agriculture, and is also threatened by grazing.

VISION

The vision for fragrant fritillary is to maintain populations of this California Native Plant Society List 1B plant species.

The vision for recurved larkspur is to maintain populations of this California Native Plant Society List 1B plant species.

The vision for the previous two species and perennial grassland species is to protect existing populations, promote the recovery of the species' habitat, establish new populations, and manage occupied sites properly to ensure the long-term viability of the species. A site-based evaluation of existing populations would be conducted, criteria on habitat and populations conditions developed, and all sites ranked based on the criteria in terms of low to high quality habitat. Based on the site rankings, the highest quality populations would be protected.

To ensure the long-term viability of the species, lower quality sites would be evaluated for potential habitat restoration or enhancement opportunities. Existing populations would be expanded through habitat restoration, enhancement, and appropriate management. The species' grassland habitat would be protected from overgrazing and trampling by livestock. Appropriate management techniques, such as lowered grazing regime, prescribed burns, and exotics control would be evaluated and appropriate techniques implemented to promote The health and vigor of existing and restored populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoring perennial grassland is an objective of the Cache Creek Corridor Restoration Plan and Yolo County Habitat Conservation Plan. Additional efforts to restore habitat for fragrant fritillary and recurved larkspur will involve cooperation with programs managed by several agencies and organizations. These include:

- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- Jepson Prairie Preserve,
- Putah Creek South Fork Preserve,
- Stone Lakes National Wildlife Refuge, and
- Woodbridge Ecological Reserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Fragrant fritillary and recurved larkspur are linked with a habitat ecosystem element, perennial grassland. Land use, human disturbance, and non-native species are stressors that could adversely affect the perennial grassland special-status plants.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The strategic objective for perennial grassland special-status plant species is to preserve and restore perennial grassland habitat in conjunction with restoration of wetland and riparian habitats.

LONG-TERM OBJECTIVE: Preserve and restore perennial grassland habitat that provides for special status plant species.

SHORT-TERM OBJECTIVE: Develop or utilize existing GIS overlays which depict specific sites supporting special status perennial grassland plant species and compare these sites to other proposed restoration measures for the restoration of wetland and riparian habitat.

RATIONALE: Protection and restoration of special status plant species is closely linked to actions to protect and restore perennial grasslands. In addition to supporting vernal pools, perennial grasslands provide valuable habitat for many wildlife species and provide important transitional habitat and support area for adjacent habitat. The design of restoration actions for perennial grasslands must include consideration and modification to accommodate special status plants.

STAGE 1 EXPECTATIONS: Distribution surveys will have been conducted or competed to identify special status plant habitats. This information will have been integrated into project planning for wetland and perennial grassland restoration actions.

The targets for these species include identifying and protecting high-quality habitats and populations and ensuring the long-term viability of the species on higher ranked sites.

- Acquire lands supporting existing populations or develop cooperative relationships with landowners to protect existing populations, beginning with the highest quality sites.

- Develop appropriate methods to protect and restore habitat and populations of special-status plant species.

- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species.
- Conduct a site-based evaluation of populations and rank sites based on criteria developed to assess habitat and populations conditions.

REFERENCE

Natural Diversity Data Base. 1996. Record search for occurrence of *Fritillaria liliaceae* and *Delphinium recurvatum*. California Department of Fish and Game, Sacramento, CA.

Tidal Brackish and Freshwater Marsh Special-status Plant Species

Introduction

Tidal brackish and freshwater marshes occur in transitional areas between open-water and upland habitats throughout the Bay and Delta and are important habitats for many plant, fish and wildlife of the Bay-Delta. Substantial loss of tidal brackish and freshwater marshes has been incurred as a result of reclamation and channel dredging and scouring, leading to the decline of many native fish, wildlife, and plant species. Special-status plants inhabiting Bay-Delta tidal marshes include Mason's lilaeopsis (*Lilaeopsis masonii*), Suisun Marsh aster (*Aster lentus*), bristly sedge (*Carex comosa*), Suisun thistle (*Cirsium hydrophyllum* var. *hydrophyllum*), soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*), rose-mallow (*Hibiscus lasiocarpus*), Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*), and Delta mudwort (*Limosella subulata*).

Species Descriptions

Mason's lilaeopsis. Mason's lilaeopsis is a minute, turf-forming perennial plant in the carrot family (Apiaceae). It spreads by rhizomes and produces long, narrow, jointed leaves. Mason's lilaeopsis is state-listed as rare and is considered rare, threatened, or endangered by the California Native Plant Society (List 1B). Mason's lilaeopsis is semiaquatic and is usually found on saturated clay soils which are regularly inundated by waves and tidal action. Its known distribution extends from the margins of the Napa River in Napa County, east to the channels and sloughs of the Sacramento-San Joaquin Delta in Contra Costa, Solano, Sacramento, Yolo, and San Joaquin Counties. Approximately 50 occurrences of Mason's lilaeopsis were known in 1991 (DFG 1991). Populations of this species are small and fractured and few large contiguous sites exist on non-leveed sloughs or on eroding in-channel islands.

Mason's lilaeopsis has lost a large amount of its habitat through direct loss from flood control structures and rip-rap and through erosion of remnant in-channel islands. Widening of Delta channels for water transport, dredging and dumping of spoils, recreational development, and changes in water quality resulting from decreased flows in the Delta also threaten Mason's lilaeopsis. Although much of the habitat for Mason's lilaeopsis is privately owned, several State and Federal agencies have jurisdiction over the Delta waterways. One site is protected in Solano County on a DFG Ecological Reserve. DFG has been active in coordinating research on and trying to transplant the species. The trend for Mason's lilaeopsis is one of decline (DFG 1991).

Suisun Marsh aster. Suisun Marsh aster is a rhizomatous perennial herb in the sunflower family (Asteraceae). Suisun Marsh aster is on CNPS's List 1B. Suisun Marsh aster has habitat requirements and a distribution similar to that of Mason's lilaeopsis, but is not known from Alameda County. Suisun Marsh aster is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

Bristly sedge. Bristly sedge is a rhizomatous perennial herb in the sedge family (Cyperaceae). Bristly sedge is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Bristly sedge occurs around lake margins in Contra Costa, Lake, Shasta, San Joaquin, and Sonoma Counties. It is also widespread outside of California, occurring in Idaho, Oregon, and Washington. Bristly sedge is threatened by marsh habitat alteration and loss.

MAD-DOG SKULLCAP. Mad-dog skullcap is a rhizomatous perennial herb mint family (Lamiaceae). Mad-dog skullcap is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Mad-dog skullcap inhabits mesic meadows and marshes and in California is known from only 2 occurrences in Inyo and San Joaquin Counties (Skinner and Pavlik 1994). Mad-dog skullcap also occurs in New Mexico and Oregon. Mad-dog skullcap is threatened by marsh habitat alteration and loss.

SUISUN THISTLE. Suisun thistle is a perennial herb in the sunflower family (Asteraceae). It has slender, erect stems that are 3-4.5 feet tall and are well-branched above. The spiny leaves are deeply lobed. The flower heads are pale lavender-rose and the flower head bracts have a distinct green, glutinous ridge on the back. Suisun thistle is proposed for federal listing as endangered and is on CNPS's List 1B. Suisun thistle is known from only 2 locations in the Suisun Marsh in Solano County (CFR 60(112)). It occurs on the edges of salt and brackish marshes that are periodically inundated during high tides. The total number of individuals of Suisun thistle is a few thousand individuals (CFR 60(112)). One occurrence is on DFG lands and a second occurrence is on Solano County Farmland and Open Space Foundation lands.

Suisun thistle was probably more widespread in the past, but reductions in salt marsh habitat that have resulted from drainage or filling, and possibly water pollution, may have contributed to the species' decline (Niehaus 1977). Its present highly restricted distribution increases its susceptibility to catastrophic events such as disease or pest outbreak, severe drought, oil spills, or other natural or human caused disasters. Continued habitat conversion, habitat fragmentation, indirect effects from urban development, increased salinity, projects that alter natural tidal regime, mosquito abatement activities, competition with non-native plants, and inadequate regulatory mechanisms also threaten this taxon (CFR 60(112)).

SOFT BIRD'S-BEAK. Soft bird's-beak is a sparingly-branched, semi-parasitic herbaceous annual plant in the figwort family (Scrophulariaceae). Its stems are covered by soft hairs, and it bears white two-lipped flowers. Soft bird's-beak is proposed for federal listing as endangered and is state-listed as rare. Soft bird's-beak occurs along the northern shores of the San Francisco Bay, in Suisun Marsh, and in the salt marshes south of Suisun Bay. A dozen historical occurrences were known from Marin to Contra Costa Counties, where the counties border San Francisco Bay. In 1991, the species was known to be extant at only three sites: Benicia State Recreation Area, DFG land along the Napa River at Fagan Slough, and Point Pinole Regional Shoreline (California Department of Fish and Game 1992). Recently, several new populations have been discovered at salt marshes near Martinez and at Suisun Marsh (Natural Diversity Data Base 1996). Soft bird's-beak inhabits the upper reaches of salt grass-pickleweed marshes at or near the limits of tidal action. Soft bird's-beak is susceptible to factors similar to those listed above for Suisun thistle (CFR 60(112)).

ROSE-MALLOW. Rose-mallow is a herbaceous perennial plant in the Mallow family (Malvaceae). Rose-mallow is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Rose-mallow is relatively widespread along the lower portions of the Sacramento and San Joaquin Rivers, but most occurrences are very small. the species prefers open, freshwater marsh habitats along slow-moving watercourses, and is often found on peaty substrates in association with bulrush (*Scirpus* sp.). Rose-mallow does not tolerate shade from dense woody vegetation. Rose mallow is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

DELTA TULE PEA. Delta tule pea is a herbaceous perennial plant in the legume family

(Fabaceae). Delta tule pea is on CNPS's List 1B. Delta tule pea inhabits freshwater and brackish marshes in Alameda, Contra Costa, Fresno, Marin, Napa, Sacramento, San Benito, Santa Clara, San Joaquin, and Solano Counties. Delta tule pea is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss include development, agriculture, recreation, channelization, channel maintenance activities, and marsh drainage.

DELTA MUDWORT. Delta mudwort is a stoloniferous perennial herb in the figwort family (Scrophulariacae). Delta mudwort is considered rare, threatened, or endangered in California but more common elsewhere by CNPS (List 2). Delta mudwort inhabits marshes in Contra Costa, Sacramento, San Joaquin, and Solano Counties. It is also found on the Atlantic Coast. Delta mudwort is threatened by marsh habitat alteration and loss. Factors leading to marsh habitat alteration and loss are similar to those described above for Delta tule pea.

VISION

The vision for Mason's lilaeopsis is to recover this State listed rare plant by protecting and preserving important habitat sites within the Bay-Delta.

The vision for Suisun Marsh aster is to recover this California Native Plant Society List 1B plant species.

The vision for bristly sedge is to contribute to the recovery of this California Native Plant Society List 2 plant species.

The vision for mad-dog skullcap is to maintain populations of this California Native Plant Society List 2 plant species.

The vision for Suisun thistle is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta.

The vision for soft bird's beak is to recover this federally listed endangered species by protecting and preserving important habitat sites within the Bay-Delta.

The vision for rose-mallow is to maintain populations of this California Native Plant Society List 2 plant species.

The vision for Delta tule pea is to contribute to the recovery of this California Native Plant Society List 1B plant species.

The vision for Delta mudwort is to contribute to the recovery of this California Native Plant Society List 2 plant species.

The vision for these tidal brackish and freshwater marsh guild of plant species is to provide protection for existing populations and restore habitat to provide sites for expansion of the species. Existing populations should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites. A site-based evaluation of populations would be conducted to all rank sites based on criteria developed to assess habitat and population conditions. Higher ranked sites that are protected would serve as a source of propagules for restored areas.

Higher quality sites will also be evaluated for potential enhancement opportunities through habitat expansion. Moderate or low quality sites will be restored to low elevation intertidal habitats and establishment of species in this guild promoted. Restoration efforts would include protecting eroding sites, such as on in-channel islands, from further erosion. During the restoration of habitat, ecological functions such as sediment deposition and erosion to balance the formation and loss of intertidal habitats would be promoted.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore habitat for the Delta plant species will involve cooperation with programs being implemented by DFG to promote their occurrences and cooperation from agencies with responsibility or authority for maintaining or restoring tidal perennial habitat, including:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers,
- Delta Protection Commission
- Benicia State Recreation Area,
- Point Pinole Regional Shoreline, and
- Solano County Farmland and Open Space Foundation.

Other programs that could be solicited for collaboration to benefit the Delta species include the Montezuma Wetlands Project and Tidal Wetlands Species Recovery Plan

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The Delta guild of plant species is integrally linked with the restoration of tidal perennial aquatic habitat. Stressors that could affect the Delta guild include non-native species such as water hyacinth that shades out habitat when occurring in dense patches; levees, bridges, and bank protection; dredging' water management; human disturbance; and contaminants. Tides are an important primary physical process that affects the tidal brackish and freshwater plant species guild.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore at-risk endemic tidal brackish and freshwater tidal marsh plants.

LONG-TERM OBJECTIVE: Have self-sustaining populations of Mason's lilaeopsis, Suisun Marsh aster, Suisun thistle, soft birds-beak, rose-mallow, Delta mudwort, and Delta tule pea and similar declining endemic species located throughout their original native range in marshes associated with the Bay-Delta system.

SHORT-TERM OBJECTIVE: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require tidal or brackish water marshes.

RATIONALE: The species listed here are examples of plants that are largely endemic to brackish water marshes of Suisun Bay and elsewhere in the estuary. The likelihood of extinction among these species varies from very high for Suisun thistle, known from only four occurrences, to moderate for Mason's lilaeopsis, which is widely distributed throughout the Delta. In combination, these seven species require a range of declining tidal marsh habitats in the Bay-Delta system. Although only two of the species (Suisun thistle and soft bird's beak) are formally listed as endangered, restoration of all these species to the point where they are fairly common would indicate that major marsh restoration projects in the region had succeeded.

STAGE 1 EXPECTATIONS: The status of the seven species listed here will have improved. Surveys of present ranges of the species (and other rare marsh plants), studies of their ecological requirements, and identification of key restoration sites will have been completed. Ongoing marsh restoration projects in the Bay-Delta system will have been evaluated according to their success at restoring rare native plant species and lessons learned applied to new projects.

The following actions would contribute to improving the tidal brackish and freshwater marsh special-status plant species populations:

- Conduct a site-based evaluation of populations and rank sites based on criteria developed to assess habitat and populations conditions.
- Acquire lands supporting existing populations or develop cooperative relationships with landowners to protect existing populations, beginning with the highest quality sites.
- Develop appropriate methods to protect and restore habitat and populations of the tidal brackish and freshwater marsh special-status plant species.
- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species. Include management techniques such as exotic weed control and hydrologic regulation.
- Restore moderate or low quality sites to low elevation intertidal habitats and promote establishment of species in this guild. During the restoration of habitat, promote ecological functions such as sediment deposition and erosion to balance the formation and loss of intertidal habitats.

REFERENCES

Department of Fish and Game. 1991. Annual Report on the Status of California State Listed Threatened and Endangered Animals and Plants. Sacramento, CA.

California Department of Fish and Game 1992 - CALFED Bay-Delta Program Special Status Plants and Animals Draft Affected Environment Technical Report (Appendix A. Federally Listed Plants and Animals) Sept. 23, 1996

Niehaus 1977 - CALFED Bay-Delta Program Special Status Plants and Animals Draft Affected Environment Technical Report (Appendix A. Federally Listed Plants and Animals) Sept. 23, 1996

Stone, R.D., G.L. Clifton, W.B. Davilla, J.C. Stebbins, and D.W. Taylor. 1987. Endangerment status of the grass tribe Orcuttieae and *Chamaesyce hooveri* (Euphorbiaceae) in the Central Valley of California.

Aquatic Habitat Special-Status Plant Species

Introduction

Aquatic habitats associated with shorelines of rivers and the Delta include shaded riverine aquatic and riparian habitats. Riverine aquatic habitat shaded by riparian vegetation provides important habitat for many species of fish, waterfowl, and wildlife. Nontidal perennial aquatic habitat is another aquatic habitat that occurs in the Bay-Delta as permanent open water that is no longer subject to tidal influences.

Riverine aquatic habitat is characterized by the relatively shallow submerged and seasonally flooded areas in estuary and river channel beds. Channel beds contain gravel beds, bars, and riffles; transient sandy shoals; waterlogged woody debris piles; and the shaded riverine aquatic habitat zone. This habitat zone is located where the river meets the riparian canopy. Riverine aquatic zones provide spawning substrate, rearing and escape cover, feeding sites, and refuge from turbulent stormflows for fish and other aquatic organisms. Riparian and riverine aquatic habitats are created and sustained by natural fluvial processes associated with rivers.

The nontidal perennial aquatic habitat is present in certain low-elevation areas in the Bay-Delta estuary. In many places within the Delta, this habitat type has replaced the native tidal aquatic habitats that existed prior to reclamation. Most nontidal perennial aquatic habitat areas were established by constructing dikes and levees as part of reclamation activities. As land was converted to agricultural uses, perennial aquatic habitats established in large agricultural drains; small farm ponds; industrial ponds; ponds managed for waterfowl and other wildlife; and Delta island blowout ponds, which were created by levee failures that scoured island interiors deeply enough to maintain permanent water through seepage. Some historical nontidal perennial habitat was created naturally as a result of shifts in river alignments that occasionally resulted in establishment of isolated oxbow lakes. Eel-grass pondweed *(Potamogeton zosteriformis)* is the only aquatic habitat special-status plant species that is expected to occur in the study area.

Species Description

Eel-grass pondweed *(Potamogeton zosteriformis)* is an annual aquatic plant with narrow linear leaves that grows less than 24 inches tall and is submerged in ditches, ponds, lakes, and slow-moving streams generally below the 5,000-foot elevation (Mason 1957, Hickman 1993). Eel-grass pondweed is more common outside the State of California, although suitable habitat exists for it in the Central Valley, where it is considered rare. It is known to have occurred in Lassen, Shasta, and Modoc Counties in the State based on six records in the California Department of Fish and Game Natural Diversity Data Base (1996) that were documented between 1897 and 1949. Eel-grass pondweed is expected to occur in the San Joaquin River Delta (Mason 1957, Munz and Keck 1973). The species has not been listed for protection by the State or the federal government. It has been assigned to List 2 by the California Native Plant Society (Skinner and Pavlik 1994).

Vision

The vision for eel-grass pondweed is to maintain populations of this California Native Plant Society List 2 plant species.

The overall vision for aquatic habitat plant species is to provide protection for and enhance existing populations. The vision for eel-grass pondweed and other aquatic habitat plant species should be initiated by conducting surveys in the project area to identify locations of sites. Following identification of sites, it will be necessary to conduct site-based evaluations of populations, develop criteria on habitat and population conditions, and rank all sites based on the criteria in terms of low- to high-quality. Higher ranked sites should be identified for protection. Restoration efforts should be focused on restoring existing habitat and promoting establishment of aquatic plant species on restored sites or at other sites with suitable habitats.

Existing populations of aquatic species should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to achieve the vision for riverine aquatic habitat (including riparian habitat) may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- SB 1086 Advisory Council efforts and river corridor management plan for the Sacramento River;
- the San Joaquin River Parkway and Management plans;
- ongoing Sacramento Valley conservation planning by the Nature Conservancy and other private nonprofit conservation organizations;
- expansion plans and conservation easements underway for the Sacramento River National Wildlife Refuge and California Department of Fish and Game Sacramento River Wildlife Management Area; and
- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Riverine aquatic habitat is important to many fish, wildlife, and plant species and communities. It is adversely affected by stressors that include levee construction, gravel mining, flow patterns, fragmentation of existing stands of riparian vegetation, competition and displacement by non-native plant species.

Restoration of nontidal perennial aquatic habitat is linked with ecosystem processes including:

- the geologic and hydrologic condition, stream meander, and tidal function necessary to maintain permanent surface water;
- a range of elevations sufficient to support deep-water (greater than 3 feet in depth) and shallow-water areas; and
- adjacent wetland and riparian (streambank) vegetation.

The value of nontidal perennial aquatic habitat to wildlife greatly increases if emergent vegetation is present along shorelines and in shallow-water areas. Adjacent dense upland herbaceous vegetation and riparian woodland further increase the value to wildlife.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore eel-grass pondweed in nontidal perennial aquatic habitats in the Bay-Delta estuary.

Long-term Objective: Have self-sustaining populations of eel-grass pondweed located throughout their original native range in marshes associated with the Bay-Delta estuary.

Short-term Objective: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require nontidal aquatic habitat.

Rationale: Eel-grass pondweed requires nontidal aquatic habitat. The restoration of nontidal aquatic habitat should provide for a diversity of plant and animal species including eel-grass pondweed.

Stage 1 Expectations: The status of eel-grass pondweed will have improved. Surveys of present ranges of the species, studies of its ecological requirements, and identification of key restoration sites will have been completed. On-going nontidal perennial aquatic habitat restoration projects in the Bay-Delta will have been evaluated according to their success or potential support for restoring rare native plant species and lessons learned applied to new projects.

The targets for eel-grass pondweed include identifying and protecting high-quality habitats and populations throughout the range of this species in the study area, and ensuring the long-term viability of the species on higher ranked sites. Implementation of the following actions would contribute to achieving the targets:

- Conduct a site-based evaluation of populations, develop criteria on habitat and population conditions, and rank all sites based on the criteria in terms of low- to high-quality. Based on the ranking of sites identify the higher ranked sites for protection.
- Protect higher ranked sites through acquisition or cooperative efforts with landowners.
- Conduct studies to determine the microhabitat requirements of eel-grass pondweed and determine reasons for limited distribution.
- Develop and implement a habitat management plan to protect eel-grass pondweed on higher ranked sites.

References

Hickman, J.C. (ed.). 1993. The Jepson Manual, Higher Plants of California. University of California Press, Berkeley, CA.

Mason, H. L. 1957. A flora of the marshes of California. University of California Press, Berkeley, CA.

Munz and Keck. 1973. A California flora and fauna supplement. University of California Press, Berkeley, CA.

Natural Diversity Data Base. 1996. Records search for occurrences of Eel-grass pondweed *(Potamogeton zosteriformis)*. California Department of Fish and Game, Sacramento, CA.

Skinner, Mark W. And Bruce M. Pavlik. 1994. California Native Plant Society's inventory of rare and endangered vascular plant of California. Fifth edition. (Special Publication No. 1.) California Native Plant Society. Sacramento, CA.

VERNAL POOL SPECIAL-STATUS PLANT SPECIES

INTRODUCTION

Vernal pools are seasonally flooded depressions that support a distinctive biota adapted to periodic or continuous inundation during the wet season and desiccated soils during the dry season (Holland and Jain 1977, Holland 1978, Thorne 1984, Jones & Stokes Associates 1990). Vernal pools usually occur in troughs between the ridges of a gently rolling or reticulated landscape, in the depressions between small mounds in a landscape dotted by "mima mounds", or on localized flats or steps in a seasonally wet swale. Some appear as isolated anomalies on ridge tops or flat terrain. Vernal pools vary in size from several yards to well over 1 acre, but most range from several thousandths to a few tenths of an acre. The largest vernal pools are really seasonal lakes, like Olcott Lake at the Jepson Prairie Preserve in Solano County and Boggs Lake at the Boggs Lake Preserve in Lake County.

Vernal pools support a unique associated of plant species. Some of the plants are restricted to vernal pools, while others occur primarily in vernal pools but also occur in other seasonal wetland habitats. Vernal pools are well known for their high level of endemism (Jain 1976) and abundance of rare, threatened, or endangered species (Skinner and Pavlik 1994, Jones & Stokes Associates 1990).

SPECIES DESCRIPTION

COLUSA GRASS *(Neostapfia colusana)* is a pale green annual member of the grass family (Poaceae), with several stems of loosely folded, clasping leaves and thick terminal spikes of flowers. Colusa grass is state listed as endangered and federally listed as threatened. It is considered rare, threatened, or endangered in California and elsewhere by the California Native Plant Society (CNPS) List 1B. Colusa grass grows in the bottoms of large or deep vernal pools with substrates of adobe mud and is somewhat resistant to light grazing. Colusa grass is endemic to the southern Sacramento and northern San Joaquin Valleys. Its historical distribution included Merced, Stanislaus, Solano and Colusa Counties, but is now extirpated from Colusa County. Two new populations have been found in Yolo County. The primary reasons for decline of Colusa grass include the conversion of vernal pools to agricultural and developed lands, heavy grazing by cattle, and competition from introduced weedy species that tend to displace it. (DFG 1992)

BOGGS LAKE HEDGE-HYSSOP *(Gratiola heterosepala)* is a small, semi-aquatic, herbaceous annual in the figwort family (Scrophulariaceae). It has opposite leaves, blunt, unequal sepals, and yellow and white flowers on short stalks. Boggs Lake hedge-hyssop is state endangered and considered rare, threatened, or endangered in California and elsewhere by CNPS (List 1B). Boggs Lake hedge hyssop is found in Fresno, Lassen, Lake, Madera, Modoc, Placer, Sacramento, Shasta, San Joaquin, Solano, and Tehama counties and in Oregon. This species is found in shallow waters or moist clay soils of vernal pools and lake margins. Boggs Lake hedge hyssop has undergone substantial habitat reduction from development and agricultural conversion. Current threats include agriculture, development, grazing, and ORV's. Many occurrences are on privately owned land. (DFG 1992)

CONTRA COSTA GOLDFIELDS *(Lasthenia conjugens)* is a showy spring annual in the aster family (Asteraceae) that grows 10 to 30 centimeters tall with opposite light green leaves. Contra Costa goldfields is federally listed as endangered and is on CNPS list 1B. The historical distribution of Contra Costa goldfields extended from Mendocino to Santa Barbara Counties. Currently its distribution is limited to a few locations in Solano and Napa Counties. It inhabits vernal pools and seasonally moist grassy areas. In the past, the species may have also occurred in coastal prairies (Ornduff 1979). The decline of the Contra Costa goldfields has been attributed to the loss of vernal pools by development and agriculture. Continued threats include urbanization and overgrazing.

LEGENERE *(Legenere limosa)* is a slender annual that grows in wet margins of deep vernal pools. Legenere is considered by the U.S. Fish and Wildlife Service (USFWS) to be a species of concern and CNPS list 1B. Historical distribution of Legenere includes Lake, Napa, Placer, Sacramento, San Mateo, Solano, Sonoma, Stanislaus and Tehama Counties. It has now become extirpated from Sonoma and Stanislaus Counties. At the Jepson Prairie Preserve it is found in the bottom of hogwallow. Threats to this species are primarily loss of vernal pools by agriculture. Other threats include grazing and development.

ALKALI MILK-VETCH *(Astragalus tener var. tener)* is rare, threatened, or endangered in California and elsewhere by CNPS (List 1B). Historical distribution of Alkali milk-vetch includes Alameda, contra Costa, Merced, Monterey, Napa, San Benito, San Francisco, San Joaquin, Solano, Sonoma, Stanislaus, and Yolo Counties. Currently its distribution is Merced, Napa, Solano, and Yolo Counties. The primary threat to this species is sheep and cattle grazing (NDDB 1996).

DWARF DOWNINGIA *(Downingia pusilla)* is considered rare, threatened, or endangered in California and elsewhere by CNPS (List 1B). Dwarf downingia occurs in margins of vernal pools, swales. Distribution includes Merced, Mariposa, Napa, Placer, Sacramento, Solano, Sonoma, Stanislaus and Tehama Counties. Threats to this species are ORV's, grazing and development (NDDB 1996).

CRAMPTON'S TUCTORIA *(Tuctoria mucronata)* is a sticky, aromatic annual grass, with a dense spike of overlapping flower spikelets that emerge from the upper leaves. Crampton's tuctoria is state and federally listed as endangered and CNPS list 1B. It occurs in only two counties Solano and Yolo. It grows in the clay bottoms of drying vernal pools and lakes. The Nature Conservancy owns and protects a portion of the habitat at the Jepson Prairie Preserve, but the plant has not been seen since 1987 at the preserve (DFG 1992). Threats to the two known occurrences include alternation of local drainage patterns that feed the pools, off-road vehicle recreation, local farming operations, and trampling by livestock. Roads and transmission corridors have also degraded the habitat. Most of Crampton's tuctoria habitat is privately owned. The USFWS has prepared a recovery plan for Crampton's tuctoria which provides management recommendations (DFG 1992).

HEARTSCALE *(Atriplex cordulata)* is considered by the USFWS to be a species of concern and CNPS list 1B. Distribution of heartscale includes Alameda, Contra Costa, Butte, Fresno, Glenn, King, Kern, Madera, Merced, Solano, and Tulare Counties and no longer occurs in San Joaquin, Stanislaus or Yolo Counties (NDDB 1996).

VISION

The vision for Colusa grass is to maintain populations of this federally listed threatened and State-listed endangered species.

The vision for Boggs Lake hedge-hyssop is to maintain populations of this State-listed endangered species.

The vision for Contra Costs goldfields is to maintain populations of this federally listed endangered species.

The vision for legenere is to maintain populations of this California Native Plant Society List 1B plant species.

The vision for alkali milkvetch is to contribute to the recovery of this California Native Plant Society List 1B plant species.

The vision for dwarf downingia is to maintain populations of this California Native Plant Society List 2 plant species.

The vision for Crampton's tuctoria is to contribute to the recovery of this federally and State-listed endangered species.

The vision for heartscale is to maintain populations of this California Native Plant Society List 2 species.

The vision for vernal pool plant species is to provide protection for and enhance existing populations. Existing populations should be protected through acquisition or cooperative efforts with landowners, beginning with the highest quality sites. Preservation and proper management of all existing populations would ensure the long-term viability of the species. To provide for proper management on protected sites, research would be conducted to determine the optimal conditions for the growth. For example, on sites with a high cover of non-native species, experimental burning and/or grazing would be conducted to determine if such treatments are beneficial for the species. Colusa grass's response to light and moderate grazing could also be investigated. Research on reproduction and recruitment would be conducted to better understand the species' biology.

Following experimental research, habitat management techniques to promote conditions suitable for the growth and establishment would be implemented. This may include, but is not limited to, reduction in grazing; use of prescribed burns, restoration of winter flood/summer drought regime; and removal of other stresses.

Integration with Other Restoration Programs

Efforts to restore seasonal wetlands would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- California Department of Fish and Game wildlife areas,
- Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- the Nature Conservancy,
- U. S. Fish and Wildlife Service,
- Yolo County Habitat Conservation Plan,
- and Central Valley Habitat Joint Venture.

Two occurrences of Colusa grass are currently protected: the Solano County occurrence at the Nature Conservancy's (TNC) Jepson Prairie Preserve and the Flying M Ranch in Merced County, where conservation easements protect some of the large vernal pools. Heartscale occurs with two other species dwarf downingia and legenere at the Nature Conservancy's Jepson Prairie Preserve.

Linkage with Other Ecosystem Elements

The vernal pool guild of plant species is linked with the restoration of vernal pool habitat. Stressors that could effect these species include: non-native weedy grasses and grazing.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore at-risk endemic vernal pool plants.

Long-term Objective: Have self-sustaining populations of Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, legenere, alkali milk-vetch, dwarf downingia, Crampton's tuctoria, and heartscale and similar declining endemic species located throughout their original native range in vernal pools associated with the Bay-Delta estuary.

Short-term Objective: Protect existing populations of the species and restore habitat to provide sites for expansion of all rare native species that require vernal pool or other wetland habitat.

Rationale: The eight species listed here are examples of plants that are largely endemic to vernal pool and other wetland areas throughout the Bay-Delta estuary and watershed. Restoration of these species to the point where they were no longer in danger of extinction would indicate that major perennial grassland-vernal pool-wetland restoration projects in the region had succeeded.

Stage 1 Expectations: The status of the eight species listed here will have improved. Surveys of present ranges of the species (and other rare vernal pool plants), studies of their ecological requirements, and identification of key restoration sites will have been completed. On-going marsh restoration projects in the Bay-Delta will have been evaluated according to their success at restoring rare native plant species and lessons learned applied to new projects.

The targets for vernal pool special-status species include identifying high-quality habitats and populations and restoration and reestablishment of populations in order to maintain diversity and ensure the sustainability of each species.

- Protect existing habitat and restore and reestablish vernal pool habitats within and adjacent to existing ecological reserves.
- Implement restoration of habitat and reintroduction of species on historic sites in conjunction with long-term monitoring and maintenance of existing and newly established populations.
- Conduct reproduction and recruitment research to better understand the species biology.
- Conduct site-based evaluation of populations and develop criteria for ranking sites and protection of high-quality sites.

References

Department of Fish and Game. 1992. Annual report on the status of California State listed threatened and endangered animals and plants. Sacramento, CA.

Holland, R. F., and S. Jain. 1977. Vernal pools. Pages 515-533 in M. E. Barbour and J. Major (eds.), Terrestrial vegetation of California. John Wiley & Sons. New York, NY.

Holland, R. F. 1978. The geographic and edaphic distribution of vernal pools in the Great Central Valley, California. (Special Publication No. 4.) California Native Plant Society. Berkeley, CA.

Jain, S. 1976. Some biogeographic aspects of plant communities in vernal pools. Pages 15-21 in S. Jain (ed.), Vernal pools: their ecology and conservation. (Institute of

Ecology Publication No. 9.) University of California. Davis, CA.

Jones & Stokes Associates, Inc. 1990. Sacramento County vernal pools: their distribution, classification, ecology, and management. (JSA 89-303.) Sacramento, CA. Prepared for Sacramento County Planning and Community Development Department, Sacramento, CA.

Natural Diversity Data Base (NDDB). 1996. Record search for occurrence of *Neostapfia colusana, Gratiola heterosepala, Lasthenia conjugens, Legenere limosa, Astragalus tener var. tener, Downingia pusilla, Tuctoria mucronata,* and *Atriplex cordulata.* California Department of Fish and Game, Sacramento, CA.

Ornduff, R. 1979. Unpublished status report on Lasthenia conjugens. California Native Plant Society, Sacramento, CA.

Skinner, M. W., and B. M. Pavlik. 1994. Inventory of rare and endangered vascular plants in California. 5th edition. (Special Publication No. 1.) California Native Plant Society. Sacramento, CA.

Thorne, R. F. 1984. Are California's vernal pools unique? Pages 1-8 in S. Jain and P. Moyle (eds.) Vernal pools and intermittent streams. (Institute of Ecology Publication No. 28.) University of California. Davis, CA.

Inland Dune Special-Status Plant Species

Introduction

Inland dunes are extremely limited to the Delta, occurring only in the vicinity of the Antioch Dunes Ecological Reserve. This habitat supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Both plants are State-listed endangered species. Visions are provided here for the two plant species, Antioch Dunes evening-primrose (*Oenothera deltoides* ssp. *howellii*) and Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*).

Species Descriptions

Antioch Dunes evening-primrose. Antioch Dunes evening-primrose is a showy, white-flowered, highly branched perennial herb with grayish toothed or divided leaves. It is a member of the evening primrose family (Onagraceae). Antioch Dunes evening-primrose is both state and federally listed as endangered. Additionally, this species is considered rare, threatened, or endangered in California and elsewhere by the California Native Plant Society (CNPS) (List 1B). Antioch Dunes evening-primrose is endemic to loose sand and stabilized dunes near river margins in the vicinity of Antioch. It is known from only 7 occurrences (Skinner and Pavlik 1994). Most remaining plants occur at the Antioch Dunes National Wildlife Refuge. In 1992, the population size of this species at 2 disjunct sites on the Antioch Dunes was only 1,200 plants (Greene 1994). Attempts have been made to introduce the species to several other locations with remnant dunes, including Brannan Island State Recreation Area in Rio Vista. Antioch dunes evening-primrose evolved from desert flora which occupied the sand dunes of the Sacramento Valley 5,000 to 8,000 years ago (Green 1994). In recent times, dune habitat in the Delta has been lost to conversion to agriculture, sand mining, and industrial development. Present threats include competition for water with ripgut brome (*Bromus diandrus*) and recreational and fire control activities. The recent trend for Antioch Dunes evening-primrose is one of stability, but its total population size and distribution is still very limited (DFG 1991).

Contra Costa wallflower. Contra Costa wallflower, a member of the mustard family (Brassicaceae), is a coarse-stemmed, erect, herbaceous biennial herb with yellowish-orange flowers. Contra Costa wallflower is state and federally listed as endangered and is also on CNPS's List 1B. Contra Costa wallflower co-occurs with Antioch Dunes evening-primrose at the Antioch Dunes NWR, and is known from only 2 occurrences at the Antioch Dunes. It is threatened by factors similar to those affecting Antioch Dunes evening primrose. The wallflower population is surveyed annually and has shown considerable increase since 1978 (DFG 1991).

Vision

The vision for Antioch Dunes evening-primrose is to recover this federally and State-listed endangered species.

The vision for Contra Costa wallflower is to recover this federally and State-listed endangered species.

The overall vision for both species is to protect existing populations and ensure the long-term viability of the species through habitat restoration, enhancement, and appropriate management. Effective management techniques would be developed and employed to protect existing populations. Existing knowledge acquired primarily at the Antioch Dunes Refuge would serve as a basis of establishing effective management techniques. Prescribed burning is an example of a management technique that has been successful in promoting Antioch Dunes evening-primrose colonization. Controlling non-native competitors would also be an element of on-going management for the species. One study showed that removal of ripgut brome near adult Antioch Dunes evening-primrose plants increased seedling germination (Greene 1994).

Establishing additional populations would greatly increase the recovery potential for Antioch Dunes evening-primrose and Contra Costa wallflower. To promote the expansion of the species, historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Zone would be reestablished and species establishment promoted. Sand dune creation techniques developed at the Antioch Dunes would be employed. Protecting and restoring inland dune scrub that serves as habitat for Antioch Dunes evening-primrose and Contra Costa wallflower would be enhanced by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat for Antioch Dunes evening-primrose and Contra Costa wallflower would be protected and restored.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore habitat for Antioch Dunes evening-primrose and Contra Costa wallflower will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- the Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Antioch Dunes evening-primrose and Contra Costa wallflower are linked with a habitat ecosystem element, inland dune scrub. These species and habitat elements are closely associated with each other and are limited to the area near the Antioch Dunes Ecological Reserve. Non-native plant species are stressors that compete with Antioch Dunes evening-primrose and Contra Costa wallflower for habitat.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore at-risk inland dune special status plants.

LONG-TERM OBJECTIVE: Establish additional self-sustaining populations of Antioch Dunes evening-primrose and Contra Costa wallflower and similar declining endemic species located throughout their original native range in the vicinity of Antioch Dunes.

SHORT-TERM OBJECTIVE: Protect existing populations of the species and restore habitat to provide sites for establishing addition self-sustaining populations.

RATIONALE: The two species listed here are examples of plants that are endemic to Antioch

Dunes. Restoration of these species to the point where they were no longer in danger of extinction would indicate that dune restoration and protection projects in the region had succeeded.

STAGE 1 EXPECTATIONS: The status of the two species listed here will have improved. Surveys of present ranges of the species, studies of their ecological requirements, and identification of key restoration sites will have been completed.

The general target for the inland dune special-status plant species is to establish and protect a large enough number of populations of each species to maintain genetic diversity, prevent species extinction from localized catastrophic occurrences, and promote the sustainability of each species.

The following actions would contribute to improving the inland dune special-status plant species populations:

- Develop appropriate methods to protect and restore habitat and populations of the inland dune special-status plant species.
- Manage protected areas occupied by the inland dune special-status species to reduce disturbance of dunes and dune vegetation.
- Manage protected areas occupied by the species to promote conditions favorable for the establishment, growth, and vigor of the species. Include management techniques such as prescribed burning and exotic weed control.
- Acquire historic inland dunes adjacent to existing ecological reserves and reestablish dune habitat and inland dune special-status species populations.

REFERENCES

Department of Fish and Game. 1991. Annual Report on the Status of California State Listed Threatened and Endangered Animals and Plants. Sacramento, CA.

Greene, Jule A. 1994. Rancho Santa Ana Botanic Garden Supports Research on Endangered *Oenothera* (Onagraceae). Plant Conservation. Vol 8(2). pp. 6-7.

Skinner, Mark W. and Bruce M. Pavlik. 1994. California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California. Publication No. 1. Fifth edition. California Native Plant Society. Sacramento, CA.

Department of Fish and Game. 1991. Annual Report on the Status of California State Listed Threatened and Endangered Animals and Plants. Sacramento, CA.

California Department of Fish and Game 1992 - CALFED Bay-Delta Program Special Status Plants and Animals Draft Affected Environment Technical Report (Appendix A. Federally Listed Plants and Animals) Sept. 23, 1996

Niehaus 1977 - CALFED Bay-Delta Program Special Status Plants and Animals Draft Affected Environment Technical Report (Appendix A. Federally Listed Plants and Animals) Sept. 23, 1996

Stone, R.D., G.L. Clifton, W.B. Davilla, J.C. Stebbins, and D.W. Taylor. 1987. Endangerment status of the grass tribe Orcuttieae and *Chamaesyce hooveri* (Euphorbiaceae) in the Central Valley of California.

◆ VALLEY ELDERBERRY LONGHORN BEETLE

INTRODUCTION

The valley elderberry longhorn beetle (VELB) is a federally listed threatened species associated with riparian habitats. The distribution and populations of this species has declined substantially, primarily as a result of the loss or degradation of habitat within its range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

VELB has been found only in association with its host plant, elderberry (*Sambucus* spp.). Elderberry is a component of the remaining riparian forests and adjacent grasslands of the Central Valley. Entomologists estimate that the range of this beetle extends from Redding at the northern end of the Central Valley to the Bakersfield area in the south. Important stressors on VELB are fragmentation of riparian habitat; grazing; and excessive collection of the species for commercial, recreational, scientific, or educational purposes. Local populations can also be severely damaged by pesticides inadvertently drifting from nearby agricultural lands into occupied habitat areas.

VISION

The vision for VELB is to assist in the recovery of the VELB by increasing its populations and abundance through habitat restoration.

Protecting existing and restoring additional suitable riparian habitats and establishing new populations will be critical to recovery of the VELB in the Bay-Delta. Restoration of riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of habitats used by these species.

The period required to achieve recovery of the VELB could be reduced by introducing the species into unoccupied or restored habitat areas. Such a strategy could be implemented through cooperative agreements with land management agencies or cooperative agreements with willing landowners. The VELB would also benefit from development and implementation of alternative designs for and maintenance of flood control, bank protection, and other structures that reduce their potential adverse effects on existing riparian habitats.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley. The benefit of these restorations for recovery of the VELB would be increased by implementing restoration of riparian habitats in a manner that links isolated areas supporting existing VELB populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,

- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to increase and maintain valley elderberry longhorn beetle habitat.

LONG-TERM OBJECTIVE: Restore riparian habitat throughout the Central Valley that includes components (i.e., elderberry thickets) suitable for populations of valley elderberry beetle throughout its native range.

SHORT-TERM OBJECTIVE: Contribute to recovery of this species as defined in the Valley Elderberry Longhorn Beetle Recovery Plan (U.S. Fish and Wildlife Service 1984) by restoring habitat for the species in riparian restoration projects in its native range where feasible.

RATIONALE: The valley elderberry longhorn beetle is a federally listed threatened species, although its status and factors limiting its populations are poorly understood. These beetles depend on elderberry bushes for breeding and rearing of young and will sometimes occupy bushes growing in degraded habitat (e.g., levees). Presumably, its populations will respond positively to riparian restoration projects in the Central Valley and Delta.

STAGE 1 EXPECTATIONS: A program will have been developed to minimize clearing of levees or additional habitats will have been developed to offset levee maintenance practices and existing habitat will have been maintained. A comprehensive study will have been completed to locate populations of the beetle and assess their population size. A program will have been implemented to maintain existing habitat and plant new elderberry bushes where possible, particulary in conjunction with the restoration or riparian and riverine aquatic habitats.

The following general targets will assist in meeting the Strategic Objective:

- Increase the numbers and distribution of valley elderberry longhorn beetle.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore wetland, riparian, and grassland habitat.
- Implement control measures to eradicate invasive plant species.
- Reduce land and water management practices that degrade habitats used by these species.

REFERENCE

U.S. Fish and Wildlife Service. 1984. Recovery plan for the valley elderberry longhorn beetle.

♦ At-risk Native Species (Priority Group III)

Introduction

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. The first Strategic Goal focuses on at-risk species:

> ***GOAL 1: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.***

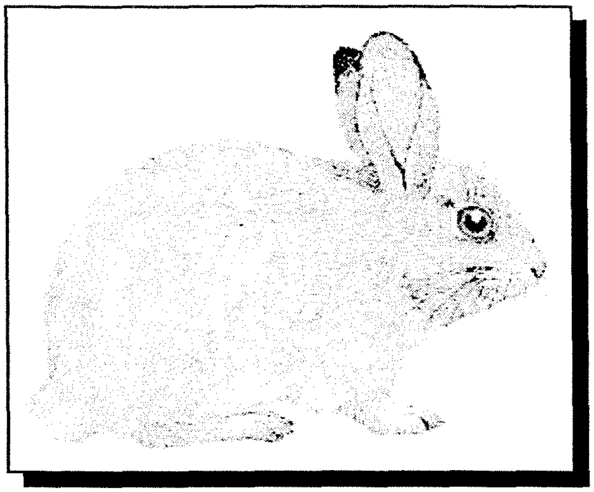
Because there are so many species covered under this goal, they have been divided into four groups in terms of priority for CALFED attention. Many are "at-risk" species, which are in danger of extinction if present trends continue.

Third priority species are at-risk species that primarily live upstream of the estuary or in San Francisco Bay for which CALFED will contribute to their recovery.

The objectives and expectations for this goal are narrowly aimed, for the most part, on actions that benefit individual at-risk species. In the short run, this is appropriate because ecosystem restoration requires that we keep all the pieces around for the rebuilding process.

Species in Priority Group III include:

- Riparian brush rabbit
- San Joaquin Valley woodrat
- Sacramento perch
- Greater sandhill crane
- Western yellow-billed cuckoo
- Bank swallow
- Western least bittern
- Least Bell's vireo
- California yellow warbler
- Little willow flycatcher
- Giant garter snake
- California tiger salamander
- Western spadefoot
- California red-legged frog
- Native anuran amphibians
- Western pond turtle
- Delta green ground beetle
- Lange's metalmark
- California freshwater shrimp



INTRODUCTION

The riparian brush rabbit is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta from loss of riparian habitat. Elsewhere, the population and distribution of this species have declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as endangered under the California Endangered Species Act.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the riparian brush rabbit depends, in the Delta and San Joaquin River floodplain.

RESOURCE DESCRIPTION

The remaining population of riparian brush rabbit is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. Unlike other rabbits, the riparian brush rabbit occupies riparian forests that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species' habitat was throughout the floodplain on the valley floor in northern San Joaquin Valley, including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded.

The remnant population of riparian brush rabbit is now restricted to 198 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park in southern San Joaquin County in the East San Joaquin Basin Ecological Management Zone. It is considered the most sensitive mammal in California because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities. The large-scale loss of riparian forest has resulted in over a 99% decline in the riparian brush rabbit population from historical levels. A population census conducted during January 1993, found that the population size ranged from about 210 to 310 individuals. Subsequent surveys following the January 1997 flood indicate that this species may be close to extinction. No brush rabbits were trapped in 22 nights of trapping between April 21 and May 30, 1997.

Overall, the decline of the riparian brush rabbit was caused by the destruction, fragmentation, and degradation of the San Joaquin Valley native riparian forest habitat. Less than 6% of the original habitat remains. Remaining suitable habitat is so severely fragmented that the rabbit has no means of naturally dispersing to other areas and establishing additional populations. Because the remaining riparian brush rabbit population occurs within one small area, any of the following events threaten the remaining population:

- Caswell Memorial State Park is subject to periodic flooding that often inundates the entire area. Without adequate cover on adjacent upland areas, the rabbits become easy targets for both native and non-native predators.

- The normal buildup of downed logs, dried vegetation, and ground litter in the riparian forest increases the potential severity of wildfires. Although this type of habitat is preferred and typically occupied by the riparian brush rabbit, any wildfire occurring within the remaining habitat could cause direct mortality as well as massive habitat destruction.

- Human activities have modified the habitat. The modified habitat has "selected" against the riparian brush rabbit and for the desert cottontail. The desert cottontail presents two threats: one from competition and the other from diseases common to rabbits and carried by the species. These diseases are typically contagious and fatal; any disease becomes epidemic in this small and restricted population of rabbits.

VISION

The vision for the riparian brush rabbit is to contribute to the recovery of this federally proposed and State-listed endangered species in the Bay-Delta through improvements in riparian habitat and reintroduction to its former habitat.

Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the riparian brush rabbit. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding. Mature riparian forests with a brushy understory and adjacent upland habitat with sufficient cover during flooding would be suitable restored habitat. A healthy, brushy understory would contain:

- wild rose,
- blackberries,
- elderberries,
- wild grape,
- a buildup of downed logs,
- dried vegetation, and
- ground litter.

Restoring riparian habitat in the East San Joaquin Basin Ecological Management Zone to expand the area of suitable riparian brush rabbit habitat adjacent to occupied habitat along the Stanislaus River will help to protect and allow the existing population of brush rabbits to expand. Establishing additional populations within the riparian brush rabbit's historical range in the Sacramento-San Joaquin Delta Ecological Management Zone would help to avoid potential species extinction. To ensure the survival of introduced populations, newly occupied habitat areas should be suitable only for the riparian brush rabbit. That would reduce the likelihood of disease transmission from the desert cottontail. Hunting regulations should be modified to preclude hunting of rabbits and hares in and near reintroduction sites to limit the harvest of riparian brush rabbits until the species has recovered.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

A draft San Joaquin Recovery Plan has been developed which contains specific measures for the riparian brush rabbit. Resources agencies have identified Christman Island, part of the San Joaquin River National Wildlife Refuge, as possessing the greatest potential for providing habitat needed by the riparian brush rabbit. The agencies also agreed to continue work to identify one or more other sites on public property along the San Joaquin River in Merced County for restoration and reestablishment of a third population of the riparian brush rabbit. The California Department of Fish and Game and the U. S. Fish and Wildlife Service should continue the interagency coordination and commitment necessary to halt the further loss and deterioration of habitat and begin restoration and preservation of suitable habitat deemed essential to maintaining the subspecies in perpetuity.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and protection of riparian brush rabbit is integrally linked with restoration of riparian forests and adjacent grasslands and reduction in wildfires and human disturbance in the northern San Joaquin Valley and the Delta.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore riparian brush rabbit throughout its historical range.

LONG-TERM OBJECTIVE: Recover brush rabbit populations to the point where the species can removed from the state endangered species list.

SHORT-TERM OBJECTIVE: Establish five additional self-sustaining populations of riparian brush rabbits along the San Joaquin River and in the Delta.

RATIONALE: The riparian brush rabbit a distinct subspecies of cottontail rabbit that historically lived in riparian areas along the San Joaquin River and Delta. It is listed an endangered by the State of California and has been proposed for federal listing. It currently exists as one tiny remnant population in Caswell State Park that is in continuous threat of extinction. It has declined because of the loss of riparian habitats and the conversion of adjacent upland habitats to cropland. This species requires high ground, with extensive cover that it can move to when its primary riparian habitat floods. Due to the possibility of being extirpated by floods and wildfires it is important to develop other self-sustaining populations and restore riparian areas. Develop more brush habitat within the park to allow for good coverage and areas of minimal disturbance.

STAGE 1 EXPECTATIONS: The existing population will have been protected from further decline by protecting the species from seasonal flooding. More brushy riparian habitat within Caswell State Park will have been developed to provide good cover and areas of minimal disturbance. An inventory of potential restoration sites will have been completed and work begun on making them suitable for brush rabbit reintroduction. Due to low population numbers, the benefits and detriments of a captive breeding program will have been evaluated and implemented if the resource agencies find that captive breeding will prevent extinction of the species during the period that habitat is being restored.

The following general targets will assist in meeting the implementation objective:

- Increase abundance in remaining population.
- Increase the number of rabbit populations
- Investigate the health of riparian brush rabbits in the existing population to determine the effect of non-native rabbit populations, if any,

and take measures to improve their health if necessary.

The following general programmatic actions will assist in meeting the targets:

- Expand the amount of riparian forest in the northern San Joaquin Valley and the Delta.
- Increase the amounts of specific habitat features needed by rabbits in riparian forests where the existing population occurs or where introduced.
- Expand the amount of upland habitat adjacent to riparian habitat where the existing populations occurs or to where new populations will be introduced.
- Manage existing and new habitats to reduce potential threat of wildfire and human disturbance including hunting.
- Control predators and non-native competitors where populations exist or will be introduced.

REFERENCES

Basey, G.E. 1990. Distribution, ecology, and population status of the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*). M.S. Thesis, California State University, Stanislaus. 76 pp.

Blankenship, D.S. 1989. Caswell Memorial State Park sensitive species management. California Department of Parks and Recreation. project Status Report. 6 pp. (unpublished)

Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, California, 494 pp.

Larsen, C.J. 1993. Status review of the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*) in California. California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Report No. 93-12, 23 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Williams, D.F. 1986. Mammalian species of special concern in California. California Department of Fish and Game, Wildlife Management Division Administrative Report No. 86-1, 112 pp.

__________. 1993. Population census of Riparian Brush Rabbits and Riparian Woodrats at Caswell Memorial State Park during January 1993. California Department of Parks and Recreation, Inland Region, and U.S. Fish and Wildlife Service San Joaquin Valley Endangered Species Recovery Planning Program, Fresno, 15 pp.

◆ SAN JOAQUIN VALLEY WOODRAT

INTRODUCTION

The San Joaquin Valley woodrat is associated with riparian habitats of the Central Valley floodplain. It has been eliminated from the Delta due to loss of riparian habitat. Elsewhere, the population and distribution of this species has declined substantially, primarily as a result of the loss or degradation of its habitat. The loss of habitat and declining populations have warranted its listing as a California Special Concern species.

The major factor that limits this resource's contribution to the health of the Delta is related to adverse effects of the historical loss and degradation of the mature riparian forests, on which the San Joaquin Valley woodrat depends, in the Delta and San Joaquin River floodplain.

RESOURCE DESCRIPTION

The remaining population of San Joaquin Valley woodrat is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. Unlike other woodrats, the San Joaquin Valley woodrat occupies riparian forests that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species' habitat was throughout the floodplain on the valley floor in northern San Joaquin Valley, including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded.

The remnant population of San Joaquin Valley woodrat is now restricted to 198 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park and possibly on private property directly across from the Park in southern San Joaquin County in the east San Joaquin Basin Ecological Management Zone. It is considered a sensitive mammal because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities. The large-scale loss of riparian forest has resulted in a substantial decline in the woodrats' population from historical levels.

Overall, the decline of the San Joaquin Valley woodrat was caused by the destruction, fragmentation, and degradation of the San Joaquin Valley native riparian forest habitat. Less than 6% of the original habitat remains. Remaining suitable habitat is so severely fragmented that the woodrat has no means of naturally dispersing to other areas and establishing additional populations. Because the remaining San Joaquin Valley woodrat population is known to occur within one small area, any of the following events threaten the remaining populations:

- Caswell Memorial State Park is subject to periodic flooding that often inundates the entire area. Without adequate cover on adjacent upland areas, the woodrats become easy targets for both native and non-native predators.

- The normal buildup of downed logs, dried vegetation, and ground litter is the riparian forest increases the potential severity of wildfires. Although this type of habitat is preferred and typically occupied by the San Joaquin Valley woodrat, any wildfire occurring within the remaining habitat could cause direct mortality as well as massive habitat destruction.

- Human activities have modified the habitat. The modified habitat has "selected" against the San Joaquin Valley woodrat.

VISION

The vision for the San Joaquin Valley woodrat is to contribute to the recovery of this federally proposed endangered species through improvement in its habitat to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Restoring suitable mature riparian forest, protecting and expanding the existing population, and establishing new populations will be critical to the recovery of the San Joaquin Valley woodrat. Restoration of riparian habitats in the South Delta Ecological Management Unit of the Sacramento-San Joaquin Delta Ecological Management Zone and the East San Joaquin Basin Ecological Management Zone and adjacent upland plant communities will help the recovery of this species by increasing habitat area and providing refuge from flooding. Mature riparian forests with a brushy understory and adjacent upland habitat with sufficient cover during flooding would be suitable restored habitat. A healthy, brushy understory would contain: wild rose, blackberries, elderberries, wild grape, a buildup of downed logs, dried vegetation, and ground litter.

Restoring riparian habitat in the East San Joaquin Basin Ecological Management Zone to expand the area of suitable San Joaquin Valley woodrat habitat adjacent to occupied habitat along the Stanislaus River will help protect and allow the existing population of woodrats to expand. Establishing additional populations within the San Joaquin Valley woodrat's historical range in the Sacramento-San Joaquin Delta Ecological Management Zone would help to avoid potential species extinction. To ensure the survival of introduced populations, newly occupied habitat areas should be suitable only for the San Joaquin Valley woodrat and the riparian brush rabbit.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

A draft San Joaquin Recovery Plan has been developed which contains specific measures for the riparian brush rabbit which also would benefit the San Joaquin Valley woodrat. Resource agencies have identified Christman Island, part of the San Joaquin River National Wildlife Refuge, as possessing the greatest potential for providing habitat needed by the riparian brush rabbit. The agencies also agreed to continue work to identify one or more other sites on public property along the San Joaquin River in Merced County for restoration and reestablishment of a third population of the riparian brush rabbit; both of these efforts would also benefit the San Joaquin Valley woodrat. The California Department of Fish and Game and the U.S. Fish and Wildlife Service should continue the interagency coordination and commitment necessary to halt the further loss and deterioration of habitat and begin restoration and preservation of suitable habitat deemed essential to maintaining the subspecies in perpetuity.

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and protection of the San Joaquin Valley woodrat is integrally linked with restoration of riparian forests reduction in wildfires and human disturbance in the northern San Joaquin Valley and the Delta.

The San Joaquin Valley woodrat is associated with the riparian brush rabbit in the riparian forests of the upper San Joaquin Valley. The historic range of this subspecies is nearly identical to that of the riparian brush rabbit. Presumably, suitable habitat restoration, expansion, and preservation for the San Joaquin Valley woodrat will also benefit the riparian brush rabbit.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective to restore San Joaquin Valley woodrat to the full extent of its habitat.

LONG-TERM OBJECTIVE: Establish San Joaquin Valley woodrat populations in riparian areas throughout its former range along the San Joaquin River.

SHORT-TERM OBJECTIVE: Increase the population sizes along the San Joaquin River in Stanislaus, Merced, and San Joaquin counties to the point where the woodrat will no longer be regarded as threatened.

RATIONALE: The San Joaquin Valley woodrat is a riparian-dwelling species whose distribution and ecology is poorly understood, but it apparently is confined to riparian areas in the San Joaquin Valley. It has been proposed for federal endangered status and is a state Species of Special Concern. Because this population is known to exist in such a limited area in which most riparian habitat has been degraded, its long-term survival is likely to depend upon creation of more riparian habitat along the San Joaquin River, especially in Stanislaus, Merced, and San Joaquin counties. Any additional loss of habitat would have a significant negative impact on this species.

STAGE 1 EXPECTATIONS: A thorough survey of all riparian areas in the San Joaquin Valley will have been undertaken, both to identify the extent of existing populations and to identify habitats that would be good restoration sites for the woodrat and other riparian species. All precautions will have been taken to protect the existing populations from further decline.

The following general targets will assist in meeting the implementation objective:

- Increase abundance in remaining population.
- Increase the number of woodrat populations.
- Increase the health of woodrats in the populations.

The following general programmatic actions will assist in meeting the targets:

- Expand the amount of riparian forest in the northern San Joaquin Valley and the Delta.

- Increase the amounts of specific habitat features needed by woodrats in riparian forests where the existing population occurs or where introduced.

- Expand the amount of upland habitat adjacent to riparian habitat where the existing populations occur or to where new populations will be introduced.

- Manage existing and new habitats to reduce potential threat of wildfire and human disturbance including hunting.

- Control predators where populations exist or will be introduced.

REFERENCES

Basey, G.E. 1990. Distribution, ecology, and population status of the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*). M.S. Thesis, California State University, Stanislaus. 76 pp.

Blankenship, D.S. 1989. Caswell Memorial State Park sensitive species management. California Department of Parks and Recreation. project Status Report. 6 pp. (unpublished)

Ingles, L.G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, California, 494 pp.

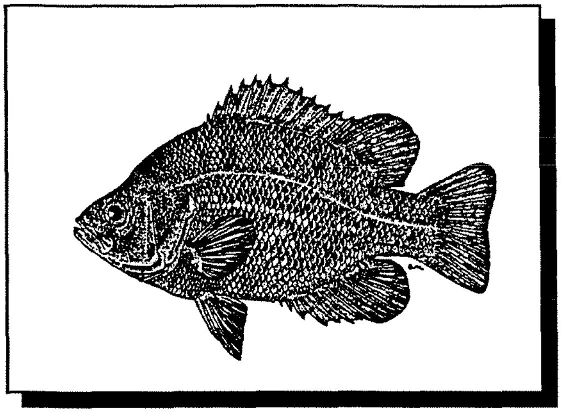
Larsen, C.J. 1993. Status review of the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*) in California. California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section Report No. 93-12, 23 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Williams, D.F. 1986. Mammalian species of special concern in California. California Department of Fish and Game, Wildlife Management Division Administrative Report No. 86-1, 112 pp.

__________. 1993. Population census of Riparian Brush Rabbits and Riparian Woodrats at Caswell Memorial State Park during January 1993. California Department of Parks and Recreation, Inland Region, and U.S. Fish and Wildlife Service San Joaquin Valley Endangered Species Recovery Planning Program, Fresno, 15 pp.

◆ SACRAMENTO PERCH



Sacramento Perch

INTRODUCTION

The Sacramento perch evolved in the Central Valley and is the only native sunfish in California and the only sunfish to evolve west of the Rocky Mountains (Moyle 1976). As a result of its isolation and lack of competition from other related species, it has retained many primitive structural and behavioral features. Given its historical lack of competition, it is not surprising that Sacramento perch have virtually disappeared from its native habitat following the introduction of a variety of sunfishes from the eastern United States.

Between 1888 and 1899, 40,000 to 432,000 pounds of Sacramento perch were sold annually in San Francisco. Sacramento perch are very rare today in the Delta. The decline, however, is probably not linked to harvest, but to three major stressors: habitat alteration or destruction, interspecific competition, and egg predation.

Sacramento perch are listed as a California species of special concern.

RESOURCE DESCRIPTION

Prior to development, Sacramento perch inhabited much of the Central Valley with sloughs, sluggish rivers, and lakes in the valley floor as their primary habitats. Sacramento perch evolved with the ability to withstand high turbidities, high temperatures, and high salinities and alkalinities, all relatively common in the waters of the Central Valley (Moyle 1976).

Like many other aquatic species, Sacramento perch were likely affected by the construction of levees, the draining of overflow "swamp lands", and general loss of historic habitat. During this period, sunfishes from the eastern United States were introduced in to the Central Valley as well as catfish and carp. All of these introduced species were more aggressive than the native Sacramento perch and the resulting interspecific competition for food and space contributed to the population decline. In addition, these introduced species were able to consume Sacramento perch eggs as the eggs were undefended by adult perch.

VISION

The vision for the Sacramento perch is to contribute to the recovery of this California species of special concern and contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that could potentially involve this species and restoration efforts will be coordinated with agencies that have responsibility for implementing programs to restore certain types of wetlands:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- Delta Protection Commission,
- Wildlife Conservation Board.

Efforts to restore and maintain Sacramento perch would involve cooperation and support from other established programs that protect and improve conditions for the delta smelt, striped bass, and other species.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes.
- Central Valley Project Improvement Act will implement actions that will benefit the Sacramento perch.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The reintroduction of Sacramento perch into selected habitats in the Central Valley is closely linked to restoration of non-tidal perennial aquatic habitats, Delta sloughs, and elimination of interspecific competitor or predator species. It may be feasible to link the reintroduction of Sacramento perch with efforts to reverse subsidence in certain Delta islands. One approach to reversing subsidence may be to flood sections of subsided land for the purpose of promoting the growth of aquatic vegetation such as cattails and tules, plants which can contribute organic matter for rebuilding peat. These shallow water, heavily vegetated experimental plots may provide ideal habitat to design an experiment that addresses the reintroduction of Sacramento perch.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore Sacramento perch within its native range.

LONG-TERM OBJECTIVE: Establish multiple, self-sustaining populations of Sacramento perch within the Central Valley region.

SHORT-TERM OBJECTIVE: Evaluate the status and biology of Sacramento perch to determine if restoration of wild populations within its native range is feasible.

RATIONALE: The Sacramento perch was once one of the most abundant fish in lowland habitats of the Central Valley. With the exception of a small population in Clear Lake, it has been extirpated from natural habitats within its native range, apparently because of competition and predation from introduced centrarchid fishes, such as black bass. It would be certainly be formally listed as an endangered species except that it has been widely introduced into reservoirs, lakes, and ponds outside its native habitats in California and other western states. Although some of these introduced populations are probably secure, most are in artificial waters subject to dewatering and other perturbations and a number have disappeared in recent years. There is thus a need to establish populations in places within their native range that can be closely monitored to be sure this species persists in the future. It is quite likely that many, if not all, of these places will be artificial habitats (e.g., ponds, reservoirs).

STAGE 1 EXPECTATIONS: A thorough status review of the Sacramento perch will have been completed and a plan for its long-term preservation in the Central Valley developed. At least one experimental population will have been established in the Delta.

Sacramento perch would benefit from the following actions and restoration activities:

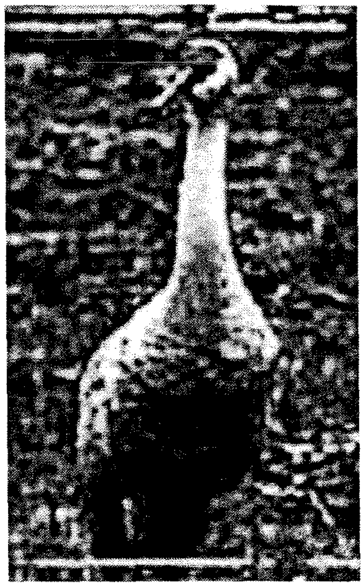
- adding and modification of aquatic habitat,
- creation of tidally influenced wetlands,
- creation of set-back levees to increase shallow water habitat along existing channels,
- eliminating water hyacinth and other noxious aquatic plants from Delta channels,
- updating existing fish protection facilities at South Delta pumping plants,
- installing screens on unscreened diversions,
- removing competitors for similar habitats and food sources, and
- preventing further introductions of non-native aquatic organisms

REFERENCES

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Greater Sandhill Crane



Introduction

This subspecies of the sandhill crane primarily winters in the Delta and forages and roosts in agricultural fields and pastures. Because the winter range of the greater sandhill crane overlaps the winter range of other sandhill crane subspecies, all subspecies are considered important resources. The greater sandhill crane population has declined primarily as a result of loss of suitable wetland nesting habitats. The loss of habitat and declining condition of the subspecies' population have warranted its listing as threatened under the California Endangered Species Act. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of conversion of grassland and wetland habitats for agricultural, industrial, and urban uses.

Resource Description

The greater sandhill crane is an important part of the biological integrity and health of the Bay-Delta and Sacramento-San Joaquin Valley ecosystems. The greater sandhill crane is found throughout most of the Central Valley in winter and nests in northeastern California and Oregon.

Habitats used by the sandhill crane include seasonal and fresh emergent wetlands, grasslands, and agricultural lands. Large wintering populations of greater and lesser sandhill cranes congregate in the Sacramento and San Joaquin Valleys. Generally, crane wintering habitat consists of shallowly flooded grasslands that are used as loafing and roosting sites and nearby agricultural areas that provide food sources include rice, sorghum, barley, and corn. In the Delta, in adequate roost sites, relatively free from disturbance and quality and quantity of forage, are potential limiting factors on the wintering population.

The State-listed greater sandhill crane is a fully protected species because the small remaining population depends on habitat that is threatened with loss or degradation. The conversion of grasslands, wetlands, and agricultural land to urban development is an ongoing process that is not likely to be reversed. The sandhill crane now depends primarily on artificially created areas where natural wetland and grassland habitats have been eliminated. Disturbance associated with human activities, illegal harvest, and predation have also affected the overall health of the crane population, although less severely than the loss and degradation of its habitats.

Vision

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

Maintenance of healthy populations of other sandhill crane subspecies will also improve by providing sufficient wintering habitat in the Bay-Delta. Habitat restoration these in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations.

The greater sandhill crane will benefit from restoration of shallowly flooded wetlands. Implementing existing crane recovery and waterfowl management plans will also help achieve this vision. Such strategies could be implemented through collaborative work with organizations to maintain and improve existing preserves, cooperative agreements with land management agencies, or conservation easements or purchase from willing sellers.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow seasonal and fresh emergent wetlands and grasslands to develop that will provide habitat for wintering sandhill cranes elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration of sandhill cranes in the Central Valley is conducted by the following programs:

- A Pacific Flyway Management Plan for the Central Valley population of greater sandhill cranes to recover the population has been developed and is being implemented by the U.S. Fish and Wildlife Service and the California and Oregon Departments of Fish and Game.
- The Central Valley Habitat Joint Venture Implementation Plan contains goals to protect and restore Central Valley aquatic and upland habitats that are needed for waterfowl. This plan provides indirect benefits for the greater sandhill crane and other species that use these wetland and upland habitats.
- California Department of Fish and Game and The Nature Conservancy are working to protect and restore crane habitat in the area of the Woodbridge Ecological Reserve and the Cosumnes River Preserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and recovery of the greater sandhill crane population of the Central Valley is integrally linked with wetland and riparian habitat restoration, and agricultural habitat improvement.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to increase greater sandhill crane populations in the Central Valley.

LONG-TERM OBJECTIVE: Restore roosting, foraging, and loafing habitat for the greater sandhill crane in the Central Valley.

SHORT-TERM OBJECTIVE: Restore populations to the point where the crane can be removed from the state threatened species list.

RATIONALE: The greater sandhill crane is a spectacular bird that listed as threatened in California and fully protected under the Fish and Game Code. It is a year around resident, nesting in grasslands and wetlands. Much of their nesting habitat has been lost to agricultural conversion and intensive cattle grazing. They will forage in moist cropland and as well as in emergent wetlands, newly planted and sprouting crops, harvested crops, fallow fields, uncultivated areas, canals and irrigation ditch banks. Greater sandhill cranes prefer open areas with shallow fresh water for drinking and bathing. Most winter in the Delta region and require protected roosting habitat near dormant agricultural fields in which they forage.

STAGE 1 EXPECTATIONS: A program will have been implemented to protect wintering (foraging, roosting, and loafing habitats) habitat that already exists and maintain population size. Current populations within the Central Valley will have been monitored.

General targets for greater sandhill crane are to:

- Increase the number of greater sandhill cranes in the Central Valley population,
- Increase the distribution of greater sandhill crane in the Central Valley,
- Decrease disturbance at roosting sites due to waterfowl, pheasant, and rabbit hunters, and
- Increase the number and sizes of "closed areas" on wildlife areas to provide undisturbed areas for the crane.

General programmatic actions to help reach the targets include:

- Protect existing habitats and restore additional suitable seasonal and fresh emergent wetlands grasslands, riparian woodlands, fallow fields, and harvested fields,
- Increase the number of duck clubs that retain water after the waterfowl season ends, and
- Improve agricultural land management to reduce disturbance caused by human activities.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ WESTERN YELLOW-BILLED CUCKOO

INTRODUCTION

The western yellow-billed cuckoo is associated with mixed riparian and cottonwood forests. This species has been eliminated from the Bay-Delta. Elsewhere, the population and range of this species have declined primarily as a result of the loss or degradation of extensive, mature and successional riparian cottonwood forests. The loss of habitat and declining condition of the species' population have warranted its listing as endangered under the California Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of flood control and bank protection projects, which resulted in the direct loss of riparian forests and reduced or eliminated the processes that create and maintain floodplains that support riparian forests, and reclamation of riparian forests for agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

Historically, the yellow-billed cuckoo commonly occurred from the Mexican border along the coast belt through the San Francisco Bay region as far as Sebastopol, Sonoma County, and through the Sacramento and San Joaquin Valleys. Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abut rivers, backwaters, or seeps. The cuckoo, is limited to some reaches of the Sacramento River, Sanborn Slough in the Butte Sink, and the Feather River. The population of this species is critically low.

Dense, large patches of willow-cottonwood riparian habitat are the preferred nesting habitat for this neotropical migrant. This habitat was once much more common, particularly along the Sacramento and San Joaquin rivers; however, conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat. Other stressors that continue to adversely affect the species are loss of habitat as a result of bank protection projects, mortality associated with non-native nest parasites and predators, and inadvertent drift of some types of herbicides and pesticides into habitat areas.

VISION

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

Protection and restoration of existing and suitable mature riparian forest will be critical to the recovery of the yellow-billed cuckoo. Restoration of riparian habitats in the Sacramento-San Joaquin Delta, Sacramento River, Cottonwood Creek, Colusa Basin, Feather River/Sutter Basin, and American River Basin Ecological Management Zones will help to recover this species by increasing the quality and quantity of its habitat.

Integration with Other Restoration Programs

No program is specifically charged with restoring yellow-billed cuckoo populations. Restoration efforts sponsored by the Upper Sacramento Fish and Riparian Habitat Advisory Council (SB1086) have the potential for benefitting the species. The purpose of riparian habitat planning through the SB1086 program is to preserve remaining riparian habitat and reestablish a continuous riparian ecosystem along the Sacramento River.

Linkage with Other Ecosystem Elements

Restoration and recovery of the yellow-billed cuckoo population of the Central Valley is integrally linked with wetland and riparian habitat restoration, and agricultural habitat improvement.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore yellow-billed cuckoo throughout its historical range in the Central Valley.

Long-Term Objective: Establish breeding populations of western yellow-billed cuckoo in riparian areas throughout the Central Valley.

Short-Term Objective: Restore enough populations to western yellow-billed cuckoo so it can be removed from the list of California endangered species.

Rationale: The yellow-billed cuckoo is listed as an endangered species in California because it has disappeared from most of the riparian areas it once inhabited. The cause of their decline seems too have been loss and alteration of riparian forests, combined with heavy pesticide use in adjacent farmland. Yellow-billed cuckoos have strict habitat requirements for successful breeding, including humid conditions and dense strands of willows and cottonwoods along riverbeds. Yellow-billed cuckoos do not just inhabit old growth trees so reforested areas can be used as successful breeding areas. Limiting pesticide use in the area is needed so there is an ample food supply of insects to feed the young.

Stage 1 Expectations: Existing populations will have been stabilized and any further loss of feeding and nesting habitat will have been prevented. Riparian areas suitable for yellow-billed cuckoo will have been identified and prioritized for restoration and, if necessary, reintroduction of cuckoos.

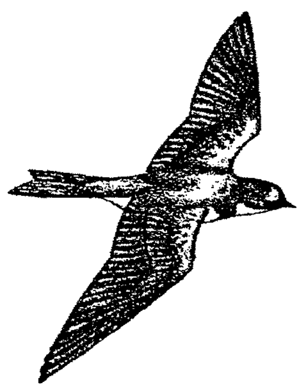
The general target is to increase the population of yellow-billed cuckoo in the Central Valley.

The general programmatic action which will assist in reaching the target is:

- Improve and restore riparian forest habitat suitable for the yellow-billed cuckoo in the Central and Sacramento valleys.

Reference

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



Bank Swallow
Threatened (State)

INTRODUCTION

The bank swallow is associated with riparian and riverine habitats and nests in vertical cliff and bank faces eroded by rivers. The population and range of this species have declined primarily as a result of the loss or degradation of ecosystem processes that maintain suitable nesting substrates along streams and rivers. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the California Endangered Species Act. The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of levees and bank-protection structures on river and stream channel migration. These structures inhibit or prevent the channels' ability to erode its banks and form the nesting cliffs and banks required by the species.

RESOURCE DESCRIPTION

Once an abundant lowland species in California, the bank swallow is now limited to breeding in a small part of its former range. The bank swallow is found in only a small number of ecological units within the Central Valley's ecological management zones that are adjacent to major rivers and their tributaries. The species is not known to occur in the Sacramento-San Joaquin Delta or the Suisun Marsh/North San Francisco Bay Ecological Management Zones. Nesting colonies are found along the Sacramento River from mile 143 to 243, with 40-60 colonies remaining along the upper Sacramento River and approximately 10-20 colonies on the Feather River. A total of 5-10 colonies are located above and below miles 143 on the Sacramento River. Other small colonies are found along other waterways, including: the American River, Thomes Creek, Cache Creek, and the Cosumnes River.

Bank swallows breed in vertical banks or cliffs that are created when streams and rivers erode their banks. Friable soils are an important habitat requirement. Their population is estimated to have been reduced by 50% since 1900. Only a few colonies remain within the State as a result of stream channelization, bank protection, and flood control projects, which have reduced the availability of breeding sites (i.e., cliffs) by constraining rivers from eroding their banks. As much as 75% of the current breeding population in California concentrates along the banks of the Central Valley's streams; 70-80% of remaining breeding habitat is found along a small stretch of the Sacramento River.

The decline of the bank swallow can be attributed primarily to human activities that have changed the ecosystem processes that create and sustain its bank and bluff nesting habitat. Stream meander migration is necessary to maintain, enhance, and create the fine-textured or sandy-type vertical banks or cliffs in which bank swallows dig their nesting holes. Levees and riprapped banks along streams and rivers have impeded the creation of nesting cliffs by preventing channels from following the natural process of erosion, deposition, and meandering. Currently proposed projects for confining channels within the species' nesting range represent the largest threat to maintaining existing bank swallow colonies. The general deterioration or loss of adjacent floodplain habitats (e.g., shaded riverine aquatic, riparian corridors and forests, and open grasslands) has also, although to a lesser degree, contributed to the species' decline.

VISION

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

Protecting existing nesting colonies from activities that could result in their loss or degradation and restoring ecological process of confined channel migration will be critical to the recovery of the bank swallow. The Ecosystem Restoration Program Plan's proposed restoration of stream meander and riparian habitat in the Sacramento River and Butte Basin Ecological Management Zones will help to protect the remaining nesting colonies along the Sacramento and Feather rivers. Protecting the remaining nesting colonies is an essential requirement to preventing the bank swallow population from declining to a point where restoration efforts may offer little help to the species.

Recent studies have shown that most nesting colonies are adjacent to open grasslands. Other colonies live in agricultural lands and riparian and oak forests. Restoring these habitats while protecting and restoring streamside banks and levees would also help maintain or increase existing bank swallow populations.

Restoring Sacramento River meander belts and other confined streams and rivers is an approach that would restore, on a large scale, the processes that create nesting banks. Partially restoring the processes that create nesting sites would be feasible in some areas by modifying flood control and bank stabilization practices to allow channels to migrate and cut banks.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring riparian systems and bank swallow habitat include:

- the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB 1086),
- the Central Valley Improvement Act,
- Anadromous Fish Restoration Program,
- Cosumnes River Preserve,
- Delta Native Fishes Recovery Team,
- Department of Fish and Game Central Valley Salmon and Steelhead Management and Restoration Program,
- Riparian Habitat Joint Venture, and
- California Department of Fish and Game's recovery plan for the bank swallow.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the bank swallow population and its habitat will be integrally linked to restoration of natural stream meander corridors in the rivers of the Central Valley.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to increase the number of breeding colonies of bank swallow in the Central Valley.

Long-Term Objective: Create the conditions that will allow nesting colonies of bank swallows to thrive along the Sacramento and San Joaquin rivers, as well as their major tributaries, especially the Feather River.

Short-Term Objective: Recover sufficient populations so that the bank swallow can be removed from the state list of threatened species.

Rationale: The bank swallow is listed as a state threatened species. It has declined because of the progressive loss of its prime nesting habitat: freshly exposed steep riverbanks, in which it digs burrows. Stabilization of river channels, placement of rip-rap on eroding banks , and other factors which decrease the availability of fresh-cut banks have reduced potential spawning areas throughout the Central Valley. This is a species that will benefit from the creation of "meander zones" in large rivers and other actions that increase the ability of rivers to find their natural channels.

Stage 1 Expectations: An inventory will have been completed of areas of dynamic river bank which meet requirements for bank swallow nesting habitat. Methods will have been developed by which to maintain the creation of fresh-cut banks in these regions to keep the creation of new nesting habitat at least even with the natural deterioration of old habitat.

The general target is to increase the number of bank swallow pair in the Central Valley.

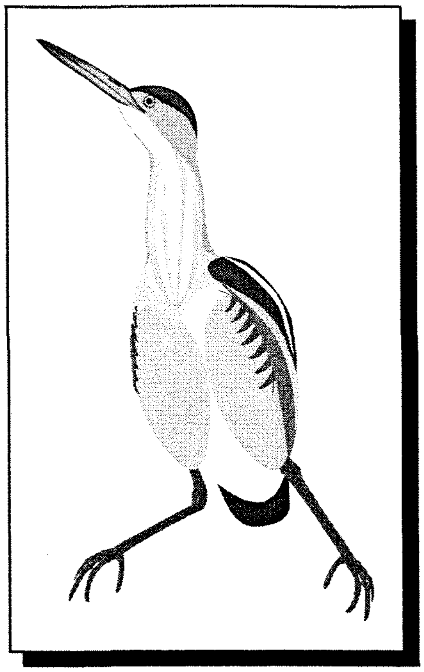
General programmatic actions which will contribute to reaching the target include:

- protect existing nesting colonies along the Sacramento River, Feather River and their tributaries,
- restore natural river meander process, and
- increase and link potential nesting habitat.

Reference

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ WESTERN LEAST BITTERN



INTRODUCTION

This species is considered part of the heron family and is its smallest member. The Western least bittern utilizes freshwater tidal and nontidal marshes and wetlands for foraging and nesting habitat. The population and distribution of this species have declined substantially primarily as a result of reclamation of its wetland habitats and because of its decline is a Department of Fish and Game California "Special Concern Species," is on Audubon's Blue List, and is a U.S. Fish and Wildlife Service "Migratory Nongame Bird of Management Concern." The major factor that limits this resource's contribution to the health of the Delta is related to the adverse effects of historical and current loss or degradation of freshwater wetlands.

RESOURCE DESCRIPTION

The Western least bittern inhabits stands of emergent vegetation within freshwater marshes and wetlands. Shallow water, emergent cover, and substrate with high invertebrate abundance are the most important features of Western least bittern habitat. The bittern is also known to feed on amphibians, fish, crayfish, and small mammals. Much of the Western least bittern's wetland habitats have been destroyed or modified since the mid-180's. This decline in wetlands has reduced population densities of the bitterns throughout their range.

Habitat loss is largely a result of reclamation for agricultural, industrial, and urban uses and water management projects. The total area of those remaining habitats represents only a small percentage of their history level. These habitats continue to be threatened by sedimentation, water diversions, recreational activities, water quality, and land use practices. Insufficient quantity and quality of wetland habitat is the primary factor limiting recovery of the species' population in the estuary. Other factors that can also adversely affect the Western least bittern include disturbance during its breeding period, contaminants, and excessive predation by non-native species.

VISION

The vision for the Western least bittern is to contribute to the recovery of this species to contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Restoring suitable tidal and nontidal freshwater wetlands in the Bay-Delta is critical to the recovery of the species in the estuary. These restored habitats would provide nesting and foraging habitat for the Western least bittern. Although the Western least bittern's range extends into other ecological management zones, the primary focus for habitat restoration will be in the Sacramento-San Joaquin Delta Ecological Management Zone. Efforts outside the Delta to restore freshwater habitats would also benefit the species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Many programs designed to benefit broader groups of fish and wildlife that use or depend on wetlands, sloughs, or adjacent aquatic systems in the Bay-Delta also benefit the Western least bittern. some of these are operated by the following organizations:

- San Francisco Bay Area Wetlands Ecosystem Goals Project,
- California Coastal Conservancy,
- Delta Native Fisheries Recovery Team,
- San Francisco Bay National Wildlife Refuge,
- U.S. Fish and Wildlife Service San Francisco Bay Program, and
- Tidal Wetlands Recovery Plan Ecosystem Wetland Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and recovery of the Western least bittern population of the Bay-Delta is integrally linked with wetland restoration, and water quality (contaminants) improvement.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore the wintering populations of western least bittern in the Central Valley to historic levels.

LONG-TERM OBJECTIVE: Restore the western least bittern to the status as a common overwintering marsh bird in the Central Valley and Delta.

SHORT-TERM OBJECTIVE: Develop wintering habitat for least bitterns by creating "no disturbance" refuges along the central corridor of the Central Valley and Delta for all shore and wading birds.

RATIONALE: The western least bittern, a California Department of Fish and Game Species of Special Concern nests in emergent wetlands of cattails and tules in the upper and lower reaches of the Central Valley but winters in marshlands along the main rivers and in the Delta. Least bitterns were apparently once a common wintering bird in the Central Valley but are now scarce. The loss of wintering habitat as a result of channelization and reclamation of marsh lands along the major rivers and Delta has been a major factor in their decline. Therefore, to increase their overwintering survival, there needs to be an increase in contiguous areas of emergent marsh along both the Sacramento and San Joaquin rivers. Important, but less critical, is the need protect breeding habitats not only in the Central Valley but along the Colorado River and Salton Sea.

STAGE 1 EXPECTATIONS: A thorough review of the status and habitat requirements of western least bittern will have been conducted. Areas within the Central Valley will have been set aside as "no disturbance" refuges to protect wintering habitat of bitterns and other wading and shore birds from human disturbance.

The general target is to increase the number of breeding pairs of Western least bittern in the Bay-Delta.

General programmatic actions to achieve the target for the Western least bittern include:

- restore the natural tidal action of aquatic habitats;
- preserve the remaining populations of Western least bittern, tidal and nontidal freshwater marsh habitats;
- implementation of management programs for small water diversions, disturbance, land use changes, and contaminants would improve habitat, reproductive potential, and recruitment for Western least bitterns;
- protect tidal and nontidal freshwater marshes and wetlands from adverse land uses;
- protect nearby unoccupied suitable habitats areas would help ensure natural expansion area is available;
- protect existing suitable habitats by implementing conservation easement purchasing from willing landowners, or establishing incentive programs to maintain suitable habitat;
- develop and implement alternatives to land management practices on public lands that continue to degrade the quality or inhibit the recovery of Western least bittern habitats; and
- restore, protect, and improve tidal and nontidal wetlands.

REFERENCES

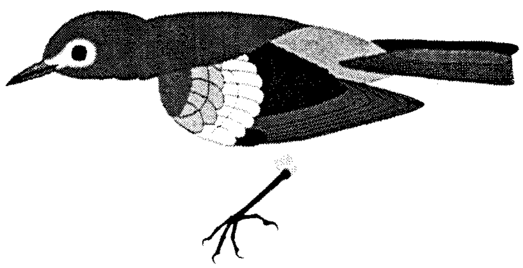
Bent, A.C. 1963. Life histories of North American marsh birds. Dover Publications, Inc., New York. 392 pp.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Tacha, T.C., and C.E. Braun, editors. 1994. Migratory Shore and Upland Game bird Management in North America. International Associations of Fish and Wildlife Agencies, Washington, D.C. 223 pp.

Zeiner, D.C. and W.F. Laudenslayer, Jr., eds. 1990. California's Wildlife, Volume II, Birds, California Statewide Wildlife Habitat Relationships System, State of California, the Resources Agency, Department of Fish and Game, Sacramento, CA. 732 pp.

◆ LEAST BELL'S VIREO



INTRODUCTION

The least Bell's vireo is listed as both a federal and state endangered species. It is a rare summer resident in parts of southern California and northern Baja. It is most likely seen in San Benito and Monterey counties in the canyons and willows and other dense valley-foothill riparian habitat.

The major factors affecting the least bell vireo's population is cowbird parasitism and habitat destruction and degradation.

RESOURCE DESCRIPTION

The least Bell's vireo population in California has declined drastically over the past few decades in both numbers and expanse of the breeding range. The northern range of the population once extended to Chico, California, currently however it is limited to Santa Barbara county. It is estimated that the current population of least Bell's vireo in California is limited to 450 nesting pairs. The decline of the least Bell's vireo can be attributed to two different events that directly affect the population. Nest parasitism by brown-headed cowbirds and the degradation and loss of riparian habitat to support breeding populations through out California.

Nesting occurs from mid-April to July at the edge of riparian thickets or open fields with nesting pairs building at least two nests per territory. The eggs hatch in 14 days and the young fledge from the nest in 11 to 12 days.

VISION

The vision for the Least Bell's vireo is to contribute to the recovery of this State and federally listed endangered species to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. This will be accomplished by increasing the existing breeding range in California to historic levels in the early 1900s. It is believed that increasing the amount of nesting habitat will spread out current breeding pairs and reduce the level of brown-headed cowbird nest parasitism and reduce nesting failures.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 program),
- San Joaquin River Management Program, and

- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the least Bell's vireo and its riparian habitat is linked to restoring healthy and diverse riparian communities throughout California.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore least Bell's vireo to representative habitats throughout its former range.

LONG-TERM OBJECTIVE: Restore populations of least Bell's vireo to riparian areas throughout California.

SHORT-TERM OBJECTIVE: Recover least Bell's vireo populations to the point where it can be removed from state and federal endangered species lists.

RATIONALE: The least Bell's vireo was once quite common throughout the coastal and Sacramento and San Joaquin Valleys. The current distribution of least Bell's vireo in California is in isolated pockets in Southern California and along the Colorado River. Currently, the least Bell's vireo is listed as an endangered species by both the state and federal governments due to its rapid decline in population and distribution. The least Bell's vireo's decline has been attributed to degradation and destruction of nesting habitat among riparian thickets. Nest parasitism by cowbirds, a side effect of the narrowing and isolation of riparian habitats, has also contributed to the decline of least Bell's vireo.

STAGE 1 EXPECTATIONS: The current distribution and population of least Bell's vireo within California will have been determined and strategies for reintroducing it into central California will have been completed. Riparian restoration programs will have included the idea of recreating habitat for this bird.

The target would be to increase the number of nesting pairs and their distribution within historic ranges.

Least Bell's vireo will benefit from the following actions and restoration activities:

- Reduce the amount of brood parasitism by brown-headed cowbirds on California yellow warblers.
- Increase the amount of riparian habitat throughout California.
- Improve the quality of existing degraded riparian habitat.

REFERENCES

Bent, A.C. 1965. Life Histories of North American Wagtails, Shrikes, Vireos, and the allies. New York: Dover Publications, Inc., pp. 265-268

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Warner, R.E., and K.M. 1984. Hendrix. California Riparian Systems. Berkeley: University of California Press. pg. 605.

Zeiner, D.C., ed., et al. 1990. California's Wildlife. Sacramento: California Department of Fish and Game. pp. 568, 652.

◆ CALIFORNIA YELLOW WARBLER

INTRODUCTION

As a neotropical migrant, the California yellow warbler is present in California from April to October. During these months the California yellow warbler primarily utilizes underbrush of open deciduous riparian woodlands for home territories, foraging areas and nesting sites. Recently, breeding populations in valley areas have been declining due to destruction of riparian habitats as well as nest parasitism by the brown-headed cowbirds. Due to a consistent, gradual decline of breeding populations in California, the California yellow warbler has been listed as a California Species of Special Concern.

RESOURCE DESCRIPTION

California yellow warblers summer throughout northern California and in the coastal regions of southern California. In recent decades there has been a marked decline in the breeding population of California yellow warblers in the San Joaquin and Sacramento valleys. Once common in these areas, the California yellow warbler has been displaced due to loss of riparian habitat caused by agricultural and urban development.

Another cause of breeding population decline is brood parasitism by brown-headed cowbirds. Brood parasitism by cowbirds has been documented to lower the reproductive success of warblers. In areas where cowbird populations are high the population numbers of California yellow warblers are very low despite the quality of habitat, therefore, decline of warbler populations due to parasitism can be attributed to loss of the birds' common habitat. As habitat decreases both birds must use more common habitat for foraging and territory creating a situation where California yellow warblers are more accessible and therefore more easily parasitized by brown-headed cowbirds.

VISION

The vision for the California yellow warbler is to contribute to the recovery of this California species of special concern. This will be accomplished by increasing the size and quality of riparian habitats in California, especially in those areas with high populations of brown-headed cowbirds. By increasing the area of riparian habitats, the California yellow warbler and the brown-headed cowbird populations will not be as compacted. Greater areas of riparian habitat and lowering population densities of yellow warblers and cowbirds will allow for higher population numbers of passerine species that the cowbird can also parasitize. With more habitat and greater numbers of those species that the cowbird can parasitize, the rate at which California yellow warblers are being parasitized should decrease. Furthermore, by creating more riparian habitat and improving the quality of existing habitat, a more diverse and sustainable riparian community will be created.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 program),

- San Joaquin River Management Program, and
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the California yellow warbler and its riparian habitat is linked to restoring healthy and diverse riparian communities throughout California.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for the California yellow warbler is to restore and protect habitats used by neotropical migrant birds for breeding and foraging in the Central Valley.

LONG-TERM OBJECTIVES: Substantially improve breeding and migration habitats for all neotropical migrant birds to increase their rates of reproduction and survival.

SHORT-TERM OBJECTIVES: Maintain breeding populations at present levels and develop restoration projects that will benefit migrating individuals.

RATIONALE: Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.

STAGE 1 EXPECTATIONS: A "master plan" will have been developed for the conservation of neotropical migrants in the Bay-Delta watershed that includes status reports and habitat requirements for all species. This information will have been used to integrate neotropical migrant conservation into various restoration projects or to develop restoration projects specifically aimed at improving migration and breeding habitat for selected members of this group.

The following targets will aid in achieving the implementation objective:

- Increase breeding numbers of California yellow warblers throughout California.
- Reduce the amount of brood parasitism by brown-headed cowbirds on California yellow warblers.

The following programmatic actions will aid in achieving the target recommendations:

- Increase the amount of riparian habitat throughout California
- Improve the quality of disturbed riparian habitat

REFERENCES

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Warner, R.E., and K.M. Hendrix. 1984. California Riparian Systems. Berkeley: University of California Press. pg. 605.

Zeiner, D.C., ed., et al. 1990. California's Wildlife. Sacramento: California Department of Fish and Game. pp. 568, 652.

◆ LITTLE WILLOW FLYCATCHER

INTRODUCTION

The little willow flycatcher is one of many neotropical migrants which is a relatively widespread summer resident in wooded settings near water and open areas. It prefers dense shrub cover to timber, especially willow thickets. It is dependent upon the flora of California to forage and reproduce, typically from about May until September. The rest of the year is normally spent in Central America and South America.

Efforts to protect and restore the habitat needed to attain a healthy state for this species will not only require the restoration of a number of ecological process and functions, but will also require the combined efforts of federal, state, private organizations, and landowners to provide sufficient restored and improved habitat for the survival of this species.

RESOURCE DESCRIPTION

Habitats used by this species include forested woodland, riparian, unforested lowlands, grasslands, montane riparian habitats, and shrub habitats near open areas or water. These habitats have been and continue to be lost due to the alteration of habitat by agricultural conversions and urban land development.

VISION

The vision for the little willow flycatcher is to contribute to the recovery of this State-listed endangered species. Recovery of the little willow flycatcher would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta. The vision will be attained by improving nesting and foraging habitat in the Central Valley and foothills of the State through the restoration of natural processes and functions which will help lead to sustained healthy populations. Restoring broad bands of dense willow-cottonwood riparian and riparian scrub habitat will contribute to sustaining improved ecosystem processes and functions to restore the health of aquatic and terrestrial resources in and dependent on the riverine and riparian systems. While attaining this vision, habitat improvements will support an increased level of production of insects and other macro invertebrates which are important elements of the food web for fish and wildlife including rearing chinook salmon.

The restored riparian habitat and natural processes in the relevant ecological management zones will improve river and channel water temperatures, and support stream meander and flood processes that will all contribute to improving the ecological health of the aquatic resources in and dependent on the Bay-Delta. This vision is congruent with CALFED's vision to restore the Bay-Delta ecosystem to a healthy state for listed fish and wildlife.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Examples of related restoration programs include the following:

- Central Valley Project Improvement Act;
- Cache Creek Corridor Restoration Plan;
- Cosumnes River Preserve;
- Riparian Habitat Joint Venture;
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 Program);
- San Joaquin River Management Program; and,
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

All these programs will play important and integral roles, coordinated through CALFED, to achieve the vision for the little willow flycatcher.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Efforts to protect and restore the habitat needed to attain a healthy state for this species will not only require the restoration of a number of ecological process and functions, but will also require the combined efforts of federal, state, private organizations, and landowners to provide sufficient restored and improved habitat for the survival of this species.

ECOSYSTEM PROCESSES. The primary ecological processes that help recruit neotropical migrants include nutrient inputs and vegetation succession. These two processes supply the food and cover components required such as the invertebrates which invariably become prey items. These processes are currently influenced by land uses and other human disturbances and their restoration is vital to improve ecological health of the Bay-Delta. Through the restoration of several ecological process including stream meander belts, vegetation succession, overbank flooding, floodplain inundation, and secondary production the essential elements needed by this species will be restored to improve the food web as well as provide optimum breeding and roosting habitat.

HABITAT. The primary threat to neotropical migratory birds has been, and continues to be, loss and alteration of habitat by agricultural conversion (plowing and leveling of land), river channelization, dam construction, drainage and pipeline construction. The little willow flycatcher and other species' nests are parasitized by brown-headed cowbirds when adequate vegetative cover is not available. Species that are deep forest nesters have been the most adversely affected by habitat fragmentation.

Restoration of habitats used by neotropical birds such as riparian, perennial grasslands, and oak woodlands, in conjunction with restoring related ecosystem functions and processes, will be the primary approach used to achieve CALFED's vision. Large scale restoration of nesting habitat will help reduce nest parasitism and predation.

STRESSORS. Stressors at one time or another contribute to reduced reproductive success of neotropical avian species. Land use, human disturbance, elevated levels of competition and predation by exotic species, wildfire, and contaminants are all stressors that affect the ecological health of this species. For instance, insect populations that form the base of the food web can be severely impacted by pesticide drift from nearby agricultural lands.

Reducing the effects of stressors will be a major factor in preventing further loss of existing nesting and foraging habitat. Where consistent with flood control needs, modification of levees and bank protection measures which would otherwise inhibit the natural establishment of vegetation succession will allow areas to naturally change over time. By controlling human disturbance in nesting areas and improving water management a number of species will benefit. The implementation of fire breaks and other types of buffers would be useful in preventing the adverse impacts of wildfires.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore little willow flycatcher populations to habitats throughout its former range in Central California.

LONG-TERM OBJECTIVE: Restore little willow flycatcher to abundance throughout its native range by protecting and restoring contiguous expanses of montane riparian habitats in the Sierra Nevada and Cascade ranges.

SHORT-TERM OBJECTIVE: Have enough self-sustaining populations of little willow flycatcher so that the species can be removed from the state list of endangered species.

RATIONALE: The little willow flycatcher is a neotropical migrant bird that is listed by the state as endangered and by federal government as a species of concern. Little willow flycatchers nest and roost in montane riparian habitats in the Sierra Nevada and Cascade ranges consisting of dense willow thickets. Lower exposed perches provide singing and hunting platforms. In areas that are heavily grazed by cattle little willow flycatchers are absent from areas that appear to provide suitable habitat. Restoration of this bird will presumably require restoring large expanses of riparian thickets within the habitat ranges of the little willow flycatcher, in part by excluding cattle grazing.

STAGE 1 EXPECTATIONS: The range within California of the little willow flycatcher will have been determined and measures to protect and enhance remaining habitat areas will have been implemented.

The short-term target for restoring the neotropical migratory bird little willow flycatcher is to restore 3,000 to 5,000 acres of riparian habitat in the Delta Ecological Management Zone; 2,000 to 3,000 acres in the Sacramento River Ecological Management Zone; and, 3,000 to 5,000 acres in the San Joaquin Ecological Management Zone. The actions proposed to achieve this target will be implemented in conjunction with actions taken by CALFED members and cooperating agencies to restore aquatic resources in and dependent on the Bay-Delta

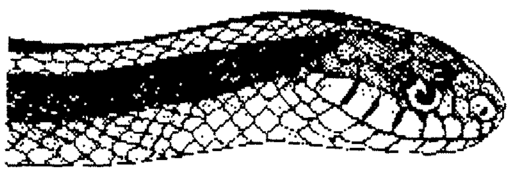
The long-term target for restoring the neotropical migratory bird guild is to restore 5,000 to 7,000 acres of riparian habitat in the Delta Ecological Management Zone; 3,000 to 5,000 acres in the Sacramento River Ecological Management Zone; and, 5,000 to 7,000 acres in the San Joaquin Ecological Management Zone. The following are potential actions that if implemented by themselves or in combination would help achieve the short and long-term targets:

- Set back levees to create hydrologic conditions necessary for seasonal flooding and vegetation succession.
- Establish programs for landowners that provide incentives for the establishment and maintenance of shaded riverine aquatic and oak woodland habitat.
- Modify, where consistent with flood control objectives, vegetation management practices along levees to allow for the natural reestablishment of shaded riverine aquatic vegetation.
- Develop and implement alternatives to land management practices on public lands that now continue to degrade woodland and shaded riverine aquatic habitat quality or inhibit recovery and provide incentives to landowners for implementing more desirable land use practices.
- Protect 50 percent of existing habitat areas from potential future degradation through acquisition of conservation easements or in-fee title.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ GIANT GARTER SNAKE



INTRODUCTION

The giant garter snake is a species that lives in the Central Valley of California. It inhabits sloughs, low-gradient streams, marshes, ponds, small lakes, agricultural wetlands, and other waterways, where it feeds on small fish and frogs during the active season. Populations of giant garter snake are found throughout much of the ERP study area including: the Feather River/Sutter Basin, Colusa Basin, Butte Basin, Yolo Basin, East Side Delta Tributaries, American River Basin, and portions of the Sacramento-San Joaquin Delta Ecological Management Zones. The status of giant garter snake in the San Joaquin Valley is unknown. The distribution and population of these species has declined substantially, primarily as a result of the loss or degradation of wetlands and nearby uplands. The loss of habitat and declining condition of these species' populations has warranted the listing of the giant garter snake as threatened under the State and federal Endangered Species Acts.

Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of aquatic, wetland, riparian, and adjacent upland habitats to other land uses and land use practices that degrade the value of otherwise suitable habitat areas.

RESOURCE DESCRIPTION

Historic habitat areas used by these species have been substantially reduced as a result of converting land for agriculture, urban, or industrial uses or degraded as a result of ongoing land-use practices. Remaining habitat areas, such as ponds, rivers, streams, lakes, marshes, and irrigation ditches, are largely fragmented. Associated uplands, used for reproduction and hibernation, are largely unavailable. Upland habitats adjacent to aquatic habitats are now mostly isolated in small riparian bands along the tributaries that supply water to the Sacramento and San Joaquin Rivers and along canals with small levees.

Because much of the original habitat used by these species has been lost, irrigation canals and ditches (especially canals with nearby vegetation) now provide important replacement habitat for these species. Rice farming makes up a significant portion of the agricultural activity in the Sacramento Valley, and drainage ditches associated with rice farming practices provide much of this surrogate habitat. Adjacent breeding and hibernating cover, however, is often limiting for these species.

Other factors that limit these species populations include:

- some agricultural practices (e.g., discing, mowing, burning, and applying herbicides and rodenticides) that degrade habitat or cause mortality;
- introduced large predatory fish that prey on juveniles and injure adults; and
- mortality caused by flooding of hibernation sites during heavy rains, floods, or for waterfowl.

VISION

The vision for the giant garter snake is to contribute to the recovery of this State- and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The ERPP's proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration projects to improve upland and wetland agriculture and seasonal wetland and riparian habitats would be closely linked to the restoration of these species. The American River Basin is ecologically important because it contains the most stable populations of giant garter snakes. The Biological Resources Division of the USGS is presently studying stable populations of giant garter snakes that occur outside the American River Basin. These include populations in the Colusa Basin (Sacramento and Colusa National Wildlife Areas), the Badger Creed areas of the Cosumnes River Preserve, and the Gilsizer Slough area of the Sutter Basin. Restoration and agricultural improvements will be developed for implementation both north and south of the Delta.

Efforts to recover giant garter snake populations will involve cooperation and support from other established programs aimed at restoring habitat and populations.

Wetland restoration and management programs that would improve habitat for these species include the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, the Wildlife Conservation Board's Inland Wetlands Conservation Program, restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and ongoing management of State and federal wildlife refuges and private duck clubs. Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including DFG, California Department of Water Resources, USFWS, U.S. Army Corps of Engineers, and the Delta Protection Commission. USFWS is also preparing a recovery plan for the giant garter snake that will establish population recovery goals.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, stream meanders, and seasonal pools to develop that assist in the recovery of their populations elsewhere in their historic ranges.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore populations of giant garter snake to its historical range.

LONG-TERM OBJECTIVE: Establish or restore populations of giant garter snake in restored marshlands through out its original range.

SHORT-TERM OBJECTIVE: Maintain present populations with no further declines in size by ensuring that waterways known to being used by giant garter snakes have water in them year round.

RATIONALE: The giant garter snake is listed by both state and federal governments as a threatened species. Most of the original giant garter snake habitat, freshwater marshes, has been lost to agriculture. This snake resides in marsh habitat where there are pools and sloughs that exist year round to provide the frogs and invertebrates on which they feed. This snake survives today because small numbers live in rice fields and along irrigation ditches. Survival of the species, however, is likely to depend upon increasing its natural habitat through marsh restoration combined with special protection measures on the agricultural land it currently inhabits.

STAGE 1 EXPECTATIONS: Existing natural habitats that have available water all year will have been maintained, and key habitats in agricultural areas identified for special management. Sites for freshwater marsh restoration will have been identified and a restoration program established.

The general target is to increase the population size of giant garter snakes.

General programmatic actions to protect occupied habitat areas include the following:

- Implement a preservation plan to protect these areas from adverse effects associated with human encroachment and recreation,

- Create canals, side channels, and back-flow pools containing emergent vegetation within the South, East, and North Delta Ecological Units of the Sacramento-San Joaquin Delta Ecological Management Zone to provide forage habitat and escape cover, and create dispersal corridors by linking habitat areas.

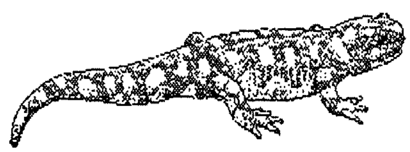
- Restore suitable adjacent upland habitat or modify land use practices to render existing uplands as suitable habitat and reestablish connectivity between wetland and upland habitat areas, provide nest and hibernation sites, and provide refuge habitat during floods.

- Create buffer zones where none currently exist to improve habitat value.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ CALIFORNIA TIGER SALAMANDER



INTRODUCTION

The California tiger salamander occur throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

RESOURCE DESCRIPTION

California tiger salamander populations have declined primarily as a result of habitat loss or degradation and competition or predation from non-native species. The abundance from population to population is unknown but is influenced by the size and quality of individual habitat patches within the fragmented pockets that the species are known to inhabit.

Tiger salamanders typically inhabit scattered ponds, intermittent streams, or vernal pools that are associated with grassland-oak woodland habitat below Elevation 1500. Vernal pools covering more than 250 square feet, with fairly turbid water, provide optimal habitats. Most surface movements of the western spadefoot and California tiger salamander, including breeding activity, are associated with the onset of fall and spring rains that fill traditional breeding ponds. Warm days followed by rains or high humidity levels at night trigger reproductive and foraging activities and adults of these species sometimes appear in large numbers.

The greatest threat to the continued existence of the tiger salamander is habitat loss and competition by non-native species. Habitat loss is a result of increased urbanization and conversion of native grasslands to agriculture. The spadefoot and salamander may be found in high densities in isolated areas but adjacent breeding habitat is increasingly being converted for other uses.

Introduction of predatory fish and bullfrogs in known breeding ponds is also an important factor attributed to the decline of these species. Juvenile and adult bullfrogs can prey on larvae and terrestrial forms of these native species. Other important stressors that affect the spadefoot and salamander are rodent control activities, which reduce the availability of summer estivation (burrowing) sites. The use of rodent burrows may be more important for the California tiger salamander than for western spadefoot. Research on the extent and necessity of burrow use by both species would be valuable. In addition to rodent control activities, development of roads between breeding ponds and terrestrial habitats, resulting in deaths from automobiles during the species' migrations, has also contributed to the decline.

Vision

The vision for the California tiger salamander is to maintain existing populations of this Federal candidate species in the Bay-Delta. Achieving this vision will 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.

Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the California tiger salamander. Restoration of vernal pool habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and vernal pools to develop that will assist in the recovery of populations of these species elsewhere in their range.

Implementing guidelines developed by DFG for vegetation, grazing, traffic, and pest management would increase these species' reproductive success and reduce the level of mortality from unnatural sources. These guidelines could be implemented through cooperative agreements with land management agencies and organizations and development and implementation of incentive programs to encourage land use practices that improve habitat conditions for and reduce mortality on these species.

Integration with Other Restoration Programs

Wetland restoration and management programs which contribute to restoration or maintenance of vernal pools that would improve habitat for the California tiger salamander include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, and
- the Wildlife Conservation Board's Inland Wetlands Conservation Program.

Linkage with Other Ecosystem Elements

Restoration of the salamander populations is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore California tiger salamander to representative habitats throughout its range.

Long-Term Objective: Establish refuges for California tiger salamander throughout its range that will maintain its present genetic and ecological diversity.

Short-Term Objective: Identify and protect remaining California tiger salamander populations in the Bay-Delta watershed.

Rationale: California tiger salamander populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat containing rodent burrows in which they can over-summer. Patches of suitable habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local conditions. Long-term survival of these diverse populations depends on numerous protected areas containing both breeding ponds and upland habitats.

STAGE 1 EXPECTATIONS: A thorough survey of tiger salamander populations in the Bay-Delta region will have been completed and actions taken to protect remaining populations in counties bordering the Bay-Delta system.

The general target for California tiger salamander is to increase the population size.

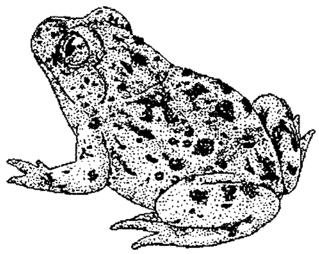
General programmatic actions that will assist in reaching the targets include:

- protecting existing habitats from urbanization and conversion to irrigated pasture,
- improve degraded habitats,
- increase vernal pool habitats in the Central Valley;
- reduce the use of herbicides that adversely affect California tiger salamander and its habitats;
- reduce mowing, to the extent feasible, to control vegetation and livestock grazing near occupied seasonal wetlands from October to March;
- reduce traffic, where feasible, on roads crossed by these species during migration periods;
- develop alternative control measures to replace the use fumigants to control rodents; and
- drain waterways used by the spadefoot and salamander during the periods when these species are dormant could be beneficial by reducing populations of non-native predatory fish and bullfrogs.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ WESTERN SPADEFOOT TOAD



INTRODUCTION

The western spadefoot occurs throughout much of the Central Valley, San Francisco Bay, and coast ranges and foothills below 3,000 feet, as well as along the coast in the southern portion of the State. Declining populations have warranted their designation as species of special concern and species of concern by the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service, respectively. Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of seasonal wetlands and adjacent uplands to other land uses and excessive mortality resulting from introduction of non-native predators and some land use practices.

RESOURCE DESCRIPTION

Western spadefoot toad populations have declined primarily as a result of habitat loss or degradation and competition or predation from non-native species. The abundance from population to population is unknown but is influenced by the size and quality of individual habitat patches within the fragmented pockets that the species are known to inhabit.

The western spadefoot toad is primarily a lowlands species, frequenting washes, river floodplains, alluvial fans, playas, and alkali flats, but also ranges into the foothills and mountain valleys. Vernal pools covering more than 250 square feet, with fairly turbid water, provide optimal habitats. Most surface movements of the western spadefoot, including breeding activity, are associated with the onset of fall and spring rains that fill traditional breeding ponds. Warm days followed by rains or high humidity levels at night trigger reproductive and foraging activities and adults of these species sometimes appear in large numbers.

The greatest threat to the continued existence of the toad is habitat loss and competition by non-native species. Habitat loss is a result of increased urbanization and conversion of native grasslands to agriculture. The spadefoot may be found in high densities in isolated areas but adjacent breeding habitat is increasingly being converted for other uses.

Introduction of predatory fish and bullfrogs in known breeding ponds is also an important factor attributed to the decline of these species. Juvenile and adult bullfrogs can prey on larvae and terrestrial forms of these native species. Other important stressors that affect the spadefoot are rodent control activities, which reduce the availability of summer estivation (burrowing) sites. The use of rodent burrows may be more important for the California tiger salamander than for western spadefoot because spadefoots can build their own burrows and also use other appropriate niches. Research on the extent and necessity of burrow use by both species would be valuable. In addition to rodent control activities, development of roads between breeding ponds and terrestrial habitats, resulting in deaths from automobiles during the species' migrations, has also contributed to the decline.

VISION

The vision for the western spadefoot toad is to maintain this California species of special concern in the Bay-Delta. Achieving this vision will 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.

Protecting and restoring existing and additional suitable aquatic, wetland, and floodplain habitats and reducing the effect of other factors that can suppress breeding success will be critical to the recovery of the western spadefoot. Restoration of vernal pool habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help recover this species by increasing habitat quality and area. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and vernal pools to develop that will assist in the recovery of spadefoot populations.

Implementing guidelines developed by DFG for vegetation, grazing, traffic, and pest management would increase these species' reproductive success and reduce the level of mortality from unnatural sources. These guidelines could be implemented through cooperative agreements with land management agencies and organizations and development and implementation of incentive programs to encourage land use practices that improve habitat conditions for and reduce mortality on these species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Wetland restoration and management programs which contribute to restoration or maintenance of vernal pools that would improve habitat for the western spadefoot include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, and
- the Wildlife Conservation Board's Inland Wetlands Conservation Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the toad and salamander populations is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore spadefoot populations to representative habitats throughout its range.

LONG-TERM OBJECTIVE: Establish refuges for California spadefoot toad throughout its range.

SHORT-TERM OBJECTIVE: Identify and protect remaining spadefoot toad populations in the Bay-Delta watershed.

RATIONALE: Spadefoot toad populations are disappearing rapidly in the Bay-Delta watershed because of habitat alteration, especially urban development, and introductions of non-native fishes into their breeding ponds. They require fish-free breeding ponds next to upland habitat in which they can burrow for over summering. These habitats are naturally somewhat isolated from one another, promoting genetic diversity within the species which presumably reflects adaptations to local habitat conditions. Long-term survival of these diverse populations depends on protected areas containing both breeding ponds and upland habitats.

STAGE 1 EXPECTATIONS: A thorough survey of spadefoot toad populations in the Bay-Delta watershed will have been completed and actions taken to protect remaining populations in counties bordering the Bay-Delta system.

The general target for western spadefoot is to increase the population size of each species.

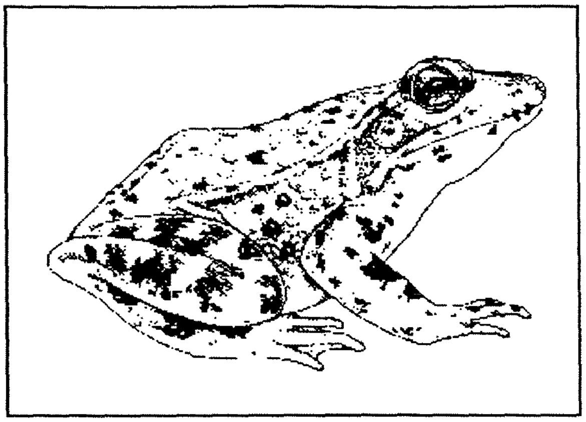
General programmatic actions that will assist in reaching the targets include:

- protecting existing habitats from urbanization and conversion to irrigated pasture,
- improve degraded habitats,
- increase vernal pool habitats in the Central Valley;
- reduce the use of herbicides that adversely affect western spadefoot and California tiger salamander and their habitats;
- reduce mowing, to the extent feasible, to control vegetation and livestock grazing near occupied seasonal wetlands from October to March;
- reduce traffic, where feasible, on roads crossed by these species during migration periods;
- develop alternative control measures to replace the use fumigants to control rodents; and
- drain waterways used by the spadefoot and salamander during the periods when these species are dormant could be beneficial by reducing populations of non-native predatory fish and bullfrogs.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ CALIFORNIA RED-LEGGED FROG



INTRODUCTION

The California red-legged frog is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. The distribution and population of this species has declined substantially, primarily as a result of habitat loss or degradation and excessive predation. The loss of habitat and declining condition of the species' population have warranted its listing as threatened under the federal Endangered Species Act and a Species of Special Concern by DFG. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of the loss or degradation of critical wetland and riparian habitats and the introduction of non-native predators.

RESOURCE DESCRIPTION

The California red-legged frog historically occurred throughout the Central Valley and now exists only in small isolated populations scattered throughout its historical range. Its current range is chiefly west of the Cascade-Sierra crest from Redding in Shasta County, California, to northwest Baja California. Small populations still exist in the Central Valley and Sierra Nevada, but numbers appear to be declining in both places. Reasons for the decline of this species include the degradation and loss of critical wetland breeding and adjacent terrestrial habitats.

Human-caused stressors add to the species decline. In occupied species-areas, some agricultural practices, such as discing, mowing, burning, and pest control, result in direct mortality or degradation of habitat. The introduction of non-native fish, bullfrogs, and crayfish, all of which prey on larval, juvenile, or adult red-legged frogs increases the threat to the survival of this species. Some introduced predatory fish are large enough to injure some adults and eat juvenile red-legged frogs. The only reasonably protected population in the Central Valley is the Corral Hollow Ecological Reserve. However, this reserve is currently threatened by siltation from off-road vehicle use and livestock grazing.

VISION

The vision for the California red-legged frog is to maintain populations of this federally listed threatened species. Achieving this vision will contribute to the overall species richness and diversity and to reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable aquatic, wetland, and riparian habitats and reducing mortality from non-native predators will be critical to achieving recovery of the California red-legged frog. Restoration of aquatic, wetland, and riparian habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of this species by increasing habitat quality and area. Establishing emergent vegetation (*Salix* sp., *Typha* sp., and *Scirpus* spp.) in canals, side channels, and backflow pools would provide breeding habitat, forage and escape cover for the California red-legged frog. Establishing these habitats in each ecological unit of the Sacramento-San Joaquin Delta Ecological Management Zone would create migration corridors by linking habitat areas.

Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, stream meanderings, and seasonal pools to develop that will assist in the recovery of population elsewhere in the red-legged frog's range. Restoring optimal red-legged frog habitat will also reduce its susceptibility to predation and will reduce suitable habitat conditions for non-native predators.

California red-legged frog cannot be adequately restored to the Central Valley or the foothill areas without re-introduction. Recovery strategies should focus on property acquisition to preserve areas where the frog is present and to conduct detailed surveys in the western valley and Sierran foothills for remnant populations. Bullfrog predation is a major concern and focused predator management should be developed and implemented on a case-by-case basis in areas identified as important to frog populations. Reintroductions on State and Federal refuge lands with a predator management scheme should be considered.

Integration with Other Restoration Programs

Wetland restoration and management programs that would improve habitat for the California red-legged frog include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and
- ongoing management of State and federal wildlife refuges and private duck clubs.

Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland aquatic habitats including:

- California Department of Fish and Game,
- California Department of Water Resources,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

Linkage with Other Ecosystem Elements

Restoration of the red-legged frog populations is integrally linked with restoration of riparian and wetland habitat in the Central Valley.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective is to restore California red-legged frog to representative habitats throughout its former range.

Long-Term Objective: Develop refuges in habitats throughout its former range that will each maintain 100+ breeding pairs of red-legged frogs, established from reintroductions.

SHORT-TERM OBJECTIVE: Locate and protect any remaining populations of red-legged frogs in the Bay-Delta watershed.

RATIONALE: Red-legged frogs are virtually extinct in the region, with just a handful of tenuous populations remaining in the Central Valley and bay region (none near the estuary). Their inability to recover from a presumed major population crash in the 19th century (due to overexploitation) has been the result of a combination of factors (in approximate order of importance): (1) predation and competition from introduced bullfrogs and fishes; (2) habitat loss, (3) pesticides and other toxins, (4) disease, and (5) other factors. Because of the poor condition of the few remaining frog populations and the continued existence of major causes of their decline, this objective may not be achievable in either the short or long term. Any refuge developed for this species will require continuous intensive management and development of experimental barriers to exclude non-native species. The long-term goal will be achievable only if the refuge experiments work and are cost-effective (e.g., it might be better to put dollars into restoring areas outside the region where red-legged frogs still maintain populations naturally). Refuges for red-legged frogs will benefit other at-risk species as well, such as giant garter snakes, Pacific pond turtles, and tiger salamanders.

STAGE 1 EXPECTATIONS: All red-legged frogs populations in the region will have been located and protective measures taken where feasible. At least one experimental population will have been established.

The general target is to increase the population size and distribution of the red-legged frog.

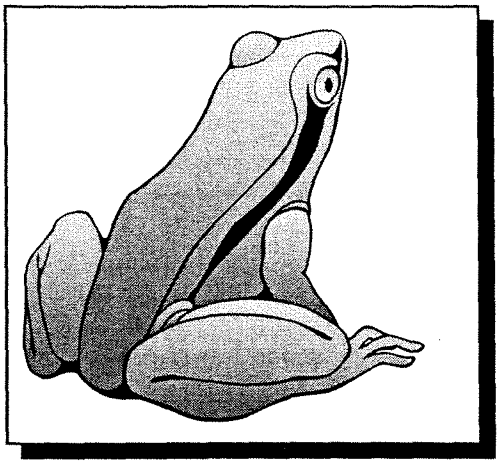
General programmatic actions to assist in reaching the target include:

- acquire land to preserve areas where frogs are present,
- develop predator (bullfrog) control programs,
- increase wetland and riparian habitats in the Central Valley;
- reduce the use of herbicides that adversely affect red-legged frog and their habitats; and
- use fumigants to control rodents from only October to March in known occupied habitats.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ NATIVE ANURAN AMPHIBIANS



INTRODUCTION

Anuran amphibians include tailed frogs, spadefoot toads, true toads, treefrogs, and true frogs. There are several species that have been listed in California that could be further impacted by CALFED, including the Yosemite toad, western spadefoot, California red-legged frog, Cascades frog, foothill yellow-legged frog, and mountain yellow-legged frog. These species have been impacted by habitat loss as well as by predation by introduced species. For more specific information on western spadefoot and California red-legged frogs refer to their previously presented sections.

RESOURCE DESCRIPTION

The species that may be affected by CALFED occur in different areas in the valley and watersheds of California and there are differing resource requirements for each species. Habitat requirements are varied including vernal pools, grassland, valley-foothill hardwood woodlands, montane wet meadows, and hardwood-conifer seasonal ponds associated with lodgepole pine, ponderosa pine, and subalpine conifer forests, quiet pools in marshes, stock ponds, mountain lakes and streams, valley-foothill riparian, coastal scrub, and mixed chaparral.

Water is essential for the anurans, yellow-legged frogs prefer partially shaded, moving water that stays cool all year. Stream alteration such as dams, clearing and destruction of natural water courses, and ponds increases ambient water temperatures and makes habitat unsuitable. Cascades frogs need standing water for reproduction and hibernate at the bottom of mountain lakes and ponds during the winter. Optimal habitat for Yosemite toads is mountain ponds and wet meadows where they lay their eggs in still water. During inactive periods they will hide in rodent burrows or move to adjacent forests. When disturbed they will often hop into nearby water.

Reproductive methods and habitat selection for spawning varies among the species. Foothill and mountain yellow-legged frogs lay egg masses on cobble sized gravel or rocks. Foothill yellow-legged frogs need cool water for proper development. Mountain yellow-legged frogs do not start reproduction until the ice melts in the lakes and streams and tadpoles may need up to two over-wintering periods to complete their development. The Cascades frog deposits eggs in clear shallow water with gravelly, sandy or silty bottoms, while the Yosemite toad lays its eggs in shallow, quiet pools. Most eat terrestrial and aquatic insects, worms, fish, smaller amphibians, and other tadpoles.

The populations have declined due to habitat loss and predation by bullfrogs and centrarchids. Introduction of bullfrogs and centrarchids to many inland streams and ponds has resulted in predation of all life stages of the native anurans. They have not been found to coexist with bullfrogs without bullfrogs becoming the prevailing species.

VISION

The vision for native anuran amphibians is to contribute to their restoration. This will be accomplished by stopping habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find subsequent populations is essential to gauge the health of the species. To stabilize and increase anuran populations, non-native predator species should be eliminated from historical habitat ranges. Increasing suitable habitat and having clean water supplies that fit the needs for the different species is essential. It will be essential to reintroduce anurans to a reclaimed area after habitat requirements are met.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration and management programs that could benefit anuran populations and that would improve habitat include:

- the Agricultural Stabilization and Conservation Service's Wetland Reserve Program,
- the Wildlife Conservation Board's Inland Wetlands Conservation Program,
- restoration programs administered by Ducks Unlimited and the California Waterfowl Association,
- on going management of State and Federal wildlife refuges and private duck clubs, and
- Efforts by CALFED Common Programs will benefit some anuran species in the upper watersheds.

Restoration efforts will be in cooperation with other agencies that have authority to conduct restoration projects including:

- California Department of Fish and Game
- California Department of Water Resources
- U.S. Fish and Wildlife Service, and
- U.S. Army Corp of Engineers.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of native anuran amphibian populations will also effect restoration of reptiles and other amphibians that coexist in the same types of habitats. It will be linked to restoring the overall health to many different types of habitats within the Central Valley as well as the Cascade, Coast, and Sierra mountain ranges.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore native anuran amphibians throughout the Central Valley.

LONG-TERM OBJECTIVE: Have self-sustaining populations of all native anuran amphibians (frogs, toads) present throughout their native ranges, in all major watersheds in the Bay-Delta watershed.

SHORT-TERM OBJECTIVE: Determine the causes of anuran amphibian declines in the Bay-Delta watershed, develop restoration strategies, and implement them where feasible.

RATIONALE: The frogs and toads of California are in a general state of decline, but especially in the Central Valley watershed. The ranid frogs (red-legged frog, foothill yellow-legged frog, mountain yellow-legged frog, cascades frog) are in steep decline. Foothill yellow-legged frogs, for example, have virtually disappeared from the San Joaquin drainage since the 1970s (when they were still common). Red-legged frogs have become so rare they are federally listed as endangered (and are treated separately as a consequence). Although the decline of these amphibians can be tied to global amphibian declines, the principal causes are probably regional: introduced species and airborne pesticides. Because pesticides also have effects on human health, any changes in farming practices to protect humans also should be designed to protect amphibians.

STAGE 1 EXPECTATIONS: Complete status surveys of all anuran amphibians will have been completed and the major causes of declines should be determined. Long-term plans will have been developed and instituted to create conditions that will allow populations to recover throughout their ranges.

The general target is to increase population sizes and distribution of the native anurans through out historical habitat ranges.

General programmatic actions to assist in reaching the target include:

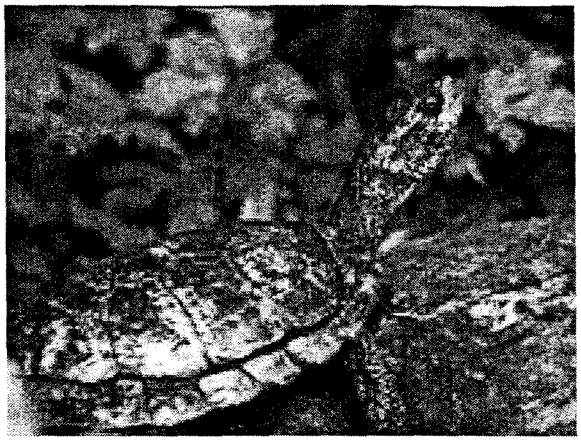
- acquire land that would increase anuran habitat and develop good water sources that meet population needs.
- develop predator control plans for bullfrogs and centrarchids,
- reintroduce native anurans to habitats that predators are eliminated.

REFERENCES

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

United States Fish and Wildlife Service, Status and Trends Report on Wildlife of the San Francisco Estuary, San Francisco Estuary Project, 1992.

Zeiner, David C., William F. Laudenslayer, Jr., Kenneth E. Mayer (ed.), California's Wildlife Volume 1 Amphibians and Reptiles, Department of Fish and Game, Sacramento, 1988.



INTRODUCTION

The loss of habitat and declining condition has warranted the listing of the western pond turtle as a species of concern by U.S. Fish and Wildlife Service (USFWS) and a Species of Special Concern by California Department of Fish and Game (DFG).

Major factors that limit these resources' contribution to the health of the Delta are related to adverse effects of conversion of aquatic, wetland, riparian, and adjacent upland habitats to other land uses and land use practices that degrade the value of otherwise suitable habitat areas.

RESOURCE DESCRIPTION

The western pond turtle inhabits ponds, rivers, streams, lakes, marshes, and irrigation ditches with rocky or muddy bottoms. Dense cover and exposed basking sites are important components of these wetland habitat types. The western pond turtle inhabits every region of California except drainages on the eastern slope of the Sierra Nevada. Population densities vary, however, and are highly influenced by the quality of isolated habitats. A disproportionately large percentage western pond turtle populations are adults, indicating poor reproductive success.

Historic habitat areas used by these species have been substantially reduced as a result of converting land for agriculture, urban, or industrial uses or degraded as a result of ongoing land-use practices. Remaining habitat areas, such as ponds, rivers, streams, lakes, marshes, and irrigation ditches, are largely fragmented. Associated uplands, used for reproduction and hibernation, are largely unavailable. Upland habitats adjacent to aquatic habitats are now mostly isolated in small riparian bands along the tributaries that supply water to the Sacramento and San Joaquin rivers and along canals with small levees.

Because much of the original habitat used by these species has been lost, irrigation canals and ditches (especially canals with nearby vegetation) now provide important replacement habitat for these species. Rice farming makes up a significant portion of the agricultural activity in the Sacramento Valley, and drainage ditches associated with rice farming practices provide much of this surrogate habitat. Adjacent breeding and hibernating cover, however, is often limiting for these species.

Other factors that limit these species populations include:

- some agricultural practices (e.g., discing, mowing, burning, and applying herbicides and rodenticides) that degrade habitat or cause mortality;
- introduced large predatory fish that prey on juveniles and injure adults; and
- mortality caused by flooding of hibernation sites during heavy rains, floods, or for waterfowl.

VISION

The vision for the western pond turtle is to maintain the abundance and distribution of this California species of special concern in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake and western pond turtle. The Ecosystem Restoration Program Plan's (ERPP's) proposed restoration of aquatic, wetland, riparian, and upland habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Restoration projects to improve upland and wetland agriculture and seasonal wetland and riparian habitats would be closely linked to the restoration of these species.

Efforts to recover western pond turtle populations will involve cooperation and support from other established programs aimed at restoring habitat and populations.

Wetland restoration and management programs that would improve habitat for these species include the Agricultural Stabilization and Conservation Service's Wetland Reserve Program, the Wildlife Conservation Board's Inland Wetlands Conservation Program, restoration programs administered by Ducks Unlimited and the California Waterfowl Association, and ongoing management of State and federal wildlife refuges and private duck clubs. Restoration efforts will be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including DFG, California Department of Water Resources, USFWS, U.S. Army Corps of Engineers, and the Delta Protection Commission. USFWS is also preparing a recovery plan for the giant garter snake that will establish population recovery goals.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, stream meanders, and seasonal pools to develop that assist in the recovery of their populations elsewhere in their historic ranges.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore self-sustaining populations of western pond turtles to habitats throughout the Central Valley, including the Delta.

LONG-TERM OBJECTIVE: Restore self-sustaining populations of western pond turtles to habitats throughout the Bay-Delta watershed including the Delta.

SHORT-TERM OBJECTIVE: Determine the status and habitat requirements of pond turtles throughout the region and develop a conservation strategy in concert with habitat protection measures.

RATIONALE: The western pond turtle is the only turtle native to the Central Valley region and to much of the western United States. Although considered to be just one widely distributed species, it is likely that the pond turtle is a complex of closely related species, each adapted for a different region. The Pacific pond turtle is still common enough in the Bay-Delta watershed so that it is not difficult to find them in habitats ranging from sloughs of the Delta and Suisun Marsh to pools in small streams. The problem is that most individuals seen are large, old individuals; hatchlings and small turtles are increasingly rare. The causes of the poor reproductive success are not well understood but factors that need to be considered include elimination of suitable breeding sites, predation on hatchlings by non-native predators (e.g., largemouth bass, bullfrogs), predation on eggs by non-native wild pigs, diseases introduced by non-native turtles, and shortage of safe upland over-wintering refuges. If present trends continue, the western pond turtle will deserve listing as a threatened species (it may already).

STAGE 1 EXPECTATIONS: Populations of turtles that appear to still have successful reproduction will have been located and protected, in conjunction with other habitat protection measures. Causes of the decline should be determined and a recovery plan developed based on the findings.

The general target is to increase the population size of western pond turtles.

General programmatic actions to protect occupied habitat areas include the following:

- Implement a preservation plan to protect these areas from adverse effects associated with human encroachment and recreation,
- Create canals, side channels, and back-flow pools containing emergent vegetation within the South, East, and North Delta Ecological Management Units of the Sacramento-San Joaquin Delta Ecological Management Zone to provide forage habitat and escape cover, and create dispersal corridors by linking habitat areas.
- Restore suitable adjacent upland habitat or modify land use practices to render existing uplands as suitable habitat and reestablish connectivity between wetland and upland habitat areas, provide nest and hibernation sites, and provide refuge habitat during floods.
- Create buffer zones where none currently exist to improve habitat value.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ DELTA GREEN GROUND BEETLE

INTRODUCTION

The Delta green ground beetle, a federally listed threatened species, is associated with vernal pool habitats. The distribution and populations of this species has declined substantially, primarily as a result of the loss or degradation of habitats within its range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The Delta green ground beetle is found at the Jepson Prairie Preserve in Solano County, which is in the Yolo Basin Ecological Management Zone. The Delta green ground beetle and its soft-bodied prey species are most often observed on moist environments such as those provided by Olcott Lake and vernal pools within the Jepson Prairie Preserve. Vernal pools and aquatic seasonal habitats supply the critical needs of the Delta green ground beetle. Entomologists believe that appropriate conditions for the species are found in open, moist habitats with limited vegetative cover.

Since 1974, entomologists have seen or collected only 75 adult Delta green ground beetles in the preserve area. Although the historical distribution of the Delta green ground beetle is unknown, the widespread disruption of wetland and grassland habitats in the Central Valley over the last 150 years strongly suggests that the range of the beetle has been reduced and fragmented. Today, the beetle predominately inhabits the borders of vernal pools and Olcott Lake at the Jepson Prairie Preserve. The primary threats to the survival of the Delta green ground beetle have been, and continue to be, loss and alteration of its wetland habitat primarily because of agricultural conversion (i.e., the plowing and leveling of land); grazing; river channelization; and construction of dams, drainage ways, and pipelines.

VISION

The vision for the Delta green ground beetle is to contribute to the recovery of this federally listed threatened species by increasing their populations and abundance through habitat restoration.

Protecting existing and restoring additional suitable seasonal wetlands, including vernal pools, and associated grasslands will be critical to recovery of the Delta green ground beetle in the Bay-Delta. Restoration of these habitats in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of habitats used by this species.

The Delta green ground beetle would also benefit from cooperative management strategies with The Nature Conservancy's Jepson Prairie Preserve.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),

- California State Parks and Recreation,
- Riparian Habitat Joint Venture,
- DFG's Calhoun Cut Reserve, and
- TNC's Jepson Prairie Preserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore Delta Green Ground Beetle to multiple populations within its presumed natural range.

LONG-TERM OBJECTIVE: Expand the existing population of Delta green ground beetle and establish at least three additional populations to remove it from the federal threatened species list.

SHORT-TERM OBJECTIVE: Expand the existing population levels of Delta green ground beetle by increasing and improving its habitat.

RATIONALE: The Delta green ground beetle is federally listed as a threatened species that is currently known only from Jepson Prairie Preserve (Solano County). Habitat requirements for this species are not clearly understood but the beetles seem to require open places near vernal pools. A better knowledge would help restoration efforts. Limiting pesticide use in adjacent areas and increasing habitat are two ways to increase population size but until we know what the ideal habitat is, a mixture of habitats that could be used by this species is essential.

STAGE 1 EXPECTATIONS: The existing population of Delta green ground beetle will have been studied in order to develop a clearer idea of what its habitat requirements are. Additional areas of vernal pool habitat in Solano County will have been acquired and managed for the beetle and other native species.

The following general target will assist in meeting the implementation objective:

- Increase the numbers and distribution of Delta green ground beetle.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore wetland, riparian, and grassland habitat.
- Implement control measures to eradicate invasive plant species.
- Design and manage restored seasonal wetlands and grasslands near Delta green ground beetle populations to improve habitat quality for the species.
- Introduce species into unoccupied or restored habitat areas.
- Reduce land and water management practices that degrade habitats used by these species.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ LANGE'S METALMARK BUTTERFLY

INTRODUCTION

The Lange's metalmark butterfly, a federally listed endangered species are associated with inland dune habitats. The distribution and populations of these species have declined substantially, primarily as a result of the loss or degradation of these habitats within their range. The loss of habitat and declining condition of these species populations have warranted their listing as threatened or endangered under the federal Endangered Species Act.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The preferred habitat of Lange's metalmark, a butterfly, is inland dune scrub. The Lange's metalmark is dependent on its host plant, naked buckwheat. The present range of Lange's metalmark has been reduced to about 70 acres of suitable habitat within the Antioch Dunes National Wildlife Refuge and on a few small parcels of privately held land on the eastern flank of the refuge. Over a 9-day sampling period in 1977, biologists estimated that only 400 adult butterflies remain at the Little Corral site. From 1986 to 1991, the population increased exponentially, from approximately 160 butterflies to nearly 2,000. In 1992, the population fell to about one-third of the peak level, but by 1996 had recovered to more that 2,000 butterflies. A wide variety of stressors (e.g., land use, wildfire, non-native plant species, sand mining, fences, and human-related disturbance) that degrade this species' habitat have contributed to the endangered status of Lange's metalmark.

VISION

The vision for the Lange's metalmark butterfly is to recover this federally listed endangered species by increasing the existing Lange's metalmark population distribution and by increasing its abundance.

Protecting existing and restoring additional suitable inland dune scrub habitat will be critical to maintaining and increasing the abundance of the Lange's metalmark population in the Bay-Delta. Habitat restoration in the Sacramento-San Joaquin Delta Ecological Management Zone will help maintain healthy populations by increasing the quality and quantity of this species habitat.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

There are a number of programs that involve these species:

- U.S. Fish and Wildlife Service,
- California Department of Fish and Game (DFG),
- California State Parks and Recreation,
- Riparian Habitat Joint Venture, and
- DFG's Calhoun Cut Reserve.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of these species is integrally linked with restoration of seasonal wetland, riparian, inland dune, perennial aquatic, and grassland habitats in the Central Valley and are adversely influenced by the detrimental effects of invasive plant species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore Lange's metalmark butterfly to multiple populations within its natural range.

LONG-TERM OBJECTIVE: Restore Lange's metalmark butterfly to populations throughout its inland dune scrub habitat, to the point where it can be removed from the federal endangered species list.

SHORT-TERM OBJECTIVE: Create multiple populations of Lange's metalmark butterfly within the Antioch Dunes region.

RATIONALE: Lange's metalmark butterfly is listed as endangered by the federal government because it exists as just one small population in one small protected area, Antioch Dunes Ecological Reserve. The reserve is a remnant of the coastal dune scrub habitat that was once widespread in the Antioch area. This butterfly depends on one host plant species, naked buckwheat, for the survival of its young. Thus protection of this site from disturbance, fires and invasions of exotic plant species is paramount for the survival of the butterfly.

STAGE 1 EXPECTATIONS: The population size and area inhabited by Lange's metalmark butterfly in Antioch Dunes Ecological Reserve will have been increased substantially. Restoration of the native dune scrub plant community and naked buckwheat populations will have continued both in the reserve and in suitable areas outside the reserve.

The following general targets will assist in meeting the implementation objective:

- Increase the number and distribution of Lange's metalmark.

The following general programmatic actions will assist in meeting the targets:

- Implement control measures to eradicate invasive plant species.
- Increase the amount of inland dune scrub habitat.
- Develop cooperative management strategies with the Antioch Dune Ecological Reserve that protect and and manage existing habitat areas.
- Maintain healthy populations of naked buckwheat within inland dune scrub habitats.
- Enhance the formation of active dunes by such means as importing clean sand of appropriate dimensions, reducing stabilizing vegetation, and increasing topographic relief, dune height, and the frequency of steep north/northwest facing erosional slopes with sparse vegetation cover.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ CALIFORNIA FRESHWATER SHRIMP

INTRODUCTION

The California freshwater shrimp is found in three California counties, Marin, Napa, and Sonoma. The shrimp has apparently been extirpated from five of ten streams in which it occurred during 1964 (Eng 1981). During a subsequent distribution study of the species, shrimp were found to inhabit six additional streams (Serpa 1991). Habitat loss and alteration have been the primary causes for is demise. Urbanization, agricultural development, overgrazing, and dam and road construction have contributed to habitat loss.

RESOURCE DESCRIPTION

The California freshwater shrimp is a small shrimp, measuring less than 2.5 inches in length. It is native to Marin, Sonoma and Napa counties and represents the only remaining species of this genus. The freshwater shrimp is found in freshwater sand and gravel bottom streams at low elevation which have a gentle gradient. The shrimp occurs primarily in pool areas away from the main streamflow. The pools have undercut bands and exposed roots. The exposed roots are the preferred winter habitat. Bankside bushes, vines and sedges that extend into the water provide favorable conditions for the shrimp, especially in the late spring and summer months.

Freshwater shrimp appear to tolerate warm water temperatures (≥73°F) and no-flow conditions that are detrimental or fatal to native salmonids. Laboratory studies indicate the freshwater shrimp should be able to tolerate brackish water conditions for short periods.

The health of California freshwater shrimp populations is adversely affected by the following general types of activities or conditions:

- urbanization
- agricultural practices
- livestock grazing and dairy farming
- timber harvesting
- gravel mining
- water development
- summer dams
- urban runoff
- wastewater discharge
- flood control
- bank protection
- culverts and grade control structures
- introduced predators.

VISION

The vision for the California freshwater shrimp is to maintain populations of this federally listed endangered species by maintaining its existing distribution and abundance. Conservation of the California freshwater shrimp would contribute to overall species richness and diversity. Achieving this vision will reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Protecting existing populations from activities that could result in their loss or degradation and restoring ecological process of confined channel migration will be critical to the recovery of the shrimp. The Ecosystem Restoration Program Plan's proposed restoration of stream meander and riparian habitat in the North San Francisco Bay/Suisun Marsh Ecological Management Zones will help to protect the remaining populations in the Napa River and its tributary, Garnett Creek, Sonoma Creek and its tributary, Yulupa Creek, and Huichica Creek. Protecting the remaining populations is an essential requirement to preventing the shrimp populations from declining to a point where restoration efforts may offer little help to the species.

Restoring these habitats while protecting and restoring streamside banks and levees would also help maintain or increase existing shrimp populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other programs linked to restoring riparian systems and California freshwater shrimp habitat include:

- Huichica Creek Land Stewardship group,
- Napa County Resource Conservation District's Natural Resource Protection and Enhancement Plan,
- Napa County's integrated resource management plan for the Napa River,
- Napa County Resource Conservation District's "Adopt-A-Watershed" program,

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of the California freshwater shrimp population and its habitat will be integrally linked to restoration of natural stream meander corridors in the rivers of the Central Valley.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore populations of California freshwater shrimp throughout its former range.

LONG-TERM OBJECTIVE: Increase and maintain populations of California freshwater shrimp.

SHORT-TERM OBJECTIVE: Implement restoration measures designed to protect existing populations and initiate design of a long-term conservation and restoration program.

RATIONALE: California freshwater shrimp is an endangered species that needs protection and restoration. Other restoration efforts within tributaries to the North Bay may affect the distribution and abundance of the shrimp. Specifically, management and restoration actions for the Napa River and Sonoma Creek ecological management areas must integrate actions to benefit numerous species.

STAGE 1 EXPECTATIONS: The abundance of the California freshwater shrimp will have increased and measures instituted to protect and restore the long-term viability of the shrimp populations.

The general target is to protect exist populations in the North Bay.

General programmatic actions which will contribute to reaching the target include:

- remove existing threats to known populations of shrimp through management of shrimp populations and habitat,
- restore habitat conditions favorable to shrimp and other native aquatic species,
- protect and monitor shrimp populations and habitat once the threats have been removed and restoration has been completed,
- assess effectiveness of various conservation efforts for shrimp,
- conduct research on the biology of the species,
- restore and maintain viable shrimp population at extirpated and existing localities,
- increase public awareness and involvement in the protection of shrimp and native cohabitating species,

REFERENCES

Eng, L. 1981. Distribution, life history, and status of the California freshwater shrimp, *Syncaris pacifica*. California Department of Fish and Game. Inland Fisheries Endangered Species Program Special Publication 81-1. 27 pp.

Serpa, L. 1991. California freshwater shrimp (*Syncaris pacifica*) survey for the U.S. Fish and Wildlife Service. Fish and Wildlife Enhancement, Sacramento Field Office. 17 pp.

U.S. Fish and Wildlife Service. 1997. Draft California Freshwater Shrimp Recovery Plan. U.S. Fish and Wildlife Service, Portland Oregon. 87 pp.

◆ DECLINING NATIVE SPECIES (PRIORITY GROUP IV)

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. The first Strategic Goal focuses on at-risk species:

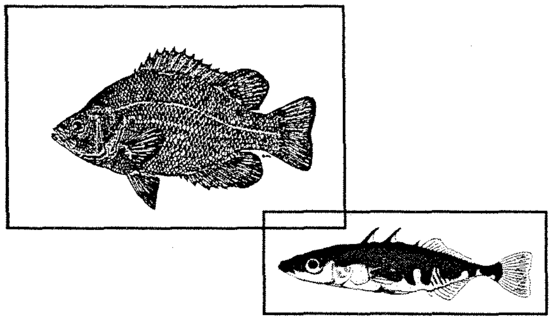
> ***GOAL 1: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.***

Because there are so many species covered under this goal, they have been divided into four groups in terms of priority for CALFED attention. Many are "at-risk" species, which are in danger of extinction if present trends continue.

PRIORITY GROUP IV. Declining native species that are regarded as having a relatively low risk of extinction and/or whose rehabilitation does not necessarily depend on conditions in the Delta or Suisun Bay.

Species in Priority Group IV include:

- Native resident fishes
- Planktonic organisms
- Shorebird guild
- Wading bird guild
- Migratory waterfowl
- Neotropical migrant bird species
- Upland game
- Plant communities
  - Aquatic habitat plant community
  - Tidal brackish and freshwater marsh habitat plant community
  - Seasonal wetland habitat plant community
  - Inland dune habitat plant community
  - Tidal riparian habitat plant community



INTRODUCTION

Native resident fish species of the Delta are important ecologically and as indicators of ecosystem health. Some, such as the tule perch, Sacramento sucker, and threespine stickleback, are important elements of the Bay-Delta foodweb. Other, such as the Sacramento pikeminnow (Sacramento squawfish), are important predators. Native resident fishes have declined as a percent of the total fish species abundance of the Bay-Delta and its watershed.

Non-native resident fishes include many species introduced to improve the foodweb and sport fishing including threadfin shad, white catfish, and largemouth bass. Others, such as the yellowfin goby, have been accidently introduced in the ballast water of ships. While some species are considered desirable, other are undesirable because they compete with or prey upon desirable native and non-native fish. The wagasagi, or pond smelt, a close relative of the delta smelt introduced by DFG to improve the foodweb of foothill reservoirs, now potentially threatens the delta smelt population through interbreeding and competition.

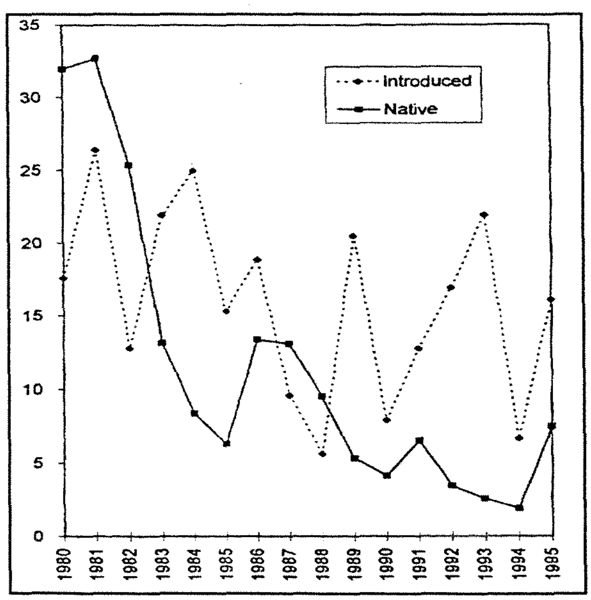
Factors contributing to the decline of some important resident species include predation and competition of non-native species, loss and degradation of habitat, poor foodweb productivity, losses to water diversions, and reduced survival from exposure to toxins in the water.

RESOURCE DESCRIPTION

Resident species compose the bulk of species found in fresh and low-salinity water (i.e., less than 4 parts per thousand salinity) of the Sacramento-San Joaquin Delta estuary. Resident species represent an important component of sport catch and the historical native fish fauna (e.g., tule perch, Sacramento blackfish); and forage fish (e.g., threadfin shad).

As with other Delta species, the habitat of resident fishes has been greatly diminished by human-caused actions. Increased habitat and expanded distribution and abundance of resident species can be realized through restoring habitat together with improving natural ecological processes and functions.

Spawning and rearing habitat includes shallow edgewaters bordered by healthy riparian and



Index of Native and Introduced Fishes in Suisun Marsh Trawl Survey aquatic plants that provide protective, food-rich environments. Productive edgewater habitats are currently very limited in the Delta. Many resident Delta species inhabit shallow areas that have structural diversity provided by riparian and aquatic vegetation. Levee construction in the 1800s created narrow channels and eliminated vast areas of tule marsh, areas most likely important as spawning and rearing habitat for Delta species. Levee maintenance programs that remove riparian vegetation and dredging continue to reduce the quality of shallow water habitat used by resident species. Erosion caused by increased flow velocity, changes in channel structure, and boat wakes continues to reduce remnant riparian, marsh, and channel island habitats. Water hyacinth and other exotic aquatic plants now clog many sloughs that are important habitat of resident fish.

Losses to Delta diversions (e.g., hundreds of small agricultural diversions, Central Valley Project and State Water Project export pumps, and Pacific Gas & Electric power generation facilities) may reduce resident species abundance through direct entrainment or indirect effects on the prey of resident fish. Large numbers of some resident species (e.g., white catfish, threadfin shad) are entrained in Delta diversions. Other resident species (e.g., largemouth bass) spend their lives in habitat that is in close proximity to where they were spawned and are not particularly susceptible to entrainment in Delta.

Food availability, toxic substances, and competition and predation are among the factors influencing abundance of resident species. In addition, harvest of many resident species for food and bait by sport anglers may affect abundance.

VISION

The vision for resident fish species is to maintain and restore the distribution and abundance of native species, such as Sacramento blackfish, hardhead, and tule perch to contribute to the overall species richness and diversity. Achieving this vision will reduce conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta.

Ecosystem processes are closely tied to habitat restoration needs and actions. Resident species would benefit from conditions to maintain productivity and suitability of spawning and rearing habitat (including production of food). Actions to rehabilitate ecosystem processes include: changing Delta configuration, facility operations (including Delta diversions and channel barriers and gates), and Delta inflow and outflow.

Stressor reduction is a major component of restoration and maintenance of resident species populations. A primary concern with regard to vulnerable species is the reduction of losses to diversions. Actions to reduce losses include upgrading existing fish protection facilities, installing fish screens on currently unscreened facilities, removing predators associated with diversions and fish protection facilities, relocating and consolidating existing diversions, changing seasonal timing of diversions, and reducing the number of diversions. Resident species would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin and may benefit from actions to prevent introduction of non-native species that would prey upon or compete with native species for habitat and food supply.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore and maintain resident species would involve cooperation and support from other established programs that protect and improve conditions for delta smelt, striped bass, and other species.

- The Recovery Plan for the Sacramento/San Joaquin Delta native fishes will be considered in the development of actions.
- Central Valley Project Improvement Act will implement actions that will benefit resident species, including changing the timing of diversions and restoring habitat.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration efforts relating to resident fish will be closely tied with efforts for delta smelt, longfin smelt, and splittail.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to reverse the decline of native resident fishes.

LONG-TERM OBJECTIVE: Within 25 years, all resident native fishes will have stable or increasing populations, in multiple localities, with localities interconnected as much as feasible.

SHORT-TERM OBJECTIVE: Determine the distribution, status, and habitat requirements of all native resident fishes in the Bay-Delta watershed to see if species-specific strategies are needed to reverse declines or if habitat-oriented restoration strategies will be adequate.

RATIONALE: The Central Valley has a native resident fish fauna that is largely endemic to the region. Some species are extinct (thicktail chub) or nearly extinct (Sacramento perch) in the wild. While some native species (e.g., Sacramento pikeminnow [squawfish], Sacramento sucker) are clearly thriving under altered conditions, others are not (e.g., hitch, Sacramento blackfish, hardhead). Although most of these species may benefit from actions listed under goal 2, there is a need to determine if some have unique problems or requirements that will prevent them from responding to general habitat improvements.

STAGE 1 EXPECTATIONS: A distribution and status survey of native stream fishes will have been completed. Sites with high species richness or containing rare species will have been identified for special management. A recovery strategy for native fish assemblages will have been developed.

The target for resident fishes is to increase their abundance indices in the DFG fall midwater trawl survey and Suisun Marsh Trawl Survey to historical levels (e.g., 20 units or higher in the Suisun marsh Trawl survey).

Resident species would benefit from the following general restoration activities:

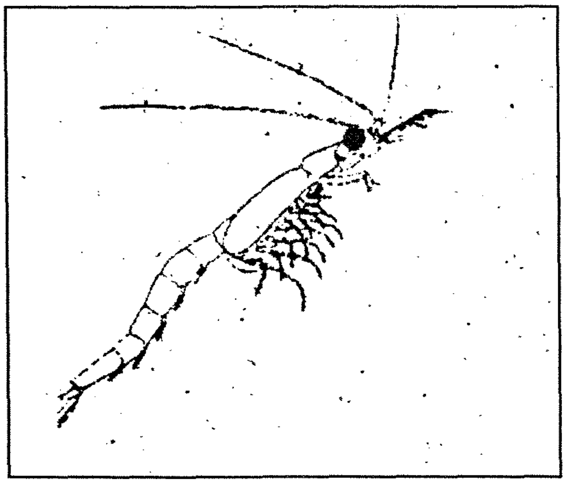
- adding and modifying physical habitat,
- breaching levees to inundate existing islands,
- setting levees back to increase shallow-water habitat along existing channels,
- restoring riparian areas,
- protecting existing shallow-water habitat from erosion,

- filling relatively deep water areas with sediment to create shallow-water habitat,
- eliminating water hyacinth and other noxious aquatic plants from Delta channels and sloughs,
- upgrading existing fish protection facilities at South Delta pumping plants,
- installing screens on unscreened diversions,
- removing predators at diversions,
- relocating or consolidating diversions,
- reducing concentrations of toxins in Bay-Delta waters, and
- preventing further introductions of non-native aquatic organisms.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Bay-Delta Aquatic Foodweb Organisms



Introduction

Bay-Delta aquatic foodweb organisms include bacteria, algae, zooplankton (e.g., copepods and cladocerans), epibenthic invertebrates (e.g., crayfish, Neomysis and Crangon shrimp), and benthic invertebrates (e.g., clams). Foodweb organisms are essential for the survival and productivity of fish, shorebird and other higher order animal populations in the Bay-Delta estuary. Some organisms are non-native species (e.g., certain zooplankton and Asian clams) that may be detrimental to native species and the foodweb in general. Recent declines in aquatic foodweb organisms of the Bay-Delta, particularly in drier years, has caused a reduction in overall Bay-Delta productivity. Important aquatic foodweb organisms include algae, bacteria, rotifers, copepods, cladocera, and mysid shrimp.

Resource Descriptions

The foodweb of the Bay-Delta ecosystem consists of all the plants, invertebrates, and other lower trophic-level organisms that serve as prey for fish, water birds, and other higher trophic-level resources of the ecosystem. Foodweb productivity of the Bay-Delta estuary is dependent primarily on the supply of nutrients and plant biomass production and transport (See Bay-Delta Aquatic Foodweb Process).

Plant communities in the Bay-Delta aquatic foodweb consist mostly of benthic algae and phytoplankton produced in the estuary and its watershed, and vascular-plants in riparian and wetland communities adjacent to the system. Algae are generally small (diameter <0.1 millimeters [mm]), easily transported, and highly nutritious. Phytoplankton are related to algae but small enough to float in the water. Most vascular-plants, by contrast, are much larger.

The Bay-Delta foodweb has undergone a number of changes since the 1960s. Most notably, phytoplankton abundance has declined in important fish nursery areas of Suisun Bay and the western Delta (Lehman 1996). A pattern of very low phytoplankton levels in Suisun Bay and the Delta beginning in 1987 concerns many scientists. Low levels in Suisun Bay and the Delta since 1986 may be the result of high densities of Asian clams (*Potamocorbula amurensis*) that colonized the Bay after being accidentally introduced from the ballast waters of ships. Large numbers of the clams colonized this area of the estuary during the drought period from 1987 to 1992 (Kimmerer and Orsi 1996).

Aquatic invertebrate population trends followed those of phytoplankton over the past three decades. Species that once dominated the aquatic invertebrate community have become relatively scarce, while some others have increased in relative abundance. Many native species have become less abundant or more narrowly distributed, while dozens of new non-native species have become well established and widely dispersed. In general, the abundance of plankton has declined, while populations of many bottom-dwelling invertebrates, most notably Asian clams, have increased. This transition has been most evident in Suisun Bay and other traditionally important fish-rearing areas. Also in these areas, populations of rotifers, copepods, and other relatively small species have declined substantially since monitoring began in the 1960s (Kimmerer and Orsi 1996). This pattern is perhaps most dramatic for the mysid shrimp, which have declined to less than one-tenth of their former abundance, particularly since 1986 (Orsi and Mecum 1996). The continued decline from 1993 to 1995, despite the return of higher flows, is of particular concern. These declines in zooplankton abundance have roughly coincided with the decline in algae, one of the main food sources for the zooplankton.

The deterioration of the zooplankton community and its algal food supply in key habitat areas of the Bay-Delta is a serious problem because striped bass, delta smelt, chinook salmon, and other species that use Suisun Bay and the Delta as a nursery area feed almost exclusively on zooplankton during early stages of their life cycles. Research indicates that survival and growth of fish larvae generally increase with increased concentration of zooplankton. Declines in the production of juveniles of these fish species appear to coincide with the declines in algae and zooplankton. Modifying the Bay-Delta ecosystem in ways that will lead to increased algae and zooplankton abundance may be critical to restoring Bay-Delta fish populations and improving the health of its ecosystem.

Areas of the Bay-Delta where hydraulic conditions allow food resources to accumulate in the water column rather than settling or washing out are important habitats for plankton foodweb organisms. This accumulation of food resources results from passive processes and from active algal, microbial, and zooplankton reproduction. The comparatively benign hydraulic conditions and abundant food resources characterizing the western Delta and Suisun Bay permit the development of high zooplankton populations on which many estuarine resident and anadromous fish depend during their early life stages. Horizontal salinity stratification enhances this process, especially when the salinity front (sometimes referred to as X2) or the "entrapment zone" is in Suisun Bay (Arthur and Ball 1979).

The decline of plankton populations in the Bay-Delta may also be a result, at least in part, of the effects of heavy metals, herbicides, pesticides or other toxic substances. Low concentrations of these substances in the water column may act individually or in combination to reduce productivity of plant and animal plankton. Research to determine the effects of these toxicants on plankton is currently underway.

VISION

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

Restoring the Bay-Delta foodweb organisms would require enhancing plankton growth and reducing loss of plankton to water exports, particularly in drier years. Several options exist for enhancing plankton growth. Improving Delta inflow and outflow in spring of drier years will be an essential element of any plan. Other elements include reducing losses to exports from the system and reducing the amount of toxic substances entering the system.

Additional improvements can be gained by increasing shallow-water habitat and tidal wetlands in the Bay and Delta. Increasing the acreage of floodplain lakes, sloughs, and other backwaters in the Sacramento River drainage will increase organic matter inputs to the Delta. This increase in plankton food supply will help increase population growth.

Restoring tidal action to leveed lands in San Pablo Bay and Suisun Marsh will increase habitat for aquatic foodweb organisms. The Yolo and Sutter Bypasses offer potential opportunities to produce more permanent slough, riparian, and wetland habitats in the Sacramento River floodplain. Setback levees or improved riparian and shallow-water habitat along leveed reaches of the rivers and Delta offer additional opportunities to increase the abundance of foodweb organisms in the Bay and Delta.

Integration with Other Restoration Programs

Efforts to restore the abundance of Bay-Delta aquatic foodweb organisms would involve the cooperation and support from established programs underway to restore habitat and fish populations in the Bay-Delta including the following:

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes calls for improving flows, reducing diversions, and increasing habitat.
- The Salt Marsh Ecosystem Recovery Plan calls for improving wetland habitat in the Bay.
- The Central Valley Project Improvement Act (PL 102-575) and its associated Anadromous Fish Restoration Plan include provisions to reduce losses of organisms into water diversions, to restore aquatic habitat, to improve water quality, to improve freshwater flows, and to restore wetland and riparian habitats in the rivers and Bay-Delta.
- The Steelhead Trout, and Anadromous Fisheries Program Act of 1988 includes elements to improve freshwater flows and riparian habitats in the Sacramento and San Joaquin Rivers and their tributaries.
- The Delta Wildlife Habitat Protection and Restoration Plan include protection and improvements to riparian and wetland habitats of the Bay-Delta.
- Central Valley Habitat Joint Venture includes restoration of riparian and wetlands of the rivers, Delta, and Suisun Marsh.
- California Senate Concurrent Resolution 28 has set a goal of doubling wetland acreage by the year 2000.
- San Francisco Estuary Project planning for wetland protection and restoration, and water quality protection and improvement.
- San Joaquin River Management Plan is a plan to restore riparian and wetland habitat and improve water quality in the San Joaquin River and its tributaries.
- SWRCB and RWQCB efforts to restore wetlands and improve water quality of the rivers and Bay-Delta.
- Suisun Resource Conservation District is developing wetlands restoration and management plans.
- Riparian Habitat Joint Venture will restore riparian habitats.

Linkage with Other Ecosystem Elements

Improving the abundance and distribution of important aquatic foodweb organisms of the Bay-Delta is integrally linked with wetland and riparian habitat restoration, water quality (contaminants) improvement, and Central Valley streamflow improvements.

Strategic Objective, Targets, and Programmatic Actions

Aquatic foodweb organisms are addressed by two Strategic Objectives. The first Strategic Objective is to restore assemblages of planktonic organisms in the Delta and Suisun Bay to states of increased abundance and greater predictability in composition.

Long-Term Objective: Increase abundance of zooplankton to the levels that existed prior to the introduction of the Asiatic clam, Potamocorbula amurensis, with zooplankton communities containing native species as significant components.

Short-Term Objective: Maintain the planktonic assemblages at roughly the range of variability of abundance and composition that they have been since the Asiatic clam became established by preventing new introductions and determining conditions that favor native organisms such as Neomysis mercedis.

Rationale: The long-term objective is quite likely impossible to achieve because recent invading species, from the Asiatic clam to various crustacean zooplankters, will continue to play major ecological roles in the system, to the detriment of native organisms. However, at the very least it is possible to stop further introductions of non-native species which have the potential to further change the system unpredictably. This objective is also a call to develop a thorough understanding of the planktonic portion of the Bay-Delta system to predict and understand the impacts of large-scale ecosystem alteration projects on the plankton.

Stage 1 Expectations: Major steps will have been taken to halt activities (e.g., dumping of contaminated ballast water) that result in the establishment of new species of invertebrates and fish in the estuary. Further development of our understanding of the how the Bay-Delta system functions should allow recommendations on how to maintain native zooplankton species, in the context of broader ecosystem management goals.

The second Strategic Objective is to prevent further human-caused irreversible changes to the benthic invertebrate assemblages in the Bay-Delta ecosystem.

Long-Term Objectives: Have diverse benthic assemblages throughout the estuary that contain the same species that are present today, including the remaining native species, and that are not dominated by one or two non-native species.

Short-Term Objectives: Halt further introductions of non-native species, determine conditions that favor remaining desirable species, and find methods (if any) to reduce dominance by single non-native species, especially the Asiatic clam in Suisun Bay.

Rationale: The benthic assemblages of invertebrates in the Bay-Delta estuary are made up largely of non-native species, although a few native crustaceans still are present in numbers. Many of these non-native invertebrates are thoroughly integrated into the food webs of the region and are major prey of native birds, mammals, and fishes. New benthic invasions, largely from ballast water introductions, are constantly occurring, however, and some, such as the invasion of the Asiatic clam, have caused major alterations to the benthic (and planktonic) assemblages. If present trends continue, further invasions can be expected with the potential to once again generate major changes in the benthos, most likely with unfavorable effects on at-risk or harvested species. In order to stabilize benthic assemblages to conditions of reasonable and desirable diversity and abundance, it is necessary to (1) halt further invasions, (2) create water quality and hydraulic conditions that favor desired assemblages (e.g., those containing abundant native Corophium spp.), and (3) reduce the dominance of single non-native species, especially the Asiatic clam. None of these actions is easy to do and the latter two will require considerable research to institute.

STAGE 1 EXPECTATIONS: All introductions of non-native invertebrates into the estuary will have been reduced. Investigations into the biology of benthic assemblages should continue, in order to find ways to create more desirable assemblages in an ecosystem context.

General targets that will assist in meeting the implementation objective include:

- Increase abundance of important food web organisms to 1960s level of abundance
- Reduce influence of non-native species in foodweb communities
- Improve distribution of important foodweb organisms in Bay-Delta.

General programmatic actions that will contribute to achieving the targets include:

- increase late winter and spring Delta outflow
- reduce losses to water diversions
- opening leveed lands to tidal or seasonal floodflows
- increasing the array of sloughs in the Delta
- reduce influx of non-native species
- protecting and restoring shallows, shoals, and channel islands in the Delta; and
- providing more natural floodplains and meander belts along rivers.

REFERENCES

Arthur, J.F., and M. D. Ball. 1979. Factors influencing the entrapment of suspended material in the San Francisco Bay-Delta estuary. Pages 143-174 *in* T.J. Conomos, ed., San Francisco Bay: the Urbanized Estuary. Pacific Division, American Association for the Advancement of Science, San Francisco, CA.

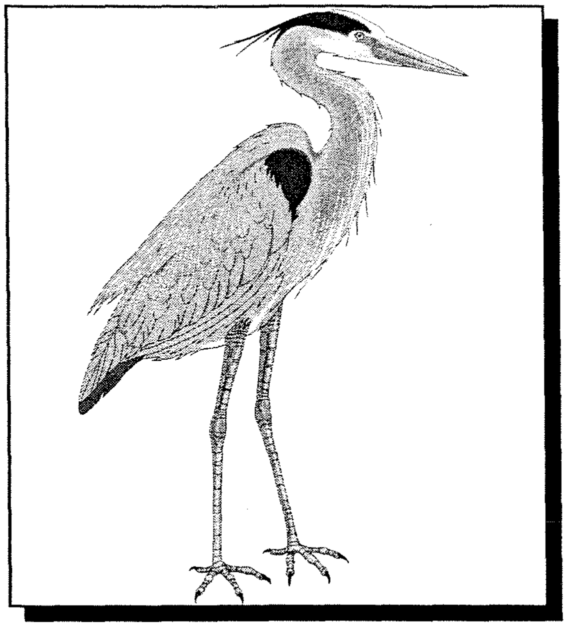
Kimmerer, W., and J.J. Orsi. 1996. Changes in the zooplankton of the San Francisco Bay estuary since the introduction of the clam Potamocorbula amurensis. Pages 403-424 *in* J. T. Hollibaugh, ed., San Francisco Bay: The Ecosystem. Pacific Division, American Association for the Advancement of Science, San Francisco, CA.

Lehman, P. 1996. Changes in chlorophyll a concentration and phytoplankton community composition with water-year type in the upper San Francisco Estuary. Pages 351-374 *in* J. T. Hollibaugh, ed., San Francisco Bay: The Ecosystem. Pacific Division, American Association for the Advancement of Science, San Francisco, CA.

Orsi, J. J., and W. L. Mecum. 1996. Food limitation as the probable cause of a long-term decline in the abundance of *Neomysis mercedis* the Opossum Shrimp in the Sacramento-San Joaquin estuary. Pages 375-401 *in* J. T. Hollibaugh, ed., San Francisco Bay: The Ecosystem. Pacific Division, American Association for the Advancement of Science, San Francisco, CA.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ SHOREBIRD AND WADING BIRD GUILD



INTRODUCTION

Over a million shorebirds and wading birds annually migrate through, winter, or breed in the Bay-Delta. Representative species of the shorebird and wading bird guild include the great blue heron, great egret, western sandpiper, and long-billed dowitcher. These species are a significant component of the ecosystem, are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels of many of these species are declining. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses and land and water management practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

Some shorebird and wading bird species are winter migrants limited to shallow water areas and shorelines. Others are statewide, year-round residents. Shorebirds and wading birds are dependent on many different habitats, although each species may be dependent on only one or a few habitats. These habitats include perennial aquatic, tidal slough, seasonal and emergent wetland, midchannel island and shoal, riparian, and agricultural.

Shorebirds and wading birds are present throughout the Central Valley. Herons and egrets are common year-round residents that breed and winter throughout the study area. Most shorebirds are only winter residents, with a small number remaining to breed. Wetland habitat conversion has eliminated 95% of the historic wetland habitat, resulting in smaller, detached patches of suitable habitat for nesting and foraging. Riparian habitats suitable for use by colonial-nesting species, such as egrets, have been lost or fragmented and are subject to increased disturbance during the nesting period.

VISION

The vision for the shorebird and wading bird guild is to maintain healthy populations of shorebirds and wading birds through habitat protection and restoration and reduction in stressors

Protecting existing and restoring additional suitable perennial aquatic, tidal slough, seasonal and emergent wetland, midchannel island and shoal, and riparian habitats and improving management of agricultural lands and reducing the effect of factors that can suppress breeding success will be critical to maintaining healthy shorebird and wading bird populations in the Bay-Delta. Restoration of these habitats in the

Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Zones will help to maintain healthy populations by increasing the quality and quantity of habitats used by these species.

Shorebirds and wading birds would also benefit from:

- management strategies that protect and maintain important existing habitat areas,
- project wetlands and wading bird nesting areas,
- improve habitat quality for shorebirds and wading birds.

Such strategies could be implemented through cooperative agreements with land management agencies or through conservation easements or purchase from willing sellers.

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow natural floodplains, meander corridors, seasonal pools, and riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Other existing programs that will directly or indirectly improve and restore habitat for shorebirds and wading birds include:

- Bay Area Wetlands Planning Group,
- Central Valley Habitat Joint Venture,
- Cosumnes River Preserve,
- Grizzly Slough Wildlife Area,
- San Francisco Bay National Wildlife Refuge,
- Sonoma Baylands Project,
- Tidal Wetlands Species Recovery Plan,
- Yolo Basin Wetlands Project, and
- San Francisco Bay Wetlands Ecosystem Goals Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of shorebirds and wading birds is integrally linked with restoration of perennial aquatic, wetland, and riparian habitats and reduction in human disturbance.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

SHOREBIRDS

The Strategic Objective is to ensure that members of the shorebird guild continue to be abundant, diverse, and important members of the local fauna.

LONG-TERM OBJECTIVE: Provide sufficient high-quality tidal and shallow water foraging habitat and upland roosting habitat to maintain large populations of all members of this guild that now occur in central California, while also providing sufficient nesting habitat for species that breed in the state.

SHORT-TERM OBJECTIVE: Maintain wintering and breeding populations at their present levels and increase populations of all threatened species sufficiently to be able remove them from lists of threatened species.

RATIONALE: The shorebird guild is an extremely diverse group of migratory and resident species (e.g., sandpiper, plover, curlew, avocet) that forage, often in mixed flocks, on invertebrates in tideflats, beaches, shallow ponds, and other shallow water areas. The Central Valley, Delta, Suisun Bay and Marsh, and San Francisco Bay are a major wintering areas for birds that breed in more northern areas, as well as staging areas for birds headed further south. Habitats suitable for shorebirds were once abundant throughout the region. However, human disturbance, filling of shallow water areas, and other forms of degradation have caused suitable foraging habitats to become diminished. These smaller and more disjunct patches of habitat have made concentrations of shorebirds more susceptible to human disturbance and to increased predation. This guild contains species that are listed as threatened by both state and federal governments (e.g., snowy plover) while others are considered to be species of special concern.

STAGE 1 EXPECTATIONS: CALFED will have cooperated with the Central Valley Habitat Joint Venture to implement the Venture's goals and objectives that relate to creating habitat for shore birds. An evaluation of threats to foraging and breeding habitats will have been conducted and ways found to alleviate threats. Areas that can restored as foraging areas, especially tide flats, will have been identified and restoration work begun.

WADING BIRDS

The Strategic Objective is to maintain or expand populations of bird species that are members of the wading bird guild.

LONG-TERM OBJECTIVE: Provide sufficient high-quality breeding and foraging habitat for all wading bird species so that the guild will continue to be diverse and abundant.

SHORT-TERM OBJECTIVE: Maintain wading bird numbers and diversity at their present level, as a minimum.

RATIONALE: The wading bird guild is a group of mostly conspicuous birds (herons, egrets, bitterns, ibis) that wade in the water to forage on fish and other aquatic organisms. Because egrets and herons are so conspicuous along the waterways of the Bay-Delta watershed, they have high symbolic value for ecosystem restoration. Some members of the guild (least bittern [treated separately] and white-faced ibis) are state species of special concern. Habitats suitable for foraging of wading birds are still common throughout the Bay-Delta watershed. However, human disturbance and degradation has caused many of these habitats to become isolated, polluted, or subject to high levels of disturbance. For many of the species, the principal limiting factor is availability of adequate nesting (rookery) habitats. Long-term persistence of this group of birds in abundance depends on extensive areas of shallow water (less than 1.5 feet deep) containing abundant food, in conjunction with riparian habitats suitable for breeding.

STAGE 1 EXPECTATIONS: CALFED will have cooperated with the Central Valley Habitat Joint Venture to implement the Venture's goals and objectives that would increase foraging habitat for this guild. In addition, existing heron and egret rookeries will have been protected and other potential rookery areas identified.

The following general targets will assist in meeting the implementation objective:

- Increase the number of shorebirds and wading birds over present levels.

- Increase the distribution of shorebirds and wading birds.

- Increase the quantity and quality of overwintering and resting habitat.

The following general programmatic actions will assist in meeting the targets:

- Increase the amount of riparian habitat in the Central Valley.

- Increase the amount of perennial aquatic habitat in the Central Valley.

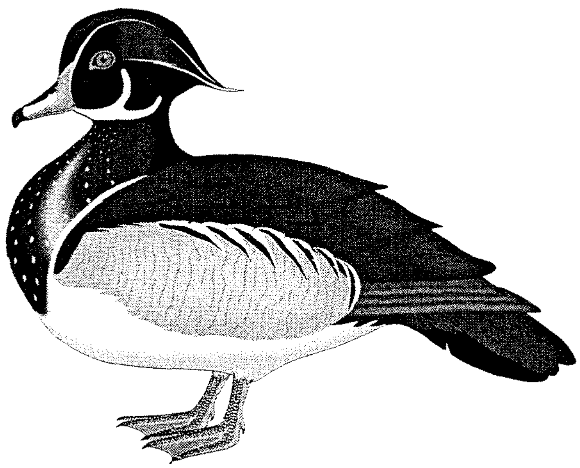
- Increase the amount of emergent and seasonal wetlands in the Central Valley.

- Improve water management and land use practices to benefit wading birds' and shorebirds.

- Limit disturbance to nesting, roosting, and foraging habitats.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Central Valley waterfall populations are a highly valued and diversified biological resource and are found in all ecological management zones within the study area. Large numbers of ducks, geese, and swans winter in the Central Valley after migrating from northern breeding areas. Some species, such as the mallard, gadwall, and Canada goose, are also year-long residents and breed locally in wetlands and nearby uplands. Waterfowl are a significant component of the ecosystem, are of high interest to recreational hunters and bird watchers, and contribute to California's economy through the sale of hunting and related equipment. Historical waterfowl wintering habitat areas have declined by approximately 95% and, as a result of substantial losses of wetland and grassland habitats, waterfowl breeding populations have declined from historical levels.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of wetland and grassland habitats to agricultural, industrial, and urban uses.

RESOURCE DESCRIPTION

Migration over long distances requires a great amount of energy. Upon arrival to wintering grounds, waterfowl depend on high-quality foraging habitat with sufficient grains, insects, and aquatic plants to replenish their energy reserves. These habitats include seasonal, permanent, tidal, and agricultural wetlands; deepwater; riparian woodlands; grasslands; and agricultural uplands and other associated habitats.

Recent declines in waterfowl populations are attributed primarily to the cumulative degradation or loss of breeding, wintering, and foraging habitats in the Central Valley and outside of California. Population declines are most likely caused by a combination of factors that have reduced or eliminated important ecosystem processes. These factors include:

- loss of natural wetlands because of altered flow regimes, resulting in the loss of natural floodplains;
- fragmentation or loss of large areas of wetlands as a result of land reclamation;
- loss of shallow-water habitat as a result of flood management practices;
- loss of riparian habitat resulting from channelization and levee protection practices;
- loss of tidal wetlands as a result of dikes and levees for flood control;
- heavy metal contamination from sources such as subsurface agriculture drainage; and
- loss of the natural mosaic of habitats required to meet the life requirements of waterfowl.

Many other factors have also contributed to the decline of waterfowl, although perhaps to a lesser degree. These include high concentrations of waterfowl in relatively small areas, which exposes greater portions of the population to diseases (such as botulism and cholera) and predation on nests and young by non-native species. Other factors that can affect waterfowl populations, such as extended periods of drought, are natural and will remain.

VISION

The vision for waterfowl is to maintain healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture as part of the North American Waterfowl Management Plan.

Protecting existing and restoring additional suitable seasonal, permanent, and tidal wetlands; deepwater; riparian woodlands; and grasslands; and other associated habitats and improving agricultural land management and reducing the effect of breeding stressors will be critical to maintaining healthy waterfowl populations in the Bay-Delta. Large-scale restoration of nesting, brood, and foraging habitat will help to reduce predation on nests and young. Diverse and widespread habitats decrease the likelihood of large-scale outbreaks of disease. Habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will help to maintain healthy populations of waterfowl by increasing the quality and quantity of habitats used by these species.

Efforts under existing migratory bird management programs have significantly improved critical habitats, including water management for seasonally managed agriculture fields, development of permanent habitat on federal refuges in the State wildlife areas, and incentives for private landowners to provide wintering habitat for migratory waterfowl.

Restoration of ecosystem processes and habitats proposed by ERPP in other ecological management zones will also allow floodplain wetland, riparian, and upland habitats to develop that will provide habitat for waterfowl elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Some of the programs that are restoring populations and habitat for waterfowl in the study area include:

- Upper Sacramento River Fishery and Riparian Habitat Council (SB 1086) Program,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- The Nature Conservancy's Jepson Prairie Preserve,
- Ducks Unlimited Valley Care Program
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan, and
- Central Valley Habitat Joint Venture

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of waterfowl populations is integrally linked with restoration of perennial aquatic, wetland, tidal slough, riparian, grassland, and agricultural habitats and reduction in contaminants such as selenium in Central Valley breeding and wintering areas.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to enhance populations of waterfowl for harvest by hunting and for nonconsumptive recreation.

LONG-TERM OBJECTIVE: Substantially increase the numbers of resident and migratory ducks and geese that use the Bay-Delta watershed by increasing habitat available to them.

SHORT-TERM OBJECTIVE: Continue restoration of wetlands suitable for waterfowl production and over-wintering, while developing strategies for management of waterfowl areas that are compatible with other species, habitat, and ecosystem process restoration goals.

RATIONALE: Waterfowl resources will be enhanced by protecting existing and restoring additional seasonal, permanent, and tidal wetlands. Improved management of agricultural lands using wildlife friendly methods will contribute to sustaining waterfowl resources in the Bay-Delta. The focus for seasonal wetlands should be in areas that may be too deep for tidal marsh restoration over the next 20 years. In concert with efforts to reduce or reverse subsidence, selected areas or islands would be managed as waterfowl habitat. Besides increasing waterfowl resources, efforts to sustain waterfowl and their habitat will help offset some of the effects of converting agricultural or seasonal wetlands to tidal action when such actions may reduce the value of an area to waterfowl such as white-fronted geese or mallard. Efforts should also be focused on improving waterfowl nesting success by improving nesting and brood habitat. Improving waterfowl populations will be done in a manner that reduces conflict with broader ecosystem restoration goals or with goals to recover endangered species. For example: Flooding of rice fields for waterfowl in late winter may require water needed by migratory salmon. Careful management of the amount and timing of those diversions and the manner in which the diversions occur (e.g. through screened diversions) can help reduce conflicts. Management of waterfowl areas will occur using management strategies developed for existing and new waterfowl areas that provide benefits to at-risk species.

STAGE 1 EXPECTATIONS: Acquisition and development of new wetlands favorable for wintering and nesting waterfowl (e.g., Yolo Basin Wildlife Area) will have continued. Significant areas of existing agriculture will be managed using wildlife friendly practices. For existing public wildlife areas, plans to reduce conflicts between waterfowl management and management for other native species, including provisions for emergency situations (e.g., levee repairs), will have been developed. For private waterfowl areas, incentives for implementing broader, ecosystem-based management goals will have improved.

The following general targets will assist in meeting the implementation objective:

- Increase waterfowl populations, and
- Increase distribution of waterfowl.

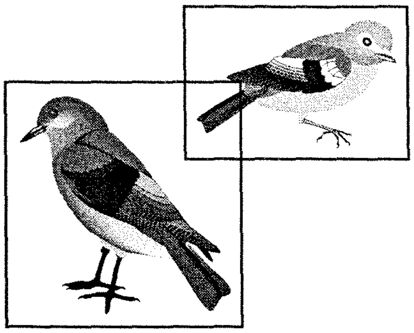
The following general programmatic actions will assist in meeting the targets:

- implementing management strategies to protect important existing habitat areas,
- increasing the quantity and quality of breeding habitat and forage on agricultural land,
- establishing new programs or expanding existing programs to provide incentives for landowner participation,
- restoring and improving wetlands in conjunction with adjacent herbaceous uplands to improve breeding habitat,
- expanding existing State and Federal wildlife areas by creating additional wetland complexes,
- improving water quality, and
- establishing programs that allow government agencies and waterfowl conservation organizations to work cooperatively to increase the efficiency of existing strategies and waterfowl management plans.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Neotropical Migratory Bird Guild



Introduction

Neotropical species breed in North America and winter in Central and South America. Many species of neotropical migratory birds migrate through or breed in the Bay-Delta. These species are a significant component of the ecosystem. These species are of high interest to recreational bird watchers, and contribute to California's economy through sales of equipment and other bird-watching-related expenditures. There have been substantial losses of historic habitat used by these species and available information suggests that population levels for many of these species is declining.

Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

Resource Description

The neotropical migratory bird guild comprises bird species that breed in North America and winter in Central and South America. Representative species of the neotropical migratory bird guild are the western kingbird, western wood-pewee, tree swallow, cliff swallow, northern oriole, Wilson's warbler, and yellow-breasted chat. Individual visions are developed for some neotropical migrants, such as the Swainson's hawk and yellow-billed cuckoo, and those visions contain more specific targets relating to those species. All species of the neotropical migratory bird guild depend on the flora of California to forage and reproduce, typically from about May until September. The birds normally spend the rest of the year in Central and South America.

Neotropical birds occur throughout the California and are associated with most of California's habitat types, including forested woodlands, riparian and montane riparian habitats, unforested lowlands, grasslands, shrub habitats, valley foothill hardwood, valley foothill hardwood-conifer, and wetlands. Population levels of many of these species has declined, primarily as a result of the loss and degradation of habitats on which they depend, both in California and on their Central and South American wintering areas. In California, the quality and quantity of important neotropical migrant bird habitats have been substantially reduced primarily by their conversion to agricultural, industrial, and urban uses, and land use practices that degrade the values provided by these habitats.

Vision

The vision for the neotropical migratory bird guild is to maintain and increase healthy populations of neotropical migratory birds through restoring habitats on which they depend.

Protecting existing and restoring additional suitable wetland, riparian, and grassland habitats will be critical to maintaining healthy neotropical migrant bird populations in the Bay-Delta. Large-scale restoration of nesting habitat will help reduce nest parasitism and predation by creating habitat conditions that render neotropical birds less susceptible to these stressors. Restoration of these habitats in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will help maintain healthy populations by increasing the quality and quantity of habitats used by these species. Restoration of ecosystem processes and habitats in other ecological management zones will also allow natural floodplains, stream meanderings, seasonal pools, and riparian vegetation to develop that will provide habitat for these species elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Related restoration programs include:

- Central Valley Project Improvement Act,
- Cache Creek Corridor Restoration Plan,
- Cosumnes River Preserve,
- Riparian Habitat Joint Venture,
- Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB1086 program),
- San Joaquin River Management Program, and
- U.S. Fish and Wildlife Service's Anadromous Fish Restoration Plan.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of neotropical migratory birds is integrally linked with restoration of wetland, riparian, grassland, and forest habitats.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore and protect habitats used by neotropical migrant birds for breeding and foraging in the Bay-Delta watershed.

LONG-TERM OBJECTIVE: Substantially improve breeding and migration habitats for all neotropical migrant birds to increase their rates of reproduction and survival.

SHORT-TERM OBJECTIVE: Maintain neotropical migratory bird breeding populations at present levels and develop restoration projects that will benefit migrating individuals.

RATIONALE: Neotropical migratory birds constitute a diverse group of largely passerine songbirds that overwinter in the tropics but breed in or migrate through the Central Valley and Bay-Delta region. As a group, they are in decline because of loss of habitat on their breeding grounds, in their migratory corridors, and in their wintering grounds. The species within this group are good indicators of habitat quality and diversity and their popularity with birders means that populations are tracked and have high public interest. They can also be good indicators of contaminant levels, by monitoring reproductive success and survival in areas near sources of contamination. Riparian forests are particularly important to this group because they are major migration corridors and breeding habitat for many species. By providing improved nesting and migratory habitat, it may be possible to partially compensate for increased mortality rates in the wintering grounds. Improved habitat for songbirds also provides habitat for many other species of animals and plants.

STAGE 1 EXPECTATIONS: A "master plan" for the conservation of neotropical migrants in the Bay-Delta watershed that includes status reports and habitat requirements for all species will have been completed. This information will have been used to integrate neotropical migrant conservation into various CALFED restoration projects or to develop restoration projects specifically aimed at improving migration and breeding habitat for selected members of this group.

The following general targets will assist in meeting the implementation objective:

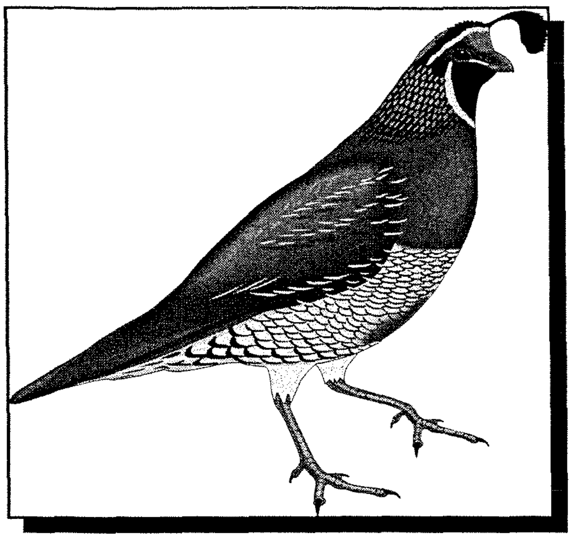
- Increase populations of neotropical birds in the Central Valley.
- Increase the distribution of neotropical birds in the Central Valley.

The following general programmatic actions will assist in meeting the targets:

- Increase wetland, riparian, grassland and habitats in the Central Valley.
- Improve upper watershed health.
- Improve specific nesting habitats for individual species within their existing and restored habitats.
- Protect nesting habitats from predators and human disturbance.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

Upland game species are of high interest to recreational hunters in the Bay-Delta and contribute to California's economy through the sale of hunting-related equipment and hunting-related expenditures. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of conversion of native upland habitats for agricultural, industrial, and urban uses, and land use practices that degrade habitats used by these species.

RESOURCE DESCRIPTION

The upland game guild includes those species defined in the California Department of Fish and Game (DFG) hunting regulations as resident and migratory upland game birds and small game. Of the three groups of upland game species that define the guild (Coastal and Central Valley, Mountain Upland, and Eastern Upland), only the coastal and Central Valley group (see table) is addressed in this vision. The montane upland game group includes species that typically inhabit the upper elevations of the Coast Ranges, Cascade Range, and Sierra Nevada. The eastern upland game group includes those species inhabiting the eastern slopes of the Sierra Nevada and eastern high deserts within California.

Upland game species commonly occur in upland habitat types, including agricultural cropland, riparian habitats, and oak woodlands. The ring-necked pheasant and wild turkey are non-native species that have successfully established in the Central Valley and are popular game for hunting. These species occur from the Central Valley floor to the foothills. Native species' population densities, with the exception of the American crow, are currently lower than they were before lands in the Bay-Delta were reclaimed. Native species are an integral part of our heritage, providing recreation and food for thousands of people. Their populations are good indicators of the health and viability of the vegetative communities on which they rely.

Throughout California, upland game habitat has been degraded or lost as a result of some types of land uses, such as logging, land conversion, water projects, intensive farming, overgrazing, and urban encroachment. Wildfires and floods also destroy many acres of nesting and escape cover.

VISION

The vision is to maintain healthy populations of upland game species at levels that can support both consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses, through protection and improvement of habitats and reduction in stressors.

Protecting and restoring existing and additional suitable riparian habitats and improving management of agricultural lands and reducing the effect of stressors that can suppress breeding success will be critical to maintaining healthy upland game populations in the Bay-Delta. The key to improving populations of upland game will be in providing increased nesting habitat and escape cover. The ERPP's proposed habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones will increase habitat quality and quantity. Restoration will also help maintain healthy populations of upland game species.

Restoring upland game habitat over a range of elevations above Bay-Delta mean-high-tide water levels would allow a greater diversity of plant species to establish. Grassland, woodland, and shrub habitats will be developed, maintained, protected, and restored in those areas that are out of the inundation zones of high water. This will provide an area that will serve as a transition zone which will greatly increase the natural processes necessary for restoring native habitat and plant communities.

Upland game species would also benefit from management strategies that would improve habitat quality. Management strategies should include protecting and maintaining important existing habitat areas and encouraging establishment and maintenance of agricultural and upland habitats used by these species. Such strategies could be implemented through cooperative agreements with land management agencies, landowner incentive programs, or conservation easements with or purchase from willing sellers.

Restoration of ecosystem processes and habitats that allow natural floodplains, meander corridors, seasonal pools, and riparian vegetation to develop will provide habitat for upland game species elsewhere in the Central Valley.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Groups that are involved in efforts to restore upland game include:

- California Department of Fish and Game wildlife program branch,
- California Department of Fish and Game's Game Bird Heritage Program,
- Pheasants Forever,
- Turkey Federation, and
- Quail Unlimited.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Protection and restoration of upland game species is integrally linked with restoration of riparian, grassland, and agricultural habitats, as well as improvements in upper watershed health.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain healthy populations and restore habitats that promote the expansion of populations at levels that can support both consumptive and nonconsumptive uses and provide additional opportunities for those uses.

LONG-TERM OBJECTIVE: Maintain self-sustaining populations of upland game birds at levels to meet or exceed population levels present during the 1970s.

SHORT-TERM OBJECTIVE: Protect and maintain important existing habitat areas and encourage the maintenance of agricultural and upland habitats used by these species.

RATIONALE: Upland game are supported by diverse agricultural and upland habitats. The key to maintaining these species is by maintaining the habitats upon which they depend.

STAGE 1 EXPECTATIONS: Important upland game habitats will have been identified as well as conditions that reduce habitat quality. Existing habitats will have been protected and, where feasible, agricultural practices will have been adjusted to improve upland game populations. The following general targets will assist in meeting the restoration objective:

- Restore grassland, shrub, and woodland habitats,
- Increase upland game populations, and
- Improve hunting opportunities.

The following general programmatic actions will assist in meeting the targets:

- Protect and restore upland habitats.
- Improve land use and agricultural land management to enhance upland game.
- Improve forest and riparian land management for upland game.
- Reduce potential for wildfire in floodplain, riparian forest, grasslands, and forest lands.

Upland Game Species and the Groups in Which They Appear

Species	Coastal and Central Valley Group	Montane Upland Game Group	Eastern Upland Game Group
Ring-necked pheasant	✔		
California quail	✔		✔
Wild turkey	✔	✔	
Common snipe	✔	✔	✔
Dove	✔	✔	✔
American crow	✔	✔	✔
Tree squirrels	✔	✔	✔
Cottontail/brush rabbit	✔	✔	✔
Black-tailed hare	✔	✔	✔
Band-tailed pigeon	✔	✔	✔
Chukar*		✔	✔
Mountain quail*		✔	✔
Sage grouse*			✔
Blue/ruffed grouse*		✔	
Ptarmigan*		✔	

*These species are not addressed by this vision.

AQUATIC HABITAT PLANT COMMUNITY GROUP

INTRODUCTION

Aquatic plant habitat in the Bay-Delta area is present in permanently flooded and intermittently exposed shallow water areas. These shallow water areas present important wetland habitat for dependent plant, wildlife, and fish species. The substantial loss of historic shallow water aquatic plant habitat has primarily resulted from reclamation and channel dredging and scouring. Loss of such habitat has reduced primary (plant) and secondary (invertebrate) productivity in the Bay-Delta area, changing important characteristics of the natural foodweb of the system and therefore leading to the decline of many native plant, fish, and wildlife species.

RESOURCE DESCRIPTION

PONDWEEDS WITH FLOATING AND SUBMERGED LEAVES. Aquatic plant habitat in the Bay-Delta area is dominated by pondweeds (*Polygonum* spp.) with floating or submerged leaves. Pondweeds are the sole or dominant herb in this community. Pondweeds with submerged leaves include crispate pondweed (*P. crispus*), eel-grass pondweed (*P. zosteriformis*), fennelleaf pondweed (*P. pectinatus*), leafy pondweed (*P. foliosus*), Nevada pondweed (*P. latifolius*), Richardson pondweed (*P. richardsonii*), Robbin pondweed (*P. robbinsii*), slenderleaf pondweed (*P. filiformis*), small pondweed (*P. pusillus*), and whitestem pondweed (*P. praelongus*). Pondweeds with floating leaves include alpine pondweed (*P. alpinus*), broadleaf pondweed (*P. amplifolius*), diverseleaf pondweed (*P. diversifolius*), floatingleaf pondweed (*P. natans*), grassleaf pondweed (*P. gramineus*), longleaf pondweed (*P. nodosus*), Nuttall pondweed (*P. epihydrus*), and shinning pondweed (*P. illinoensis*). The vegetative cover in the aquatic plant habitat ranges from continuous to intermittent or open.

VISION

The vision for plant community groups is to maintain and restore existing and rehabilitate degraded habitats that support the diverse assemblages of plants in the Bay-Delta. The vision will be attained by protecting and restoring large areas of perennial shallow water that provide habitat for pondweeds and other associated plant and wildlife species. Areas protected and restored as aquatic plant habitat would be closely associated with areas protected and restored as tidal brackish and freshwater marsh plant habitat and tidal riparian plant habitat to promote habitat diversity.

Initial efforts should focus on protecting existing aquatic habitat plant community areas. Restored areas should be linked with existing healthy habitats where feasible to provide a source of vegetative propagules and to create large contiguous areas of aquatic plant habitat. Establishing the proper gradients relative to water levels will be key in promoting the establishment of the aquatic habitat plant community. Restored habitats should have natural gradients of open water, shallow water that is suitable for supporting pondweeds, marsh, riparian, and upland habitats to increase the habitat value for a greater diversity of species.

Many leveed lands in the Bay and Delta have subsided and are too low to support shallow waters inhabited by pondweeds, and thus cannot be readily restored. The greatest subsidence has occurred in the Central and West Delta Ecological Management Unit. A comprehensive long-term program would be developed to reverse this process. Changes in land use management, and use of suitable dredged materials or other "natural materials" should be implemented to restore land elevations to suitable ranges.

Restoration efforts should focus on those leveed lands that have not yet been subjected to severe subsidence. Prime candidates are existing managed marshes and salt ponds adjacent to San Pablo and Suisun Bays. Leveed agricultural lands and some industrial lands adjacent to Suisun Bay can be readily restored to the aquatic habitat plant community.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Many programs and projects aim to protect, restore, and enhance wetland and open water habitats in the San Francisco-San Joaquin Bay-Delta estuary. These include:

- Bay Area Aquatic Habitats Planning Group;
- Cache Creek Corridor Restoration Plan;
- California Wetland Riparian Geographic Information System Project;
- Governor's California Wetland Conservation Policy;
- Inland Wetlands Conservation Program;
- Montezuma Wetlands Project;
- National Estuarine Reserve Research System;
- North Bay Initiative;
- North Bay Wetlands Protection Program;
- San Francisco Bay Regional Water Quality Control Board, and San Francisco Bay Conservation and Development Commission - Regional Wetlands Management Plan;
- San Francisco Estuary Project;
- Tidal Wetlands Species Recovery Plan;
- Wetland Reserve Program; and
- Yolo Basin Wetlands Project.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The aquatic habitat plant community group is linked to other habitats that include open water, shallow water, emergent wetland, and riparian areas, and to associated wildlife guilds. It is also linked to physical processes that include streamflow, sediment supply, geomorphology, and tides. Secondary ecosystem functions and processes that are linked with the aquatic habitat plant community group include current velocities; floodwater and sediment detention and retention; vegetation succession, overbank flooding, and floodplain inundation; and primary production. Stressors that affect this plant community group include levees, bridges, and bank protection; dredging; non-native species; dams, reservoirs, and other human-made structures; water management; gravel mining; contaminants; and human disturbance.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The strategic objective for the aquatic habitat plant community group is to increase its amount in the Delta to provide habitat for pondweeds with floating and submerged leaves as well as 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.

LONG-TERM OBJECTIVES: Develop protocols that protect existing and newly established shallow-water aquatic habitat plant communities within the Sacramento-San Joaquin Estuary from stressors and other factors. Additional efforts will need to be taken that assure newly established shallow-water aquatic plant communities consist of native aquatic vegetation and not introduced aquatic plant species (i.e. water hyacinth, hydrilla, and other aquarium trade plants).

SHORT-TERM OBJECTIVES: Establish aquatic habitat plant community in suitable areas within the Delta and Suisun Marsh. Evaluate and remove exotic plant species (i.e. water hyacinth) that out compete native aquatic vegetation. In addition, identify, reclaim, and protect areas that provide shallow-water aquatic plant communities from future development and dredging activities.

RATIONALE: Shallow-water plant communities were once abundant throughout the Sacramento-San Joaquin Estuary. Their decline came when the Delta and its associated channels were altered and dredged to form islands and exotic aquatic water plant species came into the system. The reduction in these shallow-water areas has resulted in the loss of both rearing and escape cover for many fish species that either reside in or pass through the Delta. In addition, increased shallow-water plant communities will assist in reducing turbidity and contaminate levels that exist within the system.

STAGE 1 EXPECTATIONS: Efforts will need to be undertaken that evaluate the extent of existing aquatic habitat plant community groups within the Estuary and the likely locations were additional habitats can be created and protected. Methods will also need to be developed that examine the extent of exotic aquatic plant species within the Estuary and a method of control.

The general target for restoring the aquatic habitat plant community group is to provide 500 acres in the Sacramento-San Joaquin Delta Ecological Management Zone and 500 acres in the Suisun Marsh/North San Francisco Bay Ecological Management Zone.

The following actions would help to achieve targets for the aquatic habitat plant community group restoration:

- Restore perennial shallow water habitat in concert with restoration of tidal brackish and freshwater marsh and tidal riparian plant habitat.
- Link restored areas with existing healthy habitats to provide a source of vegetative propagules and to create large contiguous areas of aquatic habitat.
- Focus restoration effort on leveed lands that have not yet experienced severe subsidence, such as leveed agricultural lands and industrial lands adjacent to Suisun Bay.
- Restore permanent open-water areas by establishing elevation gradients sufficient to maintain surface water through natural groundwater or surface-water recharge, or by pumping water into lowland areas.
- Propagate restored areas with pondweeds and control invasion by exotics until the community has become established.

TIDAL BRACKISH AND FRESHWATER MARSH HABITAT PLANT COMMUNITY GROUP

INTRODUCTION

Tidal brackish marsh habitat is located along the western edge of the Delta and in Suisun marsh. Most tidal freshwater marshes in the Delta occur as narrow, fragmented bands along island levees, channel islands, shorelines and levee blowout ponds.

Tidal brackish and freshwater marshes are important habitat areas for fish and wildlife dependent on marshes and tidal shallows and support several special-status plant species. The loss or degradation of historic tidal brackish and freshwater marshes has substantially reduced the habitat area available for associated plant, fish and wildlife species. Major factors that limit this resource's contribution to the health of the Bay-Delta are related to adverse effects of wetlands conversion to agricultural, industrial, and urban uses.

The vision for tidal brackish and freshwater marsh habitats is to restore large areas of connecting waters associated with tidal emergent wetlands and their supporting ecosystem processes. Achieving this vision will assist in the recovery of special-status plant populations depending on these habitats. It will also assist in the recovery of special-status fish populations and provide high-quality aquatic habitat for other fish and wildlife dependent on the Bay-Delta. Restoring tidal brackish and freshwater marsh would also result in higher water quality and increase the amount of shallow-water habitats; foraging and resting habitats and escape cover for water birds; and rearing and foraging habitats, and escape cover for fish. The vision for this habitat type is to protect existing tidal brackish and freshwater marshes from degradation or loss and to increase wetland habitat. Achieving this vision will assist in the recovery of special-status plant, fish, and wildlife populations, and provide high-quality habitat for other fish and wildlife dependent on the Bay-Delta.

RESOURCE DESCRIPTION

Tidal brackish marshes were once continuous from San Francisco Bay into the western Delta. Most remnants of these wetlands are narrow bands along the margins of San Pablo Bay and Suisun Marsh and Bay. Tidal brackish marshes have been substantially reduced as a result of reclamation and land use conversions to agricultural uses, actions that reduced the amount of land subject to tidal flooding.

Tidal brackish marshes are important habitats for plant, fish and wildlife species that are dependent on marshes and tidal shallows. These wetland areas serve as an important transitional habitat between open water and uplands. Furthermore, tidal exchange is the primary process that supports healthy tidal brackish marshes in the Bay-Delta. Tides flush the wetland system, replacing nutrients and balancing salinity concentrations. Land management practices such as diking have isolated most of the remaining brackish marsh wetlands from tidal flows.

Five distinct plant series are found in tidal brackish marshes; each of these is briefly described below.

PICKLEWEED SERIES: Pickelweeds (*Salicornia* species) are the dominant plants in this series. Other associated plant species can include alkali heath (*Frankenia salina)*, arrow-grasses (*Triglochin* species), dense-flowered cordgrass (*Spartina densiflora)*, dodder (*Cuscuta salina)*, fat-hen (*Atriplex patula)*, jaumea (*Jaumea carnosa)*, saltgrass (*Distichlis spicata)*, saltwort (*Batis maritima)*, sea-blite (*Suaeda californica)*, and/or sea-lavender (*Limonium californicum*). This plant series is generally less than 5 feet tall and the canopy can be continuous or intermittent.

SALTGRASS SERIES: Saltgrass (*Distichlis spicata*) is the sole or dominant grass in this series. Other associated plant species can include alkali cordgrass *(Spartina gracilis)*, alkali muhly *(Muhlenbergia asperifolia)*, alkali sacaton *(Sporobolus airoides)*, Baltic rush *(Juncus balticus)*, common pickleweed *(Salicornia virginica)*, Cooper rush *(Juncus cooperi)*, one-sided bluegrass *(Poa secunda)*, sea-lavender *(Limonium californicum)*, slender arrow-grass *(Triglochin concinna)*, and/or yerba mansa *(Anemopsis californica)*. Emergent alkali rabbitbrush *(Chrysothamnus albidus)* or iodine bush *(Allenrolfea occidentalis)* may be present. This plant series is generally less than 3.5 feet tall and the canopy can be continuous or intermittent.

BULRUSH SERIES: Bulrushes (*Scirpus* spp.) are the dominant species in this series. Common plant species include California bulrush (*Scirpus californicus)*, common three-square (*Scirpus americanus)*, common tule (*Scirpus acutus)*, Nevada bulrush *(Scirpus nevadensis)*, river bulrush (*Scirpus fluviatilis)*, and saltmarsh bulrush (*Scirpus maritimus)*. Other associated plant species can include broadleaf cattail (*Typha latifolia)*, narrowleaf cattail (*Typha angustifolia)*, saltgrass (*Distichlis spicata)*, slenderbeaked sedge (*Carex athrostachya)*, southern cattail *(Typha domingensis)*, umbrella flatsedge *(Cyperus eragrostis)*, water-plantain *(Alisma plantago-aquatica)*, and/or yerba mansa *(Anemopsis californica)*. The species in this series are generally less than 13 feet tall and the cover can be continuous or intermittent.

CATTAIL SERIES: Cattails, including broadleaf cattail *(Typha latifolia)*, narrowleaf cattail *(Typha angustifolia)*, and southern cattail *(Typha domingensis)*(*Typha* spp.) are the dominant plants in this series. Associated plant species can include California bulrush *(Scirpus californicus)*, common three-square *(Scirpus americanus)*, common tule *(Scirpus acutus)*, Nevada bulrush *(Scirpus nevadensis)*, river bulrush *(Scirpus fluviatilis)*, saltgrass *(Distichlis spicata)*, saltmarsh bulrush *(Scirpus maritimus)*, slender-beaked sedge *(Carex athrostachya)*, umbrella flatsedge *(Cyperus eragrostis)*, water-plantain *(Alisma plantago-aquatica)*, and/or yerba mansa *(Anemopsis californica)*. The plants in this series are generally less than 13 feet tall and the cover can be continuous, intermittent, or open.

COMMON REED SERIES: Common reed (*Phragmites australis*) is the dominant plant in this series. The community may include emergent shrubs and trees. However, few other species are generally present. Common reed generally grows less than 13 feet tall and the cover is typically be continuous.

Diking of historic wetlands greatly reduced the amount of tidally influenced marshes in the Delta. Reservoir operations and other water management practices that control California's inland water supplies have reduced saltwater intrusion into the Delta by retaining water during winter and releasing water during summer. These complex water management activities resulted in reduced saltwater intrusion into the Delta, thereby reducing the area that can support brackish wetlands. Preservation of the largest single area of brackish marsh habitat in California has been accomplished at Suisun Marsh through implementation of a complex water control system.

Prior to the mid-1800s, extensive areas of tidal freshwater marsh habitat occurred throughout the Central Valley, particularly in the Delta. A complex network of rivers, sloughs, and channels connected low islands and basins that supported a diverse and dense variety of freshwater marsh vegetation. This freshwater marsh vegetation supported a diversity of plant, fish and wildlife species and ecological functions. Vast areas of the Sacramento-San Joaquin Valleys were commonly flooded in winter by a slow-moving blanket of silt-laden water. Flood control activities and land settlements in the late 1800s and early 1900s led to the development of leveed Delta islands. Levees and other land uses led to the loss of freshwater marshes in the Delta. Loss of wetlands has substantially reduced habitat for wetland wildlife species in the Bay-Delta system. Freshwater marsh losses have also substantially reduced the area available for the biological conversion of nutrients in the Delta. The Delta contains insufficient wetland area to provide adequate levels of nutrient transformation, which results in lower quality water in San Francisco Bay.

The loss of freshwater marshes has substantially reduced the habitat of several plant and wildlife species. Some species have been designated as California or federal special-status species and are threatened with local extermination. At least eight special-status plant species, Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap, are native to the Delta. Most of these plants are adapted to a complex tidal cycle and are typically found with more common vegetation such as tule, cattails, common reed, and a great diversity of other herbaceous plant species. Changes in habitat conditions have allowed the invasion of hundreds of non-native weedy plant species. Some of these species, such as water hyacinth, now clog waterways and irrigation ditches and reduce overall habitat quality for native plants and wildlife. Over 50 species of birds, mammals, reptiles, and amphibians use freshwater marshes in the Delta. Populations of some wildlife species that are closely dependent on freshwater marshes, such as the California black rail, giant garter snake, and western pond turtle, have been substantially reduced in the Delta and designated as special-status species. A few wetland-associated species, such as waterfowl and egrets, have successfully adapted to foraging on some types of Delta croplands converted from historic wetland areas.

Isolating wetlands from tidal flows and removing Delta island freshwater marshes changed the ecological processes that support wetlands. Removing the perennial water and vegetation from the organic soils of Delta islands resulted in soil oxidation and, subsequently, the subsidence of the interior islands. Loss of these tidal flows to islands has reduced habitat for native species of fish, plants, and wildlife; reduced water quality; and decreased the area available for floodwater dispersion and suspended silt deposition.

High tidal velocities in confined Delta channels continue to erode remaining freshwater marshes at a greater rate than habitat formation. Continued erosion reduces the amount of freshwater marshes and changes the elevation of the land. Elevation affects the types of plant species that can grow depending on a species' ability to tolerate flooding. Flood protection and levee maintenance continue to impair wetland vegetation and prevent the natural reestablishment of freshwater marshes in some locations.

Wind, boat-wake waves, and high water velocities in confined channels actively erode the soil needed to support remnant freshwater marshes. Continued erosion of existing habitat, such as midchannel islands and levees and levee berms, is currently the primary cause of habitat loss in the Delta.

VISION

Restoration of tidal brackish and freshwater marsh habitat would focus on protecting and improving important existing wetlands, such as channel islands, and restoring wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

Restoring tidal brackish marsh is dependent on restoring tidal flows, establishing and maintaining healthy estuarine salinity gradients appropriate, and reestablishing elevation gradients from open water to uplands. The following actions would help achieve saline emergent wetlands restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;

- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to control seasonal freshwater inflows to the Delta;

- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the needs of other habitats; and

- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plant species, including special-status species, that are adapted to different elevations and provide a broader range of habitats for wildlife.

Enhancing and increasing tidal brackish marsh habitat would also help to increase water quality. Areas restored to tidal flow will contribute to the aquatic foodweb of the Bay-Delta and provide fish rearing habitat. Restoring tidal brackish marshes would improve the ecological value of adjacent associated habitats, including tidal aquatic habitats, and will provide an important transitional zone between open water and uplands.

Other habitat restoration efforts will be directed toward reestablishing native plant species, controlling competitive weedy plants, increasing the quality of adjacent upland habitats to provide refuge for wildlife during high tides, and modifying land use practices that are incompatible with maintaining healthy wetlands. Restoring saline emergent wetlands would be coordinated with restoration of other habitats to increase overall habitat values. For example, saline emergent wetland greatly increases wildlife habitat quality of deep and shallow open-water areas and adjacent grasslands.

To prevent further loss of existing freshwater marshes, erosion rates must be reduced. Inchannel islands and levee berms are of particular concern. Erosion losses could be offset by allowing deposition and wetland establishment. Wetlands erosion could be reduced by reducing boat speeds where wetlands are subject to boat-wake-induced erosion (e.g., Snodgrass Slough). Constructing protective structures around eroding channel islands would weaken wave action (e.g., wave barriers and riprap groins) in a way that retains habitat value for fish and wildlife. Protecting inchannel islands from further erosion and connecting with larger islands would provide greater protection for this unique habitat.

Restoring freshwater marsh habitat is dependent on local hydrological conditions (e.g., water depth, water velocity, and wave action); land elevation and slope; and the types and patterns of sediment deposition. The approach to restoring freshwater marshes would include:

- reestablishing the hydraulic, hydrologic, and depositional processes that sustain freshwater marshes and inchannel islands;

- restoring a full spectrum of wetland elevations to allow the establishment of a greater diversity of plant species, including special-status species adapted to different elevations within the tidal or water (nontidal sites) column; and

- providing a broader range of habitats for wildlife.

Restoration of freshwater marshes would be coordinated with restoration of other habitats to increase overall habitat values. Restoration would also include reestablishment of the full diversity of freshwater marsh plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Protecting and restoring freshwater marshes could be accomplished by implementing elements of existing restoration plans such as Central Valley Habitat Joint Venture; expanding State and federal wildlife areas to create additional wetland complexes; improving management of existing and restoring additional freshwater marshes on private lands; and reestablishing connectivity between the Delta and Delta islands, and between channels with their historic floodplains.

Major opportunities exist for restoring tidal freshwater marshes. Actions that would help restore fresh emergent wetlands include:

- Setbacks or breaches of island levees to allow water flows to naturally reestablish wetlands.
- Increase land elevations in the interior of Delta islands where subsidence has lowered land elevations below tidal emergent wetlands
- Use substrate materials to create levee berms at elevations necessary for freshwater emergent vegetation
- Modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally reestablish.
- Reintroduce native wetland plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;
- establishing additional incentive programs to encourage landowners to establish and maintain freshwater marsh wetlands; and
- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of freshwater marshes elsewhere in the Central Valley.

These protection and restoration needs could be met by establishing cooperative efforts between government and private agencies. This effort would coordinate implementation of existing restoration strategies and plans; develop and implement alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery; provide incentives to private landowners to implement desirable land use practices; establish additional incentive programs to encourage landowners to create and maintain saline emergent wetlands; and protect existing habitat areas from future degradation through acquisition of conservation easements or purchase from willing sellers.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore tidal brackish and fresh emergent marsh habitat would involve cooperation with other wetland restoration and management programs. These include:

- Agricultural Stabilization and Conservation Service's Wetland Reserve Program.
- Wildlife Conservation Board's Inland Wetland Conservation Program

- restoration programs administered by Ducks Unlimited and the California Waterfowl Association

- the Suisun Marsh Protection Plan

- ongoing management of State and federal wildlife refuges and private duck clubs

- and the San Francisco Bay Wetlands Ecosystem Goals Project

Proposed ERPP targets may be adjusted to reflect goals identified by the San Francisco Bay Wetlands Ecosystem Goals Project. Restoration efforts would be conducted in cooperation with agencies or organizations with responsibility or authority for restoring wetland and aquatic habitats, including:

- U.S. Bureau of Reclamation

- California Department of Fish and Game,

- California Department of Water Resources,

- U.S. Fish and Wildlife Service,

- U.S. Army Corps of Engineers,

- and the Delta Protection Commission

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Tidal brackish and freshwater marshes are linked to other ecological elements in the Bay. Tidal exchange is an important ecological function that restores the proper salinity and nutrient balance and mixed fresh and estuarine waters.

Tidal brackish and freshwater marshes are closely linked to open water areas and upland habitats. The value of each habitat is increased by the presence and quality of the adjacent types of habitats. A variety of aquatic and terrestrial fish, wildlife and plant communities depend on healthy tidal brackish and freshwater marshes. These include Suisun Marsh aster, California hibiscus, bristly sedge, Jepson's tule pea, Mason's lilaeopsis, marsh mudwort, Sanford's arrowplant, and marsh scullcap and the salt marsh harvest mouse.

Tidal brackish marshes are impaired by reduced seasonal inflows of fresh water, land use, and loss of upland habitat, and introduction an proliferation of invasive salt marsh plant species. Stressors that have reduced the extent of fresh emergent wetlands include flood protection practices, levee construction, and the loss of tidal flow. Increased velocities in Delta channels causes erosion of wetlands and changes the elevation of the land. Wind and boat wake erosion also contribute to the loss of soil needed to support fresh emergent wetlands in area where midchannel islands and levee berms are present.

STRATEGIC OBJECTIVE, TARGETS AND PROGRAMMATIC ACTIONS

The Strategic Objective for tidal brackish and freshwater marsh is to protect and enhance existing wetlands by restoring tidally influenced brackish and freshwater marsh areas in the Delta. The increased wetland area would expand the populations and ranges of associated special-status plant and animal species and would provide habitat for waterfowl, shorebirds, and other associated wildlife. It would also provide rearing habitat, foraging habitat and escape cover for fish.

LONG-TERM OBJECTIVES: Protect and restore, on a self-sustaining basis, throughout the Bay-

Delta, multiple large areas of tidal brackish and freshwater marsh in association with tidal perennial and perennial grassland to a point where all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVES: Identify, locate, and conserve existing, high quality tidal brackish and freshwater marsh. Restore several large areas of tidal brackish marsh in the Suisun Marsh and several large areas of tidal freshwater marsh in the Delta.

RATIONALE: Tidal brackish and freshwater marsh wetlands are two habitats that support a diverse and unique plant assemblage. Some of the most endangered plants, such as the Suisun thistle, is found only in tidal brackish marsh wetlands in the Suisun Marsh. They merit special attention because their restoration is urgently needed for the benefit of many species, both plant and animal. They also represent, by acreage, some of the largest restoration projects that are likely to be attempted in the system. Prior to implementing larger scale tidal restoration projects, a determination will be made about whether suitable elevation, topography, and geomorphological conditions exist to allow the successful restoration of natural marsh building processes.

STAGE 1 EXPECTATIONS: Ongoing efforts to restore large expanses of tidal brackish and freshwater marsh will have continued and experimental pilot projects to restore tidal marshes to areas in the Suisun Marsh and San Pablo Bay and Delta islands will have been undertaken.

The following action would help achieve tidal brackish marsh restoration:

- restore tidal flows to diked wetlands by breaching dikes in suitable areas;
- establish desirable estuarine salinity gradients by managing water diversions and water releases from upstream reservoirs to controls seasonal freshwater inflow into the Delta;
- balance seasonal flows from reservoirs for fisheries, water conveyance, flood control, and the need of other habitats;
- restore a more natural elevation gradient in wetlands to allow a greater diversity of native saline plants species, including special-status plant species that are adapted to different elevations and provide a broader range of habitats for wildlife.

Actions that would help restore tidal freshwater marsh include:

- setbacks or breaches of island levees to allow water flows to naturally reestablish wetland;
- increase land elevations in the interior of Delta islands where subsidence has lowered land elevation below tidal emergent wetlands;
- use of substrate materials to create levee berms at elevations necessary for freshwater marshes;
- modify, where consistent with flood control objectives, levee vegetation management practices to allow wetland vegetation to naturally establish;
- reintroduce native plants into suitable sites.

These protection and restoration strategies could be implemented by:

- establishing cooperative efforts between government and private agencies to coordinate the efficiency of implementing existing restoration strategies and plans;
- developing and implementing alternative land management practices on public lands to improve wetland habitat quality or promote habitat recovery, and provide incentives to private landowners to implement desirable land use practices;

- establish additional incentive programs to encourage landowners to establish and maintain freshwater marshes; and

- protecting existing habitat areas from potential future degradation through acquisition of conservation easements or purchase from willing sellers.

Restoration of stream meander belts and the process of overbank flooding along major tributaries to the Bay-Delta as proposed in the ERPP in other ecological management zones will also create the conditions necessary for the natural reestablishment of tidal brackish and freshwater marsh habitats elsewhere in the Central Valley.

Seasonal Wetland Habitat Plant Community Group

Introduction

The Bay-Delta seasonal wetland habitat plant community group includes vernal pools and seasonally flooded areas. Vernal pools are probably best described as specialized components of terrestrial (land-based) habitats and requiring specific geomorphic features. Other seasonally flooded areas may be described as areas which flood for periods that are too long to support characteristic upland vegetation. Seasonally flooded areas may occur in low grassland basins, the perimeter of the permanent marshes, and within a stream course or its floodplain. Historically, seasonal wetlands occurred throughout the Central Valley. Loss of seasonal wetland habitat, vernal pools in particular, has directly resulted in the listing of several species as threatened or endangered under the federal Endangered Species Act.

Major factors that limit the contribution of this habitat type to the health of the Bay-Delta are related to adverse effects of land conversion, and substantial reductions in seasonal overbank flooding.

Resource Description

Vernal pools are associated with soils (claypan, hardpan) that maintain standing water after winter and spring rains. In some areas of the Central Valley, high spring flows from the rivers and creeks saturate soils. Seasonal wetlands are created when puddles or small ponds form in depressions or standing water remains in low-lying grass fields after river flows recede. Although aquatic plants can establish in areas that are frequently flooded, upland plants cannot survive.

Vernal pools are seasonally flooded depressions formed where a barrier, such as a clay pan or cemented hard pan, restricts percolation of rainwater and runoff from adjacent areas during the winter rainy season. They support a distinctive herbaceous biota adapted to periodic or continuous inundation during the wet season and desiccated soils during the dry season (Holland and Jain 1977, Holland 1978, Thorne 1984, Zedler 1987, Jones & Stokes Associates 1990). Vernal pools usually occur in depressions between small mounds or ridges in a hummocky, rolling, or reticulated landscape. They vary in size from several yards to well over 1 acre and the largest pools are really seasonal lakes, like Olcott Lake at the Jepson Prairie Preserve in Solano County. Vernal pools are common in grasslands in northern Central Valley where the natural geomorphology remains relatively unchanged.

Species commonly found as dominants in vernal pools include goldfields (*Lasthenia* spp.), navarretia (*Navarretia leucocephala*), prostrate pigweed (*Polygonum arenastrum*), coyote thistle (*Eryngium* spp.), woolly marbles (*Psilocarphus* spp.), popcorn flowers (*Plagiobothrys* spp.), downingias (*Downingia* spp.), annual hairgrass (*Deschampsia danthonioides*), and common spikerush (*Eleocharis macrostachya*). Many State- and federally listed plants, invertebrates, and wildlife, including Contra Costa goldfields (*Lasthenia conjugens*), legenere (*Legenere limosa*), western spadefoot toad (*Scaphiopus hamondii*), California tiger salamander (*Ambystoma tigrinum*), and various fairy shrimp, are native to or associated with vernal pools. In addition, a variety of birds, including migrating waterfowl, shorebirds, and ground-nesting birds such as meadowlarks, commonly use seasonal wetlands habitat.

Vernal pools are best distinguished from one another by specific geomorphic features then by plant species composition. This is because the species composition and the relative cover by each species varies not only between pools, but varies from season to season within the pools. Two vernal pool ecosystem types are recognized in the Bay-Delta region. They are northern claypan vernal pools and northern hardpan vernal pools.

Northern claypan vernal pools contain mixo-saline water to freshwater ponded over claypans. They occur on neutral to alkaline, silica-cemented hardpan soils which are often saline. They are more widespread in the south San Joaquin Central Valley but range north into the Sacramento Central Valley area. Alkaline types of claypan vernal pools are characterized by a high alkaline salt content and dominance by plant species adapted to these conditions. Alkaline pools occur on extremely salty soils such as the Pescadero clay series underlying Olcott Lake in the Jepson Prairie Preserve. Alkaline pools support common alkaline plants such as alkali heath (*Frankenia salina*), alkali mallow (*Malvella leprosa*), and alkali weed (*Cressa truxillensis*). Some special status plants found in alkaline pools include bearded popcorn flower (*Allocarya histriculus*), Solano grass (*Tuctoria mucronata*), and Colusa grass (*Neostapfia colusana*).

Northern hardpan vernal pools contain mixo-saline water to freshwater impeded by hardpans. They occur on old, acidic, iron-silica cemented soils including Corning, Redding, and San Joaquin soil series. They are typically found on old alluvial fans ringing the Central Valley.

Seasonally flooded areas play a vital role in the natural succession of plant communities. Seasonally flooded areas that maintain surface water for long periods may support herbaceous plant dominants in three recognized plant communities - cattails, bulrushes, and sedges. Historically, these emergent plant species were probably prevalent along natural stream courses where long-standing water reduced the ability of upland species to establish. These types of wetlands provide the essential building blocks for the future establishment of riparian (streambank) scrub and eventually riparian woodland. Beyond the normal river flows, wetlands probably formed where rains and high flows left areas too wet for terrestrial plants to establish. These wetland areas provide high-quality habitat for a special status plant, Sanford's arrowhead (*Sagittaria sanfordii*), and a variety of wildlife including waterfowl, other migratory birds, shorebirds, red-legged frogs, giant garter snakes, and tricolored blackbirds.

The continued existence of the seasonal wetland habitat plant community group is closely linked to overall ecosystem integrity and health. Although many species that use seasonal wetlands are migratory (e.g., waterfowl and sandhill cranes), many others have evolved (e.g., spadefoot toad, fairy shrimp, and many specialized plants) and adapted to seasonal wetlands.

The extent and quality of the seasonal wetland habitat plant community group has declined because of cumulative effects of many factors, including:

- modification of natural geomorphology such as ground leveling for agriculture and development,
- adverse effects of overgrazing,
- contamination from herbicides,
- establishment of non-native species that have an adverse effect on native wetland plants and wildlife,
- flood control and water supply infrastructure that reduces overbank flooding and floodplain size, and
- reduction of the natural underground water table that supported wetlands.

Existing wetland regulations have been in effect for several years in an attempt to prevent the further loss of wetlands. The protected status of wetlands has resulted in an extensive permitting process for construction in wetland areas. Mitigation measures have been developed to offset loss of existing wetlands as a result of construction activities. These efforts have slowed the rate of wetland loss in many areas. Large-scale efforts in areas such as the Suisun Marsh, Grasslands Resource Conservation District, Yolo Bypass, Cosumnes River Preserve, Jepson Prairie Preserve, and Butte Sink have been successful in maintaining and restoring seasonal wetlands.

VISION

The vision for the seasonal wetland habitat plant community group is to improve the quality and extent of these habitat plant community group by restoring ecosystem processes that sustain them, preserving and enhancing their linkage to important other habitat plant community groups and reducing the effect of stressors.

Restoration of seasonal wetland habitat will focus on protecting and improving important existing wetlands, reestablishing vernal pools within and adjacent to existing ecological reserves, and restoring seasonal wetlands in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Seasonal wetland restoration will be coordinated with restoration of other habitats, including shallow-water and riparian woodland and scrub. Restoration would include reestablishment of the full diversity of seasonal wetland plant associations to ensure that the habitat needs of special-status and other species that are dependent on specific vegetation associations are met.

Actions that would help protect and restore seasonal wetland habitat plant communities are contained in the Vision for Seasonal Wetland habitat.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore seasonal wetland habitat plant communities would involve cooperation with other restoration programs, including:

- Upper Sacramento River Fisheries and Riparian Habitat Council,
- Suisun Marsh Protection Plan,
- California Department of Fish and Game wildlife areas,
- U.S. Fish and Wildlife Service refuges,
- Cosumnes River Preserve,
- Jepson Prairie Preserve,
- Solano County Farmland and Open Space Land Trust,
- Ducks Unlimited Valley Care Program,
- California Waterfowl Association,
- Cache Creek Corridor Restoration Plan,
- The Nature Conservancy,
- California Native Plant Society,
- Putah Creek South Fork Preserve,
- Woodbridge Ecological Reserve,
- Yolo County Habitat Conservation Plan,
- and Central Valley Habitat Joint Venture.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The seasonal wetland habitat plant community group is linked to other ecosystem elements in the ERPP Study Area. The seasonal wetland habitat plant community group includes vernal pools and seasonally flooded areas that support many species and communities of wildlife and plants. Seasonal wetland habitat plant communities are linked to primary and secondary physical processes including geomorphology, vegetation succession, overbank flooding, and floodplain inundation. Seasonal wetland habitat plant communities are linked to stressor elements including land use, non-native species, water management, and human disturbance. Seasonal wetland habitat plant communities are linked to habitat elements including vernal pool, seasonal wetland, and emergent wetland habitats. Links to wildlife elements include the greater sandhill crane, fresh emergent wetland wildlife guild, riparian wildlife guild, shorebird and wading bird guild, waterfowl guild, and native amphibians and reptiles. Vernal pool special-status plant species is also linked to seasonal wetland habitat plant communities.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for the seasonal wetland habitat plant community group is to 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 habitat for plant and wildlife resources including State- and federally listed plants, invertebrates, and wildlife that use or occur in vernal pools and seasonally flooded areas.

LONG-TERM OBJECTIVES: Restore, protect and manage, throughout the watershed, multiple large areas of seasonal wetlands in association with other aquatic, wetlands, riparian, and perennial grassland habitat types in the Central Valley to a point where the needs of seasonal wetland associated plants such as Sanford's arrowhead and alkali heath are met and all at-risk species that depend on the habitat are no longer at risk.

SHORT-TERM OBJECTIVES: in the Bay-Delta, and begin implementation of action plans for restoring significant, large areas of seasonal wetland.

RATIONALE: Restoring seasonal wetlands in combination with other wetland and upland habitat types will help restore and maintain the ecological health of aquatic, terrestrial, and plant resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Seasonal wetlands will provide high quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds. Restoration of seasonal wetlands will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Furthermore, restoring other wetland habitats in the Delta, such as tidal emergent wetland and tidal perennial aquatic habitat, can reduce habitat values for species such as waterfowl and the State listed greater sandhill crane. Increasing seasonal wetlands in the Delta will ensure that any adverse impacts associated with those habitat losses will be fully mitigated. Each habitat, including seasonal wetlands, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms and rare plants will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large seasonal wetland projects will have been initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring seasonal wetlands in heavily subsided areas where land elevations are too low to support actions to restore aquatic habitat. At least one project will be associated with expanding the vernal pool wetlands in the northeastern Suisun Marshlands and Bay Ecological Management Unit adjacent to the Yolo Basin Ecological Management Zone.

Actions that would help protect, restore, and enhance seasonal wetlands are contained in the Vision for Seasonal Wetlands and as follows:

- implement existing restoration plans,
- expand public and private preserves and wildlife areas to create additional wetland complexes, including vernal pools and seasonally flooded areas,
- improve management of existing wetlands and restore seasonal wetlands on private lands,
- reconnect channelized streams and rivers to their historic floodplains,
- develop and implement alternative land use practices on public and private lands that will protect and improve vernal pools and seasonally flooded areas and allow existing, compatible land uses, such as seasonally-managed grazing, to continue,
- establish incentive programs to encourage landowners to establish and maintain seasonal wetlands, and
- develop vegetation management programs to enhance habitat value and reduce impacts from stressors such as introduced species.

Inland Dune Habitat Plant Community Group

Introduction

Inland dune scrub is associated with inland sand dunes and is limited to the Delta in the vicinity of the Antioch Dunes Ecological Reserve. This habitat area supports two plant and one butterfly species listed as endangered under the federal Endangered Species Act. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants.

Resource Description

Antioch Dunes. Inland dune scrub is localized in areas of wind-modified stream deposits in the south and western Delta. Inland dune scrub exists between Antioch and Oakley, south of Rio Vista, and on Brannan Island. Soil information indicates that the total inland sand-dune habitat within Contra Costa, Solano, and Sacramento Counties was historically less than 10,000 acres. Remaining habitat areas are being protected. Most protected inland dune scrub is located within the Antioch Dunes Ecological Reserve and Brannan Island State Park. These protected areas represent important, but small, relictual examples of this unique habitat.

The vegetation at Antioch Dunes consists of scattered forbs and grasses that form a ground canopy. Characteristic plant species include Antioch dunes evening-primrose (*Oenotherea deltoides* ssp. *howellii*), California croton (*Croton californicus*), California matchweed (*Gutierrezia californica*), Contra Costa wallflower (*Erysimum capitatum*), devil's-lettuce (*Amsinckia tesselata*), lessingia (*Lessingia glandulifera*), nude buckwheat (*Eriogonum nudum* var. *auricalataum*), and telegraph weed (*Heterotheca grandiflora*). Individual emergent shrubs or coast live oak (*Quercus agrifolia*) trees may be present over the ground canopy. The ground layer is generally open, and annual plants are seasonally present. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes.

Direct and indirect disturbances are reducing the extent and health of inland dune scrub habitat and its associated plants and animals. Sand mining directly removes habitat. Urban development has moved onto historical dune habitat and changed wind-flow patterns. Excessive foot traffic, off-road vehicle traffic, and grazing disturb dune surfaces, which makes dunes more susceptible to erosion. Application of herbicides, pesticides, and fertilizers change ecological processes that may encourage or support non-native species. Structures or activities that reduce or accelerate winds, wind-disturbances, or barriers to wind-driven sand movement disrupt the process that sustain dunes. Wind patterns blow river-deposited sand into shifting dunes. Shifting sand offers little stability for establishing plant root systems. Plant species characteristic of dunes survive within a disturbance threshold. Direct disturbances inhibit the ability of dune-associated plants to establish and result in loss of plant vigor or mortality. Sand movement barriers create conditions unfavorable for establishing native dune vegetation. These types of disturbances create site conditions conducive to establishing invasive weedy plants. Non-native weeds compete with native dunes plants and reduce overall habitat quality. Continued disturbance of potentially restorable adjacent habitat could interfere with protecting and restoring additional areas of high-quality habitat by affecting dune structure and destroying buckwheat which serves as foot for the Lange's metalmark, a federally listed as endangered species, as well as the federally listed Antioch dunes evening primrose and Contra Costa wallflower.

VISION

The vision for inland dune scrub habitat is to protect and enhance existing areas and restore former habitat areas. Achieving this vision will provide high-quality habitat for associated special-status plant and animal populations.

Restoration of inland dune scrub would focus on protecting and improving important existing habitat areas. Historic inland dunes adjacent to existing ecological reserves in the Sacramento-San Joaquin Delta Ecological Management Zone would be reestablished. Protecting and restoring inland dune scrub habitat would begin by identifying areas that are not currently managed for their resource values. Appropriate methods to protect and restore identified areas would be developed. Protected habitat areas would be evaluated to determine effective restoration management practices to increase habitat value. The results of these evaluations would determine how habitat would be protected and restored. For example, importing sand from areas proposed for development into low-quality areas proposed for restoration will provide important natural substrate that will increase the restoration potential. Management of the inland dune areas that are currently protected should focus on maintenance of the natural conditions to assure the natural dune ecosystem process is continued.

Reduction of stressors will be the key in establishing a long-term protection programs. In protected areas, management would include reducing human access to dune areas. Development of small boardwalks will reduce human disturbance in areas where recreational access or interpretive trails are needed. Access to the dunes by motorized or other vehicles would be prevented except as part of restoration and enhancement activities. Management activities would include exotic weed plant species removal and habitat enhancement to allow the establishment of native inland dune species. Use of herbicides, pesticides, and fertilizers would be eliminated except if it is necessary for specific non-native weedy plant species removal.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore inland dune habitat will involve cooperation with programs managed by the Antioch Dunes National Wildlife Refuge. Cooperation from agencies with responsibility or authority for restoring inland dune habitat will be solicited. These include:

- California Department of Fish and Game,
- U.S. Fish and Wildlife Service,
- U.S. Army Corps of Engineers, and
- Delta Protection Commission.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Inland dune scrub habitat is limited to the area near the Antioch Dunes Ecological Reserve. This type of habitat is important for two plant and one butterfly species listed as endangered under the federal Endangered Species Act.

It is adversely affected by human caused actions that contribute to erosion and spread of non-native species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for inland dune scrub habitat is to improve low- to moderate-quality Delta inland dune habitat to support special-status plant and animal species and other associated plant and wildlife species.

LONG-TERM OBJECTIVE: Protect, manage, and restore, on a self-sustaining basis, inland dune habitat in the vicinity of Antioch Dunes Ecological Reserve and the invertebrate and plants species that depend on this habitat.

SHORT-TERM OBJECTIVE: Improve or restore existing dune habitat within the Antioch Dunes Ecological Reserve and identify and conserve existing inland dune scrub habitat adjacent to the reserve.

RATIONALE: Inland dune scrub is associated with inland sand dunes and is limited to the vicinity of the Antioch Dunes National Wildlife Refuge. Major factors that limit this resource's contribution to the health of the Delta are related to adverse effects of sand mining, dune conversion to other land uses, dune stabilization, and land use practices that maintain the dominance of non-native plants. Two special-status plant species, the Antioch Dunes evening primrose and the Antioch Dunes wallflower, are found with inland dune scrub. The Lange's metalmark, a butterfly listed as endangered under the federal Endangered Species Act (ESA), is known only from the Antioch Dunes, where it feeds on naked buckwheat. The low nutrient conditions of the soils and natural instability of dune sands limit the amount of vegetation that establishes on the inland dunes. The dunes represent a localized habitat that does not support other types of upland vegetation.

STAGE 1 EXPECTATIONS: The feasibility of reestablishing inland dune scrub habitat on historic dunes adjacent to the existing ecological reserve will have been completed. The most appropriate means to protect and restore identified areas adjacent to and within the reserve will have been completed and at least partially implemented. Small boardwalks will have been constructed to reduce human disturbance in areas where access or interpretive trails are required.

Managing protected areas could include reducing disturbance of dunes and dune vegetation. This could be accomplished by reducing vehicle and pedestrian access to dune areas. Protective structures, such as small boardwalks could be built. These actions would reduce habitat disturbance while maintaining recreational access. The following actions would help restore inland dune habitat:

- remove barriers to wind-driven sand-dune movement to increase the area that would be available for natural expansion of the sand-dune base.
- import sands from areas being developed or clean sand dredged from Bay-Delta channels to increase restoration potential and dune area.
- control non-native weeds to recreate conditions suitable for reestablishment of native dune plants.
- reduce the use of herbicide, pesticides, and fertilizers that adversely effect native dune vegetation and wildlife.

Dune habitat protection and restoration strategies could be implemented through cooperative efforts with existing ecological reserves. Restoration efforts should focus on implementing existing protection and restoration programs, establishing cooperative agreements with land management agencies, and establishing conservation easements of purchasing land from willing sellers.

Tidal Riparian Habitat Plant Community Group

Introduction

The tidally influenced shorelines of rivers and the Delta are often vegetated with woody riparian trees and shrubs. The structure of this riparian vegetation can be like that of a forest, woodland, or scrub or may be a mosaic of these formations. Riparian vegetation supports a great diversity of wildlife species and serves as important habitat for a variety of resident and migratory songbirds. Riparian vegetation also shades riverine aquatic habitat which is important habitat for many species of fish, waterfowl, and wildlife.

Major factors that limit these plant communities' contribution to the health of the Bay-Delta include historic riparian vegetation loss or degradation and nearshore aquatic habitat alteration from channelization, stabilization of channel banks with riprap, construction of levees, and control of flows.

Restoring riparian vegetation will involve reactivating or improving natural physical processes. Natural streamflows, stream meanders, and sediment transport create and sustain these vegetation types and increase the complexity and structural diversity of the habitat. Natural sources of gravel and other sediments along rivers and floodplains provide materials needed to create and sustain healthy riparian vegetation. Where improvements to physical processes do not adequately restore riparian vegetation, direct modification may be necessary to restore vegetation to its target acreage and quality.

A major increase in tidal riparian plant community groups will improve the foodweb and provide important habitat for threatened and endangered terrestrial wildlife species, such as the yellow-billed cuckoo and Swainson's hawk. More extensive and continuous riparian vegetation cover on along rivers and in the Delta will stabilize channels; help to shape submerged aquatic habitat structure; benefit the aquatic environment by contributing shade, overhead canopy, and instream cover for fish; and reduce local water temperatures. More extensive and continuous riparian vegetation associated with woody debris (branches and root wads) and leaf and insect drop in shallow aquatic habitats will increase the survival and health of juvenile salmonids and resident Delta native fish. Achieving this objective will also greatly enhance the scenic quality and recreational experience of the Delta and its waterways.

Resource Descriptions

Tidal riparian habitat includes several plant community groups. Environmental factors such as substrate, hydrology, and degree of salt water influence determine which plant community group will occur in a given area. The plant community groups that comprise tidal riparian habitat include black willow, sandbar willow, white alder, buttonbush, Mexican elderberry, and valley oak series.

Historically the Central Valley floor had approximately 922,000 acres of riparian vegetation (Katibah 1984) supported by a watershed of more than 40,000 square miles. Today, approximately 100,000 acres of riparian forest remain. About half of this riparian habitat is in a highly degraded condition, representing a decline of 90% (Katibah 1984). The Sacramento River once supported 500,000 acres of riparian forest; it now supports 10,000 - 15,000 acres, or just 2-3% of historic levels (McGill 1979, 1987). From about 1850 to the turn of the century, most of the forest was destroyed for fuel as a result of the Gold Rush and river navigation, and by large agricultural clearing. Additional clearing in the early and mid 1900s coincided with the aftermath of flood control reservoir and levee projects.

These projects allowed for the clearing of floodplain riparian vegetation for orchards, crops, flood bypasses, and urban areas. Similar activities have occurred on the San Joaquin River and other rivers in the Central Valley.

Riparian areas along rivers within the Delta, and areas within the Delta itself, are influenced by the daily ebb and flow of the tide in the Pacific Ocean. Six distinct plant series are found within these tidal riparian areas: black willow series, narrowleaf willow series, white alder series, buttonbush series, Mexican elderberry series, and valley oak series. These six series are briefly described below:

Black Willow Series: In the black willow series black willow is the sole or dominant woody plant that forms a forest or shrubland. In this series black willow can be a tree or a shrub depending on frequency or severity of disturbance, or the seral stage of the site. Other trees occasionally found in the canopy include California sycamore, Fremont's cottonwood, white alder, and Oregon ash. Other shrubs that may be present in the black willow series include other species of willow, mulefat, Mexican elderberry, and Himalaya berry. The herb layer in black willow series can vary greatly depending on substrate conditions and site hydrology (Sawyer et al. 1996).

Black willow series is typically found at sites that are seasonally flooded or saturated with freshwater along low-gradient depositions along rivers, streams, or sloughs. Black willow series intergrades with tidal brackish and freshwater marsh habitats and with narrowleaf willow series, white alder series, and buttonbush series.

Narrowleaf Willow Series: In the narrowleaf willow series narrowleaf willow is the sole or overwhelmingly dominant shrub in the canopy. Other trees or shrubs infrequently found in the canopy include other species of willow, Fremont's cottonwood, and white alder. The herb layer in narrowleaf willow series is usually sparse or absent because of the frequent scouring from flood events and the dense shade provided by the shrubs (Sawyer et al. 1996).

Narrowleaf willow series often occurs at sites along the margins of rivers that are continuously disturbed by sediment deposition. Older stands narrowleaf willow series are typically found on sites that are former sandbars that have been isolated from the main channel of a waterway either through channel migration or as a result of flood control. Narrowleaf willow series intergrades with tidal brackish and freshwater marsh habitats in some areas and with black willow series, white alder series, and buttonbush series.

White Alder Series: In the white alder series white alder is the sole or dominant tree in the canopy. Other trees that may be present include California sycamore, Oregon ash, or California box-elder. Depending on the level of flooding in this series the shrub layer can be dense to sparse. The ground, or herb, layer in white alder series can be variable, however, it is typically sparse in the Central Valley (Sawyer et al. 1996).

White alder series occurs along the banks of rivers typically in areas that experience high energy intermittent flooding. White alder series typically is best developed along the low-flow margins of rivers and streams. White alder series intergrades with black willow series, narrowleaf willow series, and valley oak series.

Buttonbush Series: In the buttonbush series buttonbush is the dominant shrub in the canopy with occasional shrubs of red osier dogwood, narrowleaf willow, or other willows also present. Buttonbush series typically forms extensive dense canopies at the water's edge and typically has a sparse ground layer (Sawyer et al. 1996).

Buttonbush series occurs along intermittently flooded and seasonally saturated freshwater sites along rivers or sloughs. Buttonbush series intergrades with black willow series, narrowleaf willow series, and tidal brackish and freshwater marsh habitat plant communities.

MEXICAN ELDERBERRY SERIES: Mexican elderberry is often the dominant shrub in the canopy of Mexican elderberry series. Other shrubs that may occur in this series include California wild grape, narrowleaf willow, Oregon ash, and coyote brush. Occasional Fremont's cottonwood or valley oak trees may also be present. Mexican elderberry is a species that also frequently occurs in valley oak series. The ground layer in Mexican elderberry series is variable but often consists of non-native grasses and herbs (Sawyer et al. 1996).

Mexican elderberry series typically occurs on high floodplains or low terraces of rivers and streams. These sites experience infrequent flooding but do have seasonally high water tables. Mexican elderberry is the host plant for the Valley elderberry longhorn beetle, a federally listed threatened species. Mexican elderberry series intergrades with valley oak series and older stands of narrowleaf willow series that occur on abandoned floodplains.

VALLEY OAK SERIES: In Valley oak series valley oak is the sole or dominant tree in the canopy. In valley oak series that occurs on the high floodplains and low terraces of rivers other tree species that may be present include California sycamore, Fremont's cottonwood, and Oregon ash. The shrub layer in valley oak series is typically sparse. Common shrubs include poison oak, Mexican elderberry, and occasional willows in wetter sites. Lianas of California wild grape growing into the canopy are common in this series. The ground layer in this series is typically grassy and is often dominated by native perennial grasses where extensive ground disturbance has not occurred.

Valley oak series typically occurs on the high floodplains and low terraces of rivers and streams. These sites are infrequently or frequently flooded for relatively short durations. Valley oak series intergrades with Mexican elderberry series and infrequently with older stands of narrowleaf willow series.

In general, tidal riparian vegetation is healthiest where ecosystem processes are in the most unaffected natural state. These unaffected sites are also the most resilient to human and natural disturbance. Ecosystem processes that are integral components of tidal riparian vegetation include sediment transport, deposition, and scour. These components support the succession and regeneration of riparian vegetation promoting its continued existence and ensuring continued habitat benefits for the aquatic environment. Riparian vegetation serves many important ecological functions. Riparian vegetation absorbs nutrients and produces primary (plant) and secondary (invertebrate) biomass at very high rates. This biomass feeds numerous fish and wildlife species. Birds and small mammals nest and take cover in the protective foliage of trees and shrubs. Trees also shade and cool floodplains and channels. Water velocities are slowed by riparian vegetation, allowing sediment to settle and create new landforms. Riparian foliage also stabilizes channels and banks, thereby rendering the characteristic geomorphology of estuaries, rivers, and streams.

Primary stressors affecting tidal riparian vegetation include:

- channel straightening and clearing
- levee construction and bank hardening to protect bridge abutments and diversion structures (e.g. with rip-rap);
- instream gravel mining and riparian zone grazing;
- flow modifications affecting sediment transport and riparian plant germination;
- removal, burning, and fragmentation of mature riparian vegetation; and

- loss of sediment and bedload from watershed sources upstream of dams.

Other stressors that affect tidal riparian vegetation include (listed in increasing importance and magnitude):

- human set fires along riparian corridors;

- new expansion of orchards and vineyards into the riparian floodplain;

- displacement by invasive non-native trees and shrubs (e.g. giant reed and black fig);

- unusually high summer stage in rivers that supply increasing demand for downstream water diversions;

- groundwater lowered below the root zone; and

- expanded clearing of channel vegetation in response to recent flood events that called into question the capacity of levee-confined rivers and streams.

Most stressors have an indirect but lasting effect on riparian vegetation. These stressors can affect the ability of riparian vegetation to recover following disturbance and can reduce the overall quality of the habitat. Collectively, these stressors have substantially reduced the quality and resilience of tidal riparian vegetation, thereby diminishing their effectiveness in providing for the life cycle requirements of fishes of the Delta and Sacramento and San Joaquin Rivers and their tributaries.

VISION

The vision for tidal riparian vegetation is to protect and increase its area and quality. Achieving this vision will assist in the recovery of special-status fish, wildlife, and plant populations and provide high-quality habitat for other fish, wildlife, and plants dependent on the Bay-Delta. The vision includes restoring native tidal riparian plant communities on both the less frequently flooded higher floodplain elevations and lower frequently flooded floodplain and streambanks.

The simple preservation of remaining natural riparian vegetation will not ensure the diversity, and resilience of these habitats. Many remnant natural sites no longer have all the physical processes necessary to ensure their continued existence and habitat value. Additionally, remaining natural riparian areas are in many cases highly fragmented and disturbed reducing their overall habitat value. Most riparian vegetation restoration projects in the Central Valley have been implemented on a relatively small scale, primarily as mitigation for project impacts or as infill of existing protected preserves.

Where natural physical processes are intact, or created through active land and water management, suitable conditions for the restoration (e.g. natural colonization or active restoration) of riparian vegetation will exist. Even partial restoration or simulation of natural physical processes will amplify ecosystem processes and resultant habitat quality. Rivers and Delta estuaries where natural fluvial processes and landforms are relatively intact need to be identified and highlighted as potential reserves of riparian vegetation.

Successful restoration of riparian vegetation depends on the recovery or simulation of natural fluvial processes and landforms. Revegetating and artificially altering stream channels will be considered only where overwhelming limitations prevent natural recovery of these physical processes and ecosystem functions.

Integration with Other Restoration Programs

Efforts to achieve the vision for tidal riparian habitat communities may involve coordination with other programs. These include:

- U.S. Army Corps of Engineers' proposed reevaluation of the Sacramento River flood control project and ongoing bank protection project, including more comprehensive floodplain management and river ecosystem restoration opportunities;

- proposed riparian habitat restoration and floodplain management and riparian restoration studies for the San Joaquin River, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by State and federal agencies and land trusts;

- ongoing Sacramento Valley conservation planning by The Nature Conservancy and other private nonprofit conservation organizations;

- ongoing coordination efforts and programs of the Wildlife Conservation Board, including the Riparian Habitat Joint Venture;

- all county-sponsored instream mining and reclamation ordinances and river and stream management plans;

- and the California Department of Conservation reclamation planning assistance programs under the Surface Mining and Reclamation Act.

Linkage with Other Ecosystem Elements

Tidal riparian vegetation is linked to the ecological health of many ERPP Ecological Management Zones and Units. This type of vegetation is important to many fish, wildlife, and plant species and communities. It is adversely affected by many stressors that include levee construction and maintenance, flood flow patterns, summer flow patterns, gravel mining, fragmentation of existing stands of vegetation, competition and displacement by invasive non-native species, land use conversion, flood control activities, and lowered groundwater levels.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective for tidal riparian vegetation is to restore and enhance black willow, narrowleaf willow, white alder, buttonbush, Mexican elderberry, and valley oak series along largely non-vegetated, riprapped banks of Delta island levees, the Sacramento and San Joaquin Rivers, and their major tributaries and abandoned farmland that once supported riparian vegetation. Restored riparian vegetation can provide shaded riverine aquatic cover for fish species, associated special-status plant and animal species, and other resident and migratory wildlife.

Long-term Objectives: Protect and restore, on a self-sustaining basis throughout the Delta, large blocks of tidal riparian habitat as a mosaic with other aquatic and wetland habitat types to a point where all at-risk species such as the valley elderberry longhorn beetle, riparian brush rabbit, and yellow-billed cuckoo that depend on this habitat are no longer at risk.

SHORT-TERM OBJECTIVES: Conserve the best examples of riparian habitats in the Delta. Begin to restore large areas of tidal riparian habitat.

RATIONALE: Restoring tidal riparian habitat in combination with other aquatic, wetland, and upland habitat types will help restore and maintain the ecological health of aquatic, terrestrial, and plant resources in the Delta and other areas of the Central Valley. Foodweb processes will be supported and the effects of contaminants reduced. Tidal riparian habitat will provide high quality foraging and nesting habitat for migratory and wintering songbirds, neotropical migrants such as the Swainson's hawk, riparian brush rabbit, and yellow-billed cuckoo. Restoration of tidal riparian habitat will occur as a by product of restoring floodplain processes in a manner that improves spawning habitat for fish species such as splittail while avoiding concurrent increases in non-native predatory fish. Each habitat, including tidal riparian habitat, supports a different assemblage of organisms and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus systematic protection of examples of the entire array of habitats in the region provides some assurance that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

STAGE 1 EXPECTATIONS: Several large tidal riparian habitat projects will have been initiated in the Delta. At least two of the projects will be associated with floodplain process restoration projects. At least two projects will be associated with restoring tidal riparian habitat in areas at the edges of the Delta where lands are not heavily subsided land elevations are appropriate to support actions to restore tidal riparian habitat.

Recovery and simulation of natural physical processes and landforms will be accomplished using the following integrated steps:

- locating setback levees to expand potential riparian floodplain;
- expanding the storage, detention, and bypass capacity of the Sacramento and San Joaquin River flood control project to allow natural expansion of riparian vegetation within levees and the Sutter and Yolo Bypasses; and
- designating, acquiring title or easements for, and deliberately managing river riparian corridors throughout the Central Valley.

The following actions would restore or enhance sediment supply to rivers and streams:

- reduce bank hardening by creating meander zones and widening floodplains;
- analyze alternative approaches for water diversions and associated intake and screening facilities on the mainstem river to avoid hardening the bank in some sections of the river;
- remove small, nonessential dams on gravel-rich streams;
- eliminate mining in streams and on low floodplains near channels;
- widen bridges to broaden out-of-bank flow and eliminate the need to riprap vulnerable bridge abutments; and
- breach or remove nonessential levees restricting former tidelands that would capture sediment needed to create tidal mudflats and estuary landforms.

Opportunities for reducing riparian vegetation stressors include:

- phasing out instream gravel mining;
- designating and acquiring "stream erosion zones" to reduce the use of bank riprap and allow greater normal recolonization;
- designing biotechnical slope protection measures that allow riparian vegetation to be established within levees;
- phasing out or reducing livestock grazing in riparian zones;
- establishing conservation easements for purchase of land or using other incentives to reduce or eliminate cropland conversion or riparian forest;
- identifying levee-confined channels and banks where routine vegetation removal by local reclamation districts can be safely discontinued; and
- establishing weed control programs to suppress the expansion of tamarisk, giant reed, locust, black fig, and other invasive non-native plants degrading habitat quality and native flora.

Reservoir operations will be evaluated to determine whether winter and spring releases can be augmented with flood simulation spikes every 1-10 years. Simulated flood spikes would mobilize bed and bank deposits to redistribute, sort, and clean spawning gravels and scour deep pools between riffles.

Restoring and enhancing riparian vegetation should be accomplished by eliminating the stressors and recovering or simulating the physical processes and fluvial landforms described above. Vegetation restored in this manner will be more resilient to future disturbances; require little or no long-term maintenance; be self-sustaining; and be more compatible with flood control requirements. However, vegetation fragmentation and severe limitations of the physical environment will not allow ecosystem processes and functions to fully recover on many segments of valley streams and Delta estuaries. In these solutions, some large-scale stream channel sculpting, gravel additions, and riparian replanting may be necessary. For example, the lower Sacramento River has abandoned river floodplains and sediment is in short supply. Naturally reactivating these habitats would be nearly impossible. Restoring these habitats would require human intervention. Revegetation projects should be contemplated only where native trees and grasses many no longer germinate naturally but have a high probability of unaided survival and vigorous growth following 1-5 years of artificial irrigation.

INTRODUCTION

The Strategic Plan for Ecosystem Restoration presents 6 goals to guide the implementation of restoration actions during the 20-30 year program. Strategic Goal 3 focuses on species which provide sustainable recreational and commercial harvest not already covered by Goal 1:

> ***Goal 3: Maintain and enhance populations of selected species for sustainable commercial and recreational harvest consistent with goals 1 and 2.***

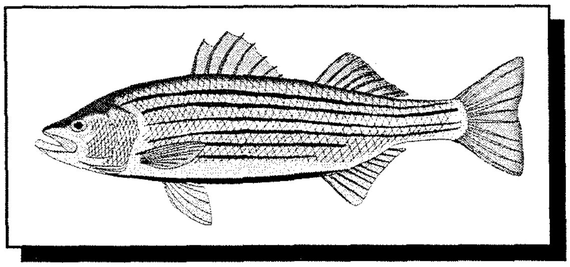
Somewhere between 40 and 50 species of fish and invertebrates are harvested in significant numbers in the CALFED region, as are a number of species of birds (waterfowl, mourning doves, ring-necked pheasants). The ERP has the potential to affect the harvest of many of these species, improving most of them in the long run. For the purposes of the ERP, the harvested species are divided into three groups according to their priority for attention by the CALFED program. *High priority* species are those whose abundance is likely to be strongly affected by CALFED actions and/or whose enhancement is likely to generate conflicts with the restoration of native species. *Second priority* species are species that support important fisheries or harvests but whose populations are not likely to be affected strongly by CALFED actions in the short run or whose enhancement is not likely to generate major conflicts with the restoration of native species. *Low priority* species, not treated here, are species that support relatively small or incidental fisheries or harvests and whose enhancement (if any) is not likely to generate major conflicts with the restoration of native species. Note: within each category, objectives are not listed in order of priority.

SPECIES IN THE HIGH PRIORITY GROUP INCLUDE:

- Striped bass
- American shad
- White sturgeon
- Non-native warmwater gamefish

SECOND PRIORITY SPECIES INCLUDE:

- Pacific herring
- Signal crayfish
- Grass shrimp



INTRODUCTION

The striped bass is an important non-native anadromous sport fish with high recreation value. It also plays an important role as a top predator in the Bay-Delta and its watershed.

Major factors that limit striped bass contribution to the health of the Delta are streamflow, water diversions, spawning and rearing habitat, legal and illegal harvest, predation and competition from non-native fishes, and reduce survival from contaminants in the water.

RESOURCE DESCRIPTION

Striped bass were introduced into the Bay-Delta from the east coast of the United States in 1879. For the past century, they have been an important sport fish, commercial fish, and top predator within the Bay-Delta and upstream rivers. They adapted well to the complex habitat conditions of the estuary and remain the premier sport fish of the Bay and Delta. Anglers seek out striped bass along the coast, in the Bay and Delta, and in the lower portions of the Sacramento and San Joaquin Rivers and their tributaries. Striped bass are also an important recreational resource in the waterways of the State and federal water projects south of the Delta.

In the Sacramento River, striped bass are commonly found from Princeton downstream to the Delta and in the lower Feather and American Rivers. In the San Joaquin basin, they are found in the lower Stanislaus, Tuolumne, and San Joaquin rivers. Striped bass spawn primarily in the Sacramento River between Colusa and Sacramento and in the San Joaquin River portion of the Delta.

Juvenile rearing habitat include sloughs, river channels, and bays of the western Delta and Suisun Bay. In wet years young fish rearing habitat extends into San Pablo Bay and adjacent tidal sloughs and marshes. Yearling striped bass are found throughout the Bay and Delta. Adult striped bass are widely distributed from the ocean to the rivers.

The number of adult striped bass and young produced each year have declined dramatically over the past several decades. The total adult population has declined from about 3 million fish in the 1960s to 1.5 million in the early 1970s. More recent estimates are 500,000 to 700,000 adult fish. A greater decline has occurred in older fish, possibly the consequences of greater numbers of older fish migrating to coastal waters, or higher mortality of individual adults from contaminants in the water.

The decline in the adult population of striped bass has been accompanied by a decline in the production of young. The young bass abundance index for summer, when they are 1.5 inches long, has declined dramatically, especially during the recent drought of the late 1980s and early 1990s, and has not recovered. Factors related to and believed to contribute to this decline include the following:

- Low spring flows in the Sacramento River are believed to reduce survival of eggs and larvae by creating poor water quality conditions, reducing plankton food supply, and increasing vulnerability to water diversions.

- Low freshwater flows through the Delta and Suisun Bay may limit the production of food organisms during critical early life stages of striped bass.

- Low Delta outflow may limit transport of eggs, larvae, and juvenile striped bass into quality nursery grounds of Suisun Bay and away from water diversions in the Delta.

- Higher transport of Sacramento River water across the Delta toward the south Delta pumping plants moves more striped bass young into areas where they are more susceptible to entrainment into agricultural diversions or water project export pumps.

The number of juveniles lost at south Delta export facilities was in the tens of millions in some years during the 1960s to mid-1970s, and again in the middle to late 1980s. The estimated loss in 1974 exceeded 100 million juveniles. Although subsequent export losses have decreased, the rate of loss per unit of population has greatly increased as population abundance has declined.

The number of adult spawners has dropped to such low levels in recent years that there may no longer be sufficient eggs spawned to bring about quick recovery in the population. Good juvenile production even when flows and habitat are excellent for survival is limited by reduced adult spawning populations.

In addition to the low survival of young fish and their low entry into the adult spawning population, mortality rates of adults have increased despite reduced harvest rates in the sport fishery. The higher mortality rates are particularly evident in older adults, and may be a result of effects of toxins, poaching, marine mammal predation, or combinations of these and other factors.

Other factors possibly contributing to the decline and low abundance of striped bass include toxins that reduce survival of young bass or their food supply, competition or predation by recently established, non-native fishes, such as gobies, or poor food production caused by the influx of Asia clams. Both the gobies and Asia clams were introduced from ballast water released from ships from Asia.

Food habit studies conducted by numerous investigators indicate that chinook salmon are not an important component in the diet of striped bass, although, at times, young salmon, primarily fall-run, have constituted a substantial part (U.S. Bureau of Reclamation 1995). Generally, this has occurred in the Sacramento River upstream of the estuary and has been localized at water management structures, bridge abutments, and other predator habitats. It also occurs at structures that cause disorientation of juveniles such as RBDD. In the Delta, it is a known problem in CCF and at sites where large numbers of artificially produced chinook salmon are released.

The studies reveal that, except at localized sites and structures, striped bass are less likely to eat salmon in Suisun Bay and the Delta than in the rivers above the Delta. The greater vulnerability of salmon in the river may be a result of the greater clarity and the smaller width of the river. In many areas, bank protection activities, such as maintaining levees and riprapping, have removed SRA habitat and eliminated escape cover needed by young fish.

The U.S. Bureau of Reclamation (1995) reported that the entire striped bass population consumes about 1.4% of the winter-run chinook salmon smolts migration from the Sacramento River. The Bureau also reported that the year-round overlap in the distribution of striped bass and delta smelt resulted in an estimated annual consumption of 195,000 delta smelt, and the striped bass had essentially no impact on splittail.

VISION

The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy. This will support a sport fishery in the Bay, Delta, and tributary rivers, and to reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta.

Over the past two decades, a major focus of striped bass recovery efforts has been Delta outflow enhancement and restrictions on spring and early summer water exports. The recent 1995 Water Quality Control Plan provided interim provisions for improving spring Delta outflows and limiting exports, but did not address summer outflows or effects of water exports in summer or fall. This vision anticipates further improvements in the following:

- spring Delta inflows and outflows in drier years when more flow is needed for successful spawning,
- Bay-Delta foodweb production,
- transporting egg and larval striped bass to nursery grounds in Suisun Bay,
- reducing the effects of water exports from the Delta, especially exports that reverse the natural flow patterns in the Delta.

Although deterioration of habitat may not be a major factor in the decline of striped bass, it could be an important detriment to their recovery. Protecting, improving, and restoring a substantial amount of shallow-water habitat in the Bay and Delta may improve the food supply for striped bass, as well as provide more area for rearing juvenile striped bass. An improved food supply and increased rearing area may help overcome other factors that have little potential for change (e.g., predation and competition from non-native species). Increases in tidal wetlands will provide tidal channels that are important rearing habitat for juvenile striped bass. Improvement and restoration of shallow waters and riparian vegetation along levees and channel islands in the Delta may provide further important habitat for young striped bass. Habitat improvements are expected to also increase the abundance of shrimp and small fish that are important prey of young and adult striped bass and may lead to higher striped bass survival rates.

Reducing the extent and effect of stressors on striped bass will also be important to their recovery. Reducing losses of young striped bass at water diversions in the Delta and Bay, particularly the very high losses at the south Delta pumping plants of the State and federal water projects, will be most important. Improvements are needed to upgrade the two fish protection facilities to reduce the loss of young bass to entrainment into the pumping plants, and to reduce indirect losses to predators associated with the fish protection facilities. Pumping plant operations could also be reduced during periods of high losses.

Longer term actions may involve relocating the pumping plant intakes, screening or reducing the number of small water diversions to agricultural lands in the Delta, and continuing to find ways to reduce entrainment losses into cooling water diversions at two power plant complexes in the Delta. Limiting further introductions of non-native species and reducing the input of contaminants into Central Valley waterways may also be important to striped bass recovery. In the short-term, recovery may depend on supplementing natural reproduction with hatchery and pen-reared striped bass, and possibly reducing illegal and legal harvest. Management actions for striped bass need to be carefully evaluated and structured to avoid adverse affects on native species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore striped bass in the Central Valley would involve cooperation and support from other programs underway to restore striped bass and other important fish.

- The Central Valley Project Improvement Act (CVPIA) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the striped bass population.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires the DFG to restore striped bass in the Central Valley.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.
- Fish and Game Commission Striped Bass Policy: (I) the Department of Fish and Game shall work toward stabilizing and then restoring the presently declining striped bass fishery of the Sacramento-San Joaquin Estuary. This goal is consistent with Commission policy that the Department shall emphasize programs that ensure, enhance, and prevent loss of sport fishing opportunities. (II) The Department shall ensure that actions to increase striped bass abundance are consistent with the Department's long-term mission and public trust responsibilities including those related to threatened and endangered species and other species of special concern. Recognizing issues associated with potential incidental take of these species, an appropriate interim objective is to restore the striped bass population to the 1980 population level of 1.1 million adults within the next 5-10 years. (III) the long-term striped bass restoration goal, as identified in the Department's 1989 Striped Bass Restoration Plan, is 3 million adults. (IV) The Department shall work toward these goals through any appropriate means. Such means may include actions to help maintain, restore, and improve habitat; pen-rearing of fish salvaged from water project screens; and artificial propagation. (*Adopted 4/5/96*) (Fish and Game Code 1997).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Because striped bass are predators, they could affect efforts to recover populations of a number of native fishes of the Central Valley including chinook salmon, steelhead, delta smelt, longfin smelt, and Sacramento splittail. Consequently, it will be necessary to consult and cooperate with the National Marine Fisheries Service and U.S. Fish and Wildlife Service under the federal Endangered Species Act (ESA) and DFG under the California ESA.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain fisheries for striped bass.

LONG-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 3 million fish through such actions as improving, maintaining, and restoring habitat, pen-rearing of fish salvaged at water project screens, and artificial propagation. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

SHORT-TERM OBJECTIVE: Restore the adult population (greater than 18 inches total length) to 1.1 million fish within the next 10 years. In addition, all measures will be taken to assure that striped bass restoration efforts do not interfere with the recovery of threatened and endangered species and other species of special concern covered under public trust responsibilities.

RATIONALE: The striped bass is a non-native species that is a favorite sport fish in the estuary. It is also the most abundant and voracious piscivorous fish in the system and it has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management for striped bass must juggle the objectives of providing opportunities for harvest while not jeopardizing recovery of native species. An appropriate policy may be to allow striped bass to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially artificial propagation. Artificially reared bass have the potential to depress not only native fish populations but also populations of wild striped bass, because larger juveniles (of hatchery origin) may prey on smaller juveniles (of wild origin). If increases in bass numbers appear to adversely affect recovery of native species, additional management measures may be required to keep bass numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: Continue investigations into the causes of striped bass decline throughout the Sacramento-San Joaquin Estuary. In addition, all efforts shall be undertaken to ensure that programs are developed that ensure, enhance, and prevent the loss of sport fishing opportunities.

General targets for striped bass are:

- restore population to levels of the 1960s,
- maintain flow in the Sacramento River at Sacramento at 13,000 cfs in the spring,
- improve health of average individual striped bass in population,
- reduce the rate of illegal harvest of striped bass, and
- reduce the percentage of young striped bass lost to entrainment at water diversions.

General programmatic actions which will help to meet the targets for striped bass include:

- protect and restore shallow water, tidal slough, and wetlands habitats,
- improve aquatic foodweb,
- maintain 13,000 cfs flow in lower Sacramento River in the spring months of all but driest years,
- increase Delta outflow in spring of dry and below normal years,
- reduce the introductions of non-native aquatic organisms into the Bay-Delta,
- improve water quality of the Bay-Delta,
- provide greater enforcement to reduce illegal harvest,
- reduce losses of eggs, larvae, and juvenile striped bass at water diversions,

- upgrade fish protection facilities at south Delta pumping plants and power generation plants in the Delta, and

- supplement striped bass population with pen-reared and hatchery-reared striped bass, as needed, until natural production is adequate to sustain the population at target level.

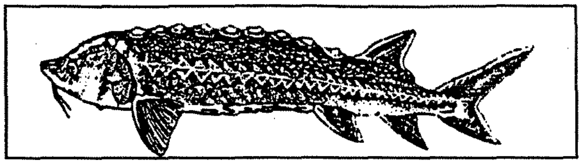
REFERENCES

Fish and Game Code. 1997. 1997 Fish and Game Code of California. LawTech Publishing Company, LTD. San Clemente, California. Page 484.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Bureau of Reclamation. 1995. Biological Assessment for the Department of Fish and Game Striped Bass Management Program, June, 1995 - June 1996. U.S. Bureau of Reclamation, 2800 Cottage Way, Sacramento, CA 95825.

◆ White Sturgeon



Introduction

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

The white sturgeon is an important native anadromous sport fish with high recreational and ecological value.

Major factors that limit sturgeon populations in the Bay-Delta are adequate streamflows for attracting adults to spawning areas in rivers and transporting young to nursery areas, illegal and legal harvest, and entrainment into water diversions.

Resource Description

White sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay-Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate. White sturgeon support a valuable sport fishery in the Bay and Delta.

Sturgeon are long-lived species. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

White sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g., levee construction) may affect sturgeon use and spawning success.

Losses of sturgeon young into water diversions reduces sturgeon productivity. However, relative to other species, the percentage of the sturgeon population caught in diversions is low.

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

Recently, white sturgeon have been feeding on Asian clams in Suisun Bay, which may indicate a very important ecological role that could feed back through foodweb productivity of the Bay-Delta. Sturgeon predation may limit clam abundance and therefore potentially decrease the loss of plankton to clam feeding. The clams also accumulate contaminants, which may pose a long-term problem for sturgeon feeding heavily on clams.

Vision

The vision for white sturgeon is to maintain and restore population distribution and abundance to historical levels. Restoration would support a sport fishery for white sturgeon and contribute to overall species richness and diversity and reduce conflict between the need for protection for this species and other beneficial uses of water in the Bay-Delta.

White sturgeon would benefit from improved ecosystem processes, including adequate streamflow to attract adults to spawning habitat, transport larvae and early juveniles to productive rearing habitat, and maintain productivity and suitability of spawning and rearing habitat (including production of food). Ecosystem processes that need improvement include streamflows, stream and channel configurations, and migration barriers (e.g., dams). Additional streamflow during late winter and spring would attract sturgeon to rivers and maintain spawning flow requirements.

White sturgeon would benefit from restoring spawning and rearing habitat. Habitat restoration may be achieved by adding and modifying physical habitat and increasing freshwater flow during critical periods. Juvenile sturgeon frequent Delta sloughs and may benefit from increases in slough habitat. Spawning habitat includes upstream river reaches that contain appropriate substrate (e.g., gravel, rock). Rearing habitat includes areas in the Sacramento and San Joaquin rivers and the Delta that provide protective, food-rich habitats such as the shallow shoals and bays of the Bay-Delta.

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

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore white sturgeon in the Central Valley would involve cooperation and support from other programs underway to restore sturgeon and other important fish.

- The Central Valley Project Improvement Act (CVPIA) (PL 102-575) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the sturgeon populations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.
- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds and actions to DFG for sturgeon restoration.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for white and green sturgeon.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration of white sturgeon populations are integrally linked with restoration of river floodplain and stream meander habitat, improvements in Central Valley streamflows, improvements in habitat, and reductions in losses to water diversions and illegal harvest.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to enhance fisheries for white sturgeon.

LONG-TERM OBJECTIVE: Increase white sturgeon numbers (and harvest) by improving habitat conditions for spawning and rearing throughout the Sacramento-San Joaquin estuary and tributaries.

SHORT-TERM OBJECTIVE: Continue to manage white sturgeon for the sustainable sport fishery, without artificial propagation.

RATIONALE: White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game, have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.

STAGE 1 EXPECTATIONS: White sturgeon will continue to support a significant sport fishery in the estuary and will not have experienced a significant decline in abundance.

General targets for sturgeon populations are:

- Restore population to levels of the 1960s,
- Improve flow in Sacramento River in spring,
- Reduce the rate of illegal harvest,
- Reduce the percentage lost of sturgeon to water diversions to that of the 1960s,

The general approach for programmatic actions are:

- Improve the aquatic foodweb,
- Improve spring flows in Sacramento River and major tributaries,
- Restore natural meander belts and add gravel substrates in upstream spawning areas,
- Increase Delta outflow in spring of dry and normal years,
- Improve water quality of Bay-Delta,
- Provide greater enforcement to reduce poaching,
- Reduce losses of eggs, larvae, and juvenile sturgeon at water diversions,
- Upgrade fish protection facilities at diversion facilities in the Delta,
- Restore tidally influenced Delta and estuarine habitat such as tidal perennial aquatic habitat and sloughs.

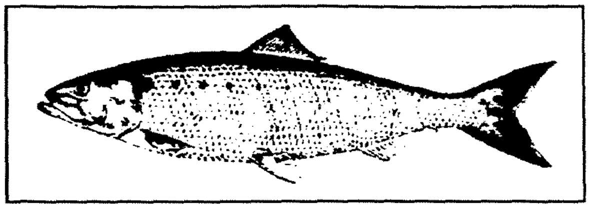
REFERENCES

California Department of Fish and Game. 1993. Restoring Central Valley streams: a plan for action. Sacramento, CA.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes. U.S. Fish and Wildlife Service, Portland, OR.

_____________. 1997. Revised draft anadromous fish restoration plan. U.S. Fish and Wildlife Service, Sacramento, CA.



INTRODUCTION

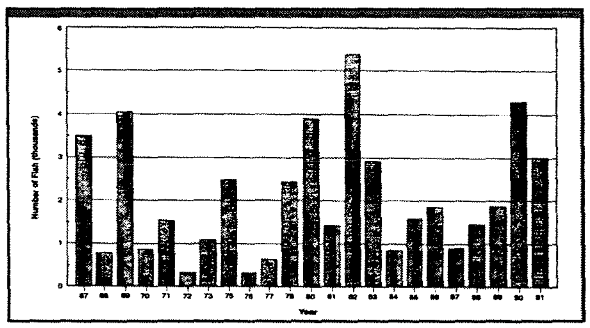
American shad is an important non-native anadromous sport fish with high recreational value. It migrates in spring from the ocean into the Bay-Delta and upstream to spawn in Central Valley rivers. Newly hatched young spend their first summer in the rivers and Delta before migrating downstream to the ocean in fall.

Major factors that limit the contribution of the American shad to the health of the Delta are streamflow, aquatic habitat, and food supply.

RESOURCE DESCRIPTION

The American shad was introduced into Central Valley rivers from the east coast in the 1870s and 1880s. It adapted well to the complex habitat conditions of the rivers and estuary. It continues to be an important sport fish in the Sacramento, Feather, Yuba, and American rivers and has extended its range as far north as the Columbia River. Adults (age 3-5) migrate into the rivers from the ocean to spawn from late April through June. Some may remain in the rivers through August before returning to the Bay-Delta and ocean. Many die during the spawning run, but about 30% of the runs are made up of repeat spawners. In the Sacramento River system, American shad are commonly found from Red Bluff downstream to the Delta and in the lower Feather, Yuba, and American rivers. American shad populations are small in the San Joaquin basin compared with those in the Sacramento basin.

When the adult population was measured in 1976 and 1977, the total Central Valley run was estimated at 3 million and 2.8 million, respectively. The California Department of Fish and Game (DFG) has conducted annual fall midwater trawl surveys in the Delta since 1967 to monitor trends in the population's health. Juvenile shad catch has generally been higher in wetter years (1967, 1969, 1975, 1978, 1980, 1982, and 1983) and lower in dry years (1968, 1972, 1976, 1977, 1984, and 1987). The production index was relatively high, however, in two recent dry years (1990 and 1991).



Index of Juvenile American Shad Abundance in Fall Midwater Trawl Survey

Ocean, estuary, and river conditions affect overall shad abundance. Growth and survival in the ocean may be affected by El Niño (ocean warming). Water temperatures and flows are important habitat factors in the spawning rivers of the Central Valley. River flows trigger the shad to move into rivers and affect their selection of spawning locations among and within the rivers. Water temperatures determine the onset of spawning (59-68°F). High water temperatures (above 68°F) may reduce adult survival. Factors believed to affect American shad production in the Central Valley include the following:

- Low flows in spring may delay or hinder shad from moving into the rivers to spawn. During their upstream migration through the Delta, adult shad may delay spawning or may die because of the higher water temperatures resulting from low flows. Low flows also may reduce downstream transport of eggs and larvae to productive nursery areas.

- Transport of Sacramento River water south across the Delta and toward the south Delta pumping plants may carry more American shad young into the southern Delta and away from their primary migration path to the ocean. Under low Delta outflow, shad young may be more susceptible to loss at agricultural diversions and water project export pumps. Annual losses of juveniles at south Delta export facilities reach into the millions.

- Poor water quality and low spring flows may limit production of American shad in the San Joaquin River and its tributaries.

- Diversion dams on valley rivers limit American shad from moving into potential spawning reaches. Examples include the Red Bluff Diversion Dam on the Sacramento River, Daguerre Dam on the Yuba River, and Woodbridge Dam on the Mokelumne River. Shad are generally unable to use the fish ladders provided at these diversion dams.

- Pollutants may affect the production and run size of American shad by reducing survival of young and their food supply.

Harvest rates of adult shad in the sport fishery are low and have little impact on production of American shad.

VISION

The vision for American shad is to maintain a naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Achieving this vision will reduce the conflict between protection of this species and other beneficial uses of water in the Bay-Delta.

A major focus of Central Valley fish recovery efforts over the past two decades has been on flow enhancement in streams and rivers. Natural river flows in dry and normal water-year types has been reduced, particularly in spring, by water development in the Central Valley. The 1995 December Delta Accord provided interim provisions for improving spring flows. Further improvements are anticipated under the Central Valley Project Improvement Act (CVPIA).

The restoration of American shad vision requires further improvements in drier years when more flow is needed to attract American shad to upstream spawning areas in the rivers and major tributaries, including the American, Feather, and Yuba rivers, and to transport egg and larval shad to nursery grounds in the lower rivers and Delta.

Habitat improvements could contribute to increases in American shad runs. Protecting, improving, and restoring shallow-water habitat in rivers and the Delta may improve the food supply for American shad and provide better rearing habitat. Improved food supply and rearing habitat may help to overcome other factors that are unlikely to change (e.g., the presence of competing non-native species).

Reducing the extent and effect of stressors will further benefit American shad runs. Most important will be reducing loss of young American shad at water diversions in rivers and the Delta, especially large losses at the south Delta pumping plants of the State and federal water projects. The two fish protection facilities should be upgraded to reduce entrainment of young American shad in the pumping plants and the concentrations of predators associated with the fish protection facilities. Screening or reducing the number of the many small water diversions to agricultural lands in the Delta may also provide benefits. Limiting further introduction of non-native species and reducing the input of toxic pollutants into Central Valley waterways will also provide benefits.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain American shad runs in Central Valley rivers would involve cooperation and support from other established programs underway to restore American shad and other important fish.

- CVPIA (PL 102-575) calls for doubling the American shad population by 2002 through changes in flows and project facilities and operations.
- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 DFG is required under State legislation to restore American shad in the Central Valley.
- The Lower American River Task Force and Water Forum will improve flows and habitat in the lower American River that will benefit American shad.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary that will include provisions to limit entrainment in diversions and protect habitat conditions for Sacramento splittail, chinook salmon, striped bass, and other species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Actions to restore populations of salmon, steelhead, striped bass, and Delta native fishes are likely to benefit the runs of American shad.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain fisheries for American shad.

LONG-TERM OBJECTIVE: Allow American shad numbers (and harvest) to increase gradually as conditions in the restored estuary and streams favor its reproduction and survival. Use harvest and other management measures to ensure that increases in American shad populations do not jeopardize programs to sustain native species.

SHORT-TERM OBJECTIVE: Maintain the fishery for American shad at its present levels but without special intervention (e.g. special flow releases).

RATIONALE: The American shad is a non-native species that is an important sport fish in the estuary and its spawning streams, although less seems to be known about its life history in the estuary than any other major game fish. It is a common planktivore and occasional piscivore in the system and it may have the potential to limit the recovery of native species, such as chinook salmon. Therefore, the management for American shad must juggle the objectives of providing opportunities for harvest without jeopardizing recovery of native species. An appropriate policy may be to allow American shad to increase in numbers as estuarine conditions permit but not to take any extraordinary measures to enhance its populations, especially flow releases specifically to favor shad reproduction. If increases in shad numbers appear to adversely affect recovery of native species, additional management measures may be required to keep shad numbers below the level that pose a threat to native species.

STAGE 1 EXPECTATIONS: No special efforts to increase American shad numbers will have been made and benefits to shad will have been derived from restoration actions directed to other species such as chinook salmon. Their impact on juvenile salmon (predation) in the Sacramento River will have been investigated.

The general target for American shad is to improve production of young, particularly in dry years as measured in the DFG fall mid-water trawl survey.

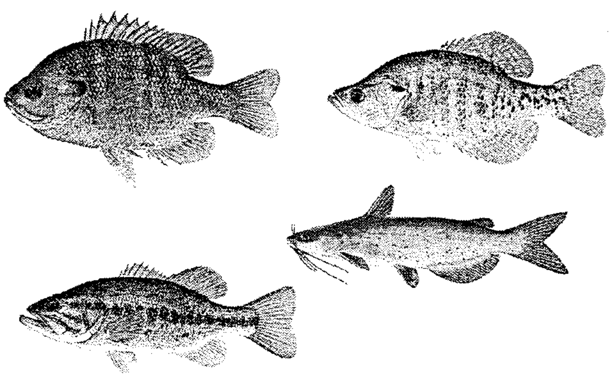
Programmatic actions that would help improve American shad populations in Central Valley rivers include the following:

- Provide additional Sacramento, Feather, Yuba, and American river flows in spring of dry and normal water years to attract adult spawners and transport young downstream to productive nursery habitat.
- Remove barriers to American shad migrations in the Sacramento, Yuba, and Mokelumne rivers.
- Reduce adverse effects of water diversions on American shad in fall.
- Allow the first natural pulse of flow in the fall to pass through the Delta to the Bay to help juvenile American shad migrate to the ocean.
- Upgrade existing fish protection facilities at south Delta pumping plants of the Central Valley Project and the State Water Project.
- Reduce the number, screen or upgrade screening, or relocate diversions that entrain American shad in the rivers and Bay-Delta.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Non-native Warmwater Gamefish



Introduction

Throughout the Sacramento-San Joaquin Delta warmwater gamefish are an important component of resource health. Not only do these species fill an important biological component, they are also of economic importance. The group of warmwater gamefish is represented by largemouth bass, white crappie, bluegill, redear, green sunfish, white and channel catfish, brown and black bullhead and striped bass to name a few. The warmwater gamefish group is best represented by both the largemouth bass (*Micropterus salmoides*) and white catfish (*Ameiurus catus*). Within the Delta over forty largemouth bass fishing tournaments are held yearly. Currently, largemouth bass populations support a 30 percent catch and release fishery in the Delta, while the white catfish has a harvest rate of around 10% to 15%.

Factors that may limit the warmwater gamefishes ability to contribute to a healthy Delta ecosystem is the degradation and loss of existing aquatic habitat as a result of channel dredging, levee stabilization, and increased channel velocities.

Resource Description

The largemouth bass was first introduced into California waters in 1870s and has since spread to suitable habitats throughout the State. The largemouth bass prefers warm, slow moving waters with low turbidity. Within the Delta the largemouth bass tends to inhabit sloughs and backwaters with large quantities of aquatic cover and submerged objects. The overall stability and health of the largemouth bass population in the Delta is at an all time high. The healthier population (related to size of the fish) of fish is due to the introduction of the "Florida strain" to the gene pool.

Spawning for largemouth bass occurs in the second or third year of life when water temperatures reach 14 to 16 degrees C in April and continues through June. Nests are shallow substrate depressions located in about one to two meters of water near submerged objects. Eggs are adhesive and hatch within two to five days after being fertilized. The nest and eggs are actively protected by the male until sac-fry emerge from nest in about five to eight days.

The white catfish was first introduced into the San Joaquin River in the mid-1870s and has since been introduced into all of the major water systems of the State (except the Colorado and Klamath systems). The white catfish prefers slow moving waters in channels devoid of heavy aquatic vegetation and is typically found in waters greater than two meters deep. The overall interest in white catfish as a gamefish is due to the fact that it is quite numerous within the Sacramento-San Joaquin Delta.

Spawning age and size for white catfish is highly variable and occurs from April through June. Nest sites are typically located in cave-like structures, like muskrat burrows, log jams, and undercut banks. Spawning activity is also triggered by water temperatures when they approach 21 to 29 degrees C, with optimum spawning occurring at 27 to 28 degrees C. The nest is actively guarded by the male. The eggs hatch in about six to ten days with the young actively swimming about two days after hatching.

Losses to Delta diversions (e.g., hundreds of small agricultural diversions, Central Valley Project and State Water Project export pumps, and Pacific Gas & Electric power generation facilities) may reduce resident species abundance through direct entrainment or indirect effects on the prey of resident fish. Large numbers of some resident species (e.g., white catfish, threadfin shad) are entrained in Delta diversions. Other resident species (e.g., largemouth bass) spend their lives in habitat that is in close proximity to where they were spawned and are not particularly susceptible to entrainment in Delta.

Food availability, toxic substances, and competition and predation are among the factors influencing abundance of resident species. In addition, harvest of many resident species for food and bait by sport anglers may affect abundance.

VISION

The vision for warmwater gamefish is to maintain self-sustaining populations in order to provide opportunities for consumptive use such as fishing. Increasing the variability in aquatic habitat types would provide additional spawning, nesting, rearing, and escape cover for all species of fish, both game and non-game species. Population levels and harvest/catch rates for all gamefish species will need to be monitored to determine restoration success.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain and enhance the population of warmwater gamefish in the Sacramento-San Joaquin Delta would also involve cooperation and support from other established programs.

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes.
- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.
- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.
- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.
- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Restoration and maintenance of warmwater gamefish populations and habitats will benefit from other CALFED actions to increase flows, enhance levees, establishing riparian corridors, and increase the productivity of the food web.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain fisheries for non-native warmwater gamefishes.

LONG-TERM OBJECTIVE: Non-native warmwater game fishes will continue to be abundant enough in many parts of the estuary and river systems to support a substantial sport fishery.

SHORT-TERM OBJECTIVE: Increase our knowledge about warmwater sport fishes in the Delta, Suisun Marsh, riverine backwaters, and elsewhere to find out their interactions with native fishes, limiting factors, and their contaminant loads (for both fish and human health).

RATIONALE: White catfish, channel catfish, brown and black bullhead, largemouth bass, and various sunfishes are among the most common fishes caught in the sport fishery in the Delta, Suisun Marsh, riverine backwaters, reservoirs, and other lowland waters. Although this fishery is poorly documented, it is probably the largest sport fishery in central California in terms of people engaged in it and in terms of numbers of fish caught. There is no sign of overexploitation of the fishes, although some (e.g., white catfish) have remarkably slow growth rates, indicating vulnerability to overexploitation. The fishes and the fishers are always going to be part of the lowland environment and deserve support of the management agencies. However, habitat improvements that favor native fishes, especially improvements that increase flows or decrease summer temperatures, may not favor these game fishes. The effects of the various CALFED actions on these fish and fisheries need to be understood, as do the interactions among the non-native fishes and the native fish CALFED is trying to protect.

STAGE 1 EXPECTATIONS: Studies will have been conducted to find out how major CALFED actions are likely to affect the warmwater fish and fisheries and how the fishes affect the recovery of native at-risk species. In particular, the potential of the non-native fishes to use and dominate newly created warmwater habitat will have been thoroughly investigated.

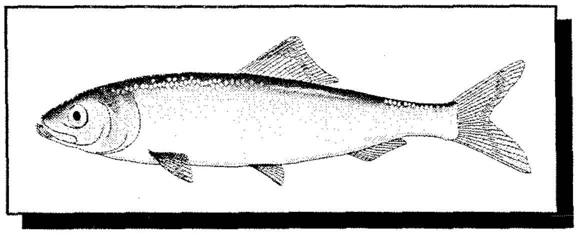
Warmwater gamefish would benefit from the following actions and restorations: activities:

- acquire and enhance aquatic habitat,
- creation of tidally influenced fresh-water woodlands,
- creation of set-back levees to increase shallow-water habitat along existing channels,
- eliminate water hyacinth and other noxious aquatic plants from the Delta,
- update existing fish protection facilities at the South Delta pumping plants,
- installing screens on unscreened diversions, and
- preventing further introductions of non-native aquatic organisms.

REFERENCES

Moyle, P. B. 1976. Inland Fishes of California. University of California Press, Berkeley. pps 242-244, 313-316.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.



INTRODUCTION

California's largest population of Pacific herring uses San Francisco Bay as a spawning and nursery grounds. This population supports a multi-million dollar a year commercial fishery for roe which is exported to Japan. The herring fishery is the best monitored fishery in California and over-exploitation of the commercial fishery is not expected to occur. Herring are also an important component of the Bay's food web for other fish, birds, mammals, and invertebrates.

The primary factor affecting the year-class strength of Pacific herring is the Bay and ocean nutrient productivity.

RESOURCE DESCRIPTION

Pacific herring inhabit areas along the Pacific coast of the North American continent. Typically adult herring reside in the ocean and return to the Bay during the November through March spawning season. However, juveniles (young of the year) have been noted in the estuary year round. Spawning activities primarily occur in the intertidal and shallow subtidal zones on a variety of substrates, including pilings, rocks, jetties, eelgrass, and seaweed.

Spawning occurs from October through April in San Francisco Bay with peak activity occurring in January. The eggs are adhesive and stick to structures or substrates and hatch in about ten days, depending on temperature.

VISION

The vision for the Pacific herring is to maintain a self-sustaining populations in order to support commercial fishing. The Pacific herring is also an integral part of the Bay food web. A major focus of efforts to maintain the fishery would be to assure that shallow intertidal zones with aquatic vegetation are protected and enhanced. CALFED will also need to assure that salinity regimes of the Bay and surrounding areas are maintained during spawning and juvenile periods. Some of the activities scheduled for implementation during Stage 1 Actions will benefit the Pacific herring.

Current efforts by the Department of Fish and Game to monitor the herring population and commercial fishing activities will be sufficient to assure the continued existence of Pacific herring.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- Central Valley Project Improvement Act: This act is required to double the natural population of Central Valley anadromous fish stocks.

- Salmon, Steelhead Trout, and Anadromous Fisheries Act: The California Department of Fish and Game is required under State legislation to double the number of anadromous fish in the Central Valley.

- Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (December 1995) and Water Rights Decision 1485 (1978).

- California Fish and Game Commission will continue to regulate and develop fishing regulations based on recommendations by the California Department of Fish and Game.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of Pacific herring populations is linked with the addition and restoration of tidal habitats, Delta outflow, and the aquatic food web within and upstream of San Francisco Bay.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to enhance fisheries for Pacific herring.

LONG-TERM OBJECTIVE: Maintain a high level of harvest management that will allow for sustainable fisheries for Pacific herring and their roe.

SHORT-TERM OBJECTIVE: Continue, with caution, the present limited-entry fishery and determine the major factors that limit both the fishery and herring spawning in San Francisco Bay.

RATIONALE: Pacific herring support the most valuable commercial fishery in San Francisco Bay. This seasonal, limited-entry fishery focuses on spawning fish, for the fish themselves, their roe, and kazunoko kombu (herring eggs on eel grass). It seems to be an example of successful fishery management because it has been able to sustain itself through a series of years with highly variable ocean and bay conditions. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.

STAGE 1 EXPECTATIONS: In the next 7-10 years the fishery will have continued at roughly present levels and investigations continued to determine factors limiting herring abundance and spawning success, especially as tied to Bay-Delta physical processes.

Pacific herring would benefit from the following restoration activities and actions:

- Limit further introductions of non-native species especially from ship ballast water.
- Restoration of tidal and shallow-water habitat in the Suisun Marsh and San Francisco Bay
- More uniform salinity regimes in the San Francisco Bay during both drought and wet water years.

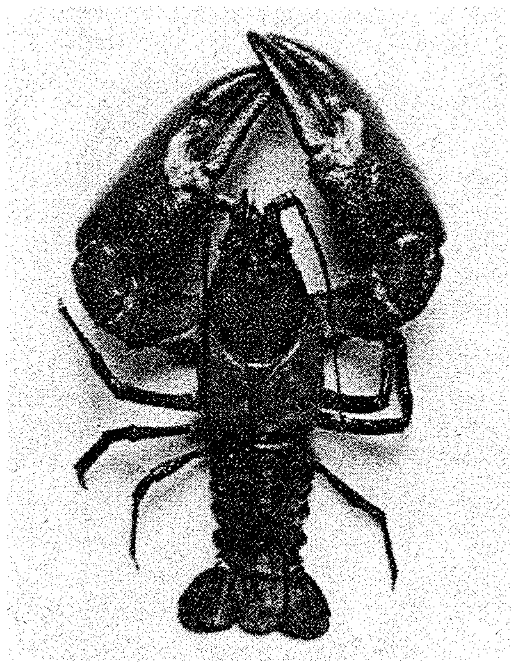
REFERENCES

Department of Fish and Game. 1998. Final Environmental Documentation for Pacific Herring Commercial Fishing Regulations.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Wang, Johnson, C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. IESP Technical Report 9. pps 3-4 through 3-7.

◆ SIGNAL CRAYFISH



INTRODUCTION

The signal crayfish is an important non-native resident invertebrate of the Central Valley and Delta. It occupies a wide range of habitats from swift large rivers to sluggish backwaters. It currently supports a recreational and an active commercial fishery that in 1977 resulted in over 500,000 pounds of crayfish being harvested. The population appears to be stable since the introduction of fishing regulations that limits the commercial take of any crayfish under 9.2 centimeters total length.

Factors that may limit the signal crayfish's ability to contribute to a healthy Central Valley ecosystem are river and stream flow, aquatic habitat, and competition from recently introduced species (mitten crab).

RESOURCE DESCRIPTION

The signal crayfish was first described in 1852 by the U.S. Exploring Expedition during their west coast expeditions. The signal crayfish was introduced into California waters from Oregon and has spread throughout Central Valley waterways. Crayfish have been known to estivate for periods of time when fields are dried and then re-flooded at a later date. This process makes them extremely adaptable to drought conditions. Habitat use has been described to not exceed over 3 meters in depth and water conditions from clear cool fast moving water to slow stagnate backwaters. Signal crayfish have also been noted in slightly brackish waters of the western Delta.

Spawning occurs in the fall with the females carrying the eggs over winter and releasing the young of the year in early spring.

VISION

The vision for the signal crayfish is to maintain self-sustaining population of crayfish in order to support recreational and commercial fishing. A major focus of efforts to maintain the fishery would be to assure that the Sacramento and San Joaquin river flows during the late summer and early fall remain above an established level for that period. Many of the efforts implemented under the Stage 1 Actions to increase tidally influenced and other aquatic habitats will benefit crayfish populations. Increases in shallow-water habitat will provide additional burrowing and foraging areas for the crayfish. Increases in crayfish numbers will provide an increased forage base for sturgeon (green and white), smallmouth bass, and terrestrial species.

Efforts will need to be implemented that look at the interaction among members of the benthic community. Specifically the interaction between crayfish and the recently introduced mitten crab (*Eriocheir sinensis)* will need to be examined.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain a sustained population of signal crayfish in the Sacramento and San Joaquin rivers and Delta would also involve cooperation and support from other established programs.

- Water Quality Control Program for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995).

- California Fish and Game Commission will continue to regulate and develop fishing regulation based on recommendations by the California Department of Fish and Game.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of the crayfish population will be benefitted by other efforts to restore populations of chinook salmon, steelhead, delta smelt, sturgeon, and riparian habitats throughout the ERPP service area.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain fisheries for signal crayfish in the Delta.

LONG-TERM OBJECTIVE: Allow signal crayfish numbers (and harvest) to increase gradually as conditions in the restored estuary favor its reproduction and survival. Use harvest and other management measures to ensure that increases in crayfish populations do not jeopardize programs to sustain native species.

SHORT-TERM OBJECTIVE: Maintain signal crayfish populations at present levels, in order to support the existing fisheries.

RATIONALE: The signal crayfish is an introduced species that supports a small commercial fishery, as well as a recreational fishery, in the Delta. It has been established in the Delta for nearly a century and appears to be integrated into the Bay-Delta system, appearing as a major food item for otters and some fish. The signal crayfish has fairly high water quality requirements so its populations will presumably increase as water quality in the freshwater portions of the Delta improves. Its role in the ecosystem and the effects of the fishery on that role need to be investigated.

STAGE 1 EXPECTATIONS: An investigation of the ecological requirements of the crayfish and the effects of the fishery will have been conducted, to find out if any special management for either is needed.

The target for signal crayfish is to maintain existing levels and eventually increase both the commercial and recreational fisheries within the Sacramento-San Joaquin Delta.

Signal crayfish would benefit from the following restoration activities and actions:

All Ecological Management Zones:

- Determine the interaction and potential effects between mitten crabs and signal crayfish on both the commercial and recreational fisheries.

- Habitat improvements and increases to both riparian and tidally influenced zones.
- Improved and sustained flows in the major rivers and streams of the Central Valley

REFERENCES

Riegal, J.A. 1959. The systematics and Distribution of Crayfishes in California. In: California Fish and Game; Volume 45, Number 1, pages 29-49.

Huner, Jay V. 1978. Exploitation of Freshwater Crayfishes in North America. In: Fisheries; Volume 3, Number 6, pages 2-5.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

INTRODUCTION

The term "grass shrimp" refers collectively to two genus of shrimp (*Crangon and Palaemon*) that are present in the San Francisco Bay. These grass shrimp are commercially fished in the Bay and sold as bait. Early this century, commercial trawls landed around three million pounds of shrimp for a dried shrimp market. Recently, catches of shrimp have been between 100,00 to 200,000 pounds of shrimp per year. The general life cycle of these shrimp is to hatch larval shrimp in highly saline areas and the juveniles migrate to less saline areas to mature. These shrimp are relatively short lived and mature in about one year.

A factor that may limit the grass shrimp's ability to contribute to a healthy ecosystem is a reduction in freshwater outflow.

RESOURCE DESCRIPTION

The genus *Crangon* is comprised of three native species (*C. franciscorum, C. nigricauda*, and *C. nigromaculata*) while the genus *Palaemon* is a single introduced species (*P. macrodactylus*). Unlike the *P. macrodactylus*, which remains in the Bay throughout its life cycle, *Crangon spp.* utilize the Bay as a nursery area and move into less saline waters to mature. *C. franciscorum* juveniles are most abundant in April through May in brackish warm waters. *C. nigricauda* juveniles peak in late-spring to early summer in higher saline waters. *C. nigromaculata* juveniles occur from May through November with all ages occurring in cool shallow coastal waters. *P. macrodactylus* larvae hatch from April to August and juveniles are abundant from June to September.

VISION

The vision for grass shrimp is to maintain self-sustaining populations in order to support existing commercial fisheries. A major focus of efforts will be to assure that average March through May outflow from the Sacramento and San Joaquin rivers is above 30,000 cfs. Many of the actions described in the Stage 1 Actions may not benefit these species. However, other CALFED actions will benefit these species such as levee improvements that will prevent the influx of more saline waters into the western Delta.

Efforts will need to be implemented that look at the interaction among members of the benthic community. Specifically the interaction between grass shrimp and the recently introduced mitten crab (*Eriocheir sinensis*) will need to be examined.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to maintain a sustained population of grass shrimp in the Sacramento and San Joaquin rivers and Delta would also involve cooperation and support from other established programs.

- Water Quality Control Program for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (May 1995).

- California Fish and Game Commission will continue to regulate and develop fishing regulation based on recommendations by the California Department of Fish and Game.
- Suisun Marsh Preservation Agreement between the Department of Fish and Game, Department of Water Resources, U.S. Bureau of Reclamation, and Suisun Resource Conservation District.
- San Francisco Bay Conservation and Development Commission

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Maintenance of grass shrimp populations will be benefitted by other efforts to restore populations of chinook salmon, steelhead, delta smelt, sturgeon, and outflow requirements in the Delta.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to maintain fisheries for grass shrimp in the San Francisco Bay.

LONG-TERM OBJECTIVE: Allow grass shrimp (Crangon spp., Paleomon) numbers (and harvest) to increase as conditions in the restored estuary favor their reproduction and survival.

SHORT-TERM OBJECTIVES: Maintain grass shrimp populations at present levels as a minimum to support the existing commercial fisheries. Determine factors regulating their populations in order to discover if the fisheries conflict with other ecosystem restoration objectives.

RATIONALE: Grass shrimp are a mixture of native and introduced species that support a small commercial fishery in San Francisco Bay, largely for bait. The relative abundance of the various species as well as their total abundance appears to be tied in part to outflow patterns. It is likely that these abundant shrimp are important in Bay-Delta food webs leading to many other species of interest. The role of these shrimp in the Bay-Delta system and the effects of the fishery on that role need to be investigated.

STAGE 1 EXPECTATIONS: An investigation of the ecological role and requirements of the shrimp species and the effects of the fishery will have been conducted, to find out if any special management for either is needed.

The target for grass shrimp is to increase the population of grass shrimp above existing levels and eventually increase the commercial fishery within San Francisco and surrounding bays.

Grass shrimp would benefit from the following restoration activities and actions:

- Determine the interaction and potential effects between mitten crabs and grass shrimp on the commercial fishery.

- Improved and sustain Delta outflow during the March through May period.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

WRINT-DFG-Exhibit # 6. 1992. 1992 Water Quality/Water Rights Proceedings in the San Francisco Bay/Sacramento - San Joaquin Delta Estuary Dependent Species.

◆ VISION FOR REDUCING OR ELIMINATING STRESSORS

INTRODUCTION

This section presents visions for stressors that adversely affect important ecosystem elements. 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. Reducing the adverse effects of stressors is a major component in the Ecosystem Restoration Program Plan (ERPP). Stressors addressed have a strong effect on an ecological process, habitat, or a species that is dependent on the Bay-Delta and can be feasibly and sufficiently reduced to improve the health of the Bay-Delta ecosystem.

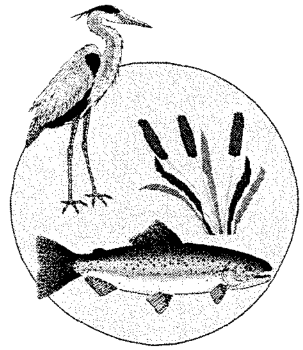


Table 15 identifies important stressors and the related ERPP Strategic Objective. Strategic Objectives are fixed and will not change through time. Table 16 presents the basis for their selection as an ecosystem stressor.

These visions describe the locations where the stressor has a substantial adverse effect in the ERPP area, and how each stressor affects ecological processes, habitats, and/or species. Restoration needs to reduce the adverse effects of stressors are also identified. The Ecosystem Restoration Program Plan, Volume II: Ecological Management Zone Visions contains more detailed objectives, targets, and programmatic actions for each stressor as it relates to a specific ecological management zone. Table 17 identifies which ecological management zones address which stressors.

Table 15. Strategic Objectives for Stressors.

Stressor	Strategic Objective
Water Diversions	Reduce entrainment of all life stages of 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 and Other Structures	Create flow and temperature regimes in regulated rivers that favor native aquatic species. Provide flow releases in regulated streams to mobilize gravel beds, drive channel migration, and inundate floodplains in order to maintain channel and sediment conditions favorable to native aquatic and riparian organisms.

Stressor	Strategic Objective
Levees, Bridges, and Bank Protection	Re-establish frequent inundation of floodplains by removing, breaching, or setting back levees and , in regulated rivers, by providing flow releases capable of inundating floodplains. (See also the Strategic Objectives for coarse sediment supply, stream meander, and natural floodplains, and flood processes.)
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	Restore coarse sediment supply to sediment-starved rivers downstream of reservoirs.
Invasive Aquatic Plants	Halt the introduction of invasive aquatic and terrestrial plants into Central California. Develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.
Invasive Aquatic Organisms	Eliminate further introductions of new species in ballast water of ships. Eliminate the use of imported marine baits. Halt the introduction of freshwater bait organisms into the waters of Central California. Halt the deliberate introduction and spread of potentially harmful species of fish or other aquatic organisms in the Bay-Delta and Central Valley. Halt the unauthorized release of non-native introduced species and other organisms from private aquaculture operations into California waters. Halt the release and spread of aquatic organisms from the aquarium/pet trade into waters of Central California. Develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.

Stressor	Strategic Objective
Invasive Riparian and Salt Marsh Plants	Halt the introduction of invasive aquatic and terrestrial plants into Central California. Develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.
Zebra Mussel	Prevent the invasion of the zebra mussel into California.
Non-Native Wildlife	Reduce the impact of exotic mammals on native birds and mammals. Develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.
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 the concentrations and loading of contaminants in all aquatic environments in the Bay-Delta watershed. Develop regional plans to reduce the effects of non-point source contaminants. Reduce contaminant loads in harvested organisms. Reduce to acceptable levels the release of oxygen-depleting substances into aquatic systems throughout the Bay-Delta watershed.
Fish and Wildlife Harvest	Enhance populations of waterfowl for harvest by hunting and for non-consumptive recreation.
Artificial Fish Propagation	Alter practices to augment chinook salmon and steelhead populations by the entire State, federal, and private hatchery system in light of CALFED goals. Change the role of trout hatchery and planting programs to make them more compatible with CALFED goals.
Stranding	Reduce or eliminate the stranding and loss of aquatic organisms due to lack of connectivity of flood bypasses, levee toe drains, and flood plain ponds with flowing waters.
Disturbance	Reduce human activities that adversely affect wildlife behavior or cause habitat destruction, decrease reproductive success, and contribute to the decline of important species.

Table 16. Basis for Selection of Stressor Ecosystem Elements

Stressors	Basis for Selection as an Ecosystem Element
Water Diversions	Diversions cause loss of water, nutrients, sediment, and organisms (entrainment). The transfer of water across the Delta through existing channels may also detour migrating resident, estuarine, and resident fish species from their primary routes. The diversion rate also contributes to reduced water residence time which reduces primary (plant) and secondary (animal) production and standing biomass.
Dams and Other Structures	Dams block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for detrimental predatory fish and wildlife.
Levees, Bridges, and Bank Protection	Levee, bridge, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains, and allow stream channels to meander. Levees prevent floodflows from entering historic floodplains, and eliminate or alter the character of floodplain ecosystem processes and habitats. Channelizing floodflows also increases scour or incision and reduces or halts channel meander and oxbow formation. Bridges have a similar, though generally more localized effect.
Dredging and Sediment Disposal	Dredging in Bay-Delta waters may damage aquatic habitat or harm aquatic animals and plants. Channel dredging also contributes to levee instability and steepens channel banks which increases shoreline habitat erosion.
Gravel Mining	Mining sand and gravels from rivers and floodplains may affect natural sediment supply, gravel movement, and sediment deposition. Sand, gravel, and sediment distribution influences the quality of wildlife habitat, abundance of aquatic predators, water quality and fish and wildlife populations. Excessive instream mining could result in riparian corridor instability.
Invasive Aquatic Plants	Invasive aquatic plants may have an adverse effect on native aquatic plants, constrain habitat quality of water ways, require control measures, and impair water conveyance systems and use of fish protective devices such as fish screens.
Invasive Aquatic Organisms	Invasive aquatic organisms may have an adverse effect on the foodweb and on native species resulting from competition for food and habitat and direct predation.
Invasive Riparian and Marsh Plants	Restoration of native riparian and marsh plants and plant communities can be hindered by introduced species which may out-compete or displace native plant species. Non-native plant species may have little value to wildlife and other riparian dependent species.

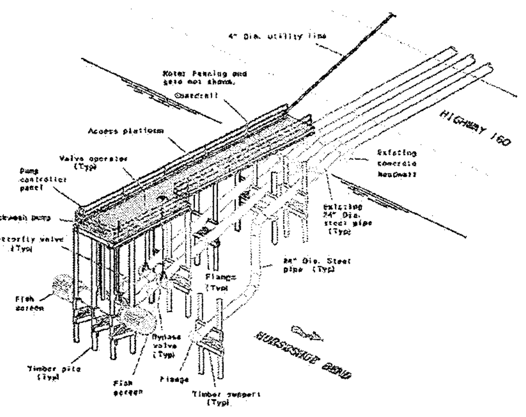
Stressors	Basis for Selection as an Ecosystem Element
Zebra Mussel	The zebra mussel has caused enormous damage to water supply infrastructure and natural ecosystems in the eastern United States. It is likely that zebra mussel will appear in California's Central Valley through any one of several means. Therefore, it is highly desirable to have in place a strategy to swiftly contain a localized invasion.
Non-native Wildlife	Introductions of non-native species may adversely affect the survival of native wildlife. Non-native wildlife has greatly altered ecological processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.
Predation and Competition	Unnatural levels of predation and competition may adversely affect populations of fish and wildlife.
Contaminants	Contaminants affect water quality and the survival of fish, waterfowl, and the aquatic foodweb.
Fish and Wildlife Harvest	Fish and wildlife harvest may affect abundance of species or viability of local populations.
Artificial Fish Propagation	Fish hatcheries and other artificial propagation programs (e.g., pen-rearing salvaged striped bass) may adversely affect populations of "wild" fish. Direct effects might be predation on wild fish or competition from artificially-produced fish. Indirect effects may occur from adverse changes in wild population genetics from interbreeding with hatchery fish. Disease may also be transferred from hatchery fish to wild fish.
Stranding	Stranding of juvenile fish and other aquatic organisms was probably a natural environmental event in the historical Central Valley. Today, many stranding events are caused by flood bypasses, construction of levee toe drains, and other anthropomorphic events. Modification to lowland areas and providing escape routes back to larger bodies of water and flowing streams will reduce the mortality related to stranding.
Disturbance	Boating, habitat disturbance, and other negative anthropogenic activities may adversely affect wildlife habitat and species abundance and distributions.

Table 17. Ecological Management Zones in Which Targets and Programmatic Actions to Reduce Stressors Are Proposed *[Note: Refer to Volume II: Ecological Management Zone Visions for information regarding specific targets and actions.]*

Stressors	Ecological Management Zone[1]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Water Diversions	●	●	●	●			●	●	●	●	●	●	●	
Dams and Other Structures			●	●			●	●			●		●	
Levees, Bridges, and Bank Protection	●		●						●			●		
Dredging and Sediment Disposal	●													
Gravel Mining				●	●					●				
Non-native Species	●	●	●	●					●	●	●			
Zebra Mussel	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Predation and Competition	●	●	●							●	●		●	
Contaminants	●	●	●			●			●	●	●	●		●
Fish and Wildlife Harvest	●	●	●	●			●	●	●		●		●	
Artificial Fish Propagation			●	●			●	●	●		●		●	
Stranding	●	●	●				●	●	●	●			●	
Disturbance	●	●												

Ecological Management Zones

[1] 1 = Sacramento-San Joaquin Delta
2 = Suisun Marsh/North San Francisco Bay
3 = Sacramento River
4 = North Sacramento Valley
5 = Cottonwood Creek
6 = Colusa Basin
7 = Butte Basin
8 = Feather River/Sutter Basin
9 = American River Basin
10 = Yolo Basin
11 = Eastside Delta Tributaries
12 = San Joaquin River
13 = East San Joaquin Basin
14 = West San Joaquin Basin



INTRODUCTION

Water diversions are found throughout Central Valley rivers and their tributaries, the Bay and Delta. Water is diverted for irrigated agriculture, municipal and industrial use, and managed wetlands.

Water diversions in the Bay-Delta watershed directly and indirectly affect fish, aquatic organisms, sediments, streamflow, habitat, foodweb productivity, and species abundance and distribution. The rate of diversion from the Delta affects residence time of water which, in turn, affects primary (plant) and secondary (animal) production.

Factors that relate to the influence that diversions have on the health of the Bay-Delta ecosystem health include diversion rate, the season in which water is diverted, the diversion location, fish species, fish life stage periodicity, and whether the diversion is equipped with adequate fish protection facilities.

In most cases, entrained organisms do not survive. Some diversions have screens that exclude most juvenile and adult fish; however, eggs and larval fish, invertebrates, planktonic plants, organic debris and dissolved nutrients are lost to diversions.

STRESSOR DESCRIPTION

Water diversion in the Bay-Delta and its watershed may vary by water year type and month of the year, and has a wide variety of effects on streamflow, aquatic organisms, habitat, and ecosystem processes. In some cases, diversions on a tributary stream remove so much flow during summer and fall that little or no flow remains in the stream.

Along the mainstem Sacramento River the following diversions exist:

- The Red Bluff Diversion Dam (RBDD) diverts Sacramento River water into the Tehama-Colusa Canal and the Corning Canal.
- The Anderson-Cottonwood Irrigation District (ACID) Diversion Dam diverts water into the ACID canal.
- The Glenn-Colusa Irrigation District's (GCID's) Hamilton City Pumping Plant. With a diversion capacity of 3,000 cubic feet per second (cfs) it is the largest diversion on the Sacramento River.
- Several hundred smaller diversions exist along the Sacramento River, more than 2,000 diversions exist in the Delta, and about 150 diversions exist in the San Joaquin.

The largest diversions have fish screens and require frequent, routine maintenance to provide consistent levels of fish protection. The effectiveness of screens is dependent on may factors, including maintenance, design, and site-specific physical conditions. A well-designed fish screen based on proved technology is effective in reducing entrainment and impingement losses of many species of juvenile fish. Screen retrofits can be fairly inexpensive, especially on smaller-sized diversions.

In the south Delta, the two largest diversions are operated by the State Water Project (SWP) and federal Central Valley Project (CVP). These two large diversions have louvers that guide juvenile fish into bypasses and holding facilities, where salvaged fish are collected and transported back to the Bay and Delta. Many fish are salvaged. Nevertheless, many more are lost to handling, predation and to bypass inefficiency during collection and holding at the fish facilities, or during fish transport. Programs to upgrade these fish protection facilities are ongoing.

Two large fossil fuel power plants are operated in the Bay-Delta, one at Antioch and one at Pittsburg. Each has large, screened intake systems. The screens, however, use 1950s technology and do not effectively screen larvae or small juvenile fish. Although the power plants return the water to the Delta, many entrained larvae and juveniles are killed by mechanical damage or heat stress. Survival rates have been measured only for striped bass and under many conditions, approximately 80% passing through the plant survive.

The Contra Costa Water District has several diversions in the Bay-Delta. They sporadically operate a diversion at Mallard Slough in Suisun Bay. New screens are in place at the new Los Vaqueros diversion on Old River. New screens are being constructed at the Contra Costa Water District Rock Slough intake.

In Suisun Bay and Suisun Marsh, far fewer agricultural diversions exist because of brackish waters. However, many State and privately managed wetlands divert water seasonally from Suisun Marsh sloughs. The larger diversions at Roaring River, Grizzly Slough, and Island Slough are screened. The smaller diversions are unscreened gates, siphons, or pumps. Recently, the Suisun Resource Conservation District (SRCD) and California Department of Fish and Game (DFG) began a program to screen some diversions with self-cleaning, fine-mesh screens.

ISSUES AND OPPORTUNITIES

ENTRAINMENT OF FISH AT PUMPS. The entrainment of fish and other biota in the CVP and SWP pumps and agricultural water diversions in the Delta and tributaries stimulate conflicts among stakeholders. However, it is not clear to what extent entrainment affects the population size of any one species of fish or invertebrate (Diversion Effects on Fish Team 1998). More information on the effects of entrainment will be pivotal in choosing a water conveyance method, because it will help determine to what extent an "isolated facility" can be expected to alleviate any problems. Reducing this uncertainty is also essential to ensure the most efficient allocation of restoration funds because proposed solutions to this problem include potentially tens of millions of dollars spent constructing fish screens and new intake facilities throughout the Bay-Delta system, not all of which may be as effective as intended at reducing population declines (Strategic Plan 1999).

VISION

The vision for water diversions is to reduce the adverse effects of water diversions, including entrainment of all life stages of aquatic species, by installing fish screens, consolidating or moving diversions to less sensitive locations, removing diversions, or reducing the volume of water diverted. Achieving this vision will assist in the recovery of State- and federally listed fish species, improve important sport fisheries, and improve the Bay-Delta aquatic foodweb.

This vision concentrates on the direct effects of aquatic organism entrainment. Cumulatively, water diversions remove large numbers of young salmon, steelhead, delta smelt, splittail, striped bass, and many other fishes and invertebrates from the rivers, Delta, and Bay.

Approaches to achieving this vision include reducing their adverse effects by removing or relocating high impact diversions. Altering the timing of some diversions would help to reduce losses of aquatic organisms. Installing positive-barrier fish screens would help to reduce losses.

On many Sacramento and San Joaquin rivers and their tributaries, diversions entrain juvenile salmon and steelhead in spawning and rearing areas, and on their migrations downstream toward the ocean. Adequate positive barrier fish screens will protect juvenile salmon and steelhead from being entrained. Positive barrier fish screens can be employed at most of the tributary diversion sites.

Screen upgrades continue to improve screening efficiency for the large diversions along the Sacramento River, such as those of ACID, RBDD, and GCID. The Red Bluff Research Program is studying alternatives, including pumping from the river and returning entrained salmon and steelhead to the river through a bypass system. Positive-barrier screens that move fish through a bypass are also being considered for large diversions such as GCID.

The Delta Fish Facilities Technical Team is focusing on reducing entrainment losses at the south Delta pumping plants through the use of positive barrier fish screens. Salvage facilities at SWP and CVP diversions do not provide adequate fish protection, especially for small, fragile species like delta smelt.

The technical team is currently considering two parallel approaches. The first is to upgrade the screening systems of the existing facilities. The second is to provide an alternative intake location, such as in the north Delta, where entrainment losses would be less and fewer fish would be drawn into the Central and South Delta.

The preferred approach includes construction of a new screened intake at Clifton Court Forebay with protective screening criteria and construction of either a new screened diversion at Tracy with protective screening criteria; and/or an expansion of the new diversion at Clifton Court Forebay to meet the Tracy Pumping Plant export capacity. This approach is designed to improve water supply reliability, protect and improve Delta water quality, improve ecosystem heath, and reduce risk of supply disruption due to catastrophic breaching of Delta levees.

Using self-cleaning cylindrical screens on small Bay-Delta siphons and pump diversions appears feasible. In Suisun Bay and Suisun Marsh, use of either positive-barrier flat screens or conical screens on slough intakes (e.g., Roaring River diversion) has proven effective.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Working with individual diverters would achieve the vision to provide them with alternative sources of water, moving their intakes, revising their diversion schedules, or funding installation of screened intakes.

Efforts to reduce impacts of unscreened diversions in the Bay-Delta and its watershed will involve cooperation among several agencies' screening programs including DFG's Unscreened Diversion Program, Anadromous Fish Screen Program of the CVPIA, and NRCS's Fish Screen Program. Recently, Reclamation Districts 108 and 1004, and Princeton-Cordua-Glenn/Provident Irrigation District and other large diverters are either installing new screens or have begun the engineering needed to install screens. Hundreds of smaller diversions along the river consist of siphons or pumps; most of these are unscreened. The CVPIA Anadromous Fish Screen Program will contribute to the screening of many of these diversions on a cost-share basis. Cooperation will also be sought with agencies having responsibility or authority for dealing with screening diversions, including DFG, DWR, Reclamation, State Water Resources Control Board, NRCS, NMFS, and the U.S. Army Corps of Engineers.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Water diversions are closely linked to other ecosystem elements including processes, habitats, and species. For example, the diversion of large quantities of water in the Delta also results in the diversion of sediments, nutrients, and many lower level organisms in the Bay-Delta aquatic food chain. The management of water in the ERPP study area, particularly the delivery of water to the Delta for export, has altered natural flow patterns and ecological processes that maintain habitats in upstream rivers and tributaries and in the Delta. Entrainment also causes direct and indirect mortality to juvenile fish, eggs and larvae.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to 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 other beneficial uses of land and water.

LONG-TERM OBJECTIVE: Eliminate or reduce adverse impacts of the diversion of water to a level of little significance.

SHORT-TERM OBJECTIVE: Construct and screen a new SWP intake to Clifton Court Forebay. Construct a new screened intake at the CVP intake and/or expand the new diversion at Clifton Court to meet Tracy Pumping Plant need. Screen the largest of the remaining unscreened diversions then begin screening the smaller diversions. Develop a science and data based analysis/evaluation process by which to set priorities for screening.

RATIONALE: Storage and diversion of water from Central Valley rivers and streams and from the Delta has produced significant detrimental effects on the ecosystem, including functions such as spawning, rearing, and migration, the processes that create and maintain habitat, habitat, and species that depend on the aquatic habitats. The relocation, consolidation and installation of positive barrier fish screens does not reduce the amount of water extracted, but such actions are encouraged as they will reduce the mortality resulting from the direct entrainment of young fish. The intent of the restoration program is to eliminate loss of fish resulting from the unscreened diversion of water to a level that no longer impairs efforts to rebuild fish populations to healthy levels. Likewise, the potential future relocation of the SWP and CVP intakes and installation of positive barrier fish screens does not reduce the amount of water extracted, but will reduce the mortality resulting from the direct entrainment of young fish and contribute to restoring the ecological functions of the Delta such as food web support, and spawning and rearing habitat.

STAGE 1 EXPECTATIONS: During Stage 1 of the implementation program, all diversions greater than 250 cfs will have been screened, the majority of diversions between 100 and 250 cfs will have been screened, and a process will be in place to set priorities and screen diversion smaller that 100 cfs. During this period, fish populations will exhibit a positive response and increase in abundance.

The general target is to reduce the adverse effects of water diversion so that the diversion of water, in conjunction with other restoration actions, does not impair other restoration efforts needed to restore ecological health to the Bay-Delta system.

The following activities would help to achieve this vision:

- Widen the area of concern of the Anadromous Fish Screen Program's multiagency policy level and management team for unscreened diversions which is composed of representatives from the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (Reclamation), DFG, California Department of Water Resources (DWR), and U.S. Natural Resources Conservation Service (NRCS) districts.

- Finish the development of the priority system to install positive-barrier fish screens on all diversions of more than 100 cfs in the upper Sacramento River and all diversions in tributary streams with salmon and steelhead populations by providing funding support to DFG and CVPIA screening programs.

- Construct and test a pilot screening facility in the south Delta adjacent to the Tracy Fish Facility to test a 500 cfs positive-barrier fish screen and collection system.

- Construct new screened intakes at Clifton Court and the Tracy Fish Facility; and/or expand the diversion at Clifton Court to accommodate the needs of the Tracy Pumping Plant and fish-holding facility.

- Support completion of research at the Red Bluff Research Program.

- Assess the effectiveness of test cylindrical screens at DWR siphon diversions on Sherman Island.

- Screen small diversions in Suisun Marsh, focusing on Montezuma and Suisun Sloughs.

- Continue research on fish behavior relative to screening (University of California, Davis Treadmill Study).

- Continue research on fish screening and related facilities design and operations.

- Coordinate research and testing of the various screening programs among resource agencies.

- Develop a long-term screening program plan in cooperation with DFG, USFWS, NMFS, irrigators, and other stakeholders.

- Screen small siphon and pump diversions in the Delta, mainstem rivers, and lower tributaries.

- Develop an incentive plan to encourage local diverters to consolidate smaller diversions where possible to increase the cost-effectiveness of screening.

- Consider an upgrade to existing screens at PG&E's Pittsburg power plant and Contra Costa Water District's Mallard Slough diversion with positive-barrier fish screens.

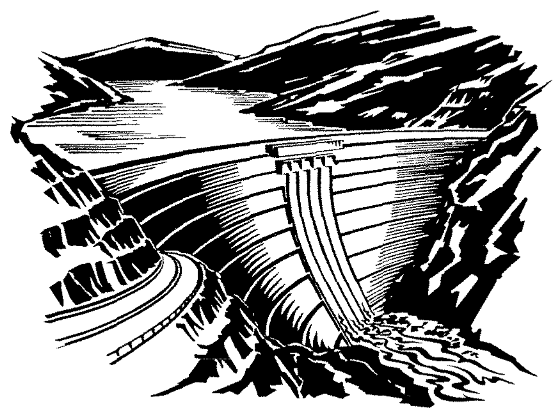
- Provide alternative sources of water to diversions, where possible, in lower portions of tributaries and agricultural lands and managed wetlands along rivers and in the Delta and Suisun Marsh.

REFERENCES

The Resources Agency. 1989. Upper Sacramento River fisheries and riparian habitat management plan. Sacramento, CA.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Dams and Other Structures



Introduction

Dams and other human-made structures come in various forms, from the largest dam (Shasta), to small weirs on tributary streams. Dams stop downstream water flow and capture sediment derived from erosion in the upper watersheds. The captured water backs up to create a reservoir. Seven major dams restrict streamflows from entering the Bay-Delta.

Diversion dams exist throughout the watershed of the Sacramento-San Joaquin rivers and Bay-Delta. Larger weirs are located along the Sacramento River at the Yolo, Sutter, and Sacramento bypasses. Small weirs can be found on most upper watershed tributaries.

Dams and other human-made structures act as stressors on ecosystem processes, important habitats, and species in aquatic ecosystems. For example, dams and their associated reservoirs block fish migration, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. The construction, operation, and maintenance of these structures in the Central Valley have contributed to the decline of many species.

Stressor Description

Dams in any form block or hinder upstream and downstream migrations of anadromous fish and hinder downstream transport of sediment. Larger dams completely block anadromous fish migration. These large dams resulted in the loss, and in some cases extinction, of local salmon and steelhead populations (Mills et al. 1996).

Many moderately sized diversion dams, such as Red Bluff Diversion Dam (RBDD) and Anderson-Cottonwood Irrigation District (ACID) Diversion Dam, contain fish ladders to allow fish passage. Some dams, such as Capay Dam on Cache Creek and Solano Dam on Putah Creek, do not.

Small diversion dams are generally constructed to seasonally divert water for irrigation. Although many have been fitted with ladders to allow fish passage, many are technologically outdated and only marginally effective. Often, salmon and steelhead can negotiate the fish ladders, but other species, such as American shad, green sturgeon, and white sturgeon, cannot. In some cases, fish ladders delay adult salmon and steelhead from reaching upstream spawning grounds or downstream migrating juvenile salmon and steelhead.

In high-flow years, water flows from the river into the bypasses and downstream to return to the river or Delta. In such cases, adult salmon and steelhead may migrate upstream through the bypasses and become blocked below the weirs opposite the river. A similar situation occurs in the Sacramento Ship Channel. Blockage and delay of steelhead and winter-run salmon are of particular concern because the fish usually migrate upstream during the winter and spring high-flow periods.

Larger irrigation returns in wetter years have relatively high flows that may attract anadromous fish. Fish attracted to these returns may become lost or delayed. The Colusa Basin drain, which enters the Sacramento River near Knights Landing, is an example of an irrigation return that is known to attract adult salmon.

ISSUES AND OPPORTUNITIES

OPPORTUNITIES FOR RIVERS: Mimic natural flow regimes through innovative methods to manage reservoir releases. There is underutilized potential to modify reservoir operations rules to create more dynamic, natural high-flow regimes in regulated rivers without seriously impinging on the water storage purposes for which the reservoir was constructed. Water release operating rules could be changed to ensure greater variability of flow, provide adequate spring flows for riparian vegetation establishment, simulate effects of natural floods in scouring riverbeds and creating point bars, and increase the frequency and duration of overflow onto adjacent floodplains. In some cases, downstream infrastructure of river floodways may require upgrading to safely accommodate a more desirable natural variability and peak discharge magnitude associated with moderate floodflows (e.g., strengthen or set levees back) (Strategic Plan 1999).

Remove barriers to anadromous fish migration where feasible. Significant progress has been made in recent years to improve salmon passage on several spawning streams (e.g., Butte Creek, Battle Creek) by removing barriers, consolidating diversion weirs, or constructing state-of-the-art fish passage structures. Existing and potential spawning areas in the ERP focus area that are not obstructed by major reservoir dams, but are currently obstructed by other barriers, should be identified and action taken to restore anadromous fish spawning upstream (Strategic Plan 1999).

VISION

The vision for dams and other structures is to reduce their adverse effects by improving fish passage and enhancing downstream fish habitat. Reducing these adverse effects will assist in the recovery of State- and federally listed fish species and contribute to sustainable sport and commercial fisheries.

To accomplish this vision, the Ecosystem Restoration Program (ERP) proposes to address a variety of problems caused by these structures which effect natural processes (e.g., sediment transport), habitats (e.g., riverine and riparian aquatic habitat), and species (e.g., winter-run chinook salmon and steelhead).

For rivers with large dams that block anadromous fish migration, ERPP proposes to improve flow and habitat conditions below these dams. Flow and habitat improvements would enhance salmon and steelhead populations in the lower river reaches. The feasibility of restoring anadromous fish above some of these dams may be considered in the future. Cooperation will be required from local irrigation districts and landowners to rectify these problems.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to reduce the effects of human-made structures on the aquatic ecosystem would involve cooperation and support from other established programs underway to protect and improve conditions for anadromous fish and native resident fishes in the Bay-Delta and its watershed. The recovery plan for the Sacramento/San Joaquin Delta native fishes will be considered in the development of proposed actions (USFWS 1996). CVPIA will implement actions that will reduce adverse effects caused by structures (USFWS 1997). California's Salmon, Steelhead Trout, and

Anadromous Fisheries Program Act includes actions to reduce adverse effects of structures (Reynolds et al 1993). The Four Pumps Agreement Program continues to develop projects to reduce effects of structures. Endangered Species Act requirements (biological opinions and habitat conservation plans) will ensure maintenance of existing habitat conditions and implementation of recovery actions (NMFS 1997).

The blockage of migrating anadromous fish in mainstem rivers and tributary streams is a major concern of the Central Valley Project Improvement Act's (CVPIA's) Anadromous Fish Restoration Program (AFRP) and California Department of Fish and Game's (DFG's) Salmon and Steelhead Restoration Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Dams and other humanmade structures are found throughout the ERPP Study Area and its ecological management zones. Large water storage and flood control dams are present on the large rivers and streams and many smaller streams. Water storage and diversion structures impair ecological processes such as Central Valley streamflow, natural sediment supply, stream meander, natural floodplain and flood processes, and Central Valley stream temperatures. This group of stressors also impairs a variety of habitats needed to support fish, wildlife, and plant communities. The most adversely affected habitat is riparian and riverine aquatic habitat. Virtually all fish, wildlife and plant community populations which are dependent on seasonal and perennial aquatic habitats have been reduced. This is particularly true for anadromous fish populations which no longer have access to their former oversummering, spawning, and rearing areas above the major dams.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for dams and other structures is to make sure that high flows occur frequently enough in regulated streams to maintain channel and sediment conditions favorable to native aquatic and riparian organisms.

LONG-TERM OBJECTIVE: For regulated rivers in the region, establish scientifically based high-flow events necessary to maintain dynamic channel processes, channel complexity, bed sediment quality, and natural riparian habitats where feasible.

SHORT-TERM OBJECTIVE: Through management of the reservoir pool or deliberate reservoir releases, provide a series of experimental high-flow events in regulated rivers to observe flow effects on bed mobility, bed sediment quality, channel migration, invertebrate assemblages, fish abundance, and riparian habitats over a period of years. Use the findings of these studies to reestablish natural stream processes where feasible, including restoration of periodic inundation of remaining undeveloped floodplains.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. By deliberately releasing such flows from reservoirs, at least some of these physical and ecological functions can probably be recreated. A program of such high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species.

STAGE 1 EXPECTATIONS: Studies should be conducted on five to 10 regulated rivers in the Central Valley to determine the effects of high-flow releases. Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations should be developed and instituted where feasible.

A second Strategic Objective for flow is to create flow and temperature regimes in regulated rivers that favor native aquatic species.

LONG-TERM OBJECTIVE: Native fish and invertebrate assemblages will be restored to regulated streams where feasible, using methods developed during the short-term objective phase.

SHORT-TERM OBJECTIVE: Provide adequate flows, temperatures, and other conditions to double the number of miles (as of 1998) of regulated streams that are dominated (>75% by numbers and biomass) by assemblages with four or more native fish species.

RATIONALE: Virtually all streams in the region are regulated to some degree, and the regulated flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Achievement of this objective will require additional systematic manipulations of flows below dams (or the re-regulation of existing flow regimes) to determine the optimal flow and habitat conditions for native organisms, as part of the short-term goal. Part of the studies should be to determine if the objective can be achieved without "new" water, by just altering the timing of releases or by developing conjunctive use agreements that allow more water to flow down the stream channel. Ways to restore native fish communities that do not involve changed flows should be developed (where feasible) to be used in place of or synergistically with changed flows. These findings can then be applied opportunistically to achieve the long-term goal of restoring native fish communities.

STAGE 1 EXPECTATIONS: Surveys will have been completed to determine the status of native fishes in all regulated streams of the Central Valley and flow recommendations made to restore native fishes where feasible. During negotiations for relicensing of dams, agency personnel should request flow regimes favorable for native fishes.

The general target for dams and other human-made structures is to reduce or eliminate their adverse influence on ecological processes, habitats, and dependent species.

The following actions would help to restore healthy populations of Central Valley fish:

- Upgrade existing ladder systems to improve fish passage where needed.
- Construct fish ladders, where appropriate, to minimize blockages of upstream migrating anadromous fish behind weirs.
- Provide adequate fish passage, including fish ladders and appropriate attraction flows to the ladders, for small- to moderate-sized diversion dams.
- Where feasible and consistent with other uses, reconstruct diversions or remove dams to allow fish passage.

REFERENCES

Mills, T.J., D.R. McEwan, and M.R. Jennings. 1996. California salmon and steelhead: beyond the crossroads, p. 91-111. *In* D. Stouder, P. Bisson, and R. Naiman (eds.), Pacific salmon and their ecosystems: status and future options. Chapman and Hall, New York.

NMFS 1997. NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon. National Marine Fisheries Service, August 1997.

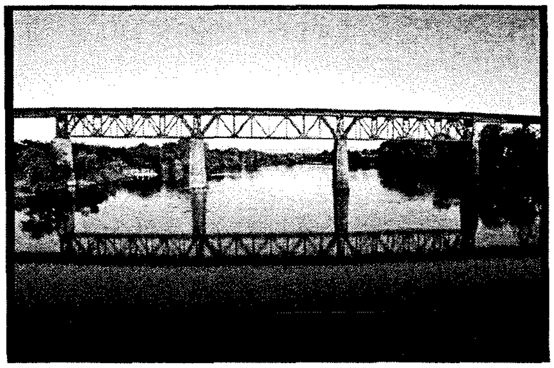
Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

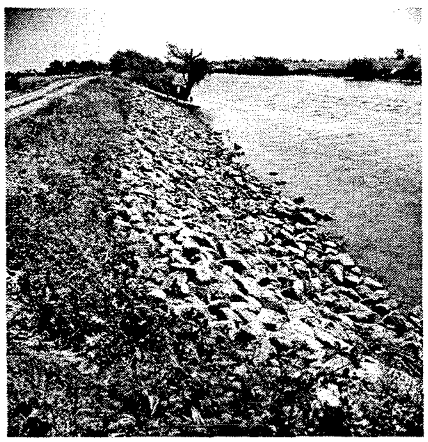
Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

USFWS 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997 114 p.

USFWS 1996. Recovery plan for the Sacramento/San Joaquin Delta native fishes. U.S. Fish and Wildlife Service, 1996. 195 p.

◆ LEVEES, BRIDGES, AND BANK PROTECTION





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INTRODUCTION

Three major bypass systems (Butte Basin Overflow, Yolo Bypass, and Sutter Bypass) and more than 2,000 miles of major levees confine floodflow in the Sacramento-San Joaquin Valley tributaries, rivers, and the Bay-Delta.

Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains, and allow stream channels to meander. Levees prevent floodflows from entering historic floodplains behind levees, stopping floodplain evolution, and eliminating or altering the character of floodplain habitats. Confining floodflows to channels also increases the fluvial energy that scours or incises channel beds and reduces or halts channel meander and oxbow formation. Bridges have a similar, though generally more localized effect, on channel morphology and sediment transport.

Factors that relate to the degree of influence levees, bridges, and bank protection have on the Bay-Delta include the location and maintenance requirements of these structures.

STRESSOR DESCRIPTION

Levees were constructed in the late 19th and early 20th Century to contain the frequent flood flows. Protecting farms, towns, and cities from the devastation of floods drove levee decisions. Another driving force behind levee construction was enhancing river navigation. Thus, levees were placed near riverbanks to increase scour and prevent shoal and bar formation while making the most land available for reclamation. To further improve navigability, a fleet of "snag boats" was employed to remove fallen trees in the channel between the Delta and Red Bluff.

Each section of paired levees, constructed by State and federal projects along major rivers in the valley, is designed to carry a particular flow or flood event. Design flow is determined with the assumption that channel "roughness" (i.e., resistance to flow) will not exceed certain values. Sometimes levees fail even when floodflow is below the maximum design stage, particularly when floodflows have a long duration, such as in January 1997.

Construction materials and standards used to build the early levees would not meet present U.S. Army Corps of Engineers (Corps) structural criteria. Delta levees allowed tidally-influenced emergent marsh to be converted to productive farmland and towns.

In some cases, bank protection has been installed on channelbanks without a levee to protect the landside from erosion inside the river's active floodplain.

In some places, the width of the levees is only a little wider than the width of the channel at low flow, such as along the Sacramento River downstream of Colusa. Restricted channels typically cause deeper, faster velocities during high stage. The amount and width of potential riparian vegetation are restricted by narrow levees, and these river reaches have a low ratio of shallow-water habitats to deep, open water. Cross sections of these channels are typically trapezoidal, rather than a more natural contour with low bank angles and one or more horizontal floodplain surfaces.

Today, most of the Delta levees are higher, steeper, and therefore, pose greater potential risk of failure. This is a result of land subsidence caused primarily by the oxidation, erosion, and depletion of peat soils in the Delta. The former tule islands now resemble steep-sided bowls 5-25 feet below mean sea level.

Extensive areas in San Pablo Bay, Suisun Bay, the Delta, and the Yolo and San Joaquin basins are below mean high tide but are not subject to tidal action because of levees and flapgates. This reduces the area and water volume subject to tidal mixing and reduces the size of the Delta floodplain. Reduced residence time of Delta water and nutrients restricts the development of complex molecules and foodweb organisms. Diked tidelands also may have an artificially high concentration of salt at the surface.

Perimeter Delta floodplains and intertidal zones were formerly punctuated with many miles of low-velocity backwater channels and distributaries. Backwater channels served as nutrient, sediment, and foodweb exchange and delivery systems, as well as important rearing habitat for juvenile fish. At low tides, these branching slough systems provided several miles of mudflat and shallow shoal habitat for shorebirds, wading birds, and waterfowl. Although there are many channels on Delta islands and diked tidelands, they are isolated from the rivers and estuaries by levees. Many have been filled or drained.

Upstream of the Delta, several small and large freshwater tidal sloughs and secondary oxbow channels of the Sacramento and San Joaquin Rivers were once intertwined with main river channels. However, levee construction severed the connections. Some of these former secondary channels are still present as isolated lakes, while others have been filled or drained.

The need for extensive bank protection, primarily rock riprap, has increased because riverbanks have eroded into the narrow floodplains that typically separate levees from channelbanks, highways, railroads, or bridges. In the Delta, riprap is required to protect steep-sided levees from waves caused by wind and boat wakes in wide channels.

Most Delta levees have minimum bank vegetation, and many are covered by rock riprap. Therefore, the riparian corridor is very narrow or absent along Delta channels. In addition, the physical processes necessary to sustain floodplain habitats may be absent or diminished. Riparian vegetation is not allowed to grow on or near most levees further narrowing available habitat area. The aquatic and terrestrial habitat quality of the Delta and river corridor have declined as the percentage of riprapped levee segments increases. Tens of thousands linear feet of riprap are planned for the next phase of the Sacramento River Bank Protection Project.

Bridge spans are often much more narrow than the natural floodplain width, so bridges are usually flood stage "bottlenecks." Backwater effects during high flow may cause channel instability. Additional bank revetment and reduced vegetation are often required so flood flows may safely pass under bridges. At least 31 major bridge crossings exist on the Sacramento River, 10 each across the lower Feather and American Rivers, at least 25 on major Delta sloughs and rivers, and 18 across the lower San Joaquin River to Mossdale.

Issues and Opportunities

Flood Management as Ecosystem Tool: The current approach is to control floods using dams, levees, bypass channels, and channel clearing. This approach is maintenance intensive, and the underlying cause of much of the habitat decline in the Bay-Delta system since 1850. Not only has flood control directly affected ecological resources, but confining flows between closely spaced levees also concentrates flow and increases flood problems downstream. With continued deterioration of flood control infrastructure, further levee failures are likely. Emergency flood repairs are stressful to local communities and resources and often result in degraded habitat conditions. An alternative approach is to manage floods, recognizing that they will occur, they cannot be controlled entirely, and have many ecological benefits. Allowing rivers access to more of their floodplains actually reduces the danger of levee failure because it provides more flood storage and relieves pressure on remaining levees. Valley-wide solutions for comprehensive flood management are essential to ensure public safety and to restore natural, ecological functioning of river channels and floodplains. Integrating ecosystem restoration with the Army Corps of Engineers' Comprehensive Study of Central Valley flood management can help redesign flood control infrastructure to accommodate more capacity for habitat while reducing the risks of flood damage (Strategic Plan 1999).

Opportunities: Coordinate with the various levee and flood control state, local, and federal programs to establish design criteria and standards that ensure that levee rehabilitation projects incorporate features beneficial to the aquatic and riparian environments of the Delta. The majority of the approximately 50 Delta islands are hydrologically disconnected by levees from the primary channel, open-water estuarine environment. Most of these levees are likely to remain in future years and to be reinforced with rock riprap, raised and widened, or rehabilitated in other ways to prevent levee failure. Potentially beneficial projects that could be incorporated into these programs include levee setbacks and creation of broad submerged benches, as well as the construction of broader levees to support riparian vegetation. Developing contingency plans for responses to major and multiple levee failures in different parts of the Delta can also provide ecosystem benefits and minimize disturbances associated with levee repair (Strategic Plan 1999).

Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well as providing access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris (Strategic Plan 1999).

VISION

The vision for levees, bridges, and bank protection is to reduce the adverse effects of these structures in order to improve riverine and floodplain habitat conditions to assist in the recovery of State- and federally listed fish species, and other fish and wildlife.

Depending on size, location, and type of habitat, setback levees can be used to create high-quality habitat nodes along low-quality, narrow sections of leveed rivers and streams. Much of the interior of central and west Delta islands are at an elevation too low for extensive levee setbacks to be feasible or desirable but should be evaluated on a case-by-case basis. Setback levees may be feasible in the east, north, and south in perimeter Delta areas, Levees set back to higher, firmer ground are more reliable and the setback zone may be available for restored habitats, or farmed part of the year.

In some cases, levees can simply be breached or removed so that the floodplain is setback to the natural shoreline. The soil could be used for restoration elsewhere. Breached-levee areas are prime candidates for restoring networks of small tidal sloughs and shallow backwater channels, increasing habitat complexity and diversity.

Some Delta islands pose overwhelming constraints to agricultural practices and levee and drainage-pump upkeep. Some are candidates for conversion to aquatic and tidal emergent wetland habitats. The Ecosystem Restoration Program Plan recommends a subsidence-control program to gradually restore island elevations.

Actions to control subsidence include:

- managing nontidal emergent and seasonal wetlands to accrete organic island soils.
- filling or raising with clean dredge materials, crop stubble, and soil material, excavated to expand floodway capacity.

Reflooded Delta islands would create a mosaic of interfaced habitat types. Depending on fill available material and island elevations, created habitats should include deep, open-water (greater than 6 feet below mean sea level), shallow-aquatic and nearshore habitats; intertidal mudflats and tule marsh; willow scrub; and mixed riparian forest. Saline areas also support halophytic plant communities such as saltgrass and pickleweed.

Several pilot projects to expand shallow, nearshore habitats along Delta channels using low benches along levees have been constructed and monitored in recent years. These designs will be refined and their application expanded. Other areas of the Delta that have more-than-adequate floodflow capacity could support more vegetation and fill in the channel. Because of the limited width of the area restored and high installation costs of this approach, this measure is considered a lower priority to levee setbacks and removal projects.

Integration with Other Restoration Programs

Efforts to reduce the impacts of levees, bank protection, and bridges will involve coordination with other programs. These include:

- the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council (SB1086) group efforts to limit the placement of rock on banks of the river, and other river corridor management plans;
- the Corps' proposed reevaluation of the Sacramento River Flood Control Project and ongoing Bank Protection Project, including more comprehensive floodplain management and river ecosystem restoration opportunities;
- wetland restoration, under the Delta Flood Protection Act (AB360), such as Decker Island and Sherman Island habitat projects;
- proposed riparian habitat restoration and floodplain management studies, including potential new flood bypass systems and expanded river floodplains on lands recently acquired by the California Department of Parks and Recreation and U.S. Fish and Wildlife Service;
- planned and proposed restoration of diked tidelands of Suisun Marsh and San Pablo Bay and islands in the south Yolo Bypass and Delta; and
- several studies and pilot demonstration projects by the Corps, California Department of Fish and Game, California Department of Water Resources, and others to develop new alternative designs for bank revetment or biotechnical levee protection along rivers and in the Delta that allow for shoreline riparian, marsh, and shallow aquatic habitats.

Linkage with Other Ecosystem Elements

Levees, bridges and bank protection adversely affect important ecological processes, habitats, and species in the ERPP Study Area. For example, bank protection limits stream channel meander, erosion, reduces opportunity for sediment deposition, and restricts opportunity to regenerate riparian and riverine aquatic habitats. In turn, fish, wildlife, and plant communities are restricted or imperiled.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective for levees, bridges, and bank protection is to re-establish frequent inundation of floodplains by removing, breaching, or setting back levees and, in regulated rivers, by providing flow releases capable of inundating floodplains.

Long-Term Objective: Reestablish active inundation of floodplains with area targets and inundation frequencies (1-5 years) to be set for each major alluvial river (where feasible) based on probable pre-1850 floodplain inundation regimes and on existing opportunities to modify existing land uses.

Short-Term Objective: Reestablish active inundation of at least half of all remaining unurbanized floodplains in the Central Valley, where feasible.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. The actions necessary to reestablish active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

STAGE 1 EXPECTATIONS: All existing unurbanized floodplains in the Central Valley will have been identified and a priority list for floodplain restoration projects developed. Strategies for the restoration of natural channel and floodplain dynamics will have been developed and implemented in at least two large demonstration projects. Results of initial floodplain reactivation projects will be used to increase understanding of channel-floodplain interactions and the potential for restoration of processes.

The general target for levees, bridges, and bank protection is to reduce or eliminate adverse effects on ecological processes, habitats, and dependent species to the extent possible, and in a manner consistent with flood control.

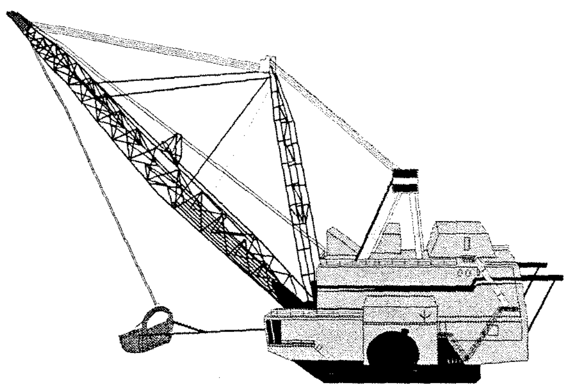
Actions to reduce adverse effects of levees, bridges, and bank protection on the Bay-Delta ecosystem would include the following:

- Investigate the feasibility of levee setbacks along rivers.
- Investigate the feasibility of levee setbacks in the Delta.
- Convert selected Delta islands to a mosaic of deep- and shallow-water and tule-marsh habitats.
- Build innovative benches to support shoreline habitats, where levees must remain.
- Tier from on-going programs to contribute to successful implementation.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ DREDGING AND SEDIMENT DISPOSAL



INTRODUCTION

Dredging and sediment disposal serves a number of purposes in the Bay-Delta. Most dredging is done to maintain or deepen navigation channels, harbors, and marinas. Dredging is also required to maintain or increase flood control and water conveyance capacity and to obtain material for levee maintenance and repair. This maintenance dredging activity is required because sediments transported to the Delta tend to accumulate in deep channels and backwater areas.

STRESSOR DESCRIPTION

Approximately 2-5 million cubic yards of bottom material must be dredged from the Bay-Delta each year to maintain adequate depth for navigation channels, harbors, and marinas and to maintain flood control and water conveyance capacity. As harbors and channels are deepened to accommodate larger cargo ships, this amount is expected to increase to more than six million cubic yards per year over the next 50 years.

Dredging maintains the Stockton ship channel through the Delta along the San Joaquin River, the Sacramento deepwater ship channel, and the storage capacity in Clifton Court Forebay. Without this maintenance dredging activity, the channels and harbors would become too shallow to accommodate container ships and other heavy vessels. Lack of dredging would also increase the frequency and severity of Delta island flooding. Conveyance of freshwater from the Sacramento River to the southern Delta pumping facilities would also become less efficient.

Dredging and the disposal of dredged material are potentially harmful to the natural productivity of the Bay-Delta ecosystem. The harmful effects of dredging could be a result of the destruction or disruption of benthic communities, turbidity (muddy water) plumes, and release of organics and contaminants from sediments.

Dredge material disposal poses potential environmental problems, particularly when it contains polychlorinated biphenyls (PCBs), elevated concentrations of trace metals, or other potentially harmful constituents. The major effects of increased suspended sediment concentrations (turbidity) at sediment disposal sites are probably on fish behavior, feeding patterns, foraging efficiency, modified prey response, and habitat choice (San Francisco Estuary Project 1993).

Historically, the main disposal sites for dredged material were in the Bay near Alcatraz Island, and offshore in an area that is now within the Gulf of the Farallones National Marine Sanctuary. The Alcatraz disposal site is no longer suitable because it has become a navigation hazard. Disposal is banned in the marine sanctuary. Efforts to identify, evaluate, and prioritize alternative disposal sites are currently underway as part of the LTMS.

Dredging material is needed for agricultural stability and for use in ecosystem restoration. Fill is needed to construct setback levees, reinforce existing levees, and restore wetlands and riparian areas, channel island habitats, and other critical areas. The need for fill will be particularly acute in the lowest-lying Delta islands, some of which are 20 feet or more below sea level. One alternative for restoration efforts in subsided areas would require using fill to stop the oxidation of organic matter in peat soils. Fill material may also be required on islands that are used for continuing agricultural production.

VISION

The vision for dredging and sediment disposal in the Bay-Delta is to maintain adequate channel depth for navigation, flood control, and water conveyance while reducing the adverse effects of dredging activities on the Bay-Delta ecosystem. Dredged material disposal would be environmentally sound and the use of nontoxic dredged material would be promoted as a resource for restoring tidal wetlands and other habitats, reversing Delta island subsidence, and improving dikes and levees.

The ERPP supports the interagency long-term management strategy (LTMS) for dredged materials in the San Francisco Bay and recommends that approximately half of the dredged material from the Bay-Delta be used to restore habitats and strengthen levees. Because one million cubic yards are equivalent to about 620 acre-feet (af), approximately one square mile (640 acres) 3 feet deep can be restored each year. The amount of high-potential tidal wetland restoration sites within the Bay is more than 10,000 acres.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

ERPP supports and seeks to extend the regional approach to dredging and sediment disposal decision making embodied in the LTMS developed by the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, the San Francisco Bay Regional Water Quality Control Board (RWQCB), the Central Valley RWQCB, and the San Francisco Bay Conservation and Development Commission with the involvement of other agencies and stakeholder groups.

One of the objectives of the LTMS is to promote the reuse of dredged materials whenever it can be shown that there is a need for the material and placement can be done in an environmentally acceptable manner. Restoring tidal wetlands, constructing setback levees, restoring riparian areas and channel islands, and other efforts needed to restore Bay-Delta foodweb productivity and the abundance of fish, waterfowl, and wildlife populations will require fill material. Therefore, there is a great opportunity for linkage between ERPP efforts and managing dredging in the Bay-Delta to the mutual benefit of the ecosystem and the industries dependent on safe and efficient navigation in the Bay-Delta.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The adverse effects of dredging and the disposal of dredge materials can be adjusted to contribute to restoring ecological health of the Bay-Delta. Dredge materials can be used to recreate shallow water habitats throughout the Delta. This will increase the acreage of this type of habitat and support aquatic and plant species dependent on shallow water habitat.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective for dredging and sediment disposal is to reduce loss and degradation of aquatic habitats 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.

Long-term Objective: To link dredging and spoil disposal with environmental restoration, reversal of subsidence, and levee maintenance.

Short-term Objective: Reduce adverse environmental impacts and further demonstrate the beneficial reuse of dredge materials.

Rationale: Dredging is a necessary activity that is conducted to maintain shipping channels and channel capacity during flood flow events. Dredging can be conducted in an environmentally benign manner and clean, uncontaminated dredge spoils can be used for many uses including levee reconstruction, wetland restoration, reversal of subsidence, and the creation of shallow water habitats.

Stage 1 Expectations: Pilot programs that demonstrate the beneficial reuse of dredge materials for ecological purposes will have been implemented by creating wetland and shallow water habitats in the Delta and Bay.

The general target for dredging and dredge disposal is reduce the loss and degradation of habitat and to contribute sediments for the recreation of shallow water habitats.

The following actions would help to achieve this vision:

- Coordinate all actions closely with federal, State, and local agencies charged with regulating dredging activities in the Bay-Delta.
- Reduce the amount of contaminants flowing into the Bay-Delta and subsequently absorbed by Bay-Delta sediments.
- Identify alternative dredged material disposal sites including upland and ocean sites, to ensure that disposal activities are flexible and avoid undue reliance on a small number of sites.
- Maximize the reuse of dredged materials for habitat restoration and other beneficial uses and minimize the amount of disposed material that is subject to resuspension and subsequent redredging.
- Support continued research on sediment transport and deposition, sediment quality and toxicity testing, the environmental effects of suspended sediment and contaminants, and the beneficial reuse of dredged materials so that dredging and sediment disposal management will continue to improve.

Reference

San Francisco Estuary Project. 1992. State of the Estuary; a report on conditions and problems in the San Francisco/Sacramento-San Joaquin Delta Estuary. Prepared under Cooperative Agreement CE-009486-02 with the Environmental Protection Agency by the Association of Bay Area Governments. 270 p.

INTRODUCTION

The natural sediment supply of Central Valley rivers and streams is composed of mineral and organic fines, sands, gravel, cobble, and woody debris (e.g., tree branches and root wads), sediments that naturally enter, transport and erode through the system. Sediment is one of the natural building blocks of the ecosystem on which many other ecological processes, functions, habitats and species depend. Gravel, for example, is important for maintaining spawning habitat of salmon and steelhead and supports many invertebrates on which young fish prey. Finer sediments and fluvial (flowing water) processes create conditions necessary to establish new riparian forests and wetlands.

Human activities have had a significant adverse effect on natural sediment processes in the Bay-Delta watershed. One of the more prominent adverse activities is the removal of sand and gravel from active stream channels. Both abandoned and active mining sites exist on virtually every stream or streamside alluvial deposit throughout the ERPP study area (Reynolds et al. 1993).

Sand and gravel mining is a valued commercial activity, but it has impaired sediment transport, gravel recruitment, and stream channel meander processes. Instream gravel extraction damages riparian vegetation, movement of groundwater, water quality, and fish and wildlife populations. In some areas, abandoned gravel pits now harbor predatory fish, serve as heat sinks that increase the ambient water temperature, or capture sediment naturally moving downstream.

STRESSOR DESCRIPTION

Development throughout the Central Valley has increased the demand for aggregate used in construction. Records of the Department of Conservation, Office of Mine Reporting and Reclamation Compliance, show that 1.53 million tons of aggregate were mined in Tehama and Shasta Counties in 1992. In Shasta County, more than half of the aggregate mined came from quarries, and was not alluvial gravel. It is also notable that in 1992, there was only one in-stream mining operation is Shasta County. County and California Department of Fish and Game permits show that up to four million tons could have been mined in the area in 1994, although the actual mined quantity may have been substantially less.

Wide-scale gravel extraction has damaged bridges, siphons, and other river-crossing structures by aggravating degradation and undermining foundations. In Glenn County, for example, the State Route 32 bridge over Stony Creek has been repaired three times at a cost of nearly $2 million. In Tehama County, the Corning Canal siphon is being exposed as the bed degrades, and repairs will cost several million dollars. The North Main Street bridge over Dibble Creek in Red Bluff has been repaired several times at a cost of more than $100,000, and the California Department of Transportation (CalTrans) has replaced the Interstate 5 bridge over Cottonwood Creek in Shasta County.

Riparian communities are affected by mining in several ways. The most obvious adverse effect is the direct removal or destruction of riparian vegetation by construction of access roads, mined areas, and storage areas. Riparian vegetation can also be lost by degradation and streambank undermining. In addition, degradation and groundwater table reductions destroy shallow-rooted riparian forest for large areas surrounding gravel mines.

Fish are directly affected by gravel removal. Anadromous fish use gravel for spawning. Salmon generally spawn in riffles with water velocities between one and 3 feet per second at a depth of between 0.5 and 3 feet. Mining activities may change riffle velocity and depth or deplete spawning-sized gravel. The Sacramento River and many of the tributaries in the Redding area have been depleted of gravel from a combination of mining and lack of gravel moving downstream from the area above Lake Shasta. In some places, the remaining substrate is too coarse for salmon spawning; in other places, bedrock is exposed over large sections of the stream.

Channel braiding caused by uniform grading during bar excavation can create conditions unsuitable for fish. Higher water temperatures are caused by lower velocities, shallower waters, and reduced vegetation cover of a braided channel. Many fish cannot survive or spawn in higher-than-normal temperatures. These effects may be avoided by maintaining a narrow and deep low-flow channel through a gravel mining area.

Instream gravel mining involves the direct removal of sand, gravel, and cobble from the channel and active floodplain of a stream. Instream mining degrades or eliminates river ecosystem functions, processes, and habitats in the following ways:

- Instream mining homogenizes the geomorphology (shape) of the river channel and its floodplain. Mining removes complex bed forms and elevated floodplains. Channels are typically widened and deepened at mining sites, creating an environment that stops downstream gravel transport. Gravel depletion can accelerate erosion and depletion of several miles of downstream gravel bars. The river will adjust to the reduced bedload by eroding valuable instream bar deposits. Therefore, instream mining causes both direct and indirect downstream loss of gravel and gravel bars.

- Historic extraction rates often exceeded the average annual yield of gravel from upstream areas. This condition further halts the downstream transport of gravel and often triggers channel incision from the upstream and downstream migration of nick points in the bed elevation as the river compensates for the loss of bedload. Instream mining may cause an increase in the downstream sediment load from fissure sediments dislodged by surface disturbance from mining or channel adjustment. Downstream sedimentation may bury spawning beds in sand and silt or suffocate fish eggs in spawning gravels. Most conditional use permits for in-stream mining issued in California in the last 10 to 15 years do not permit extraction rates to exceed annual yield.

- Instream mining of active channel bars and deep channel deposits is particularly disruptive to the sediment budget of alluvial streams below large dams. This is especially true where there are no major tributaries downstream of the dam to supply another source of gravel and sediment. An example of this condition is the lower American River, where instream and floodplain mining has ceased but where the only significant source of gravel and sediment is from bank and channel erosion below Nimbus Dam. Channel armoring has occurred where bars in the salmon spawning reach are primarily composed of cobbles that resist bed transport at the most common flows. The lower American River and the lower Yuba River are also depleted of fine sediment on bar deposits. There is little support for recruitment of cottonwood seedlings and saplings because these trees cannot germinate or survive in the coarse substrate during summer low-flow conditions.

- Historically, mining removed riparian vegetation, instream woody debris, and spawning redds. All vegetative cover and fluvial landforms were removed to gain access to the mining site and to clean and sort gravel for commercial use. These habitats may not have been replaced until instream mining ceases. Presently, conditional use permits issued in California usually require protection and non-disturbance of some or all riparian vegetation. In addition, many permits require concurrent reclamation, so that soil and vegetation is replaced as the mining progresses from one area to the next.

- Deep pit mines excavated in the channel and active floodplain may result in "pit capture." Deep pit mines, such as those prevalent in the tributaries to the San Joaquin River, are often separated by a wall of unexcavated river alluvium. These walls are easily eroded or overtopped by high flows. When this occurs, the river may avulse (move suddenly) from the natural channel into and through the pit, where most gravel bedload will then be captured. When high flows recede, fish will be trapped in the instream "lakes" that are formed. Juvenile salmonids trapped in these lakes are subject to predation and high water temperatures.

- Disturbance from instream mines often leads to the invasion of undesirable non-native plants. Streams with instream mining are often sites with high rates of colonization by invasive non-native plants, such as tamarisk, eucalyptus, giant reed, and pepperweed. These species spread through displaced stem and root fragments or by prolific seed dispersal. For example, channel grading for levee construction and mining on Stony Creek, along with bank erosion, causes giant reed plants to be transported downstream and into the Sacramento River corridor. Once in the corridor, they colonize natural bars and compete with native trees and shrubs. Freshly disturbed and exposed areas at mines also offer prime invasion sites for weedy, opportunistic plant species. This situation is partially remedied by present requirements which include reclamation plans that include comprehensive revegetation with native species and eradication of non-native invasive species.

ISSUES AND OPPORTUNITIES

CHANNEL DYNAMICS, SEDIMENT TRANSPORT, AND RIPARIAN VEGETATION: There is growing recognition that dynamic river channels, free to overflow onto floodplains and migrate within a meander zone, provide the best riverine habitats. The dynamic processes of flow, sediment transport, channel erosion and deposition, periodic inundation of floodplains, establishment of riparian vegetation after floods, and ecological succession create and maintain the natural channel and bank conditions favorable to salmon and other important species. These processes also provide important inputs of food and submerged woody substrates to the channel. The most sustainable approach to restoring freshwater aquatic and riparian habitats is by restoring dynamic channel processes; however, restoration of natural channel processes is now hampered by the presence of levees and bank protection along many miles of rivers. Below reservoirs, the reductions in high flows, natural seasonal flow variability, and supply of sand and gravel have further exacerbated the constraining effect on rivers with levees and rock banks. It is therefore a priority to identify which parts of the system still have (or can have) adequate flows to inundate floodplains and sufficient energy to erode and deposit, and to identify floodplain and meander zone areas for acquisition or easements to permit natural flooding and channel migration. Sediment deficits from in-channel gravel mining should also be identified and the feasibility or efficacy of augmenting the supply of sand and gravel in reaches below dams should be evaluated (Strategic Plan 1999).

OPPORTUNITIES: Mimic natural flows of sediment and large woody debris. Dams disrupt the continuity of sediment and organic-debris transport through rivers, with consequent loss of habitat, and commonly, river incision, downstream. In some cases, such as Englebright Dam on the Yuba River, the feasibility of dam removal should be evaluated as a sustainable solution to reestablishing continuity of sediment and debris transport, as well as opening access to important spawning and rearing areas. Most dams, however, cannot be removed, so methods must be sought to reestablish continuity of sediment and wood transport with the dam in place. Coarse sediment can be artificially added below dams to at least partially mitigate for sediment trapping by the dam and ameliorate the impacts of sediment-starved flows. This approach has been successfully used in Europe, using sediment from natural (landslide) and artificial sources (injected from barges). On the River Rhine, enough gravel and sand are added below the lowest dam to satisfy the present sediment transport capacity of the Rhine to prevent further incision of the bed (an average of over 200,000 cubic yards annually). On the Sacramento River, gravels have been added at a rate much below the river's transport capacity so they are vulnerable to washout at high flows. A more sustainable approach would be to add gravel (and sand) on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles. This latter approach requires a large commitment of resources and should be undertaken only in rivers where other factors (e.g., temperature regime) are favorable (or can be made favorable) for recovery of species (such as the upper Sacramento). Such opportunities will be more economical where sources of dredger tailings or reservoir Delta deposits are available nearby.

While recognizing the navigation and flood safety issues associated with large woody debris in rivers, the importance of this debris to the foodweb and structural habitat for fish should not be overlooked. There is an opportunity to investigate ways by which to pass debris safely through dams and bridges. This may require replacing some existing bridges with those less prone to trapping woody debris.

Identify and conserve remaining unregulated rivers and streams and take actions to restore natural processes of sediment and large woody debris flux, overbank flooding, and unimpaired channel migration. Most rivers in the Central Valley are regulated by large reservoirs and therefore require considerable investment to recreate the natural processes needed to sustain true ecosystem restoration; however, a few large unregulated rivers still exist, such as the Cosumnes River and Cottonwood Creek. Lowland alluvial rivers and streams with relatively intact natural hydrology should be identified and made a high priority for acquisition of conservation and flooding easements, setting back of levees, and other restoration actions because such actions on these rivers are likely to yield high returns in restoration of natural processes and habitats and, ultimately, fish populations.

Undertake fluviogeomorphic-ecological studies of each river before making large investments in restoration projects. River ecosystem health depends not only on the flow of water, but on the flow of sediment, nutrients, and coarse woody debris and on interactions between channels and riparian vegetation, variability in flow regime, and dynamic channel changes. It is only through interdisciplinary, watershed, and historical scale studies that the constraints and opportunities particular to each river can be understood. For example, it was only after a fluviogeomorphic study of Deer Creek that the impact of flood control actions on aquatic and riparian habitat was recognized, a recognition that has lead to a proposal for an alternative flood management approach designed to permit natural river processes to restore habitats along Lower Deer Creek.

VISION

The vision for gravel mining is to improve gravel transport and cleansing by reducing the adverse effects of instream gravel mining. Achieving this vision would help to maintain or restore flood, floodplain, and streamflow processes that govern gravel supply to improve fish spawning and floodplain habitats.

Opportunities to achieve the vision for gravel mining include reducing or eliminating instream gravel extraction by relocating gravel mining operations to alluvial deposits outside active stream channels and riparian zones and introducing gravel in deficient areas in streams until natural processes are restored to a level that will provide sufficient quantities. The Ecosystem Restoration Program Plan (ERPP) supports channel design or levee construction projects consistent with restoring floodplains to ameliorate this problem. In certain situation, gravel mining is used as a surrogate for adequate flood control to prevent flooding, for bank protection, and to protect structures.

One strategy to achieve this vision is to identify alternative sources of gravel for fishery restoration and other uses instead of extracting gravel for these purposes from active stream channels. Potential impacts and mitigations for in-stream mining, gravel bar skimming and terrace gravel operations should be evaluated on a case-by-case basis, and could be permitted, provided that an acceptable stream management and reclamation plan is prepared, funded, and implemented. However, portland cement concrete grade aggregates are found only in in-stream and terrace deposits. Materials from other sources may not be as suitable as in-stream aggregates.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Programs sponsored by other agencies that would also help to achieve the ERPP vision for gravel mining and recruitment include:

- county-sponsored instream mining and reclamation ordinances and river and stream management plans, such as new gravel and stream management plans approved in Butte and Yolo Counties;
- the State Department of Conservation's reclamation planning assistance programs under the Surface Mining and Reclamation Act;
- Anadromous Fish Restoration Program gravel replenishment programs and plans and small dam removal and/or fish ladder rehabilitation projects (USFWS 1997);
- the San Joaquin River Parkway plan; and
- efforts by the State Department of Conservation and counties to identify alternative sources of commercial sand and gravel in reservoir deltas, floodplain terrace deposits, old dredger mining cobble deposits, and hardrock sites.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Gravel and sand extraction activities have the potential to adversely effect several important ecological processes, habitats, and the dependent species. Ecological processes include natural sediment supply and stream channel meander. Riparian and riverine aquatic habitat is the most common habitat that is adversely effected by gravel mining. Many fish, wildlife, and plant species are dependent on gravel beds, sediment, and riparian corridors. These are reduced by gravel mining. However, careful planning and mitigation of gravel operations can eliminate adverse impacts.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs.

LONG-TERM OBJECTIVE: Implement a comprehensive sediment management plan for the Bay-Delta system that will minimize problems of reservoir sedimentation and sediment starvation, shift aggregate extraction from rivers to alternate sources, and restore continuity of sediment transport through the system to the extent feasible.

SHORT-TERM OBJECTIVE: Develop methods and procedures to end gravel deficits below dams and mining operations; prioritize for correction existing streams with major deficit problems and initiate action on at least 10 streams.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish. This objective can be accomplished by a wide variety of means, but most obviously through artificial importation of gravel and sand. Other possible actions include: (1) explore the feasibility of passing sediment through small reservoirs; (2) remove nonessential or low-value dams; (3) eliminate instream gravel mining on channels downstream of reservoirs, and limit extraction on unregulated channels to 50% of estimated bedload supply or less (or to levels determined not to negatively impact fish and other ecological resources); (4) develop incentives to discourage mining of gravel from river channels and adjacent floodplain sites; and (5) develop programs for comprehensive sediment management in each watershed, accounting for sediment trapped by reservoirs, availability of sediment from tributaries down stream of reservoirs, loss of reservoir capacity, release of sediment-starved water downstream, channel incision and related effects, and the need for sources of construction aggregate.

STAGE 1 EXPECTATIONS: Sediment-starved channels in the Bay-Delta system will have been identified; strategies to mitigate sediment starvation, such as shifting mining of gravel from river channels to alternate sources, adding gravel below dams, and removing nonessential dams will have been developed; demonstration projects will have been implemented (and monitored) to mitigate sediment starvation in at least six rivers.

The general target for gravel mining is work with local counties and the aggregate resource industry to relocate gravel extraction operations to areas outside the active stream channel.

Three actions to reducing the adverse effects of gravel mining include the following:

- Promote alternative gravel sources. ERPP recommends providing education and other incentives to encourage counties and mining companies to seek new off-channel sources of aggregates, including high terraces outside the active floodplain, recycled concrete, crushed cobbles from old abandoned dredge spoils, and deep pit mines away from river migration corridors. New permits for these aggregate sources can be issued in exchange for phasing out instream mines.

- Limit the extent of disturbance at instream mines. If alternative sources of aggregate are not a viable short-term solution, permits should require an undisturbed corridor of riparian vegetation and natural bar deposits adjacent to existing mines. In addition, extraction rates should be limited to the estimated yield from upstream each year. This rate will vary annually and must be verified by aerial topographic analysis or field surveys at permanent transects.

- Prevent or reduce the effects of pit capture. Deep pits should be adequately separated from the channel and measures should be taken to ensure that bank material and vegetation will resist channel migration in the direction of the pits. Alternatively, permits should require that inchannel pits be filled with overburden to the elevation of the channelbed.

REFERENCES

DWR 1994. Use of alternative gravel sources for fishery restoration and riparian habitat enhancement, Shasta and Tehama counties, California. Department of Water Resources, Northern District. August 1994. 191 p.

Resources Agency. 1989. Upper Sacramento River Fisheries and Riparian Habitat Management Plan. The Resources Agency. January 1989. 159 p.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

USFWS 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997. 112 p.

◆ Invasive Aquatic Plants

Introduction

Weeds, or invasive plant species, are types of vegetation capable of exploiting opportunities afforded by natural or human-related disturbances in the landscape, as well as those provided by relatively undisturbed habitats. Although not all weeds are non-native, most have been introduced from other parts of the world.

Invasive aquatic plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The aquatic plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.

Factors that relate to the degree of influence invasive aquatic plants have on the Bay-Delta include additional introductions from ship ballast and other sources and local water quality and hydrologic conditions that favor their establishment.

Stressor Description

Lacking the controls found in their native habitat (e.g., specific insects for which they are a food source or toxins produced by competing plants), these plants can flourish in a new landscape, gaining a competitive advantage over the native species. Many weeds have evolved characteristics that make them extraordinarily competitive in both natural and introduced environments, such as high seed production; mechanisms for effective seed dispersal; rapid growth rate; and adaptability to extremes in temperature, nutrients, and water availability.

A species is considered a weed problem because of its ability to adversely affect natural communities or human land use requirements. Introduced or native aquatic plant species are considered harmful when they reduce the biological diversity of existing natural communities by displacing native species or altering ecosystem processes such as nutrient cycling, hydrologic conditions, or water chemistry. They create problems for human society when they impair agricultural or aquacultural productivity, constrict waterways, diminish recreation and aesthetic values, or destroy structures.

Most aquatic weeds were introduced to California waterways unintentionally. They were brought in as pond ornamentals (e.g., water hyacinth) and aquarium plants (e.g., hydrilla), or through dispersal by boats. Aquatic weeds have been here for at least 100 years; water hyacinth was discovered in a Yolo County slough in 1904. Hydrilla, which was probably introduced through its use as an aquarium plant, has been in California for at least 20 years. Egeria, still a popular aquarium plant, has been in the ecosystem for over 30 years.

Most aquatic weeds pose a threat to the aquatic foodweb and rare aquatic or riparian species because they form dense mats that block sunlight or deplete oxygen supplies. The sheer mass of floating tissue can also impede navigation and damage water control structures. Establishment of invasive aquatic plants can harm or kill rare and valued fish, native plants, and other aquatic organisms; reduce biodiversity; impede navigation; damage water control structures; and increase mosquito habitat.

Many stream and river channels in the Delta and the Sacramento and San Joaquin Rivers and their tributaries have been channelized, confined by levees, impounded, and otherwise altered from their shapes of 150 years ago. With the conversion of adjacent riparian communities to other land uses, the ecosystem processes and functions have changed substantially. These changes stress native aquatic flora and fauna, leading to changes in species composition and population densities, and perhaps making the aquatic foodweb more vulnerable to further stressors.

Most weeds that infest the Delta and the Sacramento and San Joaquin Rivers and their tributaries are problems in specific locations, not throughout these waterways; however, locations of aquatic weeds have not been comprehensively mapped. The California Department of Food and Agriculture's Integrated Pest Control Branch records locations where aquatic weeds, such as hydrilla, pose a threat to agriculture. Locations of weeds that threaten natural areas are not recorded. Comprehensive mapping throughout the ERPP study area is needed for all weeds that threaten aquatic habitat as a first step to monitoring and controlling infestations.

Some non-native aquatic weeds that pose the most serious threats and need further research, monitoring and mapping, or control are egeria, hydrilla, water hyacinth, water pennywort, eurasian watermilfoil and parrot feather. Each of these is described below. These weeds flourish in a wide geographic area, sometimes in high densities, and are extremely dangerous because of their ability to displace native plant species, harm fish and wildlife, reduce foodweb productivity, or interfere with water conveyance and flood control systems.

EGERIA (*Egeria densa;* syn: *Elodea densa*): A native of South America, egeria is a popular aquarium plant, which most likely accounts for its introduction into California waterways. It is a submerged, rooted perennial that occupies the same littoral zone niche in slow-moving water as native pondweeds, thereby potentially excluding the pondweeds and reducing the habitat value for waterfowl that eat pondweeds. Egeria creates a structure having much more branching than pondweeds. It forms dense mats that block sunlight and reduce the amount of open water, leading to increased accretion of organic material and increased sedimentation. The dense mat structures may impede diving waterfowl from foraging, and the increased sedimentation may alter the population of benthic species and their predators.

Egeria has been in the Delta for perhaps 30 years or more but probably was not a major problem until the past 12 years, coinciding with the water hyacinth control program. Removing water hyacinth from waterways and a 6-year drought may have contributed to the expansion of coverage by egeria (Anderson pers. comm.).

Egeria currently infests approximately 3,000 acres, primarily in the Delta. The success of this infestation in the Delta is indicative of the greater success that hydrilla would have if it were not prevented from establishing there. Hydrilla, unlike egeria, has long-lived rhizomes, making it much more difficult to control. Egeria is listed as a "B"-rated noxious weed by the California Department of Food and Agriculture's Noxious Weed Program. This designation does not mandate its control and, because the species is so widespread, little attention has been paid to controlling it. Now that growing populations are increasingly obstructing water conveyance structures and natural wetlands, the California

Department of Boating and Waterways is given $500,000 per year to control egeria along with water hyacinth (Anderson pers. comm.). Returning native pondweeds to an egeria-infested site would probably require active restoration once the egeria is removed.

HYDRILLA (*Hydrilla verticillata*): A submerged perennial, hydrilla was introduced to North American waterways sometime after 1956 through its use as an aquarium plant. It has since spread throughout the country, infesting waterways, irrigation canals, lakes, and ponds. It can completely fill and clog waterways, restricting flow, increasing sedimentation, and hindering navigation and public water use. Like egeria, hydrilla forms dense mats that block light, deplete oxygen, and increase sedimentation and organic deposition. In slow-moving water and oxbows, hydrilla can deplete oxygen and resources to the point of causing fish kills. Unlike egeria, however, hydrilla forms rhizomes that live 5-7 years and from which new plants can grow. Because of the persistence of rhizome viability, hydrilla will be much more difficult to remove from the Delta, if it establishes there, than egeria.

Hydrilla is an "A"-rated weed in the California Department of Food and Agriculture's Noxious Weed Program. This designation means that the plant poses a serious problem to agriculture but may be contained through control efforts. Since 1976, when it was first noticed, the California Department of Food and Agriculture has spent $20 million to eradicate hydrilla (California Exotic Pest Plant Council Biocontrol Committee 1995). Hydrilla has been found in 17 counties in California and has been eradicated from nine counties. Thus far, it has been prevented from establishing in the Delta. An example of its invasiveness can be seen in Clear Lake in northern California, where it now covers about 650 acres of the lake's 43,000-acre surface area.

WATER HYACINTH (*Eichhornia crassipes*): A floating perennial, water hyacinth is native to South America. It infests streams, ponds, backwater areas, ditches, sloughs, and waterways. It grows rapidly in the summer, floating and spreading by means of buoyant stolons and seed. Water hyacinth was introduced to the United States in 1884 when it was given to visitors as souvenirs at the Cotton States Exposition. Water hyacinth was first reported in California in a Yolo County slough in 1904. Today, it is a serious pest in the Delta, the Sacramento and San Joaquin Rivers, and many sloughs and tributaries, where it clogs waterways, obstructs commercial and recreational navigation, and impedes water conveyance.

Water hyacinth is also a serious problem for the pumping and fish-screening facilities in the south Delta. Forming a dense cover over the water surface, it blocks sunlight, reduces water flow, depletes oxygen, and inhibits gaseous interchange with the air, all of which harm other aquatic organisms. Water hyacinth increases mosquito habitat by providing larval breeding sites where mosquito predators cannot reach. In backwater areas, dense concentrations of water hyacinth can increase fish mortality. It also increases sedimentation and the accretion of organic matter. Water hyacinth reportedly competes with Mason's lilaeopsis (*Lilaeopsis masonii*), an endangered freshwater emergent plant native to California (Van Ways pers. comm.).

In 1982, the California Department of Boating and Waterways formed a task force to begin controlling water hyacinth, testing different mechanical and herbicidal control methods. In 1996, the department spent $900,000 to treat 1,750 acres of water hyacinth, mostly in the central and southern Delta (Van Ways pers. comm.). Some control efforts involve aerial spraying of herbicides, but in many areas herbicides must be applied from boats. Since water hyacinth control began, egeria populations have expanded. Egeria clogs boat propellers quickly and has made continued control of water hyacinth much more difficult. As a result, the department has now been given approval and funding to control both egeria and water hyacinth.

WATER PENNYWORT (*Hydrocotyle umbellata*): A perennial native plant, water pennywort grows along streambanks and in ponds, canals, and marshy areas. It forms stems that float and creep along wet soil. Although it takes root, plants also break off and form dense, floating rafts that drift. These rafts can cause some of the same problems seen with water hyacinth. Since water hyacinth has been controlled, the pennywort population has increased and become a weed problem in some areas. (Anderson pers. comm.).

EURASIAN WATERMILFOIL (*Myriophyllum spicatum*) and **PARROTFEATHER** (*Myriophyllum aquaticum*): Both Eurasian watermilfoil and parrotfeather are submerged perennials. Eurasian watermilfoil, as its name suggests, is native to Eurasia; parrotfeather is native to South America. Parrotfeather is sold in nurseries for aquariums and backyard ponds. Eurasian milfoil is much more abundant statewide than parrotfeather; however, no comprehensive surveys have measured the extent of these two weeds. Because Eurasian milfoil has not created a specific problem for agriculture, it has not been targeted for control. An example of a Eurasian milfoil infestation is in Lake Tahoe, where it covers about 200 surface acres, mostly in the marina area. Parrotfeather is found in seasonally wet streams, small lakes, and flood control channels. An example of its infestation is found in Parks Lake on Beale Air Force Base.

Like hydrilla and egeria, both of these plants occupy areas where native pondweeds would grow. Eurasian milfoil grows mostly submerged, whereas parrotfeather extends above the water. The growth form of parrotfeather results in substantial increases in mosquito habitat. Although both plants may present problems, they can be beneficial to aquatic habitat as well. Parrotfeather is thought to provide cover for aquatic organisms, and Eurasian milfoil stems and fruits are eaten by waterfowl (Westerdahl and Getsinger 1988).

ISSUES AND OPPORTUNITIES

Develop means to control invasive aquatic plants in the Delta. Invasive plants, such as water hyacinth and Egeria densa (Brazilian water weed), are clogging many sloughs and waterways of the Delta, not only impeding boat traffic, but also creating environments that are unfavorable for native fishes. The California Department of Boating and Waterways has an Egeria control program, but has not yet received CEQA approval for use of chemical controls. There is an immediate need to develop ways by which to control these plants that are not, in themselves, environmentally harmful. An opportunity exists for the ERP to join forces implementing ambitious eradication and control measures with agencies, organizations, and water districts concerned with the deleterious effects of these water weeds on navigation in the Delta, clogging of water intakes and fish screens, and diminished recreational uses (Strategic Plan 1999).

VISION

The vision for invasive aquatic plants is to reduce their adverse effects on native species and ecological processes, water quality and conveyance systems, and major rivers and their tributaries.

Active management of Delta streams and rivers is necessary to reduce the surface area of channels and sloughs in the Delta that are covered by water hyacinth and other invasive aquatic plant species. To effectively control aquatic weeds, existing programs will need to be expanded and funded or new programs created. Currently, locations for hydrilla and noxious weeds that pose a threat to agriculture are reported as part of the California Department of Food and Agriculture's Integrated Pest Control Program; however, weeds posing a threat to natural habitats are not mapped. An improved mapping and monitoring program that efficiently maps and monitors all targeted weeds will aid in their control, especially for rapidly spreading species. Such a program will also help to assess changes in the population levels and the effectiveness of control programs. Expanding California's noxious weed program to include weeds that pose a threat to native species or habitats would also aid in building an effective long-term aquatic weed control program.

To facilitate effective control programs for these species, all groups involved must coordinate with one another to control and restore habitat in Delta waterways. A coordinated approach to eliminate all damaging weeds, rather than only selected weed species, can reduce instances where one weed infestation replaces another, as exemplified by the increases in egeria and pennywort populations following efforts to control water hyacinth. In addition, regulatory agencies and those obligated to implement control programs must coordinate their efforts to plan and implement those programs that are appropriate to meet the specific needs of each site. Because the ecological, recreational, water quality, water conveyance, and commercial needs vary at each site, a general control strategy or regulatory policy is not possible. The specific needs of a site must be assessed and the costs and risks of different control strategies must be compared to determine the most appropriate strategy for each site. As a result, some sites will require more restrictive strategies than others.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The California Department of Food and Agriculture's Integrated Pest Control Branch tracks and controls federally listed noxious weeds throughout the State. These are weeds that have an impact on agriculture, although most of the current infestations are restricted to natural and uncultivated areas. Listed weeds are given a letter designation: "A" weeds are tracked and targeted for control or eradication wherever they are found; "B" weeds are considered too widespread to require mandated control of them, and the decision to control them is left to the county agricultural commissioners; "C" weeds are so widespread that the agency does not endorse State- or county-funded eradication or control efforts except in nurseries and seed lots.

Of the weeds described in this vision statement, only hydrilla is listed as a noxious weed. With funding, the California Department of Food and Agriculture's Integrated Pest Control Branch could be expanded to include weeds that adversely affect natural areas and their existing infrastructure and the expertise of that branch could be used to track, map, and control weeds that pose problems in natural areas.

Two recently announced programs or policy changes may have a beneficial effect on the vision for controlling invasive non-native aquatic and riparian weeds. The first is a new weed policy developed by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) that regulates not only weeds that threaten agricultural or managed areas, but those affecting natural areas as well. This program will use a risk assessment to identify weeds federally listed as noxious. Among other aspects of the new policy, APHIS will have a regulatory role, detecting, assessing, and containing incipient infestations. The policy states that APHIS will act in a federal coordination role to facilitate communication and cooperation among relevant public agencies and others (Westbrooks 1995).

The second new approach was formed through a Memorandum of Understanding (MOU) signed in 1994 by 17 land-holding federal agencies. The Federal Interagency Committee for Management of Noxious and Exotic Weeds was formed, under the MOU, to enable the signing agencies to cooperatively manage noxious and non-native weeds on federal lands and to provide technical assistance on private land to achieve sustainable, healthy ecosystems that meet the needs of the society (Jackson 1995).

Many other organizations have weed issues in the Delta, all with different roles, interests, and expertise. Implementing the ERPP vision requires a coordinated effort among these groups to develop and implement weed management programs and strategies that will help meet ERPP's goals for the various resources and ecological management zones.

- The U.S. Department of Agriculture - Agricultural Research Service Aquatic Weed Control Research Laboratory in the Department of Vegetable Crops at the University of California at Davis conducts ongoing research on aquatic weed control.

- The California Weed Science Society is a 50-year-old organization serving the weed science community.

- The California Exotic Pest Plant Council is a nonprofit organization that focuses on issues regarding non-native pests and their control and educates the public on these issues.

- The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, California Department of Fish and Game, State Water Resources Control Board, Central Valley Regional Water Quality Control Board, California Department of Food and Agriculture, and California Department of Health Services have regulatory or programmatic roles pertaining to aquatic weed control in the Delta and the Sacramento and San Joaquin Rivers and their tributaries.

In addition to these, several public and private groups deal directly or indirectly with aquatic weeds in the Delta. Among them are:

- California Native Plant Society,

- The Nature Conservancy,

- the State and national parks systems, county and local parks departments,

- Animal and Plant Health Inspection Service ,

- U.S. Army Corps of Engineers,

- U.S. National Resources Conservation Services,

- Center for Natural Lands Management,

- resource conservation districts, mosquito abatement districts, flood control districts,

- California Association of Nurserymen,

- local land trusts,

- and private landowners.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive aquatic plants adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of exotic plants has impaired the proper functioning of fish protective devices such as fish screens and fish louvers in the Delta.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

Two Strategic Objectives address invasive aquatic plants.

The first Strategic Objective is to halt the introduction of invasive aquatic and terrestrial plants into Central California.

LONG-TERM OBJECTIVE: Halt the release and spread of aquarium organisms, exotic plants and aquatic pets in the Bay-Delta Watershed.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the aquarium industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of non-native species and exotic plants from the aquarium and pet trades.

RATIONALE: Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., Hydrilla) became established through aquarists dumping them in local waterways. Non-native turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles. Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult. There clearly is a need to make sure that potentially harmful organisms are not available to aquarists and that new organisms are not brought in as "hitch-hikers" in shipments of aquarium fishes. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not release aquatic pets into natural environments. A good model for this could be the program now in place in Hawaii, which (among other things) has a big public education component and requires all aquarium stores to have a special tank into which people can release unwanted aquatic organisms.

STAGE 1 EXPECTATIONS: Species in the aquarium and pet trades will have been identified and evaluated for their ability to establish populations in the Bay-Delta system. With the cooperation of the aquarium/pet industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted aquatic organisms from these sources into natural waters.

The second Strategic Objective is to develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

An example of an abundant species needing immediate attention is the water weed Egeria densa. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because E. densa beds appear to exclude native fishes and favor introduced species.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

A comprehensive strategy to reduce invasive aquatic plants and their adverse effects on the Bay-Delta ecosystem would include the following items.

- Assess aquatic weeds for their level of threat, their extent, and their potential to be controlled in the long run.
- Assess potential weed control sites to determine how effective control efforts will be in improving habitat quality, the longevity of results, and the sites' likelihood of providing the types of habitats and habitat characteristics proposed for restoration.
- Develop and implement management plans to

achieve specific targets for each weed and site.

- Implement habitat restoration (e.g., planting native pondweeds and other desirable aquatic and emergent wetland plants) concurrent with or following implementation of control measures, where appropriate.

- Eradicate water hyacinth from major tributaries and marinas, locks, important wetland areas, and wildlife refuges in the Sacramento-San Joaquin Delta Ecological Zone.

- Elsewhere, reduce the biomass of infested acreage to a lower maintenance level than of the present summer cover. This goal would be approached beginning in the tributaries entering the Delta, and aiming for total eradication there; then water hyacinth will be contained at maintenance levels in upstream locations.

- Provide technical expertise, serve as a clearinghouse for regional information and project results, and assist with implementation of high-priority local projects in specific ecological units or zones to increase the effectiveness of existing public and private programs to reduce the threat of invasive species.

REFERENCES

California Exotic Pest Plant Council Biocontrol Committee. 1995. Biological control of invasive exotic pest plant species - a report on the importance of maintaining and enhancing our nation's biological control capabilities. Cal EPPC News. California Exotic Pest Plant Council.

Jackson, N. 1995. Update: Federal Interagency Committee for Management of Noxious and Exotic Weeds (FICMNEW). Abstracts of the California Exotic Pest Plant Symposium '95. Cal EPPC News. California Exotic Pest Plant Council.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Westbrooks, R. G. 1995. Federal regulatory efforts to minimize the introduction and impacts of exotic pest plants in the United States. Abstracts of the California Exotic Pest Plant Symposium '95. Cal EPPC News. California Exotic Pest Plant Council.

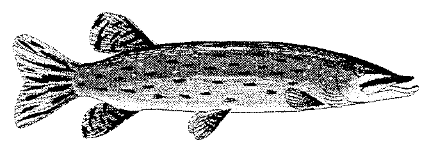
Westerdahl, H. E., and K. D. Getsinger (eds.). 1988. Aquatic plant identification and herbicide use guide. Volume II: Aquatic plants and susceptibility to herbicides. November. (Technical Report A-88-9.) U.S. Army Corps of Engineers. Washington, DC.

PERSONAL COMMUNICATIONS

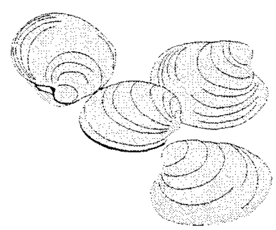
Anderson, Lars. Research leader. U.S. Department of Agriculture - Agricultural Research Service Aquatic Weed Control Research Laboratory, Department of Vegetable Crops, University of California, Davis, Davis, CA. February 2, 1997 - telephone conversation.

Van Ways, Valerie. Supervisor. Aquatic Weed Program, California Department of Boating and Waterways. October 3, 1996 - telephone conversation.

◆ INVASIVE AQUATIC ORGANISMS



Northern Pike



Asian Clams

INTRODUCTION

Most of the clams, worms and other bottom-dwelling invertebrates presently inhabiting the Bay-Delta are introduced from other estuaries. Non-native species also make up an increasing proportion of the zooplankton and fish communities of the Bay-Delta. It is estimated that a new non-native species is identified in the Bay-Delta every 15 weeks.

Many species were transported on the hulls of ships or in ship ballast water. Others arrived with the Atlantic or Japanese oysters purposely introduced into the estuary earlier in this century. Many fish, including striped bass, American shad, and largemouth bass, were introduced by federal and State resource agencies to provide sport fishing or forage fish to feed sport fish. Others, such as the northern pike, in a western Sierra reservoir, were purposely and illegally introduced.

Whether accidental or intentional, the introductions of these organisms have greatly increased the species diversity of the Bay-Delta aquatic community. However, this increase in diversity has occurred at the expense of native species, some of which have declined precipitously or even become extinct because of predation and competition from non-natives. Some introduced species are nuisances because they attach to boat hulls, bore into dock pilings, clog drainage pipes, tunnel into levees, or compete with or prey on valuable native species. Many non-native species, however, perform vital ecological functions such as serving as primary consumers of organic matter, or as a food source for Bay-Delta fish, shorebird, waterfowl, and other wildlife populations. Many non-native species have invaded the Bay-Delta successfully by filling new habitat niches that previously did not exist. Restoration of natural habitats with more natural flow regimes and hydraulic conditions throughout the Bay-Delta will hopefully favor native species. Continued study of the effects of non-native species on the abundance and distribution of native species and on the rest of the Bay-Delta ecosystem will be part of the adaptive management program guiding these restoration efforts.

STRESSOR DESCRIPTION

Invasive aquatic organisms are those non-native fish and invertebrates that have invaded the Bay-Delta at the expense of native species. Non-native aquatic invertebrates of the Bay-Delta include a wide variety of sponges, coelenterates, worms, molluscs, and crustaceans. Most are bottom-dwelling organisms as adults, but some planktonic forms have also become well established, especially in the last few years. Most were introduced accidentally from the hulls of ships passing through or abandoned or sunk in the Bay-Delta, from the release of ship ballast water, and from oysters (which usually contain dozens of nestling, symbiotic and parasitic invertebrates) brought in from Japan and the Atlantic coast for aquacultural purposes.

The first recorded introduced species, the Atlantic barnacle (*Balanus improvisus*) was observed in 1853, the single busiest year of clipper ship landings of the Gold Rush era. Since then, many species of non-native fish and invertebrates have been introduced into the estuary. The success of these introduced species is due in part to the comparatively small number of native species thought to have been present during aboriginal times and in part to environmental modifications to which non-native species were often preadapted.

The relatively low native-species diversity is thought to be a result of the relatively young age of the Bay-Delta estuary and its isolation from other Pacific Coast estuarine systems (Carlton 1979). Important environmental changes that most likely decreased native species' ability to compete with non-native species include changes in Bay-Delta morphometry, vegetation, hydraulics, and the amount and timing of Delta outflow.

It is not clear to what extent the decline in abundance of some native species is a result of environmental changes or to interactions with non-native species. It is known, however, that non-native species now figure prominently in the diets of fish species, shorebird and invertebrate-eating waterfowl, and other wildlife species. Most non-native fish and invertebrates perform a vital role in the Bay-Delta foodweb. Certain species, however, have become so abundant in some areas or have been shown to exert a negative effect on ecosystem health or economics in other areas that their mere presence in the Bay-Delta is a source of considerable concern.

The Asian clam, *Potamocorbula amurensis,* was first observed in 1986 and has since become extremely abundant in the Bay and western Delta. This species is well adapted to the Bay-Delta saltwater conditions and exerts a heavy grazing loss on phytoplankton and zooplankton in the Bay. Precisely how the Asian clam is affecting other benthic invertebrates, the zooplankton abundance and composition, or the larval and young fish health is still not well understood, but is thought to be generally detrimental. This is especially true for native species. On the positive side, Asian clams may contribute to the foodweb as an important food source for white sturgeon (Peterson 1997).

The zebra mussel, *Dreissena polymorpha*, another clam-like species many believe will soon invade the Bay-Delta, poses a similar ominous threat.

The Asian clams came on the heels of another clam invasion. *Corbicula manillensis* was also introduced from Asia. It was first described in the Delta in 1946. This clam does not tolerate saline waters. It is now very abundant in freshwater portions of the Delta and in the lower mainstem rivers adjacent to the Delta.

Another relatively new arrival to the Bay-Delta is another species from the Orient, the Chinese mitten crab (*Eriocheir sinensis*). This crab spends most of its life in fresh water and migrates downstream to spawn in salt water. Mitten crabs were first captured in south-Bay shrimp trawls in 1993. Their distribution and abundance have increased every year since then (Hieb 1997). Although these crabs may have an adverse effect on the red swamp crayfish (another non-native species), its greatest potential negative impact on the Bay-Delta may be its effect on levees. Mitten crabs dig burrows in clay-rich soils where banks are steep and lined with vegetation. These burrows accelerate bank erosion and slumping and, over time, may pose a serious threat to Delta levee integrity. The crabs also interfere with bay shrimp fishing by fouling nets.

Introduced zooplankton species have become important elements of the Bay-Delta. *Eurytemora affinis* was probably introduced with striped bass around 1880. Until recently, it was a dominant calanoid copepod of the entrapment zone. In the last decade, however, Eurytemora has been replaced by two calanoid copepods introduced from China. This replacement was a result, in part, of Eurytemora's greater vulnerability to Asian Clam grazing.

The native mysid shrimp, *Neomysis mercedis*, began dwindling in abundance in the late 1970s primarily as a result of the declining trophic status of the Bay-Delta. Its population decline was also affected by competition with *Acanthomysis aspera*, an introduced mysid shrimp of somewhat smaller size but similar feeding habits.

Although many non-native fish species have been introduced to the Bay-Delta over the past century, only a few have been considered invasive and requiring control. The most recent example is the northern pike introduced into Davis Lake, a State Water Project reservoir on the Feather River. Two unconfirmed sightings of northern pike occurred in the Delta in early 1997. Northern pike are noted predators and could, if allowed to establish themselves, pose a significant threat to native fishes, such as chinook salmon, steelhead, and delta smelt. White bass were a similar threat in the 1980s; however, a concerted effort ensured they did not move from isolated southern San Joaquin Valley reservoirs into the San Joaquin River.

ISSUES AND OPPORTUNITIES

INTRODUCED SPECIES: Introduced species have had a significant impact throughout the Bay-Delta ecosystem, and they can pose a significant impediment to achieving restoration objectives. In order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species-disruptions that could threaten to negate the benefits of restoration efforts-it is important to initiate an early program that:

- prevents or significantly reduces additional introductions of non-native species,
- develops a better understanding of how non-native species affect ecological processes and biological interactions,
- develops effective control and eradication programs, and
- establishes habitat conditions that favor native over non-native species.

DECLINE IN PRODUCTIVITY: Productivity at the base of the foodweb has declined throughout the Delta and northern San Francisco Bay. Although some of this decline can be attributed to the introduced clam Potamocorbula amurensis, or Asia clam, not all of the decline is explained. The decline at the base of the foodweb has been accompanied by declines in several (but not all) species and trophic groups, including mysids and longfin smelt. The long-term implications of this seem to be a reduction in the capacity of the system to support higher trophic levels. This implies a limit on the extent to which Bay-Delta fish populations can be restored unless creative solutions can be found to increase foodweb productivity (Strategic Plan 1999).

OPPORTUNITIES IN THE DELTA: Reduce the introduction of ballast-water organisms from ships to 5% of 1998 levels. The shipping industry can be required to greatly reduce and eventually eliminate the introduction of organisms through ballast water using existing technology. Significant progress could also be made in reducing the introduction of non-native species from other sources as well (goal 5, objectives 2-7). This is a preventative rather than a restorative activity. Given the impacts that introduced invasive species have already had on the ecology of the Bay-Delta ecosystem, however, the eventual elimination of all additional species introductions is crucial to the ultimate success of the ERP (Strategic Plan 1999).

RESEARCH: Initiate targeted research on major restoration issues, such as: (1) how to control problem invasive species such as the Asia clam

(Potamocorbula amurensis), which has a negative effect on foodweb dynamics in the estuary; (2) factors limiting the abundance of high-priority endangered species; and (3) design of habitats for shallow-water tidal marsh and bypasses. Ultimately, the limited funds available for restoration will be much more effectively spent if there is a clear understanding of the relative seriousness of the diverse problems facing the estuarine and riverine ecosystems and of the ability to solve those problems. Where the research can be linked to pilot or large-scale restoration projects, the benefits will be multiplied (Strategic Plan 1999).

VISION

The vision for invasive aquatic organisms is to reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation. This vision can be accomplished through enforcement of State laws regulating ballast water dumping and other measures designed to reduce the number of new, potentially harmful species introduced accidentally into the Bay-Delta estuary. Habitat changes or direct control measures may reduce their effects in specific cases.

The introduction of non-native species to the Bay-Delta has been a mixed blessing. Most have successfully integrated into the Bay-Delta aquatic community. Others, however, have hastened the extinction or greatly reduced the abundance of native species or have become an economic nuisance. Once established, non-native species cannot be effectively removed by harvesting or poisoning, except perhaps in small localized areas.

The only practical way to minimize the spread of non-native species and promote the growth of native species is to restore the habitats to more natural conditions. Restoring more natural, native aquatic communities should promote greater ecosystem stability by reducing the likelihood of catastrophic reductions in abundance of native organisms resulting from changes in environmental conditions.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to restore the natural environmental conditions, trophic status and native invertebrate community of the Bay-Delta will involve the cooperation and support of established programs underway to restore habitat and fish populations in the basin.

- Restoration of the plankton food supply of native fishes is a primary focus of the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1995).

- The Central Valley Project Improvement Act (CVPIA) calls for the doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon, and American shad) by 2002, through changes in flows and project facilities and operations. This program involves actions that may directly or indirectly benefit native invertebrates of the Bay-Delta foodweb.

- The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988) to restore numbers of anadromous fish in the Central Valley. Actions include restoring the food supply of anadromous fish.

- Efforts will be coordinated by the State Water Resources Control Board and Regional Water Quality Control Boards to reduce the amount of toxic substances released into Central Valley waterways, which should help reduce stresses on the native and non-native invertebrate species.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive aquatic organisms adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of these exotic organisms has altered the Bay-Delta foodweb.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

There are many Strategic Objectives related to invasive aquatic organisms.

The first Strategic Objective is to eliminate further introductions of new species in ballast water of ships.

LONG-TERM OBJECTIVE: Eliminate the dumping of all organism-contaminated ballast water and ballast sediment into the estuary.

SHORT-TERM OBJECTIVE: Eliminate the dumping of all ballast sediment into the estuary. Reduce the amount of ship ballast water contaminated with estuarine organisms from other ports that is dumped into the estuary to 5% of 1998 levels by the year 2005, and to 1% of 1998 levels by 2008.

RATIONALE: The introduction of non-native species in the ballast water of ships has made the estuary the most invaded estuary in the world; a new species is being added about every 14 weeks. The new species greatly increase the expense and difficulty of restoring the estuary. A new invader can effectively destroy the value of a restoration project. Aquatic invasions also have harmed public health, decimated fisheries, and impeded or blocked water deliveries. Substantial reductions in the number of organisms released via ballast water are readily achievable. Around the world, restrictions and regulations governing management of ballast water and other ballast materials are being promulgated to reduce the introduction of non-native species by this means. Strict controls on ballast water exchange should be enacted and enforced on shipping into San Francisco Bay at the earliest possible time. If prevention cannot work, the shipping industry must be made responsible for the damage caused by ballast water organisms because such introductions must be regarded as deliberate and unauthorized, rather than "accidental".

STAGE 1 EXPECTATIONS: Same as short-term objectives. In addition, better mechanisms to treat ballast water to eliminate unwanted organisms will have been developed. Baseline monitoring of the organisms released in ballast water should be immediately initiated so we can assess progress and monitor compliance. Studies should be completed to investigate the ecological and economic impacts of introductions into the Bay-Delta system to demonstrate that strong action is warranted.

The second Strategic Objective is to eliminate the use of imported marine baits.

LONG-TERM AND SHORT-TERM OBJECTIVE: Eliminate the use of imported live non-native marine species for bait in San Francisco Bay and elsewhere in California.

RATIONALE: At the present time, polychaete worms are shipped live from New England and southeast Asia to the San Francisco Bay Area for use as bait in marine sport fisheries. The New England worms are packed in seaweed which contains many non-native organisms, some of which have been established in San Francisco Bay as a result. This is thus an example of small activity that has the potential for large-scale economic damage (see ballast water rationale). It should be banned by the Fish and Game Commission and the baits replaced by local organisms or by artificial bait.

STAGE 1 EXPECTATIONS: The importation of live marine baits and their associated shipping materials will have been banned, unless the industry can demonstrate that all the organisms imported cannot become established in California.

The third Strategic Objective is to halt the introduction of freshwater bait organisms into the waters of Central California.

LONG-TERM OBJECTIVE: Halt the introduction of additional species of bait organisms in the Bay-Delta watershed and the further spread of species already established.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the bait industry, the fishing community, and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of organisms used as bait in fresh and brackish water.

RATIONALE: Many kinds of aquatic organisms are used for bait. Bait fishes like the red shiner have been spreading rapidly and now dominate many streams, with unknown impacts on native fishes and on fisheries. They continue to be spread by anglers releasing unused bait. Other new organisms may be brought in as "hitch-hikers" in shipments of bait fishes. There is also a need to better educate the fishing public on the adverse impacts of invasive species.

STAGE 1 EXPECTATIONS: Working with the bait industry and other interested parties, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted bait organisms into natural waters.

The fourth Strategic Objective is to halt the deliberate introduction and spread of potentially harmful species of fish or other aquatic organisms in the Bay-Delta and Central Valley.

LONG-TERM OBJECTIVE: Prevent the establishment through deliberate introductions of any additional fish species from outside the state or from other watersheds within the state, into Central California.

SHORT-TERM OBJECTIVE: Develop a program to educate the public (especially anglers) about the dangers of moving fish and other organisms around.

RATIONALE: The California Department of Fish and Game has long had a policy of not bringing new aquatic species into California to improve fishing. However, illegal introductions continue, such as that of northern pike into Davis Reservoir. If the highly predatory pike had become established in Sacramento River and Delta, it is quite likely it would have had devastating impact on salmon and native fish populations. There is a need to develop stronger prevention strategies for illegal introductions. The conflict that developed around the necessary elimination of pike from Davis Reservoir demonstrates the need for the development of better public understanding of the need to halt invasions. Education is also needed to make the point that any movement of fish and aquatic organisms by humans to new habitats is potentially harmful, even if the species is already established nearby. Brook trout introduced into a fishless mountain lake, for example, can eliminate the population of mountain yellow-legged frog that lives there, pushing the species further towards endangered species listing.

STAGE 1 EXPECTATIONS: An aggressive public information program should be developed in regard to species introductions.

The fifth Strategic Objective is to halt the unauthorized release of non-native introduced fish and other organisms from aquaculture operations into California waters.

LONG-TERM OBJECTIVE: Halt the non-deliberate introduction into natural waters of aquatic organisms from aquaculture facilities that is often a by-product of aquaculture operations. Prevent the importation from other regions of organisms from other regions into aquaculture facilities in the Bay-Delta system unless major quarantine regulations or facilities are in place.

SHORT-TERM OBJECTIVE: Institute an independent, scientific assessment of the pathways and risks of the introduction into the environment of organisms imported from other regions by aquaculture and of any changes needed in California's current management of the industry to prevent such introductions. Develop and institute strategies, working with the aquaculture industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of invasive or harmful non-native species via aquaculture.

RATIONALE: Stocks of fishes and invertebrates are imported from other regions for rearing in aquaculture facilities in the Bay-Delta system, and permits are occasionally approved to bring in new species for aquaculture. Numerous examples exist of organisms escaping from aquaculture facilities and becoming established outside of their range. These include, or potentially could include, fish, crayfish and other shellfish that could compete with or prey on native California fish and aquatic organisms, and on sport and commercial fish in central California waters. Of greater concern is the potential for the introduction of parasites and diseases of commercial, recreational, and native fish and shellfish. There are also many examples of such diseases introduced by aquaculture into various parts of the world, sometimes with devastating impact on commercially important species.

STAGE 1 EXPECTATIONS: An independent assessment of the pathways, risks and needed management of aquaculture introductions will have been completed; management measures to eliminate by-product introductions will have been adopted and implemented.

The sixth Strategic Objective is to halt the release and spread of aquatic organisms from the aquarium/pet trade into the waters of Central California.

LONG-TERM OBJECTIVE: Halt the release and spread of aquarium organisms and aquatic pets in the Bay-Delta Watershed.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the aquarium industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of non-native species from the aquarium and pet trades.

RATIONALE: Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., Hydrilla) became established through aquarists dumping them in local waterways. Non-native turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles.

Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult. There clearly is a need to make sure that potentially harmful organisms are not available to aquarists and that new organisms are not brought in as "hitch-hikers" in shipments of aquarium fishes. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not release aquatic pets into natural environments. A good model for this could be the program now in place in Hawaii, which (among other things) has a big public education component and requires all aquarium stores to have a special tank into which people can release unwanted aquatic organisms.

STAGE 1 EXPECTATIONS: Species in the aquarium and pet trades will have been identified and evaluated for their ability to establish populations in the Bay-Delta system. With the cooperation of the aquarium/pet industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of unwanted aquatic organisms from these sources into natural waters.

The seventh Strategic Objective is to develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

An example of an abundant species needing immediate attention is the water weed Egraria densa. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because E. densa beds appear to exclude native fishes and favor introduced species.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

The general target for invasive aquatic organisms is control and reduce the incidence of introductions and to implement control programs or eradicate exotic species where possible.

Actions that would help achieve this vision include more stringent enforcement of current policies regarding the introduction of non-native species. These policies seek to prevent the introduction of known noxious species and minimize the introduction of all other species. In addition to prohibiting intentional introductions, enforcing existing laws such as International Maritime Organization's Guidelines will reduce the number of accidental introductions from ship ballast water.

REFERENCES

Carlton, J. T. 1979. Introduced invertebrates of San Francisco Bay. In: San Francisco Bay: The Urbanized Estuary, T. J. Conomos (ed.). Pacific Division, American Association for the Advancement of Science. San Francisco, CA.

Hieb, K. 1997. Chinese mitten crabs in the Delta. In Vol. 10, No. 1. of Newsletter of the Interagency Ecological Program for the Sacramento-San Joaquin Estuary. California Department of Water Resources, Sacramento, CA.

Peterson, H. 1997. Clam-stuffed sturgeon. In Vol. 10, No. 1. of Newsletter of the Interagency Ecological Program for the Sacramento-San Joaquin Estuary. California Department of Water Resources, Sacramento, CA.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

U.S. Fish and Wildlife Service. 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native fishes. U.S. Fish and Wildlife Service. Portland, OR.

◆ Invasive Riparian and Marsh Plants

Introduction

Invasive riparian and marsh plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The riparian and salt marsh plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.

Factors that relate to the degree of influence invasive riparian and salt marsh plants have on the Bay-Delta include additional introductions from gardens and other sources, and ground disturbances and hydrologic regimes that create favorable conditions for their establishment.

Stressor Description

Weeds, or invasive plant species, are organisms capable of invading relatively undisturbed habitats and exploiting opportunities provided by natural or human-related disturbances in the landscape. Although not all weeds are non-native, most have been introduced from other parts of the world. In the absence of the natural biological controls found in their native habitats, such as herbivory by specific insects, weeds can flourish with fewer constraints in a new landscape, quickly gaining a competitive advantage over the native species. Many weeds have also evolved characteristics that make them extraordinarily competitive in both native and non-native environments. These specialized traits may include high seed production, both sexual and asexual reproduction, several methods of dispersal, a fast growth rate, and tolerance of a wide range of environmental conditions such as extremes in temperature, nutrients, and water availability.

A plant species becomes a weed problem when it adversely affects natural communities or land uses. Whether non-native or native, plant species are considered harmful when they reduce the biological diversity of existing natural communities by displacing native species or altering ecosystem processes such as nutrient cycling, hydrologic conditions, or the frequency of fires. They are problems to human society when they impair agricultural productivity, present fire hazards, constrict waterways, diminish recreation and aesthetic value, or destroy structures.

Since the first non-native settlers, weeds have been introduced to California and many have become established. There were at least 16 non-native plant species established by 1869, 292 by 1925, 797 by 1968, and 1,023 by 1993 (Barbour et al. 1993). Undoubtedly, non-native species introductions will continue, and correspondingly, add pressure on the native plant communities and the wildlife that depend on them.

More than 90% of the State's historic riparian habitat has been lost, primarily as a consequence of land being converted for agricultural uses (Barbour et al. 1993). What remains continues to be threatened, not only by further habitat conversions, but also by weeds. It is particularly important for the many endangered and threatened species that weeds are controlled, particularly for birds and fish that depend on native riparian plant communities.

Many riparian infestations are from species, such as Pampas grass, that spread from gardens. Others were planted intentionally along engineered or altered waterways for erosion control or in the belief that native vegetation would be too vigorous and would clog waterways (Dawson 1984). Weed infestations in riparian and salt marsh systems are magnified by both alterations to the landscape and current land use patterns. Clearing land allows weeds that thrive in disturbed areas, such as ailanthus, to invade bare areas and move into established forests. Overgrazing in riparian areas can diminish recruitment of new native trees and shrubs directly and indirectly by contributing to the establishment of a dense understory of non-native vegetation that hinders native seedling establishment. Some orchards may be a source of riparian weed infestations, as may have happened with the establishment of California black walnut, used as rootstock in English walnut orchards.

Urban development adjacent to riparian areas can lead to infestations by ornamental garden plants such as German ivy, arundo or giant reed, elm, black locust, and edible fig. Increases in summer ground and surface water from irrigation can harm some riparian vegetation, altering the species composition. It can create conditions leading to a higher rate of invasion by urban area weeds such as Bermuda grass that can compete with native seedlings, thus affecting forest regeneration. Left alone, many weeds can take over part or all of the established riparian or salt marsh communities, displacing the native vegetation and becoming the new climax successional species. Examples include arundo and tamarisk. Both were intentionally introduced and now are widespread weeds that have displaced extensive areas of native riparian vegetation throughout the western United States.

Most Central Valley and Delta riparian communities are confined to lower floodplain and river channel areas, compared to a much wider distribution over vast floodplains 150 years ago. With the conversion of riparian communities to other land uses, broad outer bands of riparian vegetation were lost or their extent greatly diminished, like those dominated by sycamores. Today, most watercourses are confined to narrower channels with little room for changing patterns of braiding and migration. Inundation and sedimentation rates are altered from historical times in river channels and are substantially reduced in floodplain areas. In the Delta, sedimentation is also altered with the erosion of islands.

Habitat losses or alterations have resulted in a pattern of habitat fragmentation. Riparian communities are often disconnected patches along river channels, and salt marshes are either newly developed from sediment deposition or smaller patches of formerly great expanses. The alteration of ecosystem processes like sedimentation, nutrient flow, fire, and hydrologic conditions, along with reduction in cover and native plant community diversity, has resulted in degraded riparian or salt marsh habitat conditions. The riparian or salt marsh community is then vulnerable to invasions by non-native species that are better adapted to the altered conditions than the native vegetation.

Species such as arundo and tamarisk are able to quickly exploit disturbed riparian sites. They, in turn, alter the ecosystem processes further, changing the frequency of fires, increasing shade and sediment capture, armoring the streambed and banks, altering soil salinity (tamarisk), and modifying the hydrologic patterns. The native species are not adapted to the new ecosystem processes, and the introduced weeds dominate the successional community.

Weeds that pose the greatest threats to riparian and salt marsh areas are those that out compete and exclude native vegetation and diminish habitat value to wildlife and reduce biodiversity of native species. All weeds listed in the following section have this potential.

Numerous weeds threaten the establishment and succession of native riparian and salt marsh vegetation in the Delta and along the Sacramento and San Joaquin Rivers and their tributaries. Some of the most invasive, listed below, include weeds that are widespread, often extensive, and extremely dangerous because of their ability to dominate riparian or salt marsh communities and affect ecosystem processes (arundo and tamarisk). Other invaders are trees or shrubs that now dominate portions of riparian forests and can invade larger areas if not controlled (ailanthus, edible fig, northern California black walnut, eucalyptus, black locust, and Russian olive). Additional examples include some weeds that are primarily a problem in a more restricted range or ecological zone type (perennial pepperweed, German ivy, cordgrass, and purple loosestrife).

Both arundo and tamarisk are widespread weeds capable of causing enormous damage to California riparian communities. They reduce biological diversity, habitat value for wildlife, and ecosystem processes such as flooding patterns and fire frequency.

ARUNDO (*Arundo donax*), also known as giant reed or false bamboo: Native to the Mediterranean area, arundo was introduced to California in the late 1800s and used for erosion control along drainage canals. It continues to be sold and planted as an ornamental. Arundo is a highly invasive bamboo-like perennial grass that can form large, fast-growing, monospecific stands that out compete and displace native riparian vegetation while restricting water flow, increasing sedimentation, and forming large debris piles in streams and rivers. It is not considered to be of value to native wildlife. Arundo spreads by growing rhizomes (lateral roots) and disperses to new sites when stems and rhizomes break off in floodwater and take root in moist streambed soils. Grading and other construction activities can and have greatly increased areas occupied by arundo. For example, Camp Pendleton's past program for clearing native vegetation to conserve water resulted in distributing arundo throughout the cleared area. When the program was halted, the arundo population continued to expand (Reiger 1988).

The effects of arundo's ability to alter ecosystem processes may be profound. It is far more susceptible to fire than native riparian species. However, although it recovers from fires, most native vegetation does not, leading to increased postfire dominance by arundo. By increasing sedimentation after establishing in stream channels, arundo stabilizes islands, hinders braiding and shifting patterns in stream channel movement, and prevents native stream channel vegetation from establishing (Peterson pers. comm.). An example of this can be seen at Stony Creek in northern California. Because arundo has a vertical structure, it does not overhang water like native riparian vegetation. The result is less shade over water, providing less cover, increased water temperatures, and altered water chemistry, all conditions that can harm fish and other existing aquatic organisms and ultimately change the aquatic species composition

By 1993, arundo accounted for as much as 50-60% of a 1,116-acre riparian community in the Riverside west quadrangle covering a portion of the Santa Ana River in southern California (Douthit 1993). Because of this, it has been implicated in the reduction of rare native stream fish populations in the Santa Ana River (Bell 1993). Some arundo populations have been mapped in southern California (Douthit 1993), and a population has been mapped along Stony Creek in northern California; however, no comprehensive statewide mapping of arundo has been conducted. Therefore, an accurate assessment of the extent and rate of spread of the weed is unknown. It is widespread throughout the Sacramento and San Joaquin River channels and their tributaries, as well as throughout the Delta. More survey mapping is needed to determine the extent of arundo, the levels of threat posed by the weed throughout the ERPP study area, how and when best to safely control it, and a prioritized strategy for removing it.

Tamarisk (*Tamarix chinensis, T. ramossisima, T. pentandra*), also known as salt cedar: This woody shrub from Eurasia was introduced in the early 1800s as an ornamental. It has since spread or been introduced into nearly every drainage system in the southwestern United States. It occupies 1.5 million acres nationwide and 16,000 acres in California. It can alter ecosystem processes such as the frequency of fires and hydrologic conditions of streams and groundwater. Tamarisk plants evapotranspire larger quantities of groundwater than do native plants, leading to reduced groundwater supplies. It traps more sediment than native vegetation, leading to a reshaping of stream bottoms and altered flooding pattern. It adds increased fuel loads to the riparian community, which can result in more fires. Tamarisk tolerates fires; native riparian species generally do not. The result of these ecosystem process changes is the eventual exclusion or reduction in cover by native plant species and altered stream shapes and flooding patterns. Studies have shown that bird usage is lower when tamarisk, rather than native tree species, dominates the riparian zone (Meents et al. 1984, Anderson and Ohmart 1984).

Tamarisk is widespread in California rivers; however, an accurate assessment of the extent and rate of spread of the weed is unknown. Like arundo, more survey mapping is needed to determine the extent of tamarisk, the levels of threat posed by the weed, the best time to safely control it, and a prioritized strategy for removing it.

Ailanthus, edible fig, northern California black walnut, eucalyptus, and black locust are examples of invasive trees or shrubs that have achieved local dominance in riparian forests in the ERPP study area. All have the potential for population expansions.

Ailanthus (*Ailanthus altissima*), also known as tree-of-heaven: Ailanthus was first introduced into the eastern United States in the late 1700s. By the mid-1800s, it was commonly sold by nurseries as a street and shade tree. It was introduced into California in the 1850s. Its horticultural popularity declined by the mid-1900s, and it became naturalized in mostly ruderal areas, but is often present in riparian habitats as well, especially those in agricultural or urban settings (Hunter 1995). Although it may not be as aggressive an invader as other riparian weeds, it has achieved local dominance in some sites, either displacing or preventing native riparian species from establishing. In agricultural settings, ailanthus roots can disrupt the integrity of levees and irrigation canal banks.

Edible Fig (*Ficus carica*): Fig is a cultivated tree native to the Mediterranean area. Its seeds are dispersed by birds and other wildlife and by floodwaters. Present in many streams and rivers throughout California, it tends to form a shady canopy that can hinder seedling establishment by native species. It also spreads vegetatively through stump sprouting and where bent branches take root, thus forming thickets that exclude native species. An example of the fig's impacts may be seen at both the Dye Creek and Cosumnes River Preserves in northern California, where active management programs are in place to eradicate the trees.

Northern California black walnut (*Juglans californica var. hindsii*): Historically, the native northern California black walnut was present only along the Sacramento River between Freeport and Rio Vista (Fuller 1978). However, Skinner and Pavlik (1994) say it historically grew in Contra Costa, Napa, Sacramento, Solano, and Yolo Counties. It is a special-status species in its native range; however, it (or a hybrid of it and the English walnut, *Juglans regia*) is now common in many Central Valley, Delta, and Bay Area riparian forests. The walnut's widespread distribution may be explained by its historical use as rootstock in English walnut orchards and possibly by active spread by Native Americans. Along the mainstem of the Sacramento River, there are dense areas of northern California black walnut saplings established under the canopy of mature valley oaks and cottonwoods. Without active management, these trees could eventually displace valley oaks and cottonwoods in many areas.

EUCALYPTUS (*Eucalyptus* spp.): Eucalyptus trees are native to Australia. They have been used commercially as fuel wood and planted horticulturally in urban settings. They are fast-growing and quickly form canopies that restrict available light from slower-growing native species. They also compete for water and form a large leaf litter layer that alters the soil chemistry and tends not to break down rapidly. The oil in the trees makes them particularly hazardous to fires, as was demonstrated in the Oakland hills and southern California fires in the summer of 1996. However, unlike native riparian plants, eucalyptus resprouts after fires. This combination of characteristics leads to dominance and expansion of the trees in riparian systems. Because the leaves are not broken down, the leaf litter can cause increased sedimentation in streams, adversely affecting invertebrate and fish populations. Eucalyptus trees growing in stream channels at maturity create flood risks because their shallow roots and large stature render them vulnerable to blow down and toppling during storm events, potentially causing debris dams during high flows. Volunteer eucalyptus stands in the channel may be found in many riparian locations, such as along Putah Creek in Yolo County.

BLACK LOCUST (*Robinia pseudoacacia*): Black locust is native to the eastern United States and is planted horticulturally in California. Once established, it spreads through seed and rhizomes to form locally dominant patches that can exclude native vegetation. Like eucalyptus, black locust resprouts after fires. Examples of its dominance may be found in sites along the Delta and lower American River and at the Cosumnes River Preserve.

Russian olive, perennial pepperweed, German ivy, cordgrass, and purple loosestrife are weeds that pose problems in a more restricted range or ecological zone type compared to the other listed weeds.

RUSSIAN OLIVE (*Elaeagnus angustifolius*): Russian olive is a cultivated shrub or tree, native to temperate Asia. It is not yet a significant problem but can become one if not controlled. It is planted in landscaping and has been planted extensively in wind breaks. It spreads into riparian areas from seed and at maturity, crowds out native species.

PERENNIAL PEPPERWEED (*Lepidium latifolium*): Perennial pepperweed is a mustard family plant, native to Eurasia, that is widespread in the United States. It was introduced to North America in the early 1800s and reportedly first introduced to Yolo County as a contaminant of sugar beet seed (Young et al. 1996). It is found in all counties in the ERPP study area. It infests freshwater riparian and wetland areas and salt-affected areas, including coastal salt marshes, often where there was past disturbance. It can also grow in areas that are only seasonally wet. The plants grow fast, up to two or more meters tall, and spread both by rhizomes and seeds, forming dense stands that exclude all other vegetation. Once stems begin growing, most herbivores will not eat the plants (Young et al. 1996). An example of a perennial pepperweed infestation may be found at Grizzly Island in the Delta.

GERMAN IVY (*Senecio milkanioides*): This vine, native to South Africa, has been planted horticulturally and has spread into primarily coastal riparian forests. German ivy can be found in Marin and Sonoma County riparian forests. It carpets large expanses of forest understory and climbs to the canopy of willow and cottonwood trees. Competing for nutrients and water and preventing sunlight from reaching seedlings, it reduces the cover of native vegetation and the riparian community structure.

CORDGRASS (*Spartina alterniflora, S. anglica, S. densiflora, S. patens*): *Spartina alterniflora*, native to eastern North America; *S. anglica, S. densiflora*, native to South America; and *S. patens*, native to the southeastern United States were intentionally introduced to San Francisco Bay areas in the 1970s (Callaway and Josselyn 1992, Daehler and Strong 1994, Spicher and Josselyn 1985, Spicher 1984). All introduced cordgrasses are a threat to the open intertidal mud and salt marsh communities in estuarine areas. The cordgrasses form tall, dense colonies in the mud with thick root systems. The result is alteration of tidal flows and increased sedimentation, as well as displacement of clams, worms, crustaceans, and shorebirds that depend on these prey species. An additional threat is to the native *S. foliosa*, which becomes overgrown by *S. alterniflora* (Callaway and Josselyn 1992) and can hybridize with it (Strong and Daehler 1996). The native *S. foliosa* community provides habitats for the clapper rail and salt marsh harvest mouse.

PURPLE LOOSESTRIFE (*Lythrum salicaria*): Native to Eurasia, this riparian herbaceous weed was introduced to North America in the early 1800s and has since invaded wetlands throughout the United States. It forms large monotypic stands, displacing native species, and can eliminate shallow open-water areas otherwise used by waterfowl and wildlife.

ISSUES AND OPPORTUNITIES

INTRODUCED SPECIES: Introduced species have had a significant impact throughout the Bay-Delta ecosystem, and they can pose a significant impediment to achieving restoration objectives. In order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species-disruptions that could threaten to negate the benefits of restoration efforts-it is important to initiate an early program that:

- prevents or significantly reduces additional introductions of non-native species,
- develops a better understanding of how non-native species affect ecological processes and biological interactions,
- develops effective control and eradication programs, and
- establishes habitat conditions that favor native over non-native species (Strategic Plan 1999).

OPPORTUNITIES: Reduce or eradicate invasive non-native shrubs and trees from riparian corridors. Of particular importance is the control of the spread of tamarisk and giant reed, two introduced species that displace native flora, offer marginal value to fish and wildlife, and cause channel instability and reduced floodway capacity. Some rivers, such as Stony Creek and Cache Creek and the lower San Joaquin River, have undergone large expansions of these non-native species, even in the past 10-15 years. A combination of large-scale eradication pilot projects and targeted research on several streams will help to temporarily reduce the rate of expansion of their range, identify the most vulnerable stream environments, and determine whether valley-wide eradication or suppression measures are warranted or feasible (Strategic Plan 1999).

VISION

The vision for invasive riparian and salt marsh plant species is to reduce their adverse effects on native species and ecological processes, water quality and water conveyance systems, and major rivers and their tributaries.

Active management is necessary to reduce invasive plant populations that compete with the establishment and succession of native riparian vegetation in the Delta and Sacramento and San Joaquin Rivers and their tributaries in order to:

- assist in the natural reestablishment of native riparian vegetation in floodplains,
- increase shaded riverine cover for fish,
- reduce stress on rare species and communities, and
- increase habitat values for riparian associated wildlife.

Reduction of populations of invasive plant species that compete with the establishment and succession of native saline and fresh emergent marsh vegetation would also assist in the natural reestablishment of these native habitats and increase habitat values for associated wildlife. Developing and enhancing programs that protect and restore our State's natural resources and biological diversity while fulfilling our flood control, water conveyance, and compatible economic development needs are necessary if efforts are to succeed on a long-term basis. Historically, governmental weed control programs have been aimed at non-native species, which has adversely affected commerce, primarily agriculture, or public services such as water delivery. Weeds in natural areas have historically not been addressed but are now areas of great and increasing concern. Expanding existing governmental and private programs or creating new, similar programs is needed to perpetually monitor, research, and control weeds that impact natural areas, and to prevent new infestations by existing weeds or new introductions. To minimize recurring infestations, programs to actively restore native habitats will require expansion into areas where infestations have been removed.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The California Department of Food and Agriculture's Integrated Pest Control Branch has responsibility for tracking and controlling federally listed noxious weeds statewide. These are weeds that have an impact on agriculture, although most of the current infestations are restricted to natural and uncultivated areas (O'Connell pers. comm.). Listed weeds are given an "A", "B", or "C" designation. "A" weeds are tracked and targeted for control or eradication wherever they are found. "B" weeds are considered too widespread to require mandated control measures; the choice for controlling them is left to the county agricultural commissioners. "C"-rated weeds are so widespread that the agency does not endorse State- or county-funded eradication or control efforts except in nurseries and seed lots. Of the weeds described in this vision statement, only perennial pepperweed and purple loosestrife are listed as noxious agricultural weeds, both with a "B" designation. With funding, the California Department of Food and Agriculture's Integrated Pest Control Branch could be expanded to include weeds adversely affecting natural areas and their existing infrastructure and expertise used to track, map, and control weeds that are problems in natural areas.

Two recently announced programs or policy changes may bear positively on the vision for controlling aquatic, riparian, and salt marsh weeds. The first is that the U.S. Department of Animal and Plant Health Inspection Service (APHIS) developed a new weed policy that includes regulation of all types of weeds, including not only those threatening agricultural or managed areas, but natural area weeds as well. The program will use a risk assessment to list and delist noxious weeds. Among other aspects of the new policy, APHIS will institute a regulatory role of detecting, assessing, and containing incipient infestations. The policy states that APHIS will play a federal coordination role to facilitate communication and cooperation between relevant public agencies and others.

The second new approach was formed through a Memorandum of Understanding (MOU) signed by 17 land-holding federal agencies in 1994. A committee was formed called the Federal Interagency Committee for Management of Noxious and Exotic Weeds. The purpose of the

MOU and committee formation is to enable the signing agencies to cooperatively manage noxious and non-native weeds on federal lands and to provide technical assistance on private land to achieve the goal of sustainable, healthy ecosystems that meet the needs of society.

The Delta Flood Protection Program (AB 369) has data on the location and extent of invasive plants associated by levees in the Delta. The program has "habitat assistance" describing the kinds and extent of plants on the levees; Arundo is particularly noted. The eradication of Arundo by levee districts is considered as a beneficial habitat change and is reimbursable by the program.

There are many other organizations with an interest in weed issues in the ERPP study area. All have different roles, interests, and expertise. To attain ERPP's goals, a coordinated effort would be needed among the groups to develop, prioritize, and implement weed management programs and strategies that will help to achieve ecological zone and resource visions.

- The University of California Weed Science Program in the Vegetable Crops Department conducts ongoing research on weed ecology and control, including non-crop and natural area problems.
- The California Exotic Pest Plant Council is a nonprofit organization that focuses on issues regarding non-native pest plants and their control, and on public education regarding the issues.
- The California Weed Science Society is a 50-year-old organization serving the weed science community.
- The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the California Department of Fish and Game have regulatory roles pertaining to weed control.

Several public and private groups dealing with weeds directly or indirectly in the ERPP study area can also be included. Among these are:

- the California Native Plant Society,
- The Nature Conservancy,
- State and national parks, county and local parks,
- U.S. Bureau of Land Management,
- APHIS,
- U.S. Army Corps of Engineers,
- U.S. Natural Resource Conservation Service,
- Center for Natural Lands Management,
- resource conservation districts,
- mosquito abatement districts,
- flood control districts,
- California Association of Nurserymen,
- Team Arundo, and Team Arundo del Norte,
- local land trusts,
- and private landowners.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive riparian and salt marsh plants adversely influence other ecosystem elements such as riparian and riverine aquatic habitat, and fish, wildlife, and plant species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

Two Strategic Objectives address invasive riparian and marsh plants.

The first Strategic Objective is to halt the introduction of invasive aquatic and terrestrial plants into Central California.

LONG-TERM OBJECTIVE: Halt the importation, sale, and use of aquatic and terrestrial plants that can have potentially harmful impacts on ecosystems in the Bay-Delta watershed.

SHORT-TERM OBJECTIVE: Develop and institute strategies, working with the horticulture industry and interests representing the environment and other sectors that may be affected by such introductions, to halt the introduction and spread of invasive plant species.

RATIONALE: Many areas of the Central California landscape are dominated by non-native plant species (e.g., annual grasslands, eucalyptus forests) that have displaced native species and have unexpected negative impacts. Parrot's feather, for example, is an ornamental aquatic plant that is now widespread, clogging ponds and ditches in the Bay-Delta watershed, thereby creating breeding habitat for mosquitoes. Many harmful species (e.g., water hyacinth) can easily be purchased in plant nurseries and so continue to be spread into natural systems. New species and varieties of plants from all over the world are constantly being brought into California with little evaluation of their invasive qualities. Some species (e.g., Atlantic and English cordgrass) have even been imported for marsh restoration projects! There clearly is a need to evaluate the plants imported into California from other regions and to better regulate the horticultural industry to make sure potentially invasive plants are not available for spreading by gardeners, landscapers, and people engaged in restoration or reclamation activities. There is also a need to better educate the public on the adverse impacts of invasive species and the need to not to allow garden plants to escape into natural environments.

STAGE 1 EXPECTATIONS: Plants sold in California by the horticulture industry that pose a threat to ecosystems in the Bay-Delta watershed will have been identified and evaluated for invasive potential. Special attention will be paid to plants imported into the region from other areas. Working with the horticulture industry and affected interests, a plan will have been developed and instituted to greatly reduce, and eventually eliminate, the introduction of additional invasive plant species into natural environments.

The second Strategic Objective for invasive riparian and marsh plants is to develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of a "rare" introduced species needing eradication that is not being dealt with is English cordgrass in the Bay. It has been described by some scientists as the most aggressive and invasive salt marsh plant in the world. It has been in the Bay, its only known California location, for 20 years without spreading, so it has not generated concern. However, in other parts of the world it has also sometimes sat around for a few decades without doing much of anything, then suddenly taken off and taken over entire estuaries in a few years. In San Francisco Bay, it is known from one site only, where it was planted, and where it exists in a single patch. It could readily be eradicated.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

The general target for invasive riparian and saltmarsh plants is to prevent them from becoming established in riparian and saltmarsh restoration areas, conduct distribution and abundance surveys throughout the ERPP Study Area, and develop and implement control and eradication programs for high priority problem areas.

A comprehensive strategy to reduce invasive riparian and salt marsh plant populations and their adverse effects on the Bay-Delta ecosystem would include the following items.

- Assess weeds for their levels of a threat, their extent, and their potential for long-term control.
- Assess potential weed control sites for their likelihood to provide the greatest return on control efforts in terms of improved habitat quality and other benefits, such as reducing flood risk and channel instability, longevity of results, and ability to supply the types of habitats and habitat characteristics proposed for restoration.
- Develop and implement management plans based on the assessment of weeds and sites to achieve specific targets for each weed and site.

- Wherever necessary and appropriate, implement habitat restoration simultaneous with or following control measures.

- For arundo and tamarisk, eradicate the weeds in watersheds where they have only small populations, then concentrate on eradicating satellite populations extending beyond major infestations, and finally, reduce and eventually eliminate the most extensive populations.

- Provide technical expertise, serve as a clearinghouse for regional information and project results, and assist with implementing high-priority local projects in specific ecological units or zones to increase the effectiveness of existing public and private programs to reduce the threat of invasive species.

REFERENCES

Anderson, B. W., and R. D. Ohmart. 1984. Avian use of revegetated riparian zones. In Richard E. Warner and Kathleen M. Hendrix, California riparian systems - ecology, conservation, and productive management. University of California Press. Berkeley, CA.

Barbour, M., B. Pavlik, F. Drysdale, and S. Lindstrom. 1993. California's changing landscapes - diversity and conservation of California vegetation. California Native Plant Society. Sacramento, CA.

Bell, G. P. 1993. Ecology and growth habits of giant reed (*Arundo donax*). *Arundo donax* Workshop Proceedings - November 19, 1993. Team Arundo.

Callaway, J. C., and M. N. Josselyn. 1992. The introduction and spread of smooth cordgrass (*Spartina alterniflora*) in south San Francisco Bay. Estuaries 15:218-226.

Daehler, C. C., and D. R. Strong. 1994. Variable reproductive output among clones of *Spartina alterniflora* (poaceae) invading San Francisco Bay, California: the influence of herbivory, pollination, and establishment site. Amer. Journal Botany 81:307-313.

Dawson, K. J. 1984. Planting design inventory techniques for modeling the restoration of native riparian landscapes. In Richard E. Warner and Kathleen M. Hendrix, California riparian systems - ecology, conservation, and productive management. University of California Press. Berkeley, CA.

Douthit, S. 1993. *Arundo donax* in the Santa Ana River Basin. *Arundo donax* Workshop Proceedings - November 19, 1993. Team Arundo.

Fuller, T. C. 1978. *Juglans hindsii* Jepson ex. R. E. Smith, northern California black walnut. Rare plant status report. California Native Plant Society.

Hunter, J. C. 1995. *Ailanthus altissima* (Miller) swingle: its biology and recent history. CalEPPC News - Newsletter of the California Exotic Pest Plant Council. Fall 1995. Volume 3(4).

Meents, J. K., B. W. Anderson, and R. D. Ohmart. 1984. Sensitivity of riparian birds to habitat loss. In Richard E. Warner and Kathleen M. Hendrix, California riparian systems - ecology, conservation, and productive management. University of California Press. Berkeley, CA.

Reiger, J. P. 1988. Riparian restoration projects in San Diego County. California Department of Transportation. Pages 213-220 in J. P. Rieger and B. K. Williams (eds.), Proceedings of the Second Native Plant Revegetation Symposium - April 15-18, 1987, San Diego, CA.

Skinner, M. W., and B. M. Pavlik. 1994. Inventory of rare and endangered vascular plants of California. Fifth edition. (Special Publication No. 1.) California Native Plant Society. Sacramento, CA.

Spicher, D. 1984. The ecology of a caespitose cordgrass (*Spartina* sp.) introduced to San Francisco Bay. M.A. thesis. San Francisco State University. San Francisco, CA.

Spicher, D., and M. Josselyn. 1985. *Spartina (Graminaea)* in northern California: distribution and taxonomic notes. Madrono 32:158-176.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

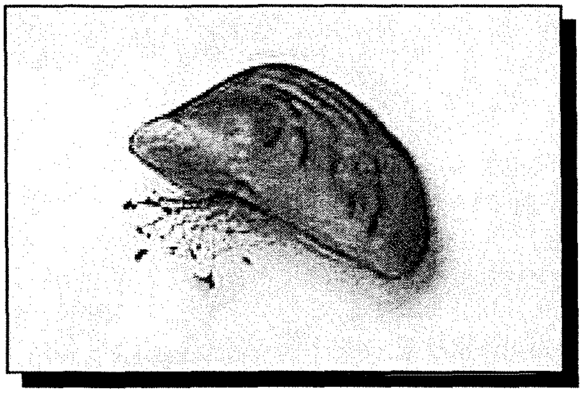
Strong, D. R., and C. C. Daehler. 1996. Alien cordgrasses in Pacific estuaries. In J. E. Lovich, J. Randall, and M. D. Kelly (eds.), Proceedings of the California Exotic Pest Plant Council Symposium '95.

Young, J. A., D. E. Palmquist, R. S. Blank, and C. E. Turner. 1996. Ecology and control of perennial pepperweed (*Lepidium latifolium* L.). In J. E. Lovich, J. Randall, and M. D. Kelly (eds.), Proceedings of the California Exotic Pest Plant Council Symposium '95.

PERSONAL COMMUNICATIONS

O'Connell, Ross. Senior agricultural biologist. California Department of Food and Agriculture, Division of Plant Industry, Integrated Pest Control Branch, Sacramento, California. January 31, 1997 - telephone conversation.

Peterson, Daryl. Sacramento River restoration project coordinator. The Nature Conservancy, Chico, California. January 30, 1997 - telephone conversation

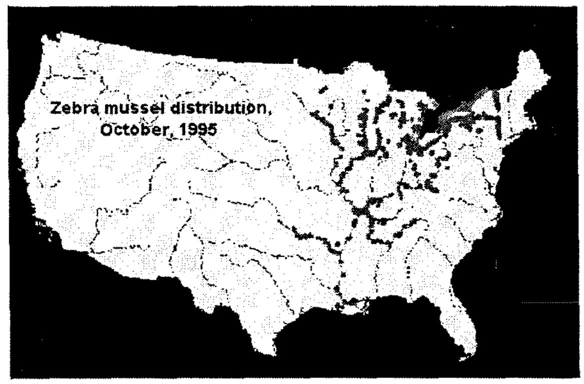


INTRODUCTION

Zebra mussels are a highly invasive exotic bivalve first discovered in the Great Lakes region in 1988 (Hebert et al. 1989). Since its introduction, the zebra mussel has caused widespread disruption of important foodweb processes in the region, altered fish species abundances, and impaired water export facilities used for municipal, industrial, and power generation purposes. The zebra mussel is not known to occur in California at this time. The introduction of zebra mussel into California's Bay-Delta watershed would be an environmental and economic catastrophe.

STRESSOR DESCRIPTION

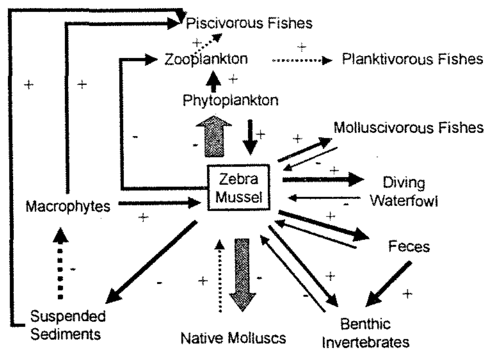
Zebra mussels are small shellfish marked by alternating light and dark bands. They are typically 2 inches or less in size. Zebra mussels are native to the drainage basins of the Black, Caspian, and Aral seas of Eastern Europe. It is believed that ships originating from European ports carried the pest in freshwater ballast which was discharged into the Great Lakes. The first North American zebra mussel as discovered in Lake St. Clair, Michigan in June 1988. By September 1991, the mussel was found in all five of the Great Lakes, the St. Lawrence River, the Finger Lakes region of New York, and throughout the Mississippi River basin. The mussel is expected to infest most areas of North America within the next few years (New Hampshire Department of Natural Resources 1998).



Zebra mussels are the only freshwater mussel which can secrete durable elastic strands, called byssal fibers, by which they can securely attach to nearly any surface, forming barnacle-like encrustations. Through this mechanism zebra mussels can attach to stone, wood, concrete, iron, steel, aluminum, plastic, fiberglass, and PVC. Zebra mussels typically colonize at densities greater than 30,000 individuals per square meter.

The specific origin of zebra mussels introduced into the Great Lakes is unknown but they are widespread throughout western and eastern Europe (Marsden 1996). Zebra mussels have successfully invaded a wide variety of aquatic habitats including freshwater lakes and rivers, cooling ponds, quarries, and irrigation ponds on golf courses (Strayer 1991). Recent information suggests that zebra mussel can invade brackish water or estuaries where salinities do not exceed 8 to 12 ppt.

Water quality factors that limit colonization by zebra mussel appear to include temperature, pH, and calcium content of the ambient water. The upper thermal tolerance is between 68 to 77 °F. Lower limit of calcium is 12 mg per liter and a



Schematic of observed (solid line) and potential (dotted line) impacts of zebra mussel in freshwater communities based on European and North American studies. Taxa benefitting from zebra mussel invasion and indicated with a (+) symbol, those adversely affected by a (-) symbol. Strong interactions are denoted by thicker arrows. Zebra mussel may indirectly impact piscivorous and planktivorous fish by altering food supply or habitat quality (Adapted from MacIsaac 1996).

combined threshold for pH and calcium is 7.1 and 8.5 mg per liter.

Adult zebra mussel tissues have a very high nutrient value and in the Great Lakes region are consumed in large quantities by crayfish, fish, and waterfowl (Mackie and Schloesser 1996),

Zebra mussels become sexually mature in their first year of life and, depending on size, can produce 30,000 to 1,610,000 eggs per female.

Zebra mussel disperse by a variety of natural and anthropogenic means. Natural means include flowing water, birds, insects, and other animals. Human-mediated events include artificial waterways, ships, amphibious aircraft, and recreational equipments such as boats and other watercraft (Mackie and Schloesser 1996).

Live mussels have been reported found in Los Angeles attached to trailered boats. The California Department of Water Resources has also reported three more boats brought into the State since June 1996 carried zebra mussels. All three boats came from the Great Lakes region and were headed for saltwater destinations. The first of these three boats was intercepted at the Hornbrook Inspection Station near the Oregon border in June 1997 and the other two were stopped at the Truckee Inspection Station in September and December of 1996. This brought the total number of boats entering California found to be infested with zebra mussel to eleven boats since 1993.

The 1986 invasion of the Great Lakes by zebra mussel provides one of the most instructive examples of ecological modification and economic damage associated with human-mediated species introductions. (Hebert et al. 1989).

The greatest abiotic effect anticipated from an invasion by zebra mussel will be problems associated the mussel biofouling. Permanent marine structures such as pilings, bridges and docks are particularly susceptible of fouling. Water intake structures for municipal, industrial, and agricultural diversions and intake structures for power generation plants are highly vulnerable to fouling or clogging if they divert water from a source contaminated with adult or juvenile zebra mussel. Power plants components that are susceptible to biofouling include crib structures, trash bars, screen houses, steam condensers, heat exchangers, penstocks, and service water systems.

Very long or narrow pipelines are particularly vulnerable to biofouling and severely restricted flows (Claudia, R. and G.L. Mackie 1993). Mussel densities at the Monroe power plant in western Lake Erie have been reported to be as high as 750,000 individuals per square meter. These extraordinary mussel densities can be achieved in raw water intakes because of the enormous number of potential colonists entrained in the intake current, constant replenishment of nutrients and removal of mussel wastes, and absence of predators (MacIsaac 1996).

One of the most predictable outcomes of a zebra mussel invasion and a significant abiotic effect is enhanced water clarity. This also is linked to a greatly diminished phytoplankton biomass. For example, rotifer abundance in western Lake Erie declined by 74% between 1988 and the 1989-1993 period, a time coincident with the establishment of an enormous zebra mussel population beginning in 1989 (Leach 1993).

VISION

The vision for zebra mussel is to establish procedures to prevent or delay their introduction and to set up protocols to swiftly treat and eliminate any introduction. This includes all appropriate efforts will be maintained to interdict potential sources of zebra mussels at all border check stations and other potential sources of introduction. The vision also includes an emergency response strategy to quickly contain and eradicate any suspected or proven mussel colonies.

This vision is consistent with the visions for other invasive species, particularly for invasive aquatic species and relies on measures to prevent introductions through contaminated ballast water.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

- California Department of Food and Agriculture's border inspection stations.
- Michigan Sea Grant Zebra Mussel/Aquatic Nuisance Species Program which serves as a centralized source of information exchange.
- Fish and Game Commission which can regulates the importation of live animals or aquatic plants.
- California Department of Fish and Game which issues permits for the importation of live animals and aquatic plants.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Invasive aquatic organisms adversely influence other ecosystem elements including ecological processes, habitats, and species. For example, introduced species have out competed and displaced many native species. The proliferation of these exotic organisms has altered the Bay-Delta foodweb.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective is to prevent the invasion of the zebra mussel into California.

LONG-TERM OBJECTIVES: Develop an emergency response strategy to quickly contain and eradicate zebra mussels should they arrive in California. Continue to inspect trailered boats at the California border to intercept zebra mussels attached to boats.

SHORT-TERM OBJECTIVES: Coordinate activites with California Department of Food and Agricultural to increase monitoring activities at port of entries (boarder crossings) into California. Develop and fund protocols for inspecting vessels that enter the State from areas where zebra mussels are know to occur. Activities would also need to be under taken with adjoining states to prevent zebra mussels from becoming established in common waterways.

RATIONALE: The zebra mussel has done enormous damage to water supply infrastructure and to natural ecosystems in the eastern United States, through which they are spreading rapidly.

It is likely that at some point a live population of zebra mussels will appear in California waters through any one of several means. Studies have already demonstrated that it will likely thrive in many parts of the California water system. Therefore, it is highly desirable to have in place a strategy to deal with a localized invasion, along with a commitment of resources from agencies so that rapid action is possible.

STAGE 1 EXPECTATIONS: A determination should be made as to which waters which are most likely to serve as an initial site of invasion for zebra mussels (taking into account both water quality and other environmental factors and the mechanisms likely to transport zebra mussels); a zebra mussel monitoring program for these waters should be developed; and a rapid response strategy should be developed to contain and eradicate an incipient zebra mussel invasion. In addition, the most likely source for introducing zebra mussels is boats carried by trailer from areas where zebra mussels are abundant. California already has an agricultural inspection program, and this program now includes inspection of boats for mussels.

REFERENCES

Claudia, R. and G.L. Mackie. 1993. Practical manual for zebra musses monitoring and control. Lewis Publishers, Boca Raton, Florida.

Hebert, P.D., B.W. Muncaster, and G.L. Mackie. 1989. Ecological and genetic studies on *Dreissena polymorpha* (Pallas, 1771), A new mollusc in the Great Lakes. Canadian Journal of Aquatic Sciences 46: 1587-1591.

Leach, J.H. 1993. Impacts of the zebra mussel *(Dreissena polymorpha)* on water quality and fish spawning reefs in western Lake Erie. *In*: T.F. Nalepa and D.W. Schloesser (eds.) Zebra mussels. Biology, impacts and control. Pp 381-397. Lewis Publishers. Boca Raton, Florida.

MacIsaac, H.J. 1996. Potential abiotic and biotic impacts of zebra mussels on the inland waters of North America. American Zoologist 36:287-299.

Mackie, G.L, and D.W. Schloesser. 1996. Comparative biology of zebra mussel in Europe and North America: an overview. American Zoologist 36:244-258.

Marsden, J.E. 1996. Review of genetic studies of Dreissena spp. American Zoologist 36:259-270.

New Hampshire Department of Natural Resources. 1998. Zebra mussels. Technical bulletin WD-BB-17.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Strayer, D.L. 1991. Projected distribution of the zebra mussel, *Dreissena polymorpha*, in North America. Canadian Journal of Aquatic Sciences 48:1389-1395.

INTRODUCTION

The large-scale restoration of emergent wetlands, riparian habitat, and adjacent perennial grasslands will be the main focus of a strategy to reduce the adverse impacts of non-native wildlife on the health of the Bay-Delta ecosystem. The goal is a restored Bay-Delta and watershed where the quality, quantity, and structure of the restored habitat discourage colonization by non-native wildlife, provide a competitive advantage to native wildlife, and reduce the vulnerability of native species to nest parasitism and predation from species such as the brown-headed cowbird and starling, and from predation by species such as the red fox and Norway rat.

STRESSOR DESCRIPTION

One of the most serious environmental problems facing California is the explosive invasion of non-native pest plants and animals. Non-native plants, wildlife, fish, and aquatic invertebrates can greatly alter the ecosystem processes, functions, habitats, species diversity, and abundance of native plants, fish, and wildlife.

Many of these invasive species spread rapidly and form dense populations primarily by out-competing native species as a result of large-scale habitat changes that tend to favor non-native species and a lack of natural controls (e.g., natural predators). These non-native species usually have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. As populations of non-native species grow, they can disrupt the ecosystem and population dynamics of native species. In some cases, habitat changes have eliminated connectivity of habitats that harbor the native predators that could help to limit populations of harmful non-native species.

The following common but harmful non-native species are found in the Bay-Delta area:

- The red fox was brought to California to be hunted for sport and raised for fur during the late 1800s and early 1900s. The population of this fox appears to be increasing and is now widespread in the Central Valley lowlands and the coastal counties south of Sonoma County. The range of this species also appears to be increasing, and the fox is a threat to many native endangered wildlife species such as the California clapper rail.

- The Norway rat was introduced unintentionally and was established in many areas by the mid-1800s. Increases in urban development, landfills, and riprap areas have resulted in large populations of these rats living along the bay shores. They are a threat to ground-nesting wildlife.

- The feral cat is a major predator to bird and mammal populations in the wetland areas of the Bay-Delta Estuary and wildlife areas elsewhere.

- The bullfrog is not native west of the Rockies but has been successfully introduced throughout most of California from Oregon to Mexico. Bullfrogs can establish and thrive in most permanent aquatic habitats that support emergent vegetation. Population levels in semipermanent aquatic habitats vary from year to year. Bullfrogs feed on most vertebrates and invertebrates that can be seized and swallowed.

- The red-eared slider is a turtle native to the southeastern United States and sold in pet stores throughout the west. The species has become established in the wild in some locations through releases by pet owners. The range and status of sliders in the Delta are unknown but it is possible that this species is successfully reproducing. If so, it could compete with aquatic species in and dependent on the Delta.

Non-native wildlife species have been sighted throughout the Sacramento and San Joaquin Valleys in a variety of habitats. These include aquatic, riparian scrub, woodland, and forest habitats; valley oak woodland; grassland and agricultural land.

Reestablishing connectivity between habitats would help to reduce non-native species. For instance, restoring the connection between Bay marshlands and upland habitats that have populations of coyotes may help to reduce populations of red fox. Nest conditions in fragmented areas of riparian habitats encourage nest predation and parasitism by non-native species such as starlings and brown-headed cowbirds. Restoring large blocks or broad bands of riparian habitats will eliminate or minimize these adverse effects. Larger blocks may also encourage additional nesting by native deep-forest-nesting species that have been previously excluded.

VISION

The vision for non-native wildlife species is to implement a program to reduce the numbers of harmful non-native wildlife species (i.e., those that threaten the diversity or abundance of native species or the ecological stability of an area).

Reducing the numbers of non-native species and therefore the effects these species have on native wildlife will require a coordinated approach that includes restoring ecosystem processes and functions where applicable and possible, restoring native habitats, reducing or eliminating other stressors that suppress native species, and efforts to control non-native species.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Efforts to control non-native species, such as the red fox, are being undertaken on a small scale in the San Francisco Bay area. Most other efforts are associated with damage control in agricultural, urban, and suburban areas in the ERPP study area. Limited efforts have been focused in State and federal wildlife areas that have undertaken control programs on a small scale.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Non-native wildlife either compete with native wildlife species or prey on them. The result is diminished abundance of native species, some of which, such as the California clapper rail, are State or federally listed endangered species. Other than direct control measures, the problems caused by non-native wildlife species can be moderated by habitat restoration programs that reconnect habitats, reduce fragmentation of riparian habitat, and restore connection between lowland and upland habitats.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

Two Strategic Objectives address non-native wildlife.

The first Strategic Objective is to reduce the impact of exotic mammals on native birds and mammals.

LONG-TERM OBJECTIVE: Establish mechanisms to minimize the negative effects of house cats, red fox, domestic dogs, roof rats, house mice and other non-native predators and competitors on populations of native birds and mammals, especially at-risk species.

SHORT-TERM OBJECTIVE: Develop both the means and the public support for limiting the invasion and impacts of non-native mammals into natural areas.

RATIONALE: Probably few issues are as potentially contentious to the public as programs to control the numbers of house cats (both tame and feral), red fox (introduced in the Central Valley and spread to marshes throughout the Bay-Delta system), and domestic dogs in natural areas. The fact remains that such predators can have a major impact on the ability of natural areas to support wildlife, including threatened native species such as clapper rails, salt marsh harvest mice, and salt marsh song sparrows. Likewise, non-native rats and mice can impact populations of native rodents and songbirds. Thus there is a major need to educate the public about the tradeoffs in protecting abundant and conspicuous predators that prey on native species, as well as programs to rid areas of other non-native mammals. Economical but lethal means of control (poisons, traps) are often controversial for many of these species and may also affect native species. There is thus a need to focus on prevention (e.g., containment and neutering of pets), on non-lethal means of removal (e.g., live-trapping) where feasible, and on developing support and methods for lethal control where necessary. Prevention and nonlethal methods are typically labor intensive, continuous, and more costly than limited agency budgets can endure. Therefore, there is a need to develop either better methods or bigger budgets for control if self-sustaining populations of many native birds and mammals are to be maintained.

STAGE 1 EXPECTATIONS: An aggressive public information program on the impacts of such non-native mammals in wildlife areas will have been conducted. Plans for long-term control of invasive mammals will have been developed, with alternatives clearly spelling out the impact of no or low control.

The second Strategic Objective is to develop focused control efforts on those introduced species where control is most feasible and of greatest benefit, including eradication where scientifically justified and technically feasible.

LONG-TERM OBJECTIVE: Eliminate, or control to a level of little significance, all undesirable non-native species, where feasible.

SHORT-TERM OBJECTIVE: Eradicate or contain those species for which this can readily be done, gaining thereby the largest benefit for the least economic and environmental cost; and to monitor for the arrival of new invasive species and, where feasible, respond quickly to eradicate them.

RATIONALE: Non-native species are now part of most aquatic, riparian, and terrestrial ecosystems in California. In most instances, control is either not possible or not desirable. However, in some instances, control of invasive species is needed to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant.

STAGE 1 EXPECTATIONS: An assessment will be completed of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. A program will have been implemented to monitor for, and respond quickly to contain and eradicate new invasions, where this is possible. A mechanism whereby new invasions can be dealt with quickly and effectively will have been developed an implemented.

The general target for non-native wildlife is develop and implement control programs to reduce population abundance and to reestablish larger blocks of connected habitats to provide more extensive habitat and protection for native wildlife.

The Ecosystem Restoration Program Plan (ERPP) supports the following activities that would reduce adverse effects of non-native wildlife on native species:

- Reduce red fox populations in and adjacent to habitat areas suitable for California clapper rail, California black rail, salt marsh harvest mouse, and San Joaquin kit fox to reduce predation on eggs, juveniles, and adults and assist in the recovery of these native species.

- Reduce Norway rat populations in and adjacent to suitable habitat areas for California clapper rail, California black rail, and salt marsh harvest mouse to reduce predation on eggs, juveniles, and adults and assist in the recovery of these species. A combination of activities would be required to prevent the rats from establishing in important habitat areas (e.g., remove garbage and rubbish; ensure proper construction of residences and food storage structures; break down stubble in field crops, such as corn, to expose the rodents to predation during winter) and reduce populations in important habitat areas where the rats are already established (e.g., use biological controls, practice the environmental controls listed above, and use rodenticides).

- Reduce feral cat populations in and adjacent to suitable habitat for California clapper rail, California black rail, salt marsh harvest mouse, San Joaquin pocket mouse, kangaroo rat, and blunt-nosed leopard lizard habitats to reduce predation on eggs, juveniles, and adults and assist in the recovery of these species.

- Periodically drain aquatic habitats inhabited by bullfrogs to reduce the populations of these species (bullfrog larvae have an extended growing season, sometimes even overwintering, compared to native amphibians such as the California red-legged frog).

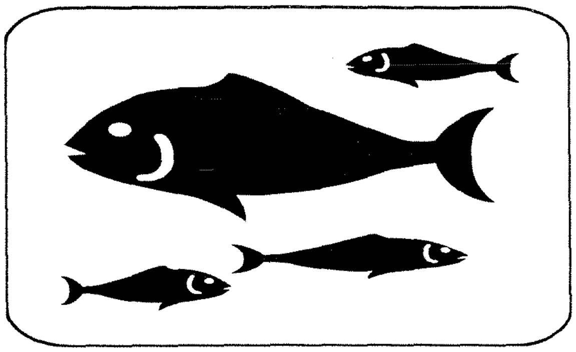
- Investigate the feasibility of increasing the harvest of bullfrogs without disturbing native species.

- Implement a "buy-back" or "take-back" program in pet stores to reduce the number of red-eared sliders released into the Delta.

REFERENCE

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

◆ Predation and Competition



Introduction

Predation and competition are natural ecological functions; however, unnatural levels of each can result in adverse effects to important sport and commercial fisheries and species of concern such as winter-run chinook salmon. For example, the potential adverse effects of competition between native and hatchery-reared salmonid stocks for food and other resources are a concern. Predation on important fish species and stocks is known to be a problem in the Central Valley, however, at specific sites or under specific environmental conditions.

Efforts to control the extent of unwanted predation and competition, particularly the loss of species of concern, are an important component in restoring health to the Bay-Delta system and in providing for other beneficial uses of water.

Stressor Description

Chinook Salmon as a Prey Species

Predation occurs throughout the river and ocean life-history stages of chinook salmon, but the magnitude and extent of predation have not been quantified. There are essentially three classes of predators on chinook salmon: birds, fishes, and marine mammals. Predatory birds include diving birds such as cormorants and gulls; terns and mergansers; wading birds such as snowy egret, great blue heron, black-crowned night heron, and green heron; and raptors such as osprey.

Predatory fish include both native and non-native species. Native predatory species include Sacramento squawfish, prickly sculpin, and steelhead. Non-native predatory species include striped bass, white catfish, channel catfish, American shad, black crappie, largemouth black bass, and bluegill.

Predation by native species is a natural phenomenon and should not have a serious effect on naturally produced chinook salmon in areas where shaded riverine aquatic (SRA) habitat and other types of escape cover are present. Chinook salmon has co-evolved with its native predators and has developed life-history strategies to avoid predation. However, predation by non-native species and increased predation resulting from artificial in-water structures and loss of instream habitat diversity may have resulted in gross imbalances in the predator-prey relationships and community structure in which chinook salmon evolved.

Artificial structures, such as dams, bridges, and diversions, create shadows and turbulence that tend to attract predator species and create an unnatural advantage for predators (Stevens 1961, Vogel et al. 1988, Decoto 1978). Specific locations where predation is of concern include Red Bluff Diversion Dam (RBDD), Glenn-Colusa Irrigation District's (GCID's) Hamilton City Pumping Plant, flood bypasses, release sites for salmon salvaged at the State and federal fish facilities, areas where rock revetment has replaced natural river bank vegetation, the Suisun Marsh Salinity Control Gates, and Clifton Court Forebay (CCF).

Predation at RBDD on juvenile chinook salmon is believed to be higher than natural levels because of the water quality and flow dynamics associated with the operation of this structure. The most important predator at RBDD is squawfish (Garcia 1989). Squawfish migrate annually upstream to RBDD from March to June, but some squawfish are present year round at the dam. Striped bass have also been captured immediately below RBDD in limited but regular numbers and have been found to have fed on juvenile salmonids (U.S. Fish and Wildlife Service unpublished data cited in Garcia 1989, Villa 1979). Striped bass were also observed by U.S. Fish and Wildlife Service (USFWS) divers below RBDD in September 1982, and five American shad captured at RBDD in June 1976 contained two to seven juvenile salmon each (Hall 1977).

Some chinook, such as juvenile winter-run chinook salmon that migrate downstream soon after emerging from the gravel in summer and early fall, will encounter RBDD when the gates are still down. They must cross Lake Red Bluff when turbidity is generally low and water temperatures are still relatively high. Because of their small size, these early emigrating winter-run juveniles may be very susceptible to predation in the lake by squawfish and cormorants (Vogel et al. 1988). In passing the dam, juveniles are subject to conditions that greatly disorient them, causing them to be highly susceptible to predation by fish or birds.

Prior to reoperation, late-migrating juvenile chinook salmon that passed RBDD in early spring most likely suffered the greatest losses because squawfish abundance was higher at that time of year and river conditions were generally favorable for predators, especially during dry years. Recent operation have reduced the aggregation of squawfish and reduced losses during the period in which the gates are up. The impacts of these losses are also more important because of the overall higher survival of these smolts (versus actively migrating fry) and their greater probability of contribution to the adult population.

There are some concerns that predation is higher in flood bypasses. In one survey of the Sutter Bypass, the most abundant species captured included chinook salmon and Sacramento squawfish (Jones & Stokes Associates 1993a).

Glenn-Colusa Irrigation District Hamilton City Pumping Plant

Evaluations at GCID Hamilton City Pumping Plant suggested that predation could be an important factor contributing to losses of juvenile salmonids at that location (Decoto 1978). In mark-recapture studies, 66% of the salmon were unaccounted for in bypass evaluations, and 82% were unaccounted for in culvert evaluations. More recent studies suggest that Sacramento squawfish is the primary predator at the pumping plant (Cramer 1992), although striped bass were also found with young chinook salmon in their stomachs.

Fish Salvage Release Sites

Orsi (1967) evaluated predation at the Jersey Island release site for salvaged fish from the State and federal fish facilities from mid-June through July in 1966 and 1967. Striped bass was the major predator at the release site, with black crappie and white catfish ranking second and third, respectively. Orsi estimated that overall predation occurred on about 10% of the salvaged fish released per day during multiple releases (one million fish/day), and more than 80% of the predation was from striped bass. He qualified this estimate as potentially being high and not applicable to other sites such as the Sacramento River. Similarly, Pickard et al. (1982) conducted predation studies of salvage release sites from 1976 to 1978. Fish, salvaged from the State's fish facility, were regularly transported and released into the lower Sacramento River at Horseshoe Bend. More predator fish were collected at the release site than at the control site, with striped bass and Sacramento squawfish being the primary predators. Also, more fish remains were found in the predators' stomachs at the release site than at the control site.

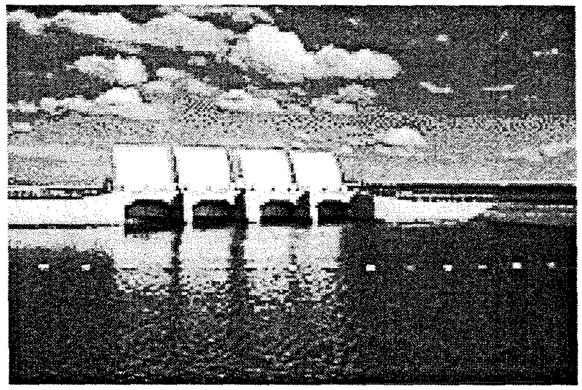
Rock Revetment Sites

USFWS conducted a study to assess the relationship of juvenile chinook salmon to the rock revetment type bank protection between Chico Landing and Red Bluff (Michny and Hampton 1984). They found that predatory fish, such as Sacramento squawfish and prickly sculpin, were more abundant at riprapped sites than at naturally eroding bank sites with riparian vegetation. Conversely, juvenile salmon were found more frequently in areas adjacent to riparian habitats than at riprapped sites. Riparian habitats provide overhead and submerged cover, an important refuge for juvenile chinook from predators.

Clifton Court Forebay

Overall predation rates for salmon smolts in CCF have been estimated at 63-98% for fall-run chinook (California Department of Fish and Game 1993a), and 77-99% for late-fall-run chinook (Table 4). In mark-recapture studies, estimated mortality rate per mile in CCF was 91.3%, compared with 2.7% for the central Delta and 0.9% for the mainstem Sacramento River (between Ryde and Chipps Island). This difference was thought to result from the greater abundance of predators, primarily striped bass, in CCF, as well as hydraulic actions and the operational and physical design of CCF. During high tide, striped bass density in CCF has been estimated to be three to 17.5 times higher than the density of striped bass in the Delta. At low tide, striped bass density in CCF has been estimated as roughly five to 21 times higher than in the Delta.

Suisun Marsh Salinity Control Structure



The California Department of Fish and Game (DFG) conducted predation studies from 1987 to 1993 at the Suisun Marsh salinity control structure to determine if the structure attracts and concentrates predators. The dominant predator species at the structure was striped bass, and juvenile chinook were identified in their stomach contents. Catch-per-unit-effort (CPUE) of bass has generally increased at the structure from 1987 (less than 0.5, preproject) to 1992 (3.0, postproject), and declined somewhat in 1993 (1.5) (California Department of Fish and Game 1994c). In comparison, CPUE was 3.44 at CCF and 1.65 at the south Delta barriers during the same period, using identical gear.

Ocean Predation

Ocean predation very likely contributes to natural mortality in naturally and hatchery-produced chinook salmon stocks; however, the level of predation is unknown. In general, chinook salmon are prey for pelagic fishes, birds, and marine mammals including harbor seals, sea lions, and killer whales. There have been recent concerns that rebounding seal and sea lion populations, following their protection under the Marine Mammal Protection Act of 1972, have resulted in substantial mortality for salmonids.

Ocean predation rates on Central Valley chinook salmon have not been evaluated, but several

Summary of Clifton Court Forebay Prescreen Loss Studies on Hatchery Juvenile Chinook Salmon

Date	Salmon Run	Prescreen Loss Rate (%)	Temperature (avg/day°F)	Pump Exports (avg. af/day)	Predator Abundance	Size at Entrainment (mm fl)
Oct 76	Fall	97.0	65.4	2,180	NA	114
Oct 78	Late-fall	87.7	57.5	4,351	NA	87
Apr 84	Fall	63.3	61.2	7,433	35,390	79
Apr 85	Fall	74.6	64.1	6,367	NA	44
Jun 92	Fall	98.7	71.7	4,760	162,281	77
Dec 92	Late-fall	77.2	45.4	8,146	156,667	121
Apr 93	Fall	94.0	62.0	6,368	223,808	66
Nov 93	Late-fall	99.2	53.7	7,917	NA	117

NA = estimates not available

Source: California Department of Fish and Game 1993.

studies have been conducted in other estuaries. At the mouth of the Russian River, Hanson (1993) found that maximum population counts of seals and sea lions corresponded with peak periods of salmonid returns to the hatchery upriver. However, Hanson concluded that predation was minimal on adult salmonids because only a few pinnipeds foraged in the area, their foraging behavior was confined to a short portion of the salmonid migration, and their capture rates were low.

In the lower Klamath River, Hart (1987) reported predation rates of about 4% and 8% in 1981 and 1982, respectively, from harbor seals on chinook, coho and steelhead. It is important to note that marine mammal and chinook salmon populations evolved together and coexisted long before humans played a role in controlling either species.

General Analysis of Striped Bass Predation on Chinook Salmon

Food habit studies conducted by numerous investigators indicate that chinook salmon are not an important component in the diet of striped bass, although, at times, young salmon, primarily fall-run, have constituted a substantial part. Generally, this has occurred in the Sacramento River upstream of the estuary and has been localized at water management structures, bridge abutments, and other predator habitats. It also occurs at structures that cause disorientation of juveniles such as RBDD. In the Delta, it is a known problem in CCF and at sites where large numbers of artificially produced chinook salmon are released.

The studies reveal that, except at localized sites and structures, striped bass are less likely to eat salmon in Suisun Bay and the Delta than in the rivers above the Delta. The greater vulnerability of salmon in the river may be a result of the greater clarity and the smaller width of the river. In many areas, bank protection activities, such as maintaining levees and riprapping, have removed SRA habitat and eliminated escape cover needed by young fish.

Opportunities to Reduce Predation

There have been only limited efforts to reduce predation problems. At RBDD, a squawfish derby was held in 1995 to reduce squawfish abundance. However, this sport fishery is unlikely to measurably alleviate predation from a native migratory species. The fishery could temporarily reduce squawfish abundance, but more squawfish are likely to repopulate the area. Sacramento squawfish are also more abundant at RBDD during spring, and a spring fishery could cause incidental catches of winter-run chinook.

The preferred solution to reduce predation at RBDD is to eliminate or reduce the feeding habitat that RBDD creates by seasonally or permanently raising the gates. It is anticipated that the GCID Hamilton City Pumping Plant will be redesigned and relocated on the main channel of the Sacramento River, upstream of its present location on an oxbow. The new design will eliminate predator habitats and should substantially reduce the existing level of predation and other problems caused by stream channel and gradient changes in the Sacramento River in recent years.

Predation problems occurring in CCF may be resolved by alternative conveyance facilities that reduce the quantity of water drawn directly into the forebay from the Delta.

Another important opportunity to reduce predation on target fish species is by recreating or restoring a more complex mosaic of instream habitats. These habitats can contribute to reduced predation and competition by allowing species to partition themselves among a more diverse array of available habitats.

Predation and Competition with Hatchery-Reared Fish

The extent of predation by hatchery salmonids on naturally produced chinook salmon and steelhead is also not known. Steelhead releases, primarily by the Coleman National Fish Hatchery, may have the greatest potential for inducing unnatural levels of predation on naturally produced chinook salmon. Coleman National Fish Hatchery has a capacity to raise about one million yearling steelhead. Present production targets a release of about 600,000 in January and February at 125-275 millimeters (mm) long (four fish/pound). Predation on hatchery-produced steelhead is thought to be further reduced because these steelhead tend to outmigrate rapidly and during a period when inriver foraging conditions are suboptimal (i.e., high turbidity, low water temperature).

Predation by residualized hatchery-released steelhead, however, could be substantial. The extent of residualization of released steelhead trout smolts is unknown. With a potential annual release of more than one million steelhead trout at Coleman National Fish Hatchery, even a small rate of residualization could result in a substantial predator population.

Predation from steelhead released by Feather River Hatchery and Nimbus Fish Hatchery has not been evaluated but may also be important. Each of these hatcheries has a capacity to raise about 400,000 yearling steelhead to a size of 3-4 fish/pound. Feather River Hatchery fish are planted in the Feather River below Yuba City, most by the end of March, and the Nimbus Fish Hatchery fish are mainly trucked and released in the Carquinez Strait between January and April (California Department of Fish and Game 1990). Feather River hatchery steelhead are released at a large enough size and at a time when they could intercept winter-run chinook. Nimbus Hatchery steelhead would also be large enough to prey on winter-run chinook salmon.

Chinook salmon and steelhead artificially produced at and released from hatcheries may compete with (or displace) their naturally produced counterparts for food or habitat in the river, estuary, and open ocean. The major source of competition from hatchery salmonids in the upper Sacramento River would be from releases from the Coleman National Fish Hatchery on Battle Creek. The extent of competition between naturally produced chinook and releases from other hatcheries is of particular concern. The extent of this competition is unknown but is believed to be low. The size differences between the various chinook salmon stocks may also result in segregation according to size-dependent habitat preferences because juvenile chinook salmon and steelhead move to faster and deeper waters as they grow and do not compete with fry (Everest and Chapman 1972).

Competition between hatchery runs and naturally produced salmon in the ocean is most likely limited in most years. The ocean environment has been assumed to be nonlimiting because, historically, the abundance of wild salmon was much higher than the combined abundances of wild and hatchery salmon at present (Chapman 1986, Bledsoe et al. 1989), and standing stocks and production rates of prey resources were estimated to far exceed the food requirements of the present ocean populations (LaBrasseur 1972, Sanger 1972). A number of studies have found evidence that ocean conditions may limit salmon production and a substantial percentage of the total natural mortality may occur during early marine life (Parker 1968, Mathews and Buckley 1976, Bax 1983, Furnell and Brett 1986, Fisher and Pearcy 1988). However, in many populations, much of this mortality appears to occur in the first month at sea regardless of the number of smolts released. Brodeur et al. (1992) suggested that local depletion of resources could occur, especially of fish prey in a warm year of reduced productivity (e.g., in 1983) when prey were smaller and competitors, such as mackerel, were abundant. But, in general, juvenile salmon do not appear to be food-limited in coastal waters during most normal years (Brodeur et al. 1992, Peterson et al. 1982, Walters et al. 1978).

VISION

The vision for predation and competition is to reduce unnatural levels to restore fish populations by removing, redesigning, or reoperating inwater structures, diversion dams, and hatchery practices.

The ERPP vision for unnatural levels of predation and competition is closely linked to physical habitat restoration objectives and targets in the visions for the Sacramento River Ecological Management Zone, the Sacramento-San Joaquin Delta Ecological Management Zone, the San Joaquin River Ecological Management Zone, and the Suisun Marsh/North San Francisco Bay Ecological Management Zone. In addition, the visions for chinook salmon, steelhead trout, striped bass, and artificial production contain strategies to ameliorate the adverse effects of competition and predation. Cumulatively, these visions present a robust integration of implementation objectives, restoration targets and actions that will contribute substantially to the restoration and maintenance of a healthy ecosystem, and healthy populations of valuable sport and commercial fisheries.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (Public Law 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002. The National Marine Fisheries Service is required under the Endangered Species

Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species. DFG is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988.

These programs, together with the ecosystem approach provided in ERPP, will cumulatively provide for substantial improvements in the health of fish populations, their habitats, and the ecosystem processes that create and maintain habitat and lessen the adverse effects of stressors.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The solutions to reducing unnatural levels of predation and competition are linked to improved hatchery management strategies which include reevaluation of release programs for hatchery produced fish. The solution also include modification to structures that promote predation such as predator habitat provided by instream structures. Some structures, such as RBDD, increase the vulnerability of young fish to predation. The restoration of riparian and riverine aquatic habitats, set back levees, and increases in the area and quality of shallow water habitat throughout the Delta and Suisun Bay will also provide important ecological components to lessen species interactions and the potential for predation.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic 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 in order to increase survival and contribute to the restoration of important species.

LONG-TERM OBJECTIVE: To rehabilitate man-made structures in the ecosystem to reduce predation losses associated with those structures to levels that will aid in the recovery and restoration of all species. Reduce competition between naturally spawned and hatchery reared species, by establishing hatchery protocols that benefit naturally spawned populations.

SHORT-TERM OBJECTIVE: Reduce the effects of predation associated with operations by better managing the State federal, and private infrastructures associated with aquatic environments . Modify physical characteristics of these facilities to detract from predator use. Study the effects of hatchery reared population have on naturally spawned populations within the ERPP study area.

RATIONALE: Predation related mortality associated with the operation of State, federal, and private facilities within the Sacramento-San Joaquin Estuary and its watershed contributes to the decline of resident and outmigrant aquatic species. Elevated predator levels in and near these man-made structures (screening facilities, diversions, and Clifton Court Forebay) and operational events (temperature plumes from power plants,) have been well documented. These structures have created an environment that is beneficial to predators. Within Clifton Court Forebay (CCF) predators have been documented orienting themselves with the radial gates when they are open, possibly feeding on hapless prey as they are drawn into the forebay (Bolster, 1986). In addition, striped bass have been noted at the trash racks, in front of the primary screens, feeding on marked fish as they are introduced into the water during a marked recapture experiment (DFG unpublished data). In studies done near the outfall of the cooling tower return and resulting thermal plume, predator populations have been demonstrated to increase as compared to other non-thermally elevated areas. Controlling these predators and developing more efficient methods to limit the exposure of prey species to these facilities will assist in the recovery of both listed and non-listed species.

Considerable discussion exists as to the effect of hatchery reared fish on non-hatchery reared fish. This information is not well documented and future efforts will reguire additional information to clarify the issue.

STAGE 1 EXPECTATION: Projects will be undertaken that identify and reduce predation associated with the operation of both State, federal, and private facilities located throughout the ERPP study area. Immediately, programs will be undertaken that reduce the current level of predation related mortality associated with facilities within the ERPP study area.

The general target is to develop and implement hatchery practices to reduce the potential interactions and competition between artificially produced and naturally produced chinook salmon, steelhead, striped bass, and other resident and estuarine fish. Predation and competition can be further reduced by restoring complex and diverse habitats throughout the mainstem rivers and Bay-Delta.

Actions which can contribute to this vision include:

- reducing shadows and turbulence created by dams, bridges, and diversions that attract predator species,
- replacing or supplementing rock revetment site with natural vegetation including shaded riverine aquatic habitats,
- restoring large blocks of riparian and shaded riverine aquatic habitats along the mainstem Sacramento and San Joaquin Rivers,
- preventing predatory fish from congregating below the Red Bluff Diversion Dam by modifying operations,
- improving fish passage through the flood control bypasses and eliminating low areas with no connection to perennial water courses,
- improving fish release sites used by the State and federal Delta fish salvage facilities,
- reevaluating opportunities to reduce predation in Clifton Court Forebay,
- evaluate alternate release strategies for Central Valley hatcheries to minimize interactions between hatchery and naturally produced fish,

REFERENCES

Bax, N. J. 1983. Early marine mortality of marked juvenile chum salmon (*Oncorhynchus keta*) released into Hood Canal, Puget Sound, Washington in 1980. Canada Journal of Fish Aquatic Science 40:426-435.

Bledsoe, L. J., D. A. Somerton, and C. M. Lynde. 1989. The Puget Sound runs of salmon: an examination of the changes in run size since 1896. Canada Special Publication Fish Aquatic Science 105:50-61.

Bolster, Betsy. 1986. Movement Patterns of Striped Bass (Morone saxatilis) in Clifton

Court Forebay, Contra Costa County, California. Master Thesis. Pages 112.

Brodeur, R. D., R. C. Francis and W. G. Pearcy. 1992. Food consumption of juvenile coho (*Oncorhynchus kisutch*) and chinook salmon (*Oncorhynchus tshawytscha*) on the continental shelf off Washington and Oregon. Canada Journal of Fish Aquatic Science 49:1670-1685.

California Department of Fish and Game. 1990. Central Valley salmon and steelhead restoration and enhancement plan. April 19. Sacramento, CA.

__________. 1993. Position on fish mortality in Clifton Court Forebay. Draft. March. Bay-Delta and Special Water Projects Division. Sacramento, CA.

__________. 1994. Predator sampling near the salinity control structure site in Montezuma Slough, May 1993. April 5. California Department of Fish and Game, Bay-Delta Division.

Chapman, D. W. 1986. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Transactions of the American Fish Society 115:662-670.

Cramer, S. P. 1992. The occurrence of winter-run chinook in the Sacramento River near the intake of the Glenn-Colusa Irrigation District. Submitted to Glenn-Colusa Irrigation District, March 1992. Sacramento, CA.

Decoto, R. J. 1978. 1975 evaluation of the Glenn-Colusa fish screen facility. California Department of Fish and Game Anadromous Fisheries Branch, Admin. Report No. 70.

Everest, F. H. and D. W. Chapman. 1972. Habitat selection and spatial interaction of juvenile chinook salmon and steelhead trout in two Idaho streams. Journal of Fish Resources Board of Canada 29:91-100.

Fisher, J. P. and W. G. Pearcy. 1988. Growth of juvenile coho salmon (*Oncorhynchus kisutch*) in the ocean off Oregon and Washington, USA, in years of differing coastal upwelling. Canada Journal of Fish Aquatic Science 45:1036-1044.

Fowler, S. W. and G. Benayoun. 1976. Influence of environmental factors on selenium flux in two marine invertebrates. Marine Biology 37:59-68.

Furnell, D. J. and J. R. Brett. 1986. Model of monthly marine growth and mortality for Babine Lake sockeye salmon (*Oncorhynchus nerka*). Canada Journal of Fish Aquatic Science 43:999-1004.

Garcia, A. 1989. The impacts of squawfish predation on juvenile chinook salmon at Red Bluff Diversion Dam and other locations in the Sacramento River. U.S. Fish and Wildlife Service Report No. AFF/FAO-89-05.

Hall, F. A. 1977. A discussion of Sacramento squawfish predation problems at Red Bluff Diversion Dam. Predation study files. California Department of Fish and Game, Bay-Delta Fishery Project. Stockton, CA.

Hanson, L. C. 1993. The foraging ecology of harbor seals, *Phoca vitulina,* and California sea lions, *Zalophus californianus,* at the mouth of the Russian River, California. Master's thesis. Sonoma State University. Sonoma, CA.

Hart, C. J. 1987. Predation by harbor seals, *Phoca vitulina,* on tagged adult chinook salmon, coho salmon and steelhead trout in the Lower Klamath River, California. California Department of Fish and Game, Inland Fisheries Admin. Rept. 87-18.

Jones & Stokes Associates, Inc. 1993a. Sutter bypass fisheries technical memorandum II: potential entrapment of juvenile chinook salmon in the proposed gravel mining pond. May 27, 1993. (JSA 91-272.) Sacramento, CA. Prepared for Teichert Aggregates, Sacramento, CA.

__________. 1993b. Strategies, potential sites, and site evaluation criteria for restoration of Sacramento River fish and wildlife habitats, Red Bluff to the Feather River. Prepared for the U.S. Army Corps of Engineers, Sacramento, CA.

LaBrasseur, R. J. 1972. Utilization of herbivore zooplankton by maturing salmon. Pages 581-588 in A. Y. Takenouti (ed.), Biological oceanography of the northern Pacific Ocean. Idemitsu Shoten. Tokyo, Japan.

Mathews, S. B. and R. Buckley. 1976. Marine mortality of Puget Sound coho salmon (*Oncorhynchus kisutch*). Journal of Fish Resources Board of Canada 33:1677-1684.

Michny, F., and M. Hampton. 1984. Sacramento River Chico Landing to Red Bluff Project, 1984 juvenile salmon study. U.S. Fish and Wildlife Service, Division of Ecological Services. Sacramento, CA.

Orsi, J. J. 1967. Predation study report, 1966-1967. California Department of Fish and Game.

Parker, R. R. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. Journal of Fish Resources Board of Canada 25:757-294.

Peterson, W. T., R. D. Brodeur, and W. G. Pearcy. 1982. Food habits of juvenile salmon in the Oregon coastal zone. Fish Bulletin U.S. 86:173-195.

Pickard, A., A. Baracco, and R. Kano. 1982. Occurrence, abundance, and size of fish at the Roaring River slough intake, Suisun Marsh, California, during the 1980-1981 and the 1981-1982 diversion seasons. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report No. 3, September 1982.

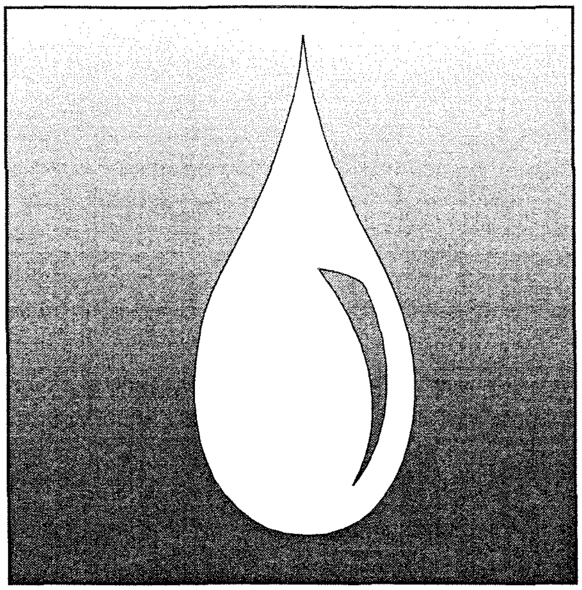
Sanger, G. A. 1972. Fishery potentials and estimated biological productivity of the subarctic Pacific region. In A.Y. Takenouti (ed.), Biological oceanography of the northern Pacific Ocean. Idemitsu Shoten. Tokyo, Japan.

Stevens, D. E. 1961. Food habits of striped bass, *Roccus saxatilis* (Walbaum), in the Vista area of the Sacramento River. Master's thesis. U.C. Berkeley. Berkeley, CA.

Villa, N. S. 1979. Predation of salmonids below Red Bluff Diversion Dam. November 16, 1979 - office memorandum to C. J. Brown. California Department of Fish and Game, Contract Services. Red Bluff, CA.

Vogel, D. A., K. R. Marine, and J. G. Smith. 1988. Fish Passage Action Program for Red Bluff Diversion Dam. Final Report. U.S. Fish and Wildlife Service Report No. FR1-FAO-88-19.

Walters, C. J., R. Hilborn, R. M. Peterman, and M. J. Staley. 1978. Model for examining early ocean limitation of Pacific salmon production. Journal of Fish Resources Board of Canada 35:1303-1315.



INTRODUCTION

Contaminants are inorganic and organic compounds and biological pathogens that introduce the risk of adverse physiological response in humans, plants, fish, and wildlife resources through waterborne or food-chain exposure. Contamination by these compounds may cause acute toxicity and mortality or long-term toxicity and associated detrimental physiological responses, such as reduced growth or reproductive impairment. Contaminant toxicity has been documented in shellfish, fish, mammal, and bird species from the Bay-Delta. The most serious contaminant problems in the Bay-Delta and its mainstem rivers and tributaries come from mine drainage, agricultural drainage, and urban runoff.

ERPP recognizes that water quality in the Delta must be protected and improved for all beneficial uses including municipal and domestic water supply, irrigation, stock watering, contact and noncontact water-related recreation, hydroelectric power generation, industrial service supply, warm and cold freshwater habitat, warmwater and coldwater spawning, fish migration, and wildlife habitats.

Although cause-and-effect relationships between levels of contaminants and the abundance of aquatic resources have not been conclusively documented, ERPP envisions a restored, healthy Bay-Delta ecosystem in which contaminant loads and concentrations are reduced to levels that do not interfere with primary and secondary productivity, nutrient cycling, and foodweb support. Such a restored ecosystem would no longer necessitate human health warnings about consuming fish and wildlife caught in the Bay-Delta estuary.

STRESSOR DESCRIPTION

An estimated 5,000-40,000 tons of contaminants enter the Bay-Delta annually. They are distributed according to complex flow patterns that are heavily influenced by inflow from rivers and the amount of water being pumped from the Delta. Although research confirms that toxicants are affecting lower trophic-level resources to varying degrees in the Bay-Delta, ecosystem- and population-level effects are not well understood. Researchers disagree about the role that contaminants have played in the current poor health of the Bay-Delta.

There are four types of contaminants, inorganic, organic, biological, and toxicity of unknown origin present in the Bay-Delta ecosystem. Inorganic contaminants are substances such as heavy metals, phosphates, and nitrates that enter the Bay-Delta ecosystem primarily in treated municipal wastewater, industrial effluent, agricultural and mine drainage, and urban runoff. Heavy metals in the water column usually occur in trace amounts. They do not break down organically; however, even small amounts of some metals can be toxic. In addition, some metals bioaccumulate within food chains in plant and animal tissue to levels that can be toxic to higher trophic organisms. The heavy metals of greatest concern in mainstem rivers and tributaries of the Bay-Delta are cadmium, copper, mercury, and zinc.

Organic contaminants such as polychlorinated biphenyls (PCBs), plastics, pesticides, fertilizers, solvents, pharmaceuticals, and detergents enter the ecosystem primarily through urban and agricultural runoff. Because they decompose very slowly, some organic contaminants (e.g., DDT and PCBs) remain in the environment for long periods and may accumulate in aquatic foodwebs to levels that are toxic.

Biological pathogens, such as viruses, bacteria, and protozoans that cause disease, enter the system through improperly treated municipal sewage, septic systems, farm and feedlot runoff, recreational boat discharges, and urban runoff. Of particular concern to humans are bacteria that cause cholera, hepatitis, salmonella, and typhoid.

Elements causing toxicity in the Sacramento and San Joaquin river watershed and the Delta have not all bee identified in present evaluations. In approximately half of the toxicity tests conducted in the Sacramento River watershed, the toxicity detected in test species has not been linked to specific chemicals. This is also true for about 30% of the toxic samples collected in the Delta and San Joaquin River watershed.

Since 1986, the Central Valley Regional Water Quality Control Board and the California Department of Fish and Game have been testing the surface waters of the Central Valley for toxicity. Sediment testing has also occurred, but on a much more limited basis. Unknown toxicity is of significant concern because it indicates that there exit agents which are bioavailable and causing toxicity that remain to be identified. Unknown toxicity is also an issue for the Sacramento River Watershed and Delta because it leads to these water bodies not being in compliance with the Narrative Toxicity Objective of the Basin Plan.

Contaminants are present in varying degrees in the water column and sediments of aquatic habitats in all 14 ecological zones of the ERPP study area. Contaminants are suspected or known to adversely affect the sustainability of healthy aquatic foodwebs and interdependent fish and wildlife populations. They also may play a key role in altering the composition of biological resources within affected aquatic and wetland habitats.

In the Sacramento River Basin, acidic drainage water from abandoned mine tailings contribute significant amounts of cadmium, copper, zinc, and mercury to tributaries and mainstem rivers that eventually flow into the Delta. Acute toxicity caused by these trace metals has resulted in fish kills, and long-term exposure is detrimental to growth and impairs reproduction. Of immediate concern is the potential hazard associated with mine drainages just upstream of the spawning area for the endangered winter-run chinook salmon on the Sacramento River. Because of elevated mercury levels, the Bay-Delta, Clear Lake, and Lake Berryessa have consumer advisories for consumption of fish. There are various mercury sources in the Sacramento River watershed including abandoned mines and Coast Range geologic sources.

In the San Joaquin River Basin, selenium leaches into agricultural drainage water during intense irrigation of selenium-rich soils. Selenium has caused reproductive failure in sensitive fish species and developmental deformities in waterfowl and shorebirds. Selenium is also prevalent in the San Francisco Bay, resulting from oil refinery discharges. Loadings of selenium into the Bay-Delta have caused an increase in concentrations of these contaminants in benthic invertebrate, fish, and wildlife populations. Concentrations of some contaminants in water, sediments, and biota of the Bay-Delta estuary are elevated compared with levels at reference sites.

In the Sacramento and San Joaquin River basins, runoff from agricultural crops, pasturelands, and orchards has introduced contaminants into tributaries and mainstem rivers, which ultimately flow into the Delta estuary and Bay. Organophosphate insecticides, such as carbofuran, chlorpyrifos, and diazinon, are present throughout the Central Valley and are dispersed in agricultural and urban runoff. Dormant spray pesticides enter rivers in winter runoff and enter the estuary in concentrations that can be toxic to invertebrates. Although the use of these chemicals has been banned, organochlorine pesticides (e.g., chlordane, DDT, and toxaphene) and organochlorine compounds (e.g., PCBs) persist in the environment. Because they accumulate in living organisms, they can become potent toxicants to fish and wildlife as they move up through the foodweb. Chlorinated pesticides are still being detected in fish and wildlife within the Delta and throughout the world.

Effluents from municipal and industrial sources are common components of mainstem rivers entering the Delta Estuary and Bay. These effluent flows may need to be reduced to restore the health of native fish and wildlife by reducing long-term and acute effects that alter aquatic foodwebs and impair the reproductive potential of these species.

ISSUES AND OPPORTUNITIES

CONTAMINANTS IN THE CENTRAL VALLEY: Researchers frequently discover in bioassays that waters and sediments in various parts of the system are toxic to fish and invertebrates. Although there is only limited evidence connecting these conditions to reductions in abundance, this chronic condition does not seem conducive to long-term restoration. Furthermore, there is an ongoing debate over the long-term consequences to human health of chronic exposure to low concentrations of many organic contaminants. Reducing the impacts of toxic contaminants have been elevated to the status of a specific goal for the ERP.

VISION

The vision for contaminants is to ensure that all waters of mainstem rivers and tributaries entering the Bay-Delta, and all waters of the Bay-Delta, are free of high concentrations of toxic substances. The vision includes preventing, controlling, or reducing damaging levels of high-priority contaminants by remediating mine wastes, minimizing boat discharges and dredging effects, managing flows, restoring habitat, managing watersheds, and supporting existing programs for controlling agricultural and urban point and nonpoint sources.

ERPP recognizes the complexities inherent in defining processes related to toxic substances and biological responses in the Bay-Delta estuary, where processes operate over a wide range of space and time scales and flow regimes. The process of ecosystem restoration would be initiated by implementing actions to prevent, control, and reduce contaminant sources that represent immediate or potential toxicological hazards to ecosystem processes. The following describes actions that would help to achieve the ERPP vision for contaminants.

One goal is to remediate abandoned mines that contribute significant amounts of heavy metals, sediments, acidified water, and other pollutants to tributaries and mainstem rivers, thereby increasing contaminant loading to the Bay-Delta estuary. Water degradation from mine drainage water can be reduced by controlling runoff based on water quality objectives for specific contaminants; regrading, sealing, and reclaiming strip-mined lands by restoring physical habitat; or using biological or chemical inhibitors to reduce acid formation.

If necessary, financial incentives could be provided to farmers who successfully implement practices to reduce contaminant loading in Central Valley waterways. The successful reduction of rice herbicides in the Sacramento River demonstrates that it is possible to successfully control nonpoint-source contaminants through cooperative efforts by farmers and regulators.

Land use conversion for habitat restoration has the potential to help reduce pesticide, herbicide, mineral salt, and trace element loadings. Converting land from agricultural uses to native wetland and upland habitats would reduce the concentrations and loads of contaminants associated with current agricultural uses. Modifying current farming practices in other areas to be more "wildlife friendly" by changing cultivation practices, introducing postharvest flooding, and reducing pesticide and herbicide application rates would also support reductions in contaminants that could affect adjacent aquatic resources.

ERPP also proposes to reduce the concentration of contaminants entering the Bay-Delta and its tributaries by improving drainwater management. Measures could include reusing drainwater, managing groundwater, scheduling releases to the San Joaquin River to coincide with flows sufficiently large to dilute concentration or acquiring dilution flows from willing sellers, installing drainwater evaporation systems, and encouraging on-farm bioremediation using flow-through systems. Potential lands to be evaluated for retirement could include areas where soils drain poorly; overlay shallow, selenium-laden groundwater tables; or are only marginally productive.

Reducing urban and industrial contaminant loading to the Bay-Delta estuary could be accomplished by assisting formation of partnerships between dischargers and regulators. Using this approach, incentives could be provided to encourage improved source control, better urban planning and development, and wastewater recycling projects that reduce contaminants.

Dredging activities should be monitored and practices developed and implemented to reduce the release and resuspension of toxic substances in contaminated sediments and the discharge of contaminated water from dewatering operations. Studies are needed to evaluate opportunities for reuse of dredged material for proposed ERPP and other habitat restoration projects.

Wetlands management should be considered as a possible means to improve water quality by controlling natural, wastewater, and stormwater contaminants. Wetlands can retain contaminants or reduce loadings by converting contaminants through biochemical processes to less-harmful forms; wetlands also stabilize sediments. Without properly managing contaminants, however, wetlands can degrade and subsequently threaten the food chains they support.

Risks of bacterial and viral contamination from domestic wastewater could be reduced by enforcing boat-discharge regulations in the Bay-Delta estuary and tributaries, reducing recreational overuse and building of recreational homes near streams or Delta waterways, and endorsing wastewater reclamation projects.

Point- and nonpoint-source contaminants can be reduced by developing or implementing existing watershed management plans that effectively reduce contaminant loadings affecting ecosystem processes. Management practices that reduce loading include reducing contaminant loading to reservoirs, protecting groundwater, controlling erosion, reclaiming mines, better planning for land use, controlling animal waste, and screening and identifying nonpoint-source contaminants.

Studies are needed to determine if sediments in the Bay-Delta are toxic. Successfully reducing contaminant loadings will require working closely with agencies that have regulatory authority to develop water and sediment quality objectives for contaminants of concern for which none have been set.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The CALFED Water Quality Program goal is to provide good water quality for environmental, agricultural, drinking water, industrial, and recreational beneficial uses. The water quality program includes programmatic actions to reduce water quality degradation for agricultural drainage, urban and industrial runoff, acid mine drainage, wastewater and industrial discharges, and natural sources which affect Bay-Delta water quality.

The geographic scope of the CALFED Water Quality Program is the legally defined Delta. This program is developing a strategy to resolve water quality problems that affect beneficial uses of the estuary. Included in this strategy is the intent to resolve water quality problems for certain species (e.g., anadromous fish) that inhabit the Delta but may be impacted at different life stages by conditions outside the Delta. In resolving the water quality problems of the Delta, CALFED may undertake actions throughout the ERPP Study Area.

Other ongoing water quality and contaminant monitoring programs are administered by the California Department of Water Resources, State Water Resources Control Board and the regional water quality control boards, U.S. Environmental Protection Agency, U.S. Geological Survey, local water districts, and many other local agencies and organizations. Some of these programs have made significant progress in controlling contaminant loading to the Bay-Delta, primarily by controlling point-source discharges from municipal wastewater treatment plants and industrial facilities. Monitoring programs that identify long-term trends in contaminants found in ecosystem biota have helped to guide restoration efforts. Current programs in the Bay-Delta are beginning to focus on assessing the toxic effects on ecosystem processes, identifying transport and fate of toxic substances, and quantifying ecological responses to toxic substances.

Many agency and organizations are concerned with the quality of water in the Central Valley and have implemented or assist in water quality monitoring and remediation programs. The total list is extensive and a few of the major elements follow:

- National Water Quality Assessment Program
- Clean Water Act
- Porter-Cologne Act
- State Water Resources Control Board's D-1485,1978 Water Quality Control Plan, and 1995 Water Quality Control Plan
- Federal Lead and Copper Rule
- California Nonpoint Source Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The presence of contaminants in the Bay-Delta system can adversely impair efforts to restore fish, wildlife, and plant species to a healthy state. The individual species affected vary throughout the system and the adverse effects or presence of contaminants varies as well. For example, juvenile winter-run chinook salmon rearing in the Sacramento River below Keswick Dam can be harmed by heavy metals originating from Iron

Mountain Mine. Lower in the system, all aquatic organisms can be adversely effected after storms by runoff of acute levels of pesticides applied in the late winter and early spring to orchards. Riparian communities can be adversely effected by overspray of herbicides.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

There are four Strategic Objectives that address contaminants.

The first Strategic Objective is to reduce the concentrations and loadings of contaminants in all aquatic environments in the CALFED region.

LONG-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants to levels that do not cause adverse affects on all organisms and ecosystems in the aquatic environment.

SHORT-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants that affect the health of organisms and ecosystems in water and sediments to the extent feasible based on benefits achieved, cost and technological feasibility.

RATIONALE: A wide variety of pesticides including herbicides, fungicides, algicides and other toxic materials enter the aquatic environment of the Bay-Delta from many sources. The number and variety of contaminants entering the rivers and estuary is poorly known, as are their toxic effects, in part because the amounts and kinds are constantly changing. However, there is good reason to think that toxic compounds are having many negative effects on aquatic organisms, both acute and chronic. These same compounds can have effects on human health, so reducing their entry into the aquatic systems should have positive health benefits as well. Reducing concentrations of toxic contaminants in the aquatic environment is not easy because it will require broad changes in land management practices and pest control practices in agricultural and residential areas. It will require reductions in the risk of contamination from pesticide use through reduction in the amount of pesticide applied, and changes in the types of pesticides and methods of application to reduce their ability to contaminate aquatic ecosystems. Changes in industrial practices that result in contaminants being released (e.g., hydrocarbons from oil refineries) will also be required.

STAGE 1 EXPECTATIONS: Strategies and financial incentives will have been developed and implemented that reduce the risk of contamination of toxic materials. Examples include the proper use of pesticides within Integrated Pest Management (IPM) frameworks, proper disposal of unused products and containers, and minimization of the movement of pesticides off-site. The monitoring of contaminants should be substantially increased, both as applied and in the environment to get a better handle on what is going where and on the association of contaminants with declines of aquatic species. Annual goals will have been established for the reduction of concentration of selected contaminants in the environment (e.g., carbofuran, chlorpyrifos, diazinon, hydrocarbons, selenium) and monitoring programs set up to determine success of reduction programs.

The second Strategic Objective for contaminants it to develop regional plans to reduce the effects of non-point source contaminants.

LONG-TERM OBJECTIVE: Implement watershed management plans for all watersheds in the Central Valley in the Delta to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

SHORT-TERM OBJECTIVE: Assist existing programs and encourage new watershed management programs to develop watershed management plans to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

RATIONALE: Contaminants from agricultural, industrial, and urban runoff are potentially major sources of mortality to aquatic organisms and can cause damage to aquatic ecosystems that is often hard to detect and regulate. Therefore, the best approach to the regulation of non-point source contaminants seems to be cooperative watershed plans with built-in incentives for reducing contaminant loadings of waterways. any watershed management programs in the Bay-Delta have been successful and they

STAGE 1 EXPECTATIONS: The CALFED Watershed Management Program will assist existing watershed programs and encourage the formation of new watershed groups in achieving these objectives. Using existing data and analyses, major watersheds in the Central Valley will have been rated or ranked according to the amount they are impaired by contaminants. Plans to reduce contaminant loads in at least 10 watersheds for which such plans do not exist at the present time should be developed an implemented.

The third Strategic Objective for contaminants is to reduce contaminant loads in harvested organisms.

LONG-TERM OBJECTIVE: Reduce contaminant loads in harvested fish, wildlife and invertebrates from the Bay-Delta system so that they are safe for consumption.

SHORT-TERM OBJECTIVE: Identify major sources of contaminants (e.g., heavy metals) in the flesh of harvested fish and invertebrates to see if reduction in sources of contaminants is likely to reduce contaminant loads in fish, wildlife and invertebrates.

RATIONALE: Many resident fish, wildlife and invertebrates contain high levels of heavy metals and other contaminants, resulting in warnings that their consumption may be harmful to human health. Elimination of this contamination in the short run is unlikely, but systematic reduction of sources may eventually make all harvested organisms in the estuary and watershed safe to eat. In some cases, such as mercury, reduction of loads to safe levels may be extremely difficult because of deposits in sediments and through absorption and bioaccumulation, but strategies to reduce concentrations are still needed.

STAGE 1 EXPECTATIONS: Major sources of contaminants in fish will have been identified and drainage-specific plans developed to reduce their entry into the ecosystems.

The fourth Strategic Objective for contaminants is to reduce to acceptable levels the release of oxygen-depleting substances into aquatic systems throughout the CALFED region.

LONG-TERM OBJECTIVE: Eliminate runoff and discharges that contain undesirable concentrations of animal wastes, sewage, and other substances that can deplete oxygen levels in streams and sloughs.

SHORT-TERM OBJECTIVE: Identify major sources of oxygen-depleting substances throughout the CALFED region and develop strategies for their reduction; reduce the aquatic areas regarded as degraded by animal waste, sewage, and other organic substance.

RATIONALE: As a result of the Clean Water Act, Safe Drinking Water Act, Toxic Substance Act, etc., local, regional, State and federal agencies have greatly decreased the amount of contamination of California's waters by sewage, animal wastes, and other substances that deplete oxygen in the water. These organic materials cause rapid eutrophication, resulting in fish kills and dominance by undesirable organisms. Such contamination, although diminished, is still common and needs to be reduced further, especially from agricultural sources. For example, low oxygen levels in the lower San Joaquin River are often a barrier to the movement of salmon and other fish. It is worth noting, however, that release of organic nutrients into aquatic systems is not necessarily always harmful, especially if the nutrients derived from human sources essentially replace those no longer entering the system from natural sources.

Some East Coast estuaries have experienced problems with pathogens that appear to be related to eutrophication and oxygen depletion. Although there are reasons not to expect these problems in the Bay-Delta system, any indication of such problems should elicit a rapid response to investigate and control these problems.

STAGE 1 EXPECTATIONS: Sources or areas of problem releases of oxygen-depleting substances will have been identified and incentive programs developed to reduce the amount of organic contamination coming from agricultural, industrial, and residential areas.

The general target for contaminants is to reduce loading, concentrations, and bioaccumulation in the food chain to levels that do not impair other efforts to restore health to fish, wildlife, and plant populations in the ERPP Study Area.

Agricultural point- and nonpoint-source controls on pesticides, herbicides, mineral salts, and trace elements could be achieved using best management practices such as:

- improving irrigation and tillage techniques,
- placing areal restrictions on pesticide spray and using integrated pest management to reduce pesticide use and consequent discharge to waterways during rainstorms,
- improving fertilizer application technologies,
- altering the amount of time pesticides are present, and
- improving water-use efficiencies.

REFERENCES

Cutter, G.A. 1989. The estuarine behavior of selenium in San Francisco Bay. Estuar., Coast. and Shelf Science 28:13-34.

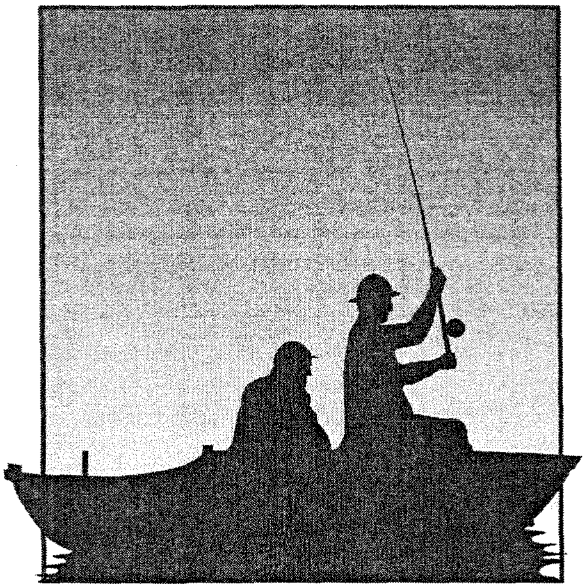
Gunther, A.F., J.A. Davis, D.J.H. Phillips, K.S. Kramer, B.J. Richardson, and P.B. Williams. 1989. Status and trends report on dredging and waterway modification in the San Francisco Estuary. San Francisco Estuary Project.

San Francisco Regional Water Quality Control Board. 1992. Mass emissions reduction strategy for selenium. Staff Report. October 12, 1992. 54 p.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

Varanasi, U., E. Casillas and J. Stein. 1993. Contaminant levels and associated biochemical effects in out migrating juvenile chinook salmon in San Francisco Bay. Final report - Year 1, Envir. Conserv. Div., NW Fisheries Science Center, NMFS, NOAA, Seattle, Wa. 20 pp. + appendices.

◆ FISH AND WILDLIFE HARVEST



INTRODUCTION

Many Central Valley fish and wildlife species whose populations are declining are not harvested commercially or recreationally (e.g., delta smelt). This suggests that underlying problems with ecosystem processes and functions and habitat conditions throughout the Bay-Delta watershed are primary causes of the decline.

For many populations, it is highly likely that harvest restrictions, in the absence of an integrated ecosystem management program, will have little benefit in the long-term sustainability of these species.

Under current harvest levels, harvest is not a stressor limiting populations of waterfowl and upland game in the Bay-Delta. Proposed restoration of wetland and upland habitats is expected to increase resident and wintering waterfowl and upland game populations. However, the Ecosystem Restoration Program Plan (ERPP) anticipates that harvest levels would also increase in response to increased species abundance. Opportunities for increased access for public hunting may also increase as a result of some proposed actions. For example, restoration of wetland and upland habitats would involve acquiring lands through conservation easements or purchase from willing sellers and, depending on the conditions of such agreements, access for hunting may be provided.

Harvest management tools include regulations that control daily and seasonal bag limits, size limits, limits based on sex, gear restrictions, and open and closed harvest seasons based on time or location.

STRESSOR DESCRIPTION

Controlling harvest, in and of itself, is unlikely to restore fish and wildlife populations to a sustainable healthy state. The present harvest management processes are sufficient to protect species and allow population increases by restoring ecological processes that create and maintain habitats. The possible exception is related to chinook salmon and modestly reducing harvest of this species may make a significant contribution to restoring populations to desired levels. ERPP visions for chinook, salmon, steelhead, and striped bass emphasize reactivating or improving ecosystem processes that create and maintain the habitats that support fish and wildlife populations. Conservative harvest strategies during the period when habitats are being restored will accelerate the rebuilding of fish and wildlife populations.

SALMON HARVEST

In addition to applying the principles of traditional harvest management, it is necessary to consider the complexities of the interactions and dependencies between harvest, health of habitat, and the overall productivity of individual salmon populations. Harvest influences salmon productivity by reducing the number of adult fish in the spawning population, the age structure of the spawning population, and the overall fecundity (fertility) of the population because older female fish are generally larger and carry more eggs. In a much broader perspective, harvest management should strive to protect the productive capacity of individual salmon stocks by pursuing the reasonable and essential objective of protecting the genetic diversity of salmon populations upon which production ultimately depends.

Extensive ocean recreational and ocean commercial troll chinook salmon fisheries exist along the California central coast, and an inland recreational fishery exists in the Central Valley. Support of these economic and recreational uses is an important component in the overall effort to restore and maintain ecological health of the Central Valley ecosystem. Elimination of chinook salmon harvest will not restore ecological health to the system. Likewise, restoring ecological processes in the absence of conservative short-term harvest management may not provide for a sufficiently rapid rebuilding of naturally spawning chinook stocks. However, past observations indicate that Central Valley chinook populations have the ability to rapidly increase in size when there are the required riverine habitat conditions and sufficient flows for juvenile rearing and emigration.

Overall chinook salmon harvest rates must be consistent with the ERPP goal of rebuilding important salmon stocks as evaluated using the Cohort Replacement Rate method. Generally, stable chinook populations will exhibit a long-term average cohort replacement rate of 1.0. During rebuilding (which may require 10-15 years), harvest and inland conditions will be improving and rebuilding will require an average replacement rate greater than 2.0 for the less abundant runs such as the winter run and spring run.

One harvest strategy may be to implement a selective ocean fishery for hatchery stocks to reduce the harvest of naturally produced stocks. This would require the mass marking of all hatchery chinook produced at Central Valley hatcheries and perhaps in the Klamath basin, Trinity basin, and southern Oregon. Another, and perhaps more realistic option, may be to consider economic incentives for commercial and charterboat operators, as well as local businesses dependent on fishing to offset negative economic impacts associated with highly restrictive fishing.

Before 1986, harvest rates were estimated at 65-75% (PFMC 1996), which may have been too high to support a sustainable fishery. Beginning in 1986, harvest rates increased coincidently with the closure of the fishery north of Fort Bragg, California. This fishery was closed to meet harvest-sharing obligations on Klamath River stocks to Native American Tribes. This closure shifted the ocean troll fishery south to the Central Valley index area.

Many conservation biologists believe that a harvest rate of about 67% is a sustainable, conservative level for naturally spawning stocks, if quality habitat conditions exist inland. Hatchery-produced stocks can support higher rates, but sustaining high rates in the ocean mixed-stock chinook fishery also requires high harvest of naturally produced stocks.

In 1996, the Pacific Fishery Management Council (PFMC) increased the minimum size limits and decreased season length in both recreational and commercial fisheries. These actions were implemented to reduce the fishery impacts on winter-run chinook salmon by 50%. Reducing harvest is one of several major elements that will contribute in both the short and long term to restoring healthy fish populations, but it will not contribute to restoring health of important ecological processes, functions, and habitat. According to available information, it appears that a sustainable chinook salmon fishery can be maintained if habitat conditions and ecosystem processes are restored throughout the Bay-Delta watershed, and if the ocean harvest index on naturally produced fall-run chinook salmon stocks is reduced by 10% below present levels.

Alternative actions that may support harvest reductions include a selective fishery that targets only externally marked chinook salmon and that releases unmarked fish. Selective fisheries can reduce harvest rates on unmarked fish by as much as 70-80% for gear types with low release and dropoff (shaker) mortality rates. However, the reduced harvest rates can be as little as 10-50% for gear types with high release and dropoff mortality rates. The application and benefits of a selective fishery for the central California coast ocean mixed-stock fishery are unknown. The potential effectiveness of a selective fishery in increasing spawning escapements of unmarked fish depends on the following factors:

- the proportion of a naturally spawning stock that would be harvested by the fishery in the absence of selective regulations,
- the impact of nonselective fisheries that harvest unmarked fish that are released in selective fisheries,
- the degree to which reduction in total abundance caused by mortality resulting from application of tags or other distinguishing marks increases harvest rates in nonselective fisheries that operate under catch quotas or bag limits, and
- the magnitude of harvest rate reductions resulting from the selective fishery.

In addition to considering the potential implementation of a mass marking and selective fishery along the California coast, ERPP is also considering the feasibility of providing economic incentives for commercial and charterboat operators to offset negative economic effects of short-term reduced harvest.

Attainment of the ERPP vision for chinook salmon harvest will rely on actions by the California Fish and Game Commission and PFMC. PFMC and seven other regional councils were created by the Magnuson Fishery Conservation and Management Act in 1976. Their primary role is to develop, monitor, and revise management plans for fisheries conducted within 3 to 200 miles of the United States coast. PFMC develops plans for ocean fisheries off California, Oregon, and Washington.

The ocean salmon fisheries off Washington, Oregon, and California have been managed by the PFMC since 1977 by using Fishery Management Plans (FMP). Since the beginning of the 1985 season, the ocean salmon fishery has been managed by a framework FMP that allows flexibility to adjust annual regulations in response to varying stock abundance.

The framework FMP contains fixed management objectives and goals that guide the PFMC's choice of flexible annual management measures. Within specified limits, PFMC may vary season length, management boundaries, bag limits, gear restrictions, and quotas annually to achieve the fixed objectives of the FMP. Some of the major provisions of the FMP are a description of the salmon stocks comprising the management unit, management objectives, and escapement goals and procedures for determining and allocating ocean harvests and in-season management procedures.

It is important to distinguish ERPP's vision for chinook salmon and the roles and responsibility of other management authorities, particularly PFMC. Although ERPP provides a long-term comprehensive plan to restore the ecosystem health of the Bay-Delta system, the harvest management objectives of PFMC are to:

- establish ocean harvest rates for commercial and recreational fisheries that are consistent with requirements for optimum spawning escapements, treaty obligations, and continuance of established recreational and commercial fisheries within the constraints of meeting conservation and allocation objectives.

- minimize fishery mortalities for those fish not landed from all ocean salmon fisheries as consistent with optimum yield;

- manage and regulate fisheries so the optimum yield encompasses the quantity and value of food produced and the recreational, social, and economic values of the fisheries;

- develop fair and creative approaches to managing fishing effort and evaluate and apply management systems as appropriate to achieve these management objectives;

- achieve long-term coordination with the member states of PFMC, the treaty Native American tribes, and management entities that are responsible for salmon habitat or production in the development of a coastwide salmon management plan;

- manage in a manner consistent with any United States-Canada salmon treaty; and

- support the enhancement of salmon stock abundance in fishing-effort management programs to facilitate a return to economically viable and socially acceptable commercial, recreational, and tribal seasons.

In addition to its management objectives, PFMC has established a set of conservation goals, many of which are consistent with ERPP. In recognizing that maintenance of a healthy resource is necessary to achieve continuing benefits to the nation, PFMC will adhere to the following conservation goals:

- Assume a more aggressive role in protecting and enhancing anadromous and marine fish habitat. PFMC will play a leadership and coordination role to support the agencies having management responsibilities and authorities.

- Manage for viable salmon stocks and maintain genetic diversity. PFMC recognizes that in areas of importance to particular stocks, habitat degradation and water development may leave no alternative but to manage for hatchery production or a combination of hatchery and natural production.

- Strengthen its efforts to work with other jurisdictions, both domestic and international, to manage stocks of fish over their entire range.

- Strongly support development of concepts and practices for managing mixed-stock and multispecies complexes and rebuild those complexes to best meet the economic and allocation objectives of PFMC.

- Support additional data collection and analyses that will improve the basis for management measures.

- Develop management measures that constrain incidental catches of fish and other animals within acceptable limits while target species are being harvested.

STEELHEAD TROUT HARVEST

The harvest of both naturally and hatchery-produced juvenile steelhead takes place throughout the Sacramento basin. Juvenile harvest is not desirable because it reduces the future adult population size, the opportunity for anglers to harvest adult steelhead, and the overall productivity and fecundity of spawning populations.

More restrictive angling regulation may be necessary to protect steelhead from overharvest and still allow anglers the opportunity for continued sport fishing. The following elements might be considered as additional protective measures for steelhead: catch-and-release fishing only, catch-and-release fishing where hooked fish are not removed from the water to decrease handling mortality, size limits to protect either juvenile fish or larger adult spawners, and barbless hooks to reduce latent mortality.

ERPP supports special recognition of the steelhead fishery of the Yuba River as an important wild steelhead fishery. As part of this recognition, regulations should be enacted to protect this valuable stock while allowing controlled angling opportunities that have a minimal adverse effect on the spawning population. ERPP also supports prohibiting the harvest of juvenile steelhead and rainbow trout in the Yuba River while providing anglers with opportunities for catch-and-release fishing for wild steelhead in other streams.

STRIPED BASS HARVEST

Adult striped bass support the most important sport fishery in the Sacramento-San Joaquin estuary, and the condition of this fishery is publicly recognized as a barometer of the status of the estuary and its biological resources. Statewide, more than 400,000 anglers fish for striped bass and most of this effort is directed at the Sacramento-San Joaquin estuary population. Unfortunately, because of the depressed state of the population, the present annual harvest of striped bass from the Sacramento-San Joaquin system is only about 80,000 fish. Recent annual harvest rates have ranged from 9-14%. In the early 1970s, when striped bass were more abundant and more anglers fished, harvest rates of 16-24% led to the harvest of more than 300,000 legal-sized fish annually. Annual harvest may have reached 750,000 fish from the high populations of the early 1960s.

ERPP supports the legal harvest of striped bass because it has not caused the decline in abundance that has occurred since the 1960s and 1970s. At the same time, efforts to curtail illegal harvest (taking undersized fish and catching over limits) should be vigorously continued. The goal of increased legal harvest should be attained by maintaining present angling regulations while increasing the abundance of adult fish. Although angler participation most likely will expand as fishing success increases, it is anticipated that present angling regulations will keep harvest rates at sustainable levels (<20%).

WHITE STURGEON HARVEST

White sturgeon provides for an important recreational fishery in the Bay-Delta. Although, commercial fishing for sturgeon is prohibited in California, historical accounts indicate that commercial fisheries greatly reduced west coast sturgeon populations, including the Sacramento-San Joaquin population, in the late 1800s. As a result, all sturgeon fishing was prohibited in 1917; the fishery was reopened in 1954 to sport angling only. With the exception of 1956 to 1963, when the minimum size limit was raised to 50-inch total length (TL), the sport fishery had the same regulations from its inception until 1989: a year-round season, 40-inch TL minimum size limit and a one-fish-per-day creel limit.

Although fluctuations in legal-sized white sturgeon abundance have been primarily dependent on variable recruitment, historical depletion by the commercial fishery indicates that the population is readily subject to overharvest. Consequently, a 40% increase in the average annual harvest rate from 7% in the 1960s and 1970s to 10% in the 1980s was cause for concern and was the impetus for angling regulation changes in the early 1990s. Starting in 1990, a maximum size limit of 72 inches was instituted and the minimum size limit was increased in 2-inch annual increments until it reached 46 inches in 1992. This slot limit is designed to protect older, more productive fish and younger fish that will be recruited into the spawning population and also to reduce overall harvest.

These angling regulations have achieved their purpose; estimated harvest rates have been <3% in recent years. Therefore, ERPP envisions supporting the present harvest strategy that protects the white sturgeon from overexploitation while providing anglers with a sustainable trophy fishery.

HARVEST OF WILDLIFE

Under current harvest levels, harvest is not a stressor limiting populations of waterfowl and upland game in the Bay-Delta. Because proposed restoration of wetland and upland habitats is expected to increase resident and wintering waterfowl and upland game populations, however, ERPP anticipates that harvest levels would also increase in response to increased species abundance. Opportunities for increased access for public hunting may also increase as a result of some proposed actions. For example, restoration of wetland and upland habitats would involve acquiring lands through conservation easements or purchase from willing sellers and, depending on the conditions of such agreements, access for hunting may be provided.

ILLEGAL HARVEST OF FISH AND WILDLIFE

The illegal harvest of fish and wildlife is known to be a problem throughout the Bay-Delta watershed. It may range from the illegal take of adult spring-run chinook salmon from their oversummering habitats in the upper sections of stream tributary to the Sacramento River, to the illegal take of undersized striped bass in the Delta. Illegal harvest can also be in the nature of a more commercial activity such as using gillnets to catch adult salmon, sturgeon, and striped bass in the Delta for sale and profit.

By its very nature, illegal harvest is difficult to control or eliminate. ERPP envisions that the California Fish and Game Code will be enforced by increasing law enforcement officer staff and that reductions in the illegal take of fish and wildlife could make important contributions in rebuilding depleted stocks. ERPP also envisions that directed enforcement is only one avenue to reduce illegal harvest and that a strong public education program is critical to the success of the enforcement effort.

VISION

The vision for fish and wildlife harvest is to support strategies that maintain a sustainable commercial and recreational chinook salmon fishery in a manner consistent with the recovery; of individual stocks; steelhead trout harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks; the continued legal harvest of striped bass and reduction of illegal harvest; and the present white sturgeon harvest strategy, which protects the species from overexploitation while providing a sustainable trophy fishery.

The vision for salmon harvest is to implement strategies that support and maintain sustainable commercial and recreational fisheries. Achieving this vision would be consistent with ecosystem restoration and recovery of endangered species and species of special concern. ERPP proposes both short-term and long-term strategies for harvesting chinook salmon.

The short-term strategy is to support the rebuilding of chinook salmon stocks to desired levels by reducing harvest of naturally produced fish.

The long-term strategy is to increase chinook salmon populations by restoring important ecosystem processes and reducing or eliminating stressors that cause direct and indirect mortality. In the long-term vision, ERPP anticipates sustainable ocean commercial harvest landings of 750,000 to 1,500,000 chinook salmon and recreational landings of 500,000 to 750,000 per season.

The vision for steelhead trout is to support harvest strategies that fully protect naturally spawning stocks while redirecting harvest to hatchery-produced stocks. This will require a marking program similar to the mass marking program proposed for chinook salmon, except the number of fish to mark would be lower. In this vision, adult steelhead harvest would be directed to steelhead produced at Coleman National Fish Hatchery on Battle Creek, Feather River Hatchery on the Feather River, Nimbus Hatchery on the American River, and Mokelumne River Fish Installation on the Mokelumne River. Harvest of these stocks would also occur on the mainstem of the Sacramento River.

The vision for striped bass harvest is to support artificial production needed to sustain annual recreational harvest of about 20% of the adult population. The vision for striped bass is closely integrated with visions for other ecosystem elements that will contribute to higher survival of resident, estuarine, and anadromous fish. This higher survival will be achieved through extensive habitat restoration, reduction or elimination of stressors, and the reactivation of ecological processes that create and maintain habitats.

The vision for white sturgeon is to support the annual recreational harvest of less than 3% of the adult population which will protect population while providing opportunity for a trophy fishery. The vision for white sturgeon is also closely linked to the visions for Central Valley streamflows, habitat improvement, and the reduction of elimination of stressors that cause direct and indirect mortality to young fish.

The vision for illegal harvest is that increased enforcement efforts and public education will reduce the adverse effects to a level consistent with restoring fish and wildlife populations.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley.

- The Secretary of the Interior is required by the Central Valley Project Improvement Act to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1997).
- The National Marine Fisheries Service is required under the federal Endangered Species Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1997).
- The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988 (Reynolds et al. 1993, McEwan and Jackson 1996).

In addition the Fish and Game Commission adopts regulations for the harvest of fish and wildlife, sets seasons, bag limits, closed areas, gear restrictions and a variety of other tools to control the harvest of fish and wildlife species. The Pacific Fishery Management Council annually sets harvest regulations for the areas along the Pacific Coast south of British Columbia.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

One of the most important components of the ERPP is restoring health to fish populations in the ERPP Study Area. Some of these species, such as winter-run chinook salmon, are State or federally listed endangered species. Others species, such as splittail and steelhead, are species of concern, and spring-run chinook salmon is designated a monitored species by the Fish and Game Commission. Overall health of fish and wildlife species is closely linked to the health of ecological processes that create and maintain habitats needed by these species. Improving the ecological functions will also improve habitat. Concurrently, a reduction or elimination of stressors will contribute to improved functions, habitats, and species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic Objective for harvest of fish and wildlife is to regulate harvest to the extent necessary to avoid impairing the reproductive capacity of the populations in relation to available habitats.

LONG-TERM OBJECTIVE: Efforts by CALFED will need to be integrated into the Pacific Fishery Management Council (PFMC) and the National Marine Fishery Service (NMFS) objectives to manage chinook salmon species with-in and adjacent-to the California coast with regards to harvest limits and regulations. Other anadromous species like the white sturgeon and striped bass will need to meet the long-term goals established in the CVPIA and DFG's Anadromous Fish Restoration Plan for their respective species. Maintain self-sustaining populations of native wildlife so that opportunities exist for viewing and hunting throughout the ERPP study area.

SHORT-TERM OBJECTIVE: Areas within the Sacramento-San Joaquin Estuary and watershed will be evaluated to determine extent of illegal harvest and exploitation rates for all gamefish and terrestrial species that reside within the ERPP Study area. This information will then be used to develop and refine current management plans and restoration efforts.

RATIONALE: Many of the fishing limits established in the ocean off the coast of California are regulated by the U.S. Department of Commerce under recommendations from the PFMC. Changes or alteration to these regulations would be implemented through the PFMC meetings under the Magneson Act. The level of illegal harvest is not well known for all species of aquatic species throughout California. In addition, the exploitation/harvest rate for many of the popular game species (white sturgeon, striped bass, largemouth bass, and white catfish) is documented.

The general target is to control harvest in a manner which contributes to attainment of fish population goals established by State and federal legislation and in a manner consistent with restoration of ecosystem health.

Actions which will contribute to this vision include:

- Adaptive management and focused research programs to mark hatchery produced chinook salmon to provide harvest and return data to better manage harvest.
- Reduce ocean harvest rates to 40-50%.
- Mark all hatchery produced steelhead and evaluate the benefits of implementing a

selective fishery which targets only marked fish.

- Provide special recognition to the Yuba River as an important wild steelhead fishery.
- Augment the striped bass population and recreational fishery by artificial production.
- Maintain the existing regulations for the white sturgeon trophy fishery.
- Increase enforcement efforts directed at illegal harvest.
- Develop a public education program designed to reduce the illegal harvest of fish and wildlife in the ERPP Study Area.

REFERENCES

McEwan, D. And T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game. 234 p.

NMFS 1997. NMFS proposed recovery plan for the Sacramento River winter-run chinook salmon. National Marine Fisheries Service, August 1997.

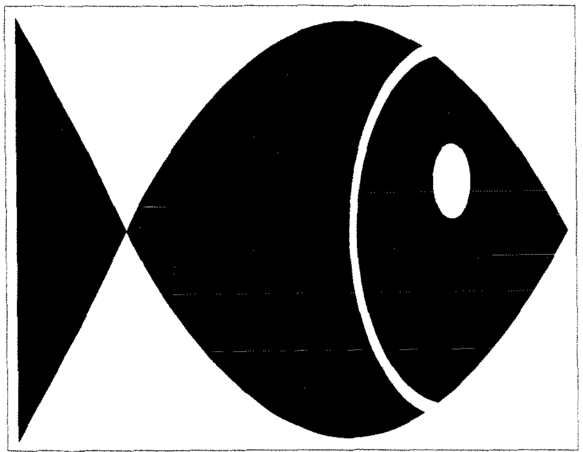
PFMC 1978. Final environmental impact statement/fishery management plan for commercial and recreational salmon fisheries of the coasts of Washington, Oregon and California commencing in 1978. Pacific Fishery Management Council. 1978.

PFMC 1 996. Review of the 1995 ocean salmon fisheries. Pacific Fishery Management Council. February 1996.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

USFWS 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997, 112 p.

◆ ARTIFICIAL FISH PROPAGATION



INTRODUCTION

The Ecosystem Restoration Program Plan (ERPP) recognizes that artificial propagation of fish has been an important tool used by salmon managers in the Central Valley for over a century. The intended goal of hatchery operation has consistently been for mitigation—typically for the non-retrievable loss of valuable migration, holding, spawning, rearing, and emigration habitats that were cut off by large dams throughout the Central Valley.

Hatchery production makes a significant contribution to commercial and sport fisheries as well as their role in providing mitigation for loss of habitats from the construction of large dams. ERPP envisions the integration of an effective management program of existing or new hatchery facilities with harvest and population management strategies that will work together to restore and sustain the health of fish species dependent on the Bay-Delta. In addition, the artificial propagation of striped bass would be an interim measure to provide for the maintenance of a healthy population and valuable sustainable sport fishery until such time that striped bass are capable of sustaining naturally spawning population levels present in the late 1960s and early 1970s (approximately three million adults).

STRESSOR DESCRIPTION

Five hatcheries currently produce chinook salmon in the Central Valley. The three largest hatcheries (Coleman, Feather River, and Nimbus) are in the Sacramento River Basin (see table), and the Mokelumne and Merced River hatcheries are in the San Joaquin Basin. Most of these salmon hatcheries were constructed between 1940 and 1970 as mitigation for specific dams and water projects, and are funded by mitigation agreements with State, federal, and public agencies and monies collected from commercial salmon fishers.

Before 1967, Nimbus and Coleman were the only hatcheries with substantial production rates, but between 1967 and 1991, total Central Valley salmon production nearly doubled. Central Valley hatcheries now produce an annual average of nearly 33 million juvenile fall-run chinook, more than one million juvenile spring-run chinook, about 0.6 million juvenile late-fall-run chinook, and more than 2.5 million juvenile steelhead.

Releasing large numbers of hatchery fish, however, can pose a threat to wild chinook stocks. Potential consequences include genetic impacts on wild fish (e.g., outbreeding and inbreeding), competition for food and other resources between wild and hatchery fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). Potential impacts to native gene pools must be evaluated in light of evidence for genetic changes in hatchery stocks (e.g., random genetic drift, selection, stock transfers, and straying), which can determine the nature and magnitude of interactions between hatchery and wild fish.

There is little evidence with which to evaluate past and current genetic impacts of Central Valley salmonid hatchery programs on the naturally spawning chinook salmon and steelhead

Central Valley Salmon and Steelhead Production Hatcheries and the Average Annual Production of Chinook Salmon and Steelhead

		Average Annual Production				
		Chinook Salmon Stock				
Facility[1] and Period of Record	Location	Fall	Spring	Late-Fall	Winter	Steelhead
Feather River Hatchery (1968-1993)	Feather River	7,434,000	1,219,000[2]	N.P.[3]	N.P.	751,000
Nimbus Hatchery (1965-1993)	American River	8,810,000	N.P.	N.P.	N.P.	767,000
Mokelumne River Hatchery (1965-1993)	Mokelumne River	946,000	N.P.	N.P.	N.P.	161,000
Merced River Hatchery (1970-1993)	Merced River	579,000	N.P.	N.P.	N.P.	N.P.
Coleman National Fish Hatchery (1940-1993)	Battle Creek[4]	14,941,000	N.P.	639,000	26,000	814,000
Sum of average statewide production		32,710,000	1,219,000	639,000	26,000	2,493,000

[1] All facilities are operated by the California Department of Fish and Game, except that Coleman National Fish Hatchery is operated by the U.S. Fish and Wildlife Service.

[2] Spring-run chinook propagated at Feather River Hatchery are believed to have interbred with fall-run chinook.

[3] N.P. = not produced.

[4] Battle Creek is a tributary of the Sacramento River.

populations. Bartley and Gall (1990), using protein electrophoresis, found that populations of chinook salmon from Central Valley hatcheries were genetically similar to wild populations and speculated that the releasing hatchery fish in the Delta may have resulted in abnormally high straying and gene flow to native stocks. However, the great genetic similarity among all Central Valley chinook populations makes it difficult to detect genetic impacts from hatchery releases. An alternative hypothesis that cannot be disproved with present data is that Central Valley hatchery stocks have diverged little from their wild ancestors, in which case the near-term genetic impacts of hatchery programs might be minimal. DNA studies may shed light on this problem (Nielsen et al. 1994).

The general literature on the genetic impacts of artificial propagation programs on Pacific salmonids suggests that Central Valley hatcheries could have serious, direct and indirect, negative effects on the naturally spawning chinook salmon and steelhead. Straying hatchery fish, for example, is a major cause of hybridization between hatchery and wild fish (Waples 1991).

Although straying, primarily among neighboring streams, is a natural phenomenon, hatchery fish have been documented to stray farther and at a higher rate than wild fish. In the Central Valley, two hatchery practices in particular might contribute to elevated straying levels: trucking smolts and yearlings to distant sites for release and transferring eggs and young fish between hatcheries. These are both practiced at Feather River and Nimbus hatcheries.

Increased production and survival of hatchery chinook salmon have resulted in increasing contributions of hatchery fish to adult spawning escapements since 1967. When hatcheries are successful at producing adult fish, the potential harvest rate may become very high. Fewer adults are needed to maintain a hatchery run because of high survival from eggs to smolts under hatchery conditions. This plants high percentages of returning hatchery fish to be harvested while still sustaining the hatchery run. As harvest rates are raised to match the potential productivity of hatchery stocks, wild stocks may become overfished.

Current harvest rates of Central Valley chinook salmon stocks are high enough to adversely affect the natural production in some rivers and adversely affect naturally produced chinook salmon stocks. Accurate quantification of the Central Valley hatchery contribution to the ocean catch of chinook salmon has not been developed because of the lack of a consistent hatchery marking program in the Central Valley. Nonetheless, Dettman and Kelley (1987) estimated that from 1978 through 1984, an average of 11% of ocean catches off California comprised Feather River hatchery fish, and an average of 13% comprised American River hatchery fish. The percentage of annual contributions of hatchery fish to escapement in recent years has been estimated as follows:

- for the Feather River, 26% average for 1975-1987 (Cramer 1990) and 78% average for 1975-1984 (Dettman and Kelley 1987);
- for the American River, 29% average for 1975-1987 (Cramer 1990) and 86.6% average for 1975-1984 (Dettman and Kelley 1987);
- for the middle Sacramento River, 40% average for 1975-1987 (Cramer 1990); and
- for the upper Sacramento River, 41% average for 1975-1988 (Cramer 1990).

VISION

The vision for the artificial propagation of fish is to modify existing hatcheries and hatchery practices in ways to augment salmon and steelhead populations without having detrimental effects on naturally spawning populations of salmon and steelhead.

The existing level of reliance on artificially produced fish in the Central Valley is clear evidence that there are great deficiencies in the existing ecosystem processes that create and maintain habitat for anadromous fish. Extensive restoration activities will be required to shift the balance back to naturally produced fish populations.

The vision for the artificial propagation of fish is closely linked to ERPP visions for harvest, chinook salmon, steelhead trout, and striped bass. Cumulatively, these visions present a robust integration of production, harvest, and restoration targets and actions that will contribute substantially to restoring and maintaining a healthy ecosystem and healthy populations of valuable sport and commercial fisheries.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Three major programs to restore chinook salmon and steelhead populations exist within the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (Public Law 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal Endangered Species Act to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species. NMFS released this document in August 1997 (NMFS 1997). In August 1996, NMFS published a proposed rule to list tem Evolutionarily Significant Units west coast steelhead at threatened or endangered under the ESA. Included in this proposed rule was a proposal to list the Central Valley stock of steelhead as endangered. NMFS subsequently deferred list the Central Valley steelhead stock for six month due to scientific disagreement about the status of the stock.

The California Department of Fish and Game is required under State legislation (The Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon and steelhead trout that were present in the Central Valley in 1988 (Reynolds et al. 1993, McEwan and Jackson 1996).

Linkage with Other Ecosystem Elements

One of the most important components of the ERPP is restoring health to fish populations in the ERPP Study Area. Some of these species, such as delta smelt and winter-run chinook salmon, are State or federally listed endangered species while others, such as splittail and steelhead, are species of concern. Artificial production programs in the ERPP Study Area need to be consistent with the principles of maintaining genetic diversity of natural stocks. These programs also need to be adaptive and implement operations to limit hatchery and wild fish interactions to reduce competition, predation, and the potential spread of diseases.

Strategic Objective, Targets, and Programmatic Actions

Two Strategic Objectives address artificial fish propagation.

The first Strategic Objective is to alter practices to augment chinook salmon and steelhead populations by the entire state, federal, and private hatchery system in light of CALFED goals.

Long-term Objective: Develop a hatchery system and hatchery practices that truly augment salmon and steelhead populations without having detrimental effects on wild populations of salmon.

Short-term Objective: Evaluate closely all salmon and steelhead hatcheries and hatchery practices in the CALFED region to determine their effects on wild populations of salmon and steelhead. Take the first steps to change these practices if needed. Construct, where needed, additional artificial production capacity to augment salmon and steelhead using hatchery operation plans that avoid impacts to wild stocks and retain stock genetic integrity.

Rationale: The hatchery system in the Central Valley for salmon and steelhead was developed with the best of intentions, to maintain the fishery for these species that would otherwise be lost or severely depleted as the result of dams and diversions blocking access to spawning habitat. Hatcheries have generally succeeded by maintaining the commercial and sport fishery for chinook salmon, particularly fall-run chinook salmon. Regardless of the hatcheries, there has been a continued decline of other runs of salmon, of wild runs of fall-run chinook, and of native steelhead stocks. Salmon and steelhead originating from hatcheries may actually have aggravated this problem by interacting with wild fish and may have resulted in elevated harvest levels on those other runs of salmon and on wild fall-run in fisheries. A major emphasis of the CALFED ERP is to restore wild runs of salmon and steelhead by improving habitat conditions for them and by augmenting flows in spawning streams. The role that hatcheries, whether state, federal, or private (non-profit) can play in this recovery is uncertain. Recent strategies have focused on hatcheries that simply augment runs under poor hydrologic conditions when under pre-water development conditions a rivers system would have supported a much larger run. For severely depleted stocks hatchery rearing can provide a temporary insurance policy against extinction due to major natural and unnatural events. For more abundant stocks, however, hatcheries producing large numbers of salmon have the potential to confuse and contravene natural means. The role of hatcheries on every run of salmon and steelhead needs to be carefully evaluated to determine if and how hatchery practices should be changed.

STAGE 1 EXPECTATIONS: The role of every hatchery in the Central Valley in restoring salmon should be evaluated by an independent panel of experts. Where information is lacking, research programs should be conducted. Artificial propagation of salmon smolts of the San Joaquin basin as a research tool for designing and operating an augmentation hatchery that uses methods that do not conflict with restoring Central Valley salmon and steelhead. San Joaquin Basin artificial propagation will be providing needed juvenile salmon fry and smolts critical for adaptive management experiments on the San Joaquin River

The second Strategic Objective is to change the role of trout hatchery and planting programs to make them more compatible with CALFED goals.

LONG-TERM OBJECTIVE: Make sure that trout hatcheries and their associated planting programs do not interfere with or negate ERP actions.

SHORT-TERM OBJECTIVE: Evaluate the trout hatchery and stocking program in California to determine its impact on populations of wild trout and other fish.

RATIONALE: State, federal, and private, have long attempted to satisfy angler demands for catchable trout by rearing domesticated fish for planting in streams, reservoirs, and lakes. There is little question that these planting programs are successful in providing angling for many people, especially in reservoirs and tailwaters of reservoirs. However, in some streams angling for domestic trout may put artificially high pressure on wild stocks of trout and steelhead or planting of domestic trout may introduce diseases to which other trout (and other organisms, including native frogs) are not immune. In some alpine lakes, regular plantings of trout are endangered native frog populations. There is thus a need to closely evaluate all trout stocking programs that take place in the CALFED area to make sure they are compatible with the CALFED goals.

STAGE 1 EXPECTATIONS: A team of experts should be appointed to formally evaluate all aspects of the state and federal trout hatchery programs and issue recommendations in 1-2 years.

The general targets for the artificial production of fish are:

- propagation programs would be managed consistent with rehabilitation of chinook salmon and steelhead stocks and the conservation of ecological and genetic values;

- propagation programs would adopt a goal of maintaining the genetic diversity that exists between and within hatchery and naturally spawning populations;

- all artificially propagated fish should receive identifiable marks; and

- decision making about the uses of hatcheries and artificially propagated fish should occur within the context of a fully implemented adaptive management program that focuses on restoration of ecological processes and habitats, not simply the number and quality of fish successfully propagated.

REFERENCES

Bartley, D. M., and G. A. E. Gall. 1990. Genetic structure and gene flow in chinook salmon populations of California. Transactions of the American Fisheries Society 119:55-71.

Cramer, S. P. 1990. Contribution of Sacramento Basin hatcheries to ocean catch and river escapement of fall chinook salmon. S. P. Cramer & Associates. Corvallis, OR. Prepared for the California Department of Water Resources.

Dettman, D. H., and D. W. Kelley. 1987. The role of Feather and Nimbus salmon and steelhead hatcheries and natural reproduction in supporting fall-run chinook salmon populations in the Sacramento River Basin. State Water Resources Control Board Hearings Document 8-4/561. July. Sacramento, CA.

McEwan, D. And T.A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game. 234 p.

Nielsen, J. L., D. Tupper, and W. K. Thomas. 1994. Mitochondrial DNA polymorphism in unique runs of chinook salmon (*Oncorhynchus tshawytscha*) from the Sacramento-San Joaquin River Basin. Conservation Biology 8(3):882-884.

NMFS 1997. NMFS proposed recovery plan for the Sacramento River winter-run chinook salmon. National Marine Fisheries Service, August 1997.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. 189 p.

Strategic Plan for Ecosystem Restoration. 1999. Appendix to the CALFED Bay-Delta Program Environmental Impact Statement /Environmental Impact Report. June 1999.

USFWS 1997. Revised draft anadromous fish restoration plan: a plan to increase the natural production of anadromous fish in the Central Valley of California. U. S. Fish and Wildlife Service, May 30, 1997, 112 p.

Waples, R. S. 1991. Pacific salmon, Oncorhynchus spp., and the definition of "species" under the Endangered Species Act. Marine Fisheries Review 53:11-22.

INTRODUCTION

Stranding of juvenile and adult fish is a natural part of a healthy Central Valley ecosystem. Trapped fish provided a valuable source of protein and nutrients to several levels of the food chain, including mammals, avian predators and native peoples. Although stranding causes individual mortality, these losses historically would have been offset by strong in-channel production of the survivors. Stranding of fish in intermittent streams or floodplain areas represented part of the cost of maintaining a broad range, genetic diversity and access to potentially higher quality rearing habitat

Although stranding was historically a natural event, today it is generally considered a stressor that contributes to the loss of important aquatic resources including adults and juveniles of important fishes. Anthropogenic changes to the valley and its tributaries have led to unnatural topography such as borrow ponds, which can trap large numbers of fish. Similarly, multiple stressors have led to declines in native fish populations, resulting in lower production to offset stranding losses. Efforts to reduce excessive stranding losses represent an important component in improving the natural production of Central Valley fish communities. Resolution of stranding in the Central Valley will require additional research and monitoring to better understand the scope of the problem and to identify key areas where stranding is a serious problem, and the implementation of experiments to refine restoration opportunities.

STRESSOR DESCRIPTION

Stranding appears to be of primary concern for migratory species such as chinook salmon, steelhead trout, sturgeon and splittail. This stressor is much less of an issue for nonnative game fish species such as largemouth and smallmouth bass, which frequently thrive in isolated ponds. Important mechanisms for stranding include: 1) stranding of adults and juveniles on bypass floodplains; 2) stranding of natal and non-natal juveniles within floodplains confined by setback levees; 3) stranding of salmonid redds as a result of flow fluctuation in river channels; and 4) stranding of migratory and resident species from Delta levee breaches.

FLOODPLAIN STRANDING ON BYPASSES

The region's largest floodplains are the Yolo and Sacramento bypasses, representing an integral parts the Sacramento Valley Flood Control System. Stranding principally occurs in wetter years, when fish mortality occurs as a result of predation, high temperature, dessication and perhaps disease or reduced oxygen levels. The Sacramento River, however, has overflowed into the Sutter Bypass every year since 1945, except during the 1977 drought, thus providing significant risk of fish mortality. Stranding is a problem in many drier years as well because weirs spill beginning at Sacramento River flows of only 30,000 cfs. The issue has been best-studied in the Yolo Bypass, a 59,000 acre engineered floodplain. Studies by California Department of Water Resources (1997, 1998a) showed that at least 40 species of fish use the basin during high flow events. Many of these fish are stranded when floodwaters recede. Notable examples of stranded juvenile fish include chinook salmon (fall-run, spring-run and winter-run size classes), steelhead trout, Sacramento splittail and Sacramento pikeminnow. Most of the same species are also present in the Sutter Bypass.

California Department of Water Resources (1997) identified three types of ponds in the Yolo Bypass where stranding occurs: 1) isolated ponds; 2) ponds that maintain some connection to the Delta; and 3) very shallow ponds, typically a few inches of water between row crops. Based on seining surveys and interpretation of aerial photographs, they provided a "ballpark" 1998 stranding estimate for the Yolo Bypass of 300,000-2 million juvenile salmon, depending on pond type. While this represents a substantial number of fish, results from 1998 sampling suggest that majority of young salmon successfully emigrate from the floodplain (California Department of Water Resources 1998a). Generally, emigration from certain types of overflow areas is relatively good because the land has been graded by farmers to drain properly. A contributing factor to the successful emigration is that Central Valley fish populations are probably adapted to take advantage of flood cycles. For example, there is evidence that growth of young salmon in the Yolo Bypass is superior to growth in the Sacramento River as a result of an abundant food supply and warmer water temperatures. Further evaluations are need, however, to determine if sampling bias affects the apparent higher growth rate. For example, when the bypass overflow stops, no additional fish are recruited into the bypass. Comparison of average size of stranded fish versus Sacramento River fish may be biased as there is continual recruitment of fish of all sizes, small and large, in the Sacramento River

This type of floodplain rearing may have been an integral part of the life history strategy for fall-run chinook and perhaps other salmon races. Additional evidence of the growth potential of bypass/floodplain areas was provided by the 1995-96 spring-run chinook salmon tagging study on upper Butte Creek (Hill 1996). Spring-run chinook fry tagged near Chico during January 1996 exhibited significant growth by the time they were recaptured downstream in the Sutter Bypass during March and April.

Recent studies (Maslin 1997 and 1998, Moore 1997) have demonstrated widespread non-natal use by juvenile salmonids of small upper Sacramento River tributaries, often finding fish several miles up the tributary from the river. Entry to these non-natal areas often occurs as the result of floodplain inundation with stranding occurring after flow recession and after low tributary flows sever the interconnectivity with the river. Preliminary results suggest that up to 10,000 winter-run chinook salmon were rearing in Mud Creek, a small tributary that joins Big Chico Creek near the Sacramento River (Maslin 1998). Such non-natal rearing was identified in 19 other small tributaries to the upper Sacramento River between Redding and Chico.

The California Department of Fish and Game has periodically rescued stranded adult chinook salmon in the ponded areas below the Tisdale, Colusa, and Moulton weirs. The magnitude of this stranding is not known as there is no consistent effort to identify stranding, and only easily accessible ponded areas are included in any rescue attempts. During April 1995, the California Department of Fish and Game rescued 74 adult spring-run chinook salmon from a pond located below the Moulton Weir (Meyer 1995).

Five overflow and recession events from the Sacramento River into the Sutter Bypass occurred between January 6 and May 15, 1995, thus providing significant opportunities for stranding. During that period, more that 50% of the entire upper Sacramento River flow was diverted through the Sutter Bypass. Stranding caused by the overflow weirs along the Sacramento River has not been systematically investigated. This source of stranding may be significant.

Additional areas where stranding needs further evaluation include managed and unmanaged wetlands, Liberty Island, Providence Island, lower Feather River floodplain, American basin, and many canals and ditches that have no connection to the rivers after overflow events.

California Department of Water Resources (1997 and unpublished data) note several locations in the Yolo Bypass where stranding rates could be reduced using relatively simple techniques. One example is Sacramento Weir, where leaky flashboards divert fish from the Sacramento River onto the Sacramento Bypass ponds, resulting in stranding rates approximately an order of magnitude higher than any other Yolo Bypass location. Similarly, adult spring run salmon, striped bass and sturgeon are stranded in deeper ponds and channels in part as a result of an outdated, inefficient fish ladder located at Fremont Weir, the upstream limit of the Yolo Bypass. Although the magnitude of this problem has not been documented, the fact that there is a popular sport fishery after the Yolo Bypass recedes suggests that fairly large numbers of adults are stranded. Both the Sacramento and Fremont Weir problems could be fixed or at least improved with fairly minor structural changes.

Stranding of Young Fish Within Floodplains Confined by Set Back Levees

Juvenile and adult fish are also stranded in floodplains adjacent to river channels. For the major rivers of the Central Valley, these floodplains are confined by set back levees. Examples include the Feather, Yuba, American, Mokelumne, Stanislaus and Tuolumne rivers. Fish stranded in these areas a subject to similar sources of mortality as for the bypasses. The level of stranding dependents on fish population levels, topography and the timing and magnitude of flow fluctuation.

In the Feather River, California Department of Water Resources (1998b) studied the effects of a relatively minor winter flow reduction (less than 10 percent) on stranding rates. They concluded that the relatively small numbers of salmon were stranded in depressions on gravel bars below Thermalito Afterbay Outlet were not biologically significant. The low stranding rates were consistent with instream flow model results, which predicted only minor ponding from the flow change. California Department of Fish and Game (1991) used similar instream flow methods for the Mokelumne River and that minor flow fluctuations resulted in little stranding area provided that discharge levels remained above 400 cfs.

Major flow fluctuations distribute fish over a much broader area, frequently exposing them to more variable topography and longer migration path to return to the channel. Whereas minor flow fluctuations occur in all water year types, large scale flow changes are most common in above normal to wet years. In contrast to the low numbers of salmon found in January 1998 in the Feather River below Thermalito Afterbay Outlet following a minor flow fluctuation, in April 1998 Jones and Stokes Associates (unpublished data) found thousands of young salmon in shallow ponds on a broad, downstream floodplain located near Nelson Slough following major flood releases in the Feather River. Fish trapped in these types of ponds may thrive if later flow pulses provide an escape route.

Stranding mortality rates are probably highest in gravel pits, borrow ponds, and spoil deposition areas. Large scale aggregate mining has been conducted for decades in Valley rivers such as the Feather, Tuolumne and Stanislaus rivers. Aggregate mines historically extracted sand and gravel from both the river channel and its adjacent floodplain. Older mines were usually created directly in the channel, creating large depressions. Some remain within the active channels of rivers such as the Tuolumne River. Both in-channel and floodplain ponds can become connected to the main channel during high flow events. These pits support warmwater predators such as largemouth and smallmouth bass that prey on juvenile salmon that migrate through the pits and become trapped after floodwaters recede. Similarly, gold mining activities resulted in dredging and deposition of tailings, converting large areas of floodplain habitat to variegated landscapes with sloughs and borrow ponds that trap migrating salmon and other fish during periods of high water.

Adult Stranding in River Channels

In the Central Valley, steelhead trout and most races of chinook salmon spawn in late summer or autumn. If flows are reduced substantially during the next three months, redds may be isolated, resulting in egg mortality from low oxygen levels or dessication. Although many Central Valley rivers have streamflow fluctuation requirements during critical periods for salmon, unusual spawning events may put fish at risk. For example, in 1991 flow fluctuations from water transfers on the Yuba River led to the stranding or isolation of hundreds of fall-run adult salmon which spawned much earlier than expected.

Stranding of Migratory and Resident Species from Delta Levee Breaches

Delta islands regularly breach in very wet years as a result of land subsidence and antiquated levees. Breaches essentially create a large-scale diversion that can draw thousands of acre-feet of water and fish onto Delta islands. Levees are generally repaired while or after the islands are emptied. During drainage fish are either stranded or pass through hazardous pumps. The magnitude of this problem has not been quantified, however accounts of extensive fish stranding during the 1996 draining of Prospect Island following a levee breach suggest that mortality can be substantial. This type of stranding is also a problem in Feather, American, and Cosumnes floodplains as well as in the Natomas Cross Channel, north of Sacramento.

Vision

The vision for stranding is to reduce the magnitude of the number of aquatic organisms lost when rivers recede or overflow into flood bypasses and to reconnect areas that become isolated with flowing water and to reduce the frequency by which low-lying areas are inundated. The vision includes improving the structure of channels and floodplains and stabilizing flows during critical periods. Achieving this vision would help to maintain or restore riparian and floodplain habitat and sustain streamflow levels that would improve fish spawning, rearing and emigration.

For bypass floodplains, the strategy is to improve drainage to allow young fish to emigrate and to modify weirs that strand juvenile fish or create passage problems for adults after floodwaters recede. Options to achieve this would be through the construction of year-round low flow channels for drainage and fish passage and the construction of fish ladders to permit upstream passage of adult fish. The focus for these actions would be the Yolo and Sutter bypasses, including the overflow weirs and bypasses which connect them to the river and which comprise the Sacramento Valley's engineered floodplains. In riparian and floodplain areas between river channels and set back levees, restoration activities would emphasize recontouring of poorly-drained areas heavily impacted by historical mining activities. Where possible, gravel and borrow ponds that connect to the main channel during high water periods would be removed or filled. Many borrow ponds provide good habitat during much of the year for a variety of aquatic dependent species and the preferred means to reduce stranding losses is to create and maintain connections with the rivers and streams. Alternatively, levees would be improved or constructed to keep these ponds separated from the active channel. In addition, flows in the smaller non-natal tributaries should be maintained as much as possible to allow positive avenues of escape for rearing juveniles. Stranding of adult spawners and their redds could be avoided by reducing flow fluctuations during critical time periods. Stranding losses from Delta levee breaks would be reduced through levee improvements or conversion of flood-prone islands to tidal wetlands and shallow water habitat.

Integration with Other Restoration Programs

Efforts to reduce stranding will involve the cooperation and support of established programs underway to restore habitat and fish populations in the basin:

- The Central Valley Project Improvement Act (CVPIA) calls for doubling of the anadromous fish populations (including striped bass, salmon, steelhead, sturgeon and American shad) by 2002 through changes in flow, project facilities and operations. The program involves actions that may reduce stranding rates through habitat or flow improvements.

- The California Department of Fish and Game is required under State Legislation (The Salmon, Steelhead, Trout and Anadromous Fisheries Program Act of 1988) to restore numbers of anadromous fish in the Central Valley.

- The Four Pumps and Tracy Fish Mitigation Agreements. These two agreements involve mitigation in the Sacramento and San Joaquin basins to offset fish losses at the SWP and CVP pumping plants. Restoration projects in these programs frequently deal directly or indirectly with fish stranding issues.

Linkage with Other Ecosystem Elements

Reducing stranding is linked to restoration of riparian, floodplain and riverine aquatic habitats and creation of set back levees. Population effects of stranding losses will be mitigated by efforts to reduce stressors to resident and migratory fish. For example, reducing levels of invasive aquatic organisms, reducing predation and competition, gravel restoration, screening of water diversions and reducing levels of toxins should help to improve fish population levels to offset unavoidable stranding losses.

Strategic Objective, Targets, and Programmatic Actions

The Strategic Objective for stranding is to create conditions that reduce or eliminate the stranding and loss of aquatic resources.

LONG-TERM OBJECTIVE: Implement a comprehensive program to reduce stranding effects in the Delta and its tributary streams.

SHORT-TERM OBJECTIVE: Reduce the adverse effects of stranding by physical modifications to problem areas and, where feasible, implementation of flow schedules that minimize adult stranding.

RATIONALE: Recontouring of floodplains including removing or isolating borrow ponds should promote successful emigration of fish following high water events and create valuable rearing habitat at the river margins. Improving at bypass weirs would eliminate diversion of fish onto floodplain ponds by leaky flashboards and provide for adult upstream passage. Reducing flow fluctuations during spawning periods would help to avoid losses of adults and eggs. Stranding losses from Delta levee breaks would be reduced through levee improvements or conversion of flood-prone islands to tidal wetlands and shallow water habitat.

STAGE 1 EXPECTATION: Actions which can contribute to this vision for bypass floodplains include:

- Improving drainage to allow young fish to emigrate. For example, check boxes could be installed in fields with low levees that border the drains for the Yolo and Sutter bypasses.
- Modifying Sacramento Weir to eliminate leakage through flashboards.
- Constructing a fish ladder at Fremont Weir and provide permanent flow to facilitate adult upstream passage.
- Constructing of a permanent low flow channel through the Yolo Bypass to improve adult passage and drainage following flow events.
- Constructing permanent low flow channels through the Moulton and Colusa bypasses.
- Investigating the potential to develop permanent low flow channels connecting the M&T, 3-B's, and Goose Lake overflow structures with Butte Creek and the Sutter Bypass.
- Developing maintenance flows to provide extended interconnectivity of upper Sacramento River non-natal rearing tributaries.

Actions which can contribute to this vision for floodplains within setback levees include:

- Recontouring heavily corrugated landscapes to improve drainage to the river channel.
- Filling gravel and borrow ponds that connect to the main channel during high water periods or, preferably, creating connectors to allow fish to migrate from ponds into the river.
- for large ponds that are uneconomical to fill, constructing or improving levees to isolate these areas from the active river channel.

Actions which can contribute to this vision for adult spawning include:

- reducing flow fluctuations during critical time periods for adult spawning and egg incubation.

Actions which can contribute to this vision for Delta islands include:

- improving levees to reduce the probability of breakage.
- converting flood-prone islands to tidal wetlands and shallow water habitat.

REFERENCES

California Department of Fish and Game, 1991. Lower Mokelumne River Fisheries Management Plan. November 1991. 239 pp.

California Department of Fish and Game. 1995. Spring-run chinook salmon rescue from Moulton Weir Pond, April 20-21. Memo: California Department of Fish and Game, Region II, Rancho Cordova, California. May 8, 1995.

California Department of Fish and Game. 1996. Butte Creek Life History Study, summary prepared for the U.S. Fish and Wildlife Service, by the California Department of Fish and Game, Region II, Rancho Cordova, California. August 6, 1996.

California Department of Water Resources 1997. Results of 1997 Yolo Bypass studies. Prepared for Department of Fish and Game by Department of Water Resources Environmental Services Office.

California Department of Water Resources 1998a. Preliminary results of 1998 Yolo Bypass studies. Prepared for National Marine Fisheries Service by Department of Water Resources Environmental Services Office, September 1998. 55 pp.

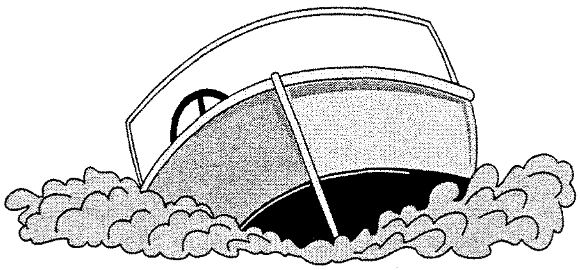
California Department of Water Resources 1998b, Feather River Juvenile Monitoring: December 15, 1997-January 15, 1998. Report to the Federal Energy Regulatory Commission by California Department of Water Resources, Environmental Services Office. February 1998.

Maslin, P., M. Lennox, J. Kindopp, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River chinook salmon. Funded through a grant from the U.S. Fish and Wildlife Service under provisions of the Central Valley Project Improvement Act. 89 pp.

_________. 1998. Draft: Intermittent streams as rearing habitat for Sacramento River chinook salmon. Funded through a grant from the U.S. Fish and Wildlife Service under provisions of the Central Valley Project Improvement Act. 40 pp.

Moore. 1997. Condition and feeding of chinook salmon in selected intermittent tributaries of the upper Sacramento River. Spring 1997. 66 pp.

USFWS and Turlock Irrigation District. 1998. Tiered Environmental Assessment and Initial Study/Mitigated Negative Declaration. Tuolumne Mining Reach and Special Pools 9/10 Restoration and Mitigation Projects. May 15, 1998. 98 pp plus attachments.



INTRODUCTION

Disturbance resulting from human activities can adversely affect habitat for a substantial variety of fish, wildlife, and plant communities including many special-status species and plant communities listed as endangered or threatened on the California and federal Endangered Species Acts (ESAs) lists. The types of disturbance include those associated with recreational boating, angling and picnicking, airplane and vehicle traffic, and the secondary effects of residential development adjacent to wildlife habitat

The Ecosystem Restoration Program Plan (ERPP) proposes to reduce disturbance where species, such as the Swainson's hawk, nest. Establishing habitat buffers around sensitive habitat or wildlife use areas (e.g., Swainson's hawk nest sites) screens wildlife from disturbance associated with motor vehicle traffic and reduces recreation-related disturbance while still allowing for careful wildlife observation activities.

Carefully designing recreational access points can also reduce the level of disturbance on wildlife (e.g., locating access points to avoid impacts to levees and to keep trespassing and vandalism of private lands to a minimum).

The vision includes providing opportunities for recreational boating in a manner that reduces the impacts of those activities on fish and wildlife. This could be achieved by improving recreational boating opportunities in selected areas of the Delta for both motorized and non-motorized craft while reducing or eliminating boating by closing sensitive biological areas during specific seasons.

STRESSOR DESCRIPTION

Recreational boating is a popular activity in the ERPP study area, particularly in the Sacramento-San Joaquin Delta and Suisun Marsh/North San Francisco Bay Ecological Management Zones. Boating activities include the use of small, human-powered craft, such as canoes and kayaks, and individual motorized craft such as jet skis, sail boats, boats ranging from small fishing skiffs to ski boats, and larger pleasure craft. Wind surfing is also expanding in popularity. Excessive, unrestricted boating activities can result in increased erosion of adjacent channel banks, increased turbidity, and conflicts with other boat operators using the same channels.

Angling and picnicking are also popular activities. Unrestricted human entry for these and other activities has contributed to levee degradation in the Delta, littering, and wildfires and can increase the likelihood of trespass and vandalism on private lands.

Vehicle traffic close to wildlife habitat reduces the value of that habitat to wildlife, particularly to species such as the greater sandhill crane. Aircraft traffic (both fixed-wing and helicopter) associated with the application of agricultural chemicals can also contribute to the disturbance of wildlife in the Delta.

Disturbance associated with the pets of people who live near wildlife habitat can result in harassment of wildlife, particularly ground-nesting birds.

VISION

The vision for disturbance is to reduce the adverse effects of boating and other recreational activities, temporary habitat disturbances, and other human activities on wildlife and their habitats in the Bay-Delta.

ERPP's general approach to achieving the vision for this stressor will be to ensure that the location of restored habitat takes into account adjacent land uses, that adequate buffer areas to protect against disturbance are used, and that recreational activities are managed to avoid or minimize conflicts with fish and wildlife habitat. Recreationists should be provided with adequate facilities in areas that are not sensitive to fish and wildlife and where trespass onto adjacent private lands can be avoided.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Agencies charged with regulating activities within their respective jurisdictions include the U.S. Coast Guard, California Department of Boating and Waterways, California Department of Parks and Recreation, local park districts such as the East Bay Municipal Parks District, local sheriffs in the affected counties, California Department of Fish and Game, California Department of Water Resources, and U.S. Fish and Wildlife Service.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

Human caused disturbance adversely affects habitats and species. Boat wake shoreline erosion can impair ERPP efforts to protect and restore shoreline vegetation and shallow water emergent vegetation, particularly in the Delta and along the mainstem Sacramento and San Joaquin Rivers. Human presence can also disturb populations of special status fish, wildlife, and plant species.

STRATEGIC OBJECTIVE, TARGETS, AND PROGRAMMATIC ACTIONS

The Strategic 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.

LONG-TERM OBJECTIVE: Eliminate or greatly reduce the adverse influence of human-induced disturbance on important fish and wildlife species by controlling access during critical times.

SHORT-TERM OBJECTIVE: Evaluate the location of public use access sites to identify potential site that may adversely influence fish and wildlife populations and identify alternative sites for public access that will reduce human-wildlife interactions.

RATIONALE: Some of the species that are known to be adversely influenced by human-induced disturbance include Swainson's hawk, California black rail, California clapper rail, greater sandhill crane, and spring-run chinook salmon. Restoration elements for these example species are strongly directed at restoring or improving habitat for nesting or spawning, forage, loafing, and other habitats required for successful completion of their life cycles. These species are particularly susceptible to disturbance during critical segments of their life cycle, especially those related to reproduction such as nesting and spawning. Reducing human disturbance is an integral component to restoring these and similar species.

STAGE 1 EXPECTATIONS: Surveys will have been completed that identify critical areas and critical times for fully protecting species that are vulnerable to human-induced disturbance. This information will have been used in refining and implementing restoration actions and in identifying sites that can be developed for recreational and public uses.

The following approaches would help achieve this vision:

- Cooperate with agencies responsible for managing the State's recreational activities to ensure properly sized and sited facilities will be provided and maintained.

- Cooperate with the Department of Boating and Waterways, U.S. Coast Guard, and local mariner organizations to identify the need and feasibility of, and implement where feasible, seasonal boating closures in sensitive wildlife use areas while maintaining alternative boating opportunities.