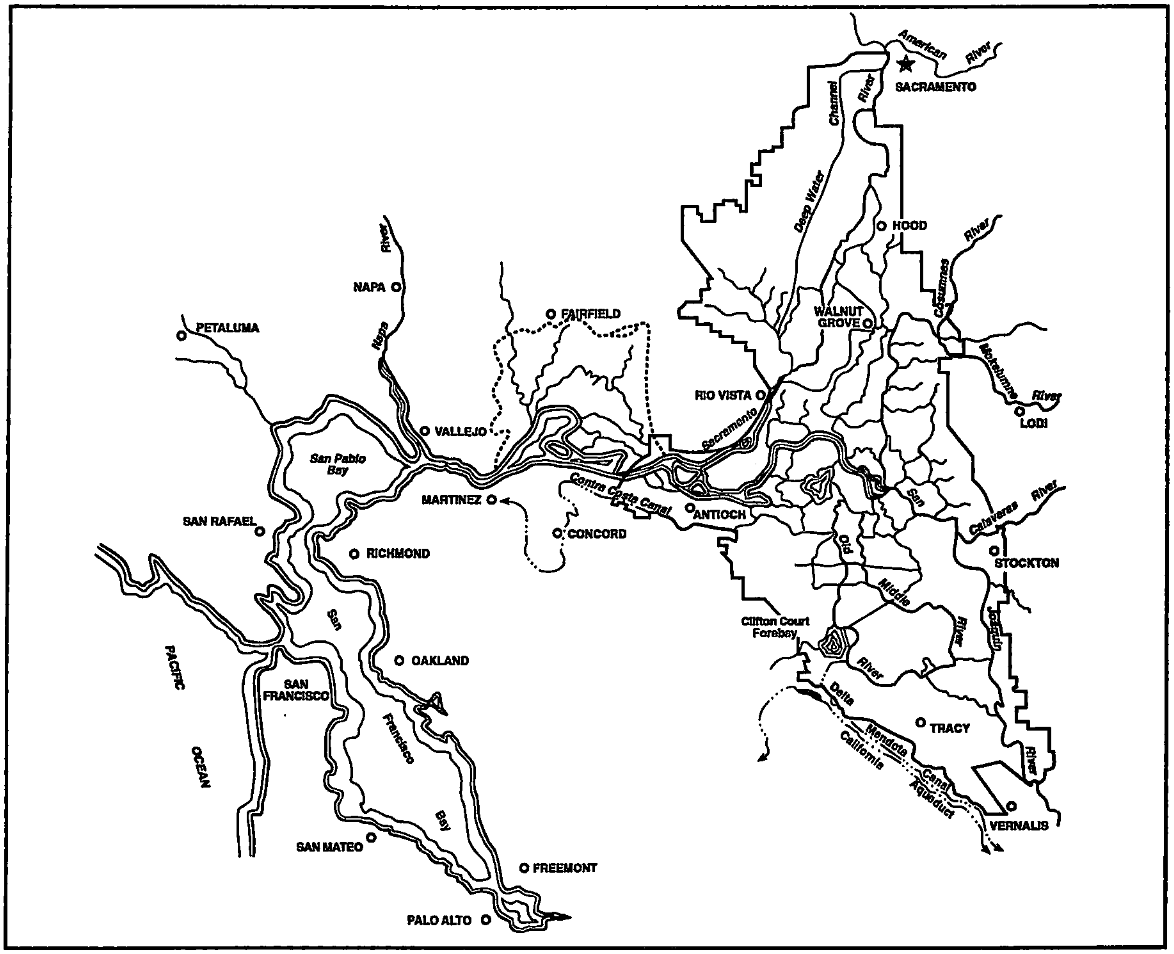

ENVIRONMENTAL REPORT

APPENDIX 1
to
Water Quality Control Plan
for the
San Francisco Bay/Sacramento-San Joaquin
Delta Estuary

95-1WR
MAY 1995

STATE WATER RESOURCES CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

STATE OF CALIFORNIA
Pete Wilson, Governor

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μ/l	micrograms per liter
U.S.C.	United States Code
X2	2 parts per thousand salinity measured near the bottom of the water column
YOY	young-of-the-year

LIST OF ACRONYMS AND AGENCIES

ACID	Anderson-Cottonwood Irrigation District
ACWA	Association of California Water Agencies
BDOC	Bay-Delta Oversight Council
CCWD	Contra Costa Water District
CEQA	California Environmental Quality Act
CMSP	Caswell Memorial State Park
CNPS	California Native Plant Society
COA	Coordinated Operation Agreement
CRBSCF	Colorado River Basin Salinity Control Forum
CUWA	California Urban Water Agencies
CVAPM	Central Valley Agricultural Production Model
CVP	Central Valley Project
CVP-OCAP	Long-term Central Valley Project Operations Criteria and Plan
CVPIA	Central Valley Project Improvement Act
DFA	California Department of Food and Agriculture
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DWR	California Department of Water Resources
DWRSIM	Department of Water Resources Simulation Model
EIR	Environmental Impact Report
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
GCID	Glenn-Colusa Irrigation District
IEP	Interagency Ecological Program
JWU	Joint Water Users
LADWP	Los Angeles Department of Water and Power
MWD	Metropolitan Water District of Southern California
NHI	Natural Heritage Institute
NMFS	National Marine Fisheries Service
PFMC	Pacific Marine Fisheries Commission
PG&E	Pacific Gas and Electric Company
PPD	Pollutant Policy Document
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SCE	Southern California Edison
SCS	U.S. Soil Conservation Service
SCVWD	Santa Clara Valley Water District

SDCWA	San Diego County Water Authority
SDWA	South Delta Water Agency
SFEP	San Francisco Estuary Project
SJRI	San Joaquin River Salmon Index
SJVDP	San Joaquin Valley Drainage Program
SJWYI	San Joaquin Water Year Index
SMPA	Suisun Preservation Agreement
SMPA-DEF	Suisun Marsh Preservation Agreement deficiency standard
SRCD	Suisun Resource Conservation District
SRI	Sacramento River Salmon Index
SWC	State Water Contractors
SWP	State Water Project
SWRCB	State Water Resources Control Board
USBR	U.S. Bureau of Reclamation
USCOE	U.S. Army Corps of Engineer
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Act
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WACO	Water Advisory Committee of Orange County
WAPA	Western Area Power Administration
WESCO	Western Ecological Services Company

CHAPTER I. INTRODUCTION

There is a critical need to divert water within and export water from the watershed of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Estuary, Bay-Delta, or Estuary). Millions of people rely upon the water originating within this watershed for municipal, industrial and agricultural purposes.

Significant declines in populations of fish and wildlife living in or migrating through the Bay-Delta Estuary (Figure I-1) have been clearly established in the recent past. These declines are due to many causes, some of which are within the regulatory authority of the State Water Resources Control Board (SWRCB).

The SWRCB is reviewing for adequacy the fish and wildlife objectives of the 1991 Water Quality Control Plan for Salinity for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (1991 Bay-Delta Plan) and the previously unmodified fish and wildlife objectives in the 1978 Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (1978 Delta Plan). California Water Code section 13240 requires that water quality control plans adopted by the SWRCB must be periodically reviewed and may be revised. In addition, section 303(c) of the federal Clean Water Act requires that water quality standards[1] adopted to fulfill requirements in the Clean Water Act be reviewed at least every three years.

The SWRCB's intent in this review of the 1991 Bay-Delta Plan is to review all of the factors that have contributed to the decline of fish and wildlife resources in the Bay-Delta Estuary. Objectives will be considered for the factors that have both contributed to the decline of fish and wildlife uses and are within the regulatory control of the SWRCB. Recommendations will be made to other agencies for action on the factors that lie within their regulatory control and have also contributed to the decline.

The SWRCB will not review objectives established for the protection of municipal, industrial and agricultural uses during this review process. These objectives are adequate to protect the designated uses.

A. PURPOSE OF REPORT

The purpose of this report is to document the SWRCB's analysis of the needs for and effects of new water quality objectives for the protection of fish and wildlife in the Bay-Delta Estuary adopted in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.

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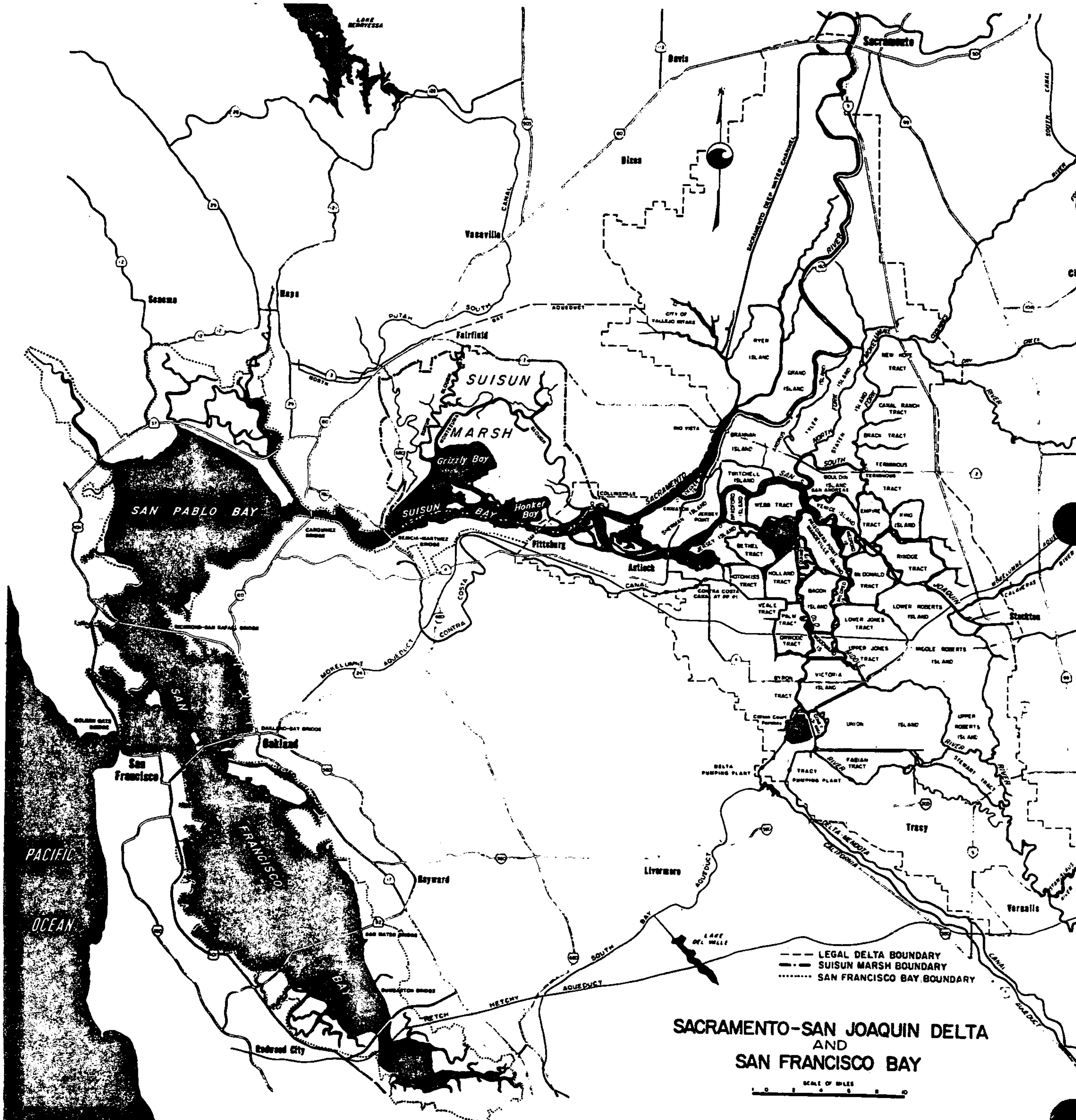
[1] The term"standard" is used variably in this document to mean, depending on the context, a standard under the federal Clean Water Act as defined at 33 U. S. C. section 1313(c)(2)(A); a water quality objective adopted under the California Water Code section 13000 et seq.; or a term, condition, or other requirement in a water right order or decision.

Figure I-1. BAY-DELTA ESTUARY



The SWRCB must comply with the requirements of the California Environmental Quality Act (CEQA) when amending a water quality control plan. CEQA requires that discretionary actions by State agencies undergo an environmental review, but CEQA also provides that a program of a State regulatory agency is exempt from the requirements for preparing Environmental Impact Reports (EIRs), Negative Declarations, and Initial Studies if certified by the Secretary of the Resources Agency as meeting the criteria in Public Resources Code section 21080.5. The SWRCB program to establish and amend water quality control plans has received this certification and is a substitute for the CEQA process (14 Cal. Code Regs. § 15251(g)). Therefore, this report, although not an EIR, fulfills the requirements of CEQA to analyze the environmental effects of a proposed regulatory activity and its alternatives.

The SWRCB must also comply with section 13241 of the Porter-Cologne Act when developing and adopting new water quality objectives. This section requires that the SWRCB consider at least the following factors in establishing water quality objectives: (1) past, present, and probable future beneficial uses of water; (2) environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto; (3) water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area; (4) economic considerations; (5) the need for developing housing within the region; and (6) the need to develop and use recycled water. All of these factors are considered in this report.

B. BACKGROUND

The background discussion is divided into three parts: institutional setting, history of SWRCB action, and legal authority.

1. Institutional Setting

a. SWRCB. The SWRCB was formed in 1967 when the State Water Rights Board and the State Water Quality Control Board were merged by the Legislature, based on the realization that decisions affecting water quality and water rights are inseparable. The SWRCB is composed of five full-time appointees of the Governor. Under its dual legal authority, the SWRCB allocates rights to the use of surface water and, together with the nine Regional Water Quality Control Boards (RWQCBs), protects water quality in all waters of the State.

The Porter-Cologne Act is the basic water quality control law for California, and it is administered by the SWRCB and the RWQCBs (Wat. Code §§ 13000 et seq). The SWRCB and the RWQCBs also implement portions of the federal Clean Water Act. One of the principal functions of the SWRCB and the RWQCBs is to prepare water quality control plans. Water quality control plans are blueprints for water quality control. The plans identify beneficial uses of waters, water quality objectives for the reasonable protection of beneficial uses, and programs of implementation for the water quality objectives. The objectives are not merely directory, but are standards that must be implemented. In most cases, water quality objectives contained in a water quality control plan are not directly enforceable. In order to ensure their implementation, water quality objectives usually are implemented through waste discharge requirements or water right permits.

The SWRCB and the RWQCBs have adopted water quality control plans that cover all areas of the State. There are two types of water quality control plans: water quality control plans adopted by the SWRCB and regional water quality control plans adopted by the RWQCBs. Water quality control plans adopted by the SWRCB supersede any regional water quality control plans for the same waters to the extent that there is any conflict. The 1991 Bay-Delta Plan is an example of a statewide plan.

The portions of the water quality control plans that fall under the jurisdiction of the federal Clean Water Act require approval by the U.S. Environmental Protection Agency (USEPA). When approved by the USEPA, the water quality objectives and beneficial use designations become water quality standards under the federal Clean Water Act.

The SWRCB is also charged with administering the State's water right system. Rights to take surface water in California include appropriative and riparian water rights. The SWRCB has authority to amend an existing water right by invoking either: (1) its reserved jurisdiction over certain permits under Water Code section 1394; (2) its continuing authority to prevent waste and unreasonable use, or unreasonable method of use, or diversion of water under the California Constitution, Article X, section 2; or (3) its continuing authority to protect public trust uses of water.

The principal authority the SWRCB used in the past to implement Bay-Delta Plans was its water rights authority because the problems addressed in these plans were largely related to salinity intrusion and entrainment in the export pumps. The only feasible options available to control these problems are to increase upstream fresh water flows and reduce export pump rates. Both of these measures require changes in water rights.

b. Water Right Holders. California has established a water right system which allows for the orderly allocation and use of its water supply. California law recognizes two primary rights to divert water: riparian water rights and appropriative water rights.

A riparian right exists by reason of ownership of land abutting a stream or other body of water. The right allows a water user to divert from the natural flow of a stream. Storage is not allowed under a riparian right. Riparian rights are correlative. If there is insufficient water for the reasonable requirements of all the riparian users, they must share the available supply. With certain limited exceptions, riparian water users have first priority to the use of the natural flow in a river. Water remaining after riparian users have taken their share is available to appropriators. No application or license is necessary to divert water under claim of riparian right; however, a record of water use under riparian claim should be established by filing a Statement of Water Diversion and Use with the SWRCB.

Appropriative water rights fall into two general categories: pre-1914 appropriative water rights and post-1914 appropriative water rights. Prior to 1872, appropriative water rights could be acquired by simply taking and beneficially using water. The priority of the right was the first substantial act leading toward putting the water to beneficial use, provided the appropriation was completed with reasonable diligence; otherwise, priority of the right did not attach until beneficial use of the water commenced. In 1872, sections 1410 through 1422 of the California Civil Code were enacted. These sections established provisions for determining a priority of right by posting a notice of appropriation at the proposed point of diversion and recording a copy of the notice with the County Recorder. If these procedures were not followed, the pre-1914 appropriative right did not attach until water was beneficially used. No application or license is necessary to divert water under claim of pre-1914 appropriative right; however, a record of water use under claim of pre-1914 appropriative right should be established by filing a Statement of Water Diversion and Use with the SWRCB.

Since 1914, appropriative rights have been obtained by receiving a permit or license from the SWRCB or its predecessor agencies. All new appropriators must file an application with the SWRCB and obtain a permit before diverting water. In granting permits, the SWRCB determines whether the water will be put to beneficial use, how much water may be taken, when and where it can be taken, and necessary conditions to protect the environment, the public trust and prior rights. If the water is diverted and applied to beneficial use in accordance with the terms of the permit for a period of years, a license may be issued confirming the extent of the permittee's right.

The largest water right holders in the Central Valley are the Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation (USBR), and the State Water Project (SWP), operated by the Department of Water Resources (DWR). The watershed protection and area of origin statutes (Water Code sections 11460 and 10505 et seq.) accord first priority to water rights for use within the watershed. The CVP and SWP water rights are subject to these provisions, and diversions for export by these projects are restricted until the needs in the watershed, including protections for beneficial uses in the Estuary, are met. At present, these two water right holders are responsible, pursuant to Water Right Decision 1485 (D-1485), for meeting all of the regulatory requirements in the 1978 Delta Plan.

c. CVP. During the 1920's the State's political leaders recognized a need for large scale water resources development for flood protection and water supply. The Legislature, in 1921, authorized a statewide water resources investigation. The resulting plan was called the State Water Plan, and in 1933 the State legislature passed the California Central Valley Project Act to implement the plan. The Act provided financing through issuance of $170 million in revenue bonds. The project was subjected to a referendum and won voters' approval, but California could not obtain funds to begin construction because the nationwide depression of the 1930's made the revenue bonds unmarketable. In 1935, federal authorization and financing were arranged, and the federal government has operated and maintained the CVP as a federal project since its construction. The early federal authorization provided that the dams and reservoirs "shall be used, first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses; and, third, for power". A description of the principal features of the CVP is presented in Chapter IV (Environmental Setting).

The CVP supplies water to agricultural contractors, municipal and industrial contractors, and wildlife refuges, either through long-term contracts or on interim bases. The USBR has established the firm yield of the northern CVP to be about 8.3 million acre-feet (MAF) per year. This calculation of firm yield assumes a year 2020 projected level of watershed development, D-1485 regulatory standards, hydrology equivalent to the critically dry period of May 1928 through October 1934, and coordinated operation with the SWP, as set forth in the Coordinated Operation Agreement (COA).

The CVP operates under water rights granted by the SWRCB and its predecessors. Many of the CVP water rights came from applications filed by the State in 1927 and 1938 in furtherance of the California Water Plan. After the federal government undertook to build the CVP, some of those applications were transferred to the USBR. Applications were made by the USBR for the additional rights necessary for the project.

In granting water rights, the SWRCB places conditions in the permits to protect prior rights, fish and wildlife, and other matters it deems to be in the public interest. Conditions requiring minimum flow below CVP dams are contained in these permits. The water right permits also specify periods of the year during which water may be directly diverted and periods when water may be placed into storage at CVP facilities. Direct diversion and re-diversion of storage are permitted year round at diversion points in the Sacramento River and in the Delta. D-1485 sets salinity and outflow requirements and limits mean monthly CVP water diversion at the Tracy Pumping Plant to a pumping rate of 3,000 cubic feet per second (cfs) in May and June. In other months pumping can take place at 4600 cfs, the capacity of the Tracy Pumping Plant.

The most recent federal legislation affecting the CVP is the Central Valley Project Improvement Act (CVPIA), which was adopted in 1992. The CVPIA expanded the purpose of the CVP to include mitigation, protection, and restoration of fish and wildlife, and it set aside 800 thousand acre-feet (TAF) of CVP yield for this purpose. Additional water was also allocated to augment Trinity River flows and refuge water supplies.

d. SWP. California experienced rapid growth in its industrial and urban areas during the 1940's. In response to this increased demand for water, the State updated its water planning studies from the 1920's and 1930's in order to identify the water resources of the State, estimate ultimate water demand, and plan for water resources development. In the 1950's, the State summarized its findings in a series of reports leading up to Bulletin 3, The California Water Plan. The plan served to guide the planning and construction of facilities needed to manage the State's water resources. The plan identified areas of water surplus, projected areas of water deficit, and recommended methods to distribute the water. The

SWP was authorized by the Burns-Porter Act in 1959 to implement portions of the plan. Construction of the initial SWP facilities was made possible by the passage of the California Water Resources Development Bond Act of 1960. The initial major facilities of the SWP were constructed by 1973. A description of the principal features of the SWP is presented in Chapter IV (Environmental Setting).

DWR has contracts with 29 public agencies to deliver up to 4.2 MAF of SWP water. These agencies in turn supply water to more than two-thirds of the State's population and to thousands of acres of land used for irrigated agriculture. In addition to these contractual obligations for water supply, the SWP provides salinity control in the Delta. Recreation, fish and wildlife enhancement, and flood control are also SWP authorized purposes.

Almost half the SWP supply originates in the upper watershed of the Feather River Basin. The remaining supply is comprised of excess flows in the Delta. The water supply capability of the SWP depends on probabilities of rainfall and snowpack, pumping capacity from the Delta, and legal constraints on project operations. The current SWP dependable supply developed by existing facilities is calculated to be about 2.3 MAF per year during the critically dry period, assuming D-1485 regulatory conditions and coordinated operations with the CVP, as set forth in the COA. With the SWP only partially complete and the rate of population growth increasing, project contractors are now requesting more water than the existing system can dependably supply.

Much like the CVP, the SWP operates, in part, under water right applications approved by the SWRCB and its predecessors and filed by the State in 1927 and 1938 in furtherance of the California Water Plan. Applications were made by the DWR for the additional rights necessary for the project. The most recent water right decision applicable to the SWP, D-1485, sets salinity and outflow requirements and limits mean monthly SWP water diversion at the Banks Pumping Plant to a pumping rate of 3,000 cfs in May and June and 4,600 cfs in July. As set out by a letter of agreement between the DWR and the Department of Fish and Game (DFG), the diversion is additionally restricted in May and June to 2,000 cfs when stored water must be released from Oroville Dam to meet water demands. In other months, diversion rates into Clifton Court Forebay are constrained by U.S. Army Corps of Engineers (USCOE) Public Notice 5820A, as amended. Under the USCOE Public Notice, the maximum diversion rate into Clifton Court Forebay is 6,680 cfs over a three day average except from December 15 to March 15 when the SWP can increase diversions by one-third of the San Joaquin River flow at Vernalis when the flow exceeds 1,000 cfs.

e. COA. The CVP and the SWP simultaneously use the same channels of the Sacramento River and the Delta to convey water, drawing upon a common water supply in the Delta. The purpose of the COA is to assure that each project obtains its share of water from the Delta and bears its share of obligations to protect other beneficial uses of water in the Delta and the Sacramento Valley. Coordinated operation can increase the efficiency of both projects.

On May 20, 1985, both agencies agreed to a COA designed to increase the efficient use of existing water supplies by defining a sharing process for the SWP and the CVP to meet in-basin use and exports. The sharing formula provides for a CVP/SWP proportionate split of 75/25 responsibility for meeting in-basin use from stored water releases and 55/45 for capture and export of excess flow.

The agreement also requires both DWR and USBR to meet a set of protective criteria for flow standards, water quality standards, and export restrictions taken from D-1485. The projects are not to be operated to meet predetermined yields, but rather to first meet the needs in the areas of origin, including the protective criteria. Only then is water exported from the Delta. During normal water supply conditions, the flow and water quality standards require about 5 MAF of Delta outflow.

2. History of SWRCB Action

Summarized below are water quality control plans and water right decisions adopted by the SWRCB or its predecessor agency dealing with management of the Bay-Delta Estuary.

a. Decision 990. The State Water Rights Board opened hearings on September 15, 1959 to consider longstanding USBR applications for water rights in the Bay-Delta watershed. Decision 990 was issued on February 9, 1961. In this decision, the State Water Rights Board approved CVP water rights for Shasta Dam, Tehama-Colusa Canal, Corning Canal, Delta-Mendota Canal and Contra Costa Canal. The permits were conditioned to prohibit export through the Delta-Mendota or Contra Costa canals by direct diversion unless in-basin demands were satisfied.

Decision 990 discussed CVP responsibility to either bypass natural flow or release storage water for Bay-Delta water quality. There was, in 1961, no impending shortage of water for the performance of that function, so the State Water Rights Board refrained from attaching specific water quality requirements to the permits. It did, however, reserve jurisdiction to impose such requirements in the future.

The State Water Rights Board urged the USBR, the DWR and the Sacramento Basin and Delta water users to negotiate an agreement for water supply by which water users would reimburse the USBR for benefits received. The USBR signed contracts with the Sacramento River water users in 1964, but negotiations between the USBR and the Delta water users did not result in a contract.

b. Decision 1275. Decision 1275, issued on May 31, 1967, provided the DWR with the water right permits necessary for operation of the SWP. In this decision, the State Water Rights Board was once again confronted with the question of how the permits should be conditioned to protect water rights in the Delta. Although the State Water Rights Board believed that sufficient information to establish permanent water quality standards was lacking, it did find that interim water quality standards for protection of agricultural productivity could be adopted. The development of comprehensive water quality standards for the Delta began with the adoption of these standards, referred to as the November 19th criteria. The November 19th criteria were developed in 1965 by representatives of the Sacramento River and Delta Water Association, the San Joaquin Water Rights Committee, the DWR, and the USBR. Decision 1275 also determined that water was not available to the SWP for diversion from the Feather River or the Delta in July, August and September.

c. Decision 1291. The DWR petitioned the State Water Rights Board to reconsider Decision 1275 because the DWR believed water was available for diversion in July, August and September. Upon reviewing the evidence, the State Water Rights Board, on November 30, 1967, granted the DWR a year-round diversion season but stated that water would not always be available to satisfy the permits. On December 29, 1967, the Contra Costa Water Agency and Jersey Island Reclamation District No. 830 filed suit against the SWRCB, newly created by the amalgamation of the State Water Rights Board and the State Water Quality Control Board, in Contra Costa County to strengthen the water quality provisions of Decisions 1275 and 1291, but the suit remained dormant.

d. Resolution 68-17. In July 1968, the Secretary of the Interior expressed concern that existing standards for the Delta did not adequately protect municipal, industrial, agricultural and fishery uses and proposed some supplemental water quality objectives for chloride and total dissolved solids (TDS) concentrations. Following receipt of the federal comments in October 1968, the SWRCB adopted a water quality control policy for the Delta through Resolution 68-17. This policy supplemented a water quality control policy for the Delta that was developed by the Central Valley RWQCB. By letter of January 9, 1969, the Secretary of the Interior notified the SWRCB that he approved the State water quality standards even though they failed to satisfy the recommendations of the federal government regarding the spawning of striped bass and the municipal, industrial and agricultural water uses of the western part of the Delta. The Secretary indicated that his approval was taken in reliance upon the commitment from the SWRCB to conduct public hearings during 1969 and to consider supplementing the salinity standards.

e. Decision 1379. In accordance with the commitment made in Resolution 68-17, a hearing was initiated on July 22, 1969, and continued with intermittent recesses until October 5, 1970. Based on that hearing record, the SWRCB issued Decision 1379 on July 28, 1971. Once again, because of concern for lack of information, the SWRCB refrained from setting permanent standards, imposing interim standards instead, subject to review no later than July 1, 1978.

Decision 1379 established comparatively high standards for agricultural and municipal and industrial consumptive uses, and it afforded protection for non-consumptive fish and wildlife uses as well. Previously, Delta water rights decisions had not specifically included standards designed to preserve the Delta's ecosystem. Eight petitions for reconsideration were filed. The water project operators and their customers claimed that the integrity of both the CVP and the SWP would be jeopardized if the SWRCB's decision was not modified because less water would be available than had been anticipated. The SWRCB, however, decided not to change its decision, and the SWRCB made only technical clarifications to the decision before readopting it on September 16, 1971. Decision 1379 was then challenged in court by the CVP and the SWP contractors. The decision was stayed, and no court ruled on it before it was superseded by D-1485.

f. Water Quality Control Plan Supplementing State Water Quality Control Policies for the Sacramento-San Joaquin Delta. The Regional Administrator of the USEPA, in an August 1972 letter, called the SWRCB's attention to the fact that there were considerations outstanding from the conditional approval previously received from the federal government. In response to that letter, the SWRCB held a hearing on proposed supplemental water quality objectives for the Delta and on April 19, 1973, by Resolution No. 73-16, adopted the "Water Quality Control Plan Supplementing State Water Quality Control Policies for the Sacramento-San Joaquin Delta".

g. D-1485 and the 1978 Delta Plan. In August 1978, the SWRCB adopted D-1485 and the 1978 Delta Plan. The 1978 Delta Plan revised existing objectives for flow and salinity in the Delta. D-1485 required the DWR and the USBR to meet the objectives. The SWRCB committed to reviewing the 1978 Delta Plan in ten years. D-1485 and the 1978 Delta Plan are discussed in greater detail in Chapter III.

Numerous lawsuits were filed by parties to the proceedings. The final appellate decision in the Delta water cases was U.S. v. State Water Resources Control Board (1986) 182 Cal.App.3d 82, 227 Cal. Rptr. 161.

h. Current Proceedings. The SWRCB started the current Bay-Delta hearing process in July 1987. A draft water quality control plan was issued in November 1988. The draft plan met intense opposition, and it was withdrawn in January 1989. Shortly thereafter, the SWRCB, with input from the San Francisco Bay and Central Valley RWQCBs, issued a draft Pollutant Policy Document (PPD) for the Bay-Delta Estuary. The draft PPD was adopted in 1990.

After withdrawing the 1988 draft plan, the SWRCB bifurcated the process. It first prepared a draft water quality control plan that did not include flow and export objectives. The plan was to be followed by a water right decision that would include flow and export requirements and allocate responsibility to meet all the standards. In May 1991, the SWRCB adopted the 1991 Bay-Delta Plan which included standards for salinity, dissolved oxygen, and temperature. Litigation ensued. In September 1991, the USEPA disapproved most of the fish and wildlife objectives in the plan. Meanwhile, the SWRCB began preparing an EIR for use in determining the environmental effects of potential changes in water rights.

In April 1992, Governor Wilson announced a new water policy. Among other provisions, the policy requested the SWRCB to initiate a hearing process to develop interim protections to stop the decline of fish and wildlife resources in the Bay-Delta Estuary.

The SWRCB conducted a water right hearing during the summer of 1992. Draft Water Right Decision 1630 (D-1630) was released in December 1992. D-1630 proposed interim water right terms and conditions to protect the Bay-Delta Estuary. On April 1, 1993, the Governor requested that the SWRCB cease its work on D-1630 and instead work on long-term protections, and the SWRCB concurred. The following two reasons for the change were cited by the SWRCB. First, the National Marine Fisheries Service (NMFS) had issued protections for winter-run chinook salmon and the U. S. Fish and Wildlife Service (USFWS) had announced that it soon would issue protections for Delta smelt. These protections, adopted under the authority of the federal Endangered Species Act (ESA), would benefit a broad range of species. Second, the end of the drought resulted in substantial uncontrolled runoff which benefitted the fishery. Under these circumstances, the interim water right decision was deemed unnecessary.

In response to litigation, the USEPA published draft water quality standards for the Bay-Delta Estuary on January 6, 1994 (59 FR 810-852). On March 25, 1994, the SWRCB gave notice of a series of workshops to review the 1991 Bay-Delta Plan. The comments and recommendations received at those workshops were used to develop this report and the plan.

In the summer of 1994, the State and federal agencies with responsibility for management of Bay-Delta resources signed a Framework Agreement in which the agencies agreed to cooperate in three areas. First, the SWRCB would update and revise its 1991 Bay-Delta Plan to meet federal Clean Water Act requirements. After approval by USEPA, the SWRCB will initiate a water right proceeding to implement the requirements in the plan. Second, a CVP/SWP coordination group will be formed consisting of representatives of USFWS, USBR, NMFS, USEPA, DFG, DWR, and SWRCB to facilitate the coordination of water project operations with all of the regulatory requirements in the Delta. Third, the State and federal agencies agreed to undertake a joint long-term solution finding process for the Bay-Delta. This plan is intended to meet the State's commitment to revise the 1991 Bay-Delta Plan.

On December 15, 1994, representatives of the State and federal governments and urban, agricultural (principally urban and agricultural water exporters), and environmental interests agreed to the implementation of a Bay-Delta protection plan. The protection plan and the institutional agreements necessary to implement the plan are contained in a document, titled "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government". This plan is consistent with the Principles for Agreement.

3. Legal Authority To Prepare And Use This Report

This document is a substitute for an EIR or negative declaration. It contains the environmental information necessary to support the accompanying water quality control plan for the Bay-Delta Estuary, and functions as a part of the plan. This document meets the requirements specified in Public Resources Code section 21080.5. The accompanying water quality control plan is prepared under the SWRCB's basin planning authority set forth in Water Code section 13000 et seq. and under the federal Clean Water Act. (33 U.S.C. §1251 et seq.)

The SWRCB's Water Quality Control (Basin)/208 Planning Program has been certified by the Secretary for Resources as meeting the requirements of Public Resources Code section 21080.5. (14 Cal. Code Regs. §15251(g)) Because the program has been certified, regulatory activities involving the adoption or approval of standards, rules, regulations or plans for use in the program are exempt from the requirements for preparing EIRs, negative declarations, and initial studies under CEQA.

The certification, dated June 1, 1979, is based on an examination by the Secretary for Resources of the laws administered by the SWRCB as part of the SWRCB's Basin Planning Program. These laws include Water Code section 13000 et seq., regulations in Title 23, Division 3 of the California Code of Regulations, the federal Water Pollution Control Act of 1972 as amended (referred to herein as the federal Clean Water Act), and the federal regulations designated to implement the Clean Water Act. The certification contains findings supporting the conclusion that the Basin Planning Program qualifies for certification under Public Resources Code section 21080.5.

Although Public Resources Code section 21080.5 exempts preparation of this plan from the requirement to prepare an EIR, negative declaration, or initial study, it does not exempt it from other provisions of CEQA, including the policies of CEQA. To meet the requirements of section 21080.5, this document includes a description of the project, alternatives to the project, and mitigation measures to avoid or reduce any significant or potentially significant effects of the project. Written responses to significant environmental points raised in comments during the evaluation of the proposed project will accompany final action on the proposed project.

Although CEQA does not require that this document meet the requirements for an EIR or negative declaration, this document is substantially similar to an EIR or negative declaration and contains significant additional information that is not specifically required by section 21080.5. For example, this document contains a project description meeting the requirements for an EIR (14 Cal. Code Regs §15124), a discussion of the regulatory and environmental setting, and analyses of short-term uses and long-term productivity, significant irreversible changes, growth-inducing impacts, economic and social impacts, and cumulative impacts.

C. INTENDED USE OF THIS REPORT

The SWRCB will use this report to document its evaluation of the environmental impacts of regulatory alternatives to protect public trust resources in the Bay-Delta Estuary. The SWRCB will establish appropriate water quality and other measures to protect public trust resources following a public hearing during which this report and other evidence will be considered. The SWRCB also may use this document in conjunction with subsequent implementation proceedings to modify D-1485 to eliminate inconsistencies between that decision and the plan.

CHAPTER II. PROJECT DESCRIPTION

A. PROJECT DEFINITION

The project is the review, and amendment where appropriate, of both the SWRCB's objectives for protection of fish and wildlife in the Bay-Delta Estuary and the program of implementation for achieving the objectives and protecting the beneficial uses. The program of implementation includes actions the SWRCB will undertake to achieve the objectives and recommendations to other entities for actions that will contribute to achieving the objectives and improve habitat conditions for fish and wildlife.

B. STATEMENT OF GOALS

The SWRCB's goals for this project are to:

1. Provide comprehensive, multi-species, ecosystem protection for the Bay-Delta Estuary;

2. Stabilize and enhance fish and wildlife resources in the Bay-Delta Estuary;

3. Minimize the impact of new standards on water supply reliability throughout the Bay-Delta watershed and export areas; and

4. Provide meaningful regulatory stability by adopting standards that meet all foreseeable State and federal requirements, including the Porter-Cologne Act, the Clean Water Act, and the State and federal ESAs.

C. PREFERRED ALTERNATIVE

The water quality objectives of the preferred alternative, in conjunction with the water quality objectives for the Bay-Delta Estuary that are included in other SWRCB-adopted water quality control plans and in the water quality control plans for the Central Valley and San Francisco Bay basins, when implemented, will: (1) provide reasonable protection of municipal, industrial, and agricultural beneficial uses; (2) provide reasonable protection of fish and wildlife beneficial uses at a level which stabilizes or enhances the conditions of aquatic resources; and (3) prevent nuisance. A list and brief descriptions of the beneficial uses established for the Bay-Delta Estuary, which are to be protected by the plan, follow. These uses are unchanged from the 1991 Bay-Delta Plan; however, nonsubstantive changes to the definitions of the uses have been made to ensure consistency with the SWRCB's current policy and uniform direction to the RWQCBs.

<u>Municipal and Domestic Supply (MUN)</u> - Uses of water for community, military,or individual water supply systems including, but not limited to, drinking water supply.

Industrial Service Supply (IND) - Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Industrial Process Supply (PROC) - Uses of water for industrial activities that depend primarily on water quality.

Agricultural Supply (AGR) - Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Ground Water Recharge (GWR) - Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Navigation (NAV) - Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Water Contact Recreation (REC-1) - Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-Contact Water Recreation (REC-2) - Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Shellfish Harvesting (SHELL) - Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Commercial and Sport Fishing (COMM) - Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Warm Freshwater Habitat (WARM) - Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) - Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Migration of Aquatic Organisms (MIGR) - Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) - Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Estuarine Habitat (EST) - Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Wildlife Habitat (WILD) - Uses of water that support estuarine ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Rare, Threatened, or Endangered Species (RARE) - Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as being rare, threatened, or endangered.

The water quality objectives of the preferred alternative for the protection of municipal and industrial, agricultural, and fish and wildlife beneficial uses are presented in Tables II-1, II-2, and II-3, respectively.

The water quality objectives in Table II-1 are included for the reasonable protection of the beneficial uses, MUN, IND, and PROC, from the effects of salinity intrusion. These municipal and industrial objectives also provide protection for the beneficial uses of REC-1, REC-2, and GWR. These objectives are unchanged from the 1991 Bay-Delta Plan.

TABLE II-1 WATER QUALITY OBJECTIVES FOR MUNICIPAL AND INDUSTRIAL BENEFICIAL USES

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT)	WATER YEAR TYPE [2]	TIME PERIOD	VALUE
Contra Costa Canal at Pumping Plant #1 -or- San Joaquin River at Antioch Water Works Intake	*C-5 (CHCCC06) D-12 (near) (RSAN007)*	*Chloride (Cl^-)*	*Maximum mean daily 150 mg/l Cl^- for at least the number of days shown during the Calendar Year. Must be provided in intervals of not less than two weeks duration. (Percentage of Calendar Year shown in parenthesis)*	* W AN BN D C*		*No. of days each Calendar Year ≤ 150 mg/l Cl^- 240 (66%) 190 (52%) 175 (48%) 165 (45%) 155 (42%)*
Contra Costa Canal at Pumping Plant #1 -and- West Canal at mouth of Clifton Court Forebay -and- Delta-Mendota Canal at Tracy Pumping Plant -and- Barker Slough at North Bay Aqueduct Intake -and- Cache Slough at City of Vallejo Intake [3]	*C-5 (CHCCC06) C-9 (CHWST0) DMC-1 (CHDMC004) — (SLBAR3) C-19 (SLCCH16)*	*Chloride (Cl^-)*	*Maximum mean daily (mg/l)*	*All*	*Oct-Sep*	*250*

[1] River Kilometer Index station number.
[2] The Sacramento Valley 40-30-30 water year hydrologic classification index (see page II-12) applies for determinations of water year type.
[3] The Cache Slough objective to be effective only when water is being diverted from this location.

The water quality objectives in Table II-2 are included for the reasonable protection of the beneficial use, AGR, from the effects of salinity intrusion and agricultural drainage in the western, interior, and southern Delta. With the exception of the effective date of the salinity objectives for the southern Delta stations on Old River, these objectives are unchanged from the 1991 Bay-Delta Plan.

The water quality objectives in Table II-3 are included for the reasonable protection of the following beneficial uses: EST, COLD, WARM, MIGR, SPWN, WILD, and RARE. These fish and wildlife beneficial uses also provide protection for the beneficial uses of SHELL, COMM, and NAV. The objectives in Table II-3, together with the program of implementation and the requirements of other water quality control plans and policies, provide comprehensive protection for the fish and wildlife beneficial uses in the Estuary. These objectives replace the objectives for fish and wildlife in the 1978 Delta Plan and the 1991 Bay-Delta Plan.

A dissolved oxygen objective is included to protect fall-run salmon migration in the lower San Joaquin River. This objective is unchanged, with the exception of including a provision for a compliance schedule, from the 1991 Bay-Delta Plan.

Salinity objectives for the lower San Joaquin River are included to protect striped bass spawning habitat. Salinity objectives for the managed portions of the Suisun Marsh are included for the protection of channel and soil water salinities which affect the vegetative composition of the marshlands. These objectives are based on standards in D-1485 and the Suisun Marsh Preservation Agreement (SMPA) among the DWR, USBR, DFG, and Suisun Resource Conservation District (SRCD). A narrative objective for the brackish tidal marshes of Suisun Bay is included to protect the remnant tidal marshes.

Delta outflow objectives are included for the protection of estuarine habitat for anadromous fish and other estuarine-dependent species. Sacramento and San Joaquin river flow objectives are included to provide attraction and transport flows and suitable habitat for various life stages of aquatic organisms, including Delta smelt and chinook salmon. A narrative objective for salmon protection is included to ensure increased natural production of salmon.

Objectives for export limits are included to protect the habitat of estuarine-dependent species by reducing the entrainment of various life stages by the major export pumps in the southern Delta. An objective for closure of the Delta Cross Channel gates is included to reduce the diversion of aquatic organisms into the interior Delta where they are more vulnerable to entrainment by the major export pumps and local agricultural diversions.

TABLE II-2 WATER QUALITY OBJECTIVES FOR AGRICULTURAL BENEFICIAL USES

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	& VALUE
WESTERN DELTA						
Sacramento River at Emmaton	*D-22 (RSAC092)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	—
				AN	*Jul 1*	*0.63*
				BN	*Jun 20*	*1.14*
				D	*Jun 15*	*1.67*
				C	—	*2.78*
San Joaquin River at Jersey Point	*D-15 (RSAN018)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	—
				AN	*Aug 15*	—
				BN	*Jun 20*	*0.74*
				D	*Jun 15*	*1.35*
				C	—	*2.20*
INTERIOR DELTA						
South Fork Mokelumne River at Terminous	*C-13 (RSMKL08)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	—
				AN	*Aug 15*	—
				BN	*Aug 15*	—
				D	*Aug 15*	—
				C	—	*0.54*
San Joaquin River at San Andreas Landing	*C-4 (RSAN032)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*		*0.45 EC April 1 to date shown*	*EC from date shown to Aug 15 [4]*
				W	*Aug 15*	—
				AN	*Aug 15*	—
				BN	*Aug 15*	—
				D	*Jun 25*	*0.58*
				C	—	*0.87*
SOUTHERN DELTA						
San Joaquin River at Airport Way Bridge, Vernalis -and- San Joaquin River at Brandt Bridge site -and- Old River near Middle River [5] -and- Old River at Tracy Road Bridge [5]	*C-10 (RSAN112)* *C-6 (RSAN073)* *C-8 (ROLD69)* *P-12 (ROLD59)*	*Electrical Conductivity (EC)*	*Maximum 30-day running average of mean daily EC (mmhos/cm)*	*All*	*Apr-Aug* *Sep-Mar*	*0.7* *1.0*
					-or-	
			If a three-party contract has been implemented among the DWR, USBR, and SDWA, that contract will be reviewed prior to implementation of the above and, after also considering the needs of other beneficial uses, revisions will be made to the objectives and compliance/monitoring locations noted, as appropriate.			
EXPORT AREA						
West Canal at mouth of Clifton Court Forebay -and- Delta-Mendota Canal at Tracy Pumping Plant	*C-9 (CHWST0)* *DMC-1 (CHDMC004)*	*Electrical Conductivity (EC)*	*Maximum monthly average of mean daily EC (mmhos/cm)*	*All*	*Oct-Sep*	*1.0*

[1] River Kilometer Index station number.
[2] Determination of compliance with an objective expressed as a running average begins on the last day of the averaging period. If the objective is not met on the last day of the averaging period, all days in the averaging period are considered out of compliance.
[3] The Sacramento Valley 40-30-30 water year hydrologic classification index (see page II-12) applies for determinations of water year type.
[4] When no date is shown, EC limit continues from April 1.
[5] The EC objectives shall be implemented at this location by December 31, 1997.

TABLE II-3 — WATER QUALITY OBJECTIVES FOR FISH AND WILDLIFE BENEFICIAL USES

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	VALUE
DISSOLVED OXYGEN						
San Joaquin River between Turner Cut & Stockton	*(RSAN050-RSAN061)*	*Dissolved Oxygen (DO)*	*Minimum DO (mg/l)*	*All*	*Sep-Nov*	*6.0 [4]*
SALMON PROTECTION						
			narrative	*Water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law.*		
SAN JOAQUIN RIVER SALINITY						
San Joaquin River at and between Jersey Point and Prisoners Point [5]	*D-15 (RSAN018) -and- D-29 (RSAN038)*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily EC (mmhos/cm)*	*W,AN,BN,D*	*Apr-May*	*0.44 [6]*
EASTERN SUISUN MARSH SALINITY						
Sacramento River at Collinsville -and- Montezuma Slough at National Steel -and- Montezuma Slough near Beldon Landing	*C-2 (RSAC081) S-64 (SLMZU25) S-49 (SLMZU11)*	*Electrical Conductivity (EC)*	*Maximum monthly average of both daily high tide EC values (mmhos/cm), or demonstrate that equivalent or better protection will be provided at the location.*	*All*	*Oct Nov-Dec Jan Feb-Mar Apr-May*	*19.0 15.5 12.5 8.0 11.0*
WESTERN SUISUN MARSH SALINITY						
Chadbourne Slough at Sunrise Duck Club -and- Suisun Slough, 300 feet south of Volanti Slough -and- Cordelia Slough at Ibis Club -and- Goodyear Slough at Morrow Island Clubhouse -and- Water supply intakes for waterfowl management areas on Van Sickle and Chipps Islands	*S-21 [7] (SLCBN1) S-42 [8] (SLSUS12) S-97 [8] (SLCRD06) S-35 [8] (SLGYR03) No locations specified*	*Electrical Conductivity (EC)*	*Maximum monthly average of both daily high tide EC values (mmhos/cm), or demonstrate that equivalent or better protection will be provided at the location.*	*All but deficiency period*	*Oct Nov Dec Jan Feb-Mar Apr-May*	*19.0 16.5 15.5 12.5 8.0 11.0*
				Deficiency period [9]	*Oct Nov Dec-Mar Apr May*	*19.0 16.5 15.6 14.0 12.5*
BRACKISH TIDAL MARSHES OF SUISUN BAY						
			narrative			*[10]*

TABLE II-3 WATER QUALITY OBJECTIVES FOR FISH AND WILDLIFE BENEFICIAL USES (continued)

COMPLIANCE LOCATION	INTERAGENCY STATION NUMBER (RKI [1])	PARAMETER	DESCRIPTION (UNIT) [2]	WATER YEAR TYPE [3]	TIME PERIOD	VALUE
DELTA OUTFLOW						
		Net Delta Outflow Index (NDOI) [11]	*Minimum monthly average [12] NDOI (cfs)*	*All*	*Jan*	*4,500 [13]*
				All	*Feb-Jun*	*[14]*
				W,AN	*Jul*	*8,000*
				BN		*6,500*
				D		*5,000*
				C		*4,000*
				W,AN,BN	*Aug*	*4,000*
				D		*3,500*
				C		*3,000*
				All	*Sep*	*3,000*
				W,AN,BN,D	*Oct*	*4,000*
				C		*3,000*
				W,AN,BN,D	*Nov-Dec*	*4,500*
				C		*3,500*
RIVER FLOWS						
Sacramento River at Rio Vista	*D-24 (RSAC101)*	*Flow rate*	*Minimum monthly average [15] flow rate (cfs)*	*All*	*Sep*	*3,000*
				W,AN,BN,D	*Oct*	*4,000*
				C		*3,000*
				W,AN,BN,D	*Nov-Dec*	*4,500*
				C		*3,500*
San Joaquin River at Airport Way Bridge, Vernalis	*C-10 (RSAN112)*	*Flow rate*	*Minimum monthly average [16] flow rate (cfs) [17]*	*W,AN*	*Feb-Apr 14 and May 16-Jun*	*2,130 or 3,420*
				BN,D		*1,420 or 2,280*
				C		*710 or 1,140*
				W	*Apr 15-May 15 [18]*	*7,330 or 8,620*
				AN		*5,730 or 7,020*
				BN		*4,620 or 5,480*
				D		*4,020 or 4,880*
				C		*3,110 or 3,540*
				All	*Oct*	*1,000 [19]*
EXPORT LIMITS						
		Combined export rate [20]	*Maximum 3-day running average (cfs)*	*All*	*Apr 15-May 15 [21]*	*[22]*
			Maximum percent of Delta inflow diverted [23] [24]	*All*	*Feb-Jun*	*35% Delta inflow [25]*
				All	*Jul-Jan*	*65% Delta inflow*
DELTA CROSS CHANNEL GATES CLOSURE						
Delta Cross Channel at Walnut Grove	—	*Closure of gates*	*Close gates*	*All*	*Nov-Jan*	*[26]*
					Feb-May 20	—
					May 21-Jun 15	*[27]*

Table II-3 Footnotes

[1] River Kilometer Index station number.

[2] Determination of compliance with an objective expressed as a running average begins on the last day of the averaging period. If the objective is not met on the last day of the averaging period, all days in the averaging period are considered out of compliance.

[3] The Sacramento Valley 40-30-30 Water Year Hydrologic Classification Index (see page II-12) applies unless otherwise specified.

[4] If it is infeasible for a waste discharger to meet this objective immediately, a time extension or schedule of compliance may be granted, but this objective must be met no later than September 1, 2005.

[5] Compliance will be determined at Jersey Point (station D15) and Prisoners Point (station D29).

[6] This standard does not apply in May when the best available May estimate of the Sacramento River Index for the water year is less than 8.1 MAF at the 90% exceedence level. [Note: The Sacramento River Index refers to the sum of the unimpaired runoff in the water year as published in the DWR Bulletin 120 for the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total unimpaired inflow to Oroville Reservoir; Yuba River at Smartville; and American River, total unimpaired inflow to Folsom Reservoir.]

[7] The effective date for objectives for this station is October 1, 1995.

[8] The effective date for objectives for this station is October 1, 1997.

[9] A deficiency period is: (1) the second consecutive dry water year following a critical year; (2) a dry water year following a year in which the Sacramento River Index (described in footnote 6) was less than 11.35; or (3) a critical water year following a dry or critical water year.

[10] Water quality conditions sufficient to support a natural gradient in species composition and wildlife habitat characteristic of a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay shall be maintained. Water quality conditions shall be maintained so that none of the following occurs: (a) loss of diversity; (b) conversion of brackish marsh to salt marsh; (c) for animals, decreased population abundance of those species vulnerable to increased mortality and loss of habitat from increased water salinity; or (d) for plants, significant reduction in stature or percent cover from increased water or soil salinity or other water quality parameters.

[11] Net Delta Outflow Index (NDOI) is defined on page II-14.

[12] For the May-January objectives, if the value is less than or equal to 5,000 cfs, the 7-day running average shall not be less than 1,000 cfs below the value; if the value is greater than 5,000 cfs, the 7-day running average shall not be less than 80% of the value.

[13] The objective is increased to 6,000 cfs if the best available estimate of the Eight River Index for December is greater than 800 TAF. [Note: The Eight River Index refers to the sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake.]

[14] The minimum daily NDOI shall be 7,100 cfs for this period, calculated as a 3-day running average. This requirement is also met if either the daily average or 14-day running average EC at the confluence of the Sacramento and the San Joaquin rivers is less than or equal to 2.64 mmhos/cm (Collinsville station C2). If the best available estimate of the Eight River Index (described in footnote 13) for January is more than 900 TAF, the daily average or 14-day running average EC at station C2 shall be less than or equal to 2.64 mmhos/cm for at least one day between February 1 and February 14; however, if the best available estimate of the Eight River Index for January is between 650 TAF and 900 TAF, the operations group established under the Framework Agreement shall decide whether this requirement will apply, with any disputes resolved by the CALFED policy group. If the best available estimate of the Eight River Index for February is less than 500 TAF, the standard may be further relaxed in March upon the recommendation of the operations group established under the Framework Agreement, with any disputes resolved by the CALFED policy group. The standard does not apply in May and June if the best available May estimate of the Sacramento River Index (described in footnote 6) for the water year is less than 8.1 MAF at the 90% exceedence level. Under this circumstance, a minimum 14-day running average flow of 4,000 cfs is required in May and June. Additional Delta outflow objectives are contained in Table A on page II-15.

[15] The 7-day running average shall not be less than 1,000 cfs below the monthly objective.

[16] Partial months are averaged for that period. For example, the flow rate for April 1-14 would be averaged over 14 days. The 7-day running average shall not be less than 20% below the flow rate objective, with the exception of the April 15-May 15 pulse flow period when this restriction does not apply.

[17] The water year classification will be established using the best available estimate of the 60-20-20 San Joaquin Valley Water Year Hydrologic Classification (see page II-13) at the 75% exceedence level. The higher flow objective applies when the 2 ppt isohaline (measured as 2.64 mmhos/cm surface salinity) is required to be at or west of Chipps Island.

[18] This time period may be varied based on real-time monitoring. One pulse, or two separate pulses of combined duration equal to the single pulse, should be scheduled to coincide with fish migration in San Joaquin River tributaries and the Delta. The time period for this 31-day flow requirement will be determined by the operations group established under the Framework Agreement.

[19] Plus up to an additional 28 TAF pulse/attraction flow during all water year types. The amount of additional water will be limited to that amount necessary to provide a monthly average flow of 2,000 cfs. The additional 28 TAF is not required in a critical year following a critical year. The pulse flow will be scheduled by the operations group established under the Framework Agreement.

[20] Combined export rate for this objective is defined as the Clifton Court Forebay inflow rate (minus actual Byron-Bethany Irrigation District diversions from Clifton Court Forebay) and the export rate of the Tracy pumping plant.

[21] This time period may be varied based on real-time monitoring and will coincide with the San Joaquin River pulse flow described in footnote 18. The time period for this 31-day export limit will be determined by the operations group established under the Framework Agreement.

[22] Maximum export rate is 1,500 cfs or 100% of 3-day running average of San Joaquin River flow at Vernalis, whichever is greater. This export restriction does not supersede the export restriction of 35% of Delta inflow. The more restrictive of these two objectives applies from April 15 to May 15. Variations to this maximum export rate are authorized if agreed to by the operations group established under the Framework Agreement. This flexibility is intended to result in no net water supply cost annually within the limits of the water quality and operational requirements of this plan. Variations may result from recommendations of agencies for protection of fish resources, including actions taken pursuant to the State and federal Endangered Species Acts. Disputes within the operations group will be resolved by the CALFED policy group. Any agreement on variations will be effective immediately and will be presented to the Executive Director of the SWRCB. If the Executive Director does not object to the variations within 10 days, the variations will remain in effect.

[23] Percent of Delta inflow diverted is defined on page II-14. For the calculation of maximum percent Delta inflow diverted, the export rate is a 3-day running average and the Delta inflow is a 14-day running average, except when the CVP or the SWP is making storage withdrawals for export, in which case both the export rate and the Delta inflow are 3-day running averages.

[24] The percent Delta inflow diverted values can be varied either up or down. Variations are authorized subject to the process described in footnote 22.

[25] If the best available estimate of the Eight River Index (described in footnote 13) for January is less than or equal to 1.0 MAF, the export limit for February is 45% of Delta inflow. If the best available estimate of the Eight River Index for January is greater than 1.5 MAF, the February export limit is 35% of Delta inflow. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be set by the operations group established under the Framework Agreement within the range of 35% to 45%. Disputes within the operations group will be resolved by the CALFED policy group.

[26] For the November-January period, close Delta Cross Channel gates for up to a total of 45 days, as needed for the protection of fish. The timing of the gate closure will be determined by the operations group established under the Framework Agreement.

[27] For the May 21-June 15 period, close Delta Cross Channel gates for a total of 14 days. The timing of the gate closure shall be based on the need for the protection of fish and will be determined by the operations group established under the Framework Agreement. Variations in the number of days of gate closure are authorized if agreed to by the operations group established under the Framework Agreement. Variations shall result from recommendations from agencies for the protection of fish resources, including actions taken pursuant to the State and federal Endangered Species Acts. The process for the approval of variations shall be similar to that described in footnote 22.

FOOTNOTE 2 FOR TABLE II-1 AND FOOTNOTE 3 FOR TABLES II-2 AND II-3

Sacramento Valley
Water Year Hydrologic Classification

Year classification shall be determined by computation of the following equation:

INDEX = 0.4 * X + 0.3 * Y + 0.3 * Z

Where:

X = Current year's April – July Sacramento Valley unimpaired runoff

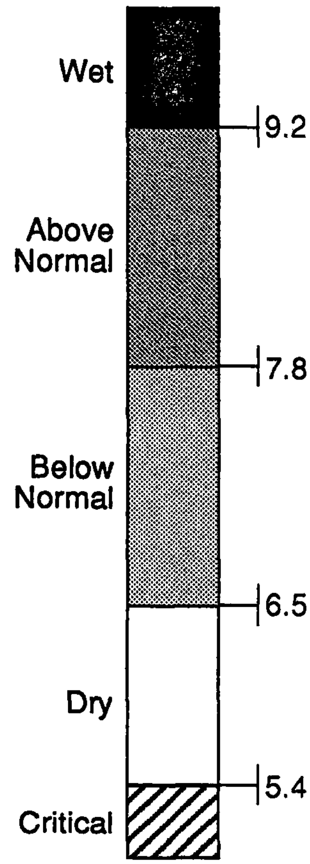
Y = Current October – March Sacramento Valley unimpaired runoff

Z = Previous year's index [1]

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet (MAF)
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8 and less than 9.2
Below Normal	Equal to or less than 7.8 and greater than 6.5
Dry	Equal to or less than 6.5 and greater than 5.4
Critical	Equal to or less than 5.4

YEAR TYPE [2]
All Years for All Objectives



Index
Millions of Acre-Feet

[1] A cap of 10.0 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

[2] The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

FOOTNOTE 17 FOR TABLE II-3

San Joaquin Valley
Water Year Hydrologic Classification

Year classification shall be determined by computation of the following equation:

$$\text{INDEX} = 0.6 * X + 0.2 * Y + 0.2 * Z$$

Where:

X = Current year's April – July San Joaquin Valley unimpaired runoff

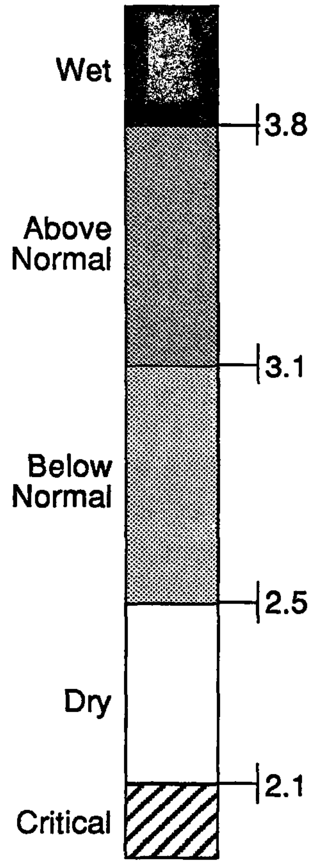
Y = Current October – March San Joaquin Valley unimpaired runoff

Z = Previous year's index [1]

The San Joaquin Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet (MAF)
Wet	Equal to or greater than 3.8
Above Normal	Greater than 3.1 and less than 3.8
Below Normal	Equal to or less than 3.1 and greater than 2.5
Dry	Equal to or less than 2.5 and greater than 2.1
Critical	Equal to or less than 2.1

YEAR TYPE [2]
All Years for All Objectives



Index
Millions of Acre-Feet

[1] A cap of 4.5 MAF is placed on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

[2] The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

FOOTNOTES 11 AND 23 FOR TABLE II-3

NDOI and PERCENT INFLOW DIVERTED [1]

The NDOI and the percent inflow diverted, as described in this footnote, shall be computed daily by the DWR and the USBR using the following formulas (all flows are in cfs):

NDOI = DELTA INFLOW - NET DELTA CONSUMPTIVE USE - DELTA EXPORTS

PERCENT INFLOW DIVERTED = (CCF + TPP) ÷ DELTA INFLOW

where *DELTA INFLOW = SAC + SRTP + YOLO + EAST + MISC + SJR*

SAC	=	Sacramento River at Freeport mean daily flow for the previous day; the 25-hour tidal cycle measurements from 12:00 midnight to 1:00 a.m. may be used instead.
SRTP	=	Sacramento Regional Treatment Plant average daily discharge for the previous week.
YOLO	=	Yolo Bypass mean daily flow for the previous day, which is equal to the flows from the Sacramento Weir, Fremont Weir, Cache Creek at Rumsey, and the South Fork of Putah Creek.
EAST	=	Eastside Streams mean daily flow for the previous day from the Mokelumne River at Woodbridge, Cosumnes River at Michigan Bar, and Calaveras River at Bellota.
MISC	=	Combined mean daily flow for the previous day of Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, Marsh Creek, and Morrison Creek.
SJR	=	San Joaquin River flow at Vernalis, mean daily flow for the previous day.

where *NET DELTA CONSUMPTIVE USE = GDEPL - PREC*

GDEPL	=	Delta gross channel depletion for the previous day based on water year type using the DWR's latest Delta land use study.[2]
PREC	=	Real-time Delta precipitation runoff for the previous day estimated from stations within the Delta.

and where *DELTA EXPORTS* [3] *= CCF + TPP + CCC + NBA*

CCF	=	Clifton Court Forebay inflow for the current day.[4]
TPP	=	Tracy Pumping Plant pumping for the current day.
CCC	=	Contra Costa Canal pumping for the current day.
NBA	=	North Bay Aqueduct pumping for the current day.

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1 Not all of the Delta tributary streams are gaged and telemetered. When appropriate, other methods of estimating stream flows, such as correlations with precipitation or runoff from nearby streams, may be used instead.

2 The DWR is currently developing new channel depletion estimates. If these new estimates are not available, DAYFLOW channel depletion estimates shall be used.

3 The term "Delta Exports" is used only to calculate the NDOI. It is not intended to distinguish among the listed diversions with respect to eligibility for protection under the area of origin provisions of the California Water Code.

4 Actual Byron-Bethany Irrigation District withdrawals from Clifton Court Forebay shall be subtracted from Clifton Court Forebay inflow. (Byron-Bethany Irrigation District water use is incorporated into the GDEPL term.)

FOOTNOTE 14 FOR TABLE II-3

TABLE A
Number of Days When Maximum Daily Average Electrical Conductivity of 2.64 mmhos/cm Must Be Maintained at Specified Location [a]

PMI [b] (TAF)	Chipps Island (Chipps Island Station D10)					PMI [b] (TAF)	Port Chicago (Port Chicago Station C14) [d]					PMI [b] (TAF)	Port Chicago (Port Chicago Station C14) [d]				
	FEB	MAR	APR	MAY	JUN		FEB	MAR	APR	MAY	JUN		FEB	MAR	APR	MAY	JUN
≤ 500	0	0	0	0	0	0	0	0	0	0	0	5250	27	29	25	26	6
750	0	0	0	0	0	250	1	0	0	0	0	5500	27	29	26	28	9
1000	28 [c]	12	2	0	0	500	4	1	0	0	0	5750	27	29	27	28	13
1250	28	31	6	0	0	750	8	2	0	0	0	6000	27	29	27	29	16
1500	28	31	13	0	0	1000	12	4	0	0	0	6250	27	30	27	29	19
1750	28	31	20	0	0	1250	15	6	1	0	0	6500	27	30	28	30	22
2000	28	31	25	1	0	1500	18	9	1	0	0	6750	27	30	28	30	24
2250	28	31	27	3	0	1750	20	12	2	0	0	7000	27	30	28	30	26
2500	28	31	29	11	1	2000	21	15	4	0	0	7250	27	30	28	30	27
2750	28	31	29	20	2	2250	22	17	5	1	0	7500	27	30	29	30	28
3000	28	31	30	27	4	2500	23	19	8	1	0	7750	27	30	29	31	28
3250	28	31	30	29	8	2750	24	21	10	2	0	8000	27	30	29	31	29
3500	28	31	30	30	13	3000	25	23	12	4	0	8250	28	30	29	31	29
3750	28	31	30	31	18	3250	25	24	14	6	0	8500	28	30	29	31	29
4000	28	31	30	31	23	3500	25	25	16	9	0	8750	28	30	29	31	30
4250	28	31	30	31	25	3750	26	26	18	12	0	9000	28	30	29	31	30
4500	28	31	30	31	27	4000	26	27	20	15	0	9250	28	30	29	31	30
4750	28	31	30	31	28	4250	26	27	21	18	1	9500	28	31	29	31	30
5000	28	31	30	31	29	4500	26	28	23	21	2	9750	28	31	29	31	30
5250	28	31	30	31	29	4750	27	28	24	23	3	10000	28	31	30	31	30
≥ 5500	28	31	30	31	30	5000	27	28	25	25	4	>10000	28	31	30	31	30

[a] The requirement for number of days the maximum daily average electrical conductivity (EC) of 2.64 mmhos per centimeter (mmhos/cm) must be maintained at Chipps Island and Port Chicago can also be met with maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average NDOIs of 11,400 cfs and 29,200 cfs, respectively. If salinity/flow objectives are met for a greater number of days than the requirements for any month, the excess days shall be applied to meeting the requirements for the following month. The number of days for values of the PMI between those specified in this table shall be determined by linear interpolation.

[b] PMI is the best available estimate of the previous month's Eight River Index. (Refer to Footnote 13 for Table 3 for a description of the Eight River Index.)

[c] When the PMI is between 800 TAF and 1000 TAF, the number of days the maximum daily average EC of 2.64 mmhos/cm (or maximum 14-day running average EC of 2.64 mmhos/cm, or 3-day running average NDOI of 11,400 cfs) must be maintained at Chipps Island in February is determined by linear interpolation between 0 and 28 days.

[d] This standard applies only in months when the average EC at Port Chicago during the 14 days immediately prior to the first day of the month is less than or equal to 2.64 mmhos/cm.

CHAPTER III. EXISTING REGULATORY CONDITIONS

The existing regulatory setting for the Bay-Delta Estuary consists of the requirements set forth in water quality control plans, water right decisions, and biological opinions issued under the federal ESA. A summary of existing requirements relevant to the adoption of fish and wildlife objectives for the estuary are presented below.

A. 1978 DELTA PLAN AND D-1485

On August 16, 1978, the SWRCB adopted both the 1978 Delta Plan and D-1485. The 1978 Delta Plan included water quality objectives intended to protect municipal and industrial, agricultural, and fish and wildlife beneficial uses in the Delta, and fish and wildlife beneficial uses in the Suisun Marsh.

D-1485 was adopted as the primary means to implement the 1978 Delta Plan. While it is consistent with the 1978 Delta Plan, D-1485 only incorporates those elements of the plan for which a State or federal water project mitigation responsibility or a compelling public interest was shown. Therefore, D-1485 requires the DWR and the USBR to meet the objectives in the 1978 Delta Plan with the exception of the agricultural objectives for the southern Delta. The SWRCB determined that, because the Delta SWP and CVP facilities had no apparent direct impact on water quality conditions in the southern Delta, requiring the projects to meet southern Delta agricultural objectives could not be justified. Water Right Decision 1422 (SWRCB 1973), adopted for the New Melones Project in 1973, already required releases of water from New Melones Reservoir for the purpose of maintaining a mean monthly total dissolved solids concentration no greater than 500 parts per million (ppm) in the San Joaquin River at Vernalis. The D-1485 water quality standards are presented in Table III-1.

The underlying principle of the 1978 Delta Plan and D-1485 standards is that water quality in the Delta should be at least as good as those levels which would have been available had the State and federal water projects not been constructed (i.e., without project conditions), as limited by the constitutional mandate of reasonable use. The standards include adjustments in the levels of protection to reflect changes in hydrologic conditions experienced under different water year types.

The level of protection for municipal and industrial uses afforded by the 1978 Delta Plan and D-1485 was equivalent to that of the Regional Water Quality Control Plan for the Sacramento-San Joaquin Delta Basin (Basin 5B Plan) that was effective in 1978. However, unlike the Basin 5B Plan, the 1978 Delta Plan and D-1485 include no standard for protection of municipal and industrial uses offshore at Antioch. The Antioch standard was terminated when the SWRCB determined that adequate substitute water supplies were available to all municipal and industrial users, including salt-sensitive industries, in the vicinity of Antioch.

Table III-1. Water Right Decision 1485 (D-1485) water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh[1/].

BENEFICIAL USE PROTECTED and LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE[2/]	VALUES	
MUNICIPAL and INDUSTRIAL					
Contra Costa Canal Intake at Pumping Plant No. 1	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250	
Contra Costa Canal Intake at Pumping Plant No. 1 or Antioch Water Works Intake on San Joaquin River	Chloride	Maximum Mean Daily 150 mg/l Chloride for at least the number of days shown during the Calendar Year. Must be provided in intervals of not less than two weeks duration. (% of Year shown in parenthesis)		Number of Days Each Calendar Year Less than 150 mg/l Chloride	
			Wet	240 (66%)	
			Ab. Normal	190 (52%)	
			Bl. Normal	175 (48%)	
			Dry	165 (45%)	
			Critical	155 (42%)	
City of Vallejo Intake at Cache Slough	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250	
Clifton Court Forebay Intake at West Canal	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250	
Delta Mendota Canal at Tracy Pumping Plant	Chloride	Maximum Mean Daily Cl^- in mg/l	All	250	
AGRICULTURE				0.45 EC April 1 to Date Shown	EC from Date Shown 3/ to Aug. 15
WESTERN DELTA					
Emmaton on the Sacramento River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet	Aug. 15	—
			Ab. Normal	July 1	0.63
			Bl. Normal	June 20	1.14
			Dry	June 15	1.67
			Critical	—	2.78
Jersey Point on the San Joaquin River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet	Aug. 15	—
			Ab. Normal	Aug. 15	—
			Bl. Normal	June 20	0.74
			Dry	June 15	1.35
			Critical	—	2.20
INTERIOR DELTA					
Terminous on the Mokelumne River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet	Aug. 15	—
			Ab. Normal	Aug. 15	—
			Bl. Normal	Aug. 15	—
			Dry	Aug. 15	—
			Critical	—	0.54
San Andreas Landing on the San Joaquin River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet	Aug. 15	—
			Ab. Normal	Aug. 15	—
			Bl. Normal	Aug. 15	—
			Dry	June 25	0.58
			Critical	—	0.87

Table III-1. Water Right Decision 1485 (D-1485) water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh1/ (continued).

FISH PROTECTIVE FACILITIES

Maintain appropriate records of the numbers, sizes, kinds of fish salvaged and of water export rates and fish facility operations.

STATE FISH PROTECTIVE FACILITY

The facility is to be operated to meet the following standards to the extent that they are compatible with water export rates:

(a) King Salmon — from November through May 14, standards shall be as follows:
  (1) Approach Velocity — 3.0 to 3.5 feet per second
  (2) Bypass Ratio — maintain 1.2:1.0 to 1.6:1.0 ratios in both primary and secondary channels
  (3) Primary Bay — not critical but use Bay B as first choice
  (4) Screened Water System — the velocity of water exiting from the screened water system is not to exceed the secondary channel approach velocity. The system may be turned off at the discretion of the operators.

(b) Striped Bass and White Catfish — from May 15 through October, standards shall be as follows:
  (1) Approach Velocity — in both the primary and secondary channels, maintain a velocity as close to 1.0 feet per second as is possible
  (2) Bypass Ratio
    (i) When only Bay A (with center wall) is in operation maintain a 1.2:1.0 ratio
    (ii) When both primary bays are in operation and the approach velocity is less than 2.5 feet per second, the bypass ratio should be 1.5:1.0
    (iii) When only Bay B is operating the bypass ratio should be 1.2:1.0
    (iv) Secondary channel bypass ratio should be 1.2:1.0 for all approach velocities.
  (3) Primary Channel — use Bay A (with center wall) in preference to Bay B
  (4) Screened Water Ratio — if the use of screened water is necessary, the velocity of water exiting the screened water system is not to exceed the secondary channel approach velocity
  (5) Clifton Court Forebay Water Level — maintain at the highest practical level.

TRACY FISH PROTECTIVE FACILITY

The secondary system is to be operated to meet the following standards, to the extent that they are compatible with water export rates:

(a) The secondary velocity should be maintained at 3.0 to 3.5 feet per second whenever possible from February through May while salmon are present
(b) To the extent possible, the secondary velocity should not exceed 2.5 feet per second and preferably 1.5 feet per second between June 1 and August 31, to increase the efficiency for striped bass, catfish, shad, and other fish. Secondary velocities should be reduced even at the expense of bypass ratios in the primary, but the ratio should not be reduced below 1:1.0
(c) The screened water discharge should be kept at the lowest possible level consistent with its purpose of minimizing debris in the holding tanks
(d) The bypass ratio in the secondary should be operated to prevent excessive velocities in the holding tanks, but in no case should the bypass velocity be less than the secondary approach velocity.

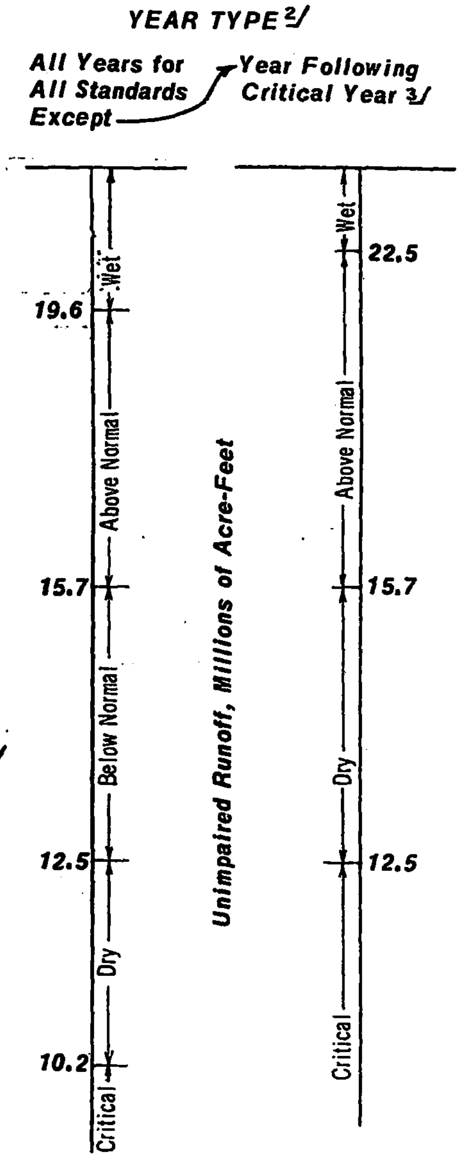
FOOTNOTES

1/ Except for flow, all values are for surface zone measurements. Except for flow, all mean daily values are based on at least hourly measurements. All dates are inclusive.
2/ Footnote 2 is set forth on next sheet.
3/ When no date is shown in the adjacent column, EC limit in this column begins on April 1.
4/ If contracts to ensure such facilities and water supplies are not executed by January 1, 1980, the Board will take appropriate enforcement actions to prevent encroachment on riparian rights in the southern Delta.
5/ For the purpose of this provision firm supplies of the Bureau shall be any water the Bureau is legally obligated to deliver under any CVP contract of 10 years or more duration, excluding the Friant Division of the CVP, subject only to dry and critical year deficiencies. Firm supplies of the Department shall be any water the Department would have delivered under Table A entitlements of water supply contracts and under prior right settlements had deficiencies not been imposed in that dry or critical year.
6/ Dry year following a wet, above normal or below normal year.
7/ Dry year following a dry or critical year.
8/ Scheduled water supplies shall be firm supplies for USBR and DWR plus additional water ordered from DWR by a contractor the previous September, and which does not exceed the ultimate annual entitlement for said contractor.

NOTE: EC values are mmhos/cm at 25°C.

Footnote 2 of Table III-1.

YEAR CLASSIFICATION



Year classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the current water year *(October 1 of the preceding calendar year through September 30 of the current calendar year)* as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

YEAR TYPE	*RUNOFF, MILLIONS OF ACRE-FEET*
Wet 1/	equal to or greater than 19.6 (except equal to or greater than 22.5 in a year following a critical year). 3/
Above Normal 1/	greater than 15.7 and less than 19.6 (except greater than 15.7 and less than 22.5 in a year following a critical year). 3/
Below Normal 1/	equal to or less than 15.7 and greater than 12.5 (except in a year following a critical year). 3/
Dry	equal to or less than 12.5 and greater than 10.2 (except equal to or less than 15.7 and greater than 12.5 in a year following a critical year). 3/
Critical	equal to or less than 10.2 (except equal to or less than 12.5 in a year following a critical year). 3/

1/ *Any otherwise wet, above normal, or below normal year may be designated a subnormal snowmelt year whenever the forecast of April through July unimpaired runoff reported in the May issue of Bulletin 120 is less than 5.9 million acre-feet.*

2/ *The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.*

3/ *"Year following critical year" classification does not apply to Agricultural, Municipal and Industrial standards.*

Table III-1. Water Right Decision 1485 (D-1485) water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh[1/] (continued).

FISH AND WILDLIFE

• STRIPED BASS SPAWNING

BENEFICIAL USE PROTECTED and LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE[2/]	VALUES
Prisoners Point on the San Joaquin River	Electrical Conductivity	Average of mean daily EC for the period not to exceed	All	April 1 to May 5: 0.550 mmhos
Chipps Island	Delta Outflow Index in cfs	Average of the daily Delta outflow index for the period, not less than	All	April 1 to April 14: 6700 cfs
Antioch Waterworks Intake on the San Joaquin River	Electrical Conductivity	Average of mean daily EC for the period, not more than	All	April 15 to May 5: 1.5 mmhos
Antioch Waterworks Intake	Electrical Conductivity (Relaxation Provision — replaces the above Antioch and Chipps Island Standard whenever the projects impose deficiencies in firm supplies 5/)	Average of mean daily EC for the period, not more than the values corresponding to the deficiencies taken (linear interpolation to be used to determine values between those shown)	All — whenever the projects impose deficiencies in firm supplies 5/	see below

Total Annual Imposed Deficiency MAF	April 1 to May 5 EC in mmhos
0	1.5
0.5	1.9
1.0	2.5
1.5	3.4
2.0	4.4
3.0	10.3
4.0 or more	25.2

• STRIPED BASS SURVIVAL

Chipps Island — Delta Outflow Index in cfs — Average of the daily Delta outflow index for each period shown not less than

YEAR TYPE	May 6–31	June	July
Wet	14,000	14,000	10,000
Ab. Normal	14,000	10,700	7,700
Bl. Normal	11,400	9,500	6,500
Subnormal Snowmelt	6,500	5,400	3,600
Dry 6/	4,300	3,600	3,200
Dry 7/ or Critical	3,300	3,100	2,900

• SALMON MIGRATIONS

Rio Vista on the Sacramento River — Computed net stream flow in cfs — Minimum 30-day running average of mean daily net flow

YEAR TYPE	Jan.	Feb. 1–Mar. 15	Mar.16–June 30
Wet	2,500	3,000	5,000
Ab. Normal	2,500	2,000	3,000
Bl. Normal	2,500	2,000	3,000
Dry or Critical	1,500	1,000	2,000

YEAR TYPE	July	Aug.	Sept. 1–Dec. 31
Wet	3,000	1,000	5,000
Ab. Normal	2,000	1,000	2,500
Bl. Normal	2,000	1,000	2,500
Dry or Critical	1,000	1,000	1,500

• SUISUN MARSH

Chipps Island at O&A Ferry Landing — Electrical Conductivity — Maximum 28-day running average of mean daily EC

YEAR TYPE	Jan.–May	Oct.–Dec.
Wet	12.5 mmhos	12.5 mmhos
Ab. Normal	12.5 mmhos	12.5 mmhos
Bl. Normal	12.5 mmhos	12.5 mmhos
Dry or Critical	12.5 mmhos	15.6 mmhos

(The 15.6 mmhos EC Standard applies only when project water users are taking deficiencies in scheduled water supplies 8/ otherwise the 12.5 mmhos EC remains in effect.)

BENEFICIAL USE PROTECTED and LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE	VALUES
Chipps Island	Delta Outflow Index in cfs	Average of the daily Delta outflow index for each month, not less than values shown	Wet	February–May: 10,000 cfs
			Subnormal Snowmelt	February–April: 10,000 cfs
		Minimum daily Delta outflow index for 60 consecutive days in the period	Ab. Norm. and Bl. Norm.	January–April: 12,000 cfs

Table III-1. Water Right Decision 1485 (D-1485) water quality standards for the Sacramento-San Joaquin Delta and Suisun Marsh[1/] (continued).

BENEFICIAL USE PROTECTED and LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE[2/]	VALUES
FISH AND WILDLIFE				
• SUISUN MARSH				
Chipps Island (continued)	Delta Outflow Index in cfs	Average of the daily Delta outflow index for each month, not less than values shown	All (if greater flow not required by above standard)—whenever storage is at or above the minimum level in the flood control reservation envelope at two out of three of the following: Shasta Reservoir, Oroville Reservoir, and CVP storage on the American River	Jan.–May 6,600 cfs
Collinsville on Sacramento River (C–2) Miens Landing on Montezuma Slough (S–64) Montezuma Slough at Cutoff Slough (S–48) Montezuma Slough near mouth Suisun Slough near Volanti Slough (S–42) Suisun Slough near mouth (S–31) Goodyear Slough south of Pierce Harbor (S–35) Cordelia Slough above S. P. R.R. (S–32)	Electrical Conductivity	The monthly average of both daily high tide values not to exceed the values shown (or demonstrate that equivalent or better protection will be provided at the location)	All – To become effective Oct. 1, 1984	Month / EC in mmhos Oct. 19.0 Nov. 15.5 Dec. 15.5 Jan. 12.5 Feb. 8.0 Mar. 8.0 Apr. 11.0 May 11.0
• OPERATIONAL CONSTRAINTS				
Minimize diversion of young striped bass from the Delta	Diversions in cfs	The mean monthly diversions from the Delta by the State Water Project (Department) not to exceed the values shown.	All	May 3,000; June 3,000; July 4,600
		The mean monthly diversions from the Delta by the Central Valley Project (Bureau), not to exceed the values shown	All	May 3,000; June 3,000
Minimize diversion of young striped bass into Central Delta		Closure of Delta cross channel gates for up to 20 days but no more than two out of four consecutive days at the discretion of the Department of Fish and Game upon 12 hours notice	All – whenever the daily Delta outflow index is greater than 12,000 cfs	April 16–May 31
Minimize cross Delta movement of Salmon		Closure of Delta Cross Channel gates (whenever the daily Delta outflow index is greater than 12,000 cfs)	All	Jan. 1–April 15

The agricultural standards for the western and interior Delta in the 1978 Delta Plan and D-1485 result in substantially greater protection for Delta agricultural uses than that established in the Basin 5B Plan.

The fish and wildlife standards in the 1978 Delta Plan and D-1485 were taken essentially from a draft Four-Agency Agreement developed among the DWR, DFG, USBR, and USFWS. While the standards in D-1485 were believed to approach a without-project level of protection for striped bass, it was acknowledged that they did not provide equivalent protection for many other species, such as white catfish, shad, and salmon. However, the level of protection provided for these species under the 1978 Delta Plan and D-1485 was believed to be reasonable until final determinations regarding a cross-Delta transfer facility or other mitigation were made.

D-1485 requires that water quality standards in the Delta must be satisfied prior to any export from the Delta to other areas for any purpose. These standards are to be achieved by reduction of direct diversion at the project pumps, release of natural flow or water in storage, operation of the Delta Cross Channel gates, or any combination of these measures. To ensure the collection of data necessary to measure compliance with the standards, D-1485 requires a monitoring program that is implemented through the terms and conditions in the DWR and the USBR water rights permits.

Other D-1485 requirements of the permitees include:

-- Develop and implement a plan for full protection of the Suisun Marsh.

-- Continue and report on negotiations with South Delta Water Agency (SDWA) concerning the construction of physical facilities or other measures for long-term protection of southern Delta agriculture.

-- Report annually on: (1) methods used to determine flows past Rio Vista and improving accuracy of Delta outflow estimates, or on studies to be commenced to determine such procedures; and (2) methods for making more precise projections of salinity distribution in the Delta under varying inflow, outflow, and export conditions.

-- Conduct special studies on the Delta and Suisun Marsh, and develop and improve water quality and biological predictive tools for the western Delta and Suisun Bay area (including Suisun Marsh), San Francisco Bay to the Golden Gate Bridge, and the interior Delta.

-- Participate in research studies to determine: (1) outflow needs in San Francisco Bay; and (2) the need for winter flows for long-term protection of striped bass and other aquatic organisms in the Delta.

Table III-2. Suisun Marsh objectives as amended in D-1485 in 1985.

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	EFFECTIVE DATES	MONTHS	VALUES
Sacramento River at Collinsville	*C-2 RSAC081*	*Eletrical Conductivity (EC)*	*Monthly average of both daily high tide values not to exceed the values shown, in mmhos/cm (or demonstrate that equivalent or better protection will be provided at the location)*	*Oct 1,1988*	*Oct*	*19.0*
					Nov	*15.5*
					Dec	*15.5*
Montezuma Slough at National Steel	*S-64(new) SLMZU25*				*Jan*	*12.5*
					Feb	*8.0*
					Mar	*8.0*
Montezuma Slough near Beldon Landing	*S-49 SLMZU11*				*Apr*	*11.0*
					May	*11.0*
Chadbourne Slough at Chadbourne Road (proposed)	*S-21(prop.) SLCBN1*					
and				*Oct 1,1991*		
Cordelia Slough 500 ft west of S.P.R.R. crossing at Cygnus	*S-33 SLCRD04*					
-or-				*or*		
Chadbourne Slough at Chadbourne Road (proposed)	*S-21(prop.) SLCBN1*					
and				*Oct 1,1993*		
Cordelia Slough at Cordelia Goodyear Ditch (proposed)	*S-97(prop.) SLCRD06*					
Goodyear Slough at Morrow Island Clubhouse	*S-35(new) SLGYR03*			*Oct 1,1991*		
-or-				*or*		
Goodyear Slough, 1.3 mi south of Morrow Island [Drainage] Ditch at Pierce	*S-75 SLGYR04*			*Oct 1,1994*		
Suisun Slough, 300 ft south of Volanti Slough	*S-42 SLSUS12*			*Oct 1,1997*		
Water Supply Intakes for Waterfowl Managecement Areas on Van Sickle and Chipps islands	*No Locations specified*					

D-1485 also provides that:

-- CVP export reductions required to minimize the diversion of young striped bass during May and June may be made up later in the year through coordinated operations involving direct diversion or re-diversion of stored water released through SWP facilities.

-- Variations in flow for experimental purposes for protection and enhancement of fish and wildlife may be allowed, upon SWRCB approval, provided that D-1485 municipal, industrial, and agricultural standards are not violated.

D-1485 adds conditions to the permits of the CVP and the SWP requiring that they meet water quality objectives. In all SWP permits and in CVP permits affecting the Delta, the SWRCB reserved jurisdiction to formulate or revise terms and conditions for salinity control and for fish and wildlife protection, and to coordinate the terms and conditions of the various permits for the two projects. This continuation of reserved jurisdiction in permits issued to the DWR and the USBR which affect Delta water supplies was based on the difficulty of setting reasonably accurate, unlimited duration conditions for the Delta.

To ensure protection of Delta beneficial uses, and to make optimum use of storage, pumping, and conveyance facilities, the operations of the CVP and SWP must be coordinated. Therefore, the terms and conditions related to the Delta are the same in all of the projects' permits. Also, in 1986, the USBR and the DWR entered into the COA (described in Chapter I) which obligates the CVP and the SWP to coordinate their operations to meet D-1485 objectives.

In 1985, some of the standards in D-1485 were amended to change or delete some monitoring stations in the Suisun Marsh and to revise the schedule for implementation of the salinity objectives. Table III-2 presents a summary of the amended Suisun Marsh requirements for the CVP and the SWP.

B. SWRCB 1991 BAY-DELTA PLAN

In May 1991, the SWRCB adopted the 1991 Bay-Delta Plan. The 1991 Bay-Delta Plan superseded: (1) the 1978 Delta Plan to the extent that the 1978 plan addressed the water quality parameters that are included in the 1991 plan; and (2) the regional water quality control plans for San Francisco Bay and the Sacramento-San Joaquin Delta (Basin 2 Plan and Basin 5B Plan, respectively) to the extent of any conflict.

The 1991 Bay-Delta Plan contains numerous water quality objectives for the protection of municipal and industrial, agricultural, and fish and wildlife beneficial uses (Table III-3). They include: salinity levels for municipal and industrial intakes, Delta agriculture, export agriculture, and estuarine fish and wildlife resources; an expanded period of protection for striped bass spawning; and temperature and dissolved oxygen levels for fisheries in the Delta.

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives.

A) MUNICIPAL AND INDUSTRIAL

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
Contra Costa Canal at Pumping Plant #1	*C-5 CHCCC06*	*Chloride (Cl-)*	*Maximum mean daily, in mg/l*	*Not Applicable*	*All*	*Oct-Sep*	*250*
Contra Costa Canal at Pumping Plant #1	*C-5 CHCCC06*	*Chloride (Cl-)*	*Maximum mean daily 150 mg/l chloride for at least the*	*Sac R 40-30-30*			*No. of days each Cal. Year < 150 mg/l Cl-*
- or -			*number of days shown during*		*W*		*240 (66%)*
San Joaquin River at Antioch Water Works Intake	*D-12(near) RSAN007*	*Chloride (Cl-)*	*the Calendar Year. Must be provided in intervals of not*	*Sac R 40-30-30*	*AN*		*190 (52%)*
					BN		*175 (48%)*
			less than two weeks duration.		*D*		*165 (45%)*
			(% of Calendar Year shown in parenthesis)		*C*		*155 (42%)*
West Canal at mouth of Clifton Court Forebay	*C-9 CHWST0*	*Chloride (Cl-)*	*Maximum mean daily, in mg/l*	*Not Applicable*	*All*	*Oct-Sep*	*250*
Delta Mendota Canal at Tracy Pumping Plant	*DMC-1 CHDMC004*	*Chloride (Cl-)*	*Maximum mean daily, in mg/l*	*Not Applicable*	*All*	*Oct-Sep*	*250*
Cache Slough at City of Vallejo Intake [1] and/or	*C-19 SLCCH16*	*Chloride (Cl-)*	*Maximum mean daily, in mg/l*	*Not Applicable*	*All*	*Oct-Sep*	*250*
Barker Slough at North Bay Aqueduct Intake	*- SLBAR3*	*Chloride (Cl-)*	*Maximum mean daily, in mg/l*	*Not Applicable*	*All*	*Oct-Sep*	*250*

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

B) AGRICULTURAL

AREA

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
1) WESTERN DELTA							
Sacramento River at Emmaton	*D-22 RSAC092*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily, in mmhos/cm (mmhos)*	*Sac R 40-30-30*		*0.45 EC April 1 to Date Shown*	*EC from Date Shown to Aug. 15 [2]*
					W	*Aug. 15*	..
					AN	*July 1*	*0.63*
					BN	*June 20*	*1.14*
					D	*June 15*	*1.67*
					C	--	*2.78*
San Joaquin River at Jersey Point	*D-15 RSAN018*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily, in mmhos*	*Sac R 40-30-30*		*0.45 EC April 1 to Date Shown*	*EC from Date Shown to Aug. 15 [2]*
					W	*Aug. 15*	..
					AN	*Aug. 15*	..
					BN	*June 20*	*0.74*
					D	*June 15*	*1.35*
					C	--	*2.20*

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

B) AGRICULTURAL

AREA

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
2) INTERIOR DELTA							
South Fork Mokelumne River at Terminous	*C-13 RSMKL08*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily, in mmhos*	*Sac R 40-30-30*		*0.45 EC April 1 to Date Shown*	*EC from Date Shown to Aug. 15 [2]*
					W	*Aug. 15*	--
					AN	*Aug. 15*	--
					BN	*Aug. 15*	--
					D	*Aug. 15*	--
					C	--	*0.54*
San Joaquin River at San Andreas Landing	*C-4 RSAN032*	*Electrical Conductivity (EC)*	*Maximum 14-day running average of mean daily, in mmhos*	*Sac R 40-30-30*		*0.45 EC April 1 to Date Shown*	*EC from Date Shown to Aug. 15 [2]*
					W	*Aug. 15*	--
					AN	*Aug. 15*	--
					BN	*Aug. 15*	--
					D	*Jun. 25*	*0.58*
					C	--	*0.87*

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

B) AGRICULTURAL

AREA

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
(To be implemented by 1996) [3]		**3) SOUTH DELTA**					
San Joaquin River at Airport Way Bridge, Vernalis	*C-10 RSAN112*	*Electrical Conductivity (EC)*	*Maximum 30-day running average of mean daily EC, in mmhos*	*Not Applicable*	*All*	*Apr 1-Aug 31*	*0.7*
						Sep 1-Mar 31	*1.0*
						or	
Old River near Middle River	*C-8 ROLD69*			*If a three-party contract has been implemented among DWR, USBR and the SDWA, that contract will be reviewed prior to implementation of the above and, after also considering the needs of other beneficial uses, revisions will be made to the objectives and compliance/monitoring locations noted above, as appropriate.*			
Old River at Tracy Road Bridge	*P-12 ROLD59*						
San Joaquin River at Brandt Bridge [site]	*C-6 RSAN073*						
		4) EXPORT					
West Canal at mouth of Clifton Court Forebay -and-	*C-9 CHWST0*	*Electrical Conductivity (EC)*	*Maximum monthly average of mean daily EC, in mmhos*	*Not Applicable*	*All*	*Oct-Sep*	*1.0*
Delta Mendota Canal at Tracy Pumping Plant	*DMC-1 CHDMC004*						

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

C) FISH AND WILDLIFE

HABITAT/SPECIES

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
CHINOOK SALMON							
DISSOLVED OXYGEN							
San Joaquin River between Turner Cut & Stockton	*RSAN050-RSAN061*	*Dissolved Oxygen (DO)*	*Minimum dissolved oxygen, in mg/l*	*Not Applicable*	*All*	*Sep 1-Nov 30*	*6.0*
TEMPERATURE							
Sacramento River at Freeport and	*RSAC155*	*Temperature*	*Narrative Objective*	*Not Applicable*	*All*	*"The daily average water temperature shall not be elevated by controllable factors above 68 deg. F from the I Street Bridge to Freeport on the Sacramento River, and at Vernalis on the San Joaquin River between April 1 through June 30 and September 1 through November 30 in all water year types." [4]*	
San Joaquin River at Airport Way Bridge, Vernalis	*C-10 RSAN112*	*Temperature*	*Narrative Objective*	*Not Applicable*	*All*		
Sacramento River at Freeport	*RSAC155*	*Temperature*	*Narrative Objective*	*Not Applicable*	*All*	*"The daily average water temperature shall not be elevated by controllable factors above 66 deg. F from the I Street Bridge to Freeport on the Sacramento River between January 1 through March 31." [4]*	

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

C) FISH AND WILDLIFE

HABITAT/SPECIES

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
STRIPED BASS - SALINITY: 1. ANTIOCH - SPAWNING							
Sacramento River at Chipps Island	*D-10 RSAC075*	*Delta outflow Index (DOI)*	*Average for the period not less than the value shown, in cfs*	*Not Applicable*	*All*	*Apr 1-Apr 14*	*6,700*
San Joaquin River at Antioch Water Works Intake	*D-12 (near) RSAN007*	*Electrical Conductivity (EC)*	*14-day running average of mean daily for the period not more than value shown, in mmhos*	*Not Applicable*	*All*	*Apr 15-May 31 (or until spawning has ended)*	*1.5*
STRIPED BASS - SALINITY: 2. ANTIOCH - SPAWNING - RELAXATION PROVISION							
San Joaquin River at Antioch Water Works Intake	*D-12 (near) RSAN007*	*Electrical Conductivity (EC)*	*14-day running average of mean daily not more than value shown corresponding to deficiencies in firm supplies declared by a set of water projects representative of the Sacramento River and San Joaquin River watersheds, for the period shown, or until spawning has ended. The specific representative projects and amounts of deficiencies will be defined in subsequent phases of the proceedings.*	*Total Annual Imposed Deficiency (MAF)*		*Apr 1-May 31 EC in mmhos*	
						Dry	*Critical*
				0.0		*1.5*	*1.5*
This relaxation provision replaces the above Antioch & Chipps Island standard whenever the projects impose deficiencies in firm supplies.				*0.5*		*1.8*	*1.9*
				1.0		*1.8*	*2.5*
				1.5		*1.8*	*3.4*
				2.0 or more		*1.8*	*3.7*
				Linear interpolation is to be used to determine values between those shown.			
STRIPED BASS - SALINITY: 3. PRISONERS POINT - SPAWNING							
San Joaquin River at: Prisoners Point	*D-29 RSAN038*	*Electrical Conductivity (EC)*	*14-day running average of mean daily for the period not more than value shown, in mmhos*	*Not Applicable*	*All*	*Apr 1-May 31 (or until spawning has ended)*	*0.44*

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives (continued).

C) FISH AND WILDLIFE

HABITAT/SPECIES

LOCATION	SAMPLING SITE NOs. (I-A/RKI)	PARAMETER	DESCRIPTION	INDEX TYPE	YEAR TYPE	DATES	VALUES
STRIPED BASS - SALINITY: 4. PRISONERS POINT - SPAWNING - RELAXATION PROVISION							
		When the relaxation provision for Antioch spawning protection is in effect:					
San Joaquin River at: Prisoners Point	*D-29 RSAN038*	*Electrical Conductivity (EC)*	*14-day running average of mean daily for the period not more than the value shown, in mmhos*	*Not Applicable*	*D&C*	*Apr 1-May 31 (or until spawning has ended)*	*0.55*

SUISUN MARSH

In regard to the Suisun Marsh, the water quality objectives for Suisun Marsh are unchanged from the 1978 Delta Plan. The implementation vehicle, Water Right Decision 1485 (D-1485), was amended in 1985 to change (or delete) some monitoring stations and to revise the schedule for implementation. The DWR, USBR, DFG, and Suisun Resource Conservation District (SRCD) have signed and adopted a set of three agreements concerning the Suisun Marsh. These are the Suisun Marsh Preservation Agreement (SMPA), the Monitoring Agreement, and the Mitigation Agreement. The SMPA contains water quality standards for the managed marshes of Suisun Marsh which the four signatories would like the State Board to adopt as water quality objectives. The SMPA also describes the physical facilities that the four signatories have agreed would serve the managed marshes in order to maintain production of preferred waterfowl food plants. The facilities built so far, including the Suisun Marsh Salinity Control Gates (previously called the Montezuma Slough Control Structure), have changed the physical regime in the Marsh.

Revised water quality objectives incorporating the SMPA (with any modifications necessitated by the biological assessment) will be adopted by the State Board after the biological assessment (discussed in Section 7.4.2.6 of the plan) is completed. Until that time, the water quality standards in the amended D-1485 will continue to be implemented; see Table 1-2 for a summary of these standards.

Table III-3. 1991 Bay-Delta Salinity Plan water quality objectives

FOOTNOTES:

[1] The Cache Slough objective to be effective only when water is being diverted from this location.

[2] When no date is shown, EC limit continues from April 1.

[3] South Delta Agriculture objectives will be implemented in stages: two interim stages and one final stage. The first interim stage will be implemented with the adoption of the WQCP, the second interim stage by 1994, and the final stage by 1996. Interim Stage 1 — 500 mg/l mean monthly TDS all year at Vernalis. Interim Stage 2 — (to be implemented no later than 1994) 0.7 mmhos/cm EC April 1 to August 31, 1.0 mmhos/cm EC September 1 to March 31, 30-day running average, at Vernalis and Brandt Bridge; with water quality monitored at three current interior stations — Mossdale, Old River, near Middle River and Tracy Road Bridge, and an additional interior monitoring station on Middle River at Howard Road Bridge. Final Stage — (to be implemented no later than 1996) 0.7 mmhos/cm EC April 1 to August 31, 1.0 mmhos/cm EC September 1 to March 31, 30-day running average, at Vernalis and Brandt Bridge on the San Joaquin River; with two interior stations at Old River Near Middle River and Old River at Tracy Road Bridge. Monitoring stations will be at Mossdale at head of Old river and Middle River at Howard Road Bridge.

OR

If a three-party contract has been implemented among DWR, USBR and the SDWA, that contract will be reviewed prior to implementation of the above and, after also considering the needs of other beneficial uses, revisions will be made to the objectives and compliance/montioring locations noted above, as appropriate.

[4] Controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of the waters of the State, that are subject to the authority of the State Board, or the Regional Board, and that may be reasonably controlled. Based on the record in these proceedings, controlling temperature in the Delta utilizing reservoir releases does not appear to be reasonable, due to the distance of the Delta downstream of reservoirs and uncontrollable factors such as ambient air temperature, water temperatures in the reservoir releases, etc. For these reasons, the State Board considers reservoir releases to control water temperatures in the Delta a waste of water; therefore, the State Board will require a test of reasonableness before consideration of reservoir releases for such a purpose.

Appendix to Table III-3. Sacramento Valley Water Year Hydrologic Classification.

Year classification shall be determined by computation of the following equation:

INDEX = 0.4 * X + 0.3 * Y + 0.3 * Z

Where: X = Current years April – July Sacramento Valley unimpaired runoff

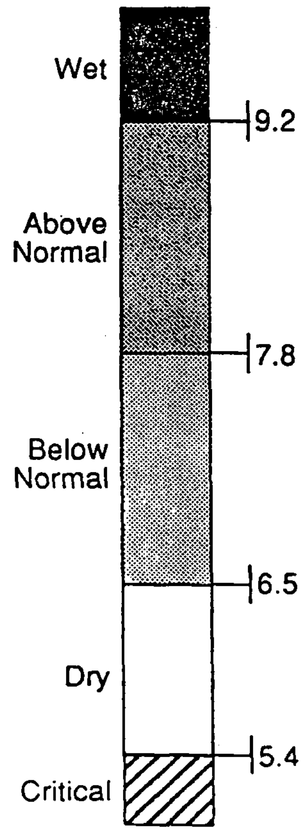
Y = Current October – March Sacramento Valley unimpaired runoff

Z = Previous years index [1]

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year) as published in California Department of Water Resources Bulletin 120 is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

Classification	Index Millions of Acre-Feet
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8 and less than 9.2
Below Normal	Equal to or less than 7.8 and greater than 6.5
Dry	Equal to or less than 6.5 and greater than 5.4
Critical	Equal to or less than 5.4

YEAR TYPE [2]
All Years for All Objectives



Index
Millions of Acre-Feet

[1] A cap of 10.0 MAF is put on the previous years index (Z) to account for required flood control reservoir releases during wet years.

[2] The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available

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Appended to Table III-3 is the water year hydrologic classification for the Sacramento Valley, adopted in the 1991 Bay-Delta Plan, which is used to decide what objectives are applicable each year upon which the application of objectives is based.

Unlike the 1978 Delta Plan, the 1991 Bay-Delta Plan does not include Delta outflow objectives and operational constraints. The flow and operational objectives in the 1978 Delta Plan remain in effect and are implemented through D-1485.

The beneficial uses and water quality objectives in the 1991 Bay-Delta Plan were submitted to the USEPA for review and approval. The USEPA approved the objectives for municipal and industrial uses, agricultural uses, and the dissolved oxygen fish and wildlife objective for the San Joaquin River. All other fish and wildlife objectives in the 1991 plan were disapproved by the USEPA. Although the 1991 plan objectives remain in effect until the USEPA promulgates substitute objectives, the requirements of the 1991 plan have not been implemented through a new water right decision. Therefore, as stated above, D-1485 constitutes the current state regulatory scheme.

C. ENDANGERED SPECIES REQUIREMENTS

Section 7 of the federal ESA requires that federal agencies that authorize, fund, or carry out any federal agency action shall, through consultation, ensure that such action is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of such species. Promptly after conclusion of consultation, a biological opinion must be issued, detailing how the agency action affects the species or its critical habitat.

If jeopardy to the continued existence of the listed species or destruction or adverse modification of critical habitat of the listed species is found by the issuing agency, the biological opinion must include reasonable and prudent alternatives (RPAs) to the proposed agency action. RPAs are defined as alternative actions identified during formal consultation (between the issuing agency and the federal agency taking some action) that the issuing agency believes will avoid jeopardy or adverse modification of habitat. Furthermore, RPAs are economically and technologically feasible measures that can be implemented in a manner consistent with the intended purpose of the agency action.

If the biological opinion concludes that the agency action or the RPA will not likely result in jeopardy yet would result in the taking of the species incidental to the action, the issuing agency must include an incidental take statement. This statement specifies the impact of any incidental taking, provides nondiscretionary reasonable and prudent measures necessary or appropriate to minimize such impact, and sets forth the terms and conditions that must be followed by the federal agency. If the biological opinion concludes that the agency action will likely result in jeopardy, the incidental take is authorized only if the RPA included in the opinion is implemented by the federal agency.

Several biological opinions have been issued to limit the effects of the CVP and SWP operations on two Bay-Delta Estuary species listed under the federal ESA: the endangered Sacramento River winter-run chinook salmon and the threatened Delta smelt. Some background information on the biological opinions for winter-run chinook salmon and Delta smelt issued by the NMFS and the USFWS, respectively, after consultation with the USBR, and a description of the current status of the biological opinions, are provided below.

1. NMFS Biological Opinion for Winter-Run Chinook Salmon

In 1989, the NMFS listed the Sacramento River winter-run chinook salmon as "threatened" under emergency provisions of the federal ESA. That same year, the State of California listed the species as "endangered" under the State ESA. The NMFS formally listed the species as "threatened" in 1990 and, subsequently, reclassified it from "threatened" to "endangered" in 1992. Later that year, the NMFS proposed critical habitat for the winter-run chinook salmon from Keswick Dam at Sacramento River Mile 302 to the Golden Gate Bridge on San Francisco Bay.

In February 1991, the NMFS requested the USBR to formally consult with the NMFS, pursuant to Section 7 of the federal ESA, to determine whether its operation of the CVP jeopardized the continued existence of the then "threatened" Sacramento River winter-run chinook salmon. In September 1992, the USBR requested initiation of formal consultation and provided drafts of the "Long-term Central Valley Project Operations Criteria and Plan" (CVP-OCAP) and biological assessment concerning the effects of long-term operations of the CVP on winter-run chinook salmon. In October 1992, the USBR submitted a final CVP-OCAP and a biological assessment. A companion assessment regarding effects of the combined operations of the CVP and SWP on the salmon was submitted by the DWR in November 1992.

On February 12, 1993, the NMFS issued a long-term biological opinion (NMFS 1993) concerning the effects of the CVP operations on winter-run chinook salmon. The opinion concluded that, based on the USBR's CVP-OCAP and biological assessment of impacts, the proposed long-term operations of the CVP and the SWP are likely to jeopardize the continued existence of Sacramento winter-run chinook salmon. The environmental baseline upon which the opinion was based consisted of proposed CVP/SWP operations under D-1485 regulatory requirements.

When the multi-party Principles for Agreement on Bay-Delta standards was signed on December 15, 1994, the NMFS agreed to initiate immediate reconsultation on the biological opinion and modify it to conform with the agreement. As of the date of adoption of the Bay-Delta Plan and this report, the revised biological opinion for winter-run chinook salmon had not been issued.

2. USFWS Biological Opinion for Delta Smelt

In March 1993, the USFWS listed the Delta smelt as a threatened species under the federal ESA. In October 1993, the USBR requested formal consultation with the USFWS and submitted a biological assessment on the effects of the 1994 operations of the CVP and the SWP on Delta smelt. Later that year, the State of California listed the species as threatened under the State ESA. On February 4, 1994, the USFWS issued a one-year biological opinion (USFWS 1994) which addressed the effects of combined operations of the CVP and the SWP on Delta smelt from February 15, 1994 to February 15, 1995. That opinion concluded that the proposed operations of the CVP and the SWP would result in jeopardy; therefore, an RPA consisting of requirements that the CVP and the SWP implement and comply with specific operational criteria was included.

When the USFWS signed the Principles for Agreement in December 1994, it agreed to initiate immediate reconsultation on the biological opinion and to modify it to conform with the agreement. As a result of reconsultation, the USFWS issued a revised biological opinion for Delta smelt on March 6, 1995 (USFWS 1995). The biological opinion establishes a working group, comprised of representatives of the USFWS, NMFS, USBR, USEPA, DWR, SWRCB, and DFG, to resolve biological and technical issues raised by the biological opinion and develop recommendations with the operations group established under the Framework Agreement.

a. <u>Biological Opinion Requirements</u>. The March 6, 1995 biological opinion states that the proposed long-term combined CVP and SWP operations, as modified by the winter-run chinook salmon biological opinion, the Principles for Agreement, and the draft Bay-Delta plan, are not likely to jeopardize the continued existence of the threatened Delta smelt or adversely modify its critical habitat. The biological opinion presents the water quality standards and operational constraints that provide biological benefits for Delta smelt. These standards and constraints are consistent with the objectives in the plan except for the following:

1. A 90% exceedence forecast, rather than a 75% exceedence forecast, shall be used to determine required San Joaquin River flows.

2. The October pulse/attraction flow for the San Joaquin River at Vernalis of up to 28 TAF does not mention that this additional flow will be limited to that amount necessary to provide a monthly average flow of 2,000 cfs.

3. During the April and May 30-day pulse flow on the San Joaquin River at Vernalis, the USBR will pursue acquisition of flow at Vernalis that exceeds the combined exports of the CVP and the SWP by an amount equal to 50% of the identified pulse flow.

4. When monitoring at the North Bay Aqueduct diversion at Barker Slough indicates the presence of Delta smelt larvae (under 20 millimeters [mm]), diversions from Barker Slough shall be reduced to a 5-day running average rate of 65 cfs, not to exceed a 75 cfs daily average for any day, for a minimum of 5 days.

b. Incidental Take Statement. In operating the CVP and the SWP, the USFWS anticipates the take and loss of Delta smelt, including that incurred by salvage activities at the Tracy and Skinner fish facilities, at the North Bay Aqueduct intake on Barker Slough, and at the Contra Costa Canal intake on Rock Slough. Take is also expected through studies done to determine screening criteria and to improve Delta smelt handling techniques. The biological opinion identifies seven reasonable and prudent measures to minimize the impact of incidental take in the Delta. The biological opinion further states that the USBR and the DWR must comply with specific terms and conditions that implement the reasonable and prudent measures. The seven reasonable and prudent measures, each followed by the terms and conditions (as presented in the biological opinion), are provided below.

1. Improve salvage operations at the Tracy and Skinner fish protection facilities during the Delta smelt spawning period.

   Between December 1 and March 30, truckloads of salvaged fish from the CVP and SWP salvage facilities shall be transported to a new release site whenever the number of adult Delta smelt observed in any salvage count preceding a truckload exceeds 0.5 adult Delta smelt per count minute. The threshold abundance value (0.5 adult Delta smelt) triggering this action may be adjusted by the working group if it is apparent that too few or too many loads are being transported to the new release site. Delta smelt handling techniques (source is specified in the biological opinion) shall be modified for use at the salvage facilities. The USFWS understands that these handling techniques are continually being improved and that all aspects of these techniques may not be appropriate for use at the fish salvage facilities. Therefore, the USBR and the DWR shall submit a plan to the USFWS to modify all aspects of the handling techniques that are appropriate for the fish salvage facilities, and a plan to update these techniques as future improvements occur, within one year of finalization of the biological opinion. Salt shall be added to maintain an 8 parts per thousand (ppt) salinity in transport water for trucking Delta smelt during this period, and this requirement shall be modified to increase survival consistent with the handling techniques modifications. At the Tracy and Skinner fish protection facilities, if Delta smelt are present in samples pulled for fish counts at a facility, Delta smelt shall not be held at that facility more than 8 hours before beginning transport to a release site.

2. Minimize take at the Tracy and Skinner fish protection facilities.

   (a) If the 14-day running average of the combined salvage of Delta smelt juveniles and adults at the CVP and the SWP salvage facilities is 400 or more, then the USBR and the DWR will consider actions to: (1) determine the significance of the increase in salvage; (2) develop and recommend to the USFWS additional monitoring to identify population distribution and the potential for adverse impacts on Delta smelt; and (3) develop recommendations for appropriate actions that can be taken by the USBR and the DWR and submit these actions to the working group. If appropriate, these recommendations may be submitted to the operations group defined in the Principles for Agreement.

(b) The USBR and the DWR shall use Table III-4 at the CVP and the SWP fish salvage facilities on a monthly basis. If reasonable operation of the CVP and the SWP cannot satisfy this requirement, the working group shall meet to develop alternative actions.

Table III-4. Monthly average Delta smelt salvage at the federal and State fish facilities from 1980 to 1992 by water year type. Numbers are total allowable incidental take for each month by water year type, with 90% exceedence forecasts used to update water year classifications monthly.

	Above Normal	Below Normal
Month	Top 25% of Years	Top 25% of Years
January	5,397	13,354
February	7,188	10,910
March	6,979	5,368
April	2,378	12,345
May	9,769	55,277
June	10,709	47,245
July	9,617	35,550
August	4,818	25,889
September	1,329	1,978
October	11,990	6,440
November	3,330	2,001
December	733	8,052

3. Minimize take at the North Bay Aqueduct intake on Barker Slough during the Delta smelt spawning period.

The monthly average of daily density for incidental take of Delta smelt larvae at the Barker Slough diversion shall be the following: 15 larvae per acre-foot (AF) for January-March and May-July, and 20 larvae per AF for April.

4. Minimize take at the Roaring River Diversion in Montezuma Slough.

The USBR and the DWR shall maintain approach velocities at the Roaring River Diversion to 0.2 feet per second (fps) when Delta smelt are present, unless and until new information on a more appropriate approach velocity becomes available. From September through November, an approach velocity of 0.5 fps for 4-6 weeks may be substituted for the above requirement upon approval by the USFWS. Any changes to these approach velocities shall be approved by the USFWS before they are implemented.

5. Minimize take at Contra Costa Water District diversions.

To minimize take of Delta smelt at the unscreened Rock Slough intake, monitoring information described in the reporting requirements of the biological opinion shall be used to determine reduction in diversion of water at the Rock Slough and Mallard Slough intakes. The intent is to minimize take of Delta smelt adults, juveniles, or larvae that are exposed to pumping and diversion-related losses during the spawning and rearing period from January 1 through August 31. Notification of proposed diversion reduction, to reduce take of Delta smelt, shall be submitted to the USFWS for approval.

6. Minimize take by monitoring abundance and distribution of Delta smelt.

(a) If ongoing monitoring indicates that flows specified in the Principles for Agreement and the Bay-Delta Plan are not sufficient to maintain rearing habitat for Delta smelt away from the southern and central Delta, then the working group will convene and make a recommendation to the operations group. The operations group shall then recommend an appropriate action to the USFWS within 10 days to protect Delta smelt, Delta smelt critical habitat, and the Sacramento splittail (proposed for listing). Based on these recommendations, the USBR and the DWR will reinitiate Section 7 consultation, or submit to the USFWS for approval prior to implementation, recommendations for project changes to protect the Delta smelt, consistent with the Principles for Agreement, the Bay-Delta Plan, and the Framework Agreement.

(b) If the summer tow-net survey shows that Delta smelt are not found distributed in three out of seven Suisun Bay stations (405-519) and four out of eight Montezuma Slough and Sacramento River stations (513-707) and/or Delta smelt larval surveys provide evidence that Delta smelt have spawned late (i.e., an average of one or more larvae collected at current [1994] sampling sites during one sampling interval in July or August), then the USBR and the DWR shall recommend that the USFWS convene the working group that will subsequently make a recommendation to the operations group. The operations group shall then recommend an appropriate action to the USFWS within 10 days of the results of the tow-net or larval surveys being available that minimizes entrainment of Delta smelt and maximizes downstream movement of fish away from the pumps. The USFWS shall make a final determination necessary for protection of Delta smelt.

7. Minimize take at the Suisun Marsh Salinity Control Structure.

The DWR shall operate the Suisun Marsh Salinity Control Structure only as required to meet the standards contained within the Bay-Delta Plan. When not operating, the gates shall remain in the raised position.

Literature Cited in Chapter III

DWR. 1994. Comments of the Department of Water Resources at the third public workshop for the review of standards for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Submitted to the State Water Resources Control Board, and presented by David Anderson and Edward Winkler, on June 14, 1994. 19 pp. plus figures and appendices.

NMFS. 1993. Biological opinion for the operation of the federal Central Valley Project and the California State Water Project for winter-run chinook salmon. National Marine Fisheries Service. February 12, 1993. 81 pp. plus attachments.

SWRCB. 1973. New Melones Project water rights decision 1422. State Water Resources Control Board. Sacramento, CA. April 1973. 37 pp.

USFWS. 1994. Biological opinion on the operation of the Central Valley Project and State Water Project effects on Delta smelt. February 4, 1994. U.S. Fish and Wildlife Service, Region 1, Portland, OR. 34 pp. plus figures.

USFWS. 1995. Biological opinion on the effects of long-term operation of the Central Valley Project and State Water Project on the threatened Delta smelt, Delta smelt critical habitat, and proposed threatened Sacramento splittail. March 6, 1995. U.S. Fish and Wildlife Service. Ecological Services. Sacramento Field Office. Sacramento, CA. 52 pp. plus figures and attachments.

CHAPTER IV. ENVIRONMENTAL SETTING

Due to the significant interdependence of water supplies and uses in California, proposing standards for the Bay-Delta Estuary is relevant not only to the Estuary itself but also to a large portion of the State. Much has been already written on the environmental setting of the Estuary, the CVP and the SWP, and affected areas. Unless otherwise cited, the information presented in this chapter is extracted from two DWR sources (DWR 1990, 1993).

This chapter presents an overview of the principal features of the Central Valley (including the Sacramento River, San Joaquin River, and Tulare Lake basins), Sacramento-San Joaquin Delta, San Francisco Bay region, Suisun Marsh, Central Coast region and Southern California (SWP service areas). Because the facilities of the CVP and SWP are relevant to these areas, this chapter begins with a brief description of the two projects.

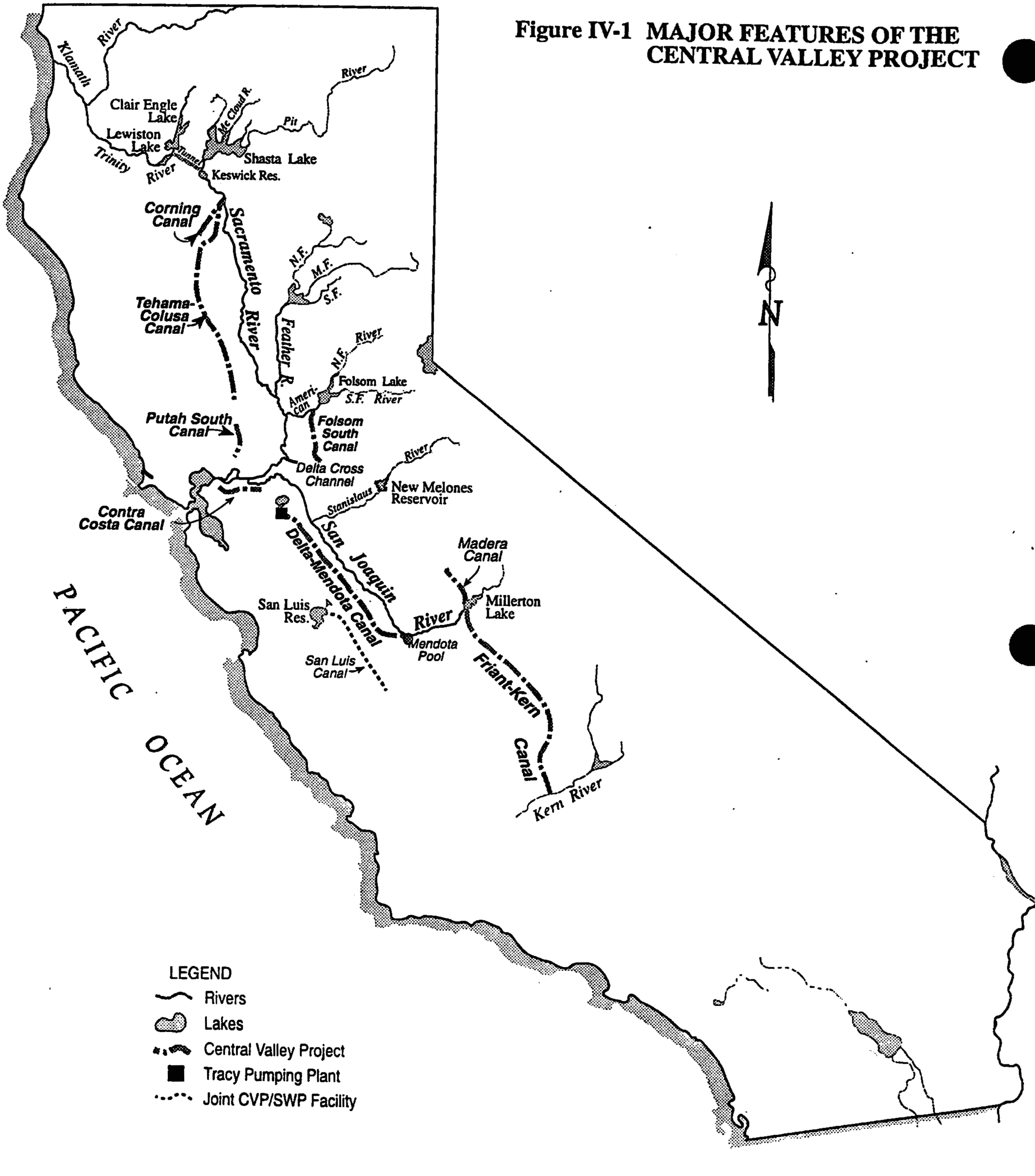
A. CENTRAL VALLEY PROJECT

The CVP, operated by the USBR, is a water storage and transport system designed to capture excess winter flows for flood control and power generation, and to deliver water for agricultural and municipal uses at various locations throughout the State. The CVP stores and controls waters of the Sacramento, Trinity, and American river basins in the northern part of the Central Valley basin for use in the Sacramento River basin and the water-deficient San Joaquin Valley. The CVP system consists of a series of facilities, including 20 reservoirs, eight hydroelectric power plants, two pumping-generating plants, and about 500 miles of major canals and aqueducts (USBR 1981, USBR and DWR 1986). The major features of the CVP are shown in Figure IV-1.

The CVP extends from the Cascade Range (at the northern end of the Central Valley) to the Kern River near Bakersfield (at the southern end of the Central Valley). The focal point of the CVP is Shasta Dam and Shasta Lake on the upper Sacramento River. This 4.5 MAF reservoir is fed by waters of the Sacramento, McCloud, and Pit rivers. Water released to the Sacramento River through Shasta Dam is augmented by water supplies from the Trinity River drainage to the west of the Central Valley. Water from the Trinity River basin, which is stored in Clair Engle and Lewiston lakes, is imported through a tunnel to the Sacramento River at Keswick Reservoir (north of Redding). At Sacramento, the Sacramento River is further augmented by water released from CVP reservoirs formed by Folsom and Nimbus dams on the American River.

A few miles downstream of the confluence with the American River, the Sacramento River enters the northern part of the Bay-Delta Estuary. About 30 miles south of Sacramento, the Delta Cross Channel regulates the passage of some Sacramento River water into interior Delta channels, with the remaining Sacramento River water flowing westward toward Suisun Bay. In the southern Delta, the CVP diverts water at Rock Slough and directly from Delta channels at the Tracy Pumping Plant. At Rock Slough, water is pumped into the Contra Costa Canal for municipal and industrial uses in Contra Costa County. At the Tracy

Figure IV-1 MAJOR FEATURES OF THE CENTRAL VALLEY PROJECT



Pumping Plant, water is lifted nearly 200 feet above sea level into the Delta-Mendota Canal and flows 117 miles southward to the Mendota Pool on the San Joaquin River.

The Delta-Mendota Canal, which follows the Coast Range foothills on the west side of the San Joaquin River, conveys water to agricultural users in the San Joaquin Valley and to the CVP's San Luis Unit for municipal, industrial, and agricultural uses. The San Luis Unit consists of some joint federal-State facilities, including O'Neill Dam and Forebay, San Luis Dam and Reservoir, and San Luis Canal. Water from the reservoir is released into the San Luis Canal for irrigation in the southern San Joaquin Valley.

At the Mendota Pool (the terminus of the Delta-Mendota Canal), waters from the north replace the natural flows of the San Joaquin River which are stored in Millerton Lake and Friant Dam in the foothills above Fresno. Water released through Friant Dam is diverted north through the Madera Canal to serve areas in the central San Joaquin Valley, and south through the Friant-Kern Canal to serve areas in the southern reaches of the San Joaquin Valley.

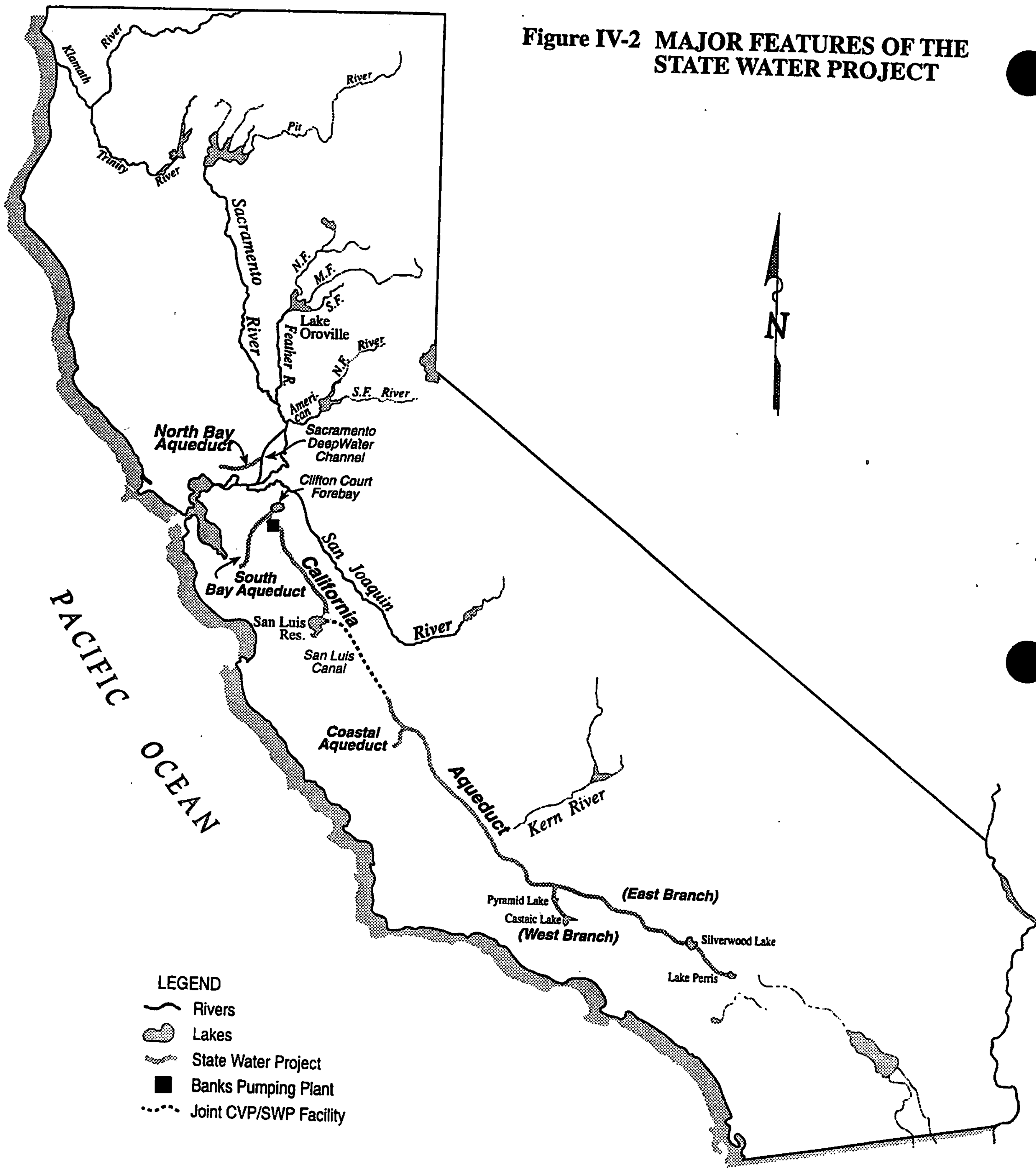
On the Stanislaus River, about 60 miles upstream from the confluence with the San Joaquin River, New Melones Dam forms New Melones Reservoir. Water from New Melones supplements existing supplies within the Stanislaus River basin and is used to maintain water quality in the San Joaquin River.

B. STATE WATER PROJECT

Like the CVP, the SWP stores runoff from the Sacramento Valley basin, releases stored water to the Sacramento River and the Delta, and pumps water out of the southern Delta for delivery to water users to the south and west. The SWP, operated by the DWR, includes 22 dams and reservoirs, 8 hydroelectric power plants, and 17 pumping plants. The major features of the SWP are shown in Figure IV-2.

The SWP's water storage facilities are on the Feather River, the chief component of which is Lake Oroville formed by Oroville Dam. Water from this 3.5 MAF capacity reservoir is released into the Feather River, where it flows into the Sacramento River 21 miles above Sacramento. This water, along with water managed by the CVP, flows in the Sacramento River to the Delta. In the northern Delta, water is diverted from Barker Slough, where it is pumped into the North Bay Aqueduct for use in Solano and Napa counties. In the southern Delta, water is diverted into Clifton Court Forebay, where the Harvey O. Banks Pumping Plant, near Byron, pumps it for diversion into the South Bay Aqueduct, which serves the southern San Francisco Bay area, and into the beginning of the California Aqueduct. The California Aqueduct is the main conveyance facility of the project and extends 444 miles from the Delta to Southern California. From the Delta, the California Aqueduct follows the west side of the San Joaquin Valley to the joint federal/State San Luis Reservoir and continues south to the Tulare Lake basin, where it serves most of the SWP agricultural users.

Figure IV-2 MAJOR FEATURES OF THE STATE WATER PROJECT



The California Aqueduct system was designed to have a capacity of not less than 10,000 cfs between the Banks Pumping Plant and San Luis Reservoir, and not less than 4,400 cfs at all points south of San Luis Reservoir where it leaves the Central Valley and is lifted nearly 2,000 feet into the Tehachapi Mountains by the A.D. Edmonston Pumping Plant. The water flows through a series of four tunnels until it splits into the West Branch, which transports water through Pyramid Lake to Castaic Lake in Los Angeles County, and the East Branch, which delivers water to the Antelope Valley and Silverwood Lake, and terminates at Lake Perris in Riverside County.

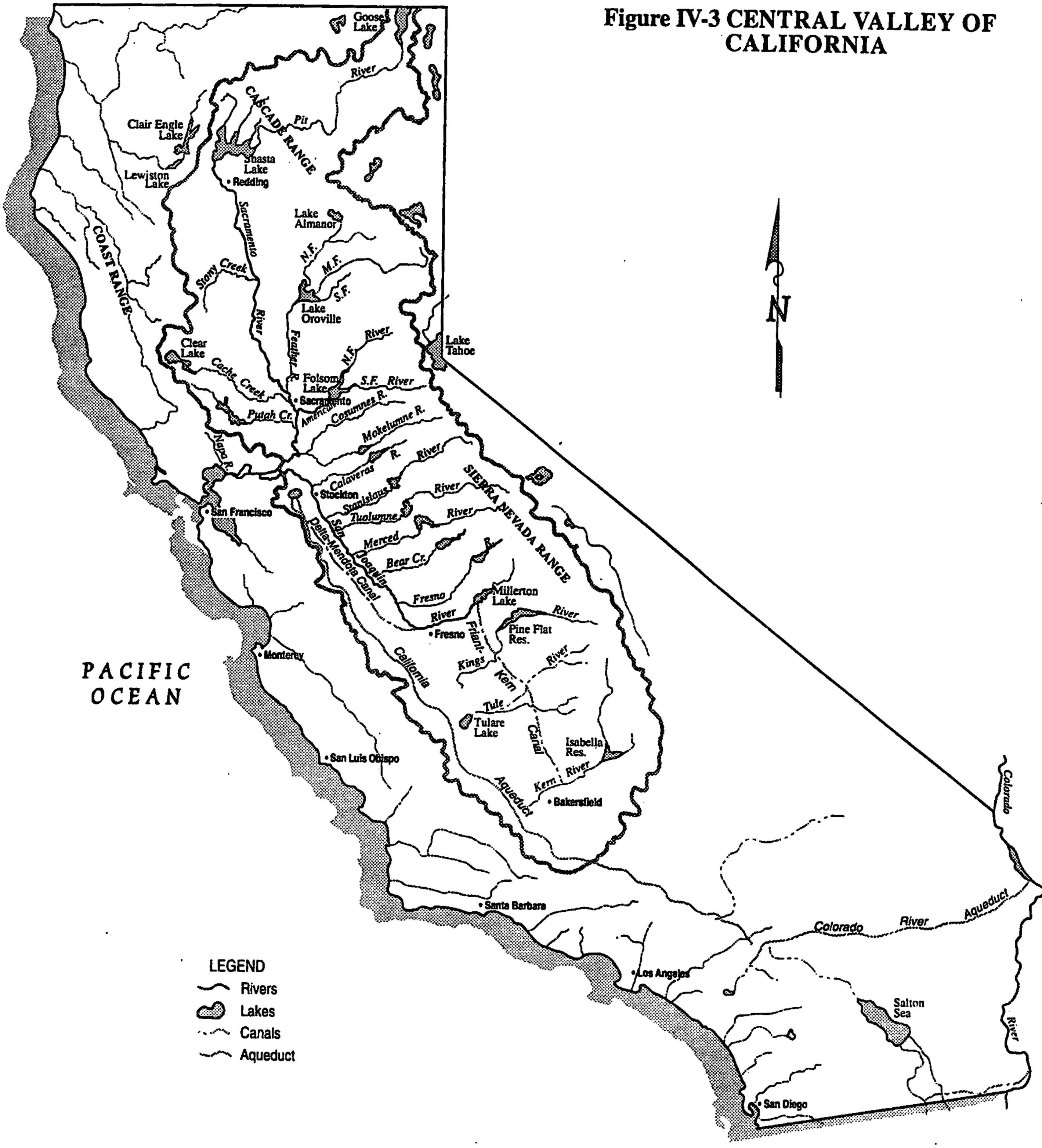
C. CENTRAL VALLEY BASIN

The Central Valley basin of California (Figure IV-3) is comprised of the 450-mile long Central Valley and the surrounding upland and mountain areas which drain into it. The basin, which encompasses about 60,000 square miles, makes up about 40 percent of California. The valley portion of the basin is an alluvial plain which is generally flat below an elevation of 400 feet and varies from 40 to 60 miles in width (USBR and DWR 1986), with an average width of about 45 miles. The valley floor occupies about one-third of the basin; the other two-thirds are mountainous. The basin is entirely surrounded by mountains except for a narrow gap on the western edge at the Carquinez Strait. The Cascade Range and Sierra Nevada on the north and east rise in elevation to about 14,000 feet. The Coast Range on the west generally rises to less than 4,000 feet, but rises to as high as 8,000 feet at the northern end.

Water supply for the Central Valley is chiefly derived from runoff from the mountains and foothills of the Sierra Nevada, with minor amounts from Coast Range streams entering the west side of the valley. Rainfall contributions on the floor of the basin add to the supply. About four-fifths of the annual precipitation, which varies widely, occurs during the winter between the last of October and the first of April, but snow storage in the high Sierra delays the runoff from that area until April, May, and June, in which months half the normal annual runoff occurs. Because a significant portion of precipitation in the basin occurs as winter snowfall in the mountains, runoff may lag precipitation, and the season of runoff often extends into late-spring and summer as the winter snows melt.

The primary use of water in the Central Valley basin is for the production of agricultural crops. However, water is also used by urban communities, industrial plants, and other uses. Surface water supplies have been developed by local irrigation districts, municipal utility districts, county agencies, private companies or corporations, and State and federal agencies. Flood control or water storage works exist on all major streams in the basin, which alters the natural flow patterns. These facilities store water for the dry season and protect against the winter floods that were common before water development. They also produce hydroelectric power, enhance recreation opportunities, and serve other purposes. A complex aquifer system underlies the Central Valley. Although ground water may occur near ground surface, the maximum depth to water is more than 900 feet. Usable storage capacity in a depth zone of 200 feet below ground surface has been estimated as between 80 to 93 MAF in the San

Figure IV-3 CENTRAL VALLEY OF CALIFORNIA



Joaquin River basin, and 22 to 33 MAF in the Sacramento River basin. Low yield in some areas is considered a limiting factor. The dissolved solids content of the ground water averages about 500 parts per million (ppm), but ranges from 64 to 10,700 ppm. The predominant water type varies with location in the aquifer, but calcium, magnesium, sodium, bicarbonates, sulfate, and chloride are all present in significant quantities.

The Central Valley basin is divided into the Sacramento Valley on the north and the San Joaquin Valley on the south. The Sacramento Valley encompasses the Sacramento River basin. The San Joaquin Valley has two sub-basins: the San Joaquin River basin and the Tulare Lake basin. The area in the center of the Central Valley where the Sacramento and San Joaquin valleys merge coincides with a break in the coastal mountains which border the basin on the west side. Here the Sacramento and San Joaquin rivers converge in the Bay-Delta Estuary, flow through Suisun Bay and Carquinez Strait into San Francisco Bay, and out the Golden Gate to the Pacific Ocean.

1. Sacramento Valley

The Sacramento Valley encompasses the drainage areas of California's largest river, the Sacramento. The valley lands comprise the western drainage of the Sierra Nevada and the Cascade Range, the eastern drainage of the Coast Range, and the valley floor (which makes up 34 percent of the basin). The Sacramento River basin (Figure IV-4) includes the McCloud and Pit river basins, the Goose Lake basin, the Feather, Yuba, Bear, and American river basins (which flow from the Sierra Nevada), and the basins of Cottonwood, Stony, Cache, and Putah creeks (which drain the Coast Range).

The climate of the valley floor areas of the Sacramento River basin is characterized by hot, dry summers and mild winters with relatively light precipitation. Warm, dry summers and cold winters with heavy rain and snow prevail in the mountainous areas where elevations exceed 5,000 feet. The average annual precipitation varies with elevation and ranges from less than 10 inches in the valley to over 95 inches in the Sierra Nevada and Cascade ranges.

Surface Water Hydrology. The Sacramento River basin has about two-thirds of the surface water supply of the Central Valley. Average runoff from the basin is estimated at 22.4 MAF per year (DWR 1994a). Water resources in the basin have been extensively developed for a wide range of purposes. The area has a total of about 16.0 MAF of surface storage capacity, with over 10.5 MAF in four major reservoirs: Lake Shasta on the Sacramento River (4.6 MAF), Oroville Reservoir on the Feather River (3.5 MAF), Folsom Lake on the American River (1.0 MAF), and Lake Berryessa on Putah Creek (1.6 MAF). A list of the major reservoirs in the Sacramento River basin is presented in Table IV-1. Substantial amounts of water are imported into the valley from the Trinity River Division of the CVP. Much smaller quantities of water are also imported into the region from the Cosumnes River (Sly Park), the Truckee River (Little Truckee Ditch), and the Echo Lake Conduit.

Figure IV-4 SACRAMENTO RIVER BASIN

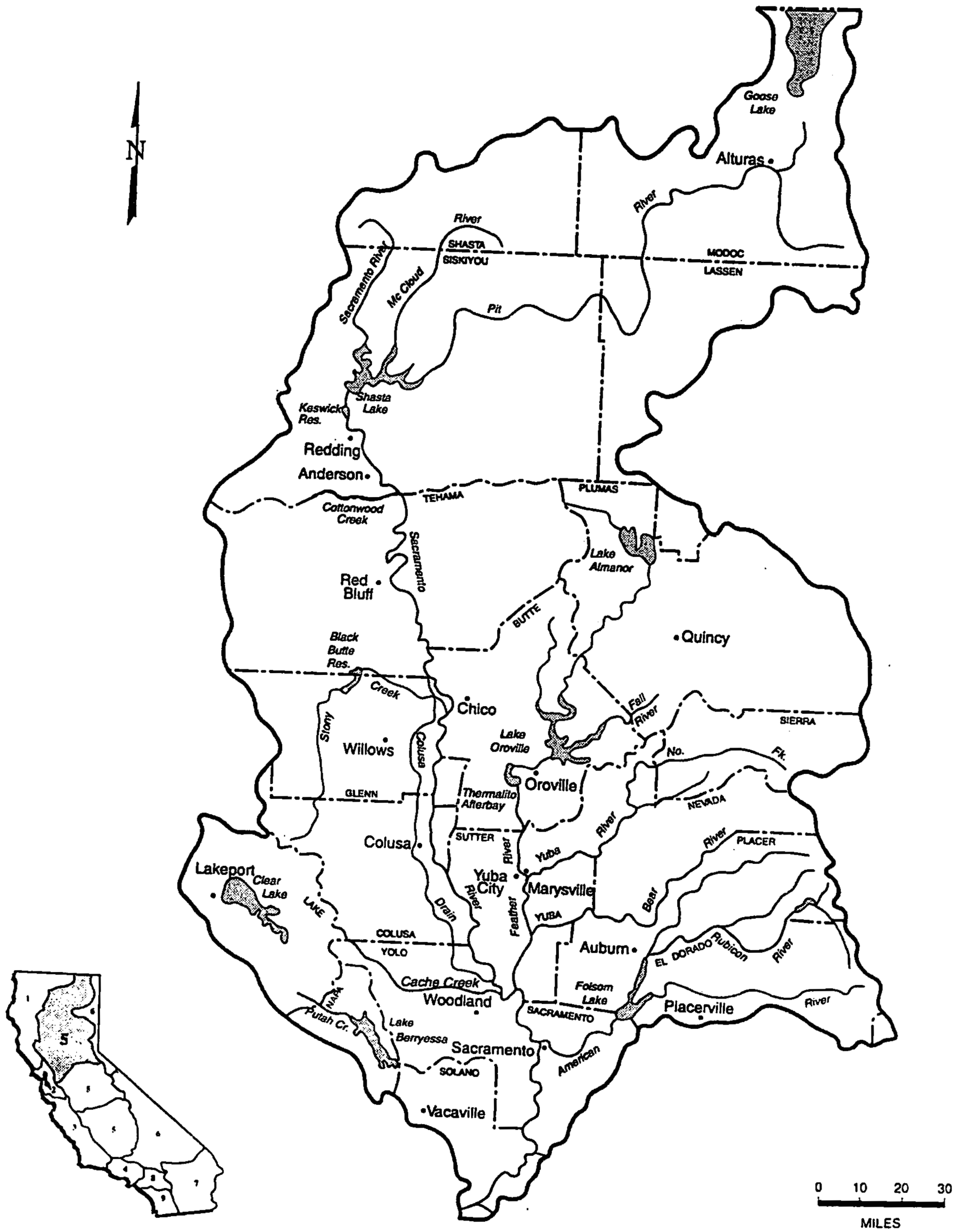


Table IV-1. Major Reservoirs in the Sacramento River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
McCloud	McCloud River	35.2	PG&E
Iron Canyon	Pit River	24.2	PG&E
Lake Britton	Pit River	40.6	PG&E
Pit No. 6	Pit River	15.9	PG&E
Pit No. 7	Pit River	34.6	PG&E
Shasta	Sacramento River	4,552.0	USBR
Keswick	Sacramento River	23.8	USBR
Whiskeytown	Clear Creek	241.1	USBR
Lake Almanor	Feather River	1,143.8	PG&E
Mountain Meadows	Feather River	23.9	PG&E
Butt Valley	Butt Creek	49.9	PG&E
Bucks Lake	Bucks Creek	105.6	PG&E
Antelope	Indian Creek	22.6	DWR
Frenchman	Little Last Chance Creek	55.5	DWR
Lake Davis	Big Grizzly Creek	84.4	DWR
Little Grass Valley	Feather River	94.7	Oroville Wyandotte ID
Sly Creek	Lost Creek	65.7	Oroville Wyandotte ID
Thermalito	Feather River	81.3	DWR
Oroville	Feather River	3,537.6	DWR
New Bullards Bar	Yuba River	966.1	Yuba County WA
Jackson Meadows	Yuba River	69.2	Nevada ID
Bowman Lake	Canyon Creek	68.5	Nevada ID
French Lake	Canyon Creek	13.8	Nevada ID
Spaulding	Yuba River	74.8	PG&E
Englebright	Yuba River	70.0	USCOE
Scotts Flat	Deer Creek	48.5	Nevada ID
Rollins	Bear River	66.0	Nevada ID
Camp Far West	Bear River	104.0	So. Sutter WD
French Meadows	American River	136.4	Placer Co. WA
Hell Hole	Rubicon River	207.6	Placer Co. WA
Loon Lake	Gerle River	76.5	SMUD
Slab Creek	American River	16.6	PG&E
Caples Lake	Caples Creek	26.6	PG&E
Union Valley	Silver Creek	277.3	SMUD
Ice House	Silver Creek	46.0	SMUD
Folsom Lake	American River	976.9	USBR
Lake Natoma	American River	9.0	USBR
East Park	Stony Creek	50.9	USBR
Stony Gorge	Stony Creek	50.4	USBR
Black Butte	Stony Creek	143.7	USCOE
Clear Lake	Cache Creek	313.0	Yolo Co. FCWCD
Indian Valley	Cache Creek	300.0	Yolo Co. FCWCD
Lake Berryessa	Putah Creek	1,600.0	USBR

Source: DWR 1994a

In addition to the major reservoirs built for flood control, there are other flood control measures consisting of more than 2.2 MAF of potential flood control storage. These are a highly developed system of flood control basins, levees, channels, and bypasses. Sacramento Valley levees and bypasses extend over 150 miles, from Red Bluff on the north to Suisun Bay on the south, and include the Butte, Colusa, Sutter, American, and Yolo basins. The basins are composed of a series of natural and man-made bypass overflow areas that act as auxiliary channels to the Sacramento River during floodwater times. The bypass areas are used for agriculture during the summer and fall months, and are valuable wetlands during the flood season.

Runoff from the upper Sacramento River watershed (the southern Cascade mountains, the Warner mountains, and the Trinity mountains) is stored in Shasta Reservoir near Redding. Major tributaries above Shasta Dam are the Pit, McCloud, and Sacramento rivers. The Pit River, which is the most extensive tributary to Shasta Reservoir contributes about 59.5 percent of the average annual surface inflow to the reservoir. The McCloud River, which originates in southeastern Siskiyou County at an elevation of about 4,900 feet, represents about 9.3 percent of the average annual surface inflow to Shasta Lake since the completion of McCloud Dam 16.5 miles upstream from Shasta Lake in 1965. Water from Lake McCloud, which has a storage capacity of 35.2 TAF, is diverted to Iron Canyon Reservoir in the Pit River drainage for power production. The Sacramento River, which originates as the north, middle, and south forks on the east slopes of the Trinity Divide in Siskiyou County, contributes about 13.9 percent of the total average annual surface inflow to Shasta Lake. Minor tributaries to the lake provide the remaining inflow.

About 8 miles downstream from Shasta Dam, Keswick Dam impounds Keswick Reservoir, with a storage capacity of 23.8 TAF, which regulates releases from Shasta and Spring Creek powerplants. To control sediment and debris above Spring Creek Powerplant and to regulate acid mine drainage from Iron Mountain Mine, the Spring Creek Debris Dam, located on Spring Creek, was constructed above the tailrace of the Spring Creek Powerplant. Releases from the 5.9 TAF reservoir are made into Keswick Reservoir.

Whiskeytown Reservoir regulates diversions from Lewiston Lake on the Trinity River. Diverted water is released into the Clear Creek Tunnel to the Judge Francis Carr Powerhouse, which discharges to Whiskeytown Reservoir. Water from Whiskeytown Lake, a 241 TAF reservoir on Clear Creek, is released through a 3-mile long tunnel to the Spring Creek Powerplant and discharged to Keswick Reservoir. Clear Creek, the second largest tributary on the west side of the basin, is tributary to the Sacramento River, below Keswick Dam between Redding and Anderson.

The 56-mile stretch of the Sacramento River from Keswick Dam to Red Bluff is largely contained by steep hills and bluffs. River flows in the upper part of this reach are highly controlled by releases from Shasta Reservoir, but become more influenced by tributary inflow downstream. Major tributaries to the Sacramento River between Keswick Dam and Red Bluff include Cow, Stillwater, Bear, Battle, Paynes, Cottonwood, and Clear creeks.

The 98 miles of Sacramento River between Red Bluff and Colusa is a meandering stream, migrating through alluvial deposits between widely spaced levees. From about Colusa to the Delta, the Sacramento River is regulated by the Sacramento River Flood Control Project system of levees, weirs, and bypasses which divert floodwater in the Sacramento River into the Sutter Bypass. Sutter Bypass, running roughly parallel and between the Sacramento and Feather Rivers, receives additional flow from the Feather River, and the combined flow enters the Yolo Bypass at Fremont Weir near Verona. American River flood flows enter the Yolo Bypass through the Sacramento Weir. The Yolo Bypass returns the entire excess flood flow to the Sacramento River, about 10 miles above Collinsville. The system provides flood protection to about 800,000 acres of agricultural lands and many communities, including the cities of Sacramento, Yuba City, and Marysville.

Stream flow in this stretch of the Sacramento River is modified well upstream by Shasta Dam and several diversion structures, especially the Sacramento River Flood Control Project. Major streams entering the Sacramento River include Thomes, Elder, Stony, and Putah creeks from the west, and Antelope, Mill, Deer, and Big Chico creeks and the Feather and American rivers from the east. Numerous small tributaries drain the low foothills on either side of the valley.

Over 200,000 acres in the Sacramento Valley in Tehama, Glenn, Colusa, and Yolo counties are served by the Sacramento Canals Unit of the CVP, which consists of the Red Bluff Diversion Dam, Corning Pumping Plant, and several canals (USBR 1975). The Red Bluff Diversion Dam, which creates a 3,900 acre-foot lake on the Sacramento River, diverts water from the river at Red Bluff to the Tehama-Colusa Canal service areas. The Corning Pumping Plant, in the canal about half a mile downstream from the Diversion Dam, lifts water 56 feet from the Tehama-Colusa Canal into the 21 mile long Corning Canal. The capacity of the Corning Canal varies from 500 cfs at the Pumping Plant to 88 cfs at the terminus, 4 miles southwest of Corning. The 122 mile long Tehama-Colusa Canal, which terminates in the northern part of Yolo County, has an initial diversion capacity of 2,300 cfs.

The Glenn Colusa Irrigation District supplies water from the Sacramento River near Hamilton City to about 175,000 acres of land, including 25,000 acres within three federal wildlife refuges. Numerous small diversions along the Sacramento River provide irrigation to riparian lands. The Colusa Basin drainage area, which consists of 1,619 square miles of watershed, is located west of the Sacramento River, extending from Orland to Knights Landing. The basin contains some 350,000 acres of rolling foothills, intersected by several stream channels located along the eastern slopes of the Coast Range, and about 650,000 acres lying in the flat agricultural lands of the Sacramento Valley. The Colusa Basin Drain, a multi-purpose drain that is used both as an irrigation supply canal and as an agricultural return flow facility, flows southerly along the eastern boundary of the basin. The drain eventually discharges into the Sacramento River through the regulated outfall gates at Knights Landing or, during flood events, into the Yolo Bypass through the Knights Landing Ridge Cut.

The Yolo Bypass, a low lying area of about 40,000 acres bordered by flood control levees, is part of the Sacramento River Flood Control Project. The flood control project consists of about 1,000 miles of levees plus overflow weirs, pumping plants, and bypass channels that provide flood protection to urban areas, communities, and agricultural lands in the Sacramento Valley and Sacramento-San Joaquin Delta. A deep channel, the Toe Drain, borders the east levee. Water enters the Yolo Bypass from the Sacramento River flood flows, local and regional stormwater runoff, tidal action, wastewater discharge, and direct diversion for agriculture. Water is present in the Bypass throughout the year, with peak flows occurring during the winter in response to storm events. During high flows, water is diverted into the Yolo Bypass from the Sacramento River via the Fremont and Sacramento weirs, near Knights Landing and West Sacramento, respectively. When the Yolo Bypass floods, large areas of seasonal wetlands, seasonal mud flats, and deep, open water cover types are created. Several private duck clubs with wetlands are located in the Yolo Bypass. In the summer, agricultural return flows enter the area primarily along the west side bypass levee.

On the Feather River, Oroville Reservoir controls potential floodwater, conserves water for release downstream, stores water for power generation, and provides recreational opportunities. The reservoir has a capacity of over 3.5 MAF. Electrical power is generated in the Hyatt-Thermalito complex at the base of the dam. The intake structure to the powerplant is designed so water can be drawn from various depths in the reservoir pool, thus allowing adjustments in the temperature of released water. Water released through the powerplant enters the Thermalito Diversion Pool created by the Thermalito Diversion Dam, about 4,000 feet downstream from Oroville Dam.

A portion of the fish maintenance flow is released directly to the Feather River from the Diversion Pool, but greater volumes of water are diverted to two irrigation canals, the Feather River Fish Hatchery, and the Thermalito Powerplant. Four canals divert from the Afterbay of the Thermalito Powerplant. Return flows from the fish hatchery and Thermalito Afterbay releases for fish and the Delta make up river flow below the Afterbay outlet. The Feather River then flows south for 65 miles before emptying into the Sacramento River near Verona, about 21 river miles above Sacramento.

Above Oroville Dam, the Feather River drains 3,634 square miles of watershed with an average annual runoff of 4.2 MAF. Three small reservoirs (Davis, Frenchman, and Antelope) on separate forks of the Feather River have a combined storage capacity of 162.4 TAF and provide local irrigation, recreation, and incidental flood control. All three reservoirs are stocked with trout, and water releases are regulated to improve downstream fish habitat. Below Oroville Dam, an additional 2,297 square miles of watershed contribute 1.5 MAF annually, principally from two large tributaries, the Yuba River and the Bear River.

The Yuba River, on the western slope of the Sierra Nevada mountains, has a watershed of about 1,300 square miles. Flows in the North Yuba River are impounded in the Yuba

County Water Agency's New Bullards Bar Reservoir about 29 miles northeast of Marysville. The reservoir has a storage capacity of 966 TAF, with a usable capacity of 727.38 TAF. Releases from New Bullards Bar Reservoir join the Middle Yuba River and flow into Englebright Reservoir, which stores 70 TAF. The South Yuba River also flows into Englebright Reservoir. Releases from Englebright Dam flow westerly 12.7 miles to Daguerra Point Dam and then 11.4 miles to join the Feather River at Marysville. Daguerra Point Dam serves both as a barrier to impair downstream movement of mining debris and as the point of diversion for the major water irrigation districts utilizing Yuba River flows. Operation of the facilities for power production, fisheries maintenance, water supply, recreation, and flood control are presently beneficial uses.

The American River drains a 1,921 square mile area in the north-central portion of the Sierra Nevada, with mean annual unimpaired runoff estimated at 2.6 MAF (at Fair Oaks). CVP facilities on the American River include Folsom Dam and Reservoir, with 1.01 MAF of storage capacity, and Nimbus Dam which impounds Lake Natomas as an afterbay for Folsom Dam. These facilities regulate river flow for irrigation, power, flood control, municipal and industrial use, and other purposes. The project provides about 500 TAF annually for irrigation and municipal water supplies. The American River joins the Sacramento River about 25 miles downstream from Nimbus Dam.

Surface Water Quality. Water quality problems in the Sacramento River basin associated with irrigated agriculture and municipal and industrial discharges are relatively minor compared with other parts of the Central Valley. This has resulted in part from the use of the Sacramento River to convey increasing quantities of water developed within the Sacramento River basin or imported from the North Coastal basin.

Water quality in Shasta Lake reflects the high quality of the tributary streams. Mineral and nutrient quality is excellent. However, mine and mine tailing contaminated runoff from Squaw and Backbone creeks causes localized copper pollution and fish kills.

Shasta Lake thermally stratifies, producing significant differences between surface and bottom water temperatures. Surface water temperatures have ranged to a maximum of 88°F, during the summer of 1976, with bottom temperatures of 47.5°F for the same period. Typically, however, surface water temperatures during the summer range from 70 to 75°F, with bottom temperatures ranging from 40 to 45°F. During summer thermal stratification, minimum dissolved oxygen levels have been found near the thermocline as low as 3 to 6 parts per million (ppm).

Surface waters in the Sacramento River area between Keswick Dam and Red Bluff are an excellent mineral quality suitable for most beneficial uses. Waste discharges originating from industrial and municipal developments enter the Sacramento River along the entire length from Keswick to Red Bluff. Lumber by-product industries, cities and towns, light industries, food product plants, and a considerable volume of irrigation return flow all contribute a significant waste load to the Sacramento River. Conversion to regional sewer plants rather than individual septic systems, while alleviating much of the concern for ground water contamination, has resulted in effluent with concentrated nutrient loads. This concentrated effluent is discharged to the Sacramento River by the cities of Redding south of Clear Creek, Red Bluff upstream from the diversion dam, and Chico. Sewer treatment plant failure has occurred at the Red Bluff facility, resulting in the discharge to the Sacramento River of untreated domestic and municipal effluent.

Drainage from abandoned mines and tailings has upon occasion caused severe local losses of fish in the upper watershed. A few miles northwest of Redding lies the Iron Mountain region containing metallic ore deposits, some of which are presently being mined. Water draining from this area, especially via Spring Creek, is frequently acidic and has undesirable concentrations of copper, zinc, iron, aluminum, and other toxic salts which are leached from tailings of both operating and abandoned mines. Water from this area is at times lethal to fish, and adversely affects animal and plant organisms on which fish feed. To alleviate this problem, USBR constructed the Spring Creek debris dam near the mouth of Spring Creek, which drains to Keswick Reservoir. Because high flows cause frequent uncontrolled releases of toxic laden water to Keswick Reservoir, USEPA has declared the Iron Mountain complex a Superfund site and has initiated actions to reduce the output of toxic materials.

Dioxins, which are closely related group of highly toxic compounds produced as by-products of various industrial processes, were discovered as a by-product of the pulp bleaching process of paper mills in 1987. High levels of dioxins are discharged with mill waste into the Sacramento River near Anderson. The Department of Health Services has issued an advisory not to eat resident fish from the Sacramento River between Keswick and Red Bluff. The Central Valley RWQCB has ordered the paper company to reduce dioxins concentrations in the discharge.

The Sacramento River downstream from Keswick Dam has been designated as spawning waters for anadromous fish, with a minimum allowable dissolved oxygen level of 7 mg/l. Dissolved oxygen concentrations have ranged from slightly below 10 mg/l to over 12 mg/l. Overall, the river remains well oxygenated throughout the reach from Keswick Dam to the Red Bluff Diversion Dam.

Warm water temperatures in the Sacramento River downstream from Shasta Dam have affected upstream salmon migration and caused egg mortalities. Temperatures are generally too warm for optimum spawning and rearing in the late-summer and fall, and too cold for optimum juvenile growth in the spring. The problem is most severe in the early-fall during dry years when low flows of relatively warm water are further influenced by high ambient air temperatures. Although high water temperatures occur naturally in the river, operation of Shasta Dam has aggravated the problem. Fall release temperatures from Shasta Dam are too warm for salmon spawning during dry years. Temperatures are partially controlled by modifying operations and importing colder water from Clair Engle Lake. Operational modifications include release of colder water through lower dam outlets, which result in loss of power generation through hydroelectric facilities at the dam. Construction of a temperature curtain in Shasta Reservoir to allow the control of temperature of water releases and the maintenance of hydroelectric power generation, although not yet started, was planned for the fall of 1994.

The Central Valley RWQCB has established a temperature objective of 56°F to be attained to the extent controllable throughout the spawning area between Keswick Dam and Hamilton City. The current interim bypass operation required under the USBR's water rights at Shasta Dam is to meet the 56°F temperature objective, most of the time, immediately between Keswick Dam and Red Bluff, except during the months of August, September, and October, when temperatures may exceed this level on occasion. Temperatures remain below 62°F at Red Bluff in 75 percent of the years during September.

Effects of Shasta Dam releases on upper Sacramento River water temperatures decrease with downstream distance. River temperatures are greatly affected by ambient air temperature between the point of release and the Red Bluff Diversion Dam, particularly during the summer months. Ambient air temperature and tributary accretions combine to produce high summer river temperatures detrimental to some fishery resources in the river between Keswick Dam and the Red Bluff Diversion Dam. Elevated temperatures in the upper river during late-summer and early-fall is a primary factor limiting winter-run chinook salmon survival, which has been listed as an endangered species by the State and federal governments.

The Sacramento River between Red Bluff and the Delta is generally of good quality. Although the river appears suitable for beneficial uses, periodic degradation occurs from the discharge of toxins, untreated sewage, and other non-point source contaminants. In the lower Sacramento River, water quality is affected by intrusion of saline sea water, which is of increasing concern as consumptive uses of freshwater continue to increase statewide.

The upper reaches of major tributaries, including the Feather, Yuba, and American rivers, all have excellent water quality characteristics. Downstream from storage reservoirs, however, some degradation occur due to various discharges. Downstream water temperature is a concern on the Yuba and American rivers.

Agricultural drainage is the major source of waste water, and contributes to lower water quality during low flow periods in the Sacramento River and lower reaches of the major tributaries. In the past, rice field herbicides caused the most significant degradation, but recent efforts by the State Department of Food and Agriculture (DFA) and the Central Valley RWQCB have largely controlled this problem.

Water quality concerns in tributaries include: low dissolved oxygen levels in Butte Slough, Sutter Bypass, and Colusa Basin Drain; high water temperatures below diversion structures on Butte Creek; concentrations of minor elements (chromium, copper, iron, lead, manganese, selenium, and zinc) that exceed beneficial use criteria in the Sutter Bypass; and pesticide residues in the Sutter and Yolo bypasses and Colusa Basin Drain. Additional concern exists for effects of tributary discharges to the Sacramento River, including elevated temperature, dissolved solids, minor elements, pesticides, and turbidity, especially from the Sutter and Yolo bypasses and Colusa Basin Drain.

Ground Water Hydrology. Ground water in the Sacramento Valley is pumped from over 20 principal basins, most of which underlie the valley floor. Total storage capacity of the 22 ground water basins in the Sacramento River basin has been estimated as 139 MAF. Of these basins, only 8 have sufficient data available to estimate usable ground water storage. The total usable storage for these basins is 22.1 MAF with 22 MAF in the Sacramento Valley. The safe ground water yield is about 1.6 MAF per year, and the annual overdraft is about 140 TAF.

Ground water in the basin between Keswick Dam and Red Bluff may be either abundant or sparse. The lack of water has precluded major development in the upper areas. The Redding Ground Water Basin contains most of the usable ground water in this portion of the Sacramento River drainage.

The Sacramento Valley ground water basin encompasses about 5,000 square miles, extending from Red Bluff to the Sacramento-San Joaquin Delta. The basin includes all of Sutter County and portions of Yuba, Tehama, Glenn, Butte, Colusa, Yolo, Solano, Placer, and Sacramento counties. Large quantities of water are stored in thick sedimentary deposits in this area. The total ground water in storage to a depth of 600 feet is estimated to be 113.6 MAF.

Ground water is used intensively in some areas and only slightly in others where surface water supplies are abundant. However, overall consumption has been increasing steadily since the early-1900's. In 1990, ground water accounted for about 29 percent of all agricultural water in the valley. The total amount of Sacramento Valley ground water pumped represents about 12 percent of the 15 MAF pumped annually from all basins in the State.

Ground water levels fluctuate according to supply and demand on daily, seasonal, annual, and even longer bases. Short-term and long-term water level changes have been recorded for wells since the first documented measurements in 1929. In the north valley, there are no consistent downward trends, but the southern representative wells show long-term declines in nearly all counties since early measurements were made.

Ground water replenishment occurs through deep percolation of stream flow, precipitation, and applied irrigation water. Stream percolation and deep percolation of rainfall combine to provide a greater amount of recharge than does applied irrigation water. Recharge by subsurface inflow is considered negligible compared to other sources. Approximately two-thirds of the basin's total recharge under natural conditions occurs north of the Sutter Buttes, with the remainder in the southern valley.

Ground Water Quality. Between Red Bluff and the Delta, ground water is generally of excellent mineral quality and is considered class 1 for irrigation purposes. This water is generally suitable for domestic and industrial uses. Poor quality water, however, does exist in the basin fringe area near the base of the foothills, where the salt water bearing Chico formation rises near the surface.

The quality of ground water is generally excellent throughout the Sacramento Valley and is suitable for most uses. Concentration of TDS is normally less than 300 mg/l, although water in some areas may contain solids to 500 mg/l. Ground water beneath the eastern basin is commonly a magnesium-calcium or calcium-magnesium bicarbonate water. High concentrations of sodium chloride waters are found at Robbins, Clarksburg, and several areas near the edge of the basin where Cretaceous-age rocks are nearby. There are also some areas where iron, manganese, and boron are present in undesirable amounts, but the water generally remains suitable for most purposes.

In terms of mineral content, ground water in the west half of the valley is significantly poorer than that in the east half. This is a reflection of the rock types in the Coast Range, which contain more soluble minerals and saline connate waters than do the igneous and metamorphic rocks in the Cascade Range and Sierra Nevada. Calcium-magnesium and magnesium-calcium bicarbonate types are common here as well, but there are areas near Maxwell, Williams, and Arbuckle where high concentrations of sodium, chloride, and sulfate water occur with TDS concentrations of 500 mg/l or more. Some of these waters are unsuitable for irrigation and drinking.

At a considerable depth beneath the valley, nearly all ground water contains sodium chloride. Depth to the base of fresh water is about 1,100 feet beneath most of the northern valley and commonly over 1,500 feet in the southern valley. Two exceptions, where saline water occurs at shallow depths, are in the Robbins area, south of Sutter Buttes, and the Colusa area. Depth of saline water may be similarly shallow at the valley margins on both sides.

Vegetation. The Sacramento River between Red Bluff and Colusa contains most of the river's remaining natural riparian vegetation, with only a small fraction of the original acreage of woody riparian vegetation still intact and relatively undisturbed in the reach of the Sacramento River between Colusa and the Delta. Riparian trees and shrubs occur along the Sacramento River in widths ranging from a few yards where the levee is the riverbank, to a flood plain riparian forest several hundred yards wide.

The primary wetland types along the Sacramento River between Red Bluff and the Delta are defined in USFWS's National Wetlands Inventory as: (1) palustrine forested, scrub-shrub, or emergent wetlands, which are freshwater wetlands dominate by trees, shrubs and emergent vegetation; and (2) riverine wetlands, which are freshwater wetlands contained within a channel. These wetlands types are in decline according to USFWS.

Four special status plant species that may occur within habitats along this portion of the Sacramento River include: Suisun Marsh aster, California hibiscus, Mason's lilaeopsis, and Delta tule pea.

__Wildlife and Fish__. The Sacramento River basin supports a large variety of game and non-game species, including millions of wintering waterfowl. The wildlife resources between Keswick Dam and Red Bluff are associated with riparian, oak woodland, marsh, and grassland habitat, in addition to agricultural lands. The riparian corridor along the river below Keswick Dam is inhabited by passerine birds, waterfowl, shore and wading birds, upland game birds, and raptors. Riparian areas are also valuable habitats for numerous species of mammals, including furbearers.

Between Red Bluff and the Delta, populations of most species that are dependent on riparian, oak woodland, marsh and grassland habitats have declined with the conversion of these habitats to agriculture and urban areas. Populations of some Sacramento Valley species have declined so greatly that they have been listed as threatened or endangered, or are under study for future listing. In many cases, most of the remaining habitat for these species in the Sacramento Valley occurs along the Sacramento River.

DFG's Wildlife Habitat Relationship Program identifies a total of 249 species of wildlife using the valley foothill/riparian habitat of the Sacramento Valley. Included in this total are 151 species of birds, 65 species of mammals, and 33 reptile and amphibian species. Riparian zones also provide food and cover to other wildlife species more typical of adjacent upland areas and provide migratory corridors for many others.

Many birds species are common year-round or seasonal residents of the Sacramento Valley, while others are migrants or only occasional visitors. Wetland areas of the basin are important as prime waterfowl wintering areas in the Pacific Flyway, where wintering waterfowl population often exceeds three million birds. Passerine birds are found in great numbers in the riparian vegetative cover along the Sacramento River and tributaries because of the excellent food and habitat value. Raptor species such as hawks and owls nest within the larger trees of the riparian and grassland habitat and feed on small animals that also inhabit the area.

The Sacramento River and tributaries between Keswick Dam and the Delta provide important habitats for a diverse assemblage of fish, both anadromous and resident species. Anadromous fish include chinook salmon (four races), steelhead trout, striped bass, American shad, green and white sturgeon, and Pacific lamprey. Resident fish can be separated into warmwater game fish (such as largemouth bass, white crappie, black crappie, channel catfish, white catfish, brown bullhead, yellow bullhead, bluegill, and green sunfish), coldwater game fish (such as rainbow and brown trout), and non-game fish (such as Sacramento squawfish, Sacramento sucker, and golden shiner). Native non-game fish such as the Sacramento perch (California's only native sunfish) and the viviparous tule perch still persist in the Sacramento River. Although the Sacramento perch is thought to be threatened with extinction in the Sacramento River, it is presently listed as status undetermined pending collection of additional information. Baseline resource information on this species is lacking.

Keswick Dam forms a complete barrier to upstream migration of fish, primarily chinook salmon and steelhead. Migratory fish trapping facilities at the dam are operated in conjunction with the Coleman National Fish Hatchery on Battle Creek, 25 miles downstream. The Sacramento River upstream from Colusa produces about half of the Central Valley chinook salmon population. About one third of the river's naturally spawning salmon (mainly the fall run) spawn directly in the reach from Colusa to Red Bluff (mainly above Chico Landing), and all salmon use the river for rearing and migration.

Approximately two-thirds of the striped bass population in the State spawn in the Sacramento River system, while the remainder spawn in the lower San Joaquin River.

Construction of Oroville Dam on the Feather River eliminated spawning areas for salmon and steelhead upstream of the dam. To compensate for this loss, the DWR built the Feather River Fish Hatchery downstream from Oroville Dam, on the northern bank of the Feather River. The Feather River Fish Barrier Dam, about a half mile downstream from Thermalito Diversion Dam, diverts migrating salmon and steelhead into the Feather River Fish Hatchery for artificial spawning.

Surveys conducted in 1976 identified 28 species of resident and anadromous fish in the Yuba River system. Anadromous fish of special concern include chinook salmon, steelhead trout, and American shad. New Bullards Bar Reservoir supports both warmwater and coldwater fisheries. Common and abundant coldwater species include rainbow and brown trout, while warmwater species include smallmouth and largemouth bass, crappie, bluegill, catfish, carp, Sacramento squawfish, Sacramento sucker, and threadfin shad. No rare or endangered species are known to occur in the reservoir. The fall-run chinook salmon is the most important and abundant anadromous fish in the lower Yuba River system.

Downstream from Folsom Dam and 30 miles upstream from the mouth of the American River is the Lake Natoma-Nimbus Dam afterbay complex. Anadromous fish cannot pass Nimbus Dam. The Nimbus Salmon and Steelhead Hatchery is located on the downstream side of Nimbus Dam. The lower American River aquatic habitat includes a meandering streambed in a broad flood plain which is delineated from surrounding urban areas by 30 foot levees. The waters' edge is bordered by native riparian vegetation, backwaters, dredge ponds, and urban recreational areas such as parks and golf courses. The river and backwater areas support at least 41 species of fish, including chinook salmon, steelhead trout, striped bass, and American shad. Common resident fish include the Sacramento sucker, black bass, carp, squawfish, and hardhead.

Species which occur in the Sacramento Valley basin that are either federally or State listed as threatened or endangered include the greater sandhill crane, bank swallow, least Bell's vireo, Swainson's hawk, western yellow billed cuckoo, California black rail, willow flycatcher, bald eagle, American peregrine falcon, Aleutian Canada goose, giant garter snake, valley elderberry longhorn beetle, and winter-run chinook salmon. Six candidate species occur in the area (California tiger salamander, tricolored blackbird, white-faced ibis, snowy plover, Sacramento anthicid beetle, and Sacramento splittail), as well as five species recommended for candidate species (western spadefoot toad, vernal pool fairy shrimp, California linderiella, conservancy fairy shrimp, and vernal pool shrimp). The California hibiscus is a species of special concern that occurs in the area.

Land Use and Economy. The economy of the Sacramento River basin is based primarily on irrigated agriculture and livestock production. Related industries include food packing and processing, agricultural services and the farm equipment industry. Another important segment of the economy in the Sacramento River basin consists of military and other federal government establishments, the State government, and the aerospace industry. Lumber industries are centered in the Sierra, Nevada, Cascade Range, Modoc Plateau, and a portion of the Coast Range. Other industries are engaged in extraction or mining and production of natural gas, clay, limestone, sand, gravel, and other minerals. Population growth has given rise to many service industries. The 1985 population for the Sacramento Valley region exceeded 1.8 million people. Major urban areas include Sacramento, West Sacramento, Redding, Chico, Davis, Placerville, Woodland, Roseville, Yuba City, Auburn, Marysville, Oroville, Willows, Red Bluff, Quincy, Nevada City, and Alturas.

Along the Sacramento River between Keswick and Red Bluff, soils are deep and fine-textured and are suitable for growing a wide variety of field and orchard crops. Crops presently grown are corn, sugar beets, safflower, strawberry plants, alfalfa, and hay. Orchards of apples, olives, walnuts, almonds, prunes, and peaches are planted. In addition, large farming areas are devoted to the raising of beef and dairy cattle.

Along the Sacramento River between Red Bluff and the Delta, alluvial soils eroded from the surrounding mountains are well suited for a variety of agricultural uses, and historically supported extensive riparian forests. Riparian woodland and grass lands have largely been converted to agricultural uses, with orchards predominating in the upper portion of this reach and row crops dominating in the lower portion. Typical agricultural crops include almonds, pears, peaches, rice, tomatoes, sugar beets, wheat, corn, and seed crops such as melons and sunflowers. Thousands of acres of wetlands and refuges also occur in the area.

Many individual residences and small communities exist along the upper river between Red Bluff and the Delta, such as Tehama, Los Molinos, Hamilton City, Princeton, and Butte City. Further from the river, larger towns and cities include Chico, Willows, and Colusa. Along the lower river, major urban development from the City of Sacramento fronts the river, with minor residential and commercial development at Knights Landing, Rio Vista, Isleton, Walnut Grove, Locke, Hood, Clarksburg, and Freeport. Marinas are common along the river in this reach, especially between Clarksburg and just upstream of Discovery Park. Agriculture is the most important segment of the economy for the smaller communities, while manufacturing and services are more important for the economy of the larger towns.

Recreation. Over 2 million visitors participate in recreational activities along the Sacramento River annually. Fishing and relaxation are the most popular recreational activities. Other types of recreation include boating, swimming, camping, picnicking, hiking, and outdoor sports. Winter-run chinook salmon fishing was very popular prior to the severe decline in the population and current State restrictions. Steelhead trout and spring, fall, and late-fall salmon runs remain popular among recreational anglers along the river. Ocean sport fishing also accounts for a large percentage of the Sacramento River anadromous fish catch.

Numerous public and private facilities provide recreational access along the Sacramento River between Keswick Dam and Red Bluff. Fishing is excellent in the river between Keswick Dam and Red Bluff. Rafting, kayaking, and canoeing are also popular because the river is fast flowing and there are a number of riffle areas. Picnicking, camping, and sightseeing are other important recreational activities.

Fishing and hiking occur throughout the year, while picnicking and camping are limited to the spring through fall months. Water contact sports, such as swimming, kayaking, and canoeing, are generally restricted to the summer months where the daytime temperatures are often over 100°F.

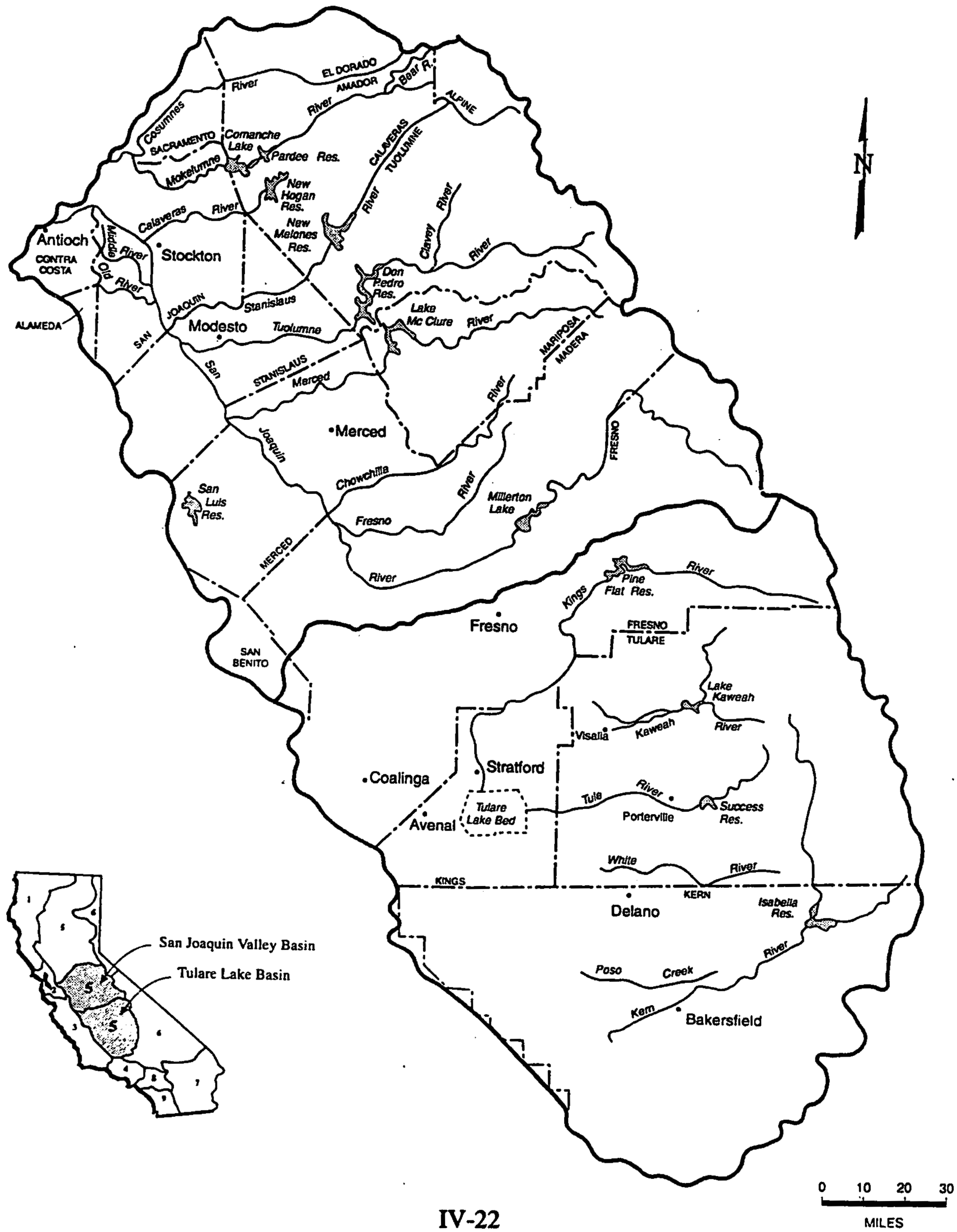
Little recreation land is available in the Sacramento Valley floor outside of riparian corridors between Red Bluff and the Delta. The Sacramento River environment is the primary remnant riparian corridor in the valley, providing the most important recreational resource for local residents. Public access to the river for recreational use is limited by the amount of public lands along the river. About 65 percent of the total recreational use on the river at and above Sacramento is by people living in counties adjacent to the river. Ninety percent of the summer day use activity is by local residents. Popular uses include fishing, boating, water skiing, picnicking, camping, and bird watching.

2. San Joaquin Valley (San Joaquin River Basin and Tulare Lake Basin)

The San Joaquin Valley extends from the Bay-Delta Estuary in the north to the Tehachapi Mountains in the south, and from the crest of the Sierra Nevada in the east to the Coast Range in the west. The valley is comprised of two hydrologic regions: the San Joaquin River basin and Tulare Lake basin (Figure IV-5). The San Joaquin River basin, located just south of the Sacramento River basin, comprises the northern part of the San Joaquin Valley. The Tulare Lake basin comprises the southern part of the valley.

The San Joaquin Valley is semiarid, characterized by hot, dry summers and mild winters except for the highest altitudes. In the mountains, summer days are warm and nights cool, but winter temperatures are often severe with heavy snowfall. The valley floor is free of frost during the growing season, with the average frost-free period being from eight to nine months. A frost-free belt extends along the Sierra Nevada foothills from Fresno County southward, providing a suitable area for citrus and other frost sensitive crops. Maximum

Figure IV-5 SAN JOAQUIN RIVER AND TULARE LAKE BASINS



summer temperatures are in the neighborhood of 110 °F and minimum winter temperatures may fall below 25°F. Relative humidities are low in the summer.

The year is divided into distinct wet and dry seasons. The major portion of the precipitation occurs in the winter season from November to April, with rain at the lower elevations and snow in the higher regions. Topography and latitude are the major factors controlling precipitation in the basin. Heaviest precipitation occurs on the west slope of the Sierra Nevada and, in general, increases with altitude up to about 7,000 feet, and then tends to decrease with increased elevation. Precipitation also decreases from north to south with lower means in the southern portion of the watershed areas. Precipitation is scanty on the valley floor.

The San Joaquin Valley is a rich agricultural region. The valley's long growing season, mild and semi-arid climate, good soils, and available water provide conditions suitable for a wide variety of crops. Major crops include cotton grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops. Agriculture and closely related industries provide the economic base that supports a large and growing population. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.

Water to the San Joaquin Valley from the Sierra Nevada is limited and there is an annual overdraft of ground water. Imported water, generally consisting of 200 to 500 mg/l TDS, is used mainly on the west side. Water used on the east side is generally of better quality than that used on the west side and in the valley trough areas. In most parts of the valley, irrigation water is reused at least once, and water quality worsens progressively with each reuse.

Types of habitat in the San Joaquin Valley are similar to those of the Sacramento Valley.

a. San Joaquin River Basin. The San Joaquin River basin, which encompasses about 7,017,000 acres, is the primary drainage in the San Joaquin Valley. The San Joaquin River flows northward toward the Delta, draining the central southern portion. Major tributaries to the San Joaquin River include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno rivers, which originate in the Sierra Nevada. In the Delta, the Cosumnes, Mokelumne, and Calaveras rivers, which also originate in the Sierra Nevada, flow into the San Joaquin River upstream of its confluence with the Sacramento River.

These Sierra streams provide the northern part of the San Joaquin Valley with high-quality water and most of its surface water supplies. Most of this water is regulated by reservoirs and used on the east side of the valley, but some is diverted across the valley to the Bay Area via the Mokelumne Aqueduct and the Hetch Hetchy Aqueduct.

On the west side of the basin, streams include Hospital, Del Puerto, Orestimba, San Luis, and Los Banos creeks. These streams are intermittent, often highly mineralized, and contribute little to water supplies.

The San Joaquin River basin is subjected to two types of floods: those due to prolonged rainstorms during the late-fall and winter, and those due to snowpack melting in the Sierra during the spring and early-summer, particularly during years of heavy snowfall. Major problem areas lie along valleys, foothill streams, and the San Joaquin River, where flood flows often exceed channel capacities and damage urban and highly developed agricultural areas (DWR 1986).

__Surface Water Hydrology__. The main stem of the San Joaquin River rises on the western slope of the Sierra Nevada at elevations in excess of 10,000 feet. From its source, the river flows southwesterly until it emerges onto the valley floor at Friant. The river then flows westerly to the center of the valley near Mendota, where it turns northwesterly to join the Sacramento River at the head of Suisun Bay. The main stream has a length of about 300 miles, one-third of which lies above Friant Dam. Surface water serves about two-thirds of the San Joaquin River basin while ground water serves the remaining areas.

Runoff from the watersheds of both the major and minor streams in the San Joaquin River basin shows wide seasonal, monthly, and daily variations modified by the effects of storage, releases from storage, diversions, and return flows. Average runoff from the basin is estimated at 7.93 MAF. Flows on the main stem of the San Joaquin River are regulated by operations of Friant Dam. There are often no flows in the mainstem itself beyond those flows originating in the three major tributaries (Merced, Tuolumne, and Stanislaus rivers) plus agricultural and municipal drainage.

Partial stream regulation of tributary streams is afforded by Pardee Dam on the Mokelumne River, New Melones, Donnells, and Beardsley dams on the Stanislaus River, Hetch Hetchy and New Don Pedro dams on the Tuolumne River, and Exchequer Dam on the Merced River. In addition, there are a number of power and irrigation developments on these streams which serve to regulate and modify the natural runoff. A list of the major reservoirs in the San Joaquin River basin is presented in Table IV-2.

Stream flows are depleted by diversions and increased by drainage and return irrigation flows along the stream courses. Stream flows in the Delta are influenced by tidal action and diversions to the Delta-Mendota Canal and the California Aqueduct. During the long dry season, the smaller streams often have no flows. Lowest flow conditions usually occur just prior to the advent of the rainy season which generally gets underway in late-November.

__Surface Water Quality__. The major water quality problems of streams on the San Joaquin Valley floor are large salt loads associated with irrigation and nutrients from municipal, industrial, and agricultural sources. Major portions of basin streams are reaching an undesirable state of nutrient enrichment. Prolific aquatic plant and algal growth are causing detriments to beneficial water uses. Aquatic plants have, on occasion, nearly blocked reaches of the lower Stanislaus River and have interfered with recreational uses.

Table IV-2. Major Reservoirs in the San Joaquin River Basin

Reservoir Name	Stream	Capacity (TAF)	Owner
New Melones	Stanislaus River	2,420	USBR
New Don Pedro	Tuolumne River	2,030	Turlock ID and Modesto ID
Hetch Hetchy	Tuolumne River	360	City of San Francisco
Lake McClure	Merced River	1,024	Merced ID
San Luis	N/A	2,040	USBR and DWR
Shaver	San Joaquin River	135	Southern California Edison
Pardee	Mokelumne River	210	EBMUD
Salt Springs	Mokelumne River	142	PG&E
Millerton	San Joaquin River	520	USBR
Edison	San Joaquin River	125	Southern California Edison
Lloyd (Cherry)	Tuolumne River	269	City of San Francisco
Mammoth Pool	San Joaquin River	123	Southern California Edison
Camanche	Mokelumne River	417	EBMUD
New Hogan	Calaveras River	317	USCOE
Eastman	Chowchilla River	150	USCOE
New Spicer Meadow	Tuolumne	189	CCWD

Source: DWR 1994a

Diurnal fluctuation of dissolved oxygen due to the presence of large algal concentrations and partially treated municipal and industrial wastes have contributed to fish kills in the Stanislaus, Tuolumne, and San Joaquin rivers. Other water quality problems include excessive coliform levels, pesticide concentrations, and turbidity.

Generally, water quality in the mainstem of the San Joaquin River is degraded downstream from Friant Dam during summer and fall months of all water years. High salt concentrations in the lower reaches of the San Joaquin River and its major tributaries arise from upstream diversion of the natural flow and the large volumes of drainage, waste waters, and return flows which, directly or indirectly, find their way into the surface drainage. At times, the entire flow in the river is comprised of used waters. The agricultural return water is estimated to carry a total annual salt load of 740,000 tons to the Sacramento-San Joaquin Delta. Although the water in the lower San Joaquin River is still usable for agriculture, severe crop damage has been occasionally experienced. Moreover, greater volume of applied water is needed to leach the greater amount of accumulated salts in the soil system. Increasing drainage problems have been associated with the increase in salt concentration.

Electrical conductivity (EC), boron, and other mineral concentrations are higher in dry and critical years due to a lack of dilution flows. This situation has imposed a slight to moderate degree of restriction on use of river water for irrigation. Water quality characteristics that were present during the 1991 water year are typical of critical year conditions. EC rises to 3,420 micromhos per centimeter (μmhos/cm) in the upper reaches downstream from Friant Dam. Conditions improved somewhat at the downstream end, where EC rises to 1,680 μmhos/cm. Water quality improves somewhat during a wet year, as in 1986 when EC measured up to 930 μmhos/cm in the upper portion, and to 980 μmhos/cm in the lower portion of the river.

Boron concentrations during 1991 measured up to 0.75 mg/l in the upper area, and to 1.2 mg/l in the lower reach. Among the trace elements analyzed during 1991, median selenium values frequently exceeded USEPA ambient water quality criteria of 5 micrograms per liter (μg/l) for the protection of aquatic life in the middle portions of the river, and routinely exceeded the primary drinking water standard of 10 μg/l. Elevated molybdenum concentrations in the upper river have been consistently found during the previous five critically dry years. The molybdenum is apparently derived from ground water seepage entering the river since the site where this element has been found is upstream from the discharge of tile drainage.

Generally, water quality in the Merced and Stanislaus rivers is good. Typically, water quality decreases during the late-summer as natural flows to the river decrease and poorer quality flows such as agricultural return flows increase. The Merced and Stanislaus rivers, though contributing freshwater flows year round, do not have sufficient flows during summer and fall months to dilute the poor quality of the mainstem San Joaquin River.

The Tuolumne River generally has good quality through much of the year. However, in late-summer and fall, when natural flows to the river decrease and lesser quality water such as agricultural return flows increase, water quality conditions are less than optimum. A contributor to the salt load of the basin is the saline water from abandoned gas wells on the Tuolumne River. The impact of this waste is such that the Tuolumne River at its mouth has about four times the salt concentration of similar adjacent rivers.

Ground Water Hydrology. In the San Joaquin River basin, 26 ground water basins and areas of potential ground water storage have been identified. Nine basins have been identified as significant sources of ground water. The total area of these nine basins is about 13,700 square miles, of which the San Joaquin Valley alone occupies 13,500 square miles and is the largest ground water basin in the State. There is an annual overdraft of approximately 209 TAF of ground water (DWR 1994a).

Subsidence in the San Joaquin Valley due to ground water extraction began in the mid-1920's. In 1942, 3 MAF were pumped for irrigation, but by 1970, pumping for irrigation exceeded 10 MAF. As a result, water levels in the western and southern portions of the valley declined at an increased rate during the 1950's and 1960's. By 1970, 5,200 square miles of valley land had been affected, and maximum subsidence exceeded 28 feet in an area west of Mendota.

Much of the Los Banos-Kettleman City subsidence area is now served by the San Luis Unit of the CVP. Since 1968, as more State and federal water has been used for irrigation, water levels have been recovering. In the future, if full contractual CVP deliveries are made, subsidence in this area is expected to cease. Since 1971, SWP deliveries to some parts of the Wheeler Ridge-Maricopa Water Storage District in Kern County have resulted in a ground water level recovery of as much as 75 feet.

Immediate problems caused by overdrafting are localized land subsidence, water quality degradation near Stockton from salt water intrusion, and higher pumping costs. Since the area will continue to rely on ground water as a source for irrigated agriculture, as well as municipal and industrial uses, water agencies are attempting to alleviate the overdraft conditions through artificial recharge and conjunctive use programs.

Ground Water Quality. Significant portions of the ground water in the basin exceed the recommended TDS concentrations in the U.S. Public Health Service Drinking Water Standards (500 mg/l). The predominant water type varies from aquifer to aquifer and the source of recharge. The character of the water on the east side of the valley is predominantly sodium-calcium bicarbonate. Water on the west side principally contains sodium sulfate. Some areas also have excessive boron concentrations.

Vegetation. Much of the native vegetation in the San Joaquin Valley has been replaced by introduced species or disturbed by cultivation or grazing. Major natural vegetation classes found within the valley include grassland, sagebrush shrub, coastal shrub, and hardwood forest-woodland.

A major portion of the CVP's San Luis service area has been developed for agriculture. On the undisturbed portions, native vegetation consists of sagebrush, saltbrush, Russian thistle, and similar cover common to semiarid regions. In years of average or better rainfall, some wild oats, brome grass, and other native grasses prevail near the foothills. Native wildflowers which previously grew within the San Luis Reservoir area were transplanted to areas above the water surface.

Wildlife and Fish. Food and cover for native wildlife are limited. The hot, dry climate of the west side of the San Joaquin Valley limits vegetation on the valley floor mostly to sagebrush, tumbleweed, and some grasses, except in a few draws and creek channels. The foothills of the Coast Range are also dry and mostly treeless except in a few creek bottoms.

Some wildlife cover plantings along the San Luis Canal have provided additional wildlife habitat.

In the trough of the San Joaquin Valley between Mendota and Gustine are tens of thousands of acres of excellent waterfowl land which constitute an important station along the Pacific Flyway. Drainage flows are an appreciable percentage of the water supply for this area and are used to grow feed and cover crops, and to provide resting ponds for the waterfowl using this area. While drainage seems to be an attractive source of water for wetland use, selenium levels in the drainage water have been toxic to waterfowl.

Most native fish populations have been eliminated by drainage projects and modifications of natural watercourses. They are now confined to farm ponds, drainage canals, and aqueducts. The only anadromous fishery in the San Joaquin River is a fall run of chinook salmon to the Merced, Tuolumne, and Stanislaus river tributaries; no spawning occurs on the mainstem.

The only rare or endangered species known to be in the general area affected by the San Luis Unit are the San Joaquin kit fox, California condor, blunt-nosed leopard lizard, and giant garter snake.

Land Use and Economy. Historically, the economy of the San Joaquin River region has been based on agriculture. By far, agriculture and food processing are still the major industries. Other major industries include the production of chemicals, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products, and various other commodities.

The valley's long growing season, mild and semi-arid climate, good soils and available water provide conditions suitable for a wide variety of crops. Major crops include cotton, grapes, tomatoes, hay, sugar beets, and various orchard and vegetable crops. Agriculture and closely related industries provide the economic base that supports a large and growing population. The population in the valley grew from 1.7 million in 1970 to 2.5 million in 1985. Urban areas include Fresno, Bakersfield, Visalia, and Modesto.

Public lands amount to about one third of the region. The national forest and park lands encompass over 2,900,000 acres of the region; state parks and recreational areas and other State-owned property account for about 80,000 acres; and Bureau of Land Management and military properties occupy some 221,000 and 37,000 acres, respectively (DWR 1994a).

Most of the lands in the San Luis service area of the CVP occupy the gently sloping coalescing alluvial fans laid down by creeks emerging from the Coast Range. These soils rank among the highest in the San Joaquin Valley in potential productivity and adaptability to a wide variety of high valued crops. The excellent soils coupled with a long, hot growing season make the area ideal for farming operations. The predominant crops are irrigated grain, cotton, alfalfa seed, field crops, melons, and small but increasing acreage of deciduous orchards. Some of the non-irrigated lands are used for dry farm grain and native pasture.

Most of the area is in large landholding, and large scale farming prevails. Except for packing sheds, cotton gins, auction yards, and similar activities directly related to the marketing of agricultural products, there are no industrial or commercial enterprises of significance. South of the service area, several oil fields have been developed. The communities of Avenal and Coalinga exist chiefly to support the oil operations in the immediate vicinity.

Agriculture and the oil industry are the primary economic activities in the SWP service area. Crops raised in the region include alfalfa, barley, safflower, sugar beets, fruits, vegetables, nuts, cotton, sweet potatoes, cantaloupe, and grapes. Beef cattle, dairy products, and poultry are also significant. Other sources of income include manufacturing, trade, services, and government. Despite substantial variations in annual SWP deliveries, total acreage in the San Joaquin service area does not normally fluctuate. Farmers rely heavily on ground water pumping in dry years and local surface water diversions in wet years to maintain the same irrigated acreage.

Recreation. San Luis Reservoir, O'Neill Forebay, Los Banos, New Melones, New Don Pedro, and New Exchequer reservoirs offer good boating and fishing most of the year. Other recreational opportunities are available elsewhere in the Basin, including fishing along the basin's rivers and streams, and boating and whitewater rafting on major tributaries. Beach developments, particularly on the forebay, have been popular. Picnicking, swimming, waterskiing, hunting, and camping are activities afforded by the reservoir. Recreational development is jointly funded by the federal and State governments, but is managed by the State Department of Parks and Recreation.

Along the California Aqueduct, many miles of walk-in fishing sites have been provided, and a stock of many kinds of fish has developed from fish and eggs surviving the CVP and SWP pumps. There are also 170 miles of bikeways along the Aqueduct.

b. Tulare Lake Basin. The Tulare Lake basin is one of the richest agricultural regions in the United States. The highly developed agricultural economy of the basin is dependent upon runoff from the Sierra Nevada, import from basins to the north, and ground water to supply its water needs.

The Tulare Lake basin, which has a land area of 11,076,000 acres, includes all San Joaquin Valley stream basins between Fresno and Bakersfield that drain into Tulare Lake rather than northward into the San Joaquin River. Located at the southern half of the San Joaquin Valley, the basin is comprised of the Kings, Kern, Tule, and Kaweah river basins. These four rivers drain westward from the southern Sierra Nevada and terminate in the Tulare Lake or Buena Vista Lake beds. Dams on each of these rivers provide flood control and water supply for ground water recharge and for urban and agricultural uses. No large streams enter the basin from the coastal ranges or the Tehachapi Mountains.

Surface Water Hydrology. Tulare Lake tributaries are heavily used for irrigation, with little water reaching the lake. Water entering Tulare Lake basin that forms Tulare Lake is from excess flood water from the Kings, Kaweah, and Tule rivers, and, to some extent, the Kern River. Floods are not an uncommon occurrence, but are variable in intensity and frequency. Levees have been built to contain the water in cells to maximize farming possibilities in the basin. Flood waters collected in the basin are used for irrigation. Other means of disposal include evaporation, some ground water recharge, and recently by pumping out of the basin. In extreme flood conditions, water can flow out of the basin through the Kings River to the San Joaquin River.

The Kings River, which drains the Sierra Nevada mountains in eastern Fresno County, is impounded by Pine Flat Reservoir. The reservoir can store about 1 MAF. The reservoir regulates water for irrigation and flood control. The Kings River interconnects with the Friant-Kern Canal east of Fresno, where it divides into the South Fork and Kings River North. The South Fork flows into the Tulare Lake basin. Kings River North flows in a northwesterly direction and can connect with the San Joaquin River through Fresno Slough, a man-made channel. Historically, the Kings and San Joaquin rivers connected in most years during heavy runoff. More recently, this event occurs only during extreme flooding, but is more commonly hydraulically connected by virtue of irrigation practices. Before irrigation development, Tulare Lake overflowed into the San Joaquin River during periods of extreme flood. The Kings River, which carries eroded material from the Sierra Nevada, has built up a low, broad ridge across the trough of a valley so that the Tulare Lake basin has essentially no natural surface water outlet.

The Kaweah River is impounded by Terminus Dam to form the 143 TAF Lake Kaweah. This reservoir provides flood control, irrigation water, ground water recharge, and recreation. During late-spring, summer, and early-fall, most Kaweah River water controlled by the dam is diverted for irrigation, leaving little flow left in the river. The Kaweah Delta Water Conservation District distributes water from the reservoir to the service area encompassing almost 340,000 acres, of which 256,000 acres are used for agriculture. Most industrial, municipal, and domestic water in the service area is supplied from ground water. All water in the Kaweah drainage is utilized within the basin except during heavy flood years. When flood releases are made from Kaweah Reservoir, all possible water is diverted for irrigation use; any excess water flows into Tulare Lake.

The Tule River drainage serves over 400,000 acres of agricultural land. About six miles east of Porterville in Tulare County, Success Dam impounds the Tule River to form the 82 TAF Lake Success. The reservoir regulates flows for flood control and irrigation.

About half the agricultural lands in the Tule River basin are upstream from Success Dam and are served by local irrigation districts. The Lower Tule River Irrigation District and Tulare Irrigation District control most diversions downstream from the dam. Numerous ponding and ground water recharge basins controlled by local irrigation districts and non-public entities also occur along the river. The numerous diversions downstream from the dam, and percolation into the river bed and flood plain, result in discontinuous flow and intermittent pools throughout the lower river. The river interconnects with the Friant-Kern Canal. During extremely wet years, water in the Tule River flows to Tulare Lake.

Lake Isabella, in northwestern Kern County east of Bakersfield, impounds water from the Kern and South Fork Kern rivers draining eastern Tulare County. The reservoir has a storage capacity of 570 TAF. As a result of numerous diversions and regulation of flow at Isabella Dam, the natural river flow is virtually nonexistent and most flows are depleted before reaching Tulare Lake in all but exceptionally large runoff years.

Surface Water Quality. The perennial streams which arise in isolated parts of the Sierra Nevada are not subject to major manmade waste loads since most discharges are applied to the land. Irrigation return water forms a major portion of the summer base flow in the lower reaches of the larger streams. Saline water from oil wells is a contributor to the basin salt load.

The salt content of Tulare Lake (about 570 mg/l TDS) is due mainly to soil salts historically in the basin and introduced fertilizers. Poso Creek also contributes salt to the southern portion of the basin, but the proportional quantity of water from this drainage is small.

Ground Water Hydrology. The ground water overdraft in the Tulare Lake basin is a significant unresolved water resource problem in California. The average annual rate of ground water overdraft was calculated to be about 341 TAF in 1990 (DWR 1994a). This is a reduction in overdraft, due to the importation of SWP water and the availability of surplus supplies, from a level of about 1.3 MAF in 1972.

Numerous public and private water agencies are engaged in the acquisition, distribution, and sale of surface water to growers in the Tulare Lake basin. Since most of the agencies overlie usable ground water and use ground water conjunctively with surface water, some of their operational practices, such as artificial recharge and use of "non-firm" surface supplies in lieu of ground water, can be viewed as elements of a ground water management program. The agencies do not, however, have the power to control ground water extractions. Such authority is a requisite to comprehensive ground water management.

Ground Water Quality. Ground water near Tulare Lake has experienced an increase in dissolved solids concentrations over the years. In some locations, ground water has been abandoned as a water source as a result of quality degradation from salt loading. Suitable salt levels in the root zone have been maintained by the practice of leaching dissolved solids downward. Significant portions of the ground water exceed the recommended TDS concentration in the U.S. Public Health Service Drinking Water Standard (500 mg/l).

Nitrogen concentrations in some ground water in the Tulare Lake basin approach or exceed the levels recommended by the drinking water standards (10 mg/l). High nitrogen concentrations are usually attributed to sewage effluent and leaching or naturally occurring nitrogen and fertilizers.

Vegetation. Plant species along the tributaries to the basin are typical of those found on the west slope of the Sierra Nevada foothills. Grassland-oak savannah and oak woodland communities are typical of this region. Valley oak savannah dominates in the valley area, but in the foothills is replaced by live oaks in progressively denser stands. Around streams and lakes, riparian habitats occur. Plants found outside the riparian area are mainly grasses and wildflowers.

A large part of the natural plant life, including that in riparian areas below the reservoirs, has been lost due to extensive agricultural encroachment and other development. However, there is a mature riparian forest on both sides of the Kaweah River immediately below Terminus Dam. Most natural vegetation below the reservoirs remains only in small disjunct patches. Further downstream, plant life becomes similar to that of the Tulare Lake basin. Plant life of the lower Kern River is characterized as valley mesquite habitat, which is uniquely found in southwestern Kern County.

There are four plants within the general area that are listed by California as either rare or endangered. The one rare species listed is Greene's Orcutt grass. Endangered species include the Kaweah brodiaea and Springville clarkia, and San Joaquin Valley Orcutt grass which is presumed to be extirpated from the recorded site.

Wildlife and Fish. A majority of the native wildlife has been extirpated from the Tulare Lake basin. The land historically was marshlands and a swamp or a lake. Many species that occurred historically in the lake basin have been greatly reduced in number due to habitat deterioration and destruction from farming and urban development in the area. Birds known to inhabit the area, at least seasonally or when the lake exists, include most species of waterfowl, wading birds, and many types of gulls. Birds that are not water oriented occur in riparian areas adjacent to the lake in rivers or canals with riparian zones.

Fish habitat downstream from tributary reservoirs is primarily warmwater. A fishery for trout exists immediately below some of the dams during the fall and winter seasons and is supported by trout moving out of the lakes. Summer water temperatures in these reaches of the rivers are too warm to sustain coldwater fish species on a year-round basis. The rivers are commonly dewatered where there is no irrigation or flood control needs, so that fish are only found seasonally and are usually from upstream areas. When intermittent pools do exist, the more hearty and well adapted species (such as carp, Sacramento blackfish, bullhead, green sunfish, bluegill, mosquitofish, hitch, golden shiner, log perch, and Mississippi silverside) can usually be found. During irrigation deliveries, many game and non-game fish migrate up from the Tulare Lake basin through ditches and canals emanating from the river.

Water diversions, channelization, and construction of canals and levees have dramatically altered aquatic and riparian habitats in the Tulare Lake area. The vast lake bottom and marsh areas of Tulare Lake and much of its native flora and fauna have also been lost. Normal irrigation and farming practices dictate that these canals often dry up seasonally. In spite of this, several species of fish occur (seasonally or perennially) in Tulare Lake. Native fish species include rainbow trout (found only infrequently as they are incidentally transported from upstream areas), tule perch, Sacramento sucker, Sacramento perch, tule perch, riffle sculpin, and endemic minnows. Most of these still exist in the area, although Sacramento perch and tule perch have not been reported recently from the drainage, and the extent and diversity of native minnow populations have diminished. Non-native species of both game and non-game fish have been introduced throughout the basin.

At least 10 endangered or threatened species may occur within the area, including the Sierra red fox, wolverine, San Joaquin kit fox, San Joaquin antelope squirrel, blunt-nosed leopard lizard, giant kangaroo rat, giant garter snake, bald eagle, California condor, peregrine falcon, Tipton kangaroo rat, black-shouldered kite, great blue heron, and spotted owl. The yellow-billed cuckoo has not been reported in this area for a number of years though it was formerly widespread in San Joaquin Valley riparian areas. Its disappearance from the area is probably due to the lack of adequate habitat since it requires relatively large areas of undisturbed riparian areas. No rare or endangered fish species are known to be present in the drainage.

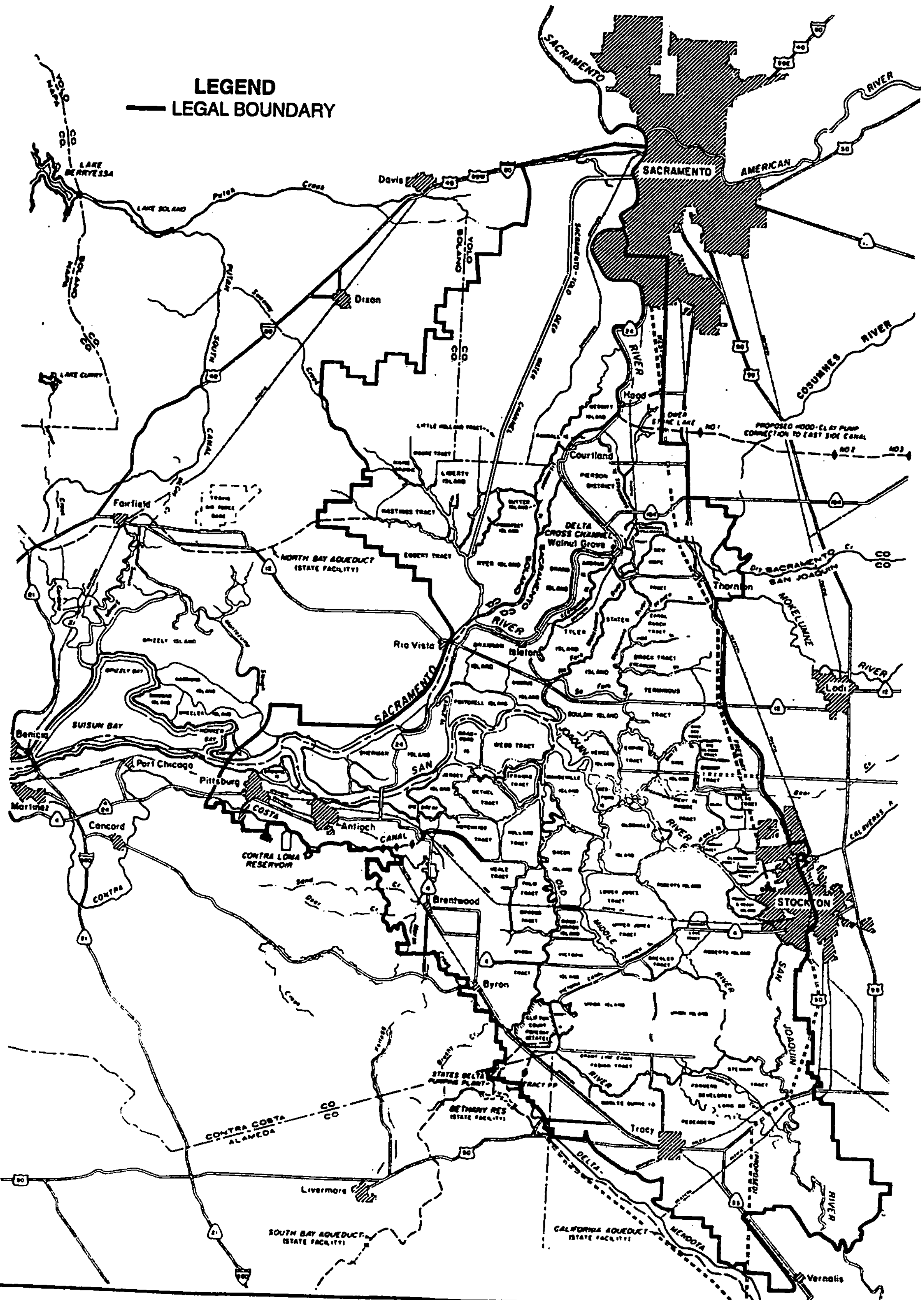
D. SACRAMENTO-SAN JOAQUIN DELTA (and Central Sierra Area)

The Delta-Central Sierra area includes the Sacramento-San Joaquin Delta and the Cosumnes, Mokelumne, and Calaveras river basins, totaling 3,109,000 acres. The Delta area forms the lowest part of the Central Valley bordering and lying between the Sacramento and San Joaquin rivers and extending from the confluence of these rivers inland as far as Sacramento and Stockton.

The Delta, which has legal boundaries established in California Water Code Section 12220 (Figure IV-6), comprises a 738,000-acre area generally bordered by the cities of Sacramento, Stockton, Tracy, and Pittsburg. This former wetland area has been reclaimed into more than 60 islands and tracts, of which about 520,000 acres are devoted to farming. The Delta is interlaced with about 700 miles of waterways. An approximate 1,110-mile network of levees protects the islands and tracts, almost all of which lie below sea level, from flooding. Prior to development, which began in the mid-19th century, the Delta was mainly tule marsh and grassland, with some high spots rising to a maximum of about 10 to 15 feet above mean sea level. The low dikes of early Delta farmers became a system of levees that now protect about 520,000 acres of farmland on 60 major islands and tracts. There are now about 1,100 miles of levees, some standing 25 feet high and reaching 200 feet across at the base.

Behind the levees, peat soils have subsided over the years due to oxidation, shrinkage, and soil loss by wind erosion. As a result, some of the island surfaces now lie more than 20 feet

Figure IV-6 SACRAMENTO-SAN JOAQUIN RIVER DELTA



below mean sea level and as much as 30 feet below high tide water levels in surrounding channels. All the major tracts and islands have been flooded at least once since their original reclamation, and a few have been allowed to remain flooded. Delta lands in the areas of deep peat soil, where subsidence has been greatest, are expensive both to protect from inundation and to reclaim from inundation once flooded.

The Delta is an important agricultural area. Historically, the area was noted for its truck crops, such as asparagus, potatoes, and celery, but since the 1920's, there has been a shift toward lower valued field crops. Corn, grain, hay, and pasture currently account for more than 75 percent of the region's total production. The shift has been attributed mainly to market conditions, although changes in technology and growing conditions have also played a role. Delta farming produces an average gross income of about $375 million.

The population of the Delta is about 200,000 people, most of which is in upland areas on the eastern and western fringes. Most Delta islands are sparsely populated, though some, including Byron Tract and Bethel Island, have large urban communities.

The Delta area has a Mediterranean climate with warm, rainless summers and cool, moist winters. The annual rainfall varies from about 18 inches in the eastern and central parts to about 12 inches in the southern part. Ocean winds, which enter the Delta through the Carquinez Strait, are very strong at times in the western Delta.

The Sacramento-San Joaquin Delta is situated near the center of the Central Valley at the confluence of the Sacramento and San Joaquin rivers.

Surface Water Hydrology. The Sacramento and San Joaquin rivers unite at the western end of the Sacramento-San Joaquin Delta at Suisun Bay. The Sacramento River contributes roughly 85 percent of the Delta inflow in most years, while the San Joaquin River contributes about 10 to 15 percent. The minor flows of the Mokelumne, Cosumnes, and Calaveras rivers, which enter into the eastern side of the Delta, contribute the remainder. The rivers flow through the Delta and into Suisun Bay. From Suisun Bay, water flows through the Carquinez Strait into San Pablo Bay, which is the northern half of San Francisco Bay, and then out to sea through the Golden Gate.

Tidal influence is important throughout the Delta. Historically, during summers when mountain runoff diminished, ocean water intruded into the Delta as far as Sacramento. During the winter and spring, fresh water from heavy rains pushed the salt water back, sometimes past the mouth of San Francisco Bay.

With the addition of Shasta, Folsom, and Oroville dams, saltwater intrusion into the Delta during summer months has been controlled by reservoir releases during what were traditionally the dry months. Typically, peaks in winter and spring flows have been dampened, and summer and fall flows have been increased. In very wet years, such as 1969, 1982, 1983, and 1986, reservoirs are unable to control runoff so that during the winter and spring the upper bays become fresh; even at the Golden Gate, the upper several feet of water column consisted of fresh water.

On the average, about 21 MAF of water reaches the Delta annually, but actual inflow varies widely from year to year and within the year. In 1977, a year of extraordinary drought, Delta inflow totaled only 5.9 MAF, while inflow for 1983, an exceptionally wet year, was about 70 MAF. On a seasonal basis, average natural flow to the Delta varies by a factor of more than 10 between the highest month in winter or spring and the lowest month in fall. During normal water years, about 10 percent of the water reaching the Delta would be withdrawn for local use, 30 percent would be withdrawn for export by the CVP and SWP, 20 percent would be needed for salinity control, and the remaining 40 percent would become Delta outflow in excess of minimum requirements. The excess outflow would occur almost entirely during the season of high inflow.

Hydraulics of the Estuary system are complex. The influence of tide is combined with freshwater outflow resulting in flow patterns that vary daily. Delta hydraulics are further complicated by a multitude of agricultural, industrial, and municipal diversions for use within the Delta itself, and by exports by the SWP and CVP.

Water Supply Developments. The Delta-Central Sierra area is the hub of the major State and federal water development facilities, and numerous local water supply projects. Water projects divert water from Delta channels to meet the needs of about two-thirds of the State's population and to irrigate 4.5 million acres. Delta agricultural water users divert directly from the channels, using more than 1,800 unscreened pumps and siphons, which vary from 4 to 30 inches in diameter, and with flow rates of 40 to about 200 cfs. These local diversions vary between 2,500 and 5,000 cfs during April through August, with maximum rates in July.

In the Delta near Walnut Grove, the federal Delta Cross Channel diverts water, by gravity, from the Sacramento River into the North and South forks of the Mokelumne River. Sacramento River water moves down these channels through the central Delta and into the San Joaquin River. Flows in the Delta Cross Channel reverse as the tide changes and, at certain stages, there is considerable flow from the channel into the Sacramento River. Flows in the Delta Cross Channel can be controlled by two radial gates. The channel is closed for flood control purposes when Sacramento River flows exceed about 25,000 cfs. Other channels that convey water across the Delta include Georgiana Slough, and the San Joaquin, Old, and Middle rivers.

In addition to the principal CVP and SWP diversions into the Delta-Mendota Canal and the California Aqueduct, respectively (which are described under the previous sections on these water projects), the CVP also diverts water into the Contra Costa Canal, and the SWP diverts water into the North Bay Aqueduct and the South Bay Aqueduct, as described below.

Contra Costa Water District Service Area. CVP water is delivered through the Contra Costa Canal to the Contra Costa Water District (CCWD). The CCWD delivers water throughout eastern Contra Costa County, including a portion of the district in the San Joaquin River region. The current contract with the USBR is for a supply of 195 TAF per year. The CCWD also has a right to divert almost 27 TAF from Mallard Slough on Suisun Bay. Most of the CCWD's demands are met through direct diversions from the Delta through the Contra Costa Canal. The CCWD has very little regulatory or emergency water supply storage to replace Delta supplies when water quality is poor. As a result, CCWD service area voters authorized funding for Los Vaqueros Reservoir in 1988. The reservoir will improve supply reliability and water quality by allowing the CCWD to pump and store water from the Delta during high flows. The Los Vaqueros Project has received all the required environmental and water rights permits, and construction has begun. The first stage of the project will be operational in the spring of 1997.

A diversity of industry is located in Contra Costa County. With its miles of waterfront linking ocean, river, and overland transportation facilities, the area offers many advantages to heavy industries requiring large supplies of cooling and processing water, large land areas, and access to a deepwater ship channel. Major industry groups in the county that require the greatest amounts of water are manufacturers of petroleum and coal products, paper and allied products, chemicals and allied products, primary metal products, and food and related products. Presently, the exceptionally high water needs of the petroleum refineries are largely met with brackish supplies from the south shores of San Pablo and Suisun bays.

The CCWD provides the municipal water needs of about 400,000 county residents. Of the nine bay area counties, Contra Costa is projected to experience the most rapid future population growth. The growing trend toward municipal water use increases the need for both improved water quality to meet State and federal standards and improved system reliability to meet peak water demands.

North Bay Service Area. The SWP delivers water through the North Bay Aqueduct to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District. The aqueduct extends over 27 miles from Barker Slough to the Napa Turnout Reservoir in southern Napa County. Maximum SWP entitlements are for 67 TAF annually. The North Bay Aqueduct also conveys water for the City of Vallejo, which purchased capacity in the aqueduct.

With an estimated population of 95,000, Napa County is known for its substantial wine, livestock, and dairy industries. The industries of Solano County, with a population of about 303,500, include field, fruit, and nut crops, livestock, and several heavy water-using industries (a cannery, refinery, brewery, food processing, and meat packing). In addition to the North Bay Aqueduct, Solano County obtains its water supply from Lake Berryessa, Lake Solano, several small reservoir and stream projects, ground water, agricultural return flows, and reclaimed waste water.

South Bay Service Area. From Bethany Reservoir, up to 300 cfs of Delta water is lifted by the South Bay Pumping Plant into the South Bay Aqueduct, which serves Alameda and Santa Clara Counties around the southern half of San Francisco Bay. Along the South Bay Aqueduct near Livermore, water is pumped into Lake Del Valle on Alameda Creek, which provides aqueduct flow regulation and flood protection.

Alameda County has some natural runoff from Alameda Creek, but only Santa Clara County has significant surface water supplies. Water is imported from the Tuolumne River via the Hetch Hetchy Aqueduct, and from the Delta via the South Bay Aqueduct and the San Felipe Project.

Ground water basins have been intensively developed for domestic, industrial, and irrigation uses and have been overdrawn, with resultant seawater intrusion and land subsidence problems. Extensive recharge programs using local and imported water supplies have allowed substantial recovery of the ground water basins.

Historically, Santa Clara County's economy was dominated by agriculture. However, the rapid urban development of the county has displaced much of the farming, which is now carried out in the less populated southern part of the county. The South Bay is northern California's leading business center. The economy of the area is diversified, with manufacturing, commerce, services, and government sectors employing significant numbers of people.

Surface Water Quality. The existing water quality problems of the Delta system may be categorized by toxic materials, eutrophication and associated dissolved oxygen fluctuations, suspended sediments and turbidity, salinity, and bacteria.

Many Delta waterways have impaired water quality due to toxic chemicals (SWRCB 1994). High concentrations of some metals from point and non-point sources appear to be ubiquitous in the Delta. Tissues from fish taken throughout the Delta exceed the National Academy of Sciences/Food and Drug Administration guidelines for mercury. There is currently a health advisory in effect for mercury in striped bass. High levels of other metals (i.e., copper, cadmium, and lead) in Delta waters are also of concern. Also, in localized areas of the Delta (e.g., near Antioch and in Mormon Slough), fish tissues contain elevated levels of dioxin as a result of industrial discharges.

Pesticides are found throughout the waters and bottom sediments of the Delta. High levels of chlordane, toxaphene, and DDT from agricultural discharges impair aquatic life beneficial uses throughout the Delta, while diazinon can be found in elevated concentrations at various locations (SWRCB 1994). The more persistent chlorinated hydrocarbon pesticides are consistently found throughout the system at higher levels than the less persistent organophosphate compounds. The sediments having the highest pesticide content are found in the western Delta. Pesticides have concentrated in aquatic life in the Delta. The long-term effects of pesticide concentrations found in aquatic life of the Delta are not known. The effects of intermittent exposure of toxic pesticide levels in water and of long-term exposure to these compounds and combinations of them are likewise unknown.

Much of the water in the Delta system is turbid as a result of an abundance of suspended silts, clays, and organic matter. Most of these sediments enter the tidal system with the flow of the major tributary rivers. Some enriched areas are turbid as a result of planktonic algal populations, but inorganic turbidity tends to suppress nuisance algal populations in much of the Delta. Continuous dredging operations to maintain deep channels for shipping has contributed to turbidity of Delta waters and is a factor in the temporary destruction of bottom organisms through displacement and suffocation.

The most serious enrichment problems in the Delta are found along the lower San Joaquin River and in certain localized areas receiving waste discharges, but having little or no net freshwater flow. These problems occur mainly in the late-summer and coincide with low river flows and high temperatures. Dissolved oxygen problems are further aggravated by channel deepening for navigational purposes. The resulting depressed dissolved oxygen levels have not been sufficient to support fish life and, therefore, prevent fish from moving through the area. In the autumn these conditions, together with reversal of natural flow patterns by export pumping, have created environmental conditions unsuitable for the passage of anadromous fish (salmon) from the Delta to spawning areas in the San Joaquin Valley.

Warm, shallow, dead-end sloughs of the eastern Delta support objectionable populations of planktonic blue-green algae during summer months. Floating and semi-attached aquatic plants, such as water primrose and water hyacinths, frequently clog waterways in the lower San Joaquin River system during the summer. Extensive growths of these plants have also been observed in localized waterways of the Delta. These plants interfere with the passage of small boat traffic and contribute to the total organic load in the Delta-Bay system as they break loose and move downstream in the fall and winter months.

Salinity control is necessary because the Delta is contiguous with the ocean, and its channels are at or below sea level. Unless repelled by continuous seaward flow of fresh water, sea water will advance up the Estuary into the Delta and degrade water quality. During winter and early-spring, flows through the Delta are usually above the minimum required to control salinity. At least for a few months in the summer and fall of most years, however, salinity must be carefully monitored and controlled. The monitoring and control is provided by the CVP and SWP, and regulated by the SWRCB under it water rights authority.

At present, salinity problems occur mainly during years of below normal runoff. In the eastern Delta, these problems are largely associated with the high concentrations of salts carried by the San Joaquin River into the Delta. Operation of the State and federal export pumping plants near Tracy draws high quality Sacramento River water across the Delta and restricts the low quality area to the southeast corner. Localized problems resulting from irrigation returns occur elsewhere, such as in dead-end sloughs. Salinity problems in the western Delta result primarily from the incursion of saline water from the San Francisco Bay system. The extent of incursion is determined by the freshwater flow from the Delta to the Bay.

Bacteriological quality of Delta waters, as measured by the presence of coliform bacteria, varies depending upon proximity of waste discharges and significant land runoff. The highest concentration of coliform organisms is generally found in the western Delta. Local exceptions to this can be found in the vicinity of major municipal waste discharges.

Another human health concern is that Delta water contains precursors of trihalomethanes (THMs), which are suspected carcinogens produced when chlorine used for disinfection reacts with natural substances during the water treatment process. Dissolved organic compounds that originate from decayed vegetation act as precursors by providing a source of carbon in THM formation reactions. During periods of low Delta outflow, tidal mixing of salts from the ocean (including bromides) extends farther into the Delta, increasing the bromide concentrations at municipal drinking water intakes. When bromides are present in water along with organic THM precursors, THMs are formed that contain bromine as well as chlorine. Drinking water supplies taken from the Delta are treated to meet current THM standards. However, more restrictive standards are being considered which, if adopted, will increase the cost and difficulty of treating present Delta water sources.

Discharges from municipal and industrial wastewater treatment plants affect the quality of surface waters. However, the increased use of secondary treatment facilities has resulted in reduced nutrient loadings, which has reduced the impact of these discharges on surface water quality in recent years.

Ground Water Quality. A major restriction on the use of ground water, particularly for municipal and industrial needs, is the variable and uncertain quality. Ground water salinity levels in the Suisun-Fairfield area typically range from 300 to 6,000 mg/l TDS, with average values generally exceeding 900 mg/l TDS. Putah Plain ground water is of somewhat better quality, with average TDS levels generally under 600 mg/l. However, the Putah Plain aquifer is distant from municipal and industrial water demand centers, so water transport facilities would have to be incorporated into any project developing ground water on a major scale.

Ground water quality is generally poor north of St. Helena and south of Napa, where it is frequently degraded by brackish water from San Francisco Bay. Because most of any additional demand for water would be for municipal and industrial use, where both quality and quantity are crucial, ground water will probably continue to be used as a supplemental source, mainly for agriculture.

__Vegetation__. The complex interface between land and water in the Estuary provides rich and varied habitat for wildlife, especially birds. Habitat or cover types in the Delta are agriculture, forest, riparian forest, riparian scrub-shrub, emergent freshwater marsh, and heavily shaded riverine aquatic.

__Wildlife and Fish__. The Delta supports many birds and mammals in the riparian and upland habitats. The area also serves as a feeding and resting area for millions of ducks, geese, swans, and other migrant waterfowl.

The wildlife and fish diversity is high due to the extensive mudflats and riparian vegetation, and gradation of aquatic habitats from freshwater (in the upper reaches of the Delta), to brackish (in the Suisun Bay region), to saline (in portions of San Francisco Bay). These three aquatic habitat zones historically graded gradually into one another. The zones move upstream or downstream, depending on the amount of freshwater outflow. Important groups of wildlife dependent on the Delta and Bay estuarine environment are waterfowl and other migratory waterbirds, game birds such as pheasant and quail, numerous nongame birds, furbearers, and other mammals.

The Delta is particularly important to waterfowl migrating via the Pacific Flyway. The principal attraction for waterfowl is winter flooded agricultural fields, mainly cereal crops, which provide food and extensive seasonal wetlands. The Delta, along with the principal wetlands that support Central Valley waterfowl, is winter habitat for 60 percent of the waterfowl on the Pacific Flyway, and for 90 percent of all waterfowl that winter in California. More than a million waterfowl are frequently in the Delta at one time.

The Estuary supports about 90 species of fish. The Delta, which is basically a freshwater environment, serves as a migratory route and nursery area for chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. All of these anadromous fishes spend most of their adult lives either in the lower bays of the Estuary or in the ocean. The Delta is a major nursery area for most of these species. Other fishes in the Estuary include Delta smelt, Sacramento splittail, Sacramento perch, catfish, largemouth bass, black bass, crappie, and bluegill.

The Delta has a large number of fishery habitat types, including estuarine, fresh, and marine water environments. The amounts of the various habitat types depend, in part, upon outflow regimes and water year hydrology. Habitats vary from dead-end sloughs to deep open water areas of the lower Sacramento and San Joaquin rivers and Suisun Bay. There are also a scattering of flooded islands offering submerged vegetative shelter. The banks of the channels are varied, and include riprap, tules, emergent marshes, and native riparian habitats. Water temperatures generally reflect ambient air temperatures. However, riverine shading may moderate summer temperatures in some areas.

Food supplies for Delta fish communities consist of phytoplankton, zooplankton, benthic invertebrates, insects, and forage fish. General productivity in the Delta is in constant flux and an evaluation of the interrelationships of the food web is now underway by the

Interagency Ecological Program. There are indications that overall productivity at the lower food chain levels has decreased during the past 15 or so years.

Biological production in the Estuary may be higher in the entrapment zone where freshwater Delta outflows meet and mix with more saline waters of the bay. The entrapment zone concentrates sediments, nutrients, phytoplankton, striped bass larvae, and fish food organisms. It is considered advantageous that outflows be sufficient to keep the entrapment zone in the upper reaches of Suisun Bay, where it can spread out over a large area, rather than in the narrower Delta channels upstream from Suisun Bay.

Numerous listed or candidate rare, threatened, or endangered vertebrate species are known to live in the Delta, but none is confined exclusively to that area. Seven listed species are birds (bald eagle, American peregrine falcon, Swainson's hawk, California black rail, Aleutian Canada goose, tricolored blackbird, and western yellow-billed cuckoo), two are mammals (salt marsh harvest mouse and San Joaquin kit fox), two are reptiles (giant garter snake and southwestern pond turtle), two are amphibians (California tiger salamander and California red-legged frog), and four are fish (winter-run chinook salmon, Delta smelt, Sacramento splittail, and Sacramento perch). There are five listed or candidate endangered or threatened invertebrate species in the Delta (valley elderberry longhorn beetle, Lange's metalmark butterfly, Delta green ground beetle, Sacramento anthicid beetle, and curve-foot hygrotus diving beetle). Twelve rare or endangered plant species, most of which are associated with freshwater marshes, can also be found in the Delta.

Land Use and Economy. Although no major cities are entirely within the Delta, it does include a portion of Stockton, Sacramento, and West Sacramento. In addition, the small cities of Antioch, Brentwood, Isleton, Pittsburg, and Tracy, plus about 14 unincorporated towns and villages, are located within the Delta. Most of the population in the legal Delta is in the upland areas on the eastern and western fringes. The Stockton area on the east and the Antioch-Pittsburg area on the west have undergone steady industrialization and urbanization. Most Delta islands are sparsely populated; however, some, including Byron Tract and Bethel Island, have large urban communities.

Recreation. Although the Delta environment has been extensively altered over the past 125 years by reclamation and development, natural and aesthetic values remain that make it a valuable and unique recreational asset. Waterfowl and wildlife are still abundant, sport fishing is still popular, and vegetation lining the channels and islands are still attractive. As a result, the miles of channels and sloughs that interlace the area attract a diverse and growing number of people seeking recreation.

With its unique and numerous recreational opportunities, the Delta will continue to support large numbers of recreationists. Motor boating and fishing are the leading activities. The extensive riparian vegetation of the Delta area is conducive to sight seeing, bird watching, and relaxing. Overnight camping, picnicking, swimming, and waterskiing are enjoyed by many people. Photography, bicycling, hunting, and sailing also occur in the Delta, although less frequently.

There are about 20 public and more than 100 commercial recreational facilities in the Delta. These facilities provide rentals, services, camping guest docks, fuel, supplies and food. Demand for and use of these facilities continue to grow.

E. SUISUN MARSH

Suisun Marsh is one of the few major marshes remaining in California and the largest remaining brackish wetland in Western North America. Located at the northern edge of Suisun Bay, just west of the confluence of the Sacramento and San Joaquin rivers and south of the City of Fairfield, the marsh consists of a unique diversity of habitats, including tidal wetlands, sloughs, managed diked wetlands, unmanaged seasonal wetlands, and upland grasslands. Most of Suisun Marsh consists of managed diked wetlands; however, numerous studies have established that tidal marshlands can have significant geomorphic and ecological values, including flood control, shoreline stabilization, sediment entrapment, water quality improvement, and food chain support for aquatic, semi-aquatic, and terrestrial plants and animals (Williams and Josselyn 1987).

Land Use. The primary managed area of Suisun Marsh contains 58,600 acres of marsh, managed wetlands, and adjacent grasslands, plus 29,500 acres of bays and waterways. An additional 27,900 acres of varying land types act as a buffer zone. Most of the managed wetlands are enclosed within levee systems. About 70 percent of the managed wetlands are privately-owned by more than 150 duck clubs. The DFG owns and manages 14,700 acres. The Solano County Farmlands and Open Space Foundation owns 1,050 acres of tidal wetlands and a 78 acre diked managed wetland. The U.S. Navy administers 1,400 acres of tidal wetlands on the channel islands of Suisun Bay.

Vegetation. Elevation and salinity are the principal factors controlling the distribution of tidal marsh plants in San Francisco Bay (NHI 1992). Vascular vegetation and the flow of tidal water maintain and ultimately control the distribution and abundance of the marshlands. The plants influence the quality and quantity of habitats for many species of wildlife. The ecological values and function of tidal marshland are largely determined by the nature of the plant community. The structure of the plant communities in tidal marshland is strongly correlated to salinity regime (Schubel 1993). Within the diked managed wetlands of the Suisun Marsh, water management, and the resulting controlled wetland hydroperiod, has been shown to have the most significant effect on the vegetation type used by several sensitive fish including delta smelt, longfin smelt, chinook salmon, and splittail.

Under a 1984 plan of protection for the marsh and a 1985 preservation agreement to mitigate the effects of upstream water projects on the marsh, the staged construction of extensive marsh water control facilities was planned. To date, the salinity control structure on Montezuma Slough, a major waterway in the marsh, has been constructed. This facility helps to ensure that a dependable supply of suitable salinity water is available to preserve marsh habitat, including food plants for waterfowl (DWR 1986).

Wildlife and Fish. Suisun Marsh supports 45 species of mammals, 230 species of birds, and 15 species of reptiles and amphibians. The marsh is a major wintering ground for waterfowl of the Pacific Flyway. Ducks, geese, swans, and other migrant waterfowl use the marsh as a feeding and resting area. As many as 25 percent of California's wintering waterfowl inhabit the marsh in dry winters. Waterfowl are attracted to the marsh by the water and the abundance of natural food plants, most valuable of which are alkali bulrush, fat hen, and brass buttons. The growth of such plants depends on proper soil salinity, which is affected by salinity of applied water. Freshwater flows from the Delta into Suisun Bay and marsh channels from October through May affect marsh salinities and waterfowl food production.

Most fish in marsh channels are striped bass, for which the marsh is an important nursery area. Other anadromous species sometimes found in the marsh include chinook salmon, sturgeon, American shad, and steelhead trout. Catfish, providing a sport fishery, are also found in Suisun Marsh.

Resident breeding populations of two endangered species (the salt marsh harvest mouse and the California clapper rail), one threatened species (the California black rail), and two candidate species (the California Suisun song sparrow and Suisun ornate shrew) have been documented in Suisun Marsh. Two state listed plant species (Mason's lilaeopsis and softbird's beak) occur in Suisun Marsh in addition to three federal candidate plant species (Suisun Slough thistle, Suisun aster, and Delta tule pea) (DWR 1994b).

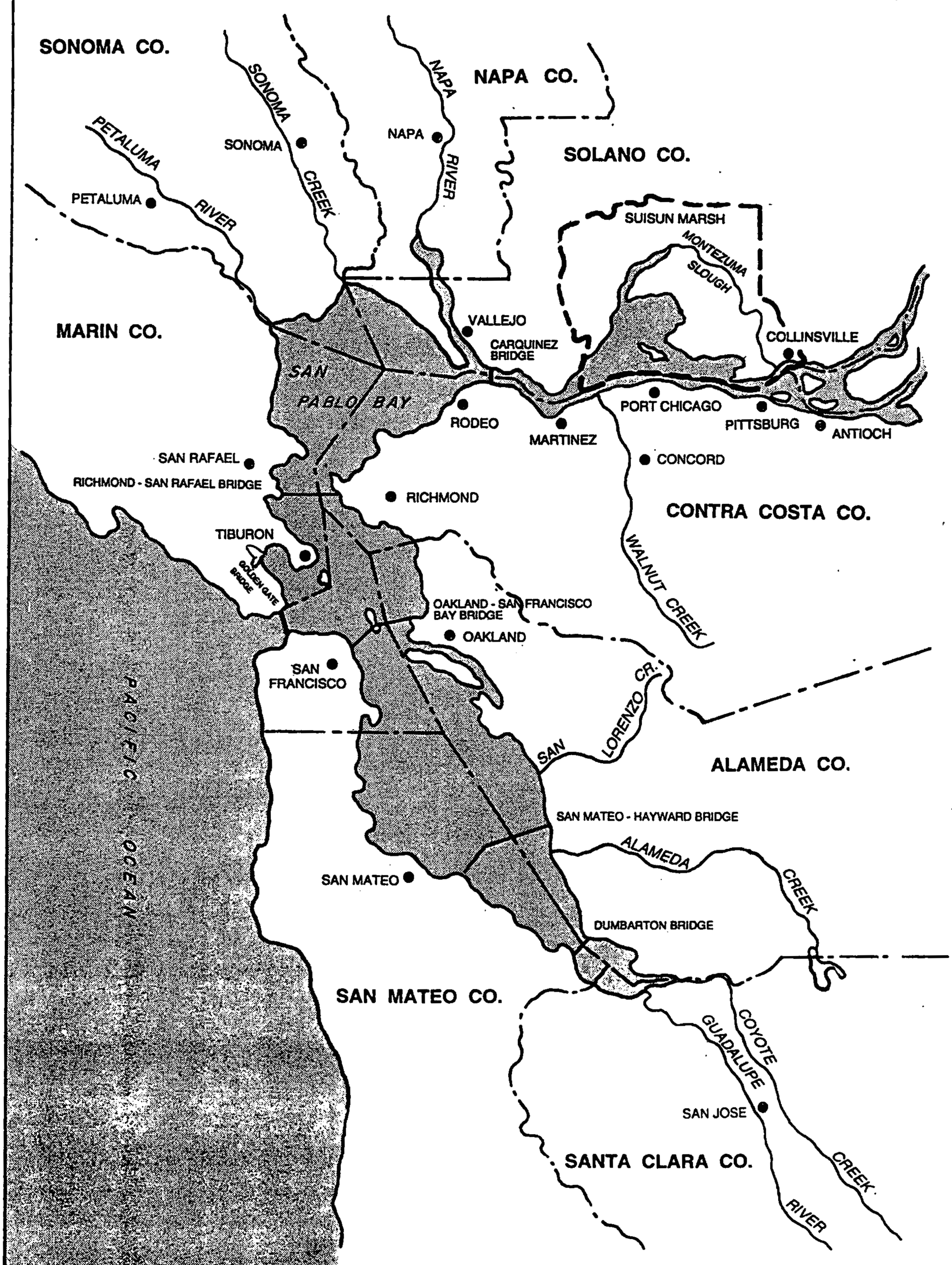
F. SAN FRANCISCO BAY

The San Francisco Bay system (Figure IV-7) is an integral part of the Central Valley and Delta ecosystems. Runoff from the northern and southern Central Valley converges in the Delta prior to discharging to the ocean through the Bay. Anadromous fish traveling to Central Valley streams to spawn or returning to the ocean travel through the Bay.

Surface Water Hydrology. San Francisco Bay, which includes Suisun, San Pablo, Central, and South bays, extends about 85 miles from the east end of Chipps Island (in Suisun Bay near the City of Antioch) westward and southward to the mouth of Coyote Creek (tributary to South Bay near the City of San Jose). The Golden Gate connects San Francisco Bay to the Pacific Ocean.

The surface area of San Francisco Bay is about 400 square miles at mean tide. This is about a 40 percent reduction, due to fill, from its original size. Most of the bay's shoreline has a flat slope, which causes the intertidal zone to be relatively large. The volume of water in the bay changes by about 21 percent from mean higher-high tide to mean lower-low tide. The depth of the bay averages 20 feet overall, with the Central Bay averaging 43 feet and the

Figure IV-7 SAN FRANCISCO BAY COMPLEX (INCLUDING SUISUN MARSH)



South Bay averaging 15 feet (DWR 1986). San Francisco Bay is surrounded by about 130 square miles of tidal flats and marshes.

The principal source of fresh water in San Francisco Bay is outflow from the Delta. Delta outflows vary greatly according to month and hydrologic year type. Historical Delta outflows have dropped to zero during critically dry periods such as 1928 and 1934. Present summer outflows are maintained by upstream reservoir releases. Although annual Delta outflow has averaged 24 MAF from 1977 to 1986, it has varied from less than 2.5 MAF in 1977 to more than 64 MAF in 1983.

Other significant sources of freshwater inflow to San Francisco Bay are the Napa, Petaluma, and Guadalupe rivers, and Alameda, Coyote, Walnut, and Sonoma creeks. These tributaries make up a total average inflow of about 350 TAF. Stream flow is highly seasonal, with more than 90 percent of the annual runoff occurring during November through April. Many streams often have very little flow during mid- or late-summer.

The surface hydrology of the bay can be divided into two distinct patterns. The northern part of the bay, including San Pablo and Suisun bays, receives freshwater outflow from the Delta and functions as part of the Estuary. The South Bay receives little runoff and behaves like a lagoon. Circulation in and flushing of the bay depend on tides and Delta outflow. Circulation is primarily a tidal process, while flushing is believed to depend on tidal action, supplemented by periodic Delta outflow surges following winter storms (USBR and DWR 1986).

Freshwater outflow from the Delta to San Francisco Bay is believed to be important in maintaining desired environmental conditions in the bay, but no standards govern such outflow. High-volume, uncontrolled outflow surges during the winter cause freshwater to penetrate well into the central bay, from which it can enter the southern bay by tidal exchange. Such events cause salinity stratification in much of the South Bay that can persist for several weeks or months following the initial appearance of freshwater.

Water requirements in the San Francisco Bay area are met by local surface and ground water supplies, and imported surface water. The conveyance systems that bring the majority of the water to the area are: the Hetch Hetchy, South Bay, North Bay, Mokelumne, Petaluma, and Santa Rosa-Sonoma aqueducts; Contra Costa and Putah South canals; Cache Slough Conduit; and the San Felipe Project. More than 60 percent of the water is imported from Delta supplies.

<u>Surface Water Quality</u>. Water quality in the San Francisco Bay system is impacted by several factors. For example, the presence of elevated concentrations of toxic pollutants in the bays, from both point and non-point sources, has caused them to be listed as impaired water bodies. The State Department of Health Services has issued health advisories on the consumption of the bays' fish and certain waterfowl due to their elevated levels of selenium and other metals (SWRCB 1994).

Pesticides in the San Francisco Bay system originate from municipal storm sewers and sanitary sewerage systems, urban runoff, and agricultural drainage from the Central Valley. The presence of these pesticides is a threat of unknown magnitude to the fisheries and wildlife resources. Fish kills have occurred in the San Francisco Bay system as a result of accidental spills of toxic materials, and discharges of inadequately treated sewage and industrial wastes. Localized fish kills involving large numbers of striped bass have occurred in Suisun Bay from unknown causes.

The San Francisco Bay area has experienced oil pollution problems mainly localized at refinery docks, ports, marinas, and near storm sewer outlets. These problems are attributable to accidental spills, deliberate discharges, pipeline leaks, and pumping of oil bilge or ballast water.

Depressed levels of dissolved oxygen in the extreme portion of South San Francisco Bay occur during the late-summer and early-fall months due to municipal waste discharges. Dissolved oxygen deficiencies also occur in the Petaluma and Napa rivers. Algal growths have caused complete lack of dissolved oxygen in the extreme reaches of some tidal sloughs, creeks, and rivers. Recent years have brought red water discoloration caused by marine ciliates, a phenomenon probably aggravated by high nutrient concentrations.

Water in much of San Francisco Bay contains coliform bacteria levels greater than those recommended for water contact sports. Substantial improvement has been reported since the initiation of chlorination of the discharge from a large municipal sewerage system.

Wildlife and Fish. The bays and surrounding lands support a wide variety of fish, migratory birds, and mammals. Open water, tidal mudflats, and marshland are used by various species, especially shorebirds and waterfowl.

The anadromous species of fish which occur in San Francisco Bay system include chinook salmon, striped bass, sturgeon, American shad, and steelhead trout. Marine fish, found mainly in the lower bays, include flatfish, sharks, and surf perch. Shellfish include mussels, oysters, clams, crabs, and shrimp. Seasonal variations in salinity in the bays, due to varying Delta outflows, affect the seasonal distribution of fish and invertebrates. Benthic invertebrates, such as clams, are limited to areas where conditions are favorable year-round. Once a thriving business, there is at present no commercial oyster industry in San Francisco Bay. There is sport clamming, although coliform bacteria concentrations are higher than the U.S. Public Health Service and State allowable limits.

Rare, threatened, or endangered animal species found in the area include the Alameda striped racer, salt marsh harvest mouse, San Francisco garter snake, California clapper rail, and California yellow-billed cuckoo.

Land Use and Economy. Nine counties surround San Francisco Bay: Marin, San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, and Sonoma. In

1987, the San Francisco Bay area, whose economy is based on commerce and industry, became the fourth largest metropolitan area in the United States.

Recreation. Mild temperatures and brisk winds make San Francisco Bay one of the world's favorite recreational boating areas. Other water-oriented recreation includes sight-seeing, picnicking, fishing, nature walking, and camping.

G. CENTRAL COAST REGION

Construction of Phase II of the Coastal Branch of the California Aqueduct will provide SWP water to the Central Coast region. The Central Coast service area, which encompasses approximately 3.9 million acres, consists of San Luis Obispo and Santa Barbara counties.

The Phase II facilities will transport 52.7 TAF of water to the area, though full SWP entitlement is 70.5 TAF per year for these areas. Santa Barbara County has the option to buy back an additional 12.2 TAF per year of SWP water. The proposed Coastal Branch Phase II, and local pipeline projects such as the Mission Hills Extension, would transect western Kern, San Luis Obispo, and Santa Barbara counties. An environmental impact report and an advance planning study were completed in May 1991.

Phase II of the Coastal Aqueduct in Kern County would be located in the northeastern portion of Antelope Valley and eastern foothill regions of the Coast Range. The area is relatively barren with few streams or other drainage. Elevation of the valley floor is about 500 feet, while hills near the project area range from 1,000 to 2,500 feet at Bluestone Ridge.

San Luis Obispo and Santa Barbara counties consist of three broad physiographic regions: a coastal plain, coastal mountains and valleys, and interior mountains and valleys. Elevations in San Luis Obispo County range from sea level along the coastal plain to 5,106 feet at the summit of Caliente Mountain in the south-east corner of the county. The seven cities in the county are Arroyo Grande, Atascadero, Grover City, Morro Bay, Paso Robles, Pismo Beach, and San Luis Obispo. The topography of Santa Barbara County is dominated by the Sierra Madre, San Rafael, and Santa Ynez mountain ranges. Elevations within Santa Barbara County vary from sea level to 6,828 feet at the summit of Big Pine Mountain. The six cities in the county are Santa Barbara, Santa Maria, Lompoc, Carpinteria, Solvang, and Guadalupe. Unincorporated communities include Goleta, Buellton, Mission Hills, Montecito, Orcutt, Santa Ynez, and Vandenberg Village. Vandenberg Air Force Base dominates the western coastal area of the county.

The climate of the Central Coast area, like much of coastal Southern California, is Mediterranean. Typically, winters are mild and moist, and summers are warm and dry. Mountain ranges intercept much of the rain, producing drier climates, and even deserts, in eastern San Luis Obispo and western Kern counties. The wettest areas occur in the Santa Lucia and Sierra Madre; the Antelope Valley in Kern County is one of the driest areas.

Precipitation varies considerably from year to year, with most occurring during November through April. Fog occurs frequently along a 2- to 15-mile-wide coastal strip.

Surface Water Hydrology. The Santa Ynez, Santa Maria, and Salinas rivers constitute the major drainage of the Central Coast service area, although numerous lesser streams exist. Dams and canals have been constructed on those rivers to conserve runoff. The Salinas River, the largest single watershed in the Central Coast area, flows northward into Monterey County and discharges into Monterey Bay. Currently, no water is imported into the Central Coast area. Ground water is the main source of water supply. Over-use of the ground water resources has led to overdrafting and water quality problems in some locations, such as the Santa Maria Valley and southern coastal Santa Barbara County.

Vegetation. Much of the natural vegetation in the two counties remains relatively undisturbed. Those areas that have been developed have mainly been the valleys, alluvial fans and plains, and terraces. Plant communities found in the area include grasslands, chaparral, scrub, riparian, marsh, woodland, and forest. Numerous sensitive plant species occur in these communities.

Wildlife and Fish. Due to the wide variety of plant communities in the area, animal populations are extremely diversified. Because of the overlap between the northern and southern floristic elements, many rare and endangered species inhabit the Central Coastal service area.

Land Use and Economy. The economy of San Luis Obispo and Santa Barbara counties depends on agriculture and related activities. In the coastal lowlands, there is considerable high value fruit and vegetable farming. In the drier lowlands, which are inland from the coast, livestock and dry-farmed grains are produced. Manufacturing is limited, but heavy water-using industries, such as petroleum production, food processing, and stone, clay, and glass products manufacturing, are present. Some mining and military installations also contribute to the region's economy. Recreation and retirement activities are increasing in the coastal communities.

H. SOUTHERN CALIFORNIA

The Southern California service area of the SWP includes Ventura, Los Angeles, and Orange counties, and parts of San Diego, Riverside, Imperial, San Bernardino, and Kern counties. The estimated population of this highly urbanized area in 1986 was over 15 million, with Los Angeles County being the most populous county in the State. SWP water is delivered to the contractors in the Southern California service area through both the East and West branches of the California Aqueduct.

Surface Water Hydrology. Due to the highly seasonal precipitation, there are no major rivers in the desert plateau region of this service area. The intermittent streams that flow from the mountains primarily percolate into groundwater basins. A limited surface water supply has been developed, and most local water supplies have been developed for flood control, groundwater recharge, and water supply. Because local water supplies are limited, imported water has played a significant role in meeting the area's growing water demands. Supplemental water is imported from three sources: (1) Los Angeles Aqueduct from the Owens Valley and Mono Lake basin, on the eastern side of the Sierra Nevada, to the City of Los Angeles; (2) Colorado River via the Colorado River Aqueduct; and (3) the SWP. Imported water was first brought into the area from Owens Valley via the Los Angeles Aqueduct by the City of Los Angeles in 1913. As development on the coastal plain increased, the Colorado River was tapped as a second imported supply in 1941 by the Metropolitan Water District, which constructed the Colorado River Aqueduct to carry this water. Both of these import facilities have been operating at or near capacity. A third major source of imported water, the SWP, first made deliveries to the Southern California area in 1972.

In Ventura and Los Angeles counties, some SWP supplies are released into natural stream channels. Piru Creek, a tributary to the Santa Clara River, serves as a conveyance to Ventura County users. In Los Angeles County, SWP water is released into Gorman Creek for recreational use. Additional opportunities exist for streamflow augmentation where the East Branch of the California Aqueduct crosses natural streams.

Surface Water Quality. Many water quality problems exist in this service area. In the coastal area, thermal discharges from electrical generation plants and nutrient overloading of streams cause local problems. In the desert areas, the problems are more general and relate to increasing salinity of both ground water and lakes. Salinity of imported water ranges from less than 220 mg/l TDS for SWP supplies to 750 mg/l TDS for Colorado River water. In some areas, SWP water is blended with imported Colorado River water to provide a better overall quality.

The quality of streams in the Antelope Valley area is good to excellent. TDS content is usually less than 300 mg/l and ranges from about 50 to 450 mg/l. The water is moderately hard, but ranges from soft to very hard, and is calcium bicarbonate in character.

The quality of water from the intermittent streams of the Mojave River area near the aqueduct is also generally good to excellent. The water is soft to moderately hard and suitable for most uses. Stormwater flow in the Mojave River is calcium bicarbonate in character and has a TDS level of less than 300 mg/l.

Ground Water Hydrology. Ground water supplies a significant portion of the water in the Southern California service area. The South Coastal hydrologic basin, which encompasses this service area, has at least 44 major groundwater basins. Although further development is possible in a few local areas, some of the basins have been over-used. Seawater barrier and artificial recharge programs have been developed to correct seawater intrusion problems, resulting from groundwater overdraft, in some areas along the coast.

Ground Water Quality. Ground water quality in the immediate vicinity of the aqueduct in the Antelope Valley is excellent. TDS concentrations of about 150 to 300 mg/l dominate, with a few smaller areas around the communities of Littlerock and Pearblossom having TDS concentrations of about 300 to 500 mg/l.

The ground water quality in the Mojave River area is fair. TDS concentrations range from about 300 to 1,000 mg/l and are predominantly calcium or sodium bicarbonate in character, with calcium predominating in the recharge area of the foothills, and sodium in the middle and lower discharge areas of the playas.

Vegetation. While some of the naturally-occurring vegetation in the Southern California service area has been altered significantly by urban and agricultural development, a large part of the region, mostly uplands, retains it native cover. The dominant natural vegetation type in the non-urbanized portion of the Southern California service area is a mixture of coastal sage scrub and chaparral communities, covering 46 percent of the land area. Chaparral has little commercial value, but it forms a valuable watershed cover and wildlife habitat.

Wildlife and Fish. The Southern California service area supports a great diversity of wildlife. Though several mammal species are found here, most of the wildlife in this area are birds. Reservoirs along the aqueduct provide habitat for numerous geese, ducks, and shore birds, including several hundred Canada geese that winter in the upper Antelope Valley.

Fish found in the California Aqueduct include largemouth bass, striped bass, green sunfish, bluegill, and catfish. In addition to these species, rainbow trout are stocked in Silverwood Lake.

The diversity of habitats available in the area, combined with the impacts of a rapidly developing human population, has resulted in a large number of rare and endangered species. Steps have been taken to preserve habitats that have unique biological significance. One endangered fish, the unarmored three-spine stickleback, exists in the service area but is no longer found in the Los Angeles, San Gabriel, and Santa Ana rivers. The population in the Santa Clara River is threatened by increased recreational use and development.

Land Use and Economy. Since the 1940's, Southern California has changed from a largely rural community with an agricultural economy to a highly urban-industrial society. This region, the State's leading center of business, contains several major industries, including aerospace, petroleum, fabricated metals, chemical production, food processing, and paper production.

In the coastal areas of Southern California, agriculture remains important economically, despite urbanization. Farms generally produce high value crops on small irrigated parcels. Agriculture is also important in the Colorado Desert, especially in the Coachella and Imperial valleys, where livestock, field crops, truck crops, sugar beets, and cotton are produced. Poultry, livestock, and field crops are produced in the Mojave Desert. On agricultural lands in the Antelope and Mojave basins, the principal crops are alfalfa and grain products. Almond, apple, apricot, pear, irrigated pasture, and some truck crops are also grown.

Recreation. Recreational facilities along the aqueduct include a bicycle trail with attendant rest facilities and fishing sites. The bikeway extends 105 miles from Quail Lake, near Interstate Highway 5, to a point near Silverwood Lake in the San Bernardino National Forest. It is available to bicycle riders, hikers, and anglers.

The U.S. Forest Service anticipates routing a portion of the Pacific Crest National Scenic Trail along the aqueduct. This would establish a hiking and equestrian route intersecting the aqueduct, moving east for 1 mile along the East Branch right-of-way to the Los Angeles Aqueduct, then north along that aqueduct, and eventually connecting with the Sequoia National Forest portion of the trail. Five fishing access sites are available along the East Branch.

The four SWP reservoirs in Southern California receive heavy year-round recreational use. Castaic Lake offers boating, swimming, fishing, waterskiing, and picnicking. Camping facilities are available in the adjoining Angeles National Forest. Facilities at Castaic Lake and Lagoon are operated by Los Angeles County Department of Parks and Recreation. Lake Perris, where recreational facilities are run by the Department of Parks and Recreation, offers swimming, boating, waterskiing, picnicking, camping, fishing, hiking, hunting, scuba diving, and rock climbing.

The other two Southern California reservoirs are farther from population centers, but are, by no means, remote. Pyramid Lake, in northwestern Los Angeles County, has facilities operated by the U.S. Forest Service. It offers boating, fishing, picnic sites, waterskiing, and swimming. Silverwood Lake, in the San Bernardino Mountains, has a State Recreation Area run by the State Department of Parks and Recreation. Recreation possibilities are fishing, picnicking, camping, hiking, swimming, bicycling, waterskiing, and boating.

Literature Cited in Chapter IV

DWR. 1986. Final Environmental Impact Report on the proposed additional pumping units, Harvey O. Banks Delta Pumping Plant. California Department of Water Resources. Sacramento, CA. January 1986. 511 pp.

DWR. 1990. Draft Environmental Impact Report/Environmental Impact Statement, North Delta Program. California Department of Water Resources. Sacramento, CA. November 1990. 619 pp.

DWR. 1993. Draft Program Environmental Impact Report, State Drought Water Bank. California Department of Water Resources. Sacramento, CA. January 1993. 198 pp. plus appendices.

DWR. 1994a. California Water Plan Update. Volume 1. Bulletin 160-93. California Department of Water Resources. Sacramento, CA. October 1994. 398 pp. Volume 2. Bulletin 160-93. October 1994. 315 pp.

DWR. 1994b. Summary of Sensitive Plants and Wildlife Resources in Suisun Marsh During Water Years 1984-1994. Department of Water Resources. Sacramento, CA. December 1994. 107 pp.

NHI. 1992. Adverse effects of increased salinity on Suisun Marsh brackish wetlands. Testimony of the Natural Heritage Institute and the Environmental Defense Fund. 6 pp. (WRINT-NHI-12)

Schubel, J.R. 1993. Managing freshwater discharge to the San Francisco Bay-Delta Estuary: the scientific basis for an estuarine standard. San Francisco Estuary Project, U.S. Environmental Protection Agency, San Francisco, CA.

SWRCB. 1994. Draft water quality assessment. State Water Resources Control Board. Sacramento, CA. May 24, 1994. 307 pp.

USBR. 1975. Central Valley Project Operations, Total Water Management Study for the Central Valley Basin, California. U.S. Bureau of Reclamation, Mid-Pacific Region. Sacramento, CA.

USBR. 1981. Central Valley Project -- Its historical background and economic impacts. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region. Sacramento, CA. July 1981. 46 pp.

USBR and DWR. 1986. Joint Environmental Impact Statement/Report for the Coordinated Operation Agreement for the Central Valley Project and the State Water Project. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region, and California Department of Water Resources, Sacramento, CA. April 1986. 145 pp. plus attachment.

Williams, P. and M. Josselyn. 1987. Recommendations for salinity standards to maintain the wetlands of Suisun Marsh. Prepared for San Francisco Bay Conservation and Development Commission. 67 pp.

V. AQUATIC RESOURCES

Populations of many aquatic resources that exist in the Bay-Delta Estuary have undergone significant declines over the past several decades. These population reductions have led to concerns about the condition of the estuarine system, as well as petitions and listings for endangered status for some species. The simultaneous declines of many estuarine species suggest that they are responding to common stresses (Jassby et al. 1994).

The following discussion is divided into three sections. First, the general causes contributing to the decline of aquatic resources are reviewed. Second, the population trends and, if relevant, causes of declines of specific aquatic resources are presented. Third, the degree to which the general causes contributing to the decline are controllable is discussed.

A. GENERAL CAUSES OF DECLINES

Numerous factors are thought to be responsible for the decline of fish and invertebrate species that live in and migrate through the Bay-Delta Estuary. The conditions in the Estuary may be only partially responsible for the decline of those species that utilize the Estuary for only a part of their life cycle. The general causes of decline for most of the species utilizing the Estuary fall within the following categories: (1) natural hydrologic variability; (2) water development; (3) introduction of non-native aquatic organisms; (4) food limitations; (5) land reclamation and waterway modification (diking, dredging, and filling); (6) pollution; (7) harvesting; and (8) oceanic conditions. These factors can cause direct, indirect, and cumulative effects on the various species in the Estuary (DFG 1994b, SFEP 1992a). The most significant factors are the human-induced factors, and of these, water development, land use practices, and harvesting of aquatic species are the most significant factors causing declines in aquatic species.

1. Natural Variability of Precipitation and Hydrology

The flow of fresh water to the Bay-Delta Estuary is determined mainly by the amount and timing of precipitation in the Central Valley watershed. Under natural conditions in an average year, flows increase in late fall as rains swell streams. Flows continue to increase throughout the winter and peak in the spring when warm temperatures melt the Sierra snowpack. After the spring snow melt, flows decline to low levels until the fall (SFEP 1992b).

Just as total precipitation varies each year, the volume of water annually flowing into the Delta has been highly variable. During the past 70 years, in years of high precipitation, the volume of inflow to the Delta may exceed 50 MAF; in years of low precipitation, Delta inflow may be less than 8 MAF. For planning and regulatory purposes, the SWRCB has developed water year classification systems that provide a relative estimate of the amount of water originating in the Sacramento and San Joaquin hydrologic basins from seasonal runoff and reservoir storage. Each system has five kinds of water years: wet, above normal, below normal, dry, and critical. Table V-1 shows the water year types for the Sacramento and San Joaquin river systems for the period 1922-1992 (SFEP 1992b). The past 20 years have included the wettest year (1983), as well as the driest and longest droughts (1976-1977 and 1987-1992), on record (NHI 1992a). In addition to year-to-year variations in flow, extreme fluctuations occur on a seasonal basis. For example, May of 1990, a critical year, was the wettest May on record (CUWA 1994).

Many of the Estuary's native aquatic species are adapted to an ecosystem characterized by this high seasonal variation in freshwater flows. One of the most important aspects of the natural flow pattern was the large volume of water that entered the Estuary in the winter and spring. These flows repelled sea salts from the Delta, ensuring appropriate water quality for freshwater wetlands. They also washed nutrients into the Estuary, stimulating growth of organisms at the base of the food web, and enabled fish to migrate, spawn, and rear successfully (SFEP 1992b).

Variation in the amount of flow to the Bay-Delta is the most commonly cited control on the abundance, distribution, and reproductive success of many species fish in the Estuary. Drought and low flow conditions can have wide-ranging impacts on aquatic resources, depending on the species and life stage requirements. For many species, drought conditions can reduce available physical habitat, elevate water temperatures, reduce the food supply, increase susceptibility to predation, and degrade spawning and rearing habitats. Poor habitat conditions in one year will likely result in reduced egg and young survivals for that year, resulting in a poor year class in the adult population. If conditions continue for multiple years, the ability of the species to recover may be reduced (CUWA 1994).

There is little doubt that the combination of floods and severe droughts have contributed to, and accelerated, the declines in populations of aquatic resources in the Bay-Delta Estuary, particularly in recent years. However, the effects of variable precipitation patterns, particularly sustained drought and low flow conditions, on aquatic species must be considered in the context of ongoing operations of water projects and other diversions (NHI 1992a, SFEP 1992b). As discussed below, the natural pattern of freshwater flow into the Bay-Delta Estuary has been changed significantly by water development.

2. Water Development

There has been extensive water development throughout the Central Valley. There are numerous direct and indirect effects on downstream water quantity and water quality, from operations of reservoirs upstream to the export pumping in the Delta.

Until the mid-1800's, the waters of the Central Valley and the Bay-Delta Estuary, and its aquatic resources, were essentially undisturbed by water development. After the discovery of gold in 1848, the diversion of water from northern Sierra streams for hydraulic mining began to modify the Estuary's freshwater flows. By 1860, more than half of the State's population of 380,000 lived around the Estuary or in its watershed. The increasing demand for food

Table V-1
Water Year Types for the Sacramento and San Joaquin River Basins [1]
1922-1992

Water Year	Sacramento River	San Joaquin River
1922	AN	W
1923	BN	AN
1924	C	C
1925	D	BN
1926	D	D
1927	W	AN
1928	AN	BN
1929	C	C
1930	D	C
1931	C	C
1932	D	AN
1933	C	D
1934	C	C
1935	BN	AN
1936	BN	AN
1937	BN	W
1938	W	W
1939	D	D
1940	AN	AN
1941	W	W
1942	W	W
1943	W	W
1944	D	BN
1945	BN	AN
1946	BN	AN
1947	D	D
1948	BN	BN
1949	D	BN
1950	BN	BN
1951	AN	AN
1952	W	W
1953	W	BN
1954	AN	BN
1955	D	D
1956	W	W
1957	AN	BN
1958	W	W
1959	BN	D
1960	D	C
1961	D	C
1962	BN	BN
1963	W	AN
1964	D	D
1965	W	W
1966	BN	BN
1967	W	W
1968	BN	D
1969	W	W
1970	W	AN
1971	W	BN
1972	BN	D
1973	AN	AN
1974	W	W
1975	W	W
1976	C	C
1977	C	C
1978	AN	W
1979	BN	AN
1980	AN	W
1981	D	D
1982	W	W
1983	W	W
1984	W	AN
1985	D	D
1986	W	W
1987	D	C
1988	C	C
1989	D	C
1990	C	C
1991	C	C
1992	C	C

[1] *Sacramento River sorted by 40-30-30 water year classification; San Joaquin River sorted by 60-20-20 water year classification*

prompted the conversion of native habitats to farmland. As agriculture became established in the Central Valley, significant volumes of water from streams were diverted to irrigate crops (SFEP 1992b).

Although hydraulic mining was ceased in 1884, the expansion of irrigated agriculture in the Central Valley continued well into this century. By 1929, more than 1.2 million acres of valley lands, excluding the Delta, were irrigated with water diverted directly from the Sacramento and San Joaquin river systems upstream of the Delta. The early-1900's was also a period of urban and industrial growth. To support the economic growth of the region, private and public water development projects were constructed in the Estuary's watershed to provide electrical generation, flood control, and water for municipal, industrial, and agricultural uses. The Mokelumne Aqueduct began delivering water from the Mokelumne River drainage to the East Bay in 1929, and the Hetch Hetchy Aqueduct began transfers of water from the Tuolumne River to San Francisco in 1935. The federal CVP, with dams on the Sacramento and San Joaquin rivers, began providing water in 1945 with the operation of the Contra Costa Canal. The CVP began transporting Delta water in the Delta-Mendota Canal in 1951. The main features of the Sacramento River Flood Control Project were completed in the mid-1940's. The SWP, which was authorized in 1959, began delivering water, via the California Aqueduct, to north of the Tehachapis in 1968; by 1972, SWP facilities were supplying water to southern coastal areas of California.

The extensive water development in the Central Valley and Delta has adversely affected fish and wildlife habitat in the Estuary and upstream areas (SFEP 1992b). An overview of impacts resulting from water development are discussed below under the following headings: upstream impacts; inflows to the Delta; Delta outflow; Delta diversions and entrainment; reverse flows; and the Delta Cross Channel and Georgiana Slough.

a. Upstream Impacts. Large multi-purpose reservoirs have been constructed on all of the Central Valley's major streams except the Cosumnes River. More than 100 reservoirs each have a storage capacity of at least 50 TAF, and the ten largest each store more than 1 MAF of water. Together, valley reservoirs can store about 27 MAF, which is about 60 percent of the State's average annual runoff (SFEP 1992b).

The construction of dams for water storage on nearly all of the Estuary tributary streams in the Central Valley has eliminated habitats for numerous aquatic species. Dams have also blocked access to thousands of miles of cool water spawning and rearing habitats for migratory species, such as salmon and steelhead trout, which rely on the upper tributaries to complete their life cycle. Upstream water development has reduced the stream spawning habitat available to salmon and steelhead from 6,000 miles to 300 miles, a 95 percent reduction from historic levels. Approximately 50 percent of the available spawning grounds in the Sacramento River were eliminated by the construction of Shasta Dam alone, and Friant Dam eliminated all salmon spawning on the main stem of the San Joaquin River above Friant (DFG 1993).

Reservoirs not only block access to cooler water upstream, but also act as heat storage facilities in the summer months (DFG 1994b). Impoundments increase stream water temperatures by releasing water that was heated in the reservoir and by reducing instream flows below the dam. Water temperature is also affected by overhanging vegetation which shades and cools the water. Shaded riverine aquatic habitat has been significantly altered through bank protection and flood control projects.

Agricultural return flows, such as those from the Colusa Basin Drain into the Sacramento River, are also major contributors of warm water to the rivers (DFG 1993). Flows in the Colusa Basin Drain occasionally exceed 2,000 cfs with water temperatures in excess of 80°F; whereas typical summer Sacramento River flows are 15,000 cfs at temperatures of 68°F. Consequently, water temperatures in the Sacramento River can exceed 70°F below Knights Landing during May and June. In all three major tributaries of the San Joaquin River system, the Merced, Stanislaus, and the Tuolumne rivers, warm water temperatures have exceeded critical temperatures for salmonid spawning, incubation, and rearing, especially in dry years (DFG 1993).

Dams also impede the replenishment of gravel necessary for salmon and steelhead spawning by preventing the movement of new gravel from upstream areas. Furthermore, gravel replacement from stream banks is limited by erosion control and bank stabilization activities. These activities have also reduced the amount of riparian habitat in the upstream areas, reducing usable fish habitat and contributing to the warming of the rivers (DFG 1994b).

In addition to the direct impacts associated with loss of habitat, the operations of upstream water projects have altered the natural flow conditions in the lower rivers. Upstream water development causes variations in stream flows which differ from the natural seasonal variation in freshwater flows to which the Estuary's native aquatic species are adapted. Central Valley reservoirs are operated primarily for flood control in the winter and for capturing the spring snowmelt runoff to be released in the summer for agriculture. Although the timing of flow releases varies from reservoir to reservoir, the overall effect of storage operations is to reduce the volume of water flowing downstream throughout the late fall, winter, and spring, and to increase flows during the summer and early fall. Under natural conditions in an average year, flows increase with rainfall in late fall, continue to increase throughout the winter, peak in the spring with the Sierra snow melt, and then decline to low levels until the fall (CUWA 1994, SFEP 1992b).

Changes in the amount and timing of flows as a result of water development have impacted aquatic resources in upstream areas by influencing the amount and quality of habitat available. Rapid reductions in flow can expose incubating eggs or strand young fish which use the edge of the stream channel. Adequate flows, particularly in the San Joaquin River system, are often not provided to maintain adequate temperatures during the salmon smolt outmigration period (DFG 1993). Delays in the transport of migratory species can increase mortality rates through increased predation and losses to diversions (CUWA 1994).

Upstream water diversions impact aquatic resources in various ways. Diversion structures, such as those on Butte, Clear, Mill, and Deer creeks in the Sacramento River basin, can cause barriers to upstream spawning habitat and delay migration (DFG 1993). Thousands of unscreened and inadequately screened diversions in upstream areas entrain aquatic organisms and increase mortality. Upstream diversions remove large volumes of fresh water from Central Valley streams that are tributary to the Delta and cause reductions in stream flow. The amount of water diverted upstream of the Delta has increased markedly since the turn of the century when slightly more than 1 MAF was removed. Today, upstream diversions reduce Delta inflow by an estimated 9.4 MAF, or about one-third of the historic average annual Delta inflow. CVP diversions account for about 4.5 MAF of the upstream depletion; the Hetch Hetchy and Mokelumne aqueducts combined remove about 470 TAF, and thousands of other agricultural and urban diversions account for the remainder (SFEP 1992b).

b. Inflows to the Delta. The total annual volume of freshwater inflow to the Estuary is highly variable. During the past 70 years, annual inflow has ranged from more than 70 MAF to 5.9 MAF, with an average of about 21 MAF. This variability is the result of precipitation patterns and upstream water development, primarily storage reservoirs and diversions (SFEP 1992b). Inflows to the Delta principally come from three Central Valley sources: the Sacramento River basin, the San Joaquin River basin, and the Central Sierra basin. These river basins contributed approximately 80, 15, and 5 percent of the average annual Delta inflow from the Central Valley (SFEP 1992b).

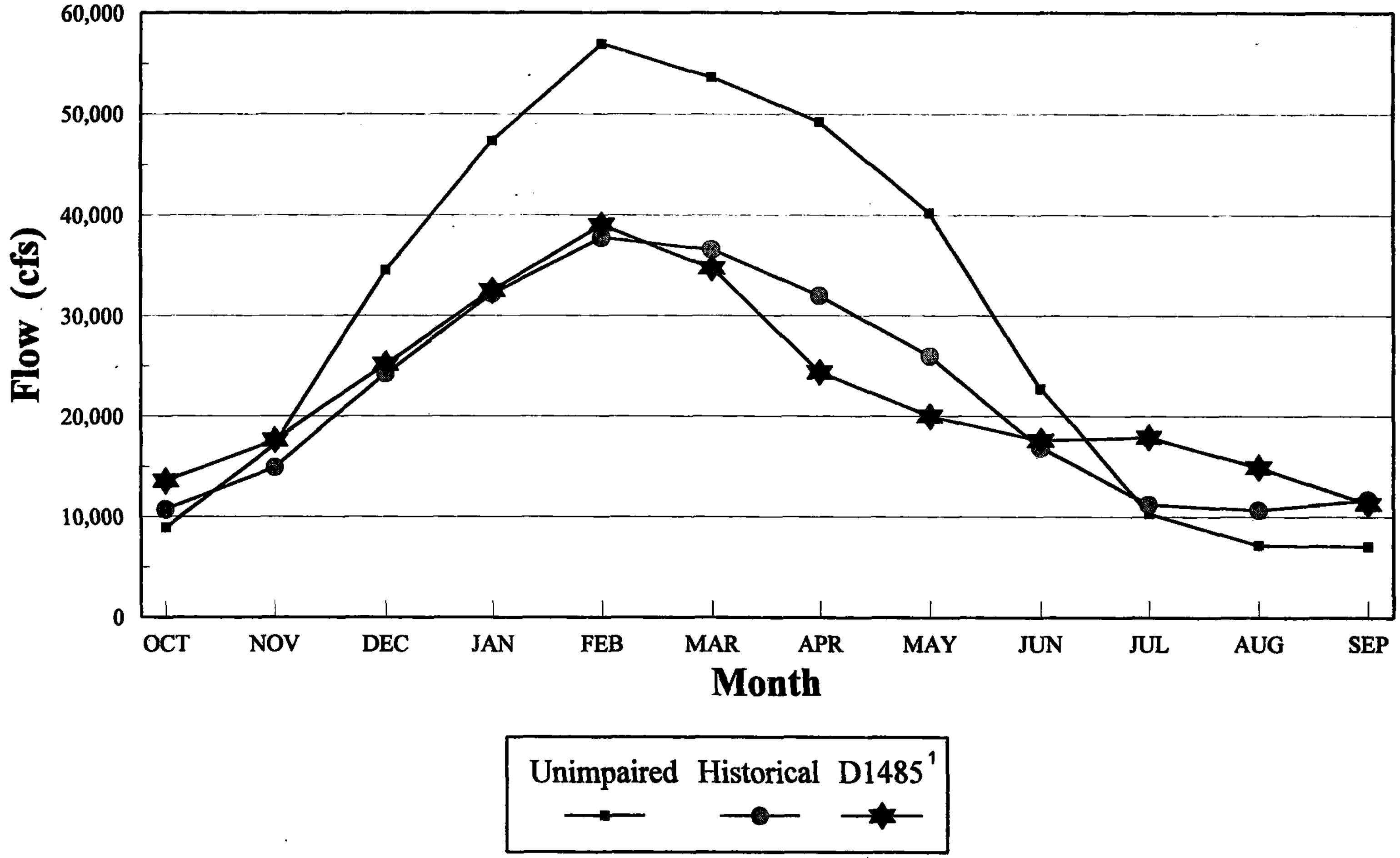
The Sacramento River basin inflow to the Delta comes from four major river systems: the Sacramento, Feather, Yuba, and American. The unimpaired flows from these river systems, often referred to as the Sacramento River Basin Four Rivers Index, represent approximately 47, 25, 13, and 15 percent, respectively, of the total flow from the Sacramento River Basin. Flows to the Delta from the Sacramento River basin are measured at Freeport. Figure V-1 shows average monthly unimpaired, historical, and D-1485 flows for the Sacramento River at Freeport over the 1930-1992 hydrological period. Unimpaired flows are those that would exist in the absence of upstream impoundments and diversions in the presence of existing channel configurations. Historical flows are those that actually occurred and were measured over the historical hydrological period; historical flows reflect upstream impoundments and diversions in the presence of existing channel configurations. D-1485 flows, which were derived from a DWRSIM operation study at the 1995 level of development, are those flows that would have occurred had the flow and operation requirements of D-1485 been implemented over the 63-year hydrological period.

Unimpaired flows in the Sacramento River at Freeport (Figure V-1) were high from January through May and low in July to September until rains began in October or November. Historical and D-1485 flows are below unimpaired flows in wetter months due to upstream diversions and storage, and are higher than unimpaired flows in the drier months due to flow requirements for meeting water quality objectives and export demands.

Figure V - 1

Sacramento River Average Monthly Flow at Freeport

1930-1992 Average Monthly Hydrology



1 - Derived from DWRSIM operation study at 1995 level of development

The San Joaquin River basin inflow to the Delta comes from the San Joaquin, Merced, Tuolumne, and Stanislaus river systems. Peak stream flows above the reservoirs on these streams, which depend on snow melt, typically occur later in spring than in the Sacramento River basin because the San Joaquin River basin mountain ranges are generally higher than those in the Sacramento basin. Flows to the Delta from the San Joaquin River basin are measured at Vernalis. Figure V-2 shows average monthly unimpaired, historical, and D-1485 flows for the San Joaquin River at Vernalis over the 1930-1992 hydrological period. The primary reasons for the differences between annual average unimpaired flows and historical and D-1485 flows are storage in the upstream reservoirs and consumptive water use by San Joaquin Valley agriculture during the irrigation season, which is generally April-September. About 77,000 acres in the San Joaquin River basin have subsurface agricultural drainage systems which discharge to the San Joaquin River, primarily via Mud and Salt sloughs. During the irrigation season, and occasionally following the flushing of the agricultural drainage water from duck clubs in January and February, agricultural drainage makes up a significant portion of San Joaquin River inflow. Low flows of poor quality in the lower San Joaquin River interfere with the upstream migrations of salmon (due to lack of attraction flows, high water temperatures, and low dissolved oxygen) and spawning of striped bass (due to high salinities). The operation of reservoirs on the four major rivers in the San Joaquin River basin has raised flows in September and October above unimpaired flow levels (DFG 1993).

The Central Sierra basin includes the Delta and watersheds of the Mokelumne, Cosumnes, and Calaveras rivers. Inflow to the Delta from this basin comes from the Mokelumne and Cosumnes river systems, sometimes called the "eastside streams" (SWRCB 1988).

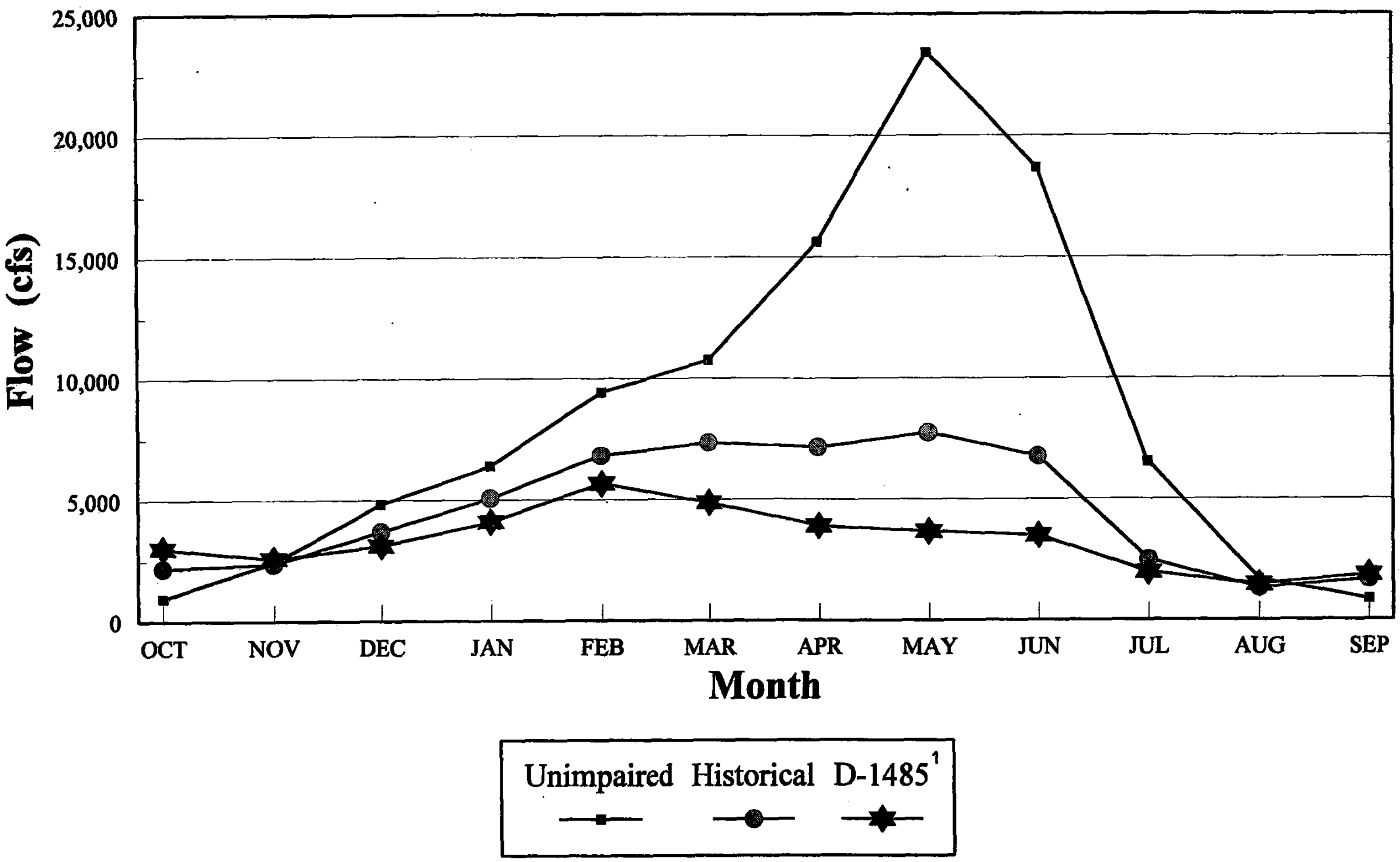
It is evident that water project operations, particularly since 1940, have altered the unimpaired flow conditions by changing the timing of flows and preventing significant volumes of fresh water from reaching the Estuary (SFEP 1992b). The overall effect of water development, in many years, is that inflow to the Delta is generally higher in the summer and early fall and considerably lower during the remainder of the year, particularly in the spring. The effect is less pronounced in wetter years. This disruption of unimpaired inflows to the Delta also contributes to the causes of the declines in aquatic species that are affected by Delta outflow.

c. Delta Cross Channel and Georgiana Slough. The Delta Cross Channel was constructed by the USBR in 1951 to improve water conveyance through the Delta. This gated channel diverts water from the Sacramento River into the eastern Delta channels, including the north and south forks of the Mokelumne River. During periods of high flow in the Sacramento River (above 25,000 cfs at Freeport), the gates are closed to limit flooding in the interior Delta channels. Georgiana Slough, a natural ungated channel located about 1 mile downstream of the Delta Cross Channel, conveys Sacramento River water to the San Joaquin River (DWR 1992a).

Figure V - 2

San Joaquin River Flow at Vernalis

1930-1992 Average Monthly Hydrology



1 - Derived from DWRSIM operation study at 1995 level of development

The Delta Cross Channel and Georgiana Slough can divert fish from the Sacramento River into the central Delta. Up to 70 percent of the Sacramento River flow can be diverted through these two channels. Studies show that fish which migrated through the central Delta experienced a higher mortality rate than those that stayed in the main river channel. Survival of fish released downstream of the gates has been about twice that of fish released above the gates (DWR 1992b, USFWS 1992).

The Delta Cross Channel is not screened to prevent fish from entering the central Delta. An interagency salmon management study concluded that screening the Delta Cross Channel was not a technically feasible alternative (DWR 1992a). Therefore, closure of the Delta Cross Channel gates is the only method available to prevent fish from being diverted into the channel. Investigation into the feasibility of a temporary rock barrier at Georgiana Slough was suspended. Studies are presently underway to determine the feasibility and effectiveness of an acoustic fish barrier to prevent diversion into Georgiana Slough.

d. Delta Outflow. Delta outflow is the calculated amount of fresh water that flows past Chipps Island into Suisun Bay. During this century, the annual depletion in the Estuary's freshwater supply due to upstream and Delta diversions has grown from about 1.5 MAF to nearly 16 MAF. Of the 16 MAF diverted, about 7 MAF are diverted from the Delta for local use and export. These Delta diversions consist of numerous agricultural diversions for Delta farmlands and exports by the CVP and SWP (SFEP 1992b).

About 1,800 unscreened agricultural diversions remove water directly from Delta channels for irrigation and leaching. The volume of water diverted each year for in-Delta farming is significant but has not changed much over the years. Taking into account agricultural return flows, Delta farms deplete Delta outflow by an average of about 960 TAF each year. During the summer, when irrigation of Delta farmlands is at a peak, these agricultural diversions may exceed 4,000 cfs; this is about the same rate at which the CVP removes water from the Delta in the summer (SFEP 1992b).

The two largest diverters of Delta water are the CVP and the SWP. Annual diversions at the CVP's Contra Costa Canal averaged about 35 TAF during the first decade of operations and about 130 TAF in 1987-1989. Major diversions from the Delta began in 1951 with the pumping of water by the CVP's Tracy Pumping Plant to the Delta-Mendota Canal (DMC). The volume of water pumped into the DMC each year has increased from an average of about 700 TAF in the 1950's to more than 2.8 MAF in 1989. In 1989, the total CVP diversion from the Delta through both canals was over 3.0 MAF. Since the SWP's Banks Pumping Plant began operation in 1968, annual SWP Delta diversions have increased steadily, reaching a peak of more than 3 MAF in 1989. In 1990, annual exports of water from the Delta by the CVP and SWP totaled nearly 6 MAF (SFEP 1992b).

Despite the long-term trend of increased annual diversions, there is disagreement concerning whether annual Delta outflow has decreased or increased. It may be that, despite increases in the volume of water diverted, average annual Delta outflows have remained fairly high due to an increasing trend in precipitation and changes in hydrological conditions (e.g., increased runoff from land use changes, water imported from outside the watershed, redistribution of ground water) that have occurred in the watershed since the 1920's. Nevertheless, it is primarily the seasonal pattern of Delta outflow, rather than the average annual volume of Delta outflow, that influences the populations of aquatic organisms which are dependent on the Estuary (SFEP 1992b).

Seasonal flows strongly affect physical variables and biological processes in the Bay-Delta Estuary, such as water temperature, salinity, pollutant concentrations, and the migration and transport of many life stages of organisms (SFEP 1992b). Changes in Delta outflow may affect estuarine and anadromous species by altering the time it takes them to move upstream or downstream. A reduction in transport time may adversely affect Delta species that spawn upstream and depend on currents to carry their eggs and larvae to downstream nursery areas (DWR 1992a). Flows during the months of April, May, and June are especially important for the reproductive success and survival of many species found in the Estuary (SFEP 1992b).

Seasonal trends in Delta outflow are illustrated in Figure V-3. Figure V-3 shows average monthly Delta outflow under unimpaired, historical, and D-1485 conditions (described above for Figures V-1 and V-2) over the 1930-1992 hydrological period. A comparison of the unimpaired Delta outflow to the historical and D-1485 levels of Delta outflow reveals that water development has drastically altered seasonal Delta outflow. Water storage and diversions generally reduce Delta outflow in every month except September and October. The reduction in outflow is especially pronounced in April, May, and June, when flows are critical for aquatic resources in the Bay-Delta Estuary. Therefore, it is widely held that the reduction of spring outflow is one of the most significant adverse impacts of water development on aquatic resources in the Estuary.

Entrapment Zone. In addition to water quality and migration/transport factors, Delta outflow, in part, influences the location of low salinity habitat in the Estuary. Understanding of the low salinity habitat and hydrodynamics of the Estuary, and their influence on the estuarine biota, is continually evolving.

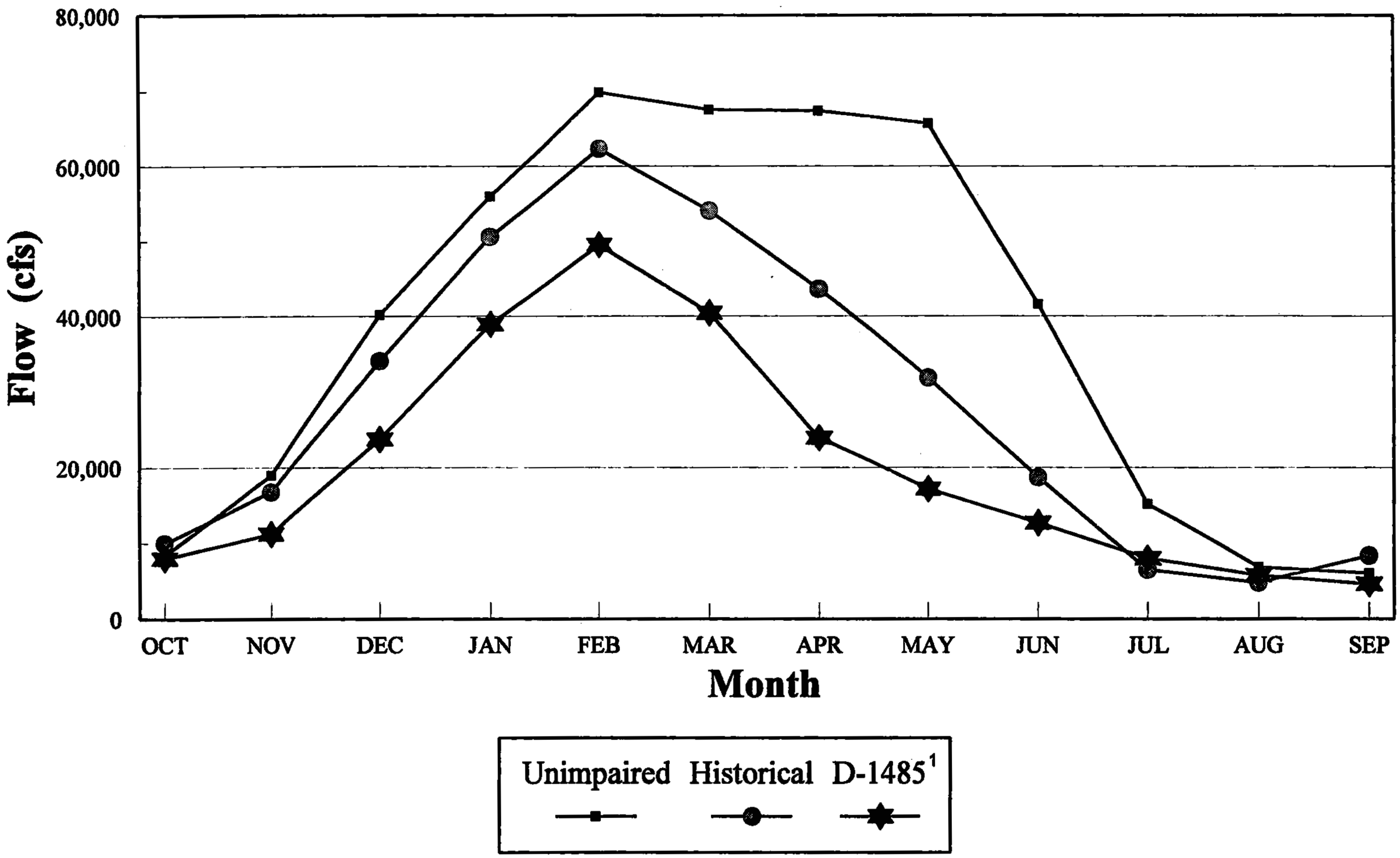
Conventional thought has been that the entrapment zone is a transient region of the Estuary where freshwater and saltwater flows interact, creating relatively low salinity habitat. The entrapment zone was believed to form principally as a result of two-layered flow, resulting in elevated concentrations of particulate matter. As fresh water flowed downstream over the more dense, landward-flowing salt water, some of the water in each layer moved vertically due to frictional forces between the layers. The combination of vertical mixing between the fresh- and salt-water layers, and the horizontal flows within these layers would trap particles with certain settling velocities.

In 1994, the USGS, with others, investigated the relationships between low salinity habitat, hydrodynamics, suspended sediment, and biology, and found evidence that disrupted the

Figure V - 3

Delta Average Monthly Outflow

1930-1992 Average Monthly Hydrology



1 - Derived from DWRSIM operation study at 1995 level of development

theory of the entrapment zone. They found that two-layered flow, called gravitational circulation, occurred in the fall, but did not occur in the spring of that year. Also, they found that gravitational circulation does not necessarily occur just downstream of the location of low salinities, but can occur much farther downstream. Therefore, gravitational circulation is not necessarily associated with the low salinity habitat. Additional investigation is continuing in 1995 to further discover the relationships between the hydrodynamics, salinity, and the distribution and abundance of the biota of the Estuary (Jon Burau, USGS, pers. comm., March 1995). (Because this discovery is very new, many recent publications cited in the following sections refer to the entrapment zone, without making a distinction between low salinity habitat and gravitational circulation.)

Nonetheless, freshwater outflows and antecedent conditions determine the location of the low salinity habitat in the Estuary. Other factors, including exports and upstream reservoir operations, may alter the location of the low salinity habitat. The location and size of low salinity habitat are also affected by the magnitude of tidal flow, bottom topography, and wind (DWR 1992a).

The entrapment zone provides habitat for species that reside in or near it, and may also serve as a food supply region for consumer species such as zooplankton and fish. It has been found to contain elevated concentrations of juvenile striped bass and some species of phytoplankton and zooplankton (SFEP 1992b).

Phytoplankton production is increased with increased outflow, in general. The phytoplankton growth rate is influenced by the location of the zone of gravitational circulation. When gravitational circulation is farther downstream, the phytoplankton have a longer residence time in the shoals and, therefore, a higher growth rate. Within the zone of gravitational circulation, phytoplankton production is decreased because of increased turbidity. Phytoplankton biomass is highest when gravitational circulation is adjacent to the shoal areas, in San Pablo and Suisun bays, due to the exchange of phytoplankton cells from the shoals (where productivity is highest) to the zone of gravitational circulation (driven by winds and tidal exchange), which then traps the cells and accounts for the higher biomass (but not higher productivity). In Suisun Bay, Delta outflows in the 5,000 to 8,000 cfs range historically have been associated with maximum phytoplankton production (SFEP 1992b, DWR 1995c).

An operational definition based on 2 ppt salinity measured on the bottom (commonly known as X2) has been used to define the approximate location of the upstream edge of the entrapment zone in the Estuary. Relationships between measures of abundance for certain aquatic species and entrapment zone position indicate that, when X2 is upstream, annual abundance indices are lower (DWR 1992a). For certain other species, this is not the case (CUWA 1994). Figure V-4 shows the entrapment zone position from 1972-1989 relative to the Golden Gate Bridge, and Figure V-5 shows the relationship between entrapment zone position and Delta outflow (Kimmerer 1992).

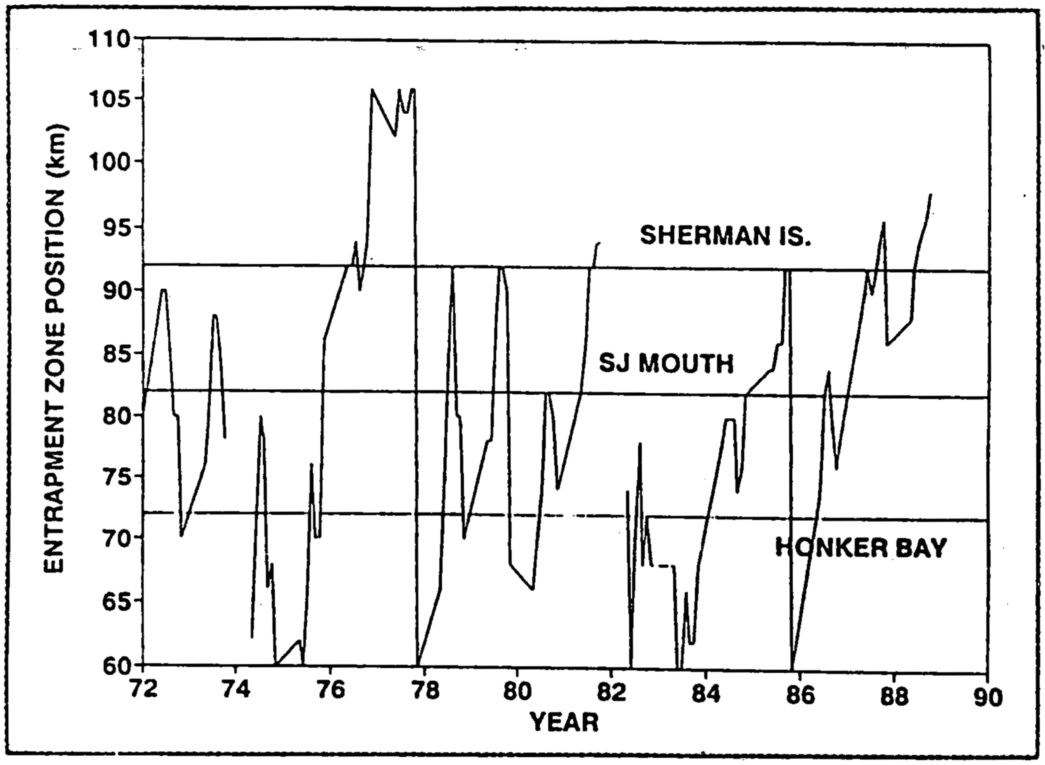


Figure V-4. Entrapment zone position (kilometers from the Golden Gate) versus time. (Source: Kimmerer 1992)

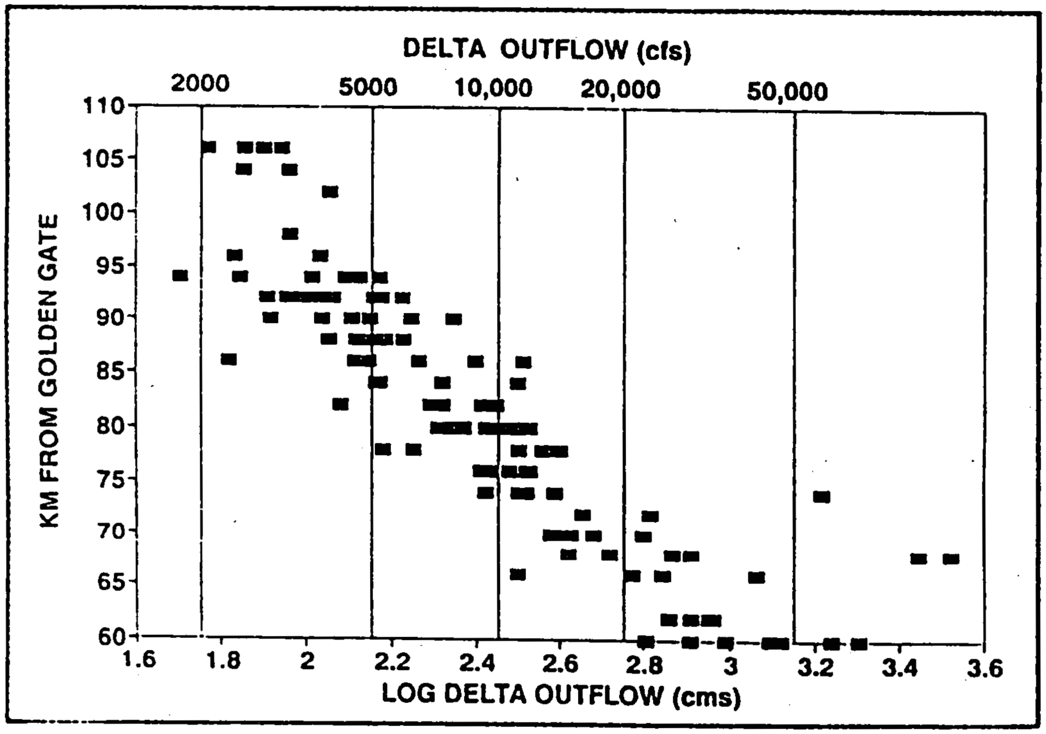


Figure V-5. Entrapment zone position (kilometers from the Golden Gate) versus log Delta outflow (shown in cubic meters per second and cubic feet per second). (Source: Kimmerer 1992)

Whether it is actually salinity or outflow that influences the abundance of certain species, and whether it is more effective to regulate one or the other, have been issues of much discussion. The DFG's submittal to the Bay-Delta Oversight Council (BDOC) states that the evidence indicates that the biological phenomena of primary interest are driven by flow rather than salinity (BDOC 1994).

e. Delta Diversions and Entrainment. Each year, as Delta water is diverted to SWP and CVP aqueducts and to Delta farmlands, millions of fish eggs, larvae, and juveniles are diverted, or entrained, as well. Delta diversions also remove nutrients, phytoplankton, zooplankton, and higher organisms from the Estuary; however, the impacts of such entrainment are not well understood (SFEP 1992b).

The State and federal pumps are screened to minimize the passage of juvenile and adult fish; however, neither the SWP nor the CVP is able to prevent removal of the millions of fish eggs and larvae that are pulled from Delta channels. Of the approximately 1,800 siphons and pumps that divert water to Delta farms (Figure V-6), at least one, and maybe six, is screened to prevent the removal of fish from the channel. The one that is known to be screened is a 16-inch siphon on Bacon Island. The effects of this diversion and the efficiency of the screen are being studied by the DWR under the IEP's Agricultural Diversion Study (CUWA 1994, SFEP 1992b, DWR 1995c).

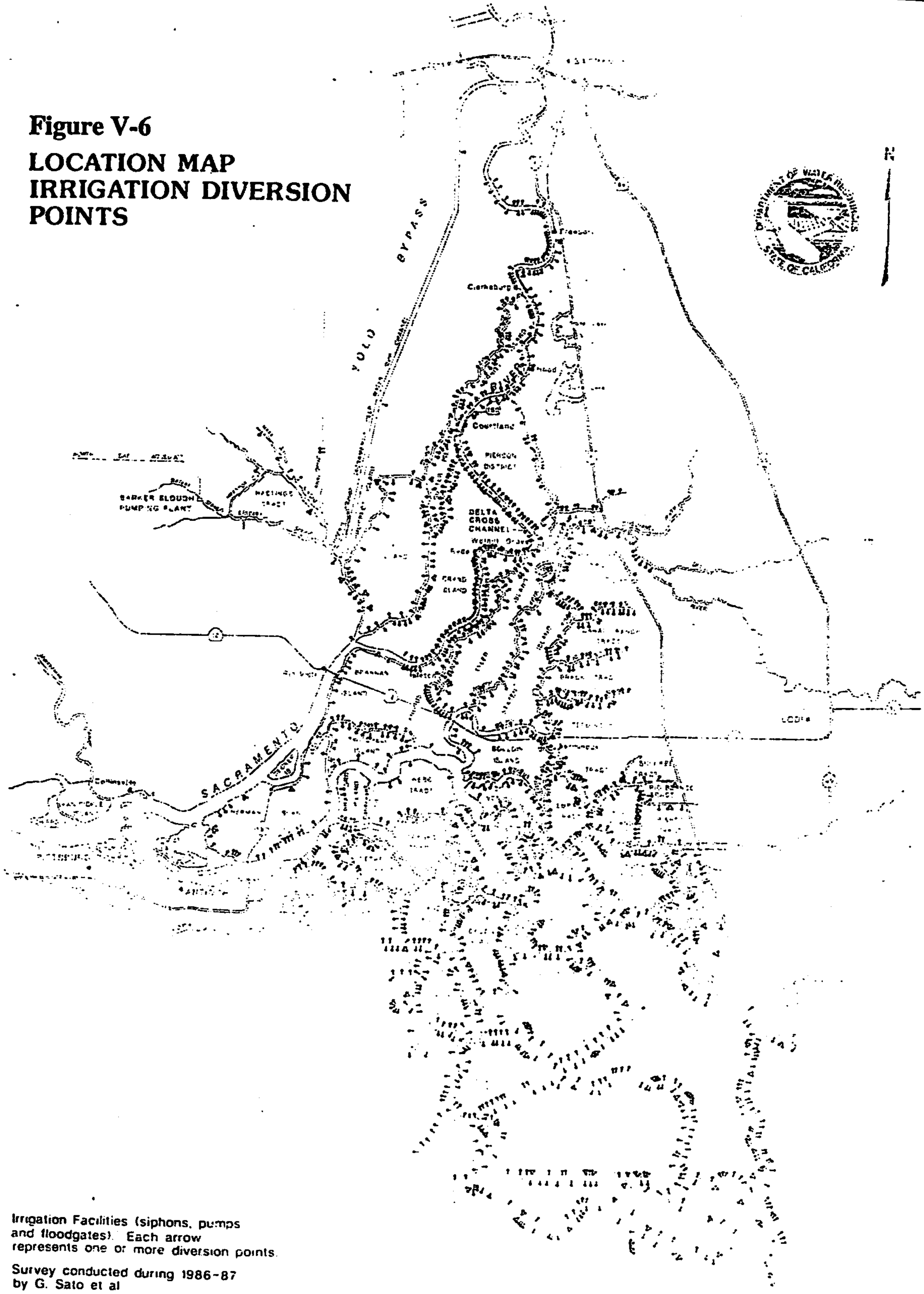
The export operations of the CVP and SWP draw water and fish out of the central and southern Delta. The term "entrainment" is used to describe the situation of fish having entered the projects' facilities. At the CVP, fish are entrained when they approach the log boom and trashrack; at the SWP, entrainment begins when fish enter Clifton Court Forebay. The term "loss" is used to identify those fish which do not survive the entrainment and salvage process. The salvage process is the successful recovery of fish entrained at the CVP and SWP fish collecting facilities (the Tracy and Skinner fish facilities, respectively). These facilities use louver fish screens to separate the fish from the water being exported. The fish that are separated from the diverted water are diverted into holding tanks. The fish are then trucked to the western Delta, beyond the immediate influence of the pumps, and released. The SWP screens are relatively efficient for larger fish; however, they are not efficient for small fish less than about 38 mm (DFG 1987).

Clifton Court Forebay at the SWP export facility causes increased losses before the fish get to the fish screen (DFG 1987), primarily due to predation (DWR and USBR 1993). It has been estimated that 75 percent of entrained fish will be lost crossing the forebay (DWR 1992a). Pre-screening losses of entrained salmon are estimated at 75 percent for the SWP and 15 percent for the CVP. Estimates of predation or efficiency of louver screens for other fish are not available (DWR and USBR 1993).

Other factors that contribute to mortality associated with SWP and CVP exports include: size of fish, water velocities at the screens, and handling and trucking losses associated with the salvage operation. Since it is impossible to count all the salvaged fish, estimates are

Figure V-6

LOCATION MAP IRRIGATION DIVERSION POINTS



← Irrigation Facilities (siphons, pumps and floodgates). Each arrow represents one or more diversion points.

Survey conducted during 1986-87 by G. Sato et al

Source: California Department of Water Resources made by subsampling periodically during the day and extrapolating the results to the entire day, which results in large but uncalculated errors. The DFG assumed control of the counting and salvage operations in 1992 and salvage data prior to 1980 are generally not used (DWR 1992a, 1992b).

Salvage records from the SWP and CVP indicate that fish are entrained year-round with peaks for various species occurring during the period that a particular life stage is vulnerable to the export pumps (DFG 1987). Pumping losses at the SWP and CVP facilities are a significant cause of mortality for many species of fish. During 1976 through 1986, pumping operations killed an annual average of 6.5 million juvenile striped bass greater than 20 mm in length. This includes a 15 percent loss rate to predators in front of the fish screens, losses to entrainment, and losses due to handling and trucking (SFEP 1992b). Estimated chinook salmon salvaged, which does not include those lost to predation and handling mortality, between 1981 and 1992 averaged 54,007 at the SWP and 79,197 at the CVP (DWR 1992a). Virtually all the species found in the Delta are salvaged during some portion of the year at the export pumps. Table V-2 shows estimated numbers of all species of fish salvaged at the CVP's Tracy fish facility and the SWP's Skinner fish facility in 1986, 1989, and 1992.

In addition to losses at the SWP and CVP pumps, agricultural diversions may well account for significant fish losses in the Delta. The peak agricultural diversion season in the Delta is April through August, coinciding with months when large number of young chinook salmon, striped bass, American shad, Delta smelt and other fish are present. The estimated total average diversion rate from Delta channels during the growing period ranges from 2,500 to 5,000 cfs (DWR 1992a). The annual removal of water from these diversions is estimated at about 2.3 MAF (NHI 1992a). It is estimated that several hundred million striped bass (less than 16 mm long), as well as tens of thousands of juvenile chinook salmon, are lost to agricultural diversions. Agricultural diversions impact Delta fish, but the magnitude of the impact is unknown (DWR 1992b). However, it is also possible that aquatic organisms have increased exposure to these diversions due to changes in flow patterns in the Delta caused by CVP and SWP pumping (NHI 1992a).

The Pacific Gas and Electric (PG&E) Company power generating facilities in the Estuary, at Pittsburg and Antioch, entrain fish less than about 38 mm in size and impinge larger fish with the intake of cooling water. Entrainment for some fish, particularly striped bass, may not be fatal. As mitigation for these losses, PG&E releases striped bass in the Estuary.

It is not certain how the operation of these facilities has affected the fish populations of the upper Estuary over the past 20 years. The available information suggests that larval and juvenile smelt of the family Osmeridae were historically one of the most abundant fish taxa in the area. PG&E, during the period of peak striped bass entrainment (May to mid-July), operates the power generation units based on fish monitoring data. This program has reduced entrainment losses of larval and juvenile striped bass by more than 75 percent. Incidental benefits to other species may be occurring as well (NHI 1992a, DWR and USBR 1994).

TABLE V-2

ESTIMATED NUMBERS OF FISH SALVAGED AT TRACY AND SKINNER FISH FACILITIES FOR THE YEARS 1986, 1989, AND 1992[1]

Fish	1986	Fish	1989	Fish	1992
Striped Bass	18,544,652	Striped Bass	10,549,877	Striped Bass	4,411,064
Sacramento Splittail *	2,391,588	Sacramento Splittail *	60,584	Sacramento Splittail *	12,082
Threadfin Shad	1,763,815	Threadfin Shad	315,867	Threadfin Shad	1,291,772
Chinook Salmon *	1,187,272	Chinook Salmon *	149,196	Chinook Salmon *	63,878
American Shad	1,139,342	American Shad	644,696	American Shad	710,154
White Catfish	997,009	White Catfish	320,621	White Catfish	228,350
Yellowfin Goby	777,627	Yellowfin Goby	283,921	Yellowfin Goby	77,355
Channel Catfish	384,309	Channel Catfish	18,475	Channel Catfish	36,636
Inland Silverside	64,689	Inland Silverside	47,363	Inland Silverside	115,595
Prickly Sculpin *	37,160	Prickly Sculpin *	54,655	Prickly Sculpin *	14,903
Bluegill	30,508	Bluegill	11,286	Bluegill	22,437
Lampreys (all spp.) *	17,023	Lampreys (all spp.) *	1,418	Lampreys (all spp.) *	1,592
Sacramento Blackfish *	11,171	Sacramento Blackfish *	18	Sacramento Blackfish *	154
Black Crappie	9,877	Black Crappie	5,487	Black Crappie	5,394
Bigscale Logperch	8,380	Bigscale Logperch	9,929	Bigscale Logperch	5,488
Mosquitofish	7,711	Mosquitofish	480	Mosquitofish	1,047
Delta Smelt *	6,380	Delta Smelt *	20,074	Delta Smelt *	6,178
Tule Perch *	5,507	Tule Perch *	5,756	Tule Perch *	3,159
Miscellaneous	4,836	Miscellaneous	4,387	Miscellaneous	25,557
Steelhead Rainbow Trout	4,746	Steelhead Rainbow Trout	17,475	Steelhead Rainbow Trout	18,745
Warmouth	3,998	Warmouth	494	Warmouth	266
Riffle Sculpin *	3,648	Riffle Sculpin *	0	Riffle Sculpin *	1,767
Goldfish	2,978	Goldfish	0	Goldfish	0
Carp	2,496	Carp	431	Carp	238
Hardhead *	2,422	Hardhead *	0	Hardhead *	4
Longfin Smelt *	2,296	Longfin Smelt *	67,545	Longfin Smelt *	3,590
Golden Shiner	2,050	Golden Shiner	1,148	Golden Shiner	4,861
Green Sunfish	1,788	Green Sunfish	0	Green Sunfish	108
Largemouth Bass	991	Largemouth Bass	1,045	Largemouth Bass	19,704
Staghorn Sculpin *	929	Staghorn Sculpin *	1,455	Staghorn Sculpin *	295
Redear Sunfish	828	Redear Sunfish	122	Redear Sunfish	276
Starry Flounder *	758	Starry Flounder *	3	Starry Flounder *	108
Yellow Bullhead	755	Yellow Bullhead	0	Yellow Bullhead	71
White Sturgeon *	666	White Sturgeon *	17	White Sturgeon *	62
Black Bullhead	502	Black Bullhead	258	Black Bullhead	155
Pumkinseed	249	Pumkinseed	0	Pumkinseed	86
Smallmouth Bass	209	Smallmouth Bass	0	Smallmouth Bass	498
White Crappie	191	White Crappie	0	White Crappie	928
Sacramento Perch *	187	Sacramento Perch *	0	Sacramento Perch *	0
Sacramento Sucker *	121	Sacramento Sucker *	0	Sacramento Sucker *	0
Green Sturgeon	49	Green Sturgeon	0	Green Sturgeon	164
Hitch *	48	Hitch *	0	Hitch *	0
Brown Bullhead	34	Brown Bullhead	364	Brown Bullhead	546
Blue Catfish	28	Blue Catfish	7,199	Blue Catfish	72
White Bass	0	White Bass	0	White Bass	18
Chameleon Goby	0	Chameleon Goby	13,020	Chameleon Goby	22,307
Total	**27,421,823**	**Total**	**12,614,666**	**Total**	**7,107,664**
Percent natives	**13.4%**	**Percent natives**	**3.0%**	**Percent natives**	**1.8%**
Percent introduced	**86.6%**	**Percent introduced**	**97.0%**	**Percent introduced**	**98.2%**

* Native Species

[1] Fish and Game Bulletin Board, "Fish Facilities Salvage Project California Department of Fish & Game", Phone No. 1-209-948-7347.

f. Reverse Flows. Tidal flows dominate water movement in this Estuary. In the western Delta the average tidal flow is 180,000 cfs and ranges from -300,000 to +300,000 cfs twice daily. The concept of reverse flows deals with net flow during the day in the same way the Delta outflow is a calculated net daily flow. The importance of reverse flow is controversial and is presented here for completeness.

Water supplies for CVP and SWP exports are obtained from Delta inflow. Typically, when export rates are high and inflow is low, Sacramento River water is pulled in an upstream direction around Sherman Island, at the confluence with the San Joaquin River. As water travels around Sherman Island, it mixes with saltier ocean water entering as tidal inflow, and is drawn upstream into the San Joaquin River and other channels that feed the CVP and SWP pumping plants. This situation, which causes a net upstream flow of water in the lower San Joaquin River toward the export pumps, is known as reverse flow. During periods of high Delta inflow and high export, there is some reverse flow, but enough water is available from the San Joaquin River, the Central Sierra Basin (eastside streams), and the Sacramento River via the Delta Cross Channel to meet export demands. Figures V-7 and V-8 show the net direction of normal (high flows, no exports) and reverse (low flows, high exports) flows, respectively.

The hydraulic capacities of the Delta Cross Channel and Georgiana Slough provide a physical limitation to the quantity of Sacramento River water that can be moved toward the SWP and CVP pumping plants in the southern Delta. These physical constraints cause reverse flows when pumping plus internal Delta demand exceeds the sum of cross-Delta flows and San Joaquin River inflows (DWR 1992a).

Reverse flows reportedly disorient anadromous fish as they migrate either upstream or downstream following the salinity gradient. The USFWS reported a weak relationship between salmon smolt survival and QWEST (USFWS 1992). QWEST is an index of San Joaquin River flow which serves as an indicator of reverse flows conditions; QWEST is calculated by subtracting Delta exports and 65 percent (representing the Delta channel depletion that occurs in the central and southern Delta areas) of net Delta consumptive use from central Delta inflow. CUWA (1994) reviewed the literature describing the effects of reverse flows on fish. According to this review, reverse flows may influence the number of fish lost via entrainment into the CVP and the SWP pumping plants. Reverse flows may carry young fish into the central or southern Delta, where habitat may not be as good or where they may be more susceptible to entrainment at local agricultural, municipal, and industrial diversions, and to SWP and CVP exports (DWR 1992a). Table V-3 shows the months during the period from 1978 to 1989 in which the average calculated flow, QWEST, was negative. As the drought continued, the numbers of months with reverse flows increased.

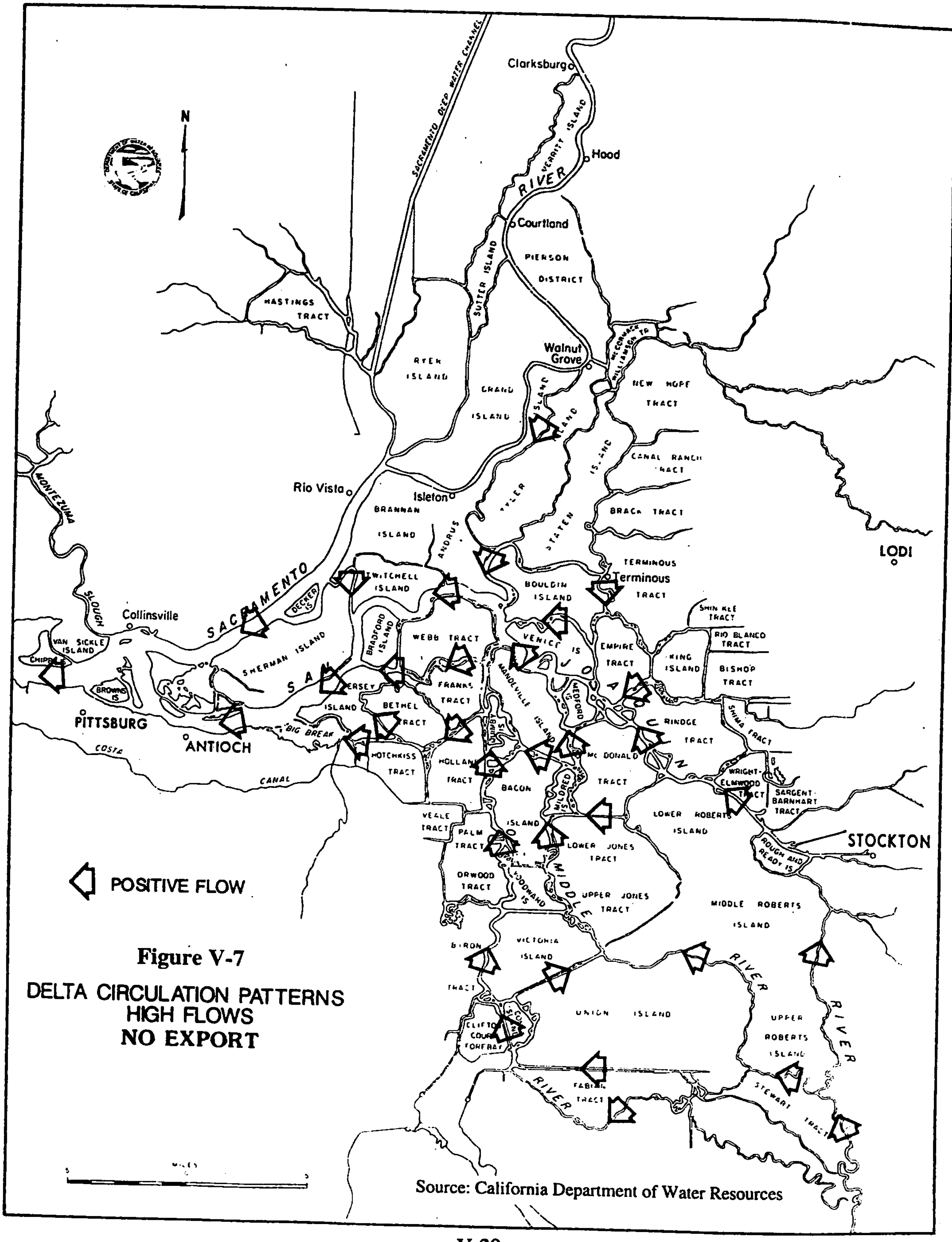


Figure V-7

DELTA CIRCULATION PATTERNS
HIGH FLOWS
NO EXPORT

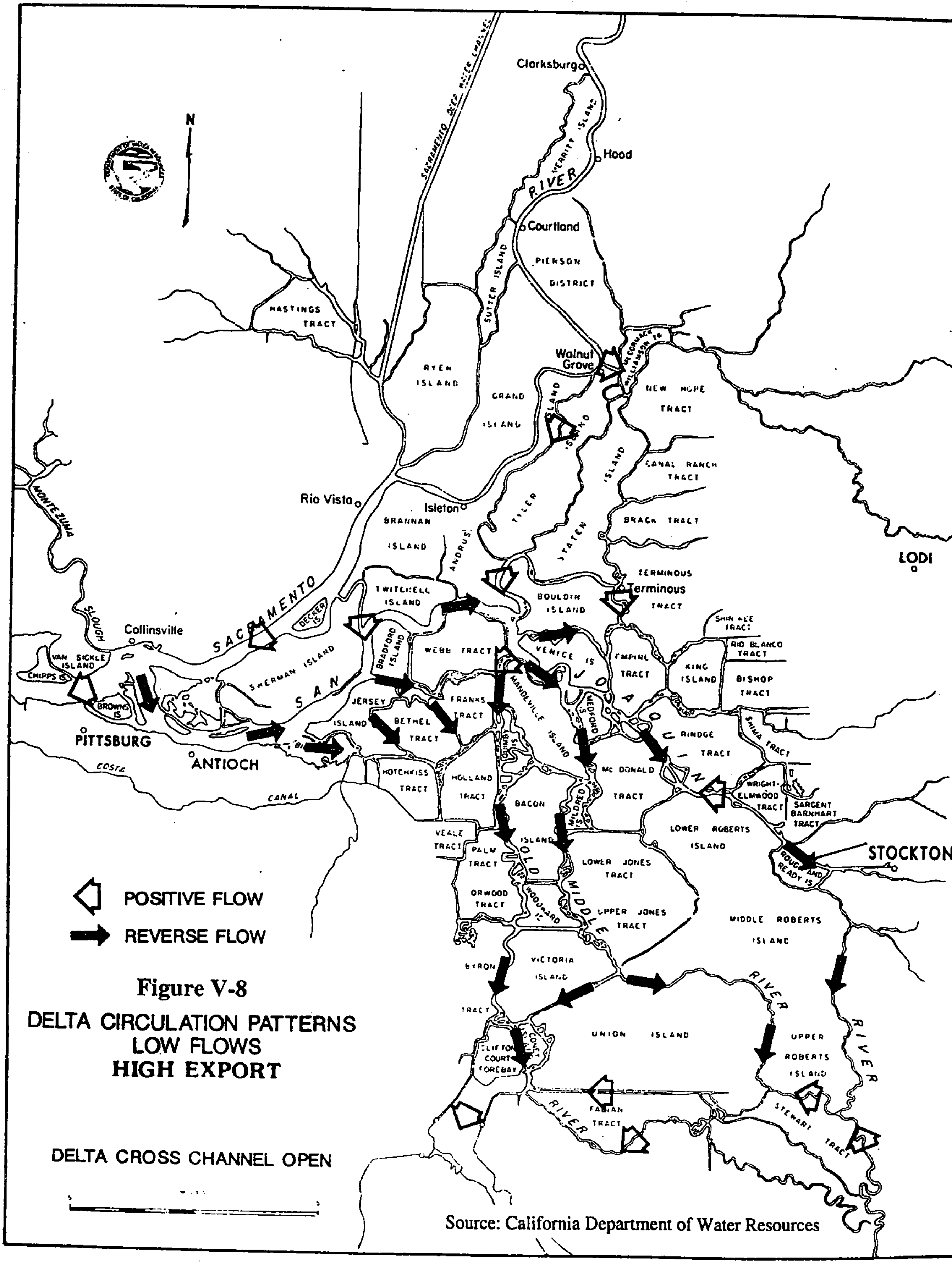


Figure V-8

DELTA CIRCULATION PATTERNS
LOW FLOWS
HIGH EXPORT

Table V-3. Months during water years 1978-1989 in which the average calculated net flow on the San Joaquin River past Jersey Point (QWEST) was negative.

Water Year	Months with Negative Flow	Water Year	Months with Negative Flow
1978	July-August	1984	July-August
1979	July-September	1985	July-December
1980	August, November	1986	July-September
1981	April, July-September	1987	January, June-December
1982	None	1988	All but April, November, December
1983	None	1989	All but March

Source: DWR (1992b)

QWEST has been used as a regulatory parameter to limit movement of winter-run chinook salmon and Delta smelt toward the CVP and the SWP export pumps. The use of QWEST is partly driven by the perception that the transport of small fish is largely dictated by QWEST. This issue is being examined because there is some evidence that QWEST is not a good indicator of entrainment losses in the interior Delta. The DWR Particle Tracking Model indicates that the export pumps have a "zone of influence" and a large percentage of modeled particles (assumed to represent young fish) within it are likely to be entrained into the CVP and the SWP facilities regardless of QWEST. Further model studies are being designed to characterize the zone of influence (DWR and USBR 1993).

3. Introduced Species

The Bay-Delta Estuary is home to more than 150 introduced aquatic species of plants and animals. About 28 of these species are non-native fish and over 100 species are non-native invertebrates (BDOC 1994). A list of the more notable introduced species in the Estuary is presented in Table V-4.

Between 1850 (when documentation of introductions of organisms to the Estuary began) and 1950, some introductions were deliberate attempts to diversify the native fish fauna of the Estuary. Intentional introductions by government agencies occurred when species such as striped bass, American shad, carp, eastern oyster, and Japanese oyster were introduced to expand the opportunities for angling, commercial fishing, or aquaculture. Species such as threadfin shad were introduced to increase the forage base for predators, and mosquitofish were introduced in an effort to control pest populations (BDOC 1994, DWR 1992a).

Table V-4. **Introduced species (and dates of introduction) in the Bay-Delta Estuary.**

Year	Common Name	Scientific Name
1850	Isopod	*Sphaeroma quoyanum*
1869	Eastern Oyster	*Crassostrea virginica*
1871	American Shad	*Alosa sapidissima*
1872	Carp	*Cyprinus carpio*
1873	Gribbles	*Limnoria* spp.
1874	Black Bullhead	*Ictalurus melas*
1874	Brown Bullhead	*Ictalurus nebulosus*
1874	Largemouth Bass	*Micropterus salmoides*
1874	Soft Shell Clam	*Mya arenaria*
1874	White Catfish	*Ictalurus catus*
1874	Yellow Bullhead	*Ictalurus natalis*
1879	Striped Bass	*Morone saxatillis*
1891	Golden Shiner	*Notemigonus crysoleucas*
1891	Green Sunfish	*Lepomis cyanellus*
1900	Goldfish	*Carassius auratus*
1908	Black Crappie	*Pomoxis nigromaculatus*
1908	Bluegill	*Lepomis macrochirus*
1913	Shipworm	*Teredo navalis*
1921	Warmouth	*Lepomis gulosus*
1922	Mosquitofish	*Gambusia affinis*
1930	Japanese Oyster	*Crassostrea gigas*
1940	Channel Catfish	*Ictalurus punctatus*
1946	Asian Clam	*Corbicula fluminea*
1946	Japanese Littleneck	*Tapes japonica*
1949	Redear Sunfish	*Lepomis microlophus*
1950	Fathead Minnow	*Pimephales promelas*
1951	White Crappie	*Pomoxis annularis*
1953	Bigscale Logperch	*Percina macrolepida*
1953	Threadfin Shad	*Dorosoma petenense*
1963	Yellowfin Goby	*Acanthogobius flavimanus*
1966	Copepod	*Oithona davisae*
1968	Inland Silverside	*Menidia beryllina*
1968	Snail	*Littorina littorea*
1978	Copepod	*Sinocalanus doerrii*
1979	Blue Catfish	*Ictalurus furcatis*
1979	Copepod	*Limnoithona sinensis*
1982	Clam	*Theora fragilis*
1983	Amphipod	*Gammarus daiberi*
1986	Asian Clam	*Potomocorbula amurensis*
1986	Crustacean	*Hemileucon hinumennsis*
1986	Copepod	*Pseudodiaptomus marinus*
1987	Copepod	*Pseudodiaptomus forbesi*
1988	Snail	*Malanoides tuberculata*
1989	Polychaete	*Potamilla* sp.
1991	European Green Crab	*Carcinus maenas*
1991	Polychaete	*Spionid* sp.

Source: CUWA (1994)

The inland silverside, which was transported to the Estuary in runoff from Clear Lake where it was introduced in an attempt to control gnats (DFG 1994b), is the only known unauthorized deliberate introduction of a fish in California (BDOC 1994).

Although intentional introductions to the Bay-Delta Estuary have decreased since 1950, accidental introductions probably have not (DFG 1994b). Accidental introductions in the Estuary have occurred incidental to other activities. Many early introductions of invertebrate species occurred incidental to the intentional transplanting of oysters in the 1870's and early-1900's. Most recent introductions of aquatic species, such as yellowfin goby, chameleon goby, and many invertebrates, have occurred when ballast water from ships was released into the Estuary (BDOC 1994).

As a result of intentional and unintentional introductions, aquatic resources in the Bay-Delta Estuary have changed dramatically. Introduced species which become established due to favorable conditions can affect native species through a wide variety of mechanisms, including: competition for food and space; predation; habitat alteration; disturbance; hybridization; and acting as pathways for and sources of diseases (BDOC 1994).

The successful establishment of non-native organisms has greatly altered the relative abundance and composition of species in the Estuary. For fish, a shift from native to introduced species has been more pronounced in the freshwater portions of the Estuary (DFG 1994b). The SWP's fish salvage facilities, which are probably the best sampler of Delta biota (DWR 1994), produce data which illustrate the relative abundances of native and introduced fish.

In 1980, 17 of the 30 species salvaged at the SWP fish screens were introduced, with 13 of them having been introduced prior to 1950. Data for 1986, 1989, and 1992 indicate that 29 of the 45 identified species salvaged were introduced species (see Table V-2, above). In 1986, 1989, and 1992, introduced species comprised 86.6, 97.0, and 98.2 percent, respectively, of the total number of identified organisms salvaged. This indicates that introduced fish species are becoming increasingly more numerous relative to native fish in the Estuary.

Changes in the composition of the Estuary's invertebrates have been more dramatic than those for fish. Several new species of zooplankton have significantly changed the species composition in the brackish and freshwater portions of the Estuary. For example, two introduced copepods, *Pseudodiaptomus forbesi* and *Sinocalanus doerrii*, have largely replaced the once dominant native copepod, *Eurytemora affinis*, which had been the principal food for young fish. The establishment of the highly efficient, filter-feeding Asian clam, *Potamocorbula amurensis*, in San Pablo and Suisun bays has also been identified as a factor in the decline of *Eurytemora* and the shift in the composition of benthic organisms in these portions of the Estuary (CUWA 1994, DFG 1994b, NHI 1992a). Another species of Asian clam, *Corbicula fluminea*, has become the dominant mollusk in the Delta since its introduction in 1946. Today, all but two of the common benthic mollusks in the Estuary are introduced species (CUWA 1994).

The introduction of aquatic plants also impacts the estuarine ecosystem. For example, the water hyacinth, *Eichhornia crassipes,* creates dense mats of vegetation that clog screens, block light, causing rooted submergent plants to die and shading phytoplankton, and provide cover for fish predators. Aquatic weeds can also increase siltation and affect water temperature and dissolved oxygen levels. Invasive introduced terrestrial plants can displace native plants and affect the habitat structure of the wetland habitat of the Estuary. For example, the eastern cordgrass, *Spartina alterniflora*, was introduced through a salt marsh restoration project in the Bay Area to mitigate for loss of wetlands. It has since spread and established itself in the higher and lower areas in the tidal zones. It is prolific, out-competing the native cordgrass and turning mudflat areas into cordgrass islands. Although it can provide additional habitat for such species as the endangered clapper rail, it diminishes mudflat communities which provide important food source for shorebirds (BDOC 1994).

The introductions of non-native species in the Bay-Delta Estuary have caused major changes in the fish fauna in the Estuary, particularly in fresh waters; however, the introductions have not coincided with the principal declines in certain fish populations, such as the striped bass and Delta smelt. Although there is no strong empirical case for recent introductions being a principal cause of the declines in some species (DFG 1994), it is likely that the establishment of non-native species in the Estuary has been a contributing factor (NHI 1992a). It is uncertain what effects the introductions may have had on some of the species and whether the introductions may make the recovery of previously abundant native species and striped bass more difficult (BDOC 1994, DFG 1994b). While few opportunities exist to effectively reduce or eliminate introduced species in the Estuary, management activities should focus on preventing additional incidental introductions and on managing the existing composition of species (BDOC 1994).

4. Food Limitations

Food supply is another factor that can affect the abundances of aquatic organisms at all trophic levels. Food may be limited in various ways, including decreased availability of nutrients, and decreased abundance and availability of food items.

Some scientists believe that a decrease in nutrients, which support the base of food webs (primarily phytoplankton), has contributed to declines in the aquatic resources of the Bay-Delta Estuary. Building dams, leveeing river channels, and diking and filling tidal wetlands have reduced the loadings of land-derived detritus, a primary nutrient source, to the Estuary (DWR 1994). Corresponding increases in water clarity may have resulted in the aperiodic blooms of the diatom, *Melosira granulata*, which is difficult for zooplankton to graze upon (NHI 1992a). In addition, reduced loadings of urban organic waste through increased treatment over the past 40 years may have also removed an important nutrient source for the base of the Estuary's food web (DWR 1994). Decreased sewage may have had a significant adverse effect on the estuarine biota, particularly in the upper Estuary. In fact, any nutrient contribution to the food web may have been cancelled by the effects of toxic pollutants associated with the sewage (NHI 1992a), both of which have now been greatly reduced.

Declines in the populations of phytoplankton, zooplankton, and fish have occurred at about the same time; however, food limitation has not yet been identified as a cause. Although zooplankton are a primary food for several species of fish, the studies that have been done to document food limitation have not been able to document such a phenomenon.

Most studies on the effects of food supply have been on striped bass. The copepod *Eurytemora affinis*, which is an important initial food for striped bass, declined following the introduction of non-native invertebrates. Although studies on food supply and striped bass production have shown that some degree of food limitation exists (probably through slowing growth and, thus, increasing mortality rates), no direct evidence of starvation of bass has been found. Young striped bass changed their diet when a newly-introduced amphipod, *Gammarus diaberi*, became a major food item for young striped bass and may have minimized the impact of reduction in *Eurytemora* (BDOC 1994). In feeding experiments, striped bass larvae, when they first start to feed, are much more adept at capturing the native *Eurytemora* and *Cyclops* than they are at capturing an introduced species of copepod, *Sinocalanus* (which have more effective escape responses). Histological analysis of striped bass larvae collected from the wild has failed to show any signs of starvation (SFEP 1992a). Although the composition of prey species has changed, no general relationships have been found between food supply and bass mortality. The changes in prey items, therefore, do not appear to be a major factor contributing to the decline in striped bass; however, it might inhibit the recovery of other fish species (BDOC 1994).

5. Land Reclamation and Waterway Modification

Land reclamation and waterway modification have caused major ecological changes both in the Estuary and throughout the Central Valley. They have destroyed most of the tidal marshes in the Estuary and the seasonally-flooded wetlands upstream of the Estuary. The vast majority of land reclamation occurred before 1920, so there is essentially no information available to estimate its consequences (DFG 1994b). Only about 3 percent of the historical acreage of wetlands (estimated at 545,000 acres) remains today, with most being reclaimed for agriculture (CUWA 1994).

An impact of the loss of wetland habitat is the reduced population sizes of fish, especially those that utilize shallow, back-water habitats, sloughs, and intertidal zones during all or part of their life cycle. Species that utilize flooded vegetation for spawning habitat have either gone extinct or have declined in abundance (CUWA 1994; DFG 1994b). The losses of habitat that have occurred throughout the Delta have probably reduced the resiliency of certain populations to respond to natural and man-induced perturbations, setting the stage for the declines in certain species. Marsh and other wetland habitat losses must be considered as one of the major factors that have served to shape and control existing populations (CUWA 1994).

The earliest, and probably most profound, cause of change in aquatic habitat in the Bay-Delta Estuary was the introduction of European methods of agriculture into the Central Valley. Diking the rivers and clearing riparian vegetation began to change the lower parts of the valley from seasonal freshwater marsh to dry cropland. Diking of islands in the Delta began in 1852. Dikes, which were constructed of dredged materials from the river or from the interior of the island, consisted of fine river sediments, easily degraded peaty soils, or a combination of both. Such diking led to weak dikes, depressed island interiors, and deeper, more U-shaped channels in the river. Water flows more quickly in dredged channels and the vertical walls are easily eroded (SFEP 1992a).

A secondary effect of diking was to change river habitats and primary productivity. Restriction of water to channels increased water velocity and led to decreased residence times of water in the Estuary, allowing less time for phytoplankton to grow. The transformation of vast areas of freshwater marsh into cropland effectively eliminated the contribution of marsh productivity to downstream food web organisms. Channelization removed the shallow margins of most river channels and prevented the growth of benthic algae (SFEP 1992a).

Almost concurrent with the first diking of Delta islands was the advent of hydraulic gold mining in the Sierras. The main impact of hydraulic mining on downstream sites was the introduction and transport of large quantities of silt. Before hydraulic mining was banned in 1884, an estimated 1.5 billion cubic yards of extra sediment was brought into the Estuary. Although the effects of mining on the aquatic resources of the Estuary are undocumented, the siltation and dewatering of spawning streams undoubtedly devastated salmonid populations (SFEP 1992a). Today, more than 6 million cubic yards of sediments enter the Estuary each year, mostly from the Sacramento and San Joaquin rivers. As many as 286 million cubic yards of existing sediments in the shallows of San Francisco Bay are resuspended by currents and wind-driven waves (SFEP 1992b).

Dredging of bottom sediments in the naturally-shallow Estuary frequently occurs to ensure water depths necessary for navigation and docking, to maintain flood control channel capacities, and for breakwater and bridge construction. The dredging and disposal of estuarine sediments temporarily increase turbidity, influence benthic communities at and near disposal sites, and may affect the behavior and physiology of fish and other organisms. These activities also may redistribute toxic pollutants and increase their availability to aquatic organisms (SFEP 1992b).

Flood control measures, such as alterations to channel configurations, removal of riparian vegetation, placement of rock revetment ("rip-rap") to reduce erosion, and construction of concrete channels, also adversely affect fish and wildlife habitat in the Estuary's tributaries. In the Delta, levee maintenance standards affect habitat conditions by limiting the extent of vegetation allowed on the levees (SFEP 1992b). The construction and maintenance of reclamation and flood control levees have also reduced detrital loading and the amount of shoal and wetland areas (DWR 1994).

Perhaps the most important and far-reaching aspect of waterway modification is the rise in sea level. Around the Bay-Delta Estuary, the relative increase in sea level will be even greater on low-lying lands where sediment-deposited soils are expected to subside from soil compaction and consolidation. For example, by the year 2037, the relative mean water level in Central Bay at Sausalito is projected to increase 0.3 to 0.48 feet above mean sea level; in South Bay at Alviso Slough, where greater land subsidence is expected, the relative mean water level is projected to rise 0.8 to 5.76 feet above mean sea level. Impacts to the Estuary that are associated with these projected increases include: saltwater intrusion in tidal marshes, freshwater tributaries, and ground water; submergence of tidal marshes in North and South bays; increased periodic flooding of previously protected low-lying areas around the bay and in the Delta; and increased shoreline and beach erosion. These conditions will adversely impact the Estuary's water quality, wetland habitat, and Estuary-dependent human activities (SFEP 1992b).

6. Pollution

The quality of water needed to support populations of freshwater, estuarine, and marine species in the Bay-Delta Estuary is dependent on more than a certain concentration of salinity at various locations. The release of pollutants which adversely affect the physical, chemical, and biological properties of water in the Estuary also impacts aquatic species.

In its natural state, the Bay-Delta Estuary exhibited few, if any, adverse effects of pollutants since the sediments and naturally-occurring chemicals that entered the Estuary from upstream were assimilated. As urban, industrial, and agricultural activities expanded throughout the watershed, pollutant loads and associated impacts to aquatic resources increased. By the end of the 1800's, untreated industrial and sewage wastes adversely affected water quality in many portions of San Francisco Bay. It is believed that pollution contributed to the decline seen in the Estuary's salmon, sturgeon, and striped bass commercial fisheries by the early 1900's (SFEP 1992b).

After World War II, the Bay-Delta Estuary was receiving large and mostly uncontrolled amounts of inadequately untreated sewage, industrial effluent, urban runoff, and agricultural wastes. The most obvious impacts were caused by the discharge of large quantities of nutrients, which resulted in increased biological oxygen demand (BOD) and suspended solids, and decreased dissolved oxygen levels. Efforts to control the effects of sewage in the Estuary were initiated in the early 1950's, when some publicly-owned wastewater treatment plants began primary treatment of municipal wastewater. Construction of facilities to enable secondary treatment, which removes a greater percentage of pollutants than primary treatment, began in the mid-1960's (SFEP 1992b).

With the implementation of the State Porter-Cologne Water Quality Control Act of 1969 and the federal Clean Water Act of 1972, rapid improvements in the quality of municipal and industrial effluent, and of the San Francisco Bay water, occurred in the 1970's (SFEP 1992b). The result of these improvements has been the steady decline of BOD loadings and suspended solids in the bay. It has been suggested that decreasing trends in abundance of the major zooplankton species correspond with the reductions of BOD loadings, which supply nutrients, in the bay (CUWA 1994).

With a decrease in nutrient loading over time, there has been an increase in chemical pollutants. Toxic chemical pollutants, which now pose the greatest pollution threat to the Estuary, include trace elements (e.g., mercury, selenium), organochlorines and other pesticides (e.g., DDT, dioxins), and petroleum hydrocarbons (e.g., benzene, chrysene). Today, 5,000 to 40,000 tons of toxic pollutants enter the Estuary each year. The bulk of these chemicals are carried in runoff from urban areas and farms. Effluent from municipal and industrial outfalls, riverine inputs, dredging and dredge material disposal, atmospheric deposition, accidental spills, marine vessel discharge, and leakage from waste disposal sites contribute the remainder. Although programs are in place to regulate the discharge of pollutants, large quantities of toxic chemicals continue to enter the Estuary (CUWA 1994, SFEP 1992b).

Pollutants are distributed within the Bay-Delta Estuary by a combination of physical, chemical, and biological processes. The loadings and concentrations of pollutants are dependent not only on the direct discharge of pollutants, but also the patterns of chemical use, land development, freshwater flows, and tidal action. Many persistent pollutants (i.e., those which do not degrade or degrade very slowly) become bound to particulate matter that settles near discharge points and accumulates in areas of sediment deposition, together with pollutants from past industrial activities. Although evidence indicates that loading rates of toxic pollutants have declined in the last 20 years, human activities (e.g., dredging) have increased rates of mobilization of toxicants previously discharged into the Estuary. Thus, although some pollutants have been banned, such as DDT and polychlorinated biphenyls (PCB's), or significantly reduced, they continue to pose potential hazards to biota. Some pollutants can become concentrated in organisms directly from the water column and by ingestion of contaminated food. These processes can result in high levels of pollutants in tissues, through bioaccumulation, even when concentrations in the water are low. The effects of selenium in causing deformities in waterfowl are well-known in this regard (SFEP 1991).

Pollutants have a wide range of effects on estuarine organisms, ranging from very subtle physiological changes to death. While it is possible to measure concentrations of pollutants in water, sediments, and animal tissue, it is often difficult to determine the overall effect of a given pollutant on individual organisms. Even more difficult to determine are the cause-and-effect relationships between pollutants and populations of a single species or the effects on the aquatic community as a whole. However, bioassays of the Estuary's water, sediments, and biota indicate that existing pollutant concentrations cause toxic effects (SFEP 1992b).

The results of bioassays and other studies on the effects of pollutants in the Estuary suggest that pollutants may be having significant effects (SFEP 1991). Examples of these affects include: high concentrations of PCB's in starry flounder have been linked to poor reproductive success and certain creeks, rivers, and some sediments are significantly toxic in bioassays; species diversity and abundance of benthic invertebrates have decreased in certain highly polluted areas; and high concentrations of silver and copper are found in shellfish in the South Bay (SFEP 1991). Researchers have also implicated pollutants as the cause of death, due to indications of liver disease, in studies of moribund adult striped bass found in Carquinez Strait. A variety of contaminants, including those from industrial, agricultural, and urban sources, were found in the livers from which the researchers concluded that the die-off may have occurred as a result of multiple stressors. Other toxicological investigations have found that the incidence of liver malformations in larval striped bass from the Sacramento River was much higher than that in larvae from other locations (DWR 1992a).

There is growing concern about nonurban runoff in the Estuary's watershed, particularly the agricultural component (SFEP 1992b). Agricultural drainage, which contains pesticides, trace elements, and solvents, may contribute over 30 percent of the total flow of the Sacramento River in May and June, and most of the flow of the San Joaquin River in the summer (SFEP 1991). The use of herbicides has raised widespread concerns over the possible toxicological effects to aquatic biota in the Delta, especially striped bass (CUWA 1994). Rice herbicides in the Sacramento River and western Delta were found to be toxic to larval striped bass. Associated chemicals are toxic to the bass' principal food organisms, resulting in a lower ration and poorer survival for larval fish. It is hypothesized that between 1973 and 1986, pesticides may have been a factor in determining the annual recruitment of 38 mm striped bass (DWR 1992a). However, since 1986, rice herbicide loads have been decreased by 99 percent in a cooperative effort of the Central Valley RWQCB and local rice growers. This decrease in rice herbicide loads has not resulted in increases in survival of young striped bass.

Most recently, the dormant spray pesticide, diazinon, which is applied to orchards in the winter, has been identified in the Sacramento and San Joaquin rivers and the upper Estuary at levels which cause lethality in organisms. The elevated concentrations, which are highest in the San Joaquin River, immediately follow rainfall events when runoff from agricultural and urban areas occurs (DWR 1994, SFEP 1992b). Studies to further determine the impacts of this chemical are ongoing.

In addition to being a source of pesticides, agricultural drainage can increase the salinities of receiving waters to levels which adversely affect some aquatic species. This situation occurs in the lower San Joaquin River where striped bass spawning habitat is impacted as a result of a combination of saline drainage and reduced freshwater flows (which can lower salinity through dilution) due to upstream water development.

Another type of pollution is one that is created by the discharge or release of relatively warm water. Thermal pollution can be caused by the discharge of cooling water from power plants or the release of warm water from reservoirs. Warm water can be an additional stress factor for species such as salmon, which depend on cool water temperatures for successful reproduction and survival. Conversely, warm water outfalls may provide temporary refuges for certain warm water species, yet such species are adversely impacted when water temperatures near such outfalls fluctuate (SFEP 1992a).

Given the major pollutant abatement actions that have occurred during the last 20 years, it is unlikely that pollution is the principal cause of the widespread declines in fishery resources during that same time period (DFG 1994b). Nevertheless, the Estuary's biota continues to be exposed to toxic levels of pollutants and the available evidence indicates that many organisms are being adversely affected (SFEP 1992b). It is, therefore, reasonable to conclude that toxic pollutants have been, and continue to be, among the factors which contribute to the decline of some species.

7. Harvesting

Many of the mollusks, crustaceans, and fish of the Bay-Delta Estuary have been heavily harvested by humans. There is little doubt that overexploitation of species such as chinook salmon, white sturgeon, softshell clam, and crangonid shrimp has contributed to their declines in the early part of this century. In fact, the sturgeon and shrimp populations showed dramatic recoveries once commercial fisheries for these organisms were eliminated or reduced (SFEP 1992a). Although most declining species are not harvested (NHI 1992a), they may be impacted by harvest techniques (e.g., seining, gill netting) targeted at exploited species (CUWA 1994).

The legal harvest of various fish undoubtedly decreases the number of spawning adults and the average age of adults. It is unclear whether legal harvest is sufficient to inhibit a population's ability to maintain itself or if it is responsible for observed changes in abundance. The possibility of overharvesting is greatest for striped bass, white sturgeon, and chinook salmon. The DFG is confident, however, that fishing regulations for striped bass and sturgeon are preventing overharvest of these species. Management of the salmon fishery is more complicated because of the sport and commercial fishery in the ocean, the presence of several regulatory bodies, and the support of populations by hatchery production. Although ocean harvests of salmon substantially reduce spawning escapement, it is believed that the fishery is not the principal limiting factor for salmon abundance. However, it is possible that the increase in fishing effort supported by hatchery production has resulted in overharvesting of wild salmon stocks (DFG 1994b).

Illegal harvest, which is more difficult to estimate than legal harvest, potentially is of greatest concern for striped bass and chinook salmon. While the DFG believes that illegal harvest of salmon does not have a significant effect on the resource as a whole, it is very likely that illegal harvest does adversely impact striped bass populations. It is estimated that about 500,000 sublegal bass are harvested each year (DFG 1994b). This is equivalent to at least 125,000 legal-sized adults lost each year. In comparison, SWP operation is estimated to result in an average loss of an equivalent of 86,000 legal-sized bass each year, which is mitigated (DWR 1992a). The DFG concluded that, although it is very likely that illegal take reduces the production of adult bass, it seems unlikely that the harvest of sublegal bass is the dominant factor causing the decline in adult bass abundance since the collection of annual harvesting data began in 1969 (DFG 1994b).

Where harvest rates have been measured for fish populations inhabiting the Bay-Delta Estuary, no evidence was found indicating that the rates were either excessive or primarily responsible for recent declines in fish stocks (DFG 1994b). It appears that overharvest has played a minor role in the long-term declines of the Estuary's aquatic resources (SFEP 1992a) and has affected fish populations mainly after they have already suffered a severe decline (NHI 1992a).

8. Oceanic Conditions

Generally, the California coast is under the influence of the Davidson Current, which brings subtropical waters northward to Point Conception, and the California Current, which brings subarctic waters southward to Point Conception. These very different currents produce profound differences in the biological communities associated with them. Near San Francisco Bay, the oceanic conditions respond markedly to the shifting strengths of the Davidson and California currents, particularly resulting in fluctuations in the coastal zooplankton populations (SFEP 1992a).

Year-to-year changes in oceanic conditions are results of large-scale meteorological activities. In most years, the conditions vary through three seasonal stages: the upwelling period, the oceanic period, and the Davidson Current period. The most significant ecological impact is associated with the strength of the upwelling period from March through August. The strength of upwelling, which is strongest near San Francisco Bay during June and July, is closely tied to the abundance and species composition of the near-shore zooplankton community. The oceanic period marks a shift in climatic conditions in September and October, when there is a lull in winds and water flows. In November, southerly winds and the north-flowing Davidson Current produce a downdraft of surface waters along the coast. The vertical movement of water causes surface temperatures to decline during upwelling and deeper water temperatures to rise during late fall and winter (SFEP 1992a).

A failure of this seasonal progression can be associated with *El Niño* events in which warmer tropical waters at the surface produce density differences between surface and bottom waters. Consequently, there is little upwelling, and productivity at all trophic levels is reduced. *El Niño* conditions have occurred during the drought of 1976-1977 and during 1983, a wet year. The high outflows generally lead to short water residence times, low productivity, and the low salinity habitat downstream of its normal position. Thus, in 1983, low oceanic productivity lowered the marine contribution of productivity to the Estuary at the same time that riverine production was small (SFEP 1992a).

Annual variations in oceanic conditions, particularly upwelling, are thought to control recruitment success in a number of marine species. However, there does not appear to be any periodicity to the strength of upwelling while there is obvious periodicity in the populations of certain marine and anadromous species (SFEP 1992a). Therefore, it may be concluded that oceanic conditions are a contributing, rather than a major, cause in the decline of the Estuary's aquatic resources.

9. Conclusion

All of the factors described above have contributed to the declines in aquatic resources in the Bay-Delta Estuary; however, quantification of the declines has only been accomplished for a few factors such as outflow and diversions.

B. POPULATION TRENDS AND CAUSES OF DECLINES

There has been a general decline in aquatic resources in the Bay-Delta Estuary which spans all trophic levels. Although the conditions of estuarine fish populations have received the most attention, trends in the abundance of organisms from other levels of the food web are also important and indicate broad ecological changes that have occurred in the Estuary. The following discussion of the population trends in aquatic resources begins with phytoplankton, followed by zooplankton, benthos, and shrimp, and then ends with freshwater, estuarine, marine, and anadromous fish. The species addressed in this chapter do not include all the species in decline in the Estuary, such as most species of surfperch, jacksmelt, and topsmelt; nor do they include all of the species in the Estuary which show increasing population trends, such as some marine species (e.g., white croaker, California halibut, chameleon goby) (DFG 1994b).

The primary sources of information on the organisms addressed in this chapter are the results of the DWR's phytoplankton monitoring, the DFG's zooplankton monitoring, the DFG's fall mid-water trawl fish surveys from the Delta to San Pablo Bay, the DFG's summer tow-net survey from the Delta to San Pablo Bay, the Delta Outflow/San Francisco Bay Study (Bay Study) of mid-water and otter trawls from South San Francisco Bay to the western Delta, the DWR/University of California Suisun Marsh fish survey, and salvage data from the CVP and SWP facilities in the southern Delta, as presented primarily by BDOC (1993, 1994), DFG (1994a, 1994b), DWR (1992a), and the San Francisco Estuary Project (SFEP 1992a). Some of the fish surveys were designed to monitor specific species, such as striped bass and salmon, yet information on other species was obtained incidentally. Other surveys were designed to monitor fish populations in specific areas. Therefore, the sampling programs have relative strengths and weaknesses with respect to various species, depending on such factors as gear selectivity, the geographic and channel area sampled, and the season and time of day sampled. Some of the data obtained from these monitoring programs were provided by the DFG and the DWR, and are included in this chapter in graphical form to illustrate general population trends.

Population Trend Graphs. Much of the variability seen in the abundance of a given species can be explained by the variability associated with salinity among sampling stations and seasonal changes over the sampling period. This is particularly true for phytoplankton and zooplankton. By removing or accounting for the effects of salinity and season as known factors which influence the abundances of estuarine species, long-term population trends (which would otherwise be obscured by a population's response to variations in salinity and season) become apparent. The calculation of anomalies is a way to transform data so that the influence of relatively short-term factors, such a salinity and season, is dampened.

Therefore, long-term population trends represented by anomaly values reveal the variance that is due to factors which are not removed by the calculation. Thus, while population trend data for most of the aquatic organisms addressed in this chapter are graphically presented in terms of catch or abundance indices, the graphs for phytoplankton and three groups of zooplankton are presented as anomalies. A discussion of the derivation and interpretation of anomaly values follows.

An anomaly is generally defined as the deviation of a particular data point from the mean of all data within some range. Data on chlorophyll *a* (which serves as a measure of phytoplankton biomass) are expressed in terms of concentration (e.g., μg/l); data on the three types of zooplankton are expressed in terms of abundance. Thus, anomalies for these types of data are expressed as either concentration anomalies or abundance anomalies. In both cases, the data for the period of record (1972-1993) are converted to $\log_{10}$ and grouped by month and salinity classes to account for (i.e., eliminate) variability due to season and salinity. Sampling of phytoplankton and zooplankton occurs in March-November (and occasionally December-February) at 35 core (consistently sampled) stations throughout the upper Estuary (Suisun Bay through the Delta). The salinities measured among the various stations over the period of record were grouped into 20 salinity classes with approximately equal numbers of stations per class.

For each combination of month and salinity class (Mar./class 1, Mar./class 2, ... , Nov./class 20), averages were calculated using data for the entire period of record (called long-term means). Then, the data for each year of sampling were grouped by month/salinity class, and the corresponding long-term mean was subtracted from each individual observation (i.e., a data point which represents a concentration or abundance measurement) in the database. For example, the "May/class 15" long-term mean was subtracted from the "May/class 15" observation for 1976. The difference between these two values is an anomaly (i.e., anomaly value = observed value - long-term mean). Thus, an anomaly value was calculated for each observation in the period of record. Finally, the anomalies within each year, regardless of month or salinity class, are averaged (called annual anomalies).

The anomaly value, zero (0), indicates where the annual mean equalled the long-term mean. Anomalies greater than zero (positive values) indicate that the annual mean was greater than the long-term mean; anomalies less than zero (negative values) indicate that the annual mean was less than the long-term mean. Therefore, bars above the zero line are positive anomalies, indicating that the annual mean population for that year is greater than the long-term mean "population"; bars below the line are negative anomalies, indicating that the annual mean population for that year is less than the long-term mean "population".

While anomaly values have the same unit or count value of the data from which they are derived (e.g., concentration in $\log_{10}$ μg/l, or actual or estimated $\log_{10}$ abundance), they are best used as relative values that show trends, rather than quantified values, over the period of record. Therefore, anomaly values, which are very small due to compression of the data through conversion to $\log_{10}$ values, serve best as a type of index rather than actual or estimated concentration or abundance. In addition, the relatively low values of anomalies compared to the absolute values of the original data do not indicate low variability; instead, highly variable data are compressed and averaged to reveal long-term trends unrelated to factors which are known to cause variability (in this case, salinity and season). With the influences of salinity and season removed through the calculation of anomalies, population trends in these graphs are more apparent. Furthermore, increasing or decreasing trends in the populations of these organisms, as illustrated by the anomaly graphs, are primarily due to factors other than salinity and season.

1. Phytoplankton

Phytoplankton are very small, usually microscopic, algae which are suspended in water and drift with the currents. The major phytoplankton groups in estuaries are diatoms, dinoflagellates, and cryptomonads. As primary producers, which mostly convert the energy of sunlight into food through photosynthesis, phytoplankton comprise an important part of the food web base in the Bay-Delta Estuary. As a component of particulate organic carbon (POC), phytoplankton serve as food for zooplankton and other animals.

Total organic carbon, which is comprised of POC and dissolved organic carbon fractions, is used as a measure of food at the base of the estuarine food web. Sources of organic carbon include: phytoplankton, benthic microalgae, macroalgae, and photosynthetic bacteria produced in the Estuary; river-borne organic loads; tidal marsh export; point sources; runoff; atmospheric deposition; spills; ground water; and animal migration. Much of the POC appears to be phytoplankton and phytoplankton-derived detritus produced in and upstream of the Estuary.

Phytoplankton productivity and abundance are influenced by several factors, including light, temperature, nutrients, and grazing by aquatic animals. These factors can be influenced by hydrologic conditions in the Estuary which in turn affect various conditions, such as the location of the low salinity habitat. Phytoplankton abundance is estimated by direct counts or by measuring the chlorophyll produced (DFG 1994b). As part of the D-1485 water quality monitoring program, the DWR routinely samples the phytoplankton composition and biomass in San Pablo and Suisun bays, and in the Delta. Estimates of phytoplankton biomass are derived from measurements of the concentrations of chlorophyll *a*, a green pigment found in all plants. Measured chlorophyll concentrations are used primarily to document abrupt changes in phytoplankton concentrations, called "blooms" (DWR 1992a).

a. Population Trends. Between 1976 and 1991, phytoplankton blooms occurred in all regions of the upper Estuary (the western, central, northern, and southern Delta, and Suisun and San Pablo bays). These blooms, which typically occur during the spring and fall, are most often dominated by one of four diatom genera: *Skeletonema*, *Thalassiosira*, *Cyclotella*, and *Melosira*. Blooms have been most intense in the southern Delta, where chlorophyll *a* concentrations have exceeded 300 μg/l, and least intense in the San Pablo Bay ship channel, where chlorophyll *a* concentrations have not exceeded 26 μg/l (DWR 1992a).

Both the frequency and intensity of phytoplankton blooms have decreased in many regions of the upper Estuary. Throughout the upper Estuary, substantially fewer blooms occurred between 1987 and 1991 than in any other 5-year period examined. Beginning in the mid- to late-1980's, a decreasing trend in bloom intensity has occurred in all monitored regions of the upper Estuary, except the southern Delta. During the drought years of 1977 and 1987-1991, as well as during the extremely wet year of 1983, phytoplankton biomass was substantially depressed, often below the background level of 10 μg/l. In the southern Delta, however, peak levels of phytoplankton biomass increased during periods of drought compared to other years (DWR 1992a). These levels may have developed in response to increases in water residence time, which can occur during periods of reduced inflow, combined with the eutrophic conditions that generally exist in this region (Hymanson et al. 1994).

The southern Delta, which is dominated by warm nutrient-rich waters of the San Joaquin River, supports high concentrations of phytoplankton. Because of higher salinities due to recirculated agricultural water, the southern Delta phytoplankton communities are similar to those of the western Delta. The northern Delta, which receives most of its water from the Sacramento River and the Yolo Bypass, supports the lowest phytoplankton concentrations in the area (SFEP 1992a).

Chlorophyll *a* levels in the central Delta increased in 1982-1986, and decreased in 1978-1981 and 1987-1990. In the western Delta, chlorophyll *a* levels increased in 1978-1982, and decreased in 1983 and after 1986 (Hymanson et al. 1994). Prior to 1976, phytoplankton blooms in the western and central Delta were dominated by *Skeletonema* spp., *Melosira* spp., *Thalassiosira* spp., or *Cyclotella* spp. Since the May 1976 bloom, almost all large blooms in the western and central Delta have been due to *Melosira granulata* (SFEP 1992a), a phytoplankton species that is not a preferred food source of zooplankton (DFG 1994b).

In Suisun Bay, chlorophyll levels generally have declined since the mid-1970's. During the 1976-1977 drought, extremely low phytoplankton levels were observed in San Pablo and Suisun bays while the highest levels were observed entering the Delta with Sacramento and San Joaquin river inflows. Since 1978, however, such high in-flowing levels of phytoplankton have not been observed (DFG 1994b). Long-term data for chlorophyll *a* at shoal stations in Grizzly and Honker bays suggest that phytoplankton productivity in Suisun Bay was low in 1977 and has been depressed since about 1983 (SFEP 1992a). From 1980 through 1990, *Thalassiosira* spp. dominated the phytoplankton populations in Suisun Bay (Hymanson et al. 1994).

Long-term chlorophyll *a* data are insufficient to adequately characterize the interannual variability in phytoplankton production in Central and San Pablo bays (SFEP 1992a). Based on the sources of organic carbon for 1980, phytoplankton production constituted about 60 percent of the total organic carbon in the South Bay (below the Bay Bridge). In the North Bay (i.e., San Pablo Bay to Chipps Island), where phytoplankton production provided only about 20 percent of the total organic carbon, the sources were dominated by the loading of organic carbon from the Sacramento and San Joaquin rivers. During 1975-1989, phytoplankton-derived particles in Suisun Bay that were attributed to river loading ranged from 20 to 90 percent, suggesting that the dominant source changes from year to year (IEP 1994b).

Unlike phytoplankton or benthic microalgae, some of this river-borne organic matter (both dissolved and particulate forms) may be metabolically inert and not capable of being incorporated into the food web. BOD measurements in the Sacramento River over many years correspond, on average, to only about 10 percent of the total organic carbon concentration, suggesting that most of the organic matter is not readily useable (IEP 1994b). Although BOD values, which are obtained for point source waste discharges, correspond to the metabolizable fraction of the organic carbon load, it is necessary to convert them to organic carbon to compare with the contributions from other sources (SFEP 1992a).

Mean chlorophyll *a* concentrations in San Pablo Bay, Suisun Bay, and the Delta for 1975-1991 are shown in Figure V-9. Because trends are less evident in data which do not account for variations in salinity and season, anomaly values (explained above) were calculated for some of the chlorophyll *a* data. Figure V-10 presents chlorophyll *a* $\log_{10}$ concentration anomalies for Suisun Bay and the Delta from 1972 through 1993. This graph illustrates the overall decline in phytoplankton biomass throughout the upper Estuary. From 1972 through 1982, chlorophyll *a* levels were relatively high, although lower levels were observed during the 1977-1978 drought. Then, overall chlorophyll *a* levels declined in 1983 (a wet year), rebounded slightly in 1984, and steadily decreased between 1985 and 1993.

b. Causes of Decline. With the exception of the southern Delta, phytoplankton production in the upper Estuary has decreased during extremely dry and wet years, and has shown a steady decline overall. The effects of Delta outflow on phytoplankton production have been linked to the location of the entrapment zone, the area in the Estuary where fresh water and saline water flow converge, resulting in the concentration of particulate matter, including phytoplankton (Arthur and Ball 1980). The concept of the entrapment zone currently is separated into two components, low salinity habitat and gravitational circulation (see section V.A.2.d).

A model of the theoretical mechanisms by which Delta outflow influences phytoplankton productivity is described by Kimmerer (1992). Generally, phytoplankton production is increased with increased outflow. The phytoplankton growth rate is higher overall in the shoals. Phytoplankton production is also influenced by the location of the entrapment zone. When the entrapment zone is farther downstream, the phytoplankton have longer residence times in the shoals and, therefore, a higher growth rate. Within the entrapment zone, phytoplankton production is decreased because of increased turbidity.

Phytoplankton biomass is highest when the entrapment zone is adjacent to the shoal areas, in San Pablo and Suisun bays. This is due to the exchange of phytoplankton cells from the shoals (where productivity is highest) to the entrapment zone (area of gravitational circulation), driven by winds and tidal exchange. The phytoplankton is trapped in this area, which accounts for the higher biomass. In Suisun Bay, Delta outflows in the 5,000 to

Figure V-9

Chlorophyll *a* Concentrations San Pablo Bay, Suisun Bay, and Delta (1975-1991)

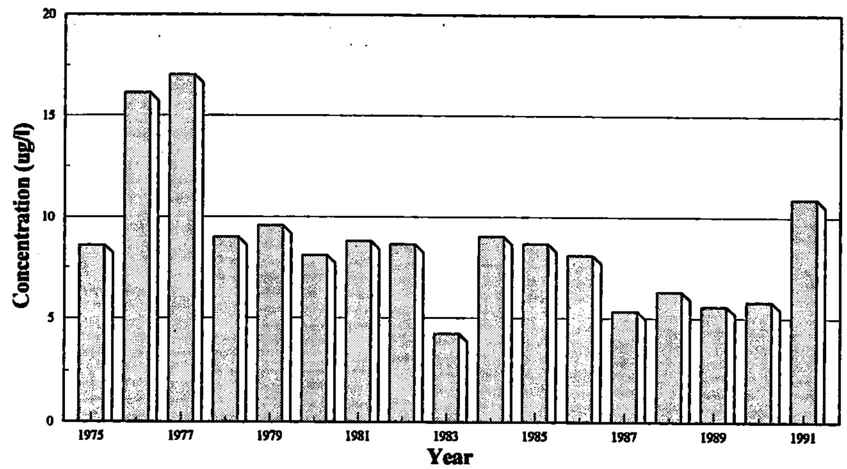
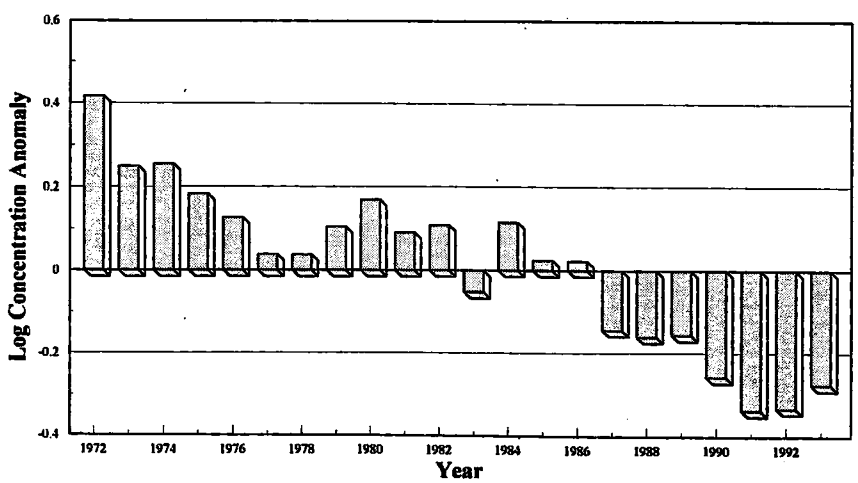


Figure V-10

Chlorophyll *a* Concentration Anomalies Suisun Bay and Delta (1972-1993)



8,000 cfs range historically have been associated with maximum phytoplankton production. When Delta outflow is less than 5,000 cfs, the entrapment zone moves upstream into the deeper Delta waters which reduces phytoplankton production in the shoals downstream (SFEP 1992b).

Based on the organic carbon budget work of Jassby (SFEP 1992a), a positive relationship between POC to Suisun Bay (including phytoplankton production and riverine loading of algal-derived particulate matter) and Delta outflow for the period 1975-1989 was demonstrated. This relationship is illustrated in Figure VI-3 of Chapter VI.

The drought-associated increases in phytoplankton biomass in the southern Delta suggest that SWP exports have not adversely impacted phytoplankton activity in this part of the Estuary during droughts. Additionally, short-term studies have found no enhancement of phytoplankton biomass during periods of curtailed exports. The central Delta is the region where phytoplankton levels could most likely be impacted by SWP operations. Increases in channel water velocities and changes in flow patterns (e.g., cross-Delta flows and reverse flows) result in reduced residence times (DWR 1992a).

Changes in sewage treatment practices and loadings could also affect the abundances of phytoplankton by reducing the amount of nutrients entering the Estuary (DWR 1992a). However, nutrients apparently do not limit the growth of phytoplankton at least until biomass reaches extremely high levels during summer blooms (Kimmerer 1992).

Finally, low phytoplankton biomass during extended drought periods could be due to increased benthic grazing that results from the gradual landward penetration of marine benthic grazers (Kimmerer 1992). However, since its discovery in 1986, the introduced Asian clam (*Potamocorbula amurensis*), a highly efficient suspension feeder that has become established at high concentrations in San Pablo Bay, Suisun Marsh, and Suisun Bay, may have also caused sustained reductions in phytoplankton biomass in some regions of the Estuary, such as Grizzly Bay (Figure V-10) (DWR 1992a). *P. amurensis* is discussed further under the section on benthos, below.

2. Zooplankton

Zooplankton are small, sometimes microscopic, aquatic invertebrate animals that drift with water currents, although they have some swimming ability. Zooplankton usually occupy intermediate trophic levels in the estuarine food web, where they may feed on phytoplankton, bacteria, protozoans, and organic detritus (e.g., POC), and are fed upon by organisms such as mollusks, shrimp, and various life stages of estuarine fish. Important zooplankters in the Bay-Delta Estuary include the rotifera, cladocera, and the copepoda, as well as the opossum shrimp.

Rotifers are microscopic, multicellular invertebrates that are most common in fresh waters, although a few purely marine species are known. Omnivorous feeding on both living and dead particulate organic matter is typical, but some species prey on protozoa, other rotifers, and other zooplankters. Dominant rotifer genera in the Bay-Delta Estuary include *Synchaeta* and *Keratella*. *Synchaeta* is most common where salinities greater than 5-10 ppt occur (e.g., in South Bay and in the western Delta in the fall). *Keratella*, which is found in fresher water, occurs in the eastern Delta and in the western Delta in the spring (SFEP 1992a).

Cladocerans, or water fleas, are often the most abundant crustaceans in fresh water. They seldom occur in waters where salinity is greater than 1 ppt and are, therefore, more abundant in the Delta than in Suisun Bay. Cladocerans are efficient feeders on a wide variety of materials from throughout the water column, including phytoplankton, bacteria, and colloidal suspensions. Among the most common cladoceran genera in the Estuary are *Bosmina*, *Daphnia*, and *Diaphanosoma*. *Bosmina* is the most widely distributed in the Estuary and is the dominant cladoceran in the Delta. *Daphnia* is also found in the Delta and Suisun Bay, but in less abundance than *Bosmina*. *Diaphanosoma* has the most restricted distribution of these three native cladocerans. The densities of all three species are highly correlated with water temperature and, except for *Diaphanosoma*, with chlorophyll *a* concentrations (SFEP 1992a).

Copepods are small crustaceans that are a major food item of plankton-feeding shrimp and fish in the Bay-Delta Estuary (NHI 1992a, SFEP 1992a). Copepods, which feed on detritus and phytoplankton, occur in a much larger range of salinities than cladocerans. In the Estuary, the abundant native copepods are sharply separated primarily by salinity and season. The dominant native copepod genera in the Estuary include *Acartia* and *Eurytemora*. Prior to the introduction of *Pseudodiaptomus*, *Cyclops* was also abundant in the Estuary. In addition to *Pseudodiaptomus*, several other copepods species were unintentionally introduced into the Estuary in the late-1970's and 1980's, including *Sinocalanus*, *Limnoithona*, and *Oithona*. *Acartia* and *Oithona* are most abundant in the more saline regions of the Estuary (e.g., South and Suisun bays); *Cyclops*, *Sinocalanus*, and *Limnoithona* are primarily freshwater copepods and can be found in the upper Estuary. *Eurytemora affinis*, an estuarine species, can be found in Suisun Bay and is the dominant native copepod in the Sacramento and San Joaquin rivers (SFEP 1992a).

The opossum shrimp (*Neomysis mercedis*) is a native mysid shrimp that is an important food source for many estuarine fish, especially young striped bass. *N. mercedis* is found in greatest abundance in Suisun Bay and the western Delta, although it occurs as far upstream as Sacramento and the lower reaches of the Mokelumne River. The diet of *N. mercedis* consists of phytoplankton, rotifers, and copepods, particularly *E. affinis* (SFEP 1992a).

a. Population Trends. Zooplankton populations in the Estuary are regularly sampled only in the Delta and Suisun Bay; therefore, trends in zooplankton abundance in South, Central, and San Pablo bays are not known. Abundances of 12 of the 20 zooplankton taxa routinely monitored in the Estuary have declined significantly between 1972 and 1988. Seven taxa showed no trend in abundance, and one introduced copepod, *Oithona davisae*, increased in abundance. In general, declines in zooplankton abundance occurred throughout the upper Estuary, but were more prevalent in the Sacramento and San Joaquin rivers than in Suisun Bay (DWR 1992a).

For the Delta and Suisun Bay from 1972 to 1993: Figures V-11 and V-12 present mean abundance and $\log_{10}$ abundance anomalies, respectively, for rotifers; Figures V-13 and V-14 present mean abundance and $\log_{10}$ abundance anomalies, respectively, for cladocerans; Figure V-15 presents the abundances of native and introduced copepods; and Figures V-16 and V-17 present mean abundance and $\log_{10}$ abundance anomalies, respectively, for opossum shrimp (*Neomysis*). Like the anomalies presented for phytoplankton, above, the anomaly values for zooplankton show population trends which generally ignore the effects of salinity and seasonal variability.

Rotifers. Overall, rotifer abundance in the Delta and Suisun Bay has steadily declined between 1972 and 1993 (Figures V-11 and V-12). Since the early 1970's, rotifer populations have declined sharply throughout the Delta (DFG 1994b), particularly in the San Joaquin River where they were formerly most abundant. Between 1972 and 1979, the rotifer populations in the Delta declined to less than 10 percent of their initial measured densities. In Suisun Bay, where rotifers were never very abundant, the decline was less severe. Since 1979, there has been no consistent difference in the abundance of rotifers in the Delta and Suisun Bay. Rotifer abundance in the Delta appears to be strongly associated with chlorophyll *a* concentrations (SFEP 1992a).

Cladocerans. The average abundance of cladocerans since the early 1970's has shown a long-term decline similar to that of the rotifers, but at a more gradual rate (Figures V-13 and V-14) (DFG 1994b). The decline in cladocera, which varies within different parts of the Estuary, is apparent in most genera except *Bosmina*. Examination of the patterns of abundance of cladocerans over time for Suisun Bay, and for Delta areas dominated by Sacramento River water and San Joaquin River water, shows the importance of Delta outflow on cladoceran abundance and distribution. Very high outflows of 1983 produced peak abundances of most cladoceran genera in Suisun Bay; moderately high outflows of 1986 produced peaks in abundance for all genera within the Delta, but had little effect on Suisun Bay populations (SFEP 1992a).

Copepods. Overall copepod abundance has remained fairly stable in recent years. However, native copepods, particularly *E. affinis*, have suffered large declines in abundance while non-native species (e.g., *Sinocalanus doerrii* and *Pseudodiaptomus forbesi*) have increased in abundance since their introductions in the late-1970's and 1980's (Figure V-15). The net result is that copepods have been at least as abundant since the late-1970's as they were previously (DFG 1994b, SFEP 1992a). In the Sacramento and San Joaquin rivers, introduced copepods are now more abundant than native copepod species, whereas in Suisun Bay, native copepods are more abundant. In the Delta, the once abundant *Cyclops* has been replaced by *Pseudodiaptomus* as the dominant copepod. However, due to increases in the populations of the introduced freshwater copepods, the average densities of copepods in the rivers are still high in most years. Within Suisun Bay, which usually supports copepod densities about twice those found in the Delta, only *E. affinis* shows a consistent pattern of decline over time. The abundance of *E. affinis* declined following the invasion of the western Delta and Suisun Bay by *S. doerrii* in 1978 and *P. forbesi* in 1987. Although

Figure V-11

**Rotifera Annual Mean Abundance
Suisun Bay and Delta
(1972-1993)**

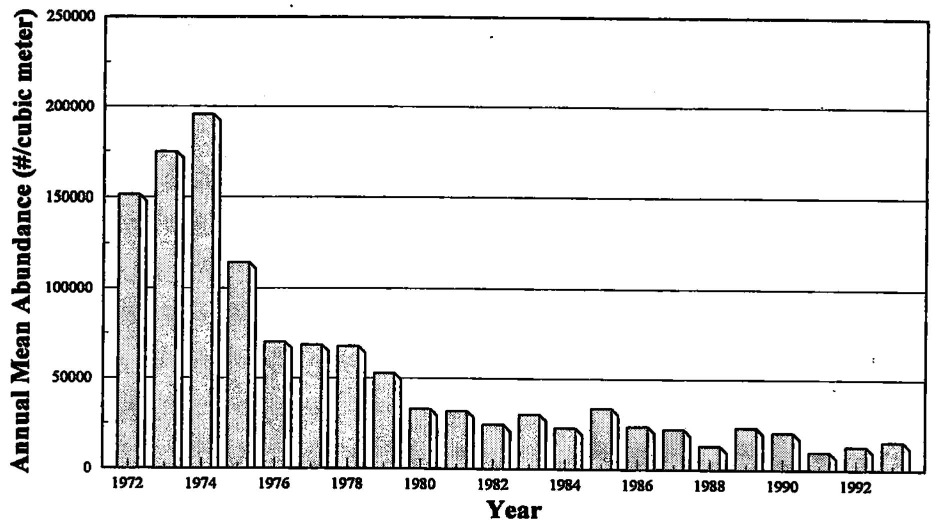


Figure V-12

**Rotifera Abundance Anomalies
Suisun Bay and Delta
(1972-1993)**

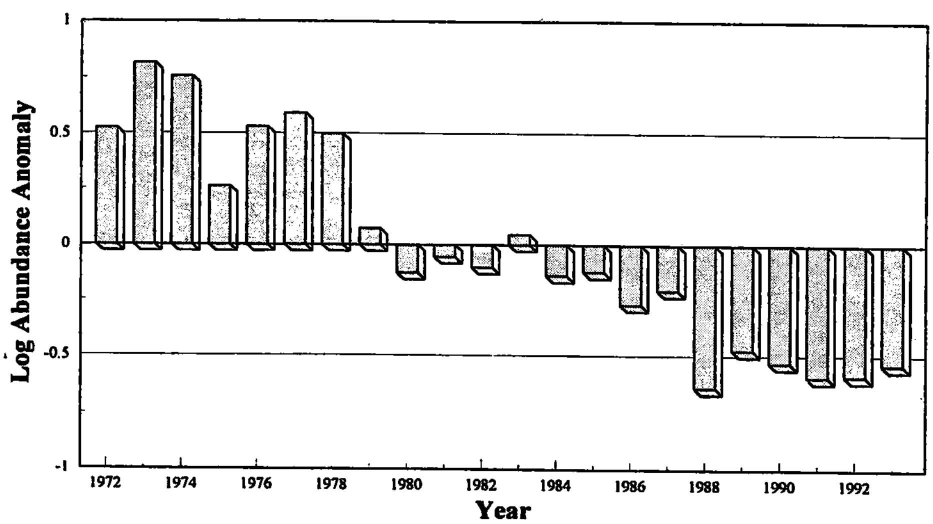


Figure V-13

Cladocera Annual Mean Abundance

Suisun Bay and Delta (1972-1993)

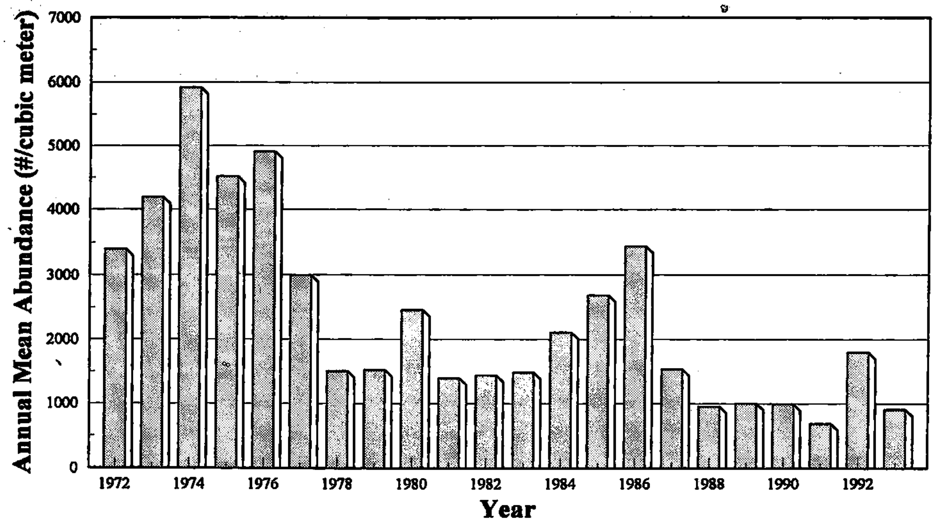


Figure V-14

Cladocera Abundance Anomalies

Suisun Bay and Delta (1972-1993)

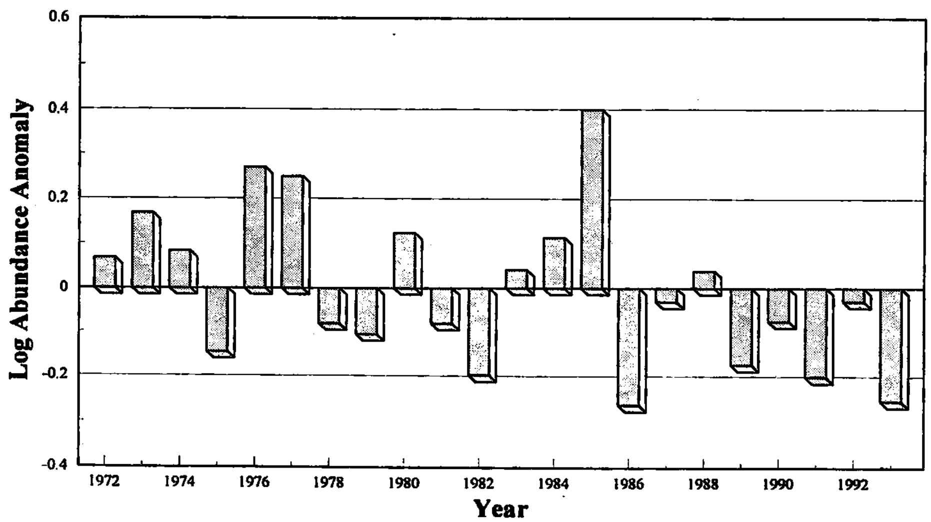


Figure V-15

Native and Introduced Copepod Abundance

Suisun Bay and Delta (1972-1993)

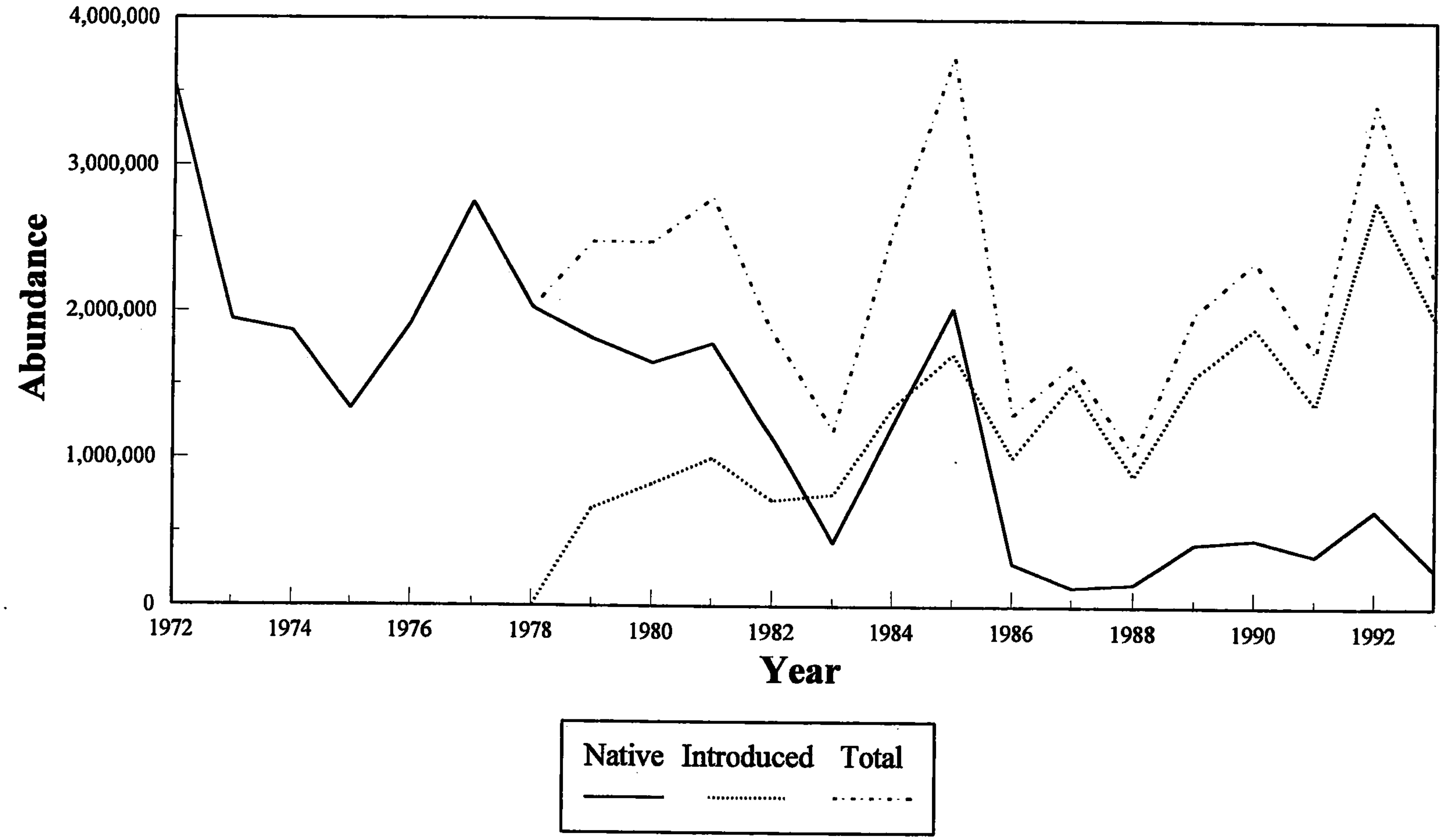


Figure V-16

Neomysis Annual Mean Abundance

Suisun Bay and Delta (1972-1993)

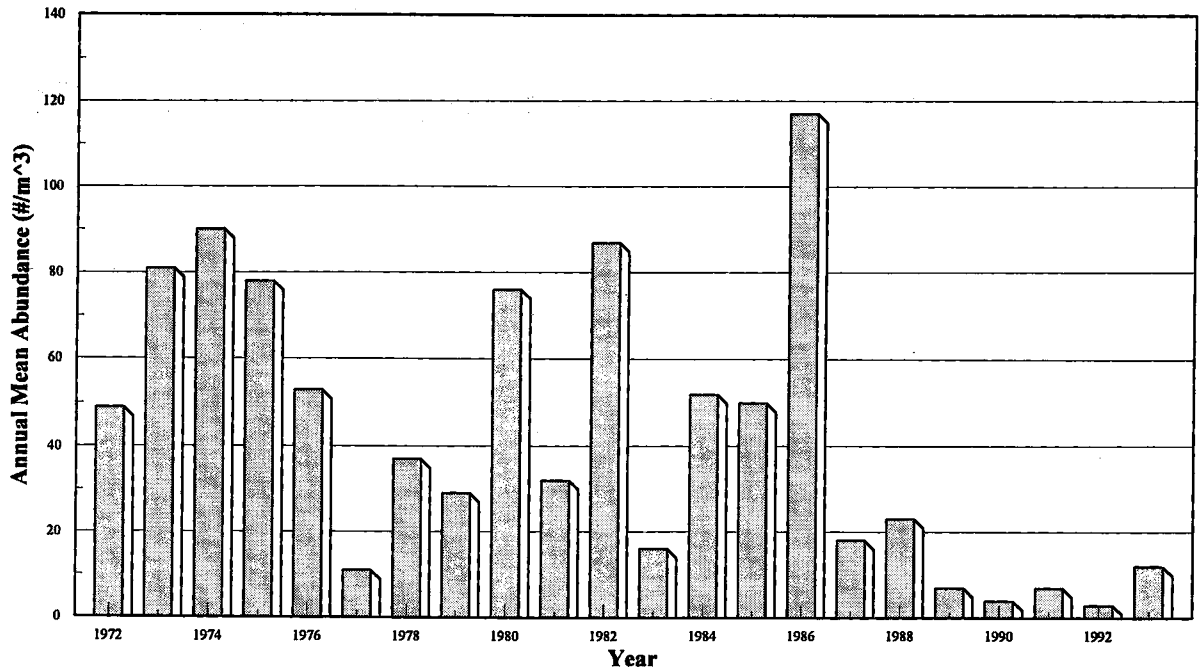
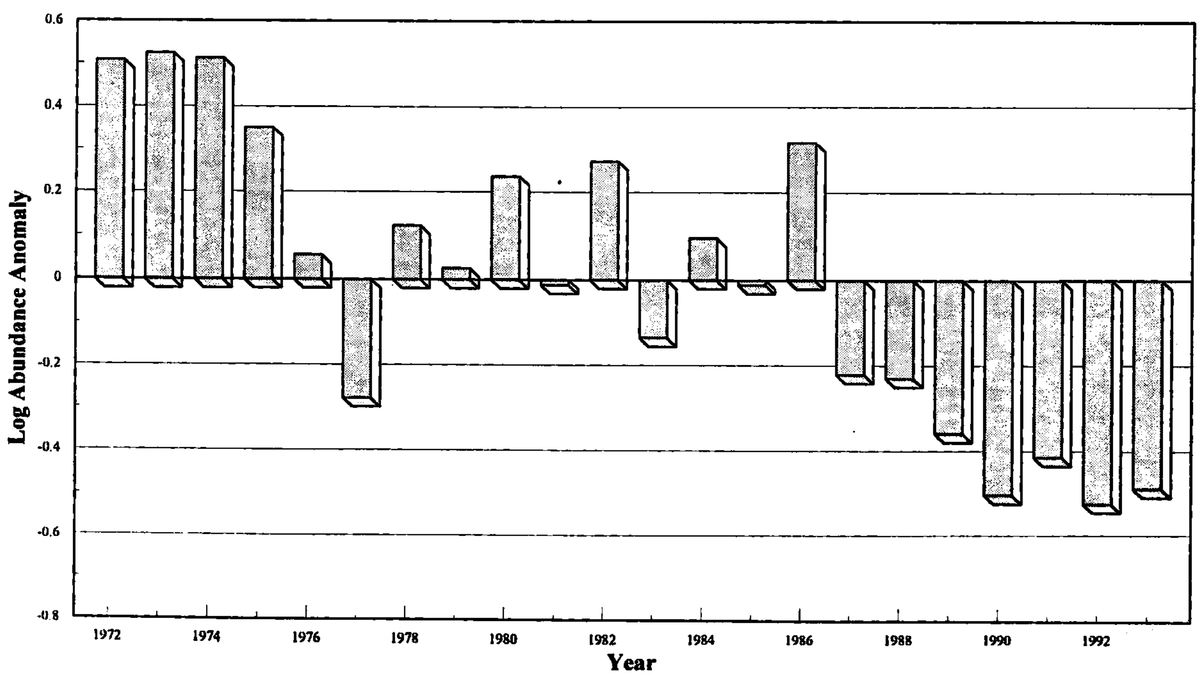


Figure V-17

Neomysis Abundance Anomalies

Suisun Bay and Delta (1972-1993)



introduced copepod species generally are not a large part of the populations in Suisun Bay, they typically increase in abundance in the bay in response to periods of high outflow (SFEP 1992a).

While most species of copepods have undergone severe, long-term declines in abundance, the marine species, *Acartia*, shows no evidence of a trend through time. This species is least abundant in the Delta and Suisun Bay during years of high outflow and is usually most abundant when salinity in Suisun Bay is greatest (SFEP 1992a).

Opossum Shrimp. During most of the 1980's, the opossum shrimp (*N. mercedis*) population varied considerably, but at a lower level of abundance than existed in the early 1970's (Figures V-16 and V-17). *N. mercedis* abundance fell dramatically after 1986 and remained at very low levels from 1990 to 1993 (DFG 1994b). Populations of *N. mercedis* have declined substantially in Suisun Bay, yet they have occasionally rebounded to high levels (BDOC 1993).

b. Causes of Declines. Reasons for the system-wide declines of several zooplankton taxa in the Bay-Delta Estuary are not known. Although the declines occurred at about the same time as declines in phytoplankton and various fish species, no cause-and-effect relationships have been established (DWR 1992a). However, several factors have been identified which are believed to have some influence on the decline of zooplankton in the Estuary.

Decrease in food supply has been associated with the decline in abundance of rotifers and the copepod, *E. affinis*. The decline of rotifers in the Delta appears to be strongly associated with declining concentrations of chlorophyll *a*, which formerly characterized the areas of greatest rotifer abundance (SFEP 1992a). However, chlorophyll and many zooplankton species have similar spatial distributions, and correlations between the two groups can arise through movement of the low salinity habitat in the Estuary. Also, while it is commonly assumed that chlorophyll is a good measure of food availability for zooplankton, *E. affinis* can subsist on detrital matter and requires larger particles than those that make up total chlorophyll. In addition, small zooplankton could provide food for many of the larger zooplankton species (Kimmerer 1992). Consistently low *E. affinis* abundance in recent years has been named as a factor that has probably contributed to the decline of *N. mercedis* (SFEP 1992a).

Introduced species have also been named as a potential cause for the decline in zooplankton abundance. For example, the introduction of *Sinocalanus* has been identified as a possible cause of the decline in abundance of *E. affinis* (Kimmerer 1992), although the introduced copepod does not have the same habitat requirements as the native copepods (NHI 1992a). However, based on the known feeding habits of a related species of *Sinocalanus*, *S. doerrii* may prey on native copepods (SFEP 1992a). In addition, predation by the introduced Asian clam, *Potamocorbula amurensis*, has been suggested as a factor in the decline of rotifer (SFEP 1992a) and *E. affinis* populations. *E. affinis* abundance in Suisun Bay decreased substantially when the clam became abundant there in 1988 (DWR 1992a). Kimmerer et al.

(1994) hypothesized that direct predation by *P. amurensis* is the cause of the reduced survival of *E. affinis* nauplii which has, therefore, depressed the abundance of the adults.

The decline in the abundance of *N. mercedis* and other zooplankton species (e.g., *E. affinis*) that are found in the low salinity habitat in relatively high abundances has been correlated with Delta outflow (see Figure VI-4 in Chapter VI). It is presumed that low outflow reduces *N. mercedis* abundance by: (1) restricting the low salinity habitat to deeper, more upstream channels which are less likely to promote high densities of *N. mercedis*; and (2) producing weaker landward currents along the bottom so that the ability of *N. mercedis* transported downstream to return to the low salinity habitat is reduced. It has also been presumed that larger numbers of *N. mercedis* may be exported through the CVP and SWP pumps as a result of the increased proportion of inflow diverted during drought years when the low salinity habitat is upstream in the Estuary. The location of the low salinity habitat within the lower river channels during dry years increases the vulnerability of *N. mercedis* to such displacement (SFEP 1992a). However, analyses by Kimmerer (1992) suggest that exports by the water projects are not a major source of losses for *N. mercedis* and *E. affinis* populations, primarily due to the small percentage of low salinity habitat volume (and low salinity habitat organisms) diverted. Depending on the timing, location, and quantity of withdrawals, in-Delta water diversions, whose net consumption is on the same order of export flows, may result in a higher rate of loss to resident zooplankton populations than export pumping.

Pollutants may be another factor in the decline of zooplankton in the upper Estuary. For example, rice herbicides have been shown to be toxic to *N. mercedis* (DWR 1992a). However, rice herbicides are largely confined to the Sacramento River, not the entire Estuary. No Estuary-wide decline in planktonic crustaceans has been associated with the timing of herbicide occurrence in the river (NHI 1992a).

3. Benthos

Benthic organisms (benthos) are animals that live in or on the bottom of an aquatic habitat. Most benthic organisms feed by straining phytoplankton and non-living organic matter from the water column. The benthos in the Bay-Delta Estuary include mollusks, such as oysters and clams, and benthic crustaceans, such as crabs, crayfish, and shrimp. With few exceptions, all of the common benthic species in the Estuary have been intentionally or accidently introduced (BDOC 1993).

The factors which most affect the abundance, composition, and health of the benthic community include local runoff, pollution, and Delta outflow. The importance of pollution in controlling benthic communities has been assumed to be very high. Lower outflows are also associated with lower phytoplankton biomass and, therefore, lower productivity during periods of low flow in parts of the Bay complex. High outflows lead to lower salinities, which particularly control the species abundance and composition in shallow areas where animals are exposed to less saline surface waters (SFEP 1992a).

In the northern reach of the Estuary, the abundance and distribution of benthic species are greatly affected by salinity variation. Historically, during high outflow years, some brackish water species decline; during low flow years, species associated with more saline water occur more frequently. However, in 1987, following several years of very low flow and high salinity, Suisun Bay was not colonized by more marine benthic species as expected. Rather, the newly-introduced Asian clam, *Potamocorbula amurensis*, (discussed below) remarkably increased in abundance (DFG 1994b).

a. **Mollusks.** With the exception of one or two species (i.e., the bay mussel, *Mytilus edulis*, and, possibly the clam, *Macoma balthica*), the common benthic mollusks of the Bay-Delta Estuary are introduced. Within the Delta, the dominant mollusk is the introduced Asiatic clam, *Corbicula fluminea* (SFEP 1992a). Introduced into California in the late 1940's, *C. fluminea* quickly became a dominant member of the benthos in the Estuary. *C. fluminea* is a suspension-feeding, freshwater clam that filters phytoplankton and organic detritus from the water column. Recent studies suggest that *C. fluminea* is able to filter a significant portion of the phytoplankton from the water column. Immature clams are readily dispersed in the Estuary by flowing water. Increased outflows result in *C. fluminea* being found throughout the upper Estuary; but salinity levels in Suisun Bay prevent the establishment of permanent populations there. Established populations appear to exist in the central Delta and, to a lesser extent, in the western Delta (Hymanson et al. 1994).

The most recently introduced mollusk in the Estuary is the Asian clam, *Potamocorbula amurensis*. Native to the estuaries along the east coast of Asia, this clam is thought to have been introduced into Suisun Bay as larvae through the discharge of ship ballast water (Hymanson et al. 1994).

Potamocorbula amurensis. Like *C. fluminea*, *P. amurensis* is a suspension-feeding clam. It is capable of consuming phytoplankton, bacterioplankton, particulate organic matter, and immature zooplankton (Hymanson et al. 1994). This small clam, which grows to a maximum size of 1 inch, has high feeding and reproductive rates. At densities as great as 25,000 individuals per square meter, the *P. amurensis* population is able to filter substantial volumes of water as it feeds (SFEP 1992a). It has been calculated that densities of *P. amurensis* in the Estuary are so high that the entire water column of San Pablo and Suisun bays can be filtered within a 24-hour period (CUWA 1994).

Population Trends. Since its discovery near Carquinez Strait in 1986, *P. amurensis* has become the most abundant benthic organism in several regions of the upper Estuary (CUWA 1994, DWR 1992a). By 1990, *P. amurensis* was well established in a variety of habitats throughout San Pablo and Suisun bays, and Suisun Marsh (Hymanson et al. 1994). Before the introduction of *P. amurensis*, shifts to more saline conditions in the Estuary, as during the low flow years of 1976 and 1977, resulted in the increase in abundance of the introduced softshell clam, *Mya arenaria* (CUWA 1994), which was first noted in the Estuary in 1874 (SFEP 1992a). It is thought that *P. amurensis* prevented the recolonization of Suisun Bay by *Corbicula* following the return to lower salinities there after the drought conditions in 1984 and 1985 (CUWA 1994). During the drought period, 1987-1992, this species spread throughout the more saline portions of the Estuary and into Suisun Bay (BDOC 1994). The persistently low salinity in the central Delta probably prevents the establishment of *P. amurensis* in this region (Hymanson et al. 1994).

Potamocorbula amurensis has altered the benthic community in Grizzly Bay and the Sacramento River near the confluence, where it has been dominant since 1988 (Hymanson et al. 1994). In Suisun Bay, the previous benthic community largely disappeared as *P. amurensis* multiplied. During this time, normal summertime phytoplankton blooms have failed to occur and chlorophyll *a* densities have remained at some of the lowest recorded values (Figure V-10) (SFEP 1992a). This species' extremely high filter-feeding rate has resulted in dramatic reductions in phytoplankton density and shifts in POC loadings. Such reductions are likely having a direct influence on the population dynamics of zooplankton and planktivorous fish (CUWA 1994).

<u>Causes of Increase</u>. The establishment and spread of *P. amurensis* indicate that this introduced species has found the conditions of the Estuary to be conducive to its propagation and growth, and that it apparently has a wide niche partition. As a filter feeder, it is able to remove and process phytoplankton from all waters that it inhabits. There has been a dramatic reduction in phytoplankton and chlorophyll *a* densities since its introduction. This has ecological significance for a number of planktivorous fish species in the Estuary which rely on both phytoplankton and zooplankton as a major food source (CUWA 1994).

While the establishment of *P. amurensis* may have increased the competition with other benthic organisms for space and food, it does provide a new and abundant food source for bottom-feeding crabs, fish, and birds (Hymanson et al. 1994). However, this clam can bioaccumulate high concentrations of selenium, which could result in higher tissue concentrations in organisms that feed on it (DWR 1992a).

b. <u>Benthic Crustaceans</u>. Unlike the mollusks, the benthic crustaceans are comprised of many native species, particularly young Dungeness crabs and other smaller crabs, as well as caridean shrimp. However, in the upper Bay complex, the epibenthos (unattached benthic organisms) consist entirely of introduced species, particularly the crayfish. The benthic epifauna, except for the Dungeness crab, is probably the least studied community of animals in the Estuary (SFEP 1992a). The DFG has also monitored the abundance of true shrimp (Caridea) in recent years. Therefore, the Dungeness crab and the caridean shrimp are discussed below as representative species of the benthic crustaceans in the Bay-Delta Estuary.

<u>Dungeness Crab</u>. The most familiar member of the benthic community in the Estuary is the Dungeness crab (*Cancer magister*). This native species reproduces at sea, enters San Francisco Bay as juveniles during May or June, and leaves the bay by August or September of the following year (SFEP 1992a). Bay-reared Dungeness crabs grow about twice as fast as, and contribute to the commercial and sport ocean fishery 1 to 2 years sooner than, ocean-reared crabs. Dungeness crab fishing is not allowed in San Francisco Bay (DFG 1987). The bay population contributes as much as 83 percent of the crabs in the Central California fishery (SFEP 1992a).

Population Trends. The Dungeness crab is generally most abundant from Richardson's Bay upstream through Suisun Bay, with the most consistently high number of juveniles in San Pablo Bay. No crabs are found where bottom salinities are less than 10.2 ppt, and the onset of high outflows from winter storms results in a mass movement of crabs to more downstream locations (SFEP 1992a).

For the first 60 years of this century, Dungeness crabs were an increasingly important fishery for San Francisco. Historical trends in Dungeness crab landings (Figure V-18) indicate that the catches rose until the late-1950's. The May and June abundance indices of juvenile crabs in the bay have varied widely since monitoring efforts of the Bay Study began in 1980 (Figure V-19). Low abundances occurred in 1983 and 1986, two years with the highest outflows ever recorded; then, they attained higher abundances in the following years, 1984 and 1987 (SFEP 1992a). The crab expanded its distribution in the bay during the low outflow years of 1981, 1984, and 1985 (DFG 1987). Overall, the species exhibits a declining trend in population size, with low abundances occurring in the late 1980's and early 1990's (DFG 1994b).

Causes of Decline. Oceanic conditions in 1959 caused the population and catch of Dungeness crabs to drop dramatically. Although oceanic conditions are probably the strongest control on the size of Dungeness crab populations (SFEP 1992a), Delta outflow has been correlated with juvenile crab abundance. There is a negative relationship between outflow and juvenile crab abundance in the bays. The estuarine flows during high outflow years may carry larval crabs too far offshore, and possibly too far north, to allow them to return to the vicinity of the bay (DFG 1987); however, the actual mechanism for transporting larval crabs to the coast is unclear. The number of crabs entering the bay is primarily a function of larval crab abundance in the ocean and, perhaps, the strength of landward-flowing bottom currents. High outflows, which appear to reduce the transport of crabs into the bay, are frequently associated with *El Niño* events and other oceanic conditions that are suspected of reducing larval crab abundance (SFEP 1992a).

Another factor which has been considered in the reductions of Dungeness crab abundance is cannibalism. Because juvenile crabs generally remain in the bays for about 15 months, two year classes (i.e., the newly-arrived juveniles that entered the Estuary in May and June, and the older juveniles that entered the Estuary in May and June of the previous year) occur together during the summer. Therefore, an abundant year class of larger juveniles could reduce the subsequent year class size of smaller juveniles through cannibalism (SFEP 1992a).

Caridean Shrimp. Five species of caridean shrimp (*Crangon franciscorum*, *C. nigricauda*, *C. nigromaculata*, *Heptacarpus stimpsoni*, and *Palaemon macrodactylus*), which seldom exceed 70 mm in total length, dominate the smaller benthic fauna in the Bay-Delta Estuary (SFEP 1992a). *Crangon* spp. are commonly called "bay shrimp" and *Palaemon* is known as "pile shrimp"; collectively, they are often referred to as "grass shrimp". The three species of *Crangon*, as well as the less abundant *H. stimpsoni*, are native shrimp, whereas *P. macrodactylus* was introduced to the Bay-Delta Estuary in the 1950's (DFG 1994b). The crangonid shrimp are common food items for many estuarine fish (SFEP 1992a). The

Figure V-18

Dungeness Crab Landings

San Francisco Area, Bodega Bay to Princeton (1941-1992)

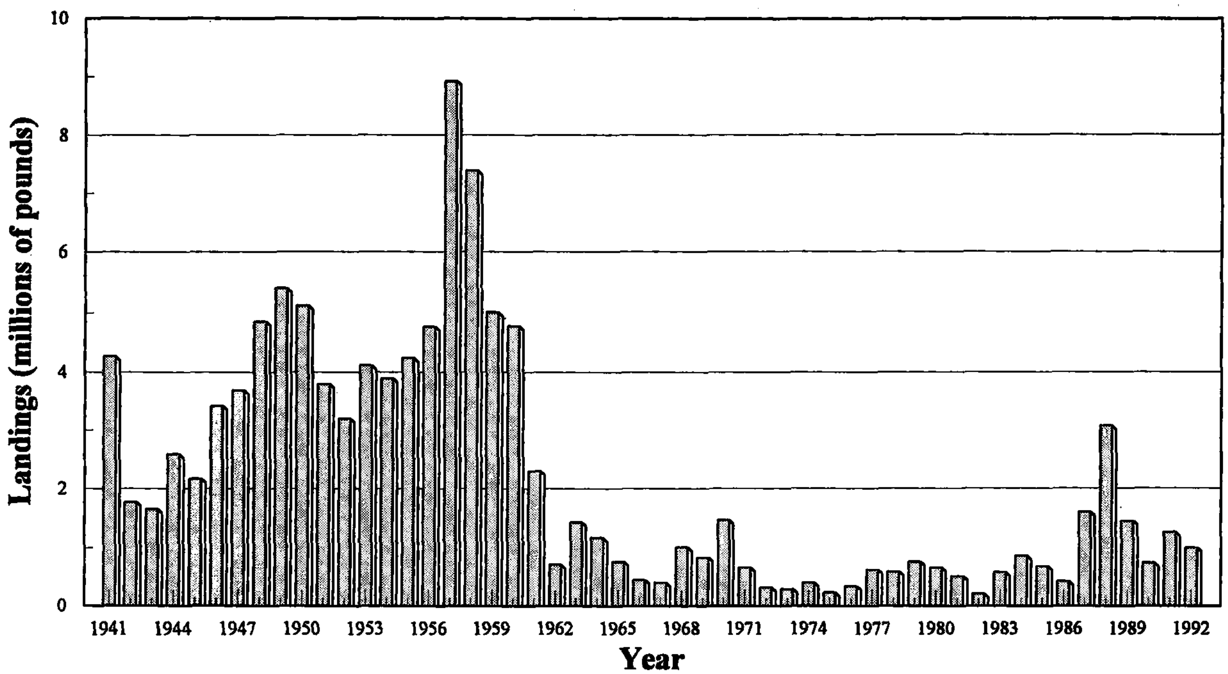
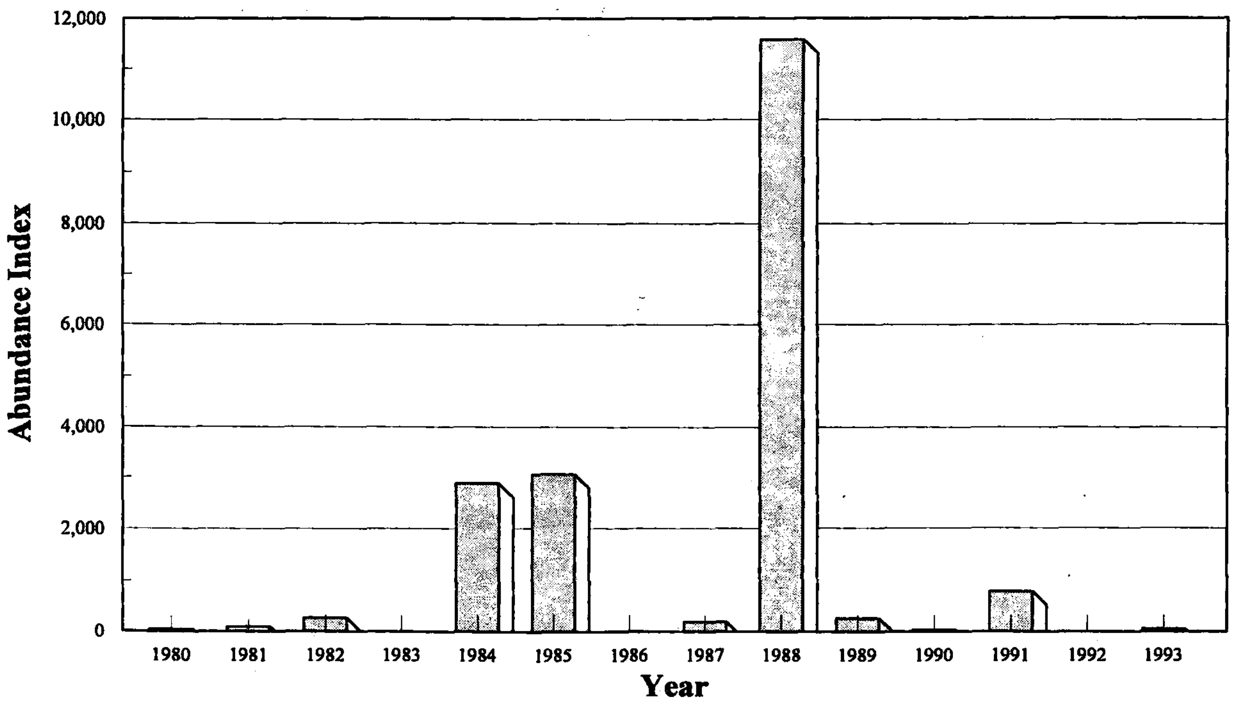


Figure V-19

Dungeness Crab (Age 0+) Abundance Indices

May-July Otter Trawl Survey (1980-1993)



California bay shrimp, *C. franciscorum,* moves between marine and brackish water during its life cycle. The larvae hatch in relatively high salinity water. The post-larvae and juveniles migrate upstream to lower salinity nursery area where they grow for 4-6 months. Mature shrimp, which live between 1 and 2 years, migrate downstream to higher salinity water to complete the life cycle (DFG 1992c).

Each of the shrimp species uses the Estuary as a nursery area to varying degrees. *P. macrodactylus* and *C. franciscorum* are Estuary-dependent. *P. macrodactylus* is most common in Suisun Bay, the western Delta, and areas adjacent to freshwater sources, such as the mouths of creeks in South and San Pablo bays. *C. franciscorum* is found in brackish, relatively warm water, *C. nigricauda* is found in higher salinity and cooler water, and *C. nigromaculata* is primarily a coastal, shallow water species that is most commonly found in the nearshore ocean area adjacent to San Francisco Bay. *H. stimpsoni* is also considered a coastal species, although it is locally abundant in the bay (DFG 1994b).

Population Trends. *Crangon* spp. and *Palaemon* support a commercial fishery in the bays. Early in the century, when there was a large market for dried shrimp, over 3 million pounds per year were landed (Figure V-20). Since 1980, this fishery has landed between 100,000 and 200,000 pounds of shrimp annually. To protect juvenile striped bass, shrimp fishing has been prohibited upstream of Carquinez Strait since 1985 (DFG 1994b).

Aside from the commercial catch data, dependable abundance indices for shrimp are only available since 1980 (Figure V-21). Since that time, there has been a change in species composition in the catches. In the early-1980's, *C. franciscorum* dominated the catches; but in the late-1980's and early-1990's, *C. nigricauda* was dominant, and *C. nigromaculata* and *H. stimpsoni* increased in abundance. This change was caused in part by the relatively stable, high salinities associated with the drought, resulting in increased habitat for species that prefer higher salinities, but decreased habitat for *C. franciscorum*, which prefers lower salinities. Abundance data for *P. macrodactylus* are inconclusive (survey methods probably are inadequate for this species) (DFG 1994b).

Reflecting this change in species composition, the contribution of shrimp catches in San Pablo and Suisun bays to the total abundance index declined, while the contribution of Central Bay catches increased. In 1992, the Suisun Bay index decreased to a study period low with only a 3 percent contribution to the total index (DFG 1994b).

Biomass indices, which serve as a relative measure of the weight of shrimp available as a food source, have declined since 1986 (Figure V-21). The divergence between the abundance and biomass indices during the recent drought is due to an increase in abundance of juveniles and species that do not grow as large as *C. franciscorum* (DFG 1994). Figure V-22 illustrates the decline in immature *C. franciscorum* abundance indices since the early-1980's.

Causes of Decline. Unlike the other caridean shrimp, *C. franciscorum* decreased in abundance in recent years. *C. franciscorum*, which can be found at a wide range of salinities

Figure V-20

Caridean Shrimp Landings

Bay-Delta Estuary (1915 - 1992)

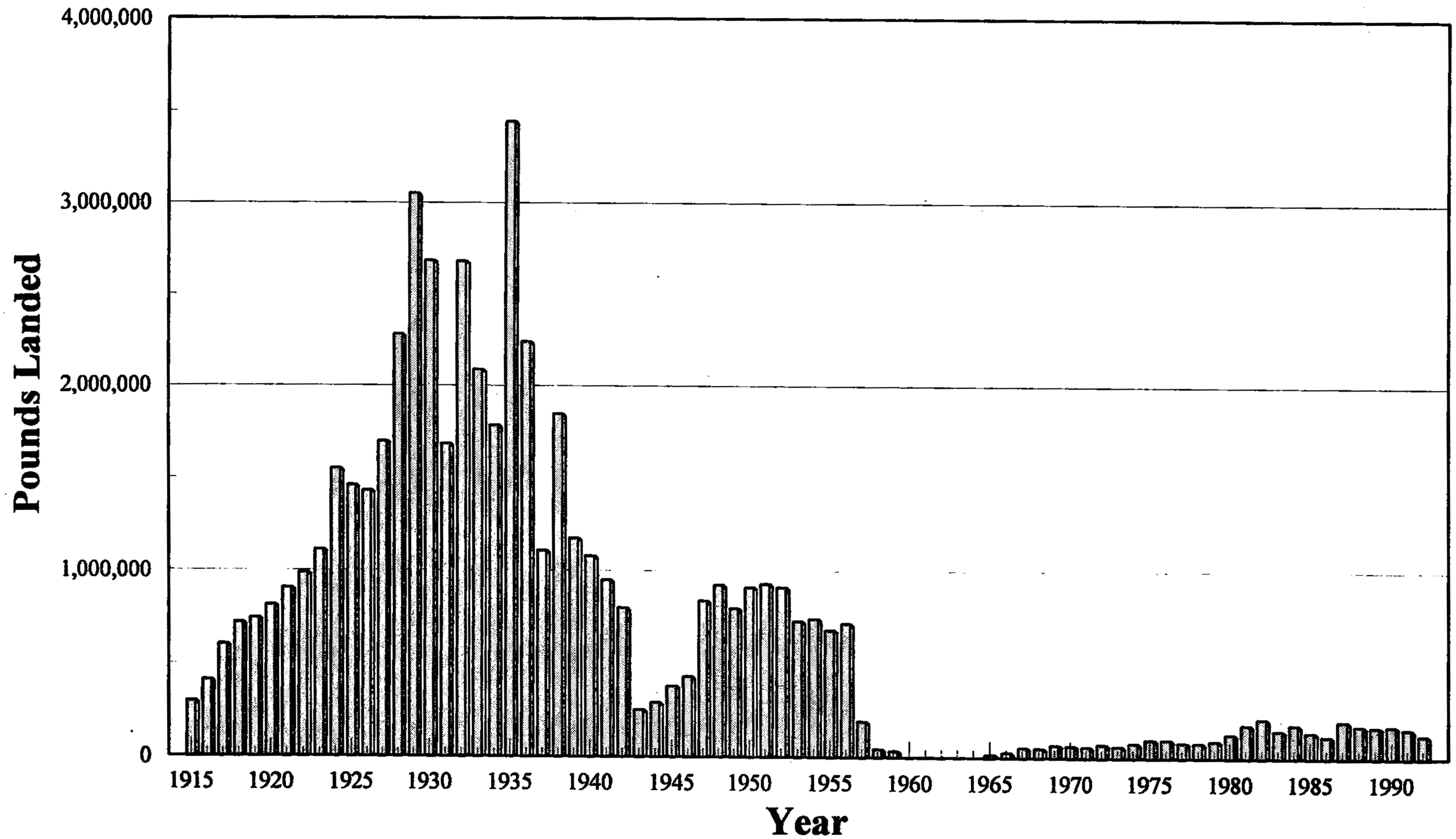


Figure V-21

Caridean Shrimp Abundance and Biomass Indices

Bay-Delta Estuary (1980-1993)

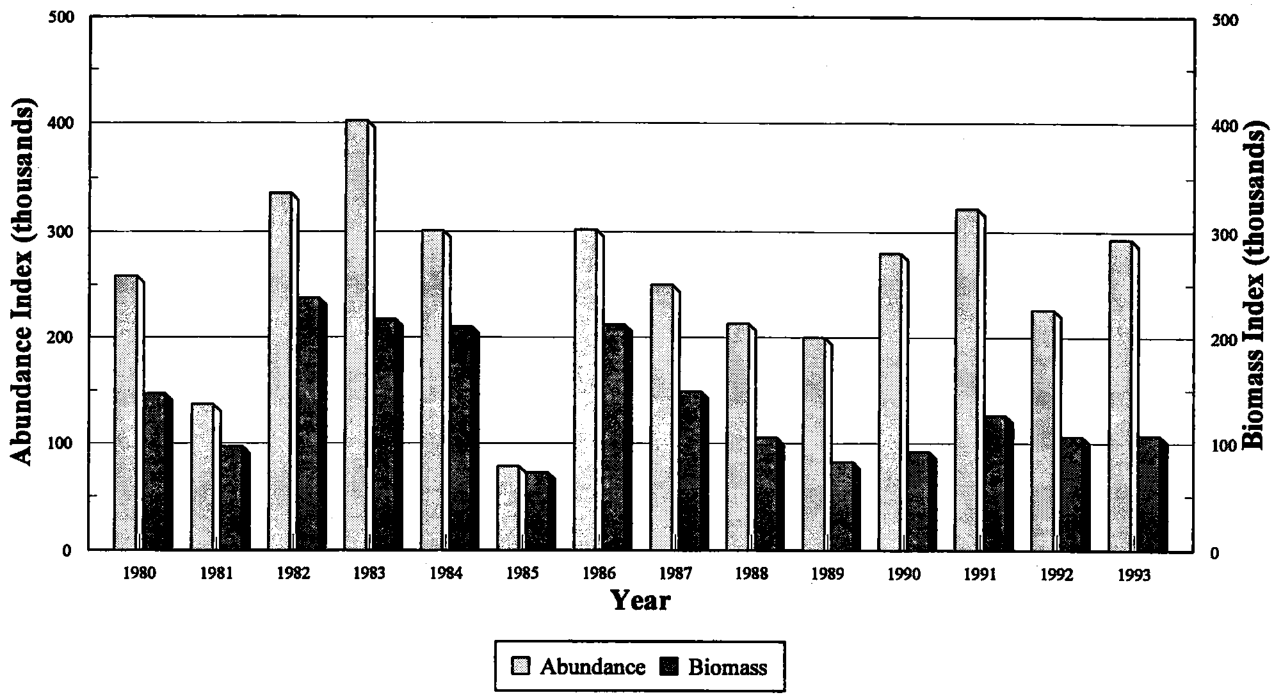
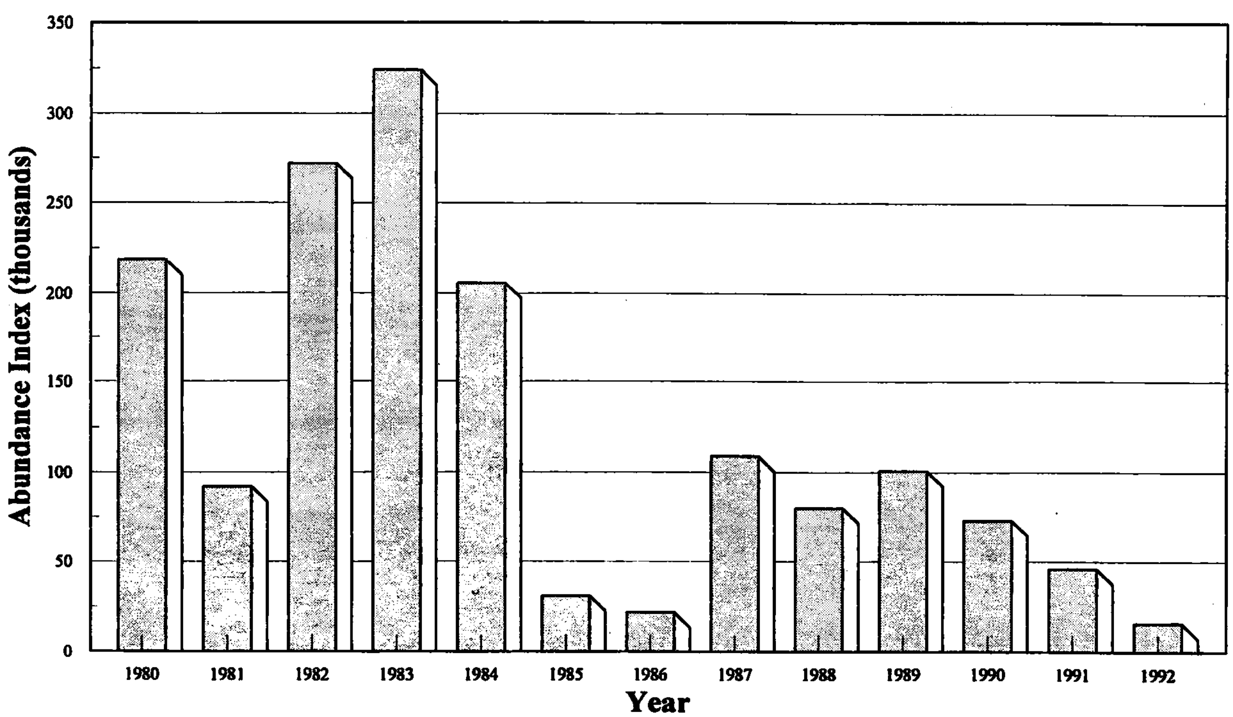


Figure V-22

Immature *Cragon franciscorum* Abundance Index

Bay-Delta Estuary (1980-1992)



and temperatures, exhibits a straightforward response to outflow alone, whereas other species of shrimp appear to respond more to salinity (SFEP 1992a). The response of *C. franciscorum* to outflow has been attributed to two flow-related mechanisms. First, higher river inflows result in larger landward-flowing currents, transporting the small post-larval shrimp into the bay and dispersing them upstream. Second, higher river inflows reduce bay salinity and increase the amount of suitable nursery habitat for juvenile shrimp (Jassby et al. 1994; SFEP 1992a).

The period March to May has been identified as the most critical period for freshwater outflow in the establishment of a strong year class of immature *C. franciscorum* in the bay. There is also a strong positive relationship between the annual abundance of mature *C. franciscorum* and freshwater outflow the previous spring (March-May) when they were recruited to the bay. Therefore, an increase in outflow in March to May should result in an increase in the abundance of *C. franciscorum*. Significant relationships between abundance and outflow were not found for the other species of shrimp. The other species of *Crangon* and *Heptacarpus* are much less estuarine-dependent than *C. franciscorum*, which is affected by freshwater outflows its entire life cycle, and their abundance is affected more by ocean conditions (DFG 1992c).

The decreased food abundance (e.g., *N. mercedis*) in Suisun Bay in recent years may also have played a role in reducing the abundance of *C. franciscorum* since it is the only crangonid found in abundance that far upstream (SFEP 1992a). Also, as with the zooplankters, *Eurytemora* and *Neomysis*, the decline of *C. franciscorum* has also been associated with the introduction of the zooplankters, *Sinocalanus doerrii* and *Pseudodiaptomus forbesi*, and the Asian clam, *Potamocorbula amurensis*, as well as pumping by the SWP and the CVP (NHI 1992a).

4. Freshwater Fish

The Bay-Delta Estuary has both native and introduced freshwater fish species. Most native fish are large minnows, such as the Sacramento splittail, Sacramento squawfish, hitch, Sacramento blackfish, and hardhead. The Sacramento splittail is discussed here as a representative native freshwater species in the Estuary. Among the many introduced species in the Estuary are centrarchids (sunfish such as bluegill and smallmouth bass), catfish, carp, threadfin shad, and inland silverside. Because there is more information on the population trends of white catfish than for any other resident freshwater species, it will be discussed here as a representative of introduced freshwater species in the Delta.

a. Sacramento Splittail. The Sacramento splittail (*Pogonichthys macrolepidotus*) is a large minnow endemic to the Bay-Delta Estuary. Historically, it was found through low elevation lakes and rivers of the Central Valley from Redding to Fresno. Data from recent surveys indicate that the splittail is still found in many of the major Central Valley tributaries, specifically, the American, Tuolumne, San Joaquin, and Mokelumne rivers. Splittail are also found in Suisun Bay, Suisun Marsh, Napa Marsh, and the Delta. Although the Sacramento splittail is considered a freshwater species, the adults and sub-adults have an unusually high tolerance for saline water, up to 10-18 ppt (Meng 1993), for a member of the minnow family (DFG 1994b). Therefore, the Sacramento splittail is often considered an estuarine species. The salt tolerance of splittail larvae is unknown (DFG 1992b).

The Sacramento splittail, which has a high reproductive capacity, can live 5-7 years and generally begin spawning at 1-2 years of age (Hanson 1994a). Spawning, which seems to be triggered by increasing water temperature and day length, occurs over beds of submerged vegetation in slow-moving stretches of water, such as flooded terrestrial areas and dead-end sloughs. Adults spawn from March through May. Hatched larvae remain in shallow, weedy areas until they move to deeper offshore habitat later in the summer. Young splittail may occur in shallow and open waters of the Delta and San Pablo Bay, but they are particularly abundant in the northern and western Delta (DFG 1992b, DWR 1992a).

Splittail are benthic foragers that feed extensively on opossum shrimp (*Neomysis mercedis*) and opportunistically on earthworms, clams, insect larvae, and other invertebrates. They are preyed upon by striped bass and other predatory fish in the Estuary (NHI 1992b).

Population Trends. Abundance indices of the Sacramento splittail, based on fall mid-water trawl catches, have varied over the years (Figure V-23). The indices, based on sampling juvenile splittail, were relatively high in the late 1960's (e.g., 66.3 in 1967) and then declined severely until 1977. After 1977, splittail abundances increased to a record high of 153.2 in 1983, after which the index declined to 3.6 in 1992. Likewise, the Bay Study indices for splittail were highly variable. Maximum abundances were attained in 1982, 1983, and 1986, all wet years; but abundance indices declined through the late 1980's, slightly increased during the early 1990's (DFG 1994b), and declined again in 1992 (Cech and Young 1994).

Because of the apparent reduced abundance and distribution of the Sacramento splittail, it is considered a species of special concern by the DFG, and the USFWS is contemplating its listing as a threatened species under the federal ESA (DFG 1994b).

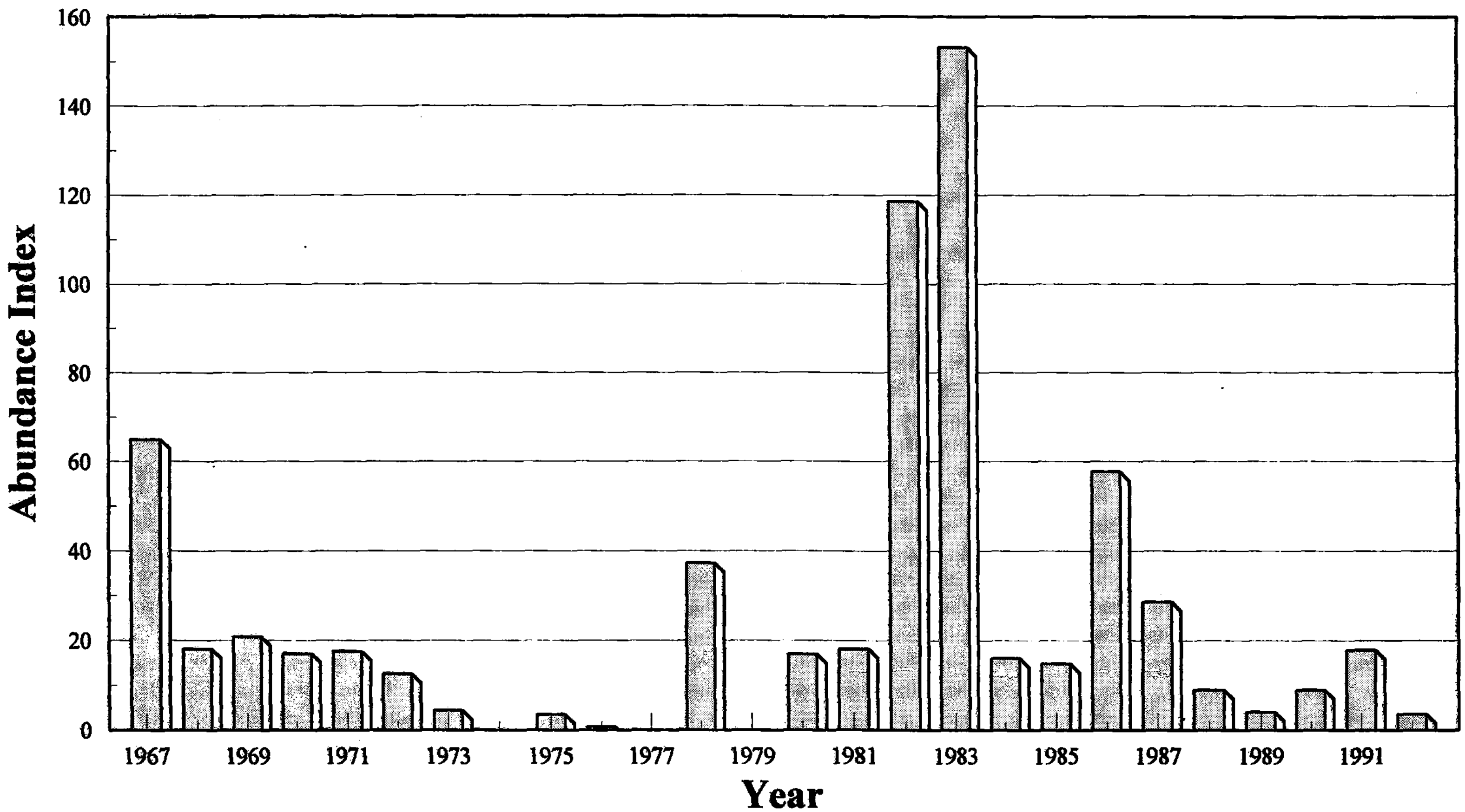
The DWR analyzed the various catch records available and made the following findings. The number of young splittail in the Estuary may have declined over the 6-year drought; however, some recent data suggest that recent levels have improved. In upstream areas, beach seine results indicate that recent young-of-the-year (YOY) abundance levels are similar to, or perhaps greater than, pre-decline levels. Adult abundance trends also indicate that the number of spawners has not declined, except in the region of Suisun Marsh and Chipps Island. The ability of the population to recover does not appear to have been compromised by conditions in the past decade. In 1993, adult indices were fairly strong in most surveys and YOY production appeared to have been substantial, based on catches upstream in the Sacramento River (DWR 1995a).

Causes of Decline. The Sacramento splittail has declined in abundance because of loss or alteration of lowland habitats following dam construction, water diversion, and agricultural development (Cech and Young 1994). The Sacramento splittail has lost much of

Figure V-23

Sacramento Splittail Abundance Indices

Fall Mid-Water Trawl Survey (1967-1992)



Note: Not sampled in 1974 and 1979.

its original foraging and spawning habitats through losses of marshlands due to land reclamation activities (CUWA 1994, DFG 1992b).

Within the Estuary, it appears that the decline in splittail abundance is a result of habitat constriction associated with the reduction of Delta outflow and changes in hydrodynamics due to Delta exports. Shallow-water habitat is important for rearing of young, and freshwater outflow may be important for the dispersion of young to appropriate nursery areas in Suisun Bay (Meng 1993). Although little data exist regarding its environmental requirements or tolerances, it is likely that high salinity restricts the downstream range of the splittail (Cech and Young 1994).

Sacramento splittail populations fluctuate on an annual basis depending on spawning success and year class strength (NHI 1992b). Successful reproduction is strongly associated with high outflows preceding, during, and following spawning, as demonstrated by high correlations between abundance of splittail in the fall mid-water trawl survey and various monthly combinations of Delta outflow from the previous winter through early summer (DFG 1992b). The DFG's statistical relationship between the juvenile splittail abundance indices and March-May (the spawning period) Delta outflow for the years 1967-1993 indicates that increased outflow in the spring corresponds with increased splittail abundance indices (see Figure VI-8 in Chapter VI).

Abundance is also correlated with the duration of floodplain inundation, which may provide a large amount of additional spawning, rearing, and foraging habitat in wet years. Except for 1993 and the current water year, little flooding has occurred in the range of splittail since 1986, perhaps leading to a series of weaker year-classes in the Estuary. The DWR states that: "Although hydrology appears to be important to the production of young splittail, the USFWS beach seine data and recent egg and larval analyses show that spawning can be successful in many areas of the Sacramento and San Joaquin rivers and the northern and central Delta in both wet and dry years" (DWR 1995a).

The strong correlation of the abundance of young Sacramento splittail with freshwater outflows (NHI 1992b; DFG 1992b) during the late winter and spring accounts, in part, for the observed decline in juvenile production during the recent drought period (Hanson 1994a). The corresponding relationship for adult splittail is very weak, indicating that the relationship between splittail and outflow is particularly important for reproduction (Meng 1993). Because a strong stock-recruitment relationship has not been established, the relationship between the observed decline in juvenile splittail abundance indices and the abundance, age structure, reproductive capacity, and population dynamics for the adult splittail population is unknown (Hanson 1994a).

The major factor cited in reducing splittail abundance is loss of spawning and nursery habitat due to reclamation activities (DFG 1992b), bank protection, and channelization. In addition, introduced species (i.e., planktonic copepods and the Asian clam, *Potamocorbula*) may have reduced the splittail's favored prey, *Neomysis mercedis*, and, therefore, are also possible factors in the decline of Sacramento splittail populations in the Estuary (NHI 1992b).

b. **White Catfish**. The white catfish (*Ictalurus catus*) was introduced into the Bay-Delta Estuary in 1874 and rapidly increased in abundance. In recent years, the white catfish has supported an important sport fishery (BDOC 1993). In the Estuary, they are most abundant in areas of slow currents and dead-end sloughs. White catfish, which can live in salinities as high as 11 to 12 ppt, are the only catfish common in Suisun Bay (Moyle 1976). As bottom-feeders, they are known to eat the eggs of other fish species (BDOC 1994).

Population Trends. Based on a 1978-1980 tagging study, the adult (≥ 7 inches) white catfish population was estimated at 3-8 million fish. Although population estimates of adult white catfish have not been made since that study, there is evidence that the abundance of white catfish has declined severely since the mid-1970's. For example, incidental catches of young (≤ 4.5 inches) white catfish in the summer tow-net survey (designed for sampling YOY striped bass) ranged from one to four fish per tow from 1969 to 1975; since 1975, the catch has not exceeded one fish per tow and, in several years, has been less than 0.06 fish per tow (Figure V-24) (DFG 1994b).

Likewise, the fall mid-water trawl survey indicates a general decline in white catfish abundance since the early 1970's before the population rebounded in 1992 (Figure V-25). Furthermore, CVP and SWP fish salvage data show that salvaged white catfish have declined dramatically since the late 1960's. Compared to about 8 million catfish salvaged in 1967, in 1990, 203,000 and 33,000 catfish were caught at the CVP and SWP export facilities, respectively (DFG 1994b).

Causes of Decline. Available evidence indicates that catfish reproduction has been concentrated in the southern and eastern Delta, and that this source of recruitment to the overall population has greatly diminished since the early 1970's (BDOC 1993). It is believed that southern Delta water exports have caused the decline in white catfish abundance for the following reasons: (1) the water project intakes draw water from the key reproductive areas for white catfish; (2) the water projects entrain large numbers of catfish; and (3) screening efficiencies for white catfish are low compared to other fish species. Negative correlations between white catfish abundance and the water exports support the hypothesis that losses of catfish to water exports in the southern Delta have depleted the catfish population (DFG 1992f).

5. Estuarine Fish

A completely estuarine species of fish in the Bay-Delta Estuary is the Delta smelt. All other Bay-Delta fish species maintain at least part of their population outside of the Estuary. Because the longfin smelt, which is similar to the Delta smelt, occurs in the Estuary and rarely outside the Golden Gate, it will be considered here following Delta smelt.

a. **Delta Smelt**. The Delta smelt (*Hypomesus transpacificus*) is a small, short-lived native fish which is found only in the Bay-Delta Estuary. This schooling species inhabits open surface and shoal waters of main river channels and Suisun Bay (DWR 1992a, SFEP 1992a). It was assumed that Delta smelt prefer shallow water; however, a study conducted to

Figure V-24

White Catfish Mean Catch Per Tow

Summer Townet Survey (1969-1992)

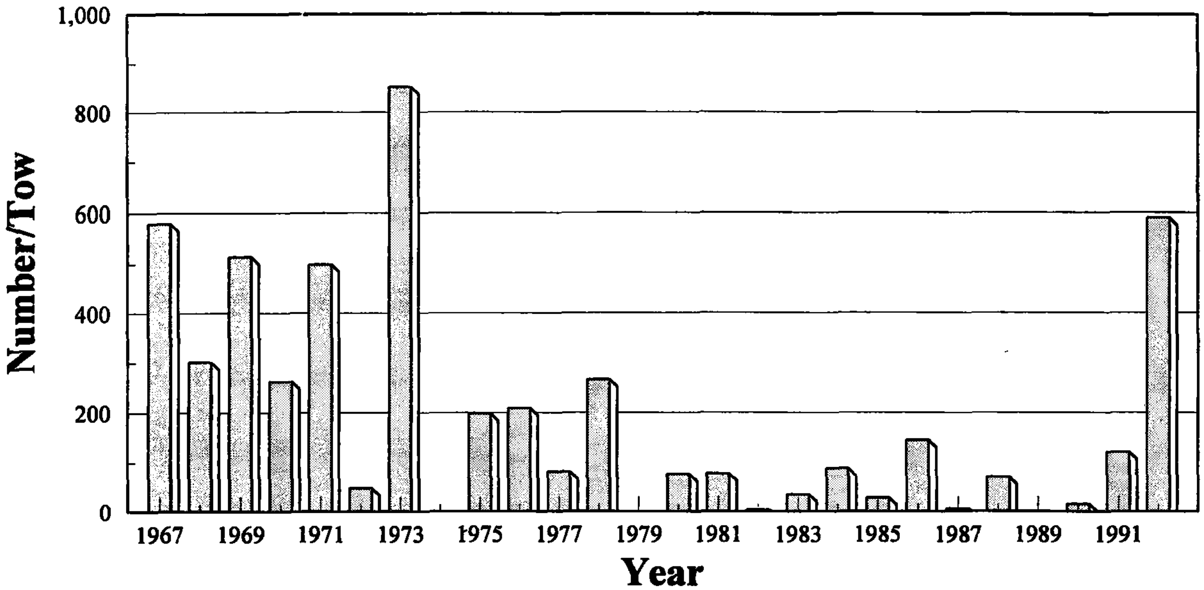
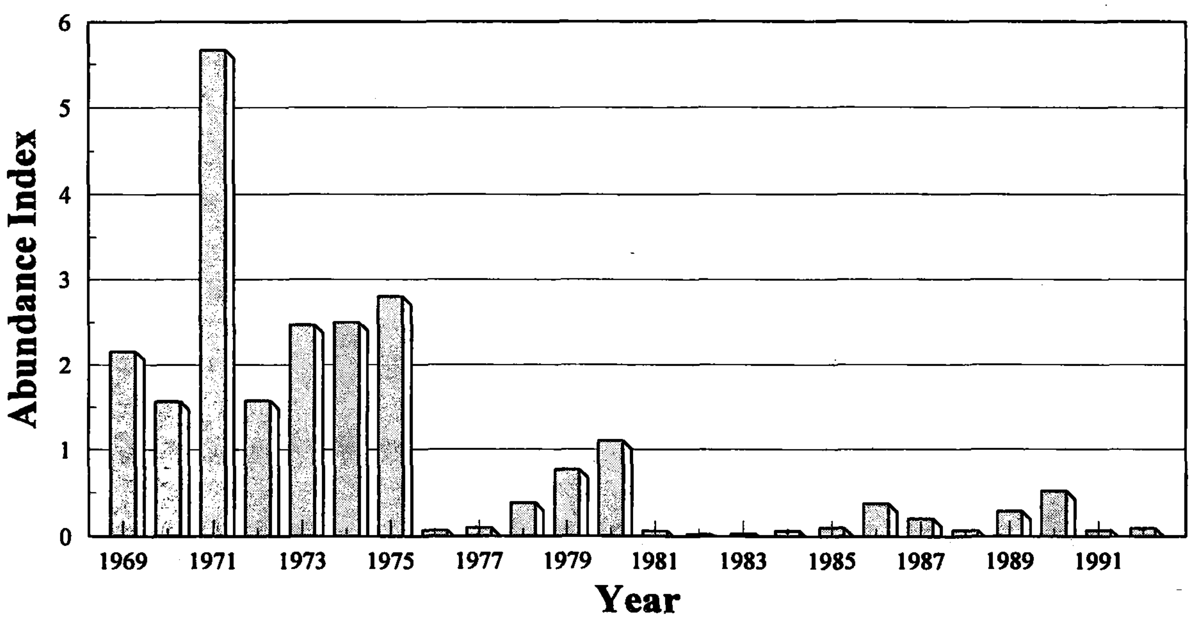


Figure V-25

White Catfish Abundance Indices

Fall Mid-Water Trawl Survey (1967-1992)



determine whether or not this is true was not conclusive. In June 1994, the IEP conducted deep and shallow water sampling in the San Joaquin River, Sacramento River, and Suisun Bay. Delta smelt densities were not significantly different between shallow (less than 10 feet deep) and deep (10-45 feet deep) water areas within the San Joaquin River and Suisun Bay; however, densities were significantly different between shallow and deep water habitats in the lower Sacramento River (Hanson 1994b, DWR 1995b).

Delta smelt have been found as far upstream as Sacramento on the Sacramento River and Mossdale on the San Joaquin River. Their normal downstream limit appears to be western Suisun Bay although, during periods of high outflow, they can be washed into San Pablo and San Francisco bays, but they do not establish permanent populations there (SFEP 1992a). They often inhabit the upper portion of the water column and at salinities ranging from 2-10 ppt (DFG 1992d). Overall, Delta smelt concentrate near or immediately upstream of the low salinity habitat. Their concentration in the low salinity habitat may simply reflect that it is the only remaining area with dense enough populations of their primary prey, copepods (SFEP 1992a).

The Delta smelt has low fecundity and is primarily an annual species, although a few individuals may survive a second year (SFEP 1992a). The location and season of Delta smelt spawning vary from year to year. Spawning, which occurs in shallow fresh or slightly brackish water in or above the low salinity habitat (DFG 1992d, USFWS 1994), has been known to occur at various sites within the Delta, including the lower Sacramento and San Joaquin rivers and Georgiana Slough, and in sloughs of the Suisun Marsh (USFWS 1994). It appears that few Delta smelt spawn in the southern Delta. Based on egg and larval trawls over the last few years, it appears that, at least in low-flow years, a significant portion of Delta smelt spawning now takes place in the northern and western Delta (DWR 1992a).

Spawning may occur from late winter (December) to early summer (July). In 1989 and 1990, peak spawning occurred in late-April and early-May (USFWS 1994). The adhesive eggs descend through the water column and likely attach to submerged substrates such as tree roots, vegetation, and gravel (DFG 1992d). After hatching, the planktonic larvae are transported downstream to the low salinity habitat where they feed on zooplankton (USFWS 1994).

After hatching, many Delta smelt may be transported downstream to the low salinity habitat while many also remain upstream to rear in the channels of the lower Sacramento and San Joaquin rivers. The mid-water trawl results, for the period of 1967-1981, show an average of 37 percent of the Delta smelt were caught in Suisun Bay and 63 percent were caught in the Delta. During the period of 1969-1981, more Delta smelt were caught in the Delta than in Suisun Bay. The summer tow-net index indicated an average of 45 percent of the smelt reared in Suisun Bay, while 55 percent reared in the upstream areas (DWR 1995b).

Population Trends. Seven surveys, although not specifically designed to gather data on Delta smelt populations in the Estuary, have charted the abundance of Delta smelt. The summer tow-net survey, which began in 1959 and was primarily designed to measure striped bass abundance, is considered one of the best measures of Delta smelt abundance because it covers much of the species' habitat and represents the longest historical record. Although the abundance indices vary considerably (Figure V-26), they have generally remained low between 1983 and 1993, although the 1993 index is the highest since 1982 (DWR and USBR 1993). The recent increase may be due to an artifact of the sampling program and recent smelt distribution patterns (NHI 1992a). The reduced population levels during the 1980's appear to have been consistent throughout the Delta and Suisun Bay, but declines may have occurred as early as the mid-1970's in the eastern and southern portions of the Delta (DWR and USBR 1993).

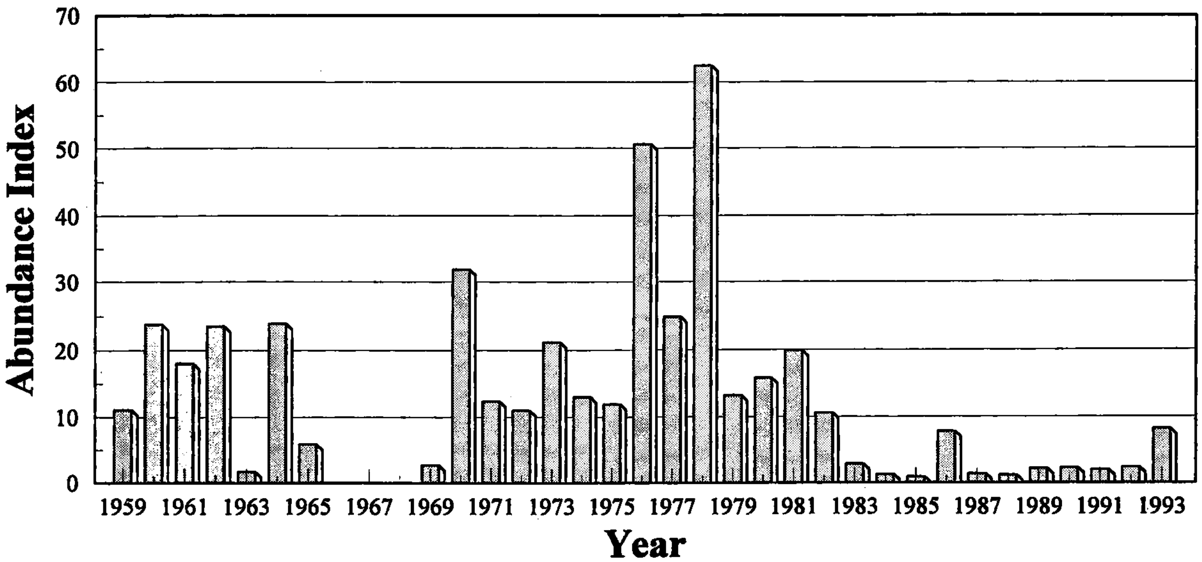
Information from the other six independent data sets have demonstrated a dramatic decline in the Delta smelt population, with particularly low levels since 1983 (DFG 1994b). The fall mid-water trawl survey, which measures relative abundance of adult smelt, yields mean monthly catches of Delta smelt that vary from month to month and from year to year. From 1967 through 1975, fall catches were generally greater than 10 smelt per trawl per month (in 6 of 8 years); from 1976 through 1989, catches were generally less than 10 smelt per trawl per month (in 13 of 14 years). Since 1986, catches have averaged considerably less than one smelt per trawl per month. The frequency of occurrence of Delta smelt in the trawls has also declined. Prior to 1983, Delta smelt were found in 30 percent or more of the fall trawl catches. In 1983-1985, they occurred in less than 30 percent of the catches, and since 1986, they have been caught in less than 10 percent of the trawls (SFEP 1992a). Figure V-27 presents the fall mid-water trawl survey data as abundance indices for adult Delta smelt. Unlike the summer tow-net survey indices, the mean catches of Delta smelt have not declined in the mid-water trawl survey. The smelt population is more dispersed in the summer than in the fall. The summer populations have decreased in average densities while the fall populations have decreased numbers of schools (DFG 1992d). Data from the Bay Study and the Suisun Marsh study show sharp declines in Delta smelt at about the same time. The exact timing of the decline is different in most of the sampling programs but falls between 1982 and 1985 (SFEP 1992a).

As a result of the sharp decline in abundance since the early 1980's, the Delta smelt was listed as a federal threatened species by the USFWS in March 1993 and as a State threatened species by the DFG in December 1993.

Causes of Decline. There are a number of theories that attempt to explain the decline in Delta smelt. Some of the theories have been disputed and still other theories are in the early stages of development. The following section presents the various theories and cites the sources of the information.

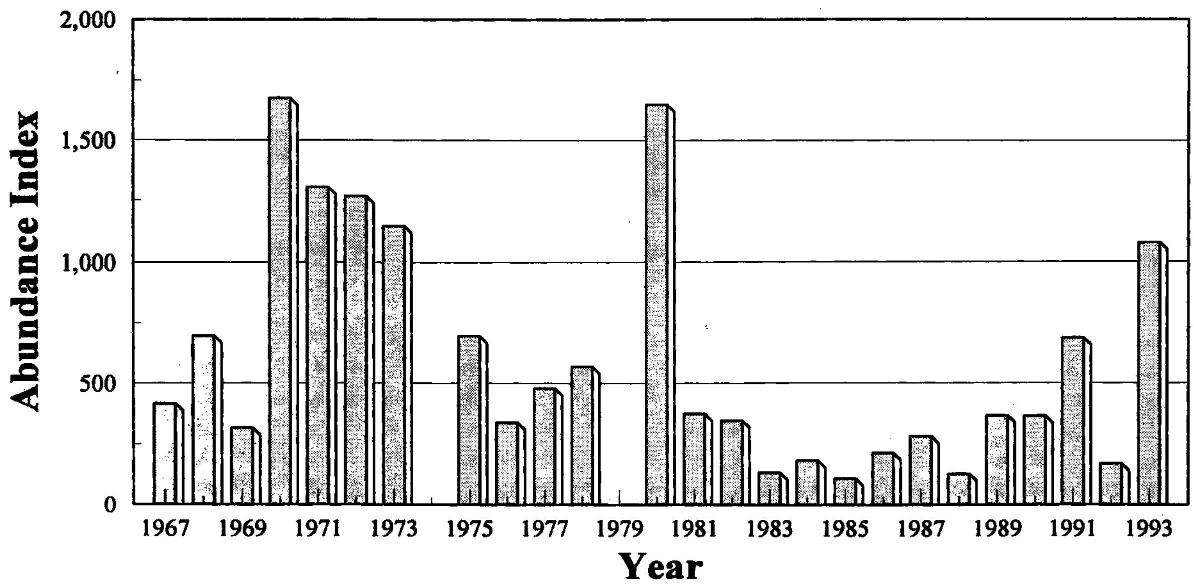
Declines in Delta smelt have been attributed primarily to restricted habitat and increased losses through entrainment by Delta diversions (DWR 1992a, SFEP 1992a, USFWS 1994). Reduced available habitat and increased entrainment occur when the low salinity habitat moves out of the productive shallows of Suisun Bay and into the channels of the lower Sacramento and San Joaquin rivers as a result of low Delta outflow. The theory is that the movement of the low salinity habitat upstream to the river channels decreases the amount of

Figure V-26
Delta Smelt Abundance Indices
Summer Townet Survey (1959-1993)



Note: Not sampled in 1966, 1967, and 1968.

Figure V-27
Delta Smelt Adult Abundance Indices
Fall Mid-Water Trawl Survey (1967-1993)



Note: Not sampled in 1974 and 1979.

area that can be occupied by smelt, and probably results in decreased phytoplankton and zooplankton as well (SFEP 1992a). When the Delta smelt are upstream in the Delta, they are more vulnerable to entrainment by the pumps of the SWP and the CVP, as well as local agricultural diversions (DWR 1992a, NHI 1992a, SFEP 1992a). Diversions in the northern and central Delta, where smelt are most abundant, are likely the greatest source of entrainment (USFWS 1994).

Increasing diversions of fresh water from the Estuary have shifted the location of the low salinity habitat and have altered the flow patterns of the Delta during most months of the year. Prior to 1984, largely before the sharp decline in Delta smelt abundance, the location of the low salinity habitat was generally in Suisun Bay during October through March, except during months with very high outflows or during years of extreme drought; during April through September, the low salinity habitat was mainly in the river channels. Since 1984, the low salinity habitat has been located mainly in the channels of the rivers during all months of the year (SFEP 1992a).

The decline in Delta smelt also coincides with increases in the proportion of water diverted in recent years. Since 1984, the proportion of the water diverted at the export pumps from October through March has been higher, and has stayed higher for longer periods of time than during any previous period, including the severe 1976-1977 drought. Because high levels of diversions draw Sacramento River water across the Delta and into the channels of the San Joaquin River downstream of the pumps, the lower San Joaquin River has a net flow upstream during these periods. The number of days of net reverse flow of the San Joaquin River has consequently increased in recent years, especially during the Delta smelt spawning period. During the months when Delta smelt are spawning, the changed flow patterns resulting from Delta diversions presumably draw larvae into the Delta channels, where they can be exported through the pumps along with locally-produced larvae (Moyle et al. 1992, SFEP 1992a).

The DWR disagrees with the hypothesis that the decline in Delta smelt is coincident with increases in the proportion of water diverted in recent years (DWR 1995b). The DWR argues that although Moyle and Herbold (1989) indicated that low Delta smelt abundance indices (fall mid-water trawl data) were associated with the number of days of negative values of QWEST, there was found no statistical association between Delta smelt abundance and the number of days of reverse flows. Nevertheless, it was observed that years of high smelt abundance usually had positive flow in the lower San Joaquin River and years of low smelt abundance usually had a higher number of days of reverse flows. Moyle and Herbold (1989) concluded that the frequency of reverse flow in the lower San Joaquin River was probably limiting smelt recruitment, but that it was not a simple direct relationship. Furthermore, results of statistical analyses between reverse flows and smelt abundance are confounded by both the inability to measure reverse flows and autocorrelations with other environmental variables.

Moyle et al. (1992) found that, until 1984, water years with 100 days of reverse flow were sporadic and rarely occurred during the Delta smelt spawning season (February-May). From

1985 to 1989, reverse flows have characterized the lower San Joaquin River for more than 150 days of the year and, in every year except 1986, reverse flows have occurred for 15-85 days of the spawning season. This pattern continued in 1990 through 1992. The DWR could not find a statistical relationship between the number of days of reverse flow and the Delta smelt mid-water trawl index (1967-1992) or the tow-net index (1959-1993) (DWR 1995b).

The relationship between Delta outflows and smelt abundance is not a simple one (Moyle et al. 1992). In fact, high outflows, such as those that occurred in February 1986, may have flushed Delta smelt out of the Estuary (SFEP 1992a). Unlike striped bass, longfin smelt, and other species with planktonic larvae, the Delta smelt does not show a strong correlation in abundance with outflows (DWR 1992a, NHI 1992, SFEP 1992a). The substantial annual variation in abundance of smelt probably masks any long-term trends linked to outflows (NHI 1992a). It is believed that February-June Delta outflows are needed to transport larval and juvenile Delta smelt away from the influence of the export pumps and into low salinity, productive rearing habitat in Suisun Bay and Suisun Marsh (USFWS 1994).

Hanson (1994c) conducted an analysis to specifically test the hypothesis that the abundance of adult Delta smelt in the fall is dependent upon geographic distribution of rearing juvenile Delta smelt earlier in the year. The importance of the geographic distribution of Delta smelt during the rearing period has been linked to: (1) the transport and distribution of early lifestages into areas downstream of the Sacramento-San Joaquin confluence; and (2) the importance of habitat within productive shallow-water areas in Suisun Bay. Under these theories, the expected result is increased abundance of sub-adult and adult Delta smelt the following fall. Hanson found no significant relationship between the percentage of juvenile Delta smelt collected downstream of the Sacramento-San Joaquin River confluence and the corresponding fall mid-water trawl abundance index. This finding does not support the theory that distributing larval and juvenile Delta smelt into Suisun Bay will result in a large fall mid-water trawl index.

Other contributing factors in the precipitous decline in the Delta smelt population may be: the presence of toxic compounds in the water (DFG 1992d, SFEP 1992a); displacement of native copepods by introduced species (DFG 1992d, SFEP 1992a); invasion of the Estuary by the Asian clam, *Potamocorbula amurensis* (SFEP 1992a); predation (USFWS 1994); very high outflows; and low spawning stock (DFG 1992d).

Pesticides in the Sacramento River at concentrations potentially harmful to larval fish and zooplankton have been recorded in recent years by the Central Valley RWQCB. Though their effects on the Delta smelt are unknown, these pesticides have occurred at high levels in fresh water prior to the most recent decline of the smelt. However, the concentration of smelt in the low salinity habitat may have allowed them to avoid the effects of pesticides through the dilution of the contaminated fresh water by inflowing seawater (SFEP 1992a).

The 1988 decline of *Eurytemora affinis*, a copepod which has been the primary food supply of Delta smelt, has been identified as a possible factor in the decline of smelt in the Estuary

(DFG 1992d). However, it may be that the decline in *E. affinis* abundance, due to the introduction of other copepod species, is not an important factor because the smelt has shifted its diet and now consumes *Pseudodiaptomus forbesi*, which was introduced into the Estuary in 1986. The clam, *Potamocorbula amurensis*, may have an indirect effect on smelt populations by reducing its food supply (SFEP 1992a, Kimmerer et al. 1994).

Predation by striped bass and other predatory fish which occur at the pumping plants and other diversions which entrain fish has also been named as a possible factor in the decline of Delta smelt (USFWS 1994). However, it is questionable if this is an important factor when both striped bass and Delta smelt were abundant in the 1960's, and the smelt was not a significant prey of the bass (DFG 1992d). It is also possible that predation on Delta smelt larvae by inland silversides, whose introduction and population explosion occurred concurrently with the early declines in Delta smelt abundance, is a contributor to the declines in smelt populations; however, research on the inland silverside in the Estuary is lacking (CUWA 1994).

Spawning stock does not appear to have a major influence on Delta smelt year class success. However, the low fecundity of this species, combined with planktonic larvae which likely have high rates of mortality, requires a large spawning stock if the population is to perpetuate itself. This may not have been an important factor in the decline of Delta smelt, but it may be important for its recovery (DFG 1992d).

b. Longfin Smelt. The longfin smelt (*Spirinchus thaleichthys*) is a small, planktivorous fish that is found in several Pacific coast estuaries from San Francisco Bay to Prince William Sound, Alaska. Until 1963, the population in San Francisco Bay was thought to be a distinct species. Within California, longfin smelt have been reported from Humboldt Bay and the mouth of the Eel River. However, data are infrequently collected from Humboldt Bay, and there are no recent records from the Eel River (SFEP 1992a). In California, the largest longfin smelt reproductive population inhabits the Bay-Delta Estuary (DFG 1992c).

Longfin smelt can tolerate salinities ranging from fresh water to sea water. Spawning occurs in fresh to brackish water over sandy-gravel substrates, rocks, or aquatic vegetation (Meng 1993). In the Bay-Delta Estuary, the longfin smelt life cycle begins with spawning in the lower Sacramento and San Joaquin rivers, the Delta, and freshwater portions of Suisun Bay (SFEP 1992a). Spawning may take place as early as November and extend into June, with the peak spawning period occurring from February to April (Meng 1993). The eggs are adhesive and, after hatching, the larvae are carried downstream by freshwater outflow to nursery areas in the lower Delta and Suisun and San Pablo bays (SFEP 1992a). The principal nursery habitat for larvae are the productive waters of Suisun and San Pablo bays. Adult longfin smelt are found mainly in Suisun, San Pablo, and San Francisco bays, although their distribution is shifted upstream in years of low outflow (Meng 1992).

With the exceptions that both longfin smelt and Delta smelt spawn adhesive eggs in river channels of the eastern Estuary and have larvae that are carried to nursery areas by freshwater outflow, the two species differ substantially. Consistently, a measurable portion of the longfin smelt population survives into a second year (SFEP 1992a). During the second year of life, they inhabit San Francisco Bay and, occasionally, the Gulf of the Farallones; thus, longfin smelt are often considered anadromous. Longfin smelt are also more broadly distributed throughout the Estuary, and are found at higher salinities, than Delta smelt. Because longfin smelt seldom occur in fresh water except to spawn, but are widely dispersed in brackish waters of the Bay, it seems likely that their range formerly extended as far up into the Delta as salt water intruded. The easternmost catch of longfin smelt in the fall mid-water trawl was at Medford Island in the central Delta. They have been caught at all stations of the Bay Study. A pronounced difference between the two species in their region of overlap in Suisun Bay is by depth; longfin smelt are caught more abundantly at deep stations (>10 m), whereas Delta smelt are more abundant at shallow stations (<3 m) (SFEP 1992a).

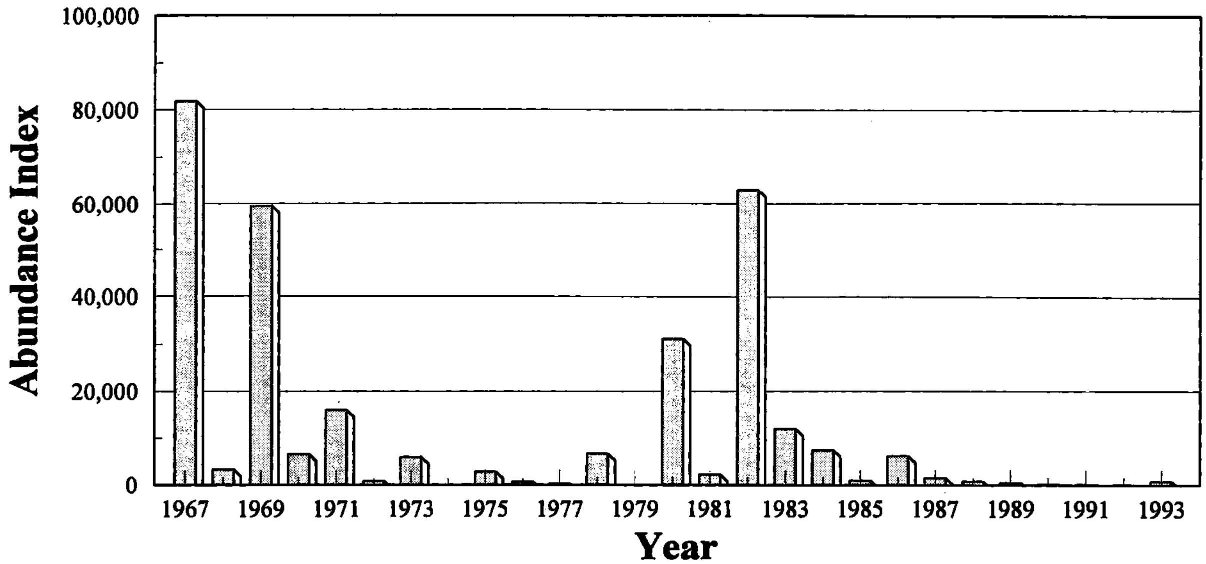
Population Trends. The longest index of longfin smelt abundance in the Estuary comes from the fall mid-water trawl survey which began in 1967. The index represents at least two year classes; however, YOY are usually predominant. Since 1967, the longfin smelt abundance index has fluctuated widely from year to year (Figure V-28). The abundance index was high in 1980, low in 1981, and high again in 1982. Since 1982, when the index was 63,000, the indices have declined precipitously. In 1992, the longfin smelt abundance index was about 14 (DFG 1994b). As recently as 1983, the longfin smelt was one of the most abundant species in San Francisco Bay (NHI 1992b). Yet since 1984, the fall mid-water trawl data indicate a 90 percent decline in the longfin smelt population (Meng 1993).

Data from the Bay Study mid-water and otter trawl sampling effort (Figure V-29), which began in 1980, substantiate the decline detected by the fall mid-water trawl program. These data show that YOY longfin smelt were generally much more abundant during the early- and mid-1980's than from 1987 to 1993 (DFG 1994b).

In both the South and Central bays, a brief dominance by longfin smelt occurred in the mid-water catch in 1983. In San Pablo and Suisun bays, their abundance in 1983 was lower than their abundance in 1982; thus, supporting the idea of washout from upstream. Longfin smelt failed to recover in 1986, nominally a wet year, because record flows in February presumably flushed a high percentage of mature adults out of the Estuary. Unlike Delta smelt, which declined in frequency of occurrence but not in abundance at the stations at which they are still caught, longfin smelt have retained most of their earlier distribution but their catch at each station has declined. Longfin smelt have nearly disappeared from San Pablo Bay (SFEP 1992a).

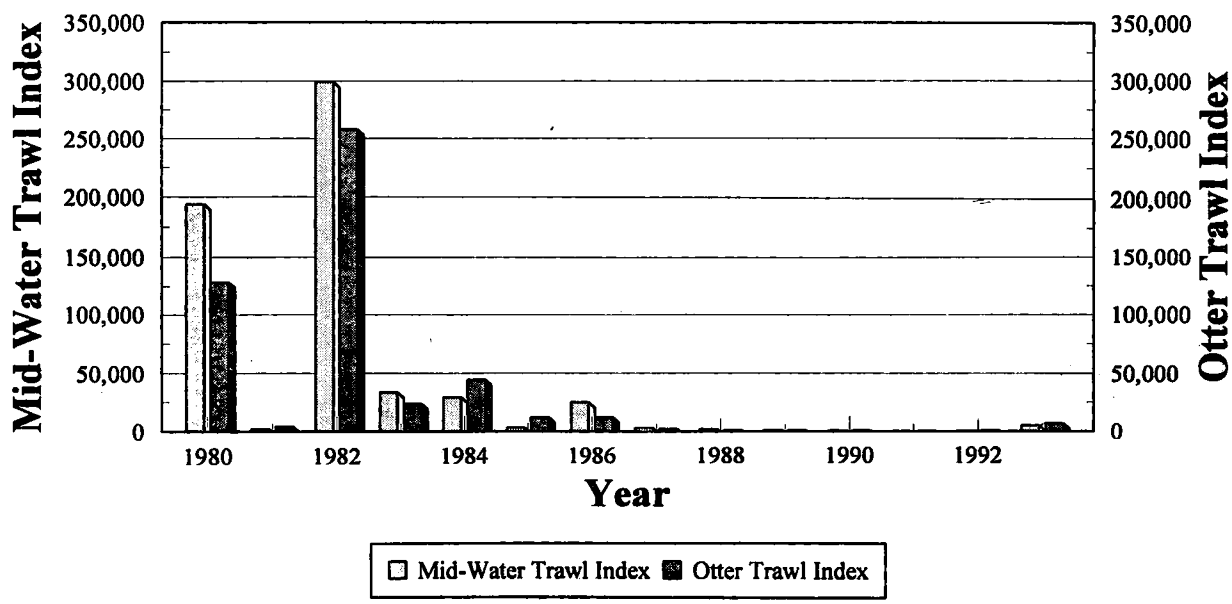
Although longfin smelt populations were known to be affected by freshwater inflow to the Estuary, there has been little concern for their persistence in the Estuary as they have been regarded as abundant and widely distributed, with additional populations in other California estuaries. A recent compilation of fish species of special concern for California (Moyle et al. 1989), for example, does not list longfin smelt (SFEP 1992a). However, the recent dramatic decline in longfin smelt abundance has prompted a petition to the USFWS to list

Figure V-28
Longfin Smelt Abundance Indices
Fall Mid-Water Trawl Survey (1967-1993)



Note: Not sampled in 1974 and 1979.

Figure V-29
Longfin Smelt Young-of-Year Abundance Indices
Otter and Mid-Water Trawl Surveys (1980-1993)



this fish as a threatened species in California (NHI 1992b). The USFWS has determined that listing of the longfin smelt is not warranted at this time because, although the southernmost populations are declining, the species may be surviving and reproducing in numerous other bays and estuaries along the Pacific Coast north of San Francisco Bay. Furthermore, based on current knowledge, the Bay-Delta Estuary population does not seem to be biologically significant to the species as a whole (Federal Register, Vol. 59, No. 4, January 6, 1994).

Causes of Decline. The factor most strongly associated with the recent decline in the abundance of longfin smelt has been the increase in water diverted by the SWP and the CVP during the winter and spring months when the smelt are spawning (NHI 1992a). A major effect of the SWP on longfin smelt appears to be due to entrainment at Clifton Court Forebay (DWR 1992a). The pumping changes the hydrology of the Delta and increases the exposure of larval, juvenile, and adult longfin smelt to predation and entrainment (NHI 1992b). Salvage data indicate that longfin smelt have been more vulnerable to pumping operations since 1984. This increase in vulnerability may be due to the concentration of longfin smelt populations in the upper Estuary, within the zone of influence of the pumps, as a result of reduced Delta outflow. Also, decreases in outflow fail to disperse the larvae downstream to Suisun Bay nursery areas, away from the effects of Delta pumping (Meng 1993).

The abundance index of longfin smelt is closely correlated with total Delta outflow (DFG 1992b, DWR 1992a, Meng 1993). The decline in 1981, a dry year, (for which Delta smelt remained at relatively high numbers) reflects the dependence of longfin smelt on high outflows (SFEP 1992a).

Correlation analyses for almost all combinations of months between December and August indicate significant positive relationships between average monthly flow into the Delta and longfin smelt abundance from the fall mid-water trawl surveys. It was determined that the most critical outflow period for longfin smelt is December through May. Most larvae begin feeding and complete fin development (which facilitates feeding efficiency and predator avoidance), and mortality is likely to be highest, during the February-May period. Estuarine conditions in December and January, prior to downstream movement of young, are also important to survival. A model of longfin smelt abundance for the December-May period shows a positive relationship between Delta outflow and smelt abundance (see Figure VI-6 in Chapter VI) (Randy Baxter, DFG, pers. comm., October 1994; DFG 1992b).

Reduced outflow during the winter may decrease the amount of spawning area in the lower Delta, and changes in spring outflow could alter the transport time for young smelt to reach downstream bays or affect the availability of rearing habitat. It is unclear, however, whether total outflow or short-term peak flows are biologically important during this period (DWR 1992a). Reduced outflow may also affect longfin smelt abundance through increased predation which occurs when water clarity increases and the young are concentrated in small volumes, and, as mentioned above, through increased losses of fish at the CVP and SWP export facilities, as well as in agriculture diversions. Higher outflows likely benefit the longfin smelt by providing increased larval dispersal and volume of nursery habitat, and possibly increase nutrients that form the base of the food chain (DFG 1992b, BDOC 1993).

Like the Sacramento splittail, the strong outflow-abundance relationship for longfin smelt appears to be breaking down, suggesting that factors besides flow are affecting abundance. It is possible that longfin smelt stocks are so depressed that there are not enough spawners to produce a good year class (Meng 1993).

Other factors which affect longfin smelt populations include entrainment into irrigation diversions and power plant cooling systems, predation from introduced species (e.g., striped bass), competition for zooplankton from introduced planktivorous fish and invertebrates, and droughts and floods. However, most of these factors have been operating prior to the recent decline in longfin smelt abundance (NHI 1992b).

6. Marine Fish

Marine fish species can be divided into those that are seasonally present in the Bay-Delta Estuary and those with at least part of their populations in the Estuary year-round. The seasonal species comprise many of the most abundant fish in the bay. Northern anchovy and Pacific herring are the first and second most abundant, respectively, of the seasonal marine fish in the bay. Other species which are found seasonally in the bay include the starry flounder, English sole, and white croaker. Resident marine species, which often fluctuate in abundance in the bay from year to year, include the native shiner perch, bay goby, and staghorn sculpin, and the introduced yellowfin goby and chameleon goby (SFEP 1992a). The Pacific herring and the starry flounder are addressed here as representative marine species.

a. Pacific Herring. The Pacific herring (*Clupea harengus*) is a native, plankton-feeding marine fish that spawns in estuaries (Moyle 1976). Adults enter San Francisco Bay in the fall and generally spawn from November through March. Most of the spawning occurs in intertidal and shallow habitats of the Tiburon Peninsula and Angel Island, although some spawning occurs on aquatic vegetation near Berkeley and Richmond (SFEP 1992a). Pacific herring use San Francisco Bay as a nursery area for approximately 6 to 8 months before migrating to the ocean (DFG 1994b). Smaller young tend to be widely distributed in shallower habitats in South, Central, and San Pablo bays. As they grow, young Pacific herring are found in deeper waters closer to the Golden Gate and leave the bay between April and August (SFEP 1992a). Pacific herring return to the bay as 2- and 3-year olds (DFG 1994b), where they support a large fishery (BDOC 1993).

Population Trends. YOY Pacific herring abundance is estimated from the Bay Study which began in 1980. YOY herring were abundant in the bay in 1980, declined through the 1983 *El Niño* year, increased to high abundance in 1986, then decreased again through the early 1990's (Figure V-30). YOY abundance was particularly low in 1990 (DFG 1994b).

Information regarding the abundance of adult Pacific herring in the bay comes from the estimated spawning biomass (Figure V-31). The spawning population of Pacific herring has been relatively stable, with the exception of a very low spawning biomass associated with the

Figure V-30
Pacific Herring Young-of-Year Abundance Indices
April-September Mid-Water Trawl (1980-1993)

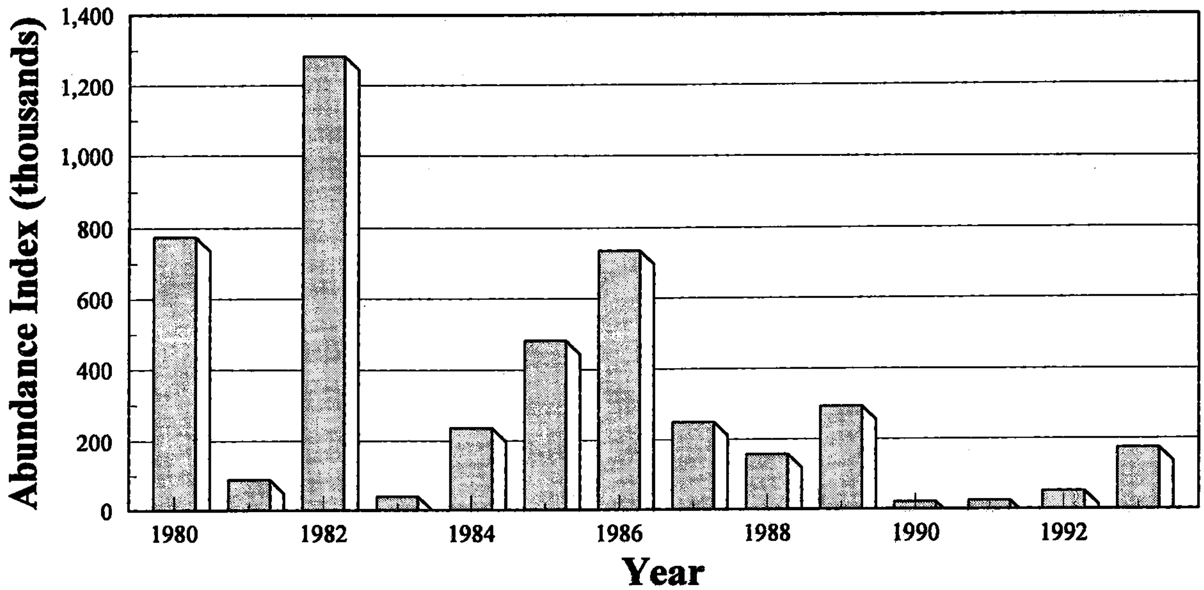
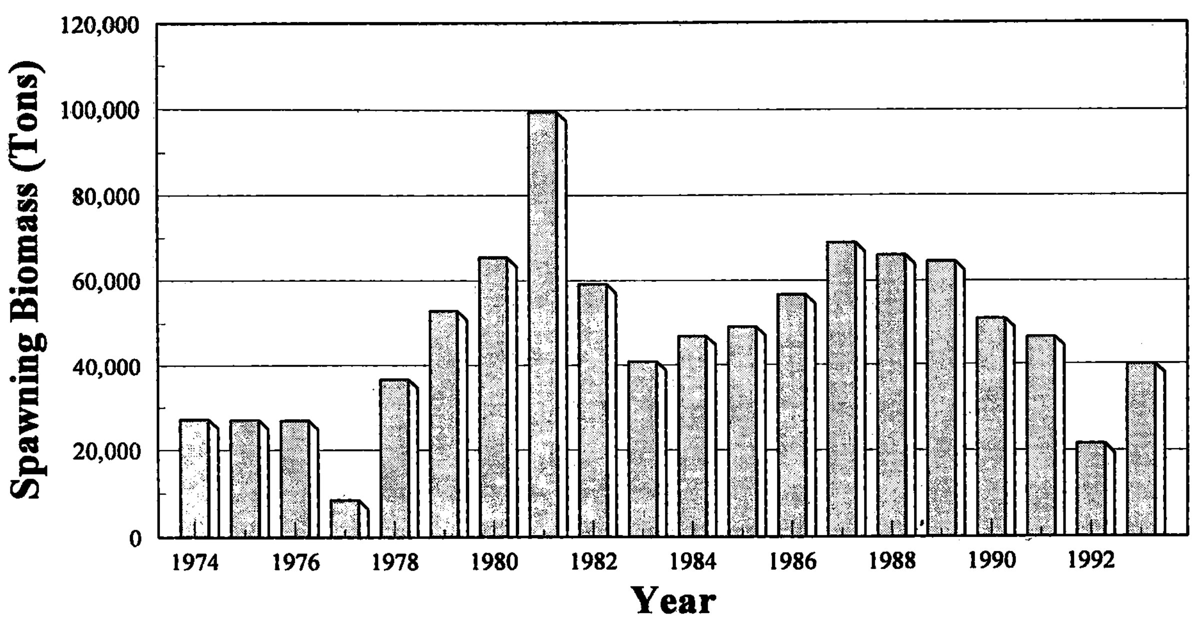


Figure V-31
Pacific Herring Estimated Spawning Biomass
San Francisco Bay (1974-1993)



1977-1978 *El Niño* condition and unusually low abundance in 1992-1993 which reflected poor recruitment from the 1990 and 1991 year classes (DFG 1994b), both critical years.

Causes of Decline. The decline in catch of YOY Pacific herring during 1983 was apparently due, at least in part, to a reduced oceanic herring population in response to reduced productivity during *El Niño* conditions (SFEP 1992a). Overall, the Pacific herring population, which supports a large fishery in San Francisco Bay, has remained relatively stable (BDOC 1993). However, the recent decline in herring biomass in the bay has prompted investigations of possible causes (e.g., increases in salinity due to drought conditions and increases in temperature due to *El Niño* conditions) (IEP 1994c).

b. Starry Flounder. The starry flounder (*Platichthys stellatus*) is a flatfish that feeds on benthic organisms (Moyle 1976). This native fish can be found in the Bay-Delta Estuary throughout the year (SFEP 1992a). Adults inhabit shallow, coastal marine waters, whereas the juveniles appear to be estuarine-dependent and seek out fresh to brackish waters of bays and estuaries as a nursery ground (DFG 1994b). Starry flounder are most abundant and most diverse in sizes in San Pablo Bay, although many young are found in Suisun Bay (SFEP 1992a).

The starry flounder spawn in near-shore areas between November and February. The pelagic eggs and young larvae are found mostly in the upper water column. About two months after hatching, the larvae settle to the bottom (DFG 1992c). Bottom density and tidal currents transport the young into San Francisco Bay (BDOC 1993, Jassby et al. 1994, SFEP 1992a), where they rear for one or more years. As they grow, juveniles move to water of higher salinity within the Estuary. During the late fall and winter, mature starry flounder probably migrate to coast waters to spawn (DFG 1992c).

Population Trends. Because the starry flounder supports a moderately important sport fishery in California (BDOC 1993), the longest historical record of abundance in San Francisco Bay come from charter boat logs. Most of the Estuary's starry flounder catch has occurred in San Pablo and Suisun bays (DFG 1994b). A sharp decline in starry flounder catches, most notably in San Pablo Bay, has occurred since 1983 (SFEP 1992a). Figure V-32 presents the total catch and catch per angler hour data for San Pablo Bay only. In general, catch and catch per hour increased between 1964 and 1971, and decreased to 1964 levels by 1976. In 1976, the total starry flounder catch and catch per hour declined rapidly and, except for a brief period in the mid-1980's, has not recovered to anywhere near previous levels (DFG 1992c).

The Bay Study otter trawl data demonstrate a dramatic decline in YOY and one-year-old starry flounder abundance since sampling began in 1980 (Figure V-33) (DFG 1994b). Such continued low abundances indicate that recruitment to and/or survival of starry flounder in the bay has been very poor for the past five years.

Causes of Decline. Like Delta smelt, longfin smelt, and striped bass, the resident population of starry flounder depends on hydrologic and other environmental conditions in

Figure V-32

Starry Flounder Catch and Catch/Angler-Hour

San Pablo Bay, January to May (1964-1990)

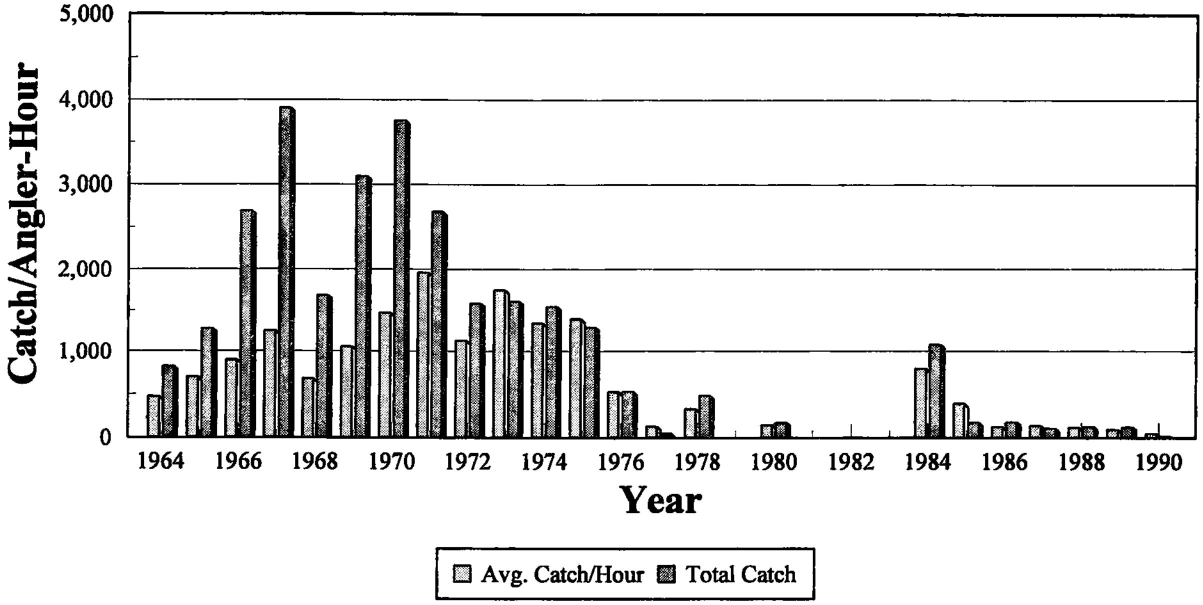
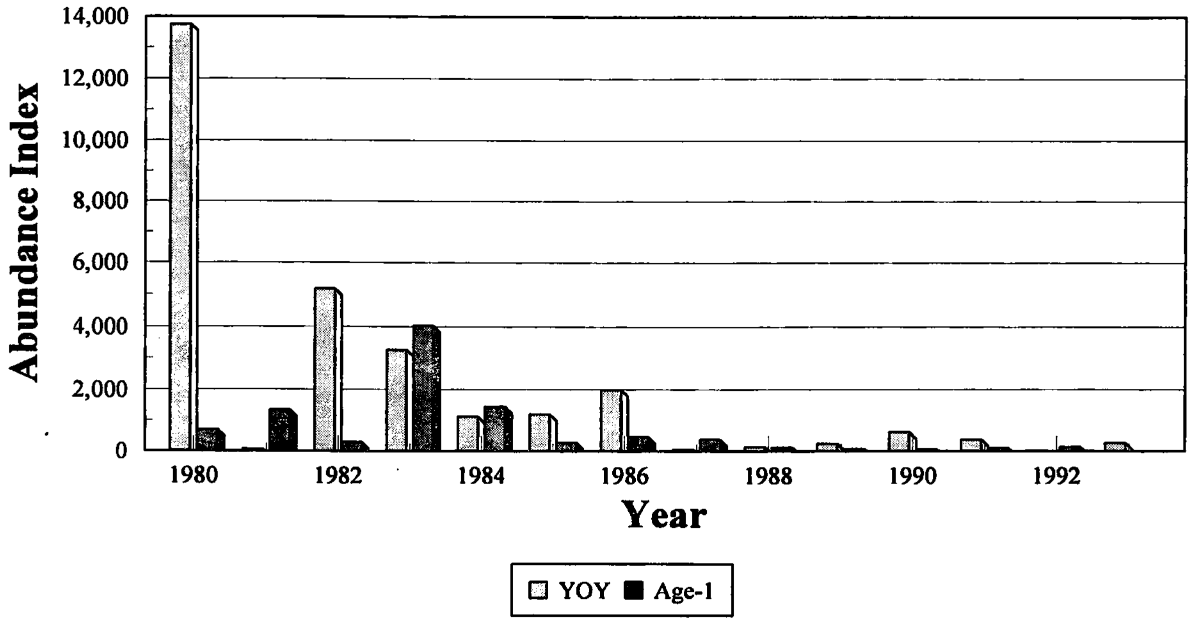


Figure V-33

Starry Flounder Young-of-Year and Age-1

Abundance Indices from Otter Trawl Catches (1980-1991)



San Pablo and Suisun bays (SFEP 1992a). It is probable that reduced Delta outflow during the winter and spring is the principal cause of the long-term decline of starry flounder (BDOC 1993). It is expected that, because bottom currents transport young flounders into the bay, higher net Delta outflows (which strengthens bottom currents) should result in higher abundance of one-year-old fish the following year (Jassby et al. 1994).

The most critical period for starry flounder has been determined to be March through June, when most of the larvae and juvenile immigration occurs. Also, the amount and location of shallow, brackish water nursery habitat for recently settled and small juveniles are most important during this period. The $\log_{10}$ average March-June outflow at Chipps Island and the $\log_{10}$ average 1-year-old starry flounder abundance index the following year have a significant positive relationship (see Figure VI-7 in Chapter VI). Good recruitment of larvae to nearshore areas is possible during both high and low outflow years, but poor recruitment only occurs when outflow is low (DFG 1992c). This indicates that starry flounder abundance in the bay probably also depends on ocean conditions, as well as other lesser known factors.

Although young starry flounder can be found upstream of Suisun Bay, especially in years of low flow, their overall distribution is such that diversion plays a minor role, if any, in their variability (Jassby et al. 1994). The decline in starry flounder abundance in Suisun Bay principally reflects a reduced production of young. Although the even sharper decline in the abundance of San Pablo Bay flounders is not explained, the concentrations of organic contaminants (e.g., PCBs) in adult starry flounder from San Pablo Bay have been shown to be sufficient to reduce reproductive success. Also, the decline of the San Pablo Bay starry flounder population coincides with increased presence of English sole, another bottom-foraging flatfish that spawns outside the Golden Gate and immigrates into the bay with bottom currents. Although the starry flounder is present in the Estuary year-round and the English sole is found seasonally, biotic interactions between the two species may be occurring (SFEP 1992a).

7. Anadromous Fish

Anadromous fish are those which migrate from the ocean to fresh water to spawn. Anadromous fish that spawn in the Sacramento and San Joaquin river basins use the Bay-Delta Estuary as a route of passage to the spawning grounds and, in some cases, as a nursery area. Native anadromous species that may be found in the Estuary include chinook salmon, steelhead trout, white sturgeon, and green sturgeon. The anadromous striped bass and American shad are introduced species in the Estuary (SFEP 1992a).

a. Chinook Salmon. The chinook salmon (*Onchorhynchus tshawytscha*), also called king salmon, is the largest and has the broadest geographic range of the five Pacific salmon species. In spite of its wide distribution, the chinook salmon is the least abundant of Pacific salmon species, yet it is an important recreational and commercial species throughout most of its range. In San Francisco Bay, the chinook salmon population is open only to sport fishing. Populations of this native, anadromous species, which is distinguished by its highly variable life history and multiple stocks, are maintained to a large extent by hatchery production (DWR 1993, SFEP 1992a).

Chinook salmon migrate to the ocean early in their life, mature in the ocean, and return inland as adults to spawn in freshwater streams (SFEP 1992a). Acceptable water temperatures for the upstream migration of adults range from 57°F to 67°F. Spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs where there is an abundance of loose gravel. The females dig spawning redds in the gravel into which their eggs are deposited and buried after fertilization by the male. The adults die a few days after spawning (DFG 1993).

Spawning requires well-oxygenated cool water that percolates through the gravel and supplies oxygen to developing embryos. The preferred temperature for chinook salmon spawning is generally 52°F, with lower and upper threshold temperatures of 42°F and 56°F. Temperatures above this range result in reduced viability of eggs or heavy mortality of developing juveniles. Total egg mortality normally occurs at 62°F. The eggs usually hatch in 40-60 days, depending on water temperature within the appropriate temperature range. The young sac-fry remain in the gravel for an additional 4-6 weeks until the yolk sac is absorbed. Thus, at 50°F, the total time from spawning to emergence is approximately 79 days. After emergence, chinook salmon fry feed in low velocity slack water and back eddies. They move to higher velocity areas as they grow larger and, eventually, migrate to the ocean as smolts. The length of rearing and migration timing varies among the various chinook salmon runs. Young salmon remain in the ocean until their third or fourth year, at which time they return to their home stream to spawn. Two- and 5-year-old fish also participate in the spawning run in small numbers (DFG 1993).

The Central Valley supports the largest population of chinook salmon in the State (SFEP 1992a). The Bay-Delta Estuary serves as a migratory corridor for upmigrating adults and outmigrating smolts, and serves as rearing habitat for salmon fry. Four distinct races of chinook salmon, distinguished by their timing of upstream migration and spawning season, enter the Estuary. Named for the season during which the adults enter fresh water, the four runs of chinook salmon are: fall-run, late-fall-run, winter-run, and spring-run.

All four races of chinook salmon spawn in the upper Sacramento River. Fall-run chinook salmon usually spawn within a few weeks of their arrival in the fall. Late-fall-run chinook salmon spawn in the winter. Spring-run chinook salmon spend the summer in deep, cool pools and spawn in early fall. Winter-run fish enter the river in the winter and spawn early the following summer. The San Joaquin River system supports fall-run, and possibly a small population of late-fall-run, chinook salmon. The fall runs of the Sacramento and San Joaquin river systems may be genetically distinct and may constitute separate races (DFG 1993). All of the runs are supplemented to some degree by hatchery production; however, the fall- and late-fall-run chinook salmon populations are principally augmented by hatchery production (DFG 1993, SFEP 1992a).

Adult fall-run chinook salmon migrate into the river systems from July through December, and spawn from early October through late December. Peak spawning occurs in October and November, although timing of the runs varies from stream to stream. Egg incubation occurs from October through March, and juvenile rearing and smolt emigration occur from January through June. Although the majority of young salmon migrate to the ocean during the first few months following emergence, a small number may remain in fresh water and migrate as yearlings (DFG 1993).

Adult late-fall-run chinook salmon migrate into the Sacramento and San Joaquin rivers from mid-October through mid-April, overlapping the mid-October through December fall-run salmon spawning migration. Late-fall-run salmon spawn from January through mid-April. Incubation occurs from January through June, and rearing and emigrations of fry and smolts occur from April through mid-October. Significant emigration of naturally-produced juveniles occurs through November, into December, and possibly January. Emigration of hatchery-produced juveniles occurs well into February (DFG 1993).

Adult winter-run salmon enter the Estuary from about November through May, and pass the Red Bluff Diversion Dam on the upper Sacramento River from December through early August. Historically, winter-run chinook salmon spawned from April through August in the upper reaches of Sacramento River tributaries, including the McCloud, Pit, and Little Sacramento rivers, and Battle Creek. Now, winter-run salmon spawn in the main stem of the Sacramento River below Keswick Dam from mid-April through August, when water storage project releases provide cool water temperatures. Egg and larval incubation occurs from mid-April through mid-October. Emigration of fry and smolts extends from July through March at Red Bluff Diversion Dam, and from September through June in the Delta (DFG 1993), but peak emigration extends from late-January through April (DFG 1994a).

Adult spring-run chinook salmon enter the Sacramento River from late-March through September. Many early arriving adults hold in cool water habitats through the summer, then spawn in the fall. Spawning occurs from mid-August through early-October, with the peak in September, overlapping with the fall-run in the main stem Sacramento River in early-October. Incubation occurs from mid-August through mid-March. Rearing and emigration of fry and smolts begin in late-November and continue through April. A significant migration of yearlings from the upper tributaries also occurs in September through December. It is likely that some individual spring-run salmon have interbred with fall-run salmon in the main stem Sacramento River and the Feather River. A genetically uncontaminated strain of spring-run chinook salmon may still exist in Deer and Mill creeks, where they are geographically separated from the fall run. Spring-run salmon are also present in Antelope, Battle, Cottonwood, Big Chico, and Butte creeks (DFG 1993).

Chinook salmon originally spawned throughout the tributaries or upper reaches of the Sacramento and San Joaquin river basins. However, dams have reduced the amount of historic river and spawning habitat available to chinook salmon by 95 percent (from about 6,000 miles to less than 300 miles). As a consequence, in both the Sacramento and San Joaquin river basins, some runs of chinook salmon have been almost totally eliminated.

About half of the potential spawning habitat in the Sacramento River basin was blocked by construction of Shasta Dam in 1942, which prevented access of enormous runs of salmon to the upper Sacramento, Pit, and McCloud rivers. Unfortunately, only sparse or incomplete population estimates are available for years prior to 1953 (DFG 1993). The construction of Red Bluff Diversion Dam in 1966 later reduced access to spawning areas below Shasta Dam. Completion of Folsom and Nimbus dams in 1955 blocked access to the historical spawning and rearing habitat on the American River. By 1965, Oroville Dam and other facilities prevented most salmon, including the wild spring-run, from reaching historic spawning grounds on the Feather River. A population of spring-run chinook salmon in the San Joaquin River was lost when Friant Dam, completed in 1949, dried up sections of the river. Friant Dam blocked access and totally eliminated salmon from the main stem and upper tributaries. Dams on the Merced, Tuolumne, and Stanislaus rivers, the major downstream tributaries to the San Joaquin River, have reduced access to chinook salmon habitat. In addition, numerous other projects have been constructed that directly or indirectly affected salmon habitat (DFG 1993, SFEP 1992a).

Four hatcheries (Mokelumne River, Nimbus, Feather River, and Coleman) were constructed in the Sacramento River basin to mitigate for habitat loss as a result of water project construction (DFG 1993). Since the early 1970's, juvenile chinook salmon produced at these hatcheries have augmented natural salmon populations (BDOC 1993). A small hatchery on the Merced River is the only mitigation for upstream salmon habitat losses in the San Joaquin River basin (DFG 1993, SFEP 1992a).

Population Trends. Historical chinook salmon abundance in the Bay-Delta Estuary prompted massive fishing efforts and the opening of the world's first salmon cannery in 1864 (SFEP 1992a). Based on commercial harvest data, it is estimated that, prior to 1915, peak chinook salmon runs in the Sacramento River system may have been as large as 800,000 to 1 million fish, with an average run size of about 600,000 fish (DFG 1993).

Chinook salmon production in the San Joaquin River system historically approached 300,000 adults and probably averaged about 150,000 fish. Large runs of salmon in the San Joaquin River during the 1940's were predominantly spring-run fish until this run was extirpated after the construction of Friant Dam. The San Joaquin River system now supports an important population of fall-run chinook salmon which is only a remnant of its former size (DFG 1993).

Since 1953, annual estimates of spawning chinook salmon in the major river systems of the Estuary have been made. These are estimates of spawning "escapement" since they describe the numbers of chinook salmon, from both natural and hatchery production, that have escaped the ocean fisheries and returned inland to spawn (DFG 1994b). Although chinook salmon escapement in the San Joaquin River system has been monitored since 1939, these data are sparse or incomplete prior to 1953. Since 1967, following completion of the Red Bluff Diversion Dam in 1966, accurate estimates of all salmon runs to the upper Sacramento River have been possible (DFG 1993).

Since the regular counts of chinook salmon abundance began in 1953, the spawning runs from all river systems have fluctuated greatly. Total runs decreased from over 600,000 in 1953 to 120,000 in 1957, then up to almost 500,000 by 1960 (DFG 1994b). In the last 20 years, the total runs have averaged about 250,000 to 300,000 fish (BDOC 1993). From 1967 to 1991, total escapement averaged 247,100 natural spawners and 28,500 hatchery spawners (DFG 1994b).

Most estimates of chinook salmon abundance indicate that most runs have been severely reduced compared to the 1967-1991 average (DFG 1994b). Wild stocks of chinook salmon have suffered very large declines in the Central Valley (SFEP 1992a). The stream systems that are supported by effective hatchery programs, such as the Feather and American rivers, have maintained adequate populations. Fall-run salmon are presently the most abundant of the four races. Approximately 80 percent of the Central Valley chinook salmon spawners are fall-run fish. About 90 percent of the Central Valley chinook salmon are produced in the Sacramento River basin. The chinook salmon runs of greatest concern are the winter-run, spring-run, and San Joaquin River basin fall-run (DFG 1994b).

Fall-Run. The fall-run comprised an average of 83 percent of all chinook salmon spawning stocks in the Central Valley from 1986-1990. The fall-run is the largest run of chinook salmon in the Sacramento River with an average spawning population of 108,000 fish since 1980. This exceeds the combined total of the other three runs and is the mainstay for the ocean commercial and recreational troll fishery (USBR 1994). An estimated 107,300 adult fall-run chinook salmon returned to the Sacramento River basin in 1992, and an estimated 147,500 returned in 1993. These recent estimates are 53 percent and 73 percent, respectively, of the average escapement of 201,100 from 1967-1991. In comparison, the 1985 and 1986 spawning escapements for the Sacramento River basin, including the Feather, Yuba, and American rivers, were 295,200 and 274,000 adults, respectively (DFG 1994b). Figure V-34 shows the annual estimated run sizes for fall-run chinook salmon, only for the upper Sacramento River above Red Bluff Diversion Dam.

The fall-run of chinook salmon in the San Joaquin River system spawn in the tributary streams; no spawning occurs on the main stem of the San Joaquin River. The fall-run populations in the Merced, Tuolumne, and Stanislaus river tributaries are now at dangerously low levels (Figure V-35). Since annual population surveys began in 1953, fall-run chinook salmon escapement in the San Joaquin River basin has fluctuated widely. In 1985, the escapement was estimated to be 76,100 (BDOC 1993). The 1991 estimate of 620 fall-run chinook salmon was the lowest escapement recently; an escapement of 320 in 1963 was the lowest ever observed in the San Joaquin River basin (USFWS 1992). The 1992 and 1993 escapements were estimated to be about 2,000 and 3,200 fish, respectively. These recent returns are much lower than the average of 20,700 adults for the 1967-1991 period (DFG 1994b).

Figure V-35 also shows estimated chinook salmon run sizes for the San Joaquin River for several years prior to the construction of Friant Dam in 1949. These fish represent the spring-run salmon that were entirely eliminated when the dam dried up parts of the river.

Figure V-34

Sacramento River Basin

Annual Estimated Chinook Salmon Run Size Above Red Bluff Diversion Dam (1967-1993)

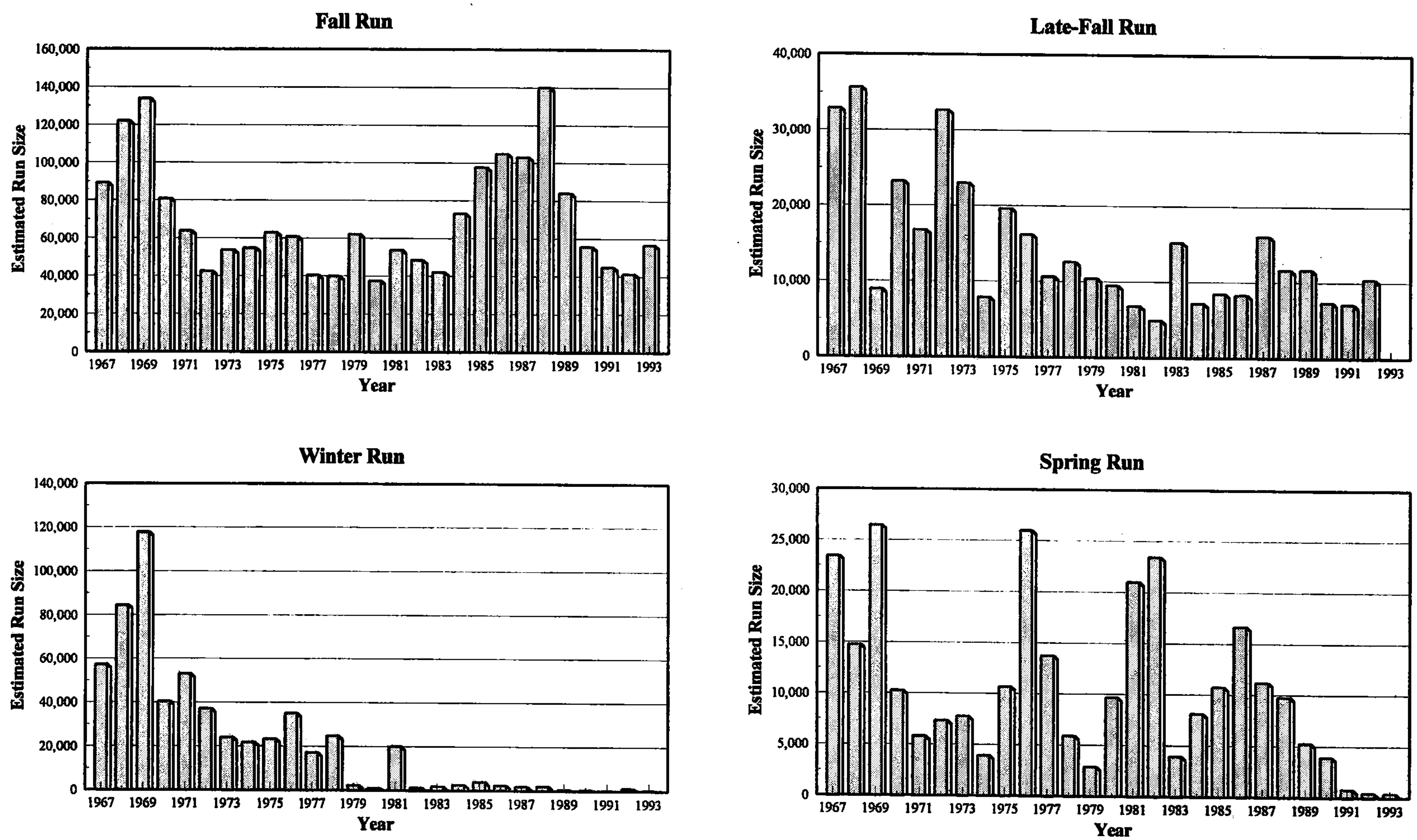
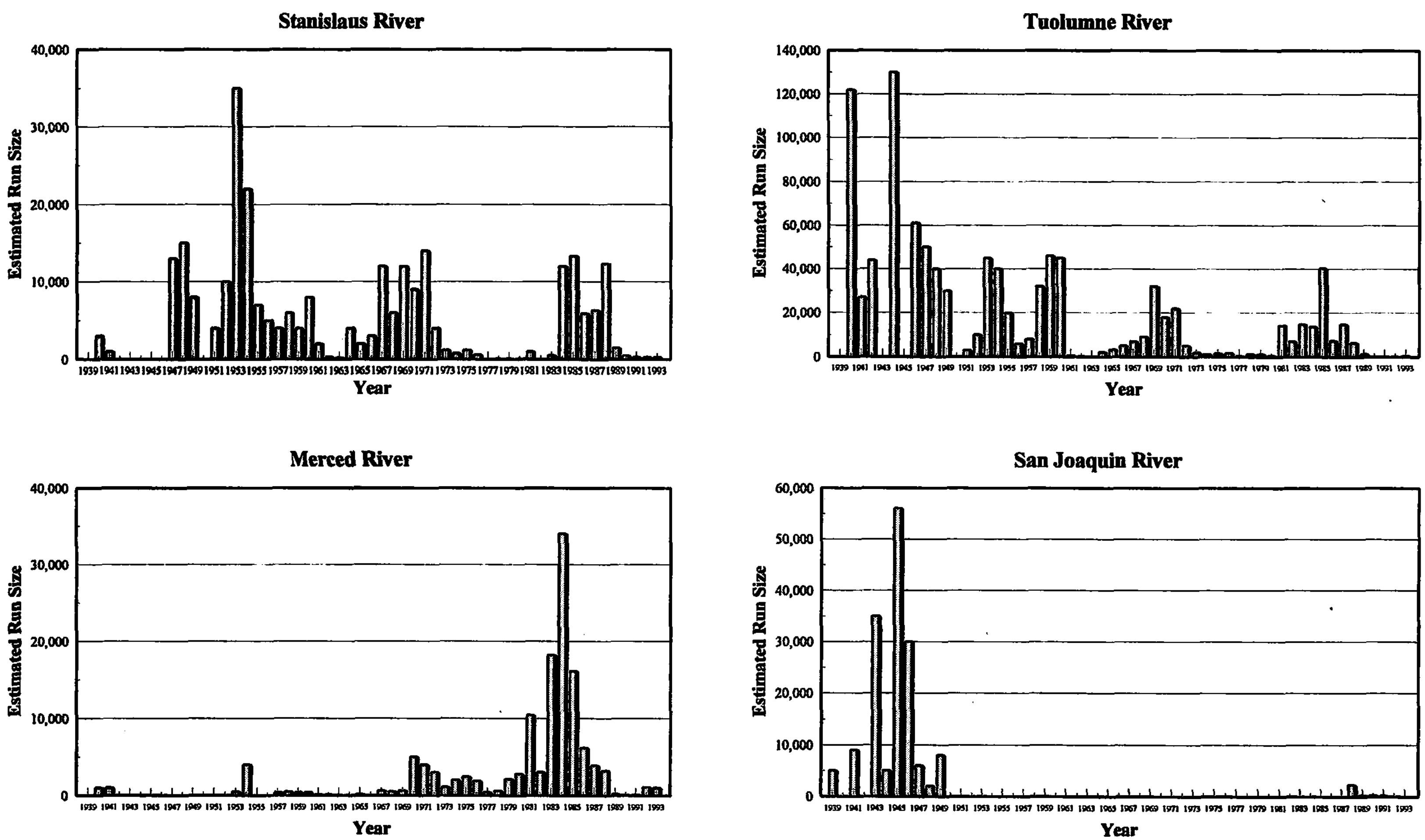


Figure V-35
San Joaquin River Basin
Annual Estimated Chinook Salmon Run Size (1939-1993)



The small populations that appear from 1988 to 1991 represent fall-run chinook salmon that strayed into Mud and Salt sloughs, tributary to the San Joaquin River, during the drought when flows in the lower tributaries were low. In the fall of 1992, a temporary fish barrier was installed across the San Joaquin River just upstream of the confluence with the Merced River and below the confluence with the sloughs to prevent salmon from straying into westside canals (DFG 1993).

Late-Fall-Run. Recent escapements of late-fall-run chinook salmon in the Sacramento River basin are below the average 14,100 late-fall escapements from 1967-1991. In 1991, an estimated 8,600 late-fall spawners returned to the upper Sacramento River and, in 1992, the estimate was 10,400 fish (Figure V-34). Operation of the Red Bluff Diversion Dam, in response to the NMFS biological opinion on the endangered winter-run chinook salmon, precludes estimating late-fall run chinook salmon escapement after 1992, until a new estimation method is developed (DFG 1994b).

Although a small population of late-fall-run chinook salmon spawns in the San Joaquin River basin, there have not been formal inventories of this stock (DFG 1994b).

Winter-Run. The Sacramento River has the only remaining winter-run chinook salmon population in the world. When completion of Shasta and Keswick dams in the early 1940's blocked access to the upper Sacramento tributary streams, the population began declining but recovered dramatically during the 1940's and 1950's, apparently by taking advantage of cool water released from the reservoirs in the summer (DFG 1993). Since estimates of winter-run salmon escapement began in 1967, the numbers of adults have steadily declined from about 118,000 fish in 1969, to an estimated 1,200 fish in 1992 and 300 fish in 1993 (Figure V-34). The average escapement from 1967 to 1991 was 23,100 winter-run chinook (DFG 1994b). The winter-run salmon returning in 1994 are the progeny of the 1991 run which was the lowest on record (191) (DFG 1994a).

The NMFS believes the sizes of the winter-run are dangerously low because it has been estimated that a run size of 400 to 1,000 fish is necessary to maintain genetic diversity in the winter-run salmon population (DFG 1994a). The State listed the winter-run chinook salmon as endangered in 1989; the NMFS listed the winter-run chinook salmon as threatened in November 1990 and endangered in 1994 (NMFS 1993). Although conservation measures have been implemented since 1987, specifically to improve habitat conditions for the winter-run, the population has continued to decline precipitously (USBR 1994).

Spring-Run. Spring-run chinook salmon were, perhaps, historically the most abundant run in the Central Valley (DFG 1993). Run sizes have varied greatly since the early 1970's (Figure V-34), averaging around 13,000 fish annually from 1967-1991. In 1992, fewer than 1,200 spring-run salmon used the Sacramento River basin. The escapement in 1993 was estimated to be 1,400 fish (DFG 1994b). Present wild spring-run salmon populations are less than 0.5 percent of the historic runs. Because of their continuing decline, the spring-run chinook salmon may be considered as a candidate for listing as an endangered species (NHI 1992a).

Causes of Declines. The loss of 95 percent of historical habitat for chinook salmon due to dams and habitat degradation has been a significant cause in the decline of salmon populations in the Central Valley. Salmon habitat loss and degradation began with hydraulic mining in the mid-1800's. By 1929, declines in the abundant spring- and fall-run chinook salmon populations in the upper Sacramento River were noted. These declines were thought to have resulted from overharvest, blockage by irrigation dams, and habitat degradation through activities such as reclamation, flood control, and logging. This period of severe loss and degradation of salmon habitat culminated with the completion of the major water project developments in the 1970's (DFG 1993).

Much of the area in which fall-run chinook salmon historically spawned was downstream from the major dam sites; therefore, this race was not as severely affected by early water project developments as were spring- and winter-run salmon, which historically spawned at higher elevations. The construction of dams that barred migration of adult spawners to upstream areas also created higher water temperatures and altered stream flows. This situation resulted in the elimination of spring-run chinook salmon in the San Joaquin River system and most other Central Valley tributaries (DFG 1993). The runs currently of greatest concern are winter-run, spring-run, and the San Joaquin River fall-run, due to low escapements and future low projections, based on population trends (DFG 1994b).

There are a number of factors in the upstream areas that affect the number of naturally-produced chinook salmon each year. These include spawning habitat access, availability and condition of habitat, water quality conditions including temperature and pollution, flow fluctuations, water diversion entrainment, and high predation rates. Survival through the Delta is critical, especially for the naturally-produced salmon and those hatchery fish released in the upstream areas. Factors which influence survival in the Delta include temperature and entrainment. The relative importance of such factors to chinook salmon survival and production varies between the Sacramento and San Joaquin river basins, and among the various salmon runs.

San Joaquin River Basin. The San Joaquin River system supports an important population of fall-run chinook salmon, which is now only a remnant of its former size. Spawning populations and production vary widely from year to year, depending upon the timing and magnitude of flows available for upstream migration, spawning, rearing, and emigration. San Joaquin River basin salmon populations also can be severely affected by pumping operations in the Delta, which may capture all of the San Joaquin River outflow (DFG 1993). Cumulative effects of prolonged drought, poor water quality, habitat deterioration, water diversion, and ocean harvest have caused greatly reduced population levels of fall-run populations in the Merced, Tuolumne, and Stanislaus river tributaries. However, low population levels occurred historically and the population rebounded in the 1980's, in association with high flows (DWR 1993).

Streamflow releases below Friant Dam are insufficient to support salmon passage, spawning, or rearing in the San Joaquin River. The dam also damaged runs to the San Joaquin River tributaries by significantly reducing total basin outflow. The reduction in fall attraction flows and spring outflows on the main stem San Joaquin River significantly reduced adult returns, and reduced production and survival of salmon throughout the system. Since Friant Dam went into operation, low spring outflows from the basin, in most years, have been a major factor contributing to low salmon production (DFG 1993).

San Joaquin River basin emigrating smolt losses can be attributed to high water temperatures, low flows, high predation losses, unscreened water diversions, and SWP and CVP diversions. Elevated water temperatures during the spring emigration period (April-June) probably reduce smolt survival in the main stem of the river and tributaries. Typical flow and water quality conditions in the Delta are detrimental to the survival of San Joaquin salmon smolts due to low inflow from the San Joaquin River and high exports by Delta water diversions. Survival of smolts migrating down the main stem San Joaquin River is higher than the survival of smolts migrating down upper Old River toward the export pumps (DFG 1993).

Chinook salmon fry and smolt losses occur at the CVP and SWP export pumps year-round, but peak levels generally occur in late winter and spring, when the most abundant salmon race, the fall-run, passes through the Delta (DWR 1992a). The proportion of outmigrants from the San Joaquin River system that show up at the CVP and SWP intakes is greater (20-70 percent) than the proportion of Sacramento River system outmigrants that show up at the intakes (2 percent) (BDOC 1993). Peak chinook salmon losses due to SWP pumping from 1980 to 1987 occurred in April-June. The majority of SWP salmon losses have been attributed to predation by striped bass in Clifton Court Forebay. Other factors associated with the water projects, such as screen efficiencies and salvage operations, also influence salmon survival (DWR 1992a).

The upstream migration of adult salmon into the San Joaquin River basin is probably delayed due to the lack of attraction flow, elevated water temperatures, and low dissolved oxygen levels, which commonly occur in the San Joaquin River in the fall. Increases in agricultural return flows in recent years, such as in Mud and Salt sloughs, have attracted significant numbers of adults salmon into sloughs and irrigation canals, where there is no suitable spawning habitat available. In the fall of 1991, an estimated 35 percent of the San Joaquin River basin salmon strayed into westside canals. Installation of a temporary fish barrier in the fall, which began in 1992, has prevented salmon straying into the westside irrigation canals and sloughs (DFG 1993). Beginning in 1995, from October through December, a fish barrier will be installed annually for 15 years on the San Joaquin River near its confluence with the Merced River to prevent the salmon from migrating upstream and into the irrigation canals and sloughs (Steve Ford, DWR, pers. comm., April 1995).

Water temperature and dissolved oxygen can vary considerably according to stream flow, water depth, and water quality. Adults migrating up the San Joaquin River in September through December must deal with warm water temperatures, which can range in the mid-70's°F in September and October, and extremely low dissolved oxygen levels. Low dissolved oxygen levels are a result of reduced flow, warm water temperatures, dredging activities in the Stockton Ship Channel and turning basin, and effluent discharges. A temporary barrier is installed each fall by the DWR at the head of Old River to improve water quality and help adult salmon migration in the lower reaches of the San Joaquin River (DFG 1993, DWR 1993).

Minimum flows in the San Joaquin River at Vernalis during the spring outmigration would improve salmon smolt survival into and through the Delta (BDOC 1993, DFG 1993). When spring outflow in the San Joaquin River at Vernalis is high, the total adult salmon escapement in the San Joaquin River basin 2.5 years later is increased (DFG 1993). Increased flows in the fall would also benefit upmigrating adults by providing attraction flow, lower water temperatures, and higher dissolved oxygen levels. Figure VI-11 in Chapter VI, shows the relationship between water temperature at Jersey Point, San Joaquin River flow, and exports.

Sacramento River Basin. Conditions in the Estuary, impacting Sacramento River basin chinook salmon, affect primarily the emigrating smolts rather than the immigrating adults. Current understanding of smolt survival in the Sacramento River and through the Delta is based primarily on studies using hatchery-reared fall-run chinook salmon (IEP 1994a). Based on the habitat requirements of fall-run chinook salmon and the USFWS salmon smolt survival model, water temperatures and diversions, rather than flow, are the principal factors affecting salmon smolt survival in the Delta (BDOC 1993). Factors found to affect smolt survival during the fall-run outmigration include water temperature, SWP and CVP export rates, percent of flow diverted into the central Delta via the Delta Cross Channel gates and Georgiana Slough (which have the combined capacity to divert about 70 percent of the flow in the main stem Sacramento River), and size of the fish (DWR 1992a, IEP 1994a). These factors, possibly excluding water temperature, likely affect the survival of the other three runs of chinook salmon as well.

During their passage through the Delta, fall-run smolts are particularly liable to suffer increased mortality if they enter the central Delta (IEP 1994a). Salmon smolts may follow Sacramento River water that is diverted into the lower San Joaquin River via the Delta Cross Channel, Georgiana Slough, and Three Mile Slough. Experiments have shown that young hatchery-reared salmon released in the Sacramento River below Walnut Grove have a survival rate twice that of smolts released upstream of Walnut Grove and diverted through the Delta Cross Channel or Georgiana Slough. Since 2 percent or less of Sacramento River salmon show up at the SWP and CVP fish screens in the southern Delta, most of the mortality is assumed to occur in central Delta channels (BDOC 1993).

Passage through the central Delta is detrimental to smolts because of warmer temperatures, increased predation rates, longer migration routes, areas of reverse flow in river channels, and entrainment by agricultural and export pumps. At the CVP and SWP export facilities in the Delta, causes of mortality include predation and entrainment. Smolts released into the Sacramento River downstream of both the Delta Cross Channel and Georgiana Slough can be entrained at the pumps even when the Delta Cross Channel gates are open and QWEST is positive. Closing the Delta Cross Channel gates can result in increased negative (reverse) flows in the central and western Delta, particularly when export rates are high (IEP 1994a).

Three years of sampling chinook salmon at the Golden Gate indicated that salmon smolts migrate through the lower Estuary faster than net flow would transport them. In those three years, smolt survival rate in that area was not related to the magnitude of Delta outflow (BDOC 1993). However, Sacramento River system fall-run smolt survival through the Delta was found to be significantly correlated with Delta outflow, although the increased survival was probably due to cooler water temperatures. Smolt survival apparently is not related to reverse flows, which tend to occur more frequently in summer and fall, after the period of peak outmigration (DWR 1992a). However, smolt survival is significantly affected by operation of the Delta Cross Channel gates. Figures VI-9 and VI-10 in Chapter VI illustrate that, for a given water temperature and smolt survival index, when the Delta Cross Channel gates are closed, exports can be higher than when the gates are open.

The release of most hatchery fish in the lower Estuary, rather than in the river, has substantially increased smolt survival (DFG 1994b). However, when Feather River hatchery and Nimbus hatchery smolts are released many miles downstream in or near the Delta, straying of these fish, when they return as adults to spawn, is substantial, resulting in fewer fish returning to the hatchery. At Coleman National Fish Hatchery, where smolts are released near the hatchery, straying is much less (DFG 1993). Increased survival, from the releasing of fish in the Delta, has enabled a relatively intense ocean fishery to continue, even with reduced natural salmon populations. However, the success of the hatchery program increases the risk of over-harvesting natural stocks (DFG 1994b). Although ocean harvests clearly reduce spawning escapement substantially, it is not the principal factor limiting salmon production. Evidence of this is that reduced San Joaquin River stocks can rebound after a wet spring, which would not be possible if overharvesting were a significant factor in salmon abundance (BDOC 1993).

Some upstream migrating adult salmon use the lower San Joaquin River, Mokelumne River, Delta Cross Channel, and Georgiana Slough on their way to the Sacramento River system spawning grounds. It is believed that this is not detrimental to the salmon if the channels are not blocked (BDOC 1993).

Numerous factors affect chinook salmon survival in the upstream areas of the Sacramento River. These include: fish passage delay and fish losses associated with Red Bluff Diversion Dam; losses associated with inadequate fish screens at Anderson-Cottonwood Irrigation District's and Glenn-Colusa Irrigation District's diversions; hundreds of unscreened diversions; bank protection and flood control projects which reduce useable instream habitat; excessive flow fluctuations and elevated water temperatures below Keswick Dam; industrial, municipal, agricultural, and mining discharges of chemical waste; and poor quality, warm agricultural drainage water from the Colusa Basin Drain. Salmon runs in the lower American River have declined significantly due to the combined effects of project-induced low flows, severe flow fluctuations which expose and dry redds and strand juveniles, and high water temperatures. Inadequate flows and elevated water temperatures are also problems for chinook salmon in the Feather River (DFG 1993).

Many of the factors that are known to affect juvenile fall-run chinook salmon survival in the spring also impact the other runs of salmon, at slightly different times of the year. Although upstream effects are responsible for the significant decline in the spring-run chinook salmon, conditions in the Estuary may contribute to their continuing decline. A key factor in the recovery of spring-run salmon is adequate Delta outflows during the smolt outmigration period to reduce their vulnerability to entrainment and Delta predators (NHI 1992a). Winter-run salmon are believed to be less vulnerable than fall-run fish to predation and temperature factors due to their greater size and the relatively cool water temperatures during their outmigration. Despite this, the survival of winter-run smolts that are diverted into the central Delta, is similarly low. Therefore, closure of the Delta Cross Channel gates, as well as measures to prevent smolts from entering Georgiana Slough, must be considered to prevent further decline of winter-run chinook salmon (IEP 1994a).

b. Steelhead Trout. The native steelhead trout (*Oncorhynchus mykiss*) is an anadromous strain of rainbow trout that is generally distributed along the Pacific Coast. Within California's Central Valley, a viable population of naturally-produced steelhead is found only in the Sacramento River (above Red Bluff Diversion Dam) and its tributaries, primarily Mill and Deer creeks (DFG 1993; Dennis McEwan, DFG, pers. comm., September, 1994). Steelhead trout comprise an important recreational fishery within the Sacramento River system (DWR 1993). No significant steelhead populations now occur in the San Joaquin River system (DFG 1993).

Steelhead trout have a life history similar to chinook salmon, although the timing and duration of different stages varies. In the Sacramento River, upstream migration occurs from early August through November, with the peak in mid-September. Spawning in the Sacramento River and its tributaries usually occurs from January through March. Unlike chinook salmon, many steelhead do not die after spawning, but return to the ocean. Individuals that survive return to the ocean between April and June, where they remain for 1 or 2 years. Egg incubation takes place from January through April. Unlike chinook salmon which typically outmigrate soon after emerging from the gravel, steelhead in the Sacramento River generally emigrate as 1-year olds, at a larger size than salmon. Average monthly SWP fish salvage data, for the years 1980-1991, indicate most steelhead are salvaged in the late winter and early spring, with the peak occurring in March and April (Steve Ford, DWR, pers. comm., April 1995). In addition, all freshwater life stages of steelhead, except rearing, require lower temperatures than chinook salmon. The preferred temperatures for steelhead trout in the Sacramento River are between 50°F and 58°F (DFG 1993).

Population Trends. With natural spawning greatly reduced in the Sacramento and San Joaquin river systems, steelhead trout populations are primarily maintained by hatcheries (DFG 1993). Approximately 15 percent of the annual steelhead runs in the Sacramento River are the result of stocked fish released as smolts or fingerlings. Steelhead escapement in the lower American River is supported entirely by hatchery production (DWR 1993).

Both natural and hatchery-maintained steelhead stocks in the Central Valley are declining (DFG 1993). Figure V-36 illustrates the combined estimates of runs of wild and hatchery steelhead above Red Bluff Diversion Dam from 1967-1994. Figure V-37 shows the number of hatchery returns for the Coleman, Feather River, and Nimbus hatcheries during the same period of record.

Causes of Decline. Because spawning usually occurs from January through March, the temperature-sensitive egg and sac-fry life stages of steelhead are not present in the main stem Sacramento River and tributaries during the warmest period of the year (USBR 1994). Summer rearing temperatures, however, can and do preclude their survival in some areas. Natural production is limited because of the lack of sufficient cold water habitat during spring and summer months (DWR 1993).

Declines in natural and hatchery-maintained steelhead stocks in the Central Valley are due mostly to water development, inadequate instream flows, rapid flow fluctuations, high summer water temperatures in streams immediately below reservoirs, diversion dams which block access, and entrainment of juveniles into unscreened or poorly-screened diversions. The operations of the SWP and the CVP, particularly the Delta pumping plants, have had a detrimental effect on steelhead smolts emigrating through the Delta to the ocean. Reverse flows, entrainment of fish into the pumping facilities, and increased predation at water facilities are major problems (DFG 1993). Although these are the same factors that affect chinook salmon, it is possible that steelhead smolts are less susceptible to reverse flows, entrainment, and predation since they are larger than salmon smolts during their migration through the Delta (DWR 1992a).

c. Sturgeon. Two species of sturgeon are found in the Bay-Delta Estuary: the green sturgeon (*Acipenser medirostris*) and the white sturgeon (*Acipenser transmontanus*). These native fish are long-lived and late-maturing, making them extremely vulnerable to overfishing. Historical accounts indicate that a commercial fishery greatly reduced the estuarine white sturgeon population in the late-1800's. All sturgeon fishing was prohibited in 1917. The sturgeon sport fishery was reopened in 1954 (BDOC 1993).

The Bay-Delta Estuary contains the southernmost of the three known spawning populations of the green sturgeon (NHI 1992a). The green sturgeon is much less common in the Estuary than the white sturgeon and comprises a minor component of the sturgeon sport fishery. They make extensive ocean migrations and enter estuaries on the Pacific coast to spawn. Green sturgeon are known to spawn in the Sacramento River. Juveniles inhabit the Estuary until they are about 4-6 years old, at which time they migrate to the ocean. Little is known about the life history of green sturgeon (DFG 1992e).

The white sturgeon is the more common sturgeon in the Estuary and supports an important sport fishery. It apparently makes less extensive ocean migrations than the green sturgeon, and spends most of its life in river and estuarine environments. In the Bay-Delta Estuary, spawning, which appears to be triggered by increasing freshwater flows, occurs in both the Sacramento and San Joaquin rivers (BDOC 1993). Tag returns suggest that spawners in the

Figure V-36

Steelhead Trout Annual Estimated Run Size

Sacramento River Above Red Bluff Diversion Dam (1967-1993)

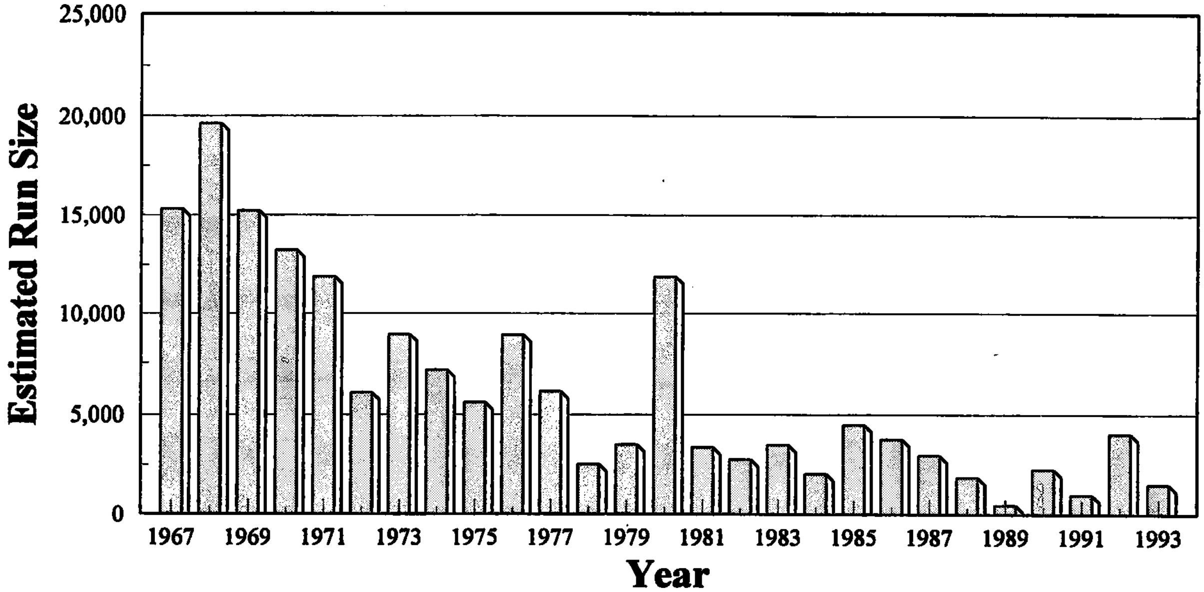
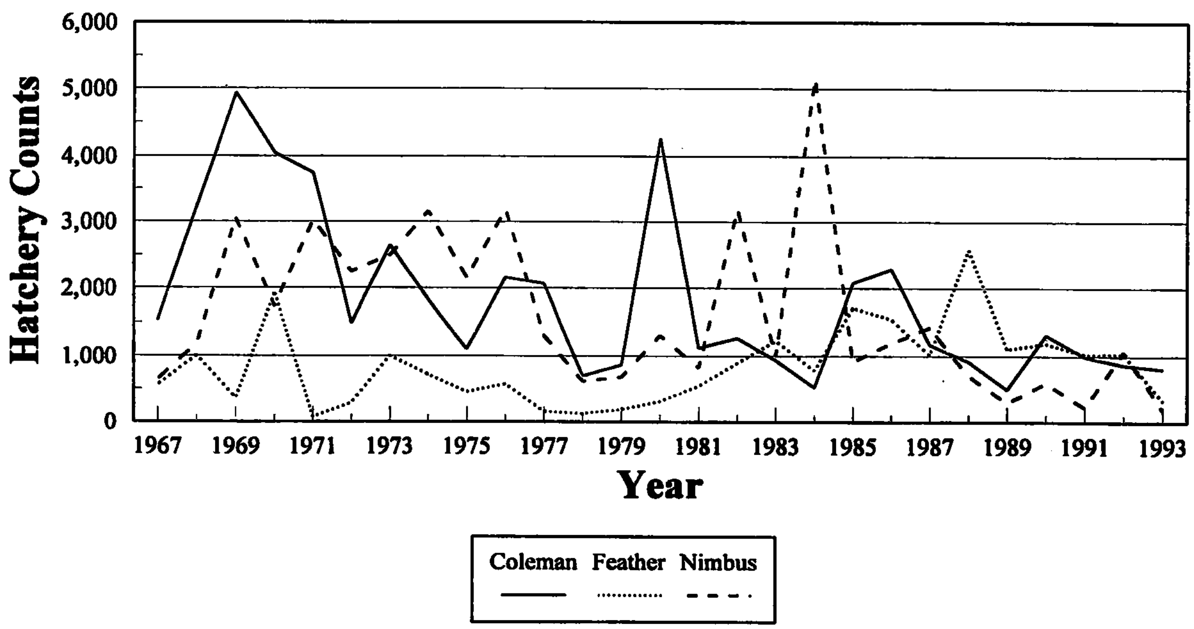


Figure V-37

Steelhead Trout Hatchery Returns

(1967-1993)



Sacramento River are about ten times more abundant than spawners in the San Joaquin River. In the Sacramento River, the spawning season extends from late February through May, with most spawning occurring in March and April at water temperatures of 46-64°F. The eggs sink to the bottom and adhere to solid substrate until they hatch in 5-10 days, depending on water temperatures. Larval movement and dispersal are also dependent on river flow; therefore, the location of the sturgeon nursery area appears to move farther downstream as flows increase (DFG 1992e).

Young white sturgeon grow rapidly, reaching 12 inches at age 1 and 18 inches at age 2. They attain 46 inches, currently the minimum legal size for the sport fishery, at age 11. White sturgeon are long-lived and can reach a large size; reportedly over 100 years old and as large as 1,300 pounds. Most females spawn for the first time at about age 15 and may spawn as infrequently as every 5 years thereafter. Food habits vary with size. Up to 1 year old, white sturgeon feed primarily on benthic invertebrates and *Neomysis*. As they grow, their diet becomes more diverse and includes clams, shrimp, crabs, polychaetes, fish, and fish eggs (DFG 1992e).

<u>Population Trends</u>. Since the sturgeon fishery was reopened to sport fishing in 1954, white sturgeon life history and population dynamics have been studied intermittently. Mark-recapture abundance estimates for white sturgeon ≥ 40 inches (the former legal size for the sport fishery) are available from intermittent tagging efforts between 1954 and 1991 (Figure V-38). Estimated abundance was 114,700 fish in 1967, 20,700 fish in 1974, 117,700 fish in 1984, and 26,800 fish in 1990. These data show that large white sturgeon abundance, which has varied over the last 35 years, has declined dramatically since 1984 (DFG 1994b).

The Bay Study's monthly otter and mid-water trawl sampling from South Bay to the western Delta estimated that the production of white sturgeon year classes declined between 1980 and 1990 (Figure V-39). Estimated production from the 1982 and 1983 year classes was substantially greater than production between 1987 and 1990. Both 1982 and 1983 were years of very high spring and early summer freshwater outflow from the Estuary; 1987-1990 were drought years with very low outflow. These data indicate a strong correlation between year class index and outflow between April and July, with spring flows being more important. Salvage data from 1968 to 1987 also indicate that the production of young sturgeon is dependent on spring outflow, especially in April and May (DFG 1992e). Therefore, recruitment in white sturgeon appears to be greatest in years of very high outflow during the spawning and nursery period (April-May) (SFEP 1992a).

Fall abundance estimates of green sturgeon have ranged from about 200 fish in 1954 and 1974, to about 1,850 fish in 1967 (Figure V-38). Overall, green sturgeon abundance in the Estuary has steadily decreased since 1979 (DFG 1994b).

<u>Causes of Decline</u>. It appears that white sturgeon abundance has declined since 1984 due to both low recruitment between 1975 and 1982, and high harvest rates in the mid- to late-1980's (DFG 1994b). Evidence suggests that recruitment to the adult population is

Figure V-38

White and Green Sturgeon Abundance Indices

Fall Mark-Recapture Estimates (Intermittent 1954-1990)

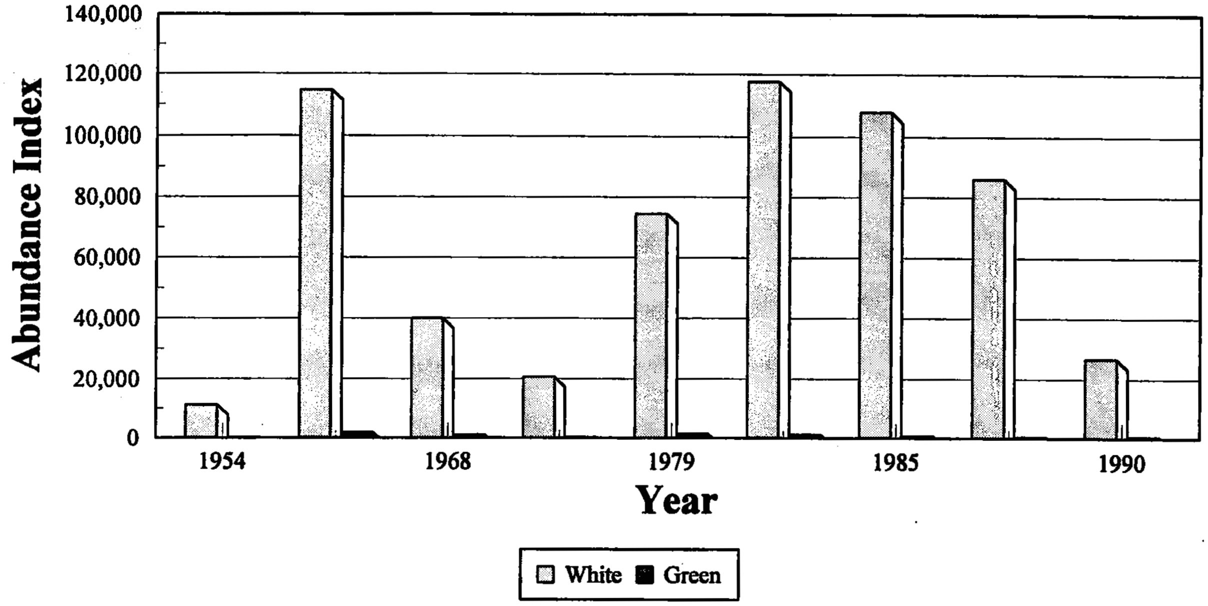
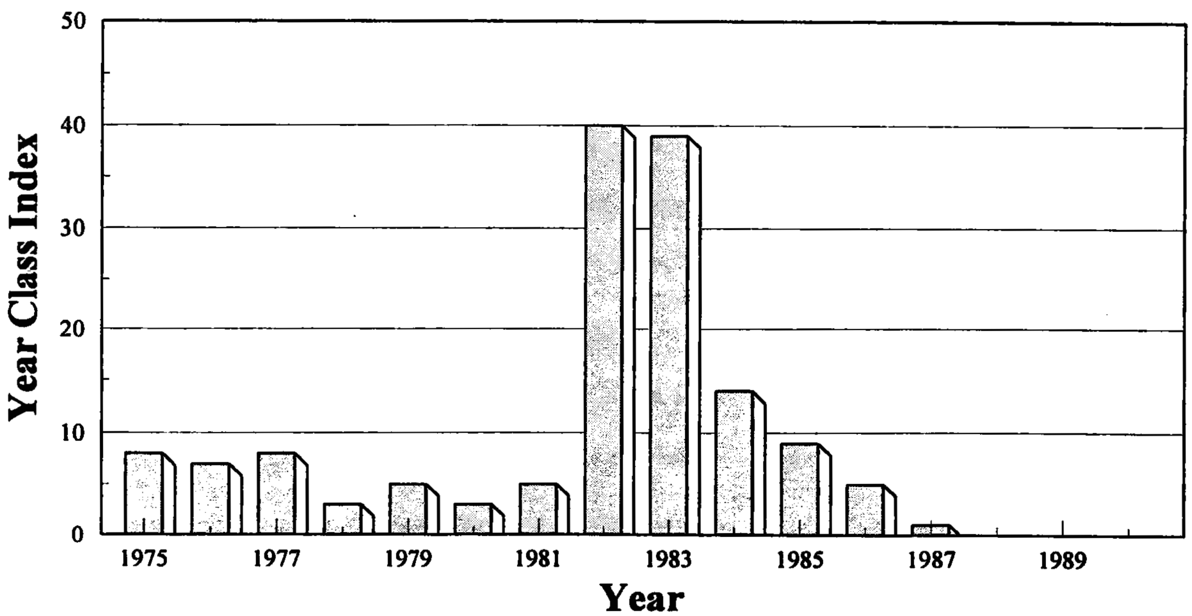


Figure V-39

White Sturgeon Year Class Indices

South Bay to Western Delta (1975-1990)



increased following years of high outflow (e.g., 1982-1983) and decreased following years of low outflow (e.g., 1987-1990). High flows may improve young sturgeon survival by transporting larvae to areas of greater food availability, dispersing larvae over a wide area, quickly moving larvae downstream of the influence of the pumps, and increasing nutrients to enhance productivity in the nursery area. Additionally, adults may experience a stronger attraction to upstream spawning areas and spawn in greater numbers in high flow years (DFG 1992e).

In addition to the effects of variable outflows on white sturgeon populations, exploitation rates in the late-1980's were about 40 percent higher than in the preceding two decades. This increase in harvesting, which occurred as a result of more sophisticated fishing techniques, may have reduced annual survival rates, abundance, and egg production (SFEP 1992a). Due to concerns about the status of the white sturgeon population, angling regulations were changed in 1990 to increase the minimum size limit from 40 inches to 46 inches and to impose a maximum size limit of 72 inches. These new restrictions have reduced the harvest rate to about one-third of the late-1980's level (DFG 1994b).

Although the green sturgeon population in the Estuary has shown a gradual decline, it is uncertain if conditions in the Estuary are affecting this species. Apparently, the green sturgeon is being overexploited throughout its range (NHI 1992a).

d. Striped Bass. The striped bass (*Morone saxatilis*) is native to streams and bays of the Atlantic Coast. It was first introduced into the Bay-Delta Estuary in 1879. Within 10 years, this highly fecund and voracious predator was supporting a commercial fishery in the Estuary (SFEP 1992a). In the Delta channels, adult striped bass primarily feed on fish. In the more saline portions of the Estuary, principal foods include anchovy, shiner perch, herring, and bay shrimp (BDOC 1994).

California striped bass spend most of their life in the Bay-Delta Estuary and along the Pacific Coast, within a few miles north and south of the Golden Gate (DWR 1992a). This anadromous fish resides in the ocean and brackish waters and enters the fresher waters of the Estuary to spawn (BDOC 1994). Approximately one-half to two-thirds of the striped bass spawn in the Sacramento River system, while the remainder spawn in the lower San Joaquin River. Important spawning areas include the main stem Sacramento River from Sacramento to Colusa, and in the San Joaquin River, between Antioch Bridge and the mouth of Middle River. Striped bass begin spawning in the Delta in spring, during April and May, when water temperatures reach about 60°F; most spawning occurs when water temperatures are between 61 and 69°F (BDOC 1993). Further up the Sacramento River, spawning occurs from about mid-May though mid-June. The difference in timing is due to temperatures rising more slowly in the Sacramento River than the lower San Joaquin River (DWR 1993).

Striped bass spawn in fresh water where there is moderate to swift currents. With slower currents, many eggs, which are slightly heavier than water, sink to the bottom and die (DFG 1993). The semi-buoyant striped bass eggs drift with river currents and are carried downstream. Larvae hatch two to three days after spawning. Initially, the larvae receive nourishment from the yolk sac, which is absorbed in five to ten days. As they move downstream toward the Delta, larvae begin feeding on small zooplankton. Upon reaching the western Delta, which is presently their primary rearing area, larvae are large enough to begin feeding or larger organisms such as the opossum shrimp (*Neomysis mercedis*). *Neomysis* remains the main food source until the striped bass reach their second year when they become large enough to feed on bay shrimp and small forage fish. They reach maturity at 3 to 4 years of age and may live to 20 to 30 years of age. In recent years, most of the adult striped bass in the Bay-Delta system are in the 4 to 7 year age classes. The older, more fecund fish, are no longer present in great numbers (DWR 1993).

Beginning in 1982, the DFG stocked striped bass in the Estuary, largely as mitigation for various projects, in an effort to maintain the population. The stocking was stopped in 1992 due to concerns that the effort was adding predators which might eat the endangered winter-run chinook salmon (BDOC 1994).

Population Trends. The striped bass population in the Bay-Delta Estuary began with a planting of 132 fish in 1879. A subsequent planting of 300 fish was made in 1882. By 1888, a commercial fishery for striped bass was established (Moyle 1976), reflecting the enormous fecundity of this species. By 1889, the striped bass fishery was landing more than 454 tons each year until 1915. Either through overfishing, habitat degradation, or the usual decline in abundance following the successful introduction of a species, the population of striped bass appears to have begun declining in the early years of the 20th century. Finally, in 1935, the commercial fishing for striped bass was banned. Although the striped bass population decline persisted, the recreational fishery continued to attract a large number of anglers until the late 1970's (SFEP 1992a).

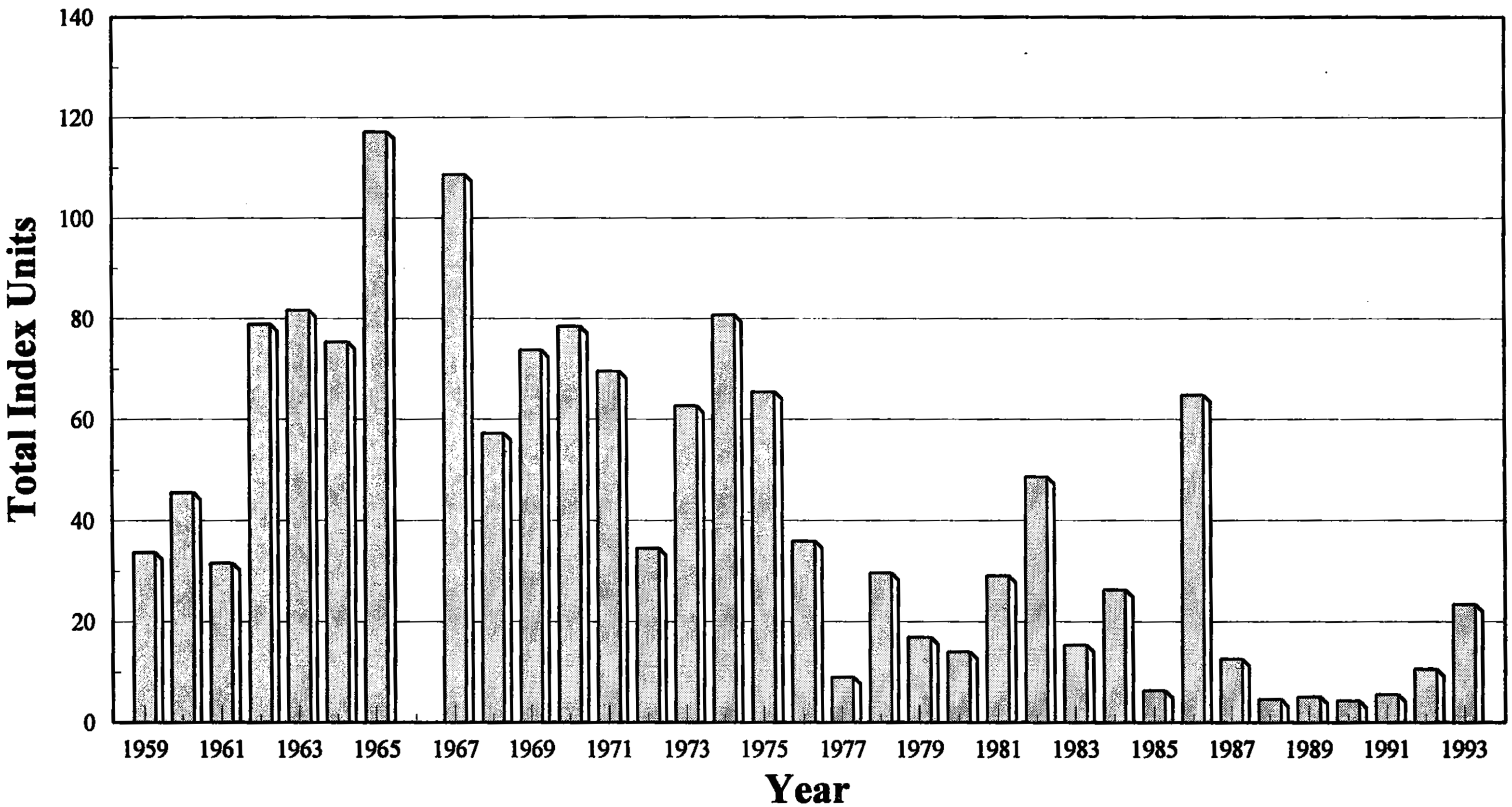
Monitoring of the striped bass population began with the DFG's mid-summer tow-net survey in 1959 (DFG 1994b, SFEP 1992a). This survey, which provides data for a striped bass index, based on the abundance of 38 mm young, peaked at 117.2 in 1965 (Figure V-40). The four lowest indices occurred from 1988 to 1991 when the average index was 4.9. From 1959-1976, the average abundance index was 66.6; since 1977, the average has been 19.4 (DFG 1994b). The declines have been more pronounced in the Delta than in Suisun Bay (SFEP 1992a).

Adult population estimates (Figure V-41) are made through extensive tagging of legal-sized striped bass during their spring migration to the Delta from the ocean and bays (BDOC 1993). Based on Petersen mark-recapture population estimates, the number of legal-sized adult striped bass was 624,000 fish in 1992. The 1992 abundance estimate for naturally-produced striped bass, excluding hatchery fish, was about 533,000 fish. This indicates a decline from approximately 1 million fish in the 1980's and 1.7 million fish in the late 1960's and early 1970's (DFG 1994b). For the years prior to 1976, estimates for the total population of adults in the Estuary were between 1,480,000 to 1,880,000; since 1977, the population ranged from 520,000 to 1,160,000 fish (SFEP 1992a). Population estimates of legal-sized 3-year-old fish (Figure V-42), which are the youngest and most numerous component of the adult population, have declined to record lows since 1988 (DFG 1994b).

Figure V-40

Striped Bass (38 mm) Index

Mid-Summer Townet Survey (1959-1993)



Notes: 1983 underestimated due to very high Delta outflows.
Not sampled in 1966.

Figure V-41
Striped Bass Legal-Size Adult (Age 3+)
Mark-Recapture Population Estimates (1969-1992)

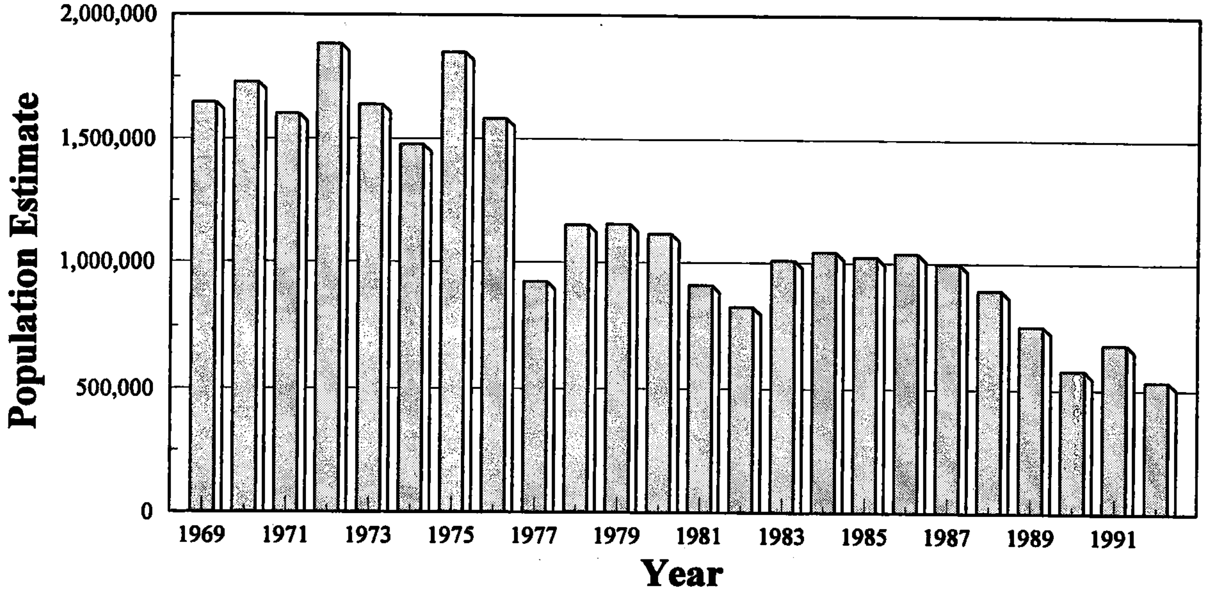
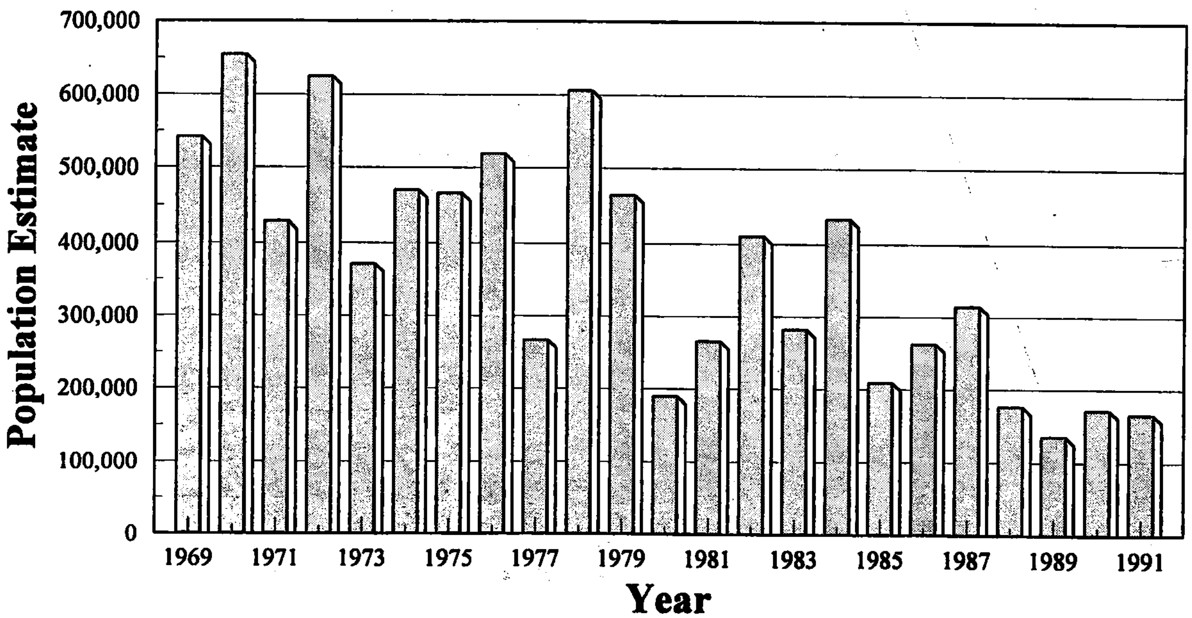


Figure V-42
Striped Bass Legal-Size Age 3
Mark-Recapture Population Estimates (1969-1991)



Causes of Decline. The adult striped bass population decline is a reflection of reduced recruitment. The decline in the adult striped bass population has resulted primarily from the irregular but steady decline of young striped bass (38 mm index) since the mid-1960's (DFG 1994b). It is believed that the decline in young bass predominately is due to a decreased survival rate during the first year of life. Increased mortality of striped bass eggs and larvae is attributed mainly to increased losses through entrainment by the CVP and SWP pumping operations and decreased outflows during the recent 6-year drought (DFG 1992a, DWR 1995c). Agricultural diversions in the Delta also impact fish (DWR 1992a).

Losses to export and entrainment are controlled by freshwater diversion, specifically by the proportion of water diverted for export and within-Delta use (Jassby et al. 1994). Higher outflows move a higher percentage of eggs and larvae out of reach of entrainment, and higher diversions lead to higher percentages of entrainment of eggs and embryos (SFEP 1992a). Higher outflows may also shift the low salinity habitat to a location downstream of the Delta, where larval striped bass appear to survive better (DWR 1992a).

The decline in recruitment due to entrainment by water project operations may have produced an adult population size that does not produce enough eggs to maintain the population. The fact that the percentage of eggs and larvae taken is independent of the numbers present, coupled with ever smaller numbers of eggs produced, makes the interaction of outflows and diversion rates the only adequate explanation for the decline of the striped bass population and its inability to rebound (SFEP 1992a).

Most entrainment of striped bass eggs and larvae at the SWP pumping plant occurs during May, June, and July. With some exceptions, such as during the 1976-1977 drought, the number of bass entrained appears to decrease rapidly from September to December. Losses occur due to passage of eggs and larvae through the fish screens, predation in Clifton Court Forebay, and handling and hauling of salvaged bass. Also, reverse flows in the San Joaquin River could impact striped bass by drawing young fish to the export pumps from spawning and nursery areas in the central and western Delta. There is a significant inverse relationship between flow in the lower San Joaquin River and the number of young bass salvaged at the SWP pumping plant in June and July (DWR 1992a).

Measurements, dating back to 1959, indicate that young striped bass survival increases in proportion to Delta outflow during April through July. There is also evidence that Delta outflow continues to influence bass survival through December. The DFG's statistical model for striped bass indicates that the survival of striped bass during their first year depends on the magnitudes of Delta outflow and State and federal exports in the southern Delta, and that these first year conditions determine subsequent abundance of adult bass (BDOC 1993). Figures VI-1 and VI-2 in Chapter VI show the relationship between mean exports and outflow during April-July and August-March, respectively, to maintain a striped bass population of 1 million, assuming various YOY indices. These figures represent a simplification of the DFG's striped bass model and illustrate how outflows and exports may be managed to maintain striped bass populations in the Estuary.

Besides reducing the likelihood of entrainment into diversions, higher outflows are thought to provide additional benefits for striped bass, including increasing: low salinity nursery habitat in Suisun Bay; primary productivity (food supply); turbidity (reduces predation on young); and providing dilution of pollutants. These factors relate to other possible causes for the continuing decline in striped bass abundance (e.g., food availability, competition, and toxics) (SFEP 1992a).

It is possible that a reduction in food supply has had an effect on striped bass abundance in the Estuary. Since the introduction of the Asian clam (*Potamocorbula amurensis*), zooplankton populations have failed to attain their normal densities. Also, the introduction of the copepod, *Sinocalanus doerrii*, which is less easily captured, has largely replaced *Eurytemora affinis*, a copepod which had comprised a major portion of the young striped bass diet (SFEP 1992a). Although laboratory experiments have demonstrated that the food density for larval striped bass in the Estuary is sometimes low enough to have an effect on both the growth and mortality rates of young bass (Jassby et al. 1994), no direct evidence of starvation has been found (BDOC 1994). Therefore, it is unlikely that decreased food supply and relatively higher abundance of less easily captured prey species has had a significant role in the striped bass decline, but these factors may make recovery of the population more difficult (SFEP 1992a).

There is a potential for competition for food between young striped bass and the introduced inland silverside. Both species have a preference for *Neomysis mercedis*. Although the inland silverside is an inshore feeder and the striped bass is a pelagic feeder, the food source and feeding sites of these two species overlap in the channels of the San Joaquin system and Suisun Bay and Marsh (CUWA 1994).

Agricultural drainage waters that enter the Sacramento and San Joaquin rivers have been acutely toxic to *Neomysis mercedis*, a major prey of young striped bass. There is also evidence that suggests that toxicity adversely affects some bass larvae. However, it is believed that toxicity is not responsible for the striped bass decline. The "background mortality" which results from toxicity, however, has not changed appreciably over the past 30 years (DFG 1992a). However, a study of the effects of rice pesticides on larval striped bass recruitment concluded that during the years investigated (1973-1986), the discharge of water, containing pesticides from rice culture, had adversely affected the striped bass population in the Estuary. The annual die-off of striped bass during May and June is apparently caused by liver deterioration associated with exposure to industrial, agricultural, and urban pollutants (DWR 1992a). Considering that toxic pollutants do impact striped bass to some degree, decreasing the effects of toxics through dilution is consistent with the concept that young striped bass survival improves with increasing outflow (DFG 1992a).

Illegal harvest of undersized striped bass may cause a serious loss to the population. It is estimated that the equivalent of at least 125,000 legal-sized adults are lost each year to poaching; whereas, an average annual loss of an equivalent of 86,000 legal-sized bass occurs due to the SWP pumping plant operations (DWR 1992a). However, the fact that illegal harvest of striped bass is not a new problem, and it is well documented that operation of the export facilities causes mortality to young bass, it is unlikely that the harvest of undersized striped bass has been the dominant factor causing the decline in adult bass abundance since 1969 (DFG 1994b).

e. American Shad. The American shad (*Alosa sapidissima*), a member of the herring family, was first introduced into the Sacramento River in 1871 and was supporting a commercial fishery by 1879 (DFG 1993). American shad are oceanic as adults except for a brief spawning run in fresh water. Most central California adults spawn in the Sacramento River or its tributaries (SFEP 1992a) from late April to early July. Shad enter the San Joaquin River and its tributaries in years when May and June outflow is high (DFG 1993).

American shad do not enter fresh water until water temperatures exceed 50°F. Peak runs and spawning occur at water temperatures between 59°F and 68°F (Moyle 1976). Spawning occurs where there is a good current in tidal fresh water or farther upstream. The fertilized eggs, which are slightly heavier than water, drift with the current, near the bottom. After hatching, from about May to late July, some young shad move downstream into brackish water, but large numbers remain in fresh water into November. By December, most young shad have left fresh water (DFG 1993). Many adults die after spawning, but some return to the ocean and spawn again in later years (SFEP 1992a). Large numbers of dead shad are particularly noticeable when spawning occurs above 68°F (Moyle 1976).

Population Trends. The DFG sampling programs do not encompass many of the times or locations where American shad occur; however, it is still possible to determine some patterns in the data. It appears that American shad recruitment increases in wetter years. Fall mid-water trawl survey data (Figure V-43) indicate that lower catches of American shad have generally occurred during drought periods (e.g., 1976-1977 and late 1980's). Runs of American shad in the Sacramento River have been estimated at 3.04 million fish in 1976 and 2.79 million fish in 1977, but populations in the early part of the century were likely two to three times as large. No recent estimates of spawning numbers seem to exist (SFEP 1992a).

Trawl data from the Bay Study show that catches of American shad fluctuated in the first five years of the study (1980-1984); however, 1981, a dry year, was not the lowest catch in this period. The four lowest catches occurred during the last four years (1985-1988) (SFEP 1992a) which, except for 1986, were dry years .

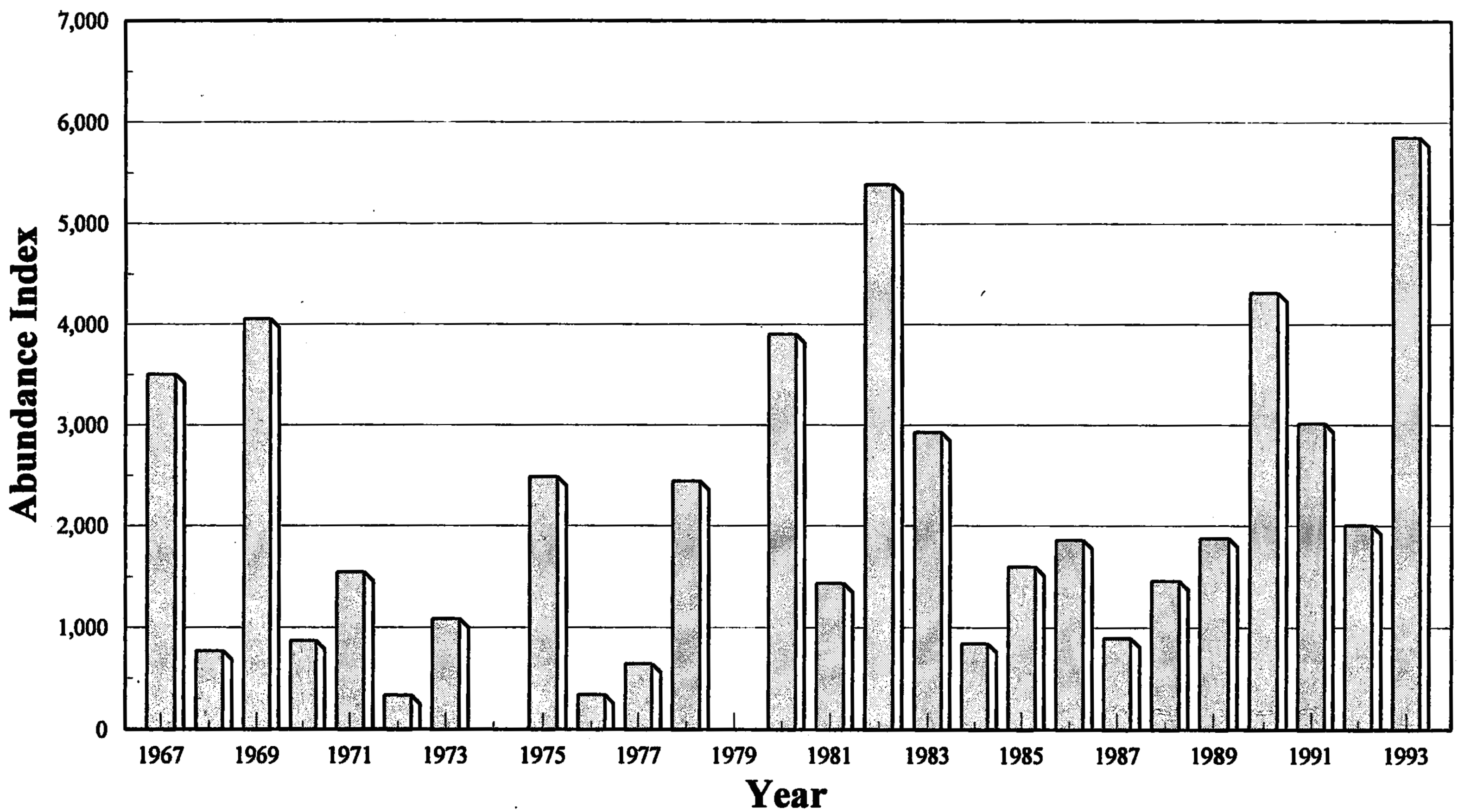
Peak salvage of young shad, at the Skinner Fish Facility, generally occurs during the main outmigration period, between July and December (DWR 1992a).

Causes of Decline. The American shad population data, though limited, appears to indicate that shad recruitment is lower during drier years (i.e., lower Delta outflow). A mechanism that may explain the linkage of shad abundance with outflow is the effect of outflow on water temperature. Drought conditions are often accompanied by increases of temperature, in the smaller volume of water, so that young shad are stressed, most likely in the Delta or upstream. Water temperatures over 68°F are known to cause increased

Figure V-43

American Shad Abundance Indices

Fall Mid-Water Trawl Survey (1967-1993)



Note: Not sampled in 1974 and 1979.

mortality in young shad. Increased entrainment during dry years probably also contributed to the decline (SFEP 1992a). It is likely that the factors that affect striped bass (e.g., Delta outflow and entrainment) also affect young American shad. It also appears that upstream conditions (e.g., flow and temperature in the rivers, where spawning occurs) play a critical role in recruitment to the population (DWR 1992a).

C. CONTROLLABLE CAUSES OF DECLINES

The factors that have been identified as causing or contributing to the declines of various aquatic species in the Bay-Delta Estuary can be grouped into two broad categories: controllable and uncontrollable. Uncontrollable factors include: climatic changes; variations in natural hydrology, due to seasonal and annual variability in precipitation; oceanic conditions; and permanent conditions, such as dams and other major constructed facilities. Although such factors undoubtedly influence the health of the Bay-Delta Estuary ecosystem, they are generally beyond the reasonable control of the people of the State. However, adverse effects of many uncontrollable factors may be offset, at least in part, by addressing controllable factors.

Controllable factors can be defined as those which can reasonably be influenced by human actions. Among the controllable factors that influence aquatic resources in the Estuary are: (1) freshwater flows; (2) entrainment; (3) water temperature; (4) pollution; (5) introduced species; and (6) harvesting. The extent to which controls can be exerted varies among these factors. Furthermore, some of these factors are outside the authority of the SWRCB. Yet, it is crucial to the success of a comprehensive approach for protection of the Bay-Delta Estuary that each factor be addressed to the extent possible.

1. Freshwater Flows

Freshwater flows to and through the Bay-Delta Estuary are primarily influenced by the amount of precipitation that occurs in the Estuary's watershed, and the existence and operations of water development project facilities. While extended drought periods are known to adversely impact aquatic resources in the Estuary, the amount and timing of precipitation is beyond human control. However, although the existence of major water project facilities are considered permanent, uncontrollable factors, their operations are controllable to a great extent.

Under its water right authority, the SWRCB can specify the amount, timing, and conditions of instream flows and water diversions in the Estuary's watershed to the extent that they are within the control of the water right holders in the basin. Thus, specific terms and conditions can be placed on water right permits and licenses toward meeting the conditions necessary for the reasonable protection of beneficial uses.

2. Entrainment

The diversion of water for offstream use or in-Delta pumping results in the entrainment and mortality of numerous aquatic organisms in the Estuary. Besides the direct mortality that occurs with physical entrainment, additional losses are incurred through predation at intakes and fish salvage facilities, and through the salvage process itself.

As part of water right permits and licenses, the SWRCB can include requirements on pumping rates and the installation of fish screens to reduce the numbers of organisms entrained by diversions. In conjunction with these requirements, losses due to entrainment can be minimized through the efforts of other entities, including: (1) designing, installing, and effectively operating fish screens or other protective devices at unscreened diversions associated with fish mortality; (2) improving screening efficiencies and salvage operations at the SWP and CVP facilities; (3) continuing the predator control program for Clifton Court Forebay; and (4) designing, installing, and effectively operating gates or other barriers at channel openings known to be associated with entrainment losses (e.g., continue evaluation of the effectiveness of an acoustic barrier on Georgiana Slough).

3. Water Temperature

Water temperatures in the rivers and the Delta have been primarily affected by changes in flow regimes and loss of streamside (riparian) vegetation. As a result, warm water temperatures that are detrimental to species that require cool water for successful spawning and migration, occasionally occur in some portions of the Bay-Delta Estuary watershed.

Under present conditions, water temperatures can only be minimally controlled. The most likely effective control is a combination of both maximizing reservoir control of cool water reserves to the benefit of downstream fisheries and increasing riparian vegetation to provide shading. These measures would improve water temperatures, primarily in the tributaries, and could provide a slight effect on Delta water temperatures. The SWRCB can encourage water project operators to evaluate and implement possible operational and structural modifications to their facilities to reduce water temperatures downstream of their projects. Such actions may include releasing water from the lower levels of the reservoir, maximizing cool water reserves, and installing temperature curtains. In addition, the SWRCB can encourage other State, federal, and local entities to undertake efforts to increase riparian vegetation along the riverine corridors.

4. Pollution

Through the efforts of the SWRCB and RWQCBs, and the USEPA, significant progress has been made in controlling the discharge of pollutants to the Bay-Delta Estuary and tributary streams. Most of the reduction in pollutant loading has occurred in the point source discharges of municipal wastewater treatment plants and industrial discharges. The most serious pollution problems in the Estuary today arise from nonpoint sources such as agricultural drainage, urban runoff, and mine drainage.

The control of pollution can be advanced through: (1) the adoption of water quality objectives/criteria for additional pollutants that adversely impact beneficial uses; (2) improvements in source control and pretreatment programs; (3) expediting the clean-up of toxic hot spots; and (4) improvements in management practices. As the waste discharge requirements of point source discharges are reissued, new water quality standards and pollution control measures are implemented. The management and control of agricultural drainage, urban runoff, and other nonpoint sources of pollution are being addressed by the SWRCB's Nonpoint Source Management Program, established in 1987. This program establishes a systematic management approach to the difficulties of nonpoint source pollution, by developing an inventory and ranking of nonpoint source problems, a statewide assessment, and management recommendations. Application of this general approach, which resulted in the significant reductions that have occurred in the concentrations of rice herbicides in the Sacramento River since 1991, is continuing with the cooperation of various entities.

5. Introduced Species

It is generally infeasible to effectively reduce or eliminate introduced species from the Bay-Delta Estuary; however, some degree of control is possible with certain non-native species, such as carp and water hyacinth. Because most introduced species cannot be completely eliminated from the Estuary, it is more desirable to focus efforts on preventing additional non-native species from being introduced. These efforts should include: prohibiting the intentional introduction of non-native species, including those intended for scientific and commercial purposes; developing, implementing, and enforcing stringent regulations to control discharges of ship ballast water within the Estuary and adjacent waters; controlling invasive terrestrial plants; restoring native plants; and investigating the feasibility of biological control for invasive non-native aquatic plants.

Although the SWRCB does not have direct control over the sources or management of introduced species, the SWRCB encourages and supports the efforts of other State and federal entities to that end.

6. Harvesting

There is no doubt that both legal and illegal harvesting of aquatic resources in the Bay-Delta Estuary reduces the abundances of populations; however, the significance of such impacts is difficult to determine. Although harvest regulations are not within the control of the SWRCB, the SWRCB would support a review and modification, if necessary, of harvest regulations for species of concern. Furthermore, the SWRCB would encourage strengthening programs to reduce the illegal harvest of aquatic species.

7. Conclusion

The management of controllable factors associated with the decline of aquatic resources is necessary. However, the relative effects of the controllable and uncontrollable factors have not been quantified. Therefore, management of controllable factors may not significantly

Literature Cited in Chapter V

Arthur, J. and D. Ball. 1980. The significance of the low salinity habitat location to the phytoplankton standing crop in the San Francisco Bay-Delta Estuary. U.S. Department of the Interior. Water and Power Resources Service. 89 pp.

BDOC. 1993. Draft briefing paper on biological resources of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Bay-Delta Oversight Council. September 1993. 42 pp. plus appendices.

BDOC. 1994. Draft briefing paper on introduced fish, wildlife and plants in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Bay-Delta Oversight Council. May 1994. 33 pp. plus appendices.

Cech, J. and P. Young. 1994. Environmental requirements and tolerances of the Sacramento splittail, *Pogonichthys macrolepidotus* (Ayres). Progress report (November 1993-February 1994). University of California, Davis. Funded by Interagency Ecological Studies Program. February 25, 1994. 13 pp.

CUWA. 1994. Draft evaluation of factors potentially limiting aquatic species abundance and distribution in the San Francisco Bay/Sacramento-San Joaquin Estuary. Prepared by R2 Resource Consultants, Inc. for The California Urban Water Agencies. 63 pp. plus appendix.

DFG. 1987. Delta outflow effects on the abundance and distribution of San Francisco Bay fish and invertebrates, 1980-1985. Exhibit 60, entered by the California Department of Fish and Game for the State Water Resources Control Board 1987 water quality/water rights proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta.

DFG. 1992a. A re-examination of factors affecting striped bass abundance in the Sacramento-San Joaquin Estuary. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Right Phase of the Bay-Delta Estuary Proceedings. 59 pp. (WRINT-DFG-2)

DFG. 1992b. Impact of water management on splittail in the Sacramento-San Joaquin Estuary. 7 pp. (WRINT-DFG-5)

DFG. 1992c. Estuary dependent species. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings of the San Francisco Bay-Sacramento-San Joaquin Delta. 97 pp. (WRINT-DFG-6)

DFG. 1992d. Written testimony on Delta smelt. Submitted by the California Department of Fish and Game to the State Water Resources Control Board. June 1992. 44 pp. (WRINT-DFG-9)

DFG. 1992e. Sturgeon in relation to water development in the Sacramento-San Joaquin Estuary. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Rights Phase of the Bay-Delta Estuary Proceedings. 13 pp. (WRINT-DFG-28)

DFG. 1992f. Status of white catfish in the Sacramento-San Joaquin Delta. 15 pp. (WRINT-DFG-4)

DFG. 1993. Restoring Central Valley streams: A plan for action. California Department of Fish and Game. November 1993. 206 pp.

DFG. 1994a. Department of Fish and Game comments on key issues of State Water Resources Control Board's May workshop for review of standards for San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Presented by Perry L. Herrgesell, Chief of Bay-Delta and Special Water Projects Division, May 16, 1994. 28 pp.

DFG. 1994b. Department of Fish and Game comments on key issues of the State Water Resources Control Board's June workshop for review of standards for San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Presented by Perry L. Herrgesell, Chief of Bay-Delta and Special Water Projects Division, June 14, 1994. 68 pp.

DWR. 1992a. Bay-Delta fish resources. California Department of Water Resources. Sacramento, CA. July 1992. 46 pp. (WRINT-DWR-30)

DWR. 1993. State drought water bank. Draft program Environmental Impact Report. California Department of Water Resources. Sacramento, CA. January 1993. 198 pp. plus appendices.

DWR. 1994. Comments of the Department of Water Resources at the third public workshop for the review of standards for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Presented by David Anderson and Edward Winkler. June 14, 1991. 19 pp. plus figures and appendices.

DWR. 1995a. Information relative to the proposed listing of Sacramento splittail. Prepared by the California Department of Water Resources, Environmental Services Office. February 21, 1995. 57 pp.

DWR. 1995b. Comments on draft Delta smelt and Sacramento splittail biological opinion. California Department of Water Resources. 10 pp.

DWR. 1995c. Comments of the Department of Water Resources on the Draft Water Quality Control Plan and Environmental Report for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Memorandum from D. Anderson to J. Caffrey. March 10, 1995. 18 pp.

DWR and USBR. 1993. Biological assessment. Effects of the Central Valley Project and State Water Project on Delta smelt. Prepared by the California Department of Water Resources and the U.S. Bureau of Reclamation for the U.S. Fish and Wildlife Service. October 1993. 134 pp.

Hanson, C. 1994a. Comments on the United States Fish and Wildlife Service's proposal to list the Sacramento splittail as threatened. Hanson Environmental, Inc. Walnut Creek, CA. 12 pp. plus figures.

Hanson, C. 1994b. Result of the June 16, 1994 Delta smelt channel vs. shoal fishery investigation. Memorandum from C. Hanson, Hanson Environmental, Inc. to Leo Winternitz, DWR. June 17, 1994. 3 pp.

Hanson, C. 1994c. Examination of the relationship between delta smelt geographic distribution during juvenile rearing and fall indices of adult abundance. Hanson Environmental, Inc., prepared for State Water Contractors. December 1994. 23 pp.

Hymanson, Z., D. Mayer, and J. Steinbeck. 1994. Long-term trends in benthos abundance and persistence in the Upper Sacramento-San Joaquin Estuary. Summary report: 1980-1990. Interagency Ecological Program for the San Francisco Bay/Delta Estuary Technical Report 38. May 1994. FWQ/BIO/IATR/94-38. 68 pp.

IEP. 1994a. Estimating winter run survival with late-fall run fish. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. Spring 1994. 11 pp. (Submitted by J. Wullschleger, USFWS).

IEP. 1994b. Phytoplankton and organic carbon sources for the Bay/Delta food web. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. Summer 1994. 12 pp. (Submitted by A. Jassby, UCD).

IEP. 1994c. Progress report: Environmental factors affecting reproduction and recruitment of Pacific herring in the San Francisco Estuary. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. Summer 1994. 12 pp. (Submitted by G. Cherr and M. Pillai, UCD).

Jassby, A., W. Kimmerer, S. Monismith, C. Armor, J. Cloern, T. Powell, J. Schubel, and T. Vendlinski. 1994. Isohaline position as a habitat indicator for estuarine populations. Ecological applications. In press. 55 pp.

Kimmerer, W. 1992. An evaluation of existing data in the entrapment zone of the San Francisco Bay Estuary. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Technical Report 33. September 1992. FS/BIO-IATR/92-93. 49 pp.

Meng. L. 1993. Status report on Sacramento splittail and longfin smelt. University of California, Davis. Submitted to U.S. Fish and Wildlife Service. August 25, 1993. 15 pp. plus figures.

Moyle, P. 1976. Inland fishes of California. University of California Press, Berkeley. 405 pp.

Moyle, P., J. Williams, and E. Wikramanayake. 1989. Fish species of special concern of California. Report for California Department of Fish and Game, Sacramento. 222 pp.

Moyle P., B. Herbold, D. Stevens, and L. Miller. 1992. Life history and status of Delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

NHI. 1992a. Causes of decline in estuarine fish species. Testimony of the Natural Heritage Institute presented by Dr. Peter Moyle, University of California, Davis to the State Water Resources Control Board. June 1992. 35 pp. (WRINT-NHI-9)

NHI. 1992b. Petition for listing longfin smelt and Sacramento splittail under the Endangered Species Act. Submitted by the Natural Heritage Institute to the U.S. Fish and Wildlife Service, November 5, 1992. 32 pp.

NMFS. 1993. Biological opinion for the operation of the federal Central Valley Project and the California State Water Project for winter-run chinook salmon. National Marine Fisheries Service. February 12, 1993. 81 pp. plus attachments.

SFEP. 1991. Status and trends report on pollutants in the San Francisco Estuary. San Francisco Estuary Project. Final Draft. Prepared under EPA Cooperative Agreement CE-009496-01 by the San Francisco Bay-Delta Aquatic Habitat Institute. March 1991. 240 pp. plus appendices.

SFEP. 1992a. Status and trends report on aquatic resources in the San Francisco Estuary. San Francisco Estuary Project. Public Report. March 1992. 257 pp. plus appendices.

SFEP. 1992b. State of the Estuary: A report on conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. June 1992. 270 pp.

USBR. 1994. Draft biological assessment. Sacramento Basin fish habitat improvement study. U.S. Department of the Interior. Bureau of Reclamation. Mid-Pacific Region. March 1994.

USFWS. 1992. Measures to improve the protection of chinook salmon in the Sacramento/San Joaquin River Delta. WRINT-USFWS-7. July 6, 1992. 61 pp.

USFWS. 1994. Biological opinion on the operation of the Central Valley Project and State Water Project effects on Delta smelt. February 4, 1994. U.S. Fish and Wildlife Service, Region 1, Portland, OR. 34 pp. plus figures.

SWRCB. 1988. Water quality control plan for salinity. San Francisco Bay-Sacramento-San Joaquin Delta Estuary. October 31, 1988.

CHAPTER VI. MODEL DESCRIPTIONS

A number of models are available to estimate the water supply, water quality, and aquatic resource impacts of alternative physical and regulatory conditions in the Bay-Delta Estuary. This chapter provides a brief discussion of the models that were used by the SWRCB to analyze the effects of the alternative standards.

A. DWR's PLANNING SIMULATION MODEL (DWRSIM)

DWRSIM is a generalized computer simulation model designed to simulate the operation of the CVP and the SWP system of reservoirs and conveyance facilities. The model accounts for system operational objectives, physical constraints, legal requirements, and institutional agreements. These parameters include requirements for flood control storage, instream flows for fish and navigation, allocation of storage among system reservoirs, hydropower production, pumping plant capacities and limitations, the COA, and required minimum Delta operations to meet water quality and Delta outflow objectives. A description of both the DWRSIM model and its operations criteria has been prepared by the DWR (Barnes and Chung 1986; DWR 1986, 1992a, 1992b).

DWRSIM studies use the historical 71-year hydrologic sequence of flows from water years 1922 through 1992 as input, adjusted to reflect the effect of estimated 1995 level land use patterns. This adjustment is developed using two other models: the Consumptive Use model and the Depletion Analysis model. The hydrology is also modified to account for current operations of local upstream reservoirs. The entire San Joaquin River system, except for New Melones Reservoir and the Stanislaus River, and local reservoir operations on the Sacramento River are treated as pre-modeled inputs to DWRSIM and are not operated to meet flow or water quality requirements in the Delta.

The CVP and SWP export demand south of the Delta is also based on a 1995 level of development and is adjusted to account for the different hydrologic conditions in central and southern California.

In summary, the model simulation results estimate how the entire system would perform when trying to meet project demands, assuming recurrence of the historical 71-year sequence of hydrology at the 1995 level of development.

DWRSIM has a number of limitations which require that caution be exercised when analyzing or interpreting model results. Many of these limitations are due to lack of information or objective criteria, and would be limitations of any similar model. Some of the more important limitations are discussed below.

1. DWRSIM operates on a monthly time step. Therefore, assumptions must be made to model any standard that is not formulated on a monthly basis. Additionally, peak

storm flows, which are usually considerably higher than monthly average flows, cannot be modeled.

2. The ESA limitations on Delta export pumping based on actual "fish take" cannot be modeled.

3. The CVPIA mandates that 600 to 800 TAF of CVP yield be allocated annually for environmental purposes. The USBR has not yet established criteria on how this obligation will change CVP operations, or how much additional Delta inflow or outflow this mandate will provide. Until such criteria are established, interpretation of modeling results are subject to the uncertainty of the CVPIA allocation.

4. The effect of the ESA requirements or other proposed standards on the sharing formula in the COA is unknown. This sharing will affect relative reservoir levels and available water for delivery between the CVP and SWP.

5. DWRSIM primarily simulates the CVP and SWP system of reservoirs and conveyance facilities. This system is, therefore, used as a surrogate to estimate water supply impacts throughout the Central Valley. Actual responsibility to meet Bay-Delta standards might be allocated among other water users as well. Operations criteria for these other water users must be incorporated into DWRSIM before more detailed modeling can proceed.

6. The Depletion Analysis model accounts for use of ground water, but ground water itself is not physically modeled.

7. DWRSIM is not capable of analyzing the water supply impacts of water quality objectives for the interior stations in the southern Delta because of a lack of adequate understanding of relationships between the San Joaquin River flow and southern Delta water quality.

B. DELTA HYDRODYNAMICS AND WATER QUALITY MODEL (DWRDSM)

DWRDSM is a mathematical model developed to simulate the hydrodynamics and water quality in the Sacramento-San Joaquin Delta. The model is a variant of the Fischer Delta Model, which was developed by Hugo Fischer and is currently under the proprietorship of Flow Science Inc. DWR incorporated a number of modifications to the Fischer Delta Model and created DWRDSM. DWRDSM was specifically designed to simulate salinity changes in the Delta as affected by changes in geometry and hydrology (DWR 1995).

The hydrodynamics of the Delta are described in the model by governing equations for long wave, non-uniform, unsteady flow in prismatic channels. These equations coupled with continuity equations are solved by different numerical schemes for flows, stages, and velocities at discrete locations. The fundamental assumptions made in deriving the governing equations for the hydrodynamics of the Delta are:

1. The flow is assumed to be one dimensional, i.e. the flow in the channel can be approximated with uniform velocity over each cross-section and the free surface is taken to be a horizontal line across the section. This implies that the centrifugal effect due to channel curvature and Coriolis effect are negligible.

2. The pressure is assumed to be hydrostatic, i.e. the vertical acceleration is neglected and the density of the fluid is assumed to be homogeneous.

3. The effects of boundary friction and turbulence can be accounted for through the introduction of a resistance force which is described by the empirical Manning or Darcy Weisbach Friction Factor equations.

The movement of water quality constituents, currently total dissolved solids, is explained in the model by two distinct processes: advection and dispersion. The advection process is largely dependent on flow velocities, which are obtained by solving the hydrodynamics equations. The dispersion process is dependent on the concentration gradient and the dispersion coefficient. The dispersion coefficients vary from one location to another and are commonly used as calibration parameters.

C. RELATIONSHIP BETWEEN OUTFLOW AND X2

There are two models that establish relationships between Delta outflow and X2, the position of the 2 ppt bottom isohaline. The first model was developed by Kimmerer and Monismith (SFEP 1993). This model predicts the location of X2 as a function of the antecedent flows. Isohaline position is a function of net Delta outflow on a particular day and the isohaline position on the previous day, as specified in the following equation:

$$X2_{(t)} = 10.16 + (0.945\ X2_{(t-1)}) - (1.487 \log(\text{Delta outflow}))$$

where $X2_{(t)}$ and $X2_{(t-1)}$ are the 2 ppt positions, in kilometers eastward from the Golden Gate Bridge, at time t and t-1 in days, respectively; and Delta outflow is the net daily mean Delta outflow in cfs.

The second model was developed by Denton (CCWD 1994). This model predicts salinity at a fixed position as a function of the antecedent flows, as specified in the following equations:

$$S(t) = (S_0 - S_b)e^{-\alpha G(t)} + S_b$$

where G(t) is a functional of the antecedent flows; and α, S_0, and S_b are empirically determined constants for the specified position. The functional, G, can be expressed in the following form:

$$dG/dt = (Q - G)G/\beta$$

where Q is the flow rate; and β is an empirically determined constant for the specified position.

D. STRIPED BASS MODEL

Three striped bass models have been developed, using outflow and export or X2 parameters, one by the DFG and two by Jassby. The DFG's model uses the variables of Delta outflow and CVP and SWP exports, and a series of life stage relationships, to predict annual survival from the egg to the 38 mm stage (YOY index) and adult striped bass abundance (DFG 1992a). The two models developed by Jassby predict survival from the egg to both the YOY index and the fall mid-water trawl index, based on X2 (SFEP 1992, 1993). The DFG's striped bass model is used in this document.

The DFG examined the relationships individually between the adult striped bass abundance, the YOY index, export losses, and the loss rate index. A positive correlation between adult abundance and YOY indices, and a negative correlation between adult abundance and both losses and the loss rate index indicate that high adult abundance results from initial strong year classes that experience only minor late summer though winter losses due to export pumping. Impacts of losses vary, depending on time of year and size of entrained fish because survival increases with age and size. Losses of large YOY fish late in the year are potentially more damaging than losses of smaller fish in summer (DFG 1992a).

The model is provided below:

Total YOY = Delta YOY + Suisun YOY + Residual YOY . . . . **Eqn. (1)**

Delta YOY = 69.33 - 0.005058 mean April-July diversion (cfs) . . . . **Eqn. (2)**

Suisun YOY = -158.86 + 46.61 $\log_{10}$ mean April-July outflow (cfs) . . . . **Eqn. (3)**

Residual YOY = [1/(0.0093 + (2.70/eggs))] - 60 . . . . **Eqn. (4)**

Egg production (billions) = 49.27 + 88.01(adult population(millions))^2 . . . . . . **Eqn. (5)**

Log_{10}(loss rate) = 4.482 + 0.00015252 mean August-March export -
0.00000594 mean August-March outflow . . . . **Eqn. (6)**

Legal-sized adults = 3,801,443 + 14,182 weighted mean YOY index - 625,944 $\log_{10}$(weighted mean loss rate) . . . . **Eqn. (7)**

The DFG's striped bass model illustrates the factors affecting adult striped bass abundance. The model indicates that freshwater outflow and water exports during the initial year of life are the primary factors controlling adult striped bass abundance in the Sacramento-San Joaquin Estuary. The model also serves to evaluate relative impacts on striped bass of alternative combinations of outflows and exports (DFG 1992a).

In order to graphically illustrate the information contained within this model, the model was simplified by assuming a constant adult striped bass population, a constant loss rate, and constant YOY indices set at 4, 8, 16, 32, and 64. The export/outflow relationships during the April through July and the August through March periods were then plotted in Figures VI-1 and VI-2, respectively. Figure VI-1 shows that, assuming a constant population, the YOY index is established based on the export/outflow relationship from April through July. Figure VI-2 then shows the export/outflow relationship that must be maintained from August through March, once the YOY index is established, in order to sustain the adult target population. The model indicates that, when the YOY index in the spring is high, larger exports can be tolerated later in the year to achieve the same adult population.

The statistical validity of the DFG's striped bass model has been reviewed (DWR 1992c). This review concluded that the model has poor predictive ability. Statistical criticisms of the model include multicollinearity, autocorrelation, averaging, and propagation of errors.

E. ESTUARINE RESOURCES MODELS

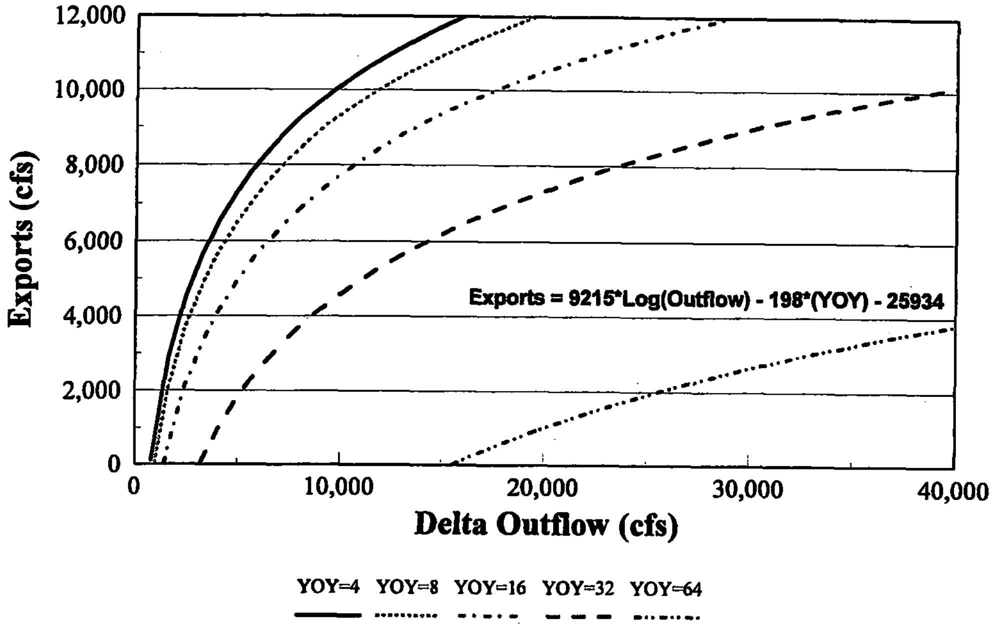
The DFG has sampled the abundance of estuarine and bay fish species for many years. Since 1980, as part of the Interagency Ecological Program (IEP), the DFG has undertaken a specific study to investigate the relationship between Delta freshwater outflow and the abundance and distribution of fish and invertebrates. Factors other than flow can affect fish and invertebrates, but the major objective of this study was to consider outflow as it influences bay fish resources (DFG 1987).

The abundance of 70 species of fish, shrimp, and crabs were analyzed for the years since 1980. A majority of the species (55.6 percent) showed no difference in their abundance between wet and dry years. Most of the species that showed no significant difference in abundance between wet and dry years were marine. In contrast, over two-thirds of the species in the study considered to be estuarine, anadromous, or freshwater were significantly

Figure VI - 1

Striped Bass Model[1]

April-July Average Exports vs. Delta Outflow

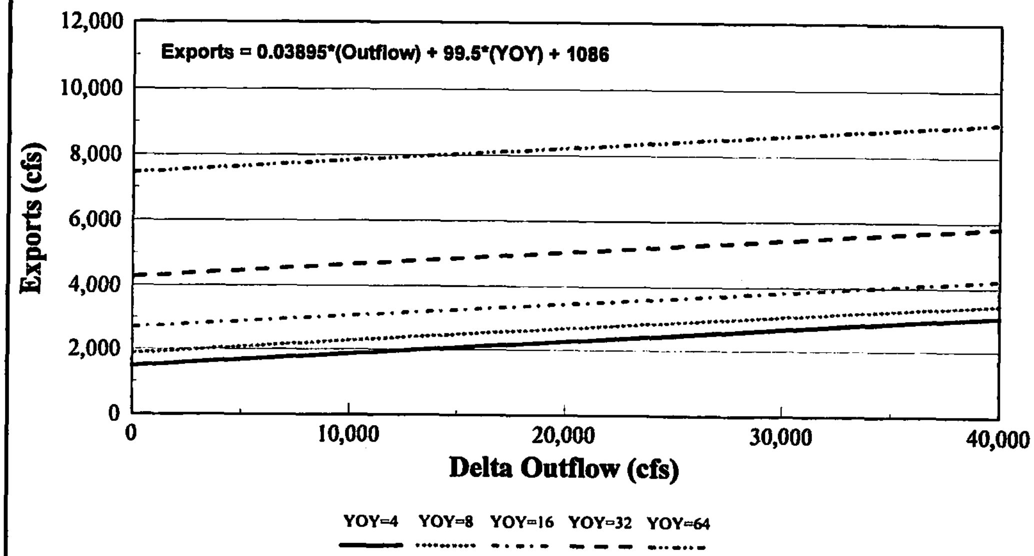


1 - assuming constant population of adult striped bass of 1,000,000 and constant loss rate

Figure VI - 2

Striped Bass Model[1]

August-March Average Exports vs. Delta Outflow



1 - assuming constant population of adult striped bass of 1,000,000 and constant loss rate

more abundant in wet years. Significant positive relationships between Delta outflow and abundance were found for four of these estuarine species: a bay shrimp, *Crangon franciscorum*; longfin smelt; starry flounder; and Sacramento splittail (DFG 1987, 1992a).

In addition to these outflow/abundance relationships, Jassby developed relationships between X2 and several aquatic resources in the Estuary, including: POC; a small mysid shrimp, *Neomysis mercedis*; *C. franciscorum*; starry flounder; longfin smelt; striped bass; and mollusks (SFEP 1992). These aquatic resources were selected because they were found by the DFG to correlate well with outflow, and because they are representative of various trophic levels in the Estuary. The regression equations and the data used to develop the equations are plotted in Figures VI-3 to VI-8. For consistency, the regressions have been expressed as outflow/abundance relationships. A brief discussion of each of the plots is provided below.

1. Particulate Organic Carbon

POC is an expression of food and energy sources at the base of the estuarine food web. Because the upstream areas can be a major source of organic carbon, it follows that flow will influence the amount of organic carbon in the Delta. A positive linear regression was calculated between increasing POC in gigagrams per year (Gg/yr) and increases in the log of average annual outflow (Figure VI-3). Although there is a great deal of variability in the data at lower outflows, at higher Delta outflows, the relationship is fairly strong.

2. *Neomysis mercedis*

The small mysid shrimp, *Neomysis mercedis*, is an important prey item for a number of fish species in the Delta. A positive linear relationship was calculated between the abundance index for the years 1972 and 1990 and average March through November outflow (Figure VI-4).

3. *Crangon franciscorum*

The DFG has developed statistical relationships between the annual abundance of mature *C. franciscorum* and freshwater outflow the previous spring (March through May), and between immature *C. franciscorum* and outflow from March through May of the same year (DFG 1992b, 1994). The DFG selected the March through May period as the most critical for freshwater outflow in the establishment of a strong year class of *C. franciscorum* in the bay because, in this period, the juveniles are recruited into the estuarine nursery areas and grow rapidly. Figure VI-5 illustrates the positive significant relationship between the abundance of immature *C. franciscorum* and the log of the March though May outflow. This model, a logarithmic versus linear relationship, indicates that large increments of increased outflow correlate with small but progressively higher abundance indices of immature *C. franciscorum*.

Figure VI - 3

Particulate Organic Carbon (POC) vs. Delta Outflow

(1975-1989)

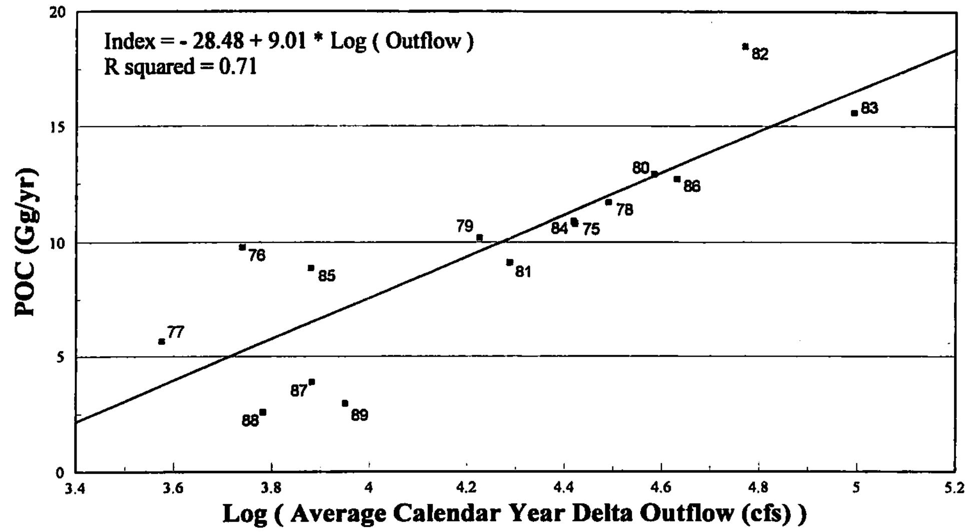


Figure VI - 4

Neomysis Abundance Index vs. Delta Outflow

(1972-1990)

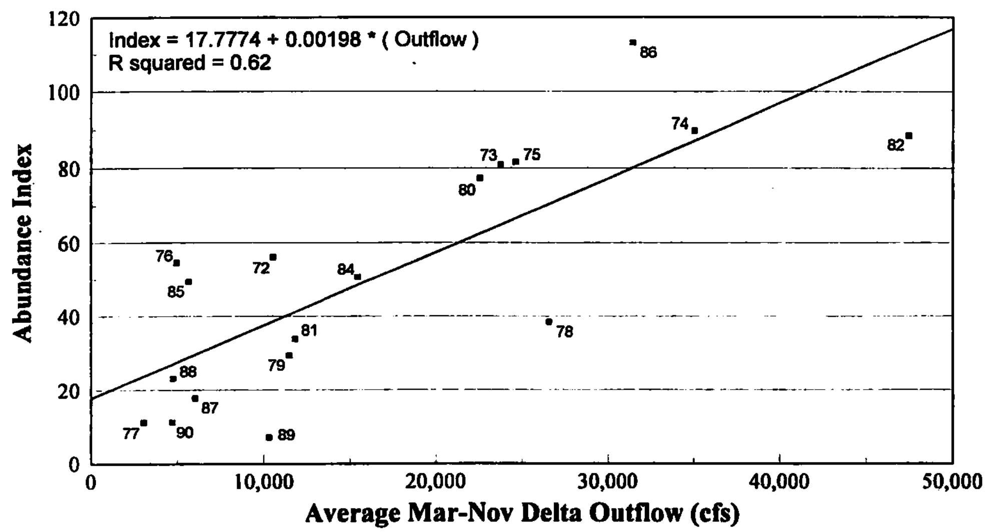


Figure VI - 5

Immature *Crangon franciscorum* Abundance vs. Delta Outflow

(1980-1993)

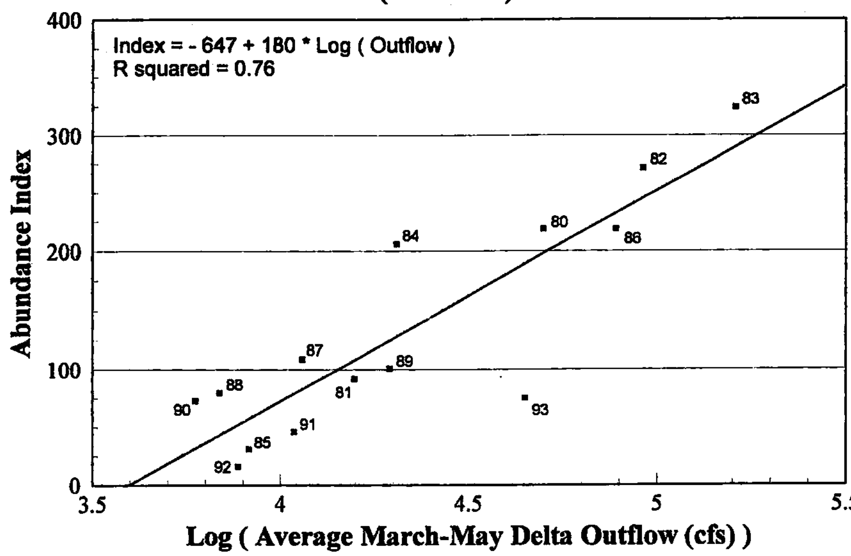
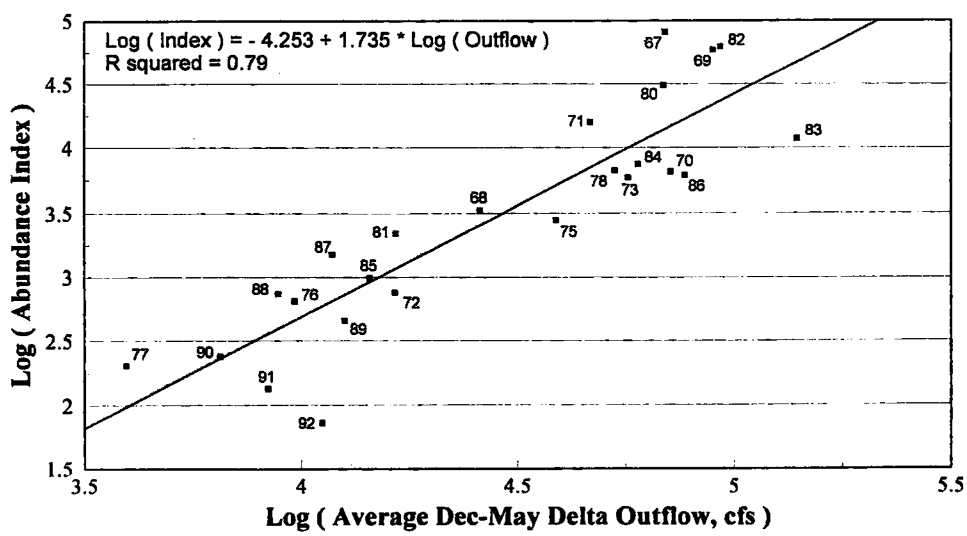


Figure VI - 6

Longfin Smelt Abundance Index vs. Delta Outflow

(1967-1992)



4. Longfin Smelt

The DFG's model for longfin smelt is based upon a significant positive relationship between the log of the abundance index and the log of December through May outflow for the years 1967-1992 (Figure VI-6). Initially, a shorter time period, the February though May period, was considered critical to the success of the longfin smelt year class because larval dispersal, first feeding, and establishment of the brackish nursery habitat all occur during this time. However, the conditions in December and January, months prior to the young moving downstream, have also been found to be important (DFG 1992b). The correlation coefficient for the December through May period is greater than for the February through May period (r^2 of 0.77 and 0.67, respectively) (DFG 1994).

5. Starry Flounder

The DFG developed an abundance index for starry flounder, and compared the log of the March through June outflow at Chipps Island with the log of the 1-year-old starry flounder abundance index for the brood years 1979-1992 (Figure VI-7). This comparison yielded a significant positive relationship. The DFG found that good recruitment of starry flounder is possible during both high and low outflow years, but only poor recruitment occurs when outflow is low. This observation indicates that increased outflow in the Delta does not necessarily guarantee a high abundance index of 1-year-old starry flounder the following year, but it would be more likely than with lower outflows (DFG 1992b).

6. Splittail

The DFG developed an abundance index from the young Sacramento splittail captured in the fall mid-water trawl survey. The DFG then developed a statistical relationship between the juvenile splittail abundance index and March through May outflow, the period in which spawning occurs, for the years 1967-1993 (Figure VI-8). The data are not log transformed, and the model indicates that increased outflow in the spring corresponds with increased splittail abundance index (DFG 1992b). Increases in the splittail abundance index are more apparent when the outflow is greater than 50,000 cfs.

F. SALMON MODELS

The USFWS has developed models for both the Sacramento and San Joaquin rivers which describe survival of fall-run chinook salmon smolts as they migrate through the Delta. For the Sacramento River, the factors that the USFWS believes best describe smolt survival are: water temperature at Freeport; percent flow diverted through the Delta Cross Channel gates and Georgiana Slough; and CVP and SWP exports from April through June (USFWS 1992a, 1992b). On the San Joaquin River, the corresponding primary factors are: percent flow diverted into upper Old River; percent flow remaining in the river at Stockton; temperature at Jersey Point; and CVP and SWP exports in April and May (USFWS 1994). In order to

Figure VI - 7

One-Year-Old Starry Flounder Abundance vs. Previous Year Delta Outflow

(1979-1992)

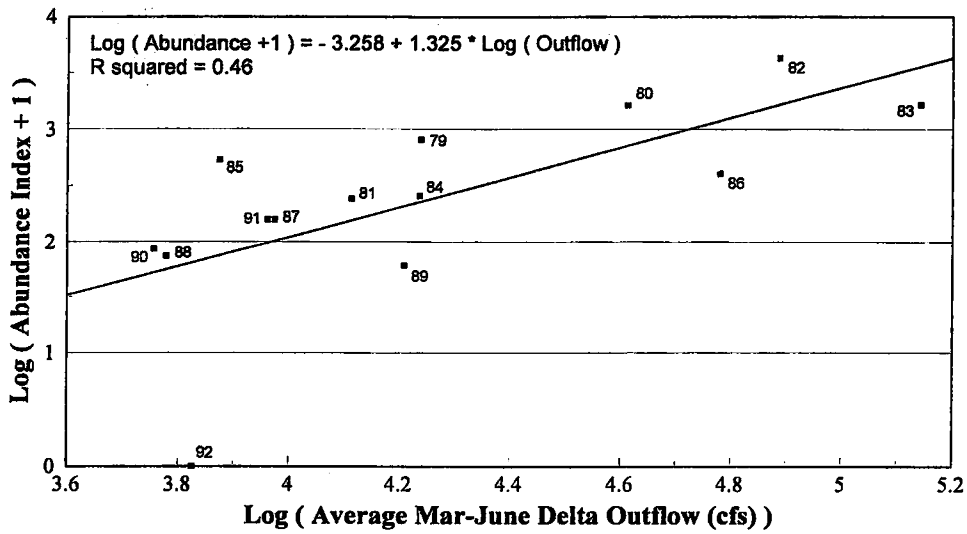
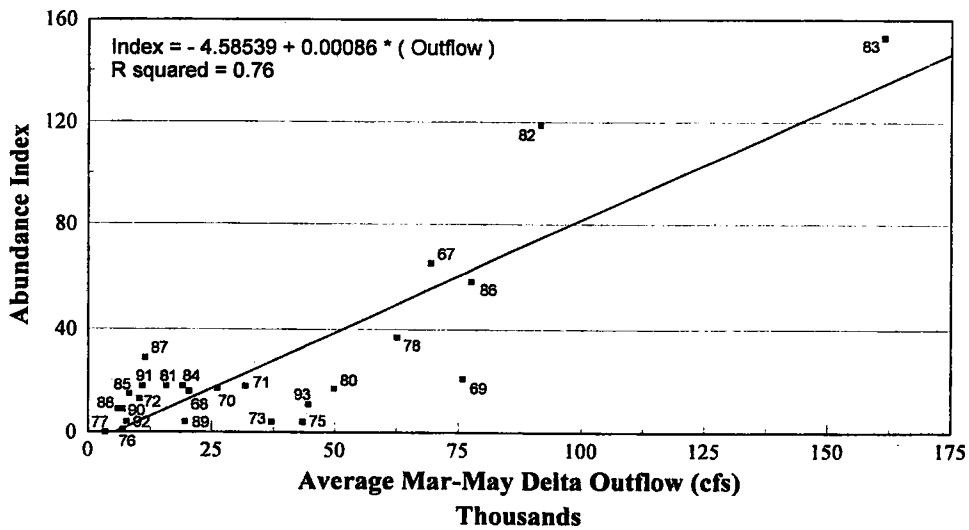


Figure VI - 8

Sacramento Splittail Abundance Index vs. Delta Outflow

(1967-1993)



illustrate the information contained within these models, the models are graphed in Figures VI-9, VI-10, and VI-11.

The model for smolt survival on the Sacramento River illustrates the importance of keeping the migrating salmon smolts on the mainstem of the Sacramento River and minimizing their diversion into the central Delta. Figure VI-9 shows the effect of temperature and export rates on smolt survival when both the Delta Cross Channel gates and Georgiana Slough are open, assuming a flow of 10,000 cfs in the Sacramento River at Sacramento. Under this circumstance, both export rates and temperature have a significant effect on survival. Figure VI-10 shows the corresponding effect of temperature and export rates when the Delta Cross Channel gates are closed and Georgiana Slough is open, with a flow of 10,000 cfs in the Sacramento River. Under these conditions, the effect of export rates on survival is significantly reduced. For example, with the Delta Cross Channel gates and Georgiana Slough open and a temperature of 64°F, exports would need to be maintained at 2,000 cfs in order to achieve a survival index of 0.2. With the same conditions but the Delta Cross Channel gates closed, a survival index of 0.2 could be achieved at an export rate of approximately 5,000 cfs. If both the Delta Cross Channel gates and Georgiana Slough are closed, the lines of constant survival become vertical, and smolt survival becomes independent of export rates.

Similarly, the model for smolt survival on the San Joaquin River illustrates the importance of keeping the migrating salmon smolts on the mainstem of the San Joaquin River and minimizing their diversion into Old River. The San Joaquin River smolt survival model incorporates flows at Vernalis, and mathematically incorporates the flow split at upper Old River and the resulting flow at Stockton, which changes with Old River flow and whether or not the barrier is assumed to be installed. The smolts that migrate down upper Old River and survive are assumed to have gone though the export salvage facilities and then been released into the Delta. The amount of flow in upper Old River substantially affects the survival index. For those smolts that migrate down the mainstem of the San Joaquin River, factors affecting survival include flow, temperature at Jersey Point, and exports. Figure VI-11 shows the effect of temperature, exports, and flow at Vernalis on salmon smolt survival when there is a barrier at the head of Old River.

The models can be used to estimate the relative benefits of implementation measures or operations of controllable parameters in the Delta, specifically, flows, exports, and Delta Cross Channel gate operation, and construction of the Old River barrier. A number of other implementation measures may also beneficially affect smolt survival, but the effects of those other measures have not been modeled.

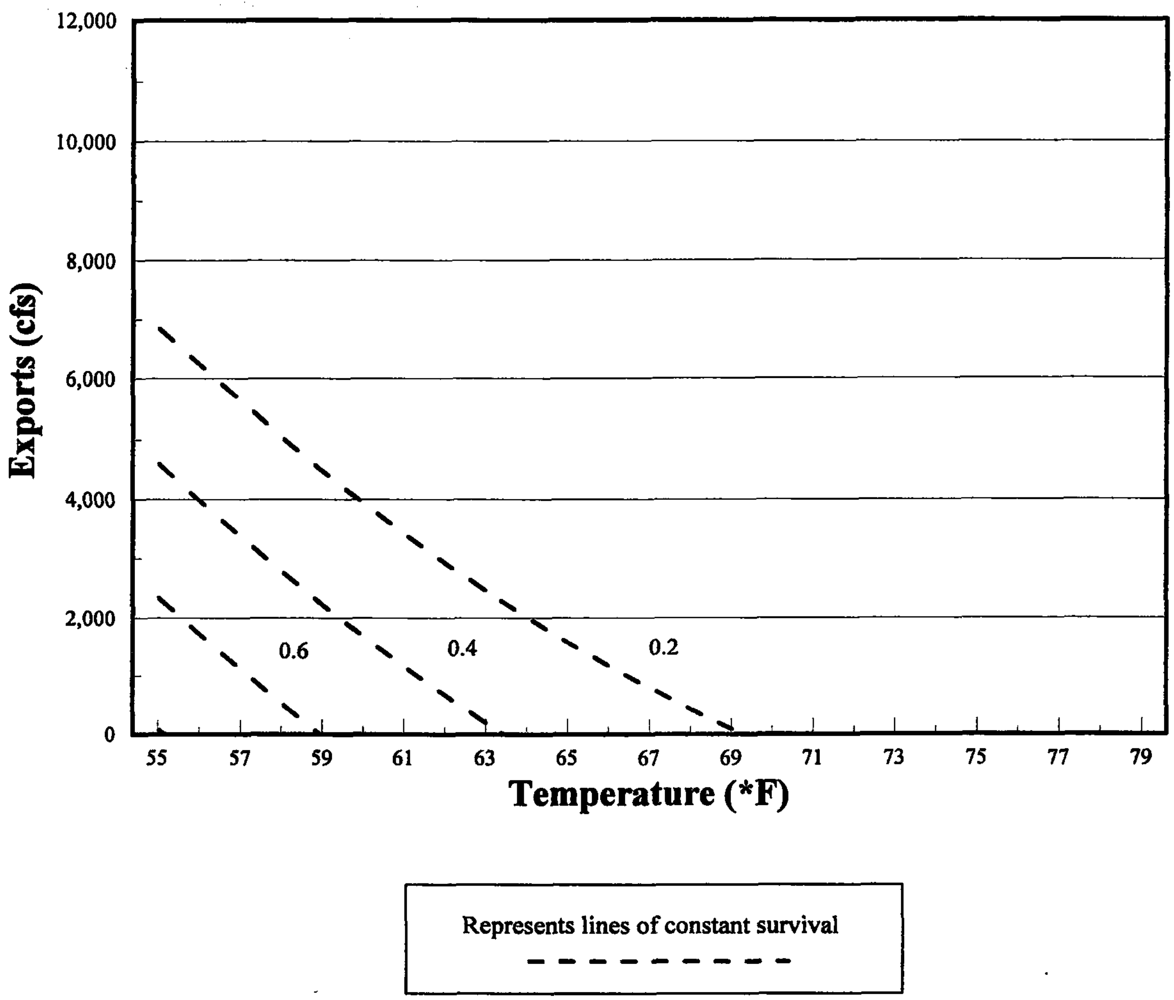
The statistical validity of the USFWS' smolt survival model has been disputed (Kimmerer 1994). A peer review analysis facilitated by Kimmerer concluded that the models are too complex, contain too many parameters, and inappropriately convert smolt survival index values to probabilities to calculate survival through successive reaches of the Delta.

Figure VI-9

Sacramento Salmon Smolt Survival Index

Delta Cross Channel and Georgiana Slough Open

(Sacramento River Flow 10,000 cfs at Sacramento)



Y = 1-[(-2.46 + 0.04T) + (-0.59 + 0.02T + 4.3E-05X)(P1) + (-1.61 + 0.03T)(P2)
- (-2.46 + 0.04T) * (-0.59 +0.02T + 4.3E-05X)(P1) - (-2.46 + 0.04T)
* (-1.61 + 0.03T)(P2)

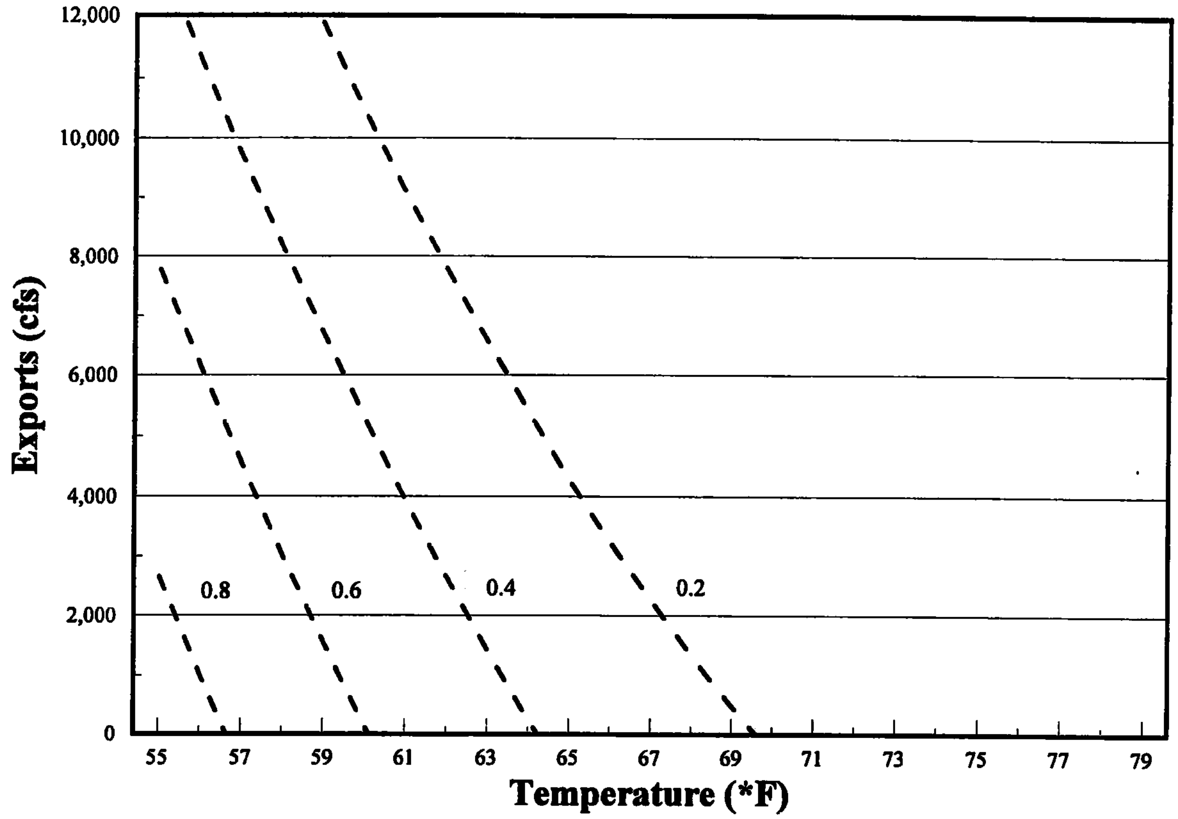
Y = Sacramento Smolt Survival Index
T = Mean monthly water temperature at Freeport (*F)
X = Mean monthly CVP+SWP exports (cfs)
P1 = Percent of water diverted into Delta Cross Channel and Georgiana Slough at Walnut Grove (flow at Sacramento-Steamboat and Sutter Sloughs)
P2 = Percent of water remaining in Sacramento River downstream of Walnut Grove (1-P1)

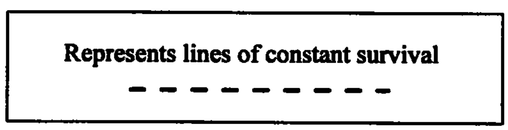
Figure VI-10

Sacramento Salmon Smolt Survival Index

Delta Cross Channel Closed and Georgiana Slough Open

(Sacramento River Flow 10,000 cfs at Sacramento)





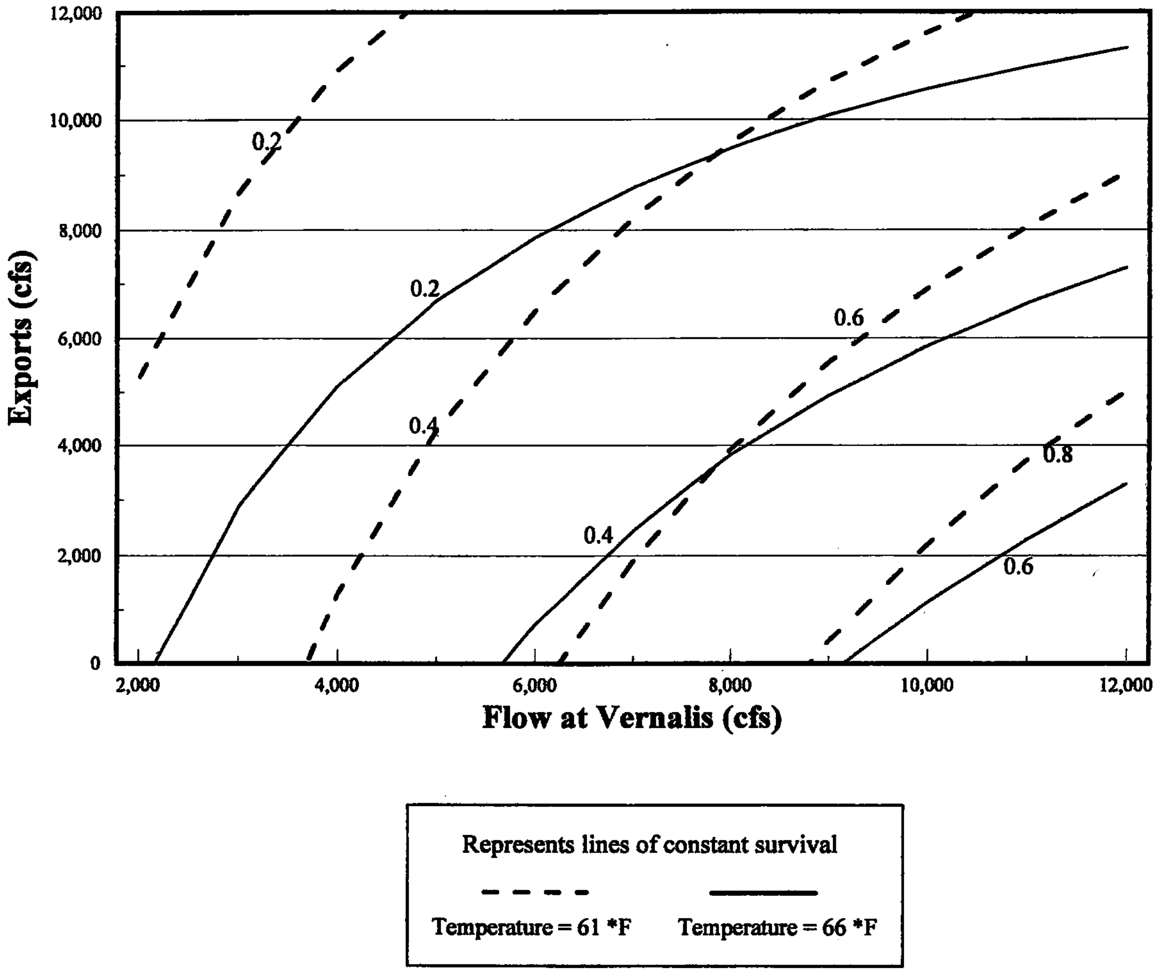
Y = 1-[(-2.46 + 0.04T) + (-0.59 + 0.02T + 4.3E-05X)(P1) + (-1.61 + 0.03T)(P2)
- (-2.46 + 0.04T) * (-0.59 +0.02T + 4.3E-05X)(P1) - (-2.46 + 0.04T)
* (-1.61 + 0.03T)(P2)

Y = Sacramento Smolt Survival Index
T = Mean monthly water temperature at Freeport (*F)
X = Mean monthly CVP+SWP exports (cfs)
P1 = Percent of water diverted into Delta Cross Channel and Georgiana Slough at Walnut Grove (flow at Sacramento-Steamboat and Sutter Sloughs)
P2 = Percent of water remaining in Sacramento River downstream of Walnut Grove (1-P1)

Figure VI-11

San Joaquin Salmon Smolt Survival Index

with a Barrier at the Head of Upper Old River
San Joaquin River Flow at Vernalis



Y = 1-[((P2)(1.01-0.0003(X1))+(P3)((0.876-0.00007(X2))+(3.66+.058(X3) +0.00005(X4))-(0.876-0.00007(X2))(-3.66+0.058(X3)+0.00005(X4)))]

Y = San Joaquin Salmon Smolt Survival Index
X1= Mean daily flow in Upper Old River (cfs)
X2= Mean daily flow at Stockton (cfs)
X3 = Mean monthly water temperature at Freeport (*F)
X4 = Mean monthly CVP+SWP exports (cfs)
P2 = Percent of water diverted in Upper Old River
P3 = Percent of water remaining in San Joaquin River (1-P2)

Literature Cited in Chapter VI

Barnes, G. and F. Chung. 1986. Operational planning for California water system. Journal of Water Resources Planning and Management 112:71-86.

CCWD. 1994. Report on Clean Water Act X2 water quality standards. Contra Costa Water District. February 1994. 44 pp.

DFG. 1987. Delta outflow effects on the abundance and distribution of San Francisco Bay fish and invertebrates, 1980-1985. California Department of Fish and Game. (I-DFG-60)

DFG. 1992a. A model for evaluating the impacts of freshwater outflow and export on striped bass in the Sacramento-San Joaquin Estuary. 44 pp. plus appendices. (WRINT-DFG-3)

DFG. 1992b. Estuary dependent species. 97 pp. (WRINT-DFG-6)

DFG. 1994. Department of Fish and Game comments on delta issues of State Water Resources Control Board's May Workshop for Review of Standards for San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Presented by Perry L. Hergessell, Chief of Bay-Delta and Special Water Projects Division, May 16, 1994.

DWR. 1986. Operations criteria applied in DWR planning simulation model. California Department of Water Resources. 62 pp.

DWR. 1992a. Comparison of DWRSIM versus the historical measured inflow to the Delta. 13 pp. (WRINT-DWR-135)

DWR. 1992b. 1995 level hydrology for the Central Valley of California (Excluding Tulare Basin). 25 pp. (WRINT-DWR-136)

DWR. 1992c. Predictive ability of the striped bass model. July 27, 1992. 18 pp. (WRINT-DWR-206)

DWR. 1995. Delta hydrodynamics and water quality model (DWRDSM). Description of model by Francis Chung. April 21, 1995. 2 pp.

Kimmerer, W. 1994. Setting goals for salmon smolt survival in the Delta. August 10, 1994. 15 pp.

SFEP. 1992. The 2 ppt bottom isohaline as an index of conditions for biological resources. Alan D. Jassby, Division of Environmental Studies, University of California, Davis. June 17, 1992. Entered by the San Francisco Estuary Project, U. S. Environmental Protection Agency, San Francisco, California. 12 pp. (WRINT-SFEP-8)

SFEP. 1993. Managing freshwater discharge to the San Francisco Bay-Delta Estuary: the scientific basis for an estuarine standard. San Francisco Estuary Project, U.S. Environmental Protection Agency, San Francisco, California. 17 pp. plus appendices.

USFWS. 1992a. Measures to improve the protection of chinook salmon in the Sacramento/San Joaquin River Delta. Expert testimony of the USFWS on chinook salmon technical information for the State Water Resources Control Board water rights phase of the Bay/Delta Estuary Proceedings, July 1992. 61 pp. (WRINT-USFWS-7)

USFWS. 1992b. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary. 1991 Annual Progress Report. June 1992. 100 pp. (WRINT-USFWS-9)

USFWS. 1994. The development of a refined San Joaquin Delta salmon smolt model. Draft. May 31, 1994. 25 pp.

CHAPTER VII. WATER SUPPLY IMPACTS OF PREFERRED ALTERNATIVE

This chapter presents the analysis of the preferred alternative's water supply impacts compared to those of the D-1485 base case. No inference should be made from this analysis regarding distribution of water supply impacts to specific water users. The SWRCB has not determined who will share in that responsibility, or how the impacts will be allocated. In this analysis, the SWP and the CVP are used as surrogates in order to determine the overall water supply impacts of the preferred alternative. The allocation process will be the subject of a water rights proceeding which will commence following adoption of the plan.

The water supply impacts of the preferred alternative are evaluated with the DWR's Planning Simulation Model, DWRSIM, by comparing the modeled results from the D-1485 base case study with the results from the preferred alternative study[1]. The D-1485 base case is described on page VII-5. The modeled impacts represent the overall impacts of replacing one set of objectives with another. Complete characterization of the water supply impacts requires consideration of three components: total export reductions, Sacramento River Basin storage changes, and San Joaquin River Basin water supply impacts. Table VII-1 provides a summary of water supply impacts for the preferred alternative relative to the base case. Export levels and reservoir storage are also discussed in Chapter VIII as a component of the environmental impact analysis.

A. MODELING ASSUMPTIONS (DWR 1994, 1995a)

This section discusses the major assumptions and operations criteria used in the model. A description of these and additional DWRSIM assumptions has been prepared by the DWR (DWR 1995a).

Hydrology. DWRSIM operates on a monthly time basis and uses the historical 71-year hydrologic sequence of flows from water years 1922 through 1992, with 1995 level hydrology and upstream depletions based on land use projections from DWR Bulletin 160-93.

Water Year Classification. Unless specified otherwise, the 60-20-20 San Joaquin Valley water year hydrologic classification system applies to all San Joaquin River flow requirements, and the 40-30-30 Sacramento Valley water year hydrologic classification system applies to all other objectives. These hydrologic classification systems are described in Chapter II.

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[1] Modeled conditions under the base case and preferred alternative are obtained from preliminary DWRSIM operation studies conducted by the DWR to assess the impacts of the draft plan of December 15, 1994 (Studies 1995c6b-MONTERY-412 and 1995c6b-SWRCB-409.MONT, respectively)

TABLE VII-1
Water Supply Impacts of the Preferred Alternative
Relative to the D-1485 Base Case
(TAF per year)

COMPONENT	Critically Dry Period Average (May 1928 - Oct 1934)	71-Year Average (1922 - 1992)
Annual exports (CVP, SWP, Contra Costa, North Bay)	-816	-229
Adjustment for upstream reservoir storage used	-32	NA
Adjustment for additional flows in excess of New Melones releases needed to meet San Joaquin River requirements	-139	-71
Average annual carryover storage in Sacramento River Basin	NA	17
Average annual carryover storage in New Melones Reservoir	NA	-666

Export Demand. Table VII-2 shows the 1995 level CVP export demand used in DWRSIM. Maximum SWP contractor demand in DWRSIM varies in response to local wetness indices, as shown in Table VII-3. In wetter years, San Joaquin Valley agricultural contractors receive reduced deliveries based on a wetness index developed from annual Kern River inflows to Lake Isabella. Similarly, the Metropolitan Water District (MWD) of Southern California receives reduced deliveries based on a 10-station southern California 2-year average precipitation index. Total SWP demand ranges from 2.619 MAF in wet years to 3.574 MAF in dry years, and total combined CVP and SWP demand ranges from 5.914 MAF to 6.869 MAF, respectively. Figure VII-1, on page VII-7, shows the frequency of maximum combined CVP and SWP demand used in DWRSIM over the historical 71-year hydrologic period.

CVP and SWP Sharing Formula. CVP and SWP sharing of responsibility for the coordinated operation of the two projects is maintained per the COA. Storage withdrawals for in-basin use are split 75 percent CVP and 25 percent SWP, and surplus flows are split 55 percent CVP and 45 percent SWP. The preferred alternative includes exports restrictions based on percent of Delta inflow diverted. Sharing of responsibility for these new standards is not specified under the present COA. An arbitrary sharing ratio of 50 percent CVP and 50 percent SWP is used whenever these export restrictions are controlling.

SWP Monterey Agreement. The Monterey Agreement between the State Water Contractors and the DWR is a set of principles which address various SWP administrative and operational issues, including amending SWP contracts to provide that all future allocations of project water from existing project facilities be based on entitlements, irrespective of type of use. The principles do not affect the annual SWP export amount, but will determine how that total amount is allocated among the SWP contractors and how contractors may manage that water once it is allocated to them.

SWP and CVP Pumping. The SWP Banks Pumping Plant's average monthly capacity with four new pumps is 6,680 cfs (or 8,500 cfs in some winter months) in accordance with the USCOE permit criteria. The CVP Tracy Pumping Plant's capacity is 4,600 cfs. However, constraints along the Delta-Mendota Canal and at the relift pumps to O'Neill Forebay restrict export capacity to 4,200 cfs during many months.

DWRSIM includes wheeling of CVP water through SWP facilities to San Luis Reservoir. When there is unused pumping capacity available at the Banks Pumping Plant, the study allows CVP wheeling as needed to meet only Cross Valley Canal demands.

San Joaquin River Flow Requirements. DWRSIM makes releases from New Melones Reservoir to meet flow requirements on the San Joaquin River. If there is insufficient water in New Melones to meet all of the requirements, the model obtains additional water from unspecified sources.

TABLE VII-2 1995 Level CVP Demand	
CVP UNIT	**TAF/year**
Contra Costa Canal	145
Delta-Mendota Canal and Exchange	1,496
CVP San Luis Unit	1,447
San Felipe Unit	135
Cross Valley Canal	72
TOTAL CVP DELTA DEMAND	**3,295**

TABLE VII-3 1995 Level SWP Demand				
MAXIMUM SWP DELIVERY	**DRY YEARS**	**AVERAGE YEARS**	**ABOVE AVERAGE YEARS**	**WET YEARS**
Kern River Flow (TAF)	<1,000	<1,000	1,000-1,400	>1,400
Maximum SWP Agriculture Delivery (TAF)	1,220	1,220	1,100	915
Southern California Precipitation (inches/yr)	<15	15-17.9	18-20.9	≥21
Maximum MWD Delivery (TAF)	1,450	1,200	900	800
Maximum Other SWP M&I Delivery (TAF)	840	840	840	840
Fixed Losses & Recreation (TAF)	64	64	64	64
TOTAL SWP DELTA DEMAND (TAF)	**3,574**			**2,619**

San Joaquin River Water Quality Objectives at Vernalis. After flow requirements on the San Joaquin River are met, DWRSIM obtains additional water releases from New Melones Reservoir, up to a maximum amount of 70 TAF per year, when necessary to meet water quality objectives at Vernalis.

Base Case. The base case for this analysis is D-1485 conditions, modified to account for upstream requirements on the Sacramento River imposed by the NMFS to protect winter-run chinook salmon. This base case was selected, even though the NMFS biological opinion has been in effect since 1992, because (1) the principal biological decline occurred under D-1485 regulatory conditions; (2) the objectives in the plan are intended to provide reasonable protection to all aquatic resources, including endangered species; (3) the preferred alternative, when compared with this base, shows the maximum reduction in exports of water from the Delta[2]; and (4) this base represents the SWRCB's currently implemented regulatory requirements that impact Bay-Delta water supplies. The following conditions define the base case for DWRSIM studies:

i) Delta conditions must satisfy D-1485 requirements.

ii) End-of-water-year (September 30) carryover storage in Shasta Reservoir must be maintained at 1.9 MAF in all but some critical years to provide suitable temperature conditions in the upper Sacramento River during the winter-run chinook salmon spawning and incubation period.

iii) New Trinity River minimum fish flows below Lewiston Dam are maintained per the May 1991 agreement between the USBR and the USFWS.

iv) Sacramento River minimum fish flows below Keswick Dam are maintained per the agreement between the USBR and the DFG, revised in October 1981.

v) Feather River fish flows are maintained per the August 26, 1983 agreement between the DWR and the DFG.

vi) Lower American River minimum fish and recreation flows are based on the available storage in Folsom Lake per USBR operation criteria.

vii) Stanislaus River minimum fish flows below New Melones vary based on storage levels, in accordance with Water Right Decision 1422 (D-1422) and the interim agreement of June 1987 between the USBR and the DFG.

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[2] Actions under the federal ESA have impacted water supplies to a similar extent as the preferred alternative. If the preferred alternative were compared with the more recent actions by other agencies, the comparison would show no measurable impact on water supplies.

B. TOTAL EXPORTS

For the water supply impact analysis in this section, total exports include SWP Banks Pumping Plant exports, CVP Tracy Pumping Plant exports, Contra Costa Canal exports, North Bay Aqueduct exports, and the City of Vallejo's diversions. Figure VII-2 shows average annual exports under the base case and the preferred alternative by water year type, with 71-year (1922-1992) and critically dry period (May 1928-October 1934) averages. Under the preferred alternative, average annual exports for individual water year types range from a wet-year average of 6.47 MAF to a critical-year average of 4.21 MAF. The 71-year average annual exports under the preferred alternative is 5.89 MAF, while the critically dry period average is 4.33 MAF.

Figure VII-3 shows the average annual change in exports from the base case. Under the preferred alternative, exports are increased by 110 TAF in wet years, and are decreased by 37 TAF in above normal years, 232 TAF in below normal years, 477 TAF in dry years, and 668 TAF in critical years. In wet years, individual annual impacts on exports range from an increase of 723 TAF to a reduction of 572 TAF; in above normal years, from an increase of 162 TAF to a reduction of 284 TAF; in below normal years, from an increase of 96 TAF to a reduction of 715 TAF; in dry years, from reductions of 218 TAF to 1,131 TAF; and in critical years, from reductions of 92 TAF to 988 TAF. Over the 71-year hydrologic period, the average annual export reduction is 229 TAF. For the critically dry period, annual exports are reduced by an average of 816 TAF under the preferred alternative. The maximum impact occurs in 1930, a dry year, when annual exports under the preferred alternative are reduced by 1.13 MAF from the base case.

Figure VII-4 shows the frequencies of exports over the 71-year hydrologic period under the base case and the preferred alternative. In 63 percent of years, annual exports under the preferred alternative would be at or above the 71-year average of 5.89 MAF. The minimum export in any one year is 3.21 MAF in 1977, while the maximum is 7.46 MAF in 1982.

C. SACRAMENTO RIVER BASIN STORAGE

To determine the effect of the preferred alternative on reservoir storage in the Sacramento River Basin, end-of-September carryover storage under the preferred alternative was compared to that of the base case. Reservoirs included in this analysis are the CVP's Clair Engle, Whiskeytown, Shasta, and Folsom reservoirs, and the SWP's Oroville Reservoir. The total storage capacity of these reservoirs is 11.7 MAF.

Under the preferred alternative, the 71-year average carryover storage in CVP reservoirs increased by 80 TAF from the base case; while that of the SWP's Oroville Reservoir decreased by 63 TAF. Combined, the 71-year average carryover storage in the Sacramento River Basin increased by 17 TAF under the preferred alternative.

FIGURE VII-1
FREQUENCY OF MAXIMUM SWP & CVP DEMAND USED IN DWRSIM STUDIES OVER 71-YEAR HYDROLOGY

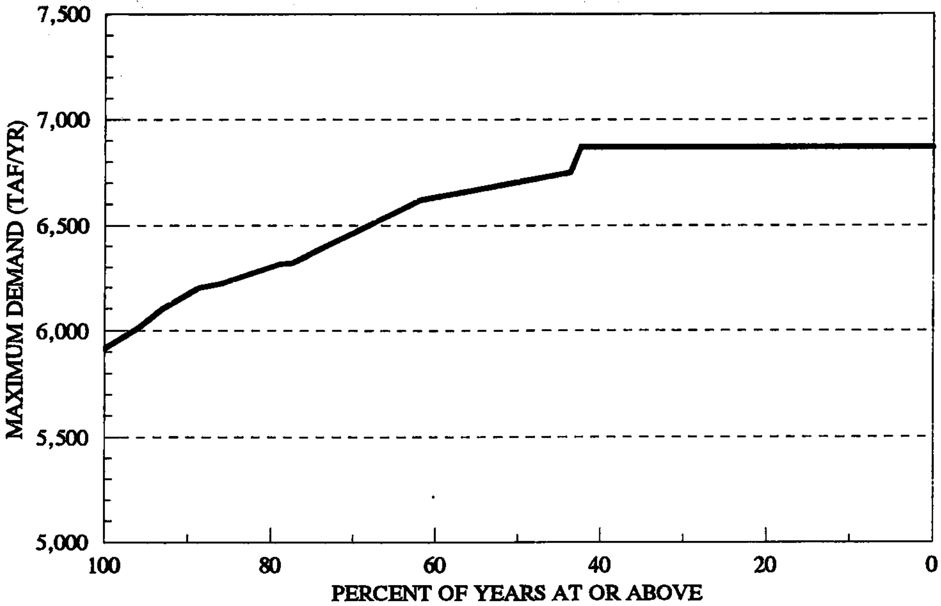
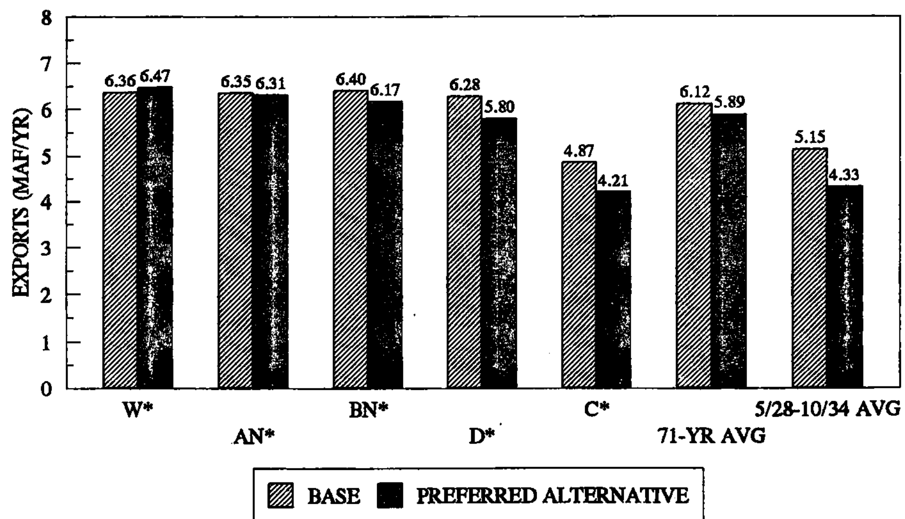
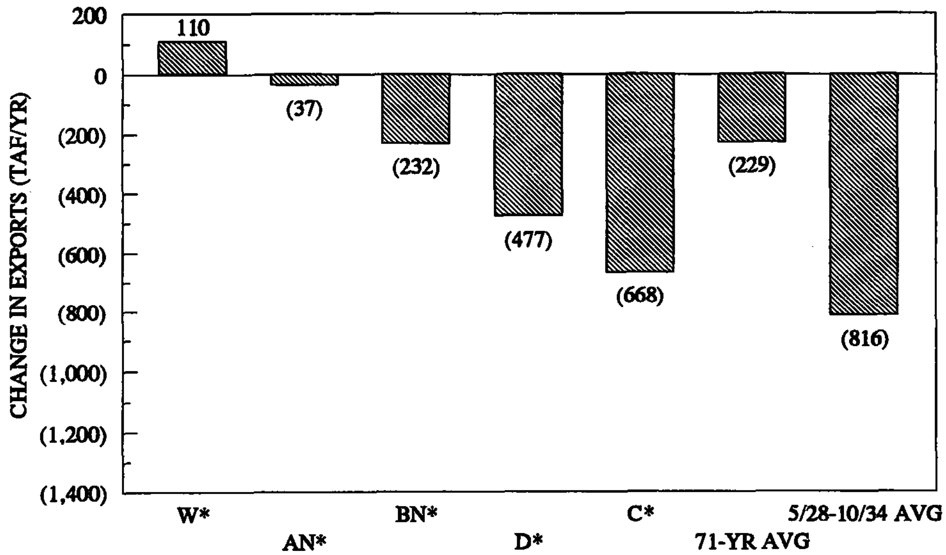


FIGURE VII-2
COMPARISON OF AVERAGE ANNUAL EXPORTS BETWEEN BASE CASE AND PREFERRED ALTERNATIVE



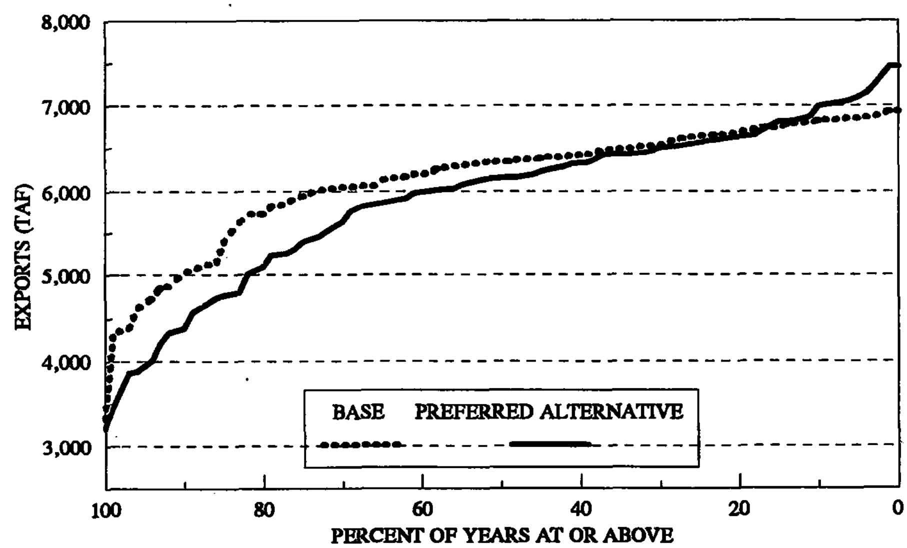
*Average exports for water year type over the 71-year hydrology
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo diversions.

FIGURE VII-3
AVERAGE ANNUAL CHANGE IN EXPORTS UNDER PREFERRED ALTERNATIVE FROM BASE CASE



*Average change in exports for water year type over the 71-year hydrology
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo diversions.

FIGURE VII-4
FREQUENCY OF ANNUAL EXPORTS OVER 71-YEAR HYDROLOGY



Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo diversions

Figure VII-5 shows the average carryover storage in Sacramento River Basin reservoirs. For the 71-year hydrology, average carryover storage under the preferred alternative is increased by 174 TAF in wet years and is decreased by 2 TAF, 26 TAF, 30 TAF, and 146 TAF in above normal, below normal, dry, and critical water years, respectively, from the base case. Figure VII-6 shows the frequency of upstream carryover storage volume over the 71-year hydrology under the base case and the preferred alternative. In 51 percent of years, carryover storage under the preferred alternative would be at or above the 71-year average of 7.23 MAF per year. Under the preferred alternative, the minimum carryover storage in any one year is 2.44 MAF in 1922, while the maximum is 10.5 MAF in 1983.

For the critically dry period, the impact on storage for upstream reservoirs in the Sacramento River Basin and New Melones Reservoir in the San Joaquin River Basin is characterized as the net change in upstream storage between the preferred alternative and the base case. The change in storage for each case is derived by subtracting storage at the end of October 1934 from storage at the beginning of May 1928, dividing by 6.5 for an annual average, and subtracting losses due to evaporation. The changes in upstream storage are 1,208 TAF under the base case, and 1,240 TAF under the preferred alternative. Therefore, under the preferred alternative, there is a net reservoir storage decrease of 32 TAF from the base case.

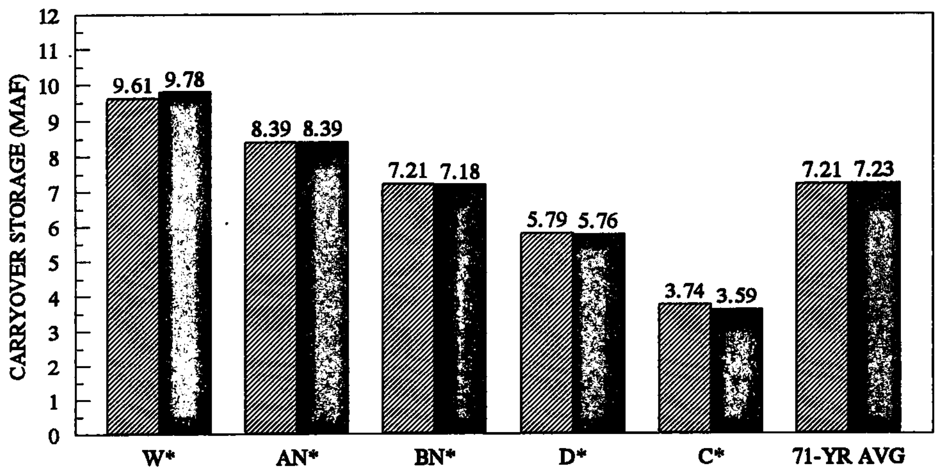
D. SAN JOAQUIN RIVER BASIN

DWRSIM does not model the San Joaquin River Basin in the same detail as the Sacramento River Basin. Reservoirs on the Merced and Tuolumne rivers are not modeled; instead, a base flow on the San Joaquin River upstream of the Stanislaus River is assumed. Consequently, the water supply impacts of the preferred alternative are less certain in the San Joaquin River Basin.

The model analysis of salinity objectives on the San Joaquin River at Vernalis assumes that salinity will be controlled by releases from New Melones Reservoir exclusively, and that releases from New Melones for this purpose would be limited to no more than 70 TAF annually. The first assumption is based on requirements in D-1422, which sets the water right terms for the operation of New Melones. D-1422 requires New Melones releases for salinity control at Vernalis. The second assumption is not based on any legal limits. D-1422 does not limit the amount of reservoir water that should be allocated for salinity control. However, the assumption of a cap is reasonable because salinity control over the long term is unlikely to be achieved exclusively through releases of high quality water from upstream reservoirs. Additional measures, including control of saline discharges and discharge of saline water to a salt sink, must also be considered. The SWRCB will consider the issue of salinity control at Vernalis during the water right phase of the proceedings.

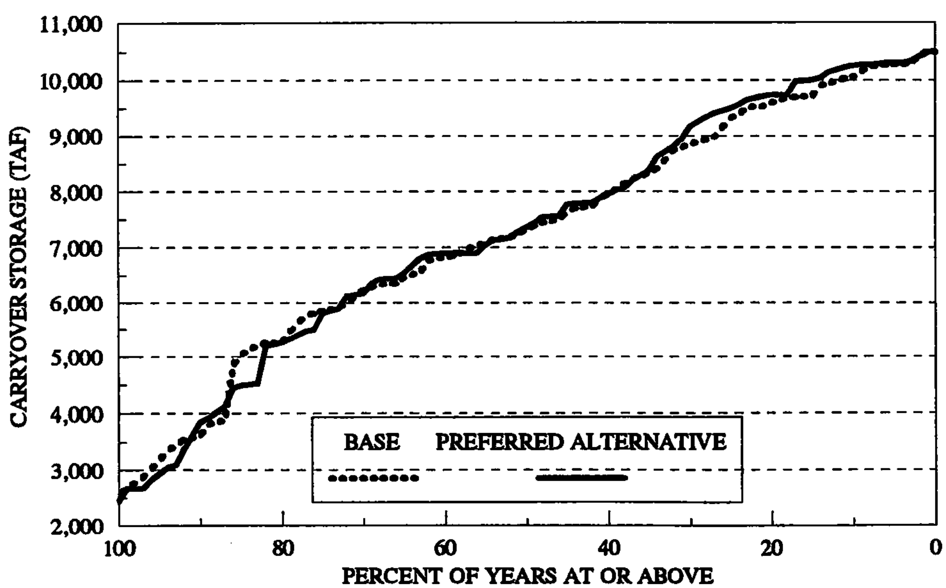
There are two limiting cases for characterizing the water supply impact of new flow objectives at Vernalis on the San Joaquin River Basin. The first limiting case assumes that the water necessary to achieve the objectives is obtained by reducing storage in San Joaquin Valley reservoirs. The second limiting case assumes that the water is obtained by reducing

FIGURE VII-5
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE IN SACRAMENTO RIVER BASIN RESERVOIRS



Includes Clair Engle, Whiskeytown, Shasta, Oroville and Folsom Reservoirs
*Average carryover storage for water year type over 71-year hydrology

FIGURE VII-6
FREQUENCY OF CARRYOVER STORAGE IN SACRAMENTO RIVER BASIN OVER 71-YEAR HYDROLOGY



Includes Clair Engle, Whiskeytown, Shasta, Oroville and Folsom Reservoirs deliveries to customers in the basin, with reservoir storage unchanged from the base case. In actuality, water users are likely to meet the requirements through a combination of these two measures.

For modeling purposes, the DWR was requested to model the first limiting case by assuming that all water in the San Joaquin River Basin necessary to meet the requirements of the plan be released from New Melones Reservoir, and that any flow requirements in excess of New Melones capacity be identified as "additional flows in excess of New Melones releases" required on the San Joaquin River. The purpose of this request was to use New Melones as a surrogate for total possible storage reductions on the San Joaquin River. The output from this study can also be used to analyze the second limiting case by comparing the additional flow required on the San Joaquin River at Vernalis between the base case and the preferred alternative. The results of these analyses are discussed below.

1. New Melones Reservoir Carryover Storage

New Melones Reservoir has a storage capacity of 2.4 MAF. DWRSIM results indicate that, under the preferred alternative, in 20 years, water in excess of New Melones releases is required to meet the Vernalis flow requirements. The average annual additional flows in excess of New Melones releases required is 71 TAF over the 71-year hydrology, and 139 TAF during the critically dry period.

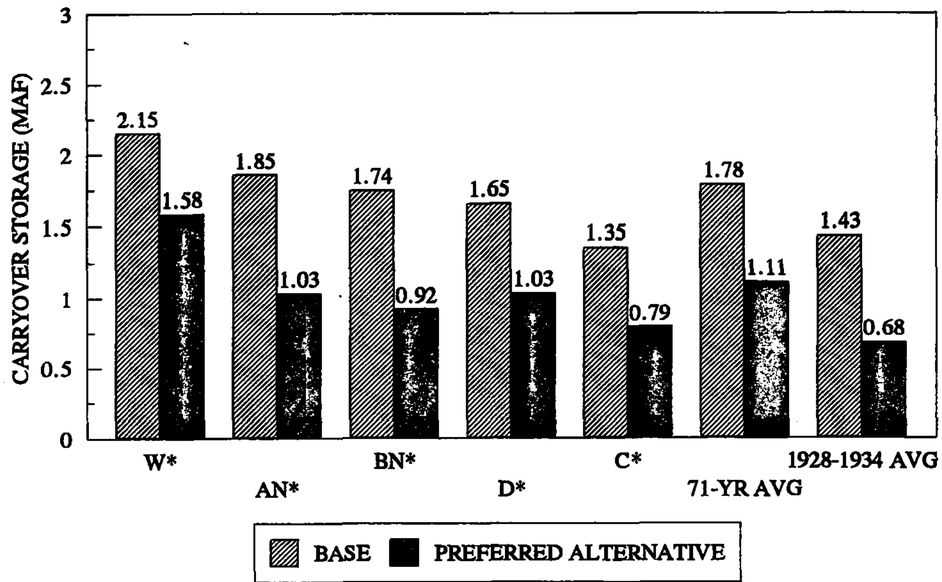
Figure VII-7 shows the average end-of-September carryover storage in New Melones. For the 71-year hydrology, average carryover storage under the preferred alternative is reduced by 562 TAF, 822 TAF, 828 TAF, 618 TAF, and 558 TAF in wet, above normal, below normal, dry, and critical years, respectively. The average annual storage reduction over the 71-year period is 666 TAF, and the reduction during the 1928-1934 period is 755 TAF.

Figure VII-8 shows frequencies of carryover storage volume in New Melones over the 71-year hydrology under the base case and the preferred alternative. In 45 percent of years, carryover storage under the preferred alternative would be at or above the 71-year average of 1.11 MAF. The minimum carryover storage under the proposed objectives is 300 TAF in 1934, while the maximum is 2.27 MAF which occurs in 1969, 1982, and 1983.

2. San Joaquin River Flow

The preferred alternative specifies minimum flow requirements on the San Joaquin River at Vernalis from February through June, and in October. As shown in Figure VII-9, over the 71-year hydrology, the preferred alternative requires, on average, additional flows from the base case of 3.4 TAF in February, 19.9 TAF in March, 90.7 TAF in April, 91.1 TAF in May, 19.8 TAF in June, and 16.3 TAF in October. Incidentally, the additional flows in February through June also provide water for meeting the San Joaquin River salinity objectives in these months. Thus, the balance of the 70 TAF required from New Melones for salinity control is shifted to later in the year. As result, Figure VII-9 shows additional

FIGURE VII-7
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE IN NEW MELONES RESERVOIR



*Average carryover storage for water year type over 71-year hydrology

FIGURE VII-8
FREQUENCY OF CARRYOVER STORAGE IN NEW MELONES OVER 71-YEAR HYDROLOGY

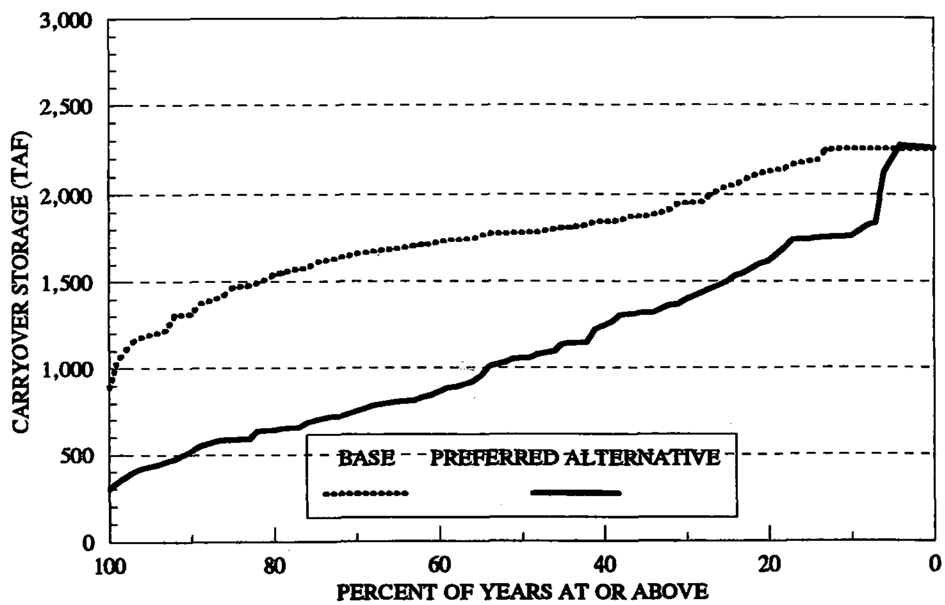
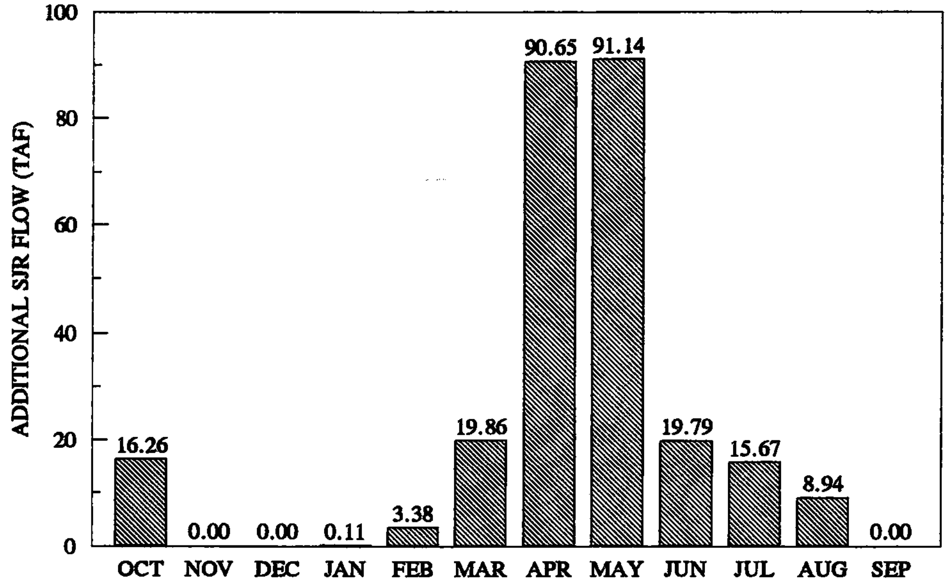
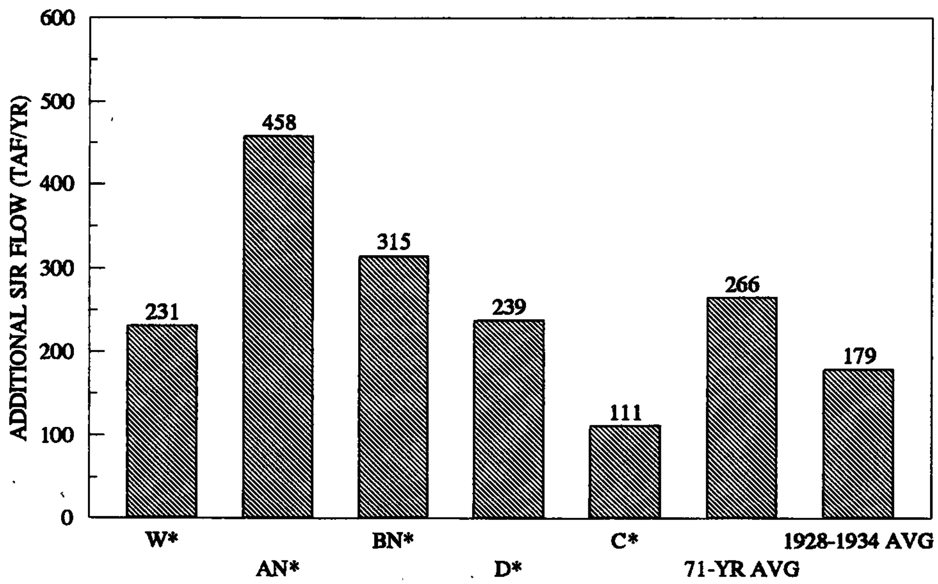


FIGURE VII-9
AVERAGE MONTHLY ADDITIONAL SAN JOAQUIN RIVER FLOW
UNDER PREFERRED ALTERNATIVE FROM BASE CASE



Average additional SJR flow from base case over 71-year hydrology

FIGURE VII-10
AVERAGE ANNUAL ADDITIONAL SAN JOAQUIN RIVER FLOW
UNDER PREFERRED ALTERNATIVE FROM BASE CASE



*Average for water year type over the 71-year hydrology

San Joaquin River flows of 15.7 TAF and 8.9 TAF in July and August, respectively, for the purpose of salinity control.

Figure VII-10 shows that the average annual increase in San Joaquin River flow from the base case varies by water year type: 231 TAF in wet years; 458 TAF in above normal years; 315 TAF in below normal years; 239 TAF in dry years; and 111 TAF in critical years. In wet years, the additional San Joaquin River flows required under the preferred alternative range from 4 TAF to 607 TAF; in above normal years, from 117 TAF to 883 TAF; in below normal years, from 230 TAF to 508 TAF; in dry years, from 122 TAF to 400 TAF; and in critical years, from 44 TAF to 168 TAF. Over the 71-year hydrology, the average annual additional flow from the base case needed to meet San Joaquin River minimum flow requirements is 266 TAF, with the maximum of 883 TAF occurring in 1963, an above normal water year. During the 1928-1934 period, the average annual additional flow from the base case needed is 179 TAF.

E. DELIVERIES

The SWP has long-term water service contracts with 30 agencies west and south of the Delta for total combined annual entitlements (expected annual delivery) of 4.2 MAF (DWR 1991). The SWP delivers entitlement and entitlement-related (carryover and surplus) water to these customers south of San Luis Reservoir. CVP deliveries to water customers west and south of the Delta are made through the Contra Costa Canal, the San Felipe Project, the Delta-Mendota Canal, the Dos Amigos Unit, and the Cross Valley Canal.

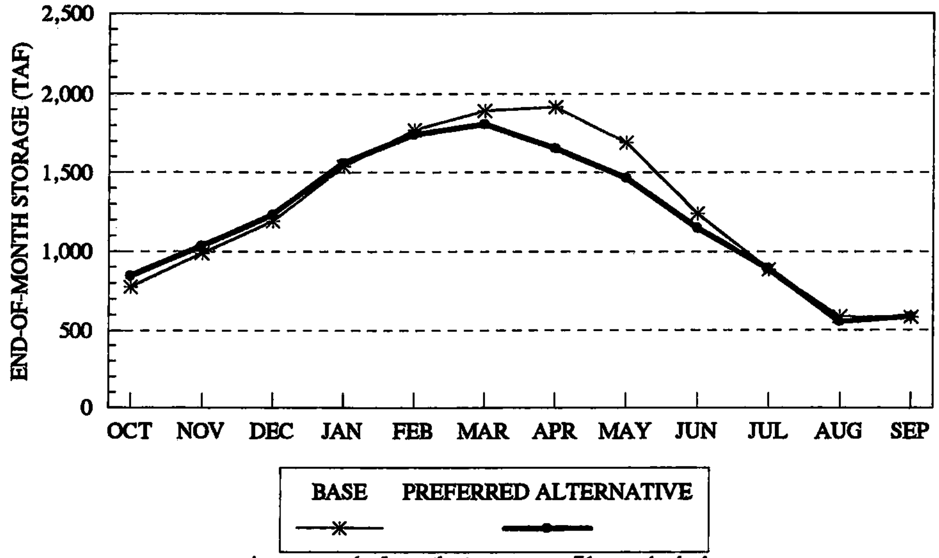
As discussed in section B of this chapter, under the preferred alternative, average annual total exports are reduced by 229 TAF from base case conditions over the 71-year hydrology, and by 816 TAF during the critically dry period. The effects of reduced total exports on deliveries to specific water customers are uncertain at this time. Discussion of these effects would be speculative because allocation of responsibility for meeting the new standards will be determined through either a future agreement between the DWR and the USBR for coordinated operation of the SWP and the CVP, or in the upcoming water right proceedings.

F. SAN LUIS RESERVOIR STORAGE

The USBR and the DWR jointly operate the 2 MAF-capacity San Luis Reservoir. San Luis provides offstream storage for surplus water pumped from the Delta through the California Aqueduct and the Delta-Mendota Canal during periods of high runoff in the winter and spring for delivery to SWP and CVP customers during the peak summer demand season. In order to maximize deliveries, San Luis Reservoir must be filled in the spring.

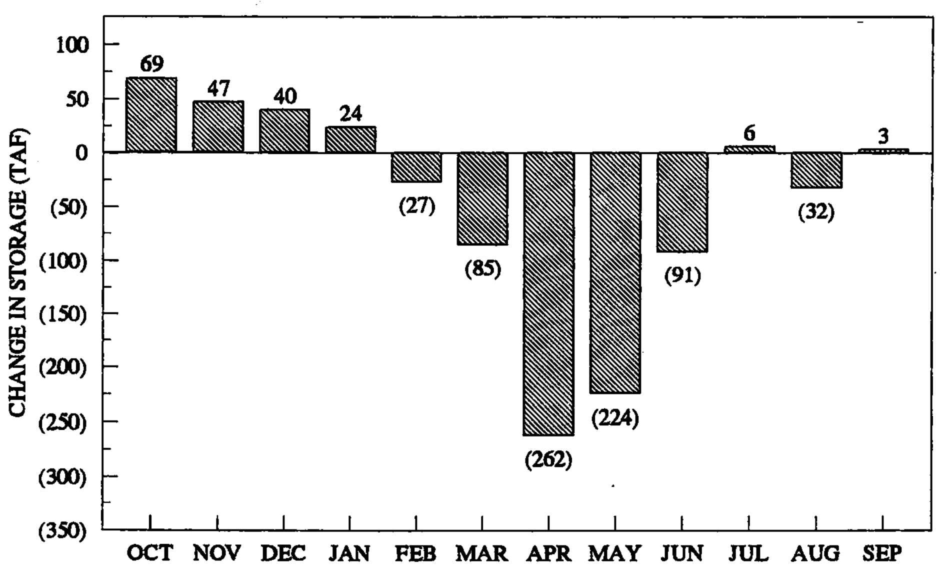
Figures VII-11 and VII-12 compare average end-of-month storage in San Luis under the base case and the preferred alternative. Greatest impacts are seen in March, April, May, and June with average storage reductions of 85 TAF, 262 TAF, 224 TAF, and 91 TAF, respectively. Under the base conditions, monthly average storage peaks at the end of April

FIGURE VII-11
AVERAGE END-OF-MONTH STORAGE IN SAN LUIS RESERVOIR



Average end-of-month storage over 71-year hydrology
Includes SWP and CVP storages in San Luis

FIGURE VII-12
AVERAGE CHANGE IN END-OF-MONTH SAN LUIS STORAGE UNDER PREFERRED ALTERNATIVE FROM BASE CASE



Average change in end-of-month storage over 71-year hydrology
Includes SWP and CVP storages in San Luis

at 1.9 MAF over the 71-year hydrology. Under the preferred alternative, the 71-year average end-of-month storage peaks in March at 1.8 MAF.

Figure VII-13 shows frequencies of end-of-March storage in San Luis. On average over the 71-year period, San Luis is filled at the end of March in 61 percent of years under base case conditions, and 59 percent of years under the preferred alternative. Figure VII-14, on page VII-16, shows frequencies of end-of-April storage in San Luis. Under the base case, San Luis is filled at the end of April in 69 percent of years, and in 18 percent of years under the preferred alternative.

Figure VII-15 shows how the preferred alternative affects the filling of San Luis Reservoir on a monthly basis. As discussed previously, under the preferred alternative, San Luis is filled earlier (in March instead of April) and less often (42 years under the preferred alternative compared to 49 years under the base case). Figure VII-16 shows the preferred alternative's impact, by water year type, on capability to fill San Luis. Under the base case, San Luis storage reaches 2 MAF in all 19 wet years (100 percent), in 10 of 14 above normal years (71 percent), in 7 of 12 below normal years (58 percent), in 9 of 11 dry years (82 percent), and in 4 of 15 critical years (27 percent). Under the preferred alternative, San Luis is filled in 100 percent of wet years, 64 percent of above normal years, 58 percent of below normal years, 55 percent of dry years and 7 percent of critical years.

G. CAPACITY FOR WATER TRANSFERS

The SWRCB supports the use of water transfers to meet future water needs. Transfers can reduce the water supply impacts in export areas identified earlier in this chapter. The SWRCB recognizes that the adoption of more restrictive standards for the protection of fish and wildlife will reduce the capacity for water transfers. This issue will be reviewed in the upcoming water right proceedings and, to the maximum extent possible, provisions will be made for transfer capacity through the Delta.

For this analysis, the period of July through October is assumed to be the most likely period for water transfers to occur. This assumption is based on historical operations and the standards in the plan which are more restrictive of exports during the February through June period. If water is available for purchase, the transfer capacity during the July through October period is principally dependent on two factors: unused pumping capacity at the Banks and Tracy pumping plants and the standards in the plan.

Two steps are used to calculate the capacity for water transfers available in July through October under the preferred alternative: (1) determine the net available pumping capacity by subtracting the pumping used at Banks and Tracy in these months (from DWRSIM study 1995c6b-SWRCB-109.MONT) from their respective pumping capacity; and (2) adjust, as necessary, the combined unused pumping capacity at Banks and Tracy to avoid exceeding the export restriction of 65 percent of Delta inflow. (More water could be transferred if the parties are willing to provide supplemental Delta inflow to avoid exceeding the 65 percent

FIGURE VII-13
FREQUENCY OF END-OF-MARCH SAN LUIS STORAGE OVER 71-YEAR HYDROLOGY

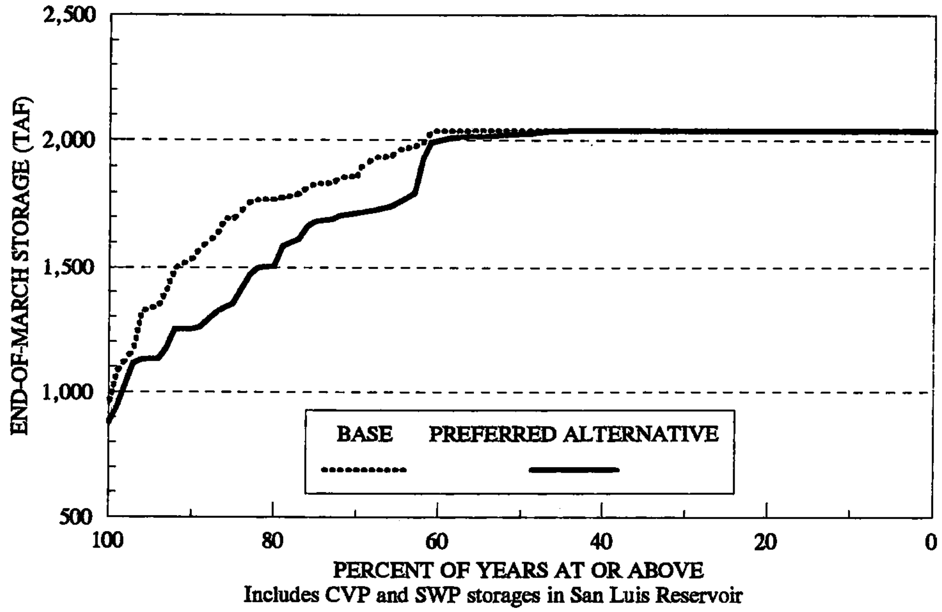
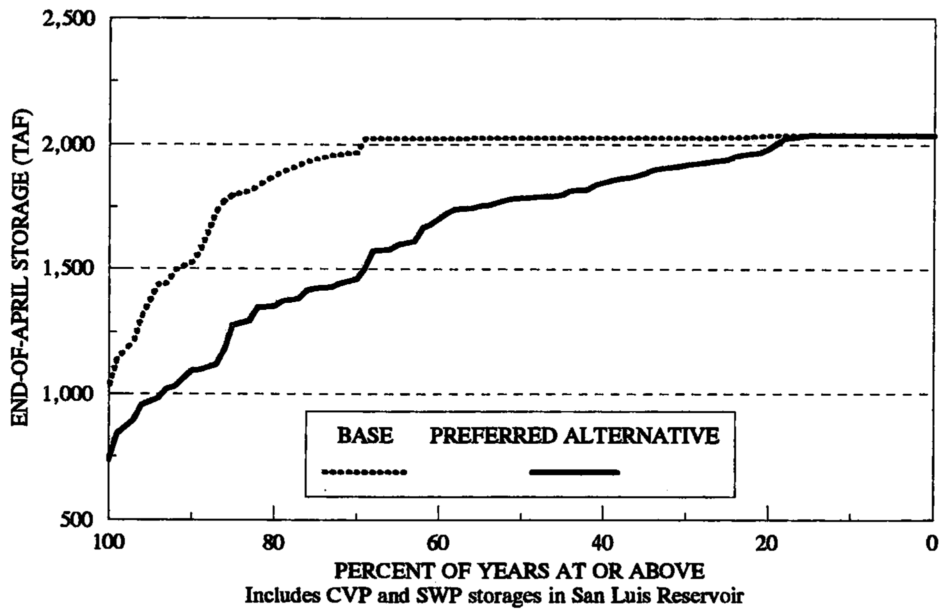


FIGURE VII-14
FREQUENCY OF END-OF-APRIL SAN LUIS STORAGE OVER 71-YEAR HYDROLOGY



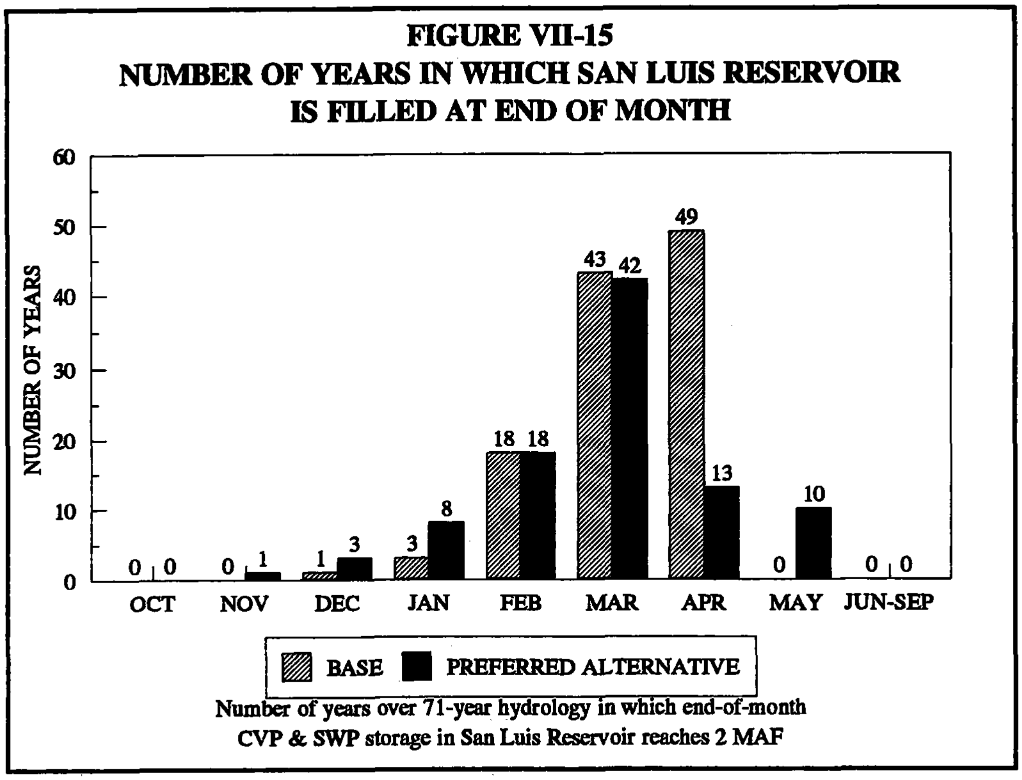


FIGURE VII-15
NUMBER OF YEARS IN WHICH SAN LUIS RESERVOIR
IS FILLED AT END OF MONTH
NUMBER OF YEARS
60
50
40
30
20
10
0
0 0
0 1
1 3
3 8
18 18
43 42
49 13
0 10
0 0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN-SEP
BASE
PREFERRED ALTERNATIVE
Number of years over 71-year hydrology in which end-of-month
CVP & SWP storage in San Luis Reservoir reaches 2 MAF

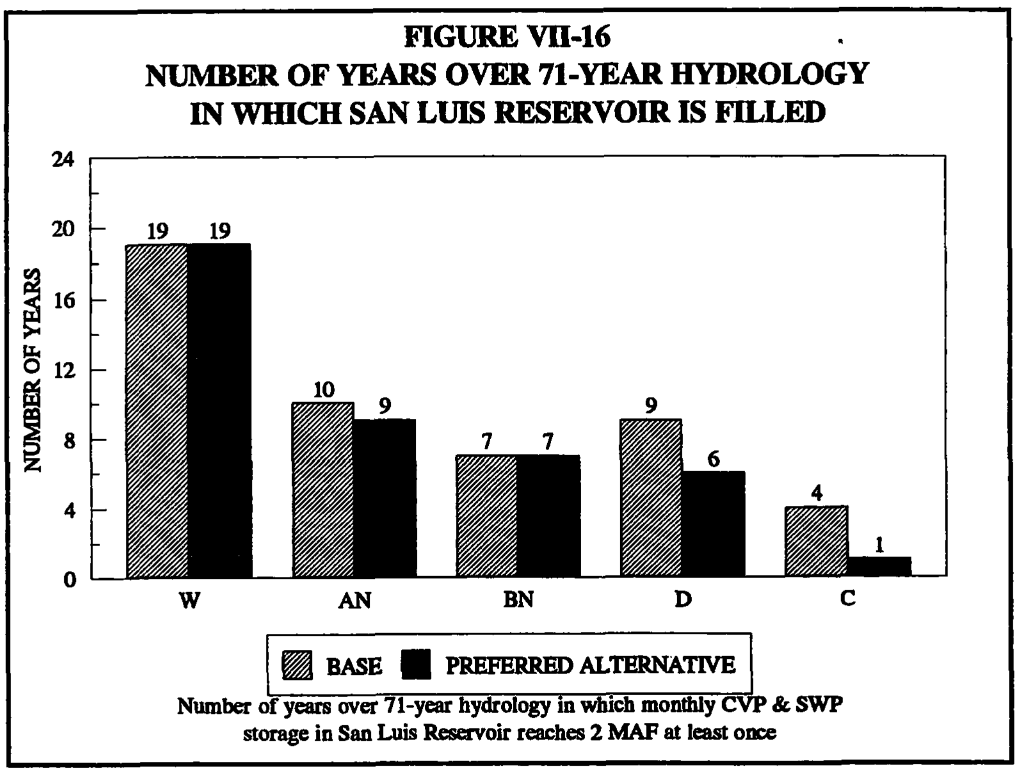
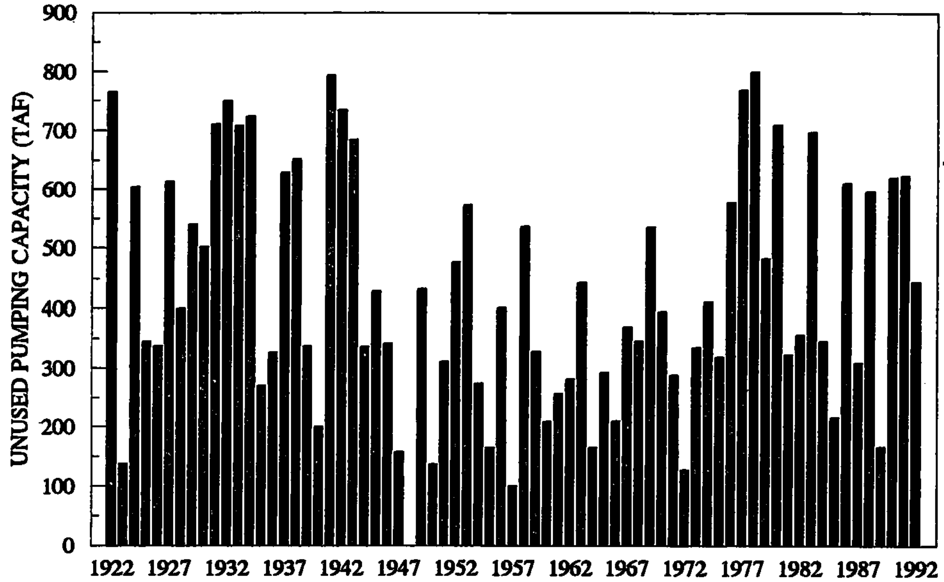


FIGURE VII-16
NUMBER OF YEARS OVER 71-YEAR HYDROLOGY
IN WHICH SAN LUIS RESERVOIR IS FILLED
NUMBER OF YEARS
24
20
16
12
8
4
0
19 19
10 9
7 7
9 6
4 1
W
AN
BN
D
C
BASE
PREFERRED ALTERNATIVE
Number of years over 71-year hydrology in which monthly CVP & SWP
storage in San Luis Reservoir reaches 2 MAF at least once

inflow export restriction.) This analysis focuses on water transfer potentials as represented by available pumping capacity and does not include other possible operational restrictions such as storage capacity south of the Delta. A summary of additional assumptions and data relevant to this analysis has been prepared by the DWR (DWR 1995b).

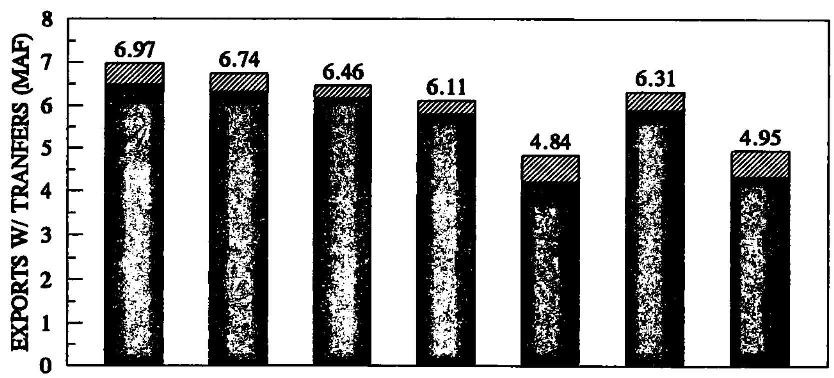
Figures VII-17 and VII-18 show the results of the water transfer analysis described above. Figure VII-7 shows the calculated unused pumping capacity at Banks and Tracy available for water transfers during July through October over the 71-year hydrology. Figure VII-18 shows the average annual total exports under the preferred alternative, as discussed in section B of this chapter, with the additional water transfers. Unused pumping capacity allows 500 TAF, 432 TAF, 288 TAF, 312 TAF, and 629 TAF of water transfers during wet, above normal, below normal, dry, and critical years, respectively. The average annual exports with water transfers are 7.0 MAF in wet years, 6.7 MAF in above normal years, 6.5 MAF in below normal years, 6.1 MAF in dry years, and 4.8 MAF in critical years. Over the 71-year hydrology, the average annual exports with water transfers are 6.3 MAF. During the critically dry period, 5.0 MAF of water exports and transfers are available annually.

FIGURE VII-17
UNUSED PUMPING CAPACITY AT BANKS AND TRACY IN JULY-OCTOBER UNDER PREFERRED ALTERNATIVE



Unused pumping capacity does not imply that water is available for transfer.

FIGURE VII-18
AVERAGE ANNUAL EXPORTS WITH WATER TRANSFERS UNDER PREFERRED ALTERNATIVE



	W*	AN*	BN*	D*	C*	71-YR AVG	5/28-10/34 AVG
EXPORTS ■	6.47	6.31	6.17	5.80	4.21	5.89	4.33
WATER TRANSFERS ▨	0.50	0.43	0.29	0.31	0.63	0.43	0.62

*Average values for water year type over 71-year hydrology.
Assumes that water is available for transfer in June-October.

Literature Cited in Chapter VII

DWR. 1991. Management of the California State Water Project (Bulletin 132-91). December 1991. California Department of Water Resources. 370 pp.

DWR. 1994. Comments of the Department of Water Resources at the Third Public Workshop for the Review of Objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Presented by David B. Anderson and Edward D. Winkler, June 14, 1994). California Department of Water Resources. 33 pp.

DWR. 1995a. SWRCB Draft Water Quality Control Plan of December 15, 1994, Planning Simulation Model (DWRSIM) assumptions (Study 1995C6B-SWRCB-407). January 1995. California Department of Water Resources. 5 pp.

DWR. 1995b. Precautionary considerations regarding the unused export capacity at SWP Banks and CVP Tracy Pumping Plants resulting from this DWRSIM study 1995c6b-SWRCB-409.MONT. March 16, 1995. California Department of Water Resources. 4 pp.

CHAPTER VIII. ENVIRONMENTAL EFFECTS OF PREFERRED ALTERNATIVE

The purpose of this triennial review is to develop a set of objectives that increases protection for the aquatic resources in the Bay-Delta Estuary while retaining existing water quality protections for the agricultural, municipal, and industrial uses of Bay-Delta waters. Therefore, the preferred alternative should have no significant adverse environmental impacts in the Bay-Delta Estuary, but it will cause adverse environmental impacts both upstream of the Estuary and in export areas due to decreases in water supply.

The following discussion of environmental effects of the standards is largely theoretical because the SWRCB will not implement the objectives by allocating responsibility to meet the objectives until the water rights phase of the proceedings. This document need not explain in detail the as-yet unknown effects of implementing the objectives, since the SWRCB will conduct an appropriate environmental analysis of the effects of implementing the objectives before the implementation measures are imposed. (14 CCR §15145) When the SWRCB commences the water rights phase, the SWRCB will prepare appropriate environmental documentation for its action. For this analysis, the SWRCB is using the SWP and the CVP as surrogates for the water rights holders in the Central Valley that may be held responsible for meeting the standards.

The reference conditions for this environmental analysis are the actual conditions that existed from 1984 through 1992. This reference condition is different than the base case for the water supply impact analysis in Chapter VII, which is defined as D-1485 conditions at the 1995 demand level assuming a repetition of the 1922-1992 historical hydrology. The base case for the water supply impact analysis was selected because water supply demands increased over the recent past and historical operations do not reflect this increased demand. The base case for the water supply impact analysis, however, is not appropriate for the environmental analysis because the Bay-Delta environment never actually experienced those modeled conditions.

The recent historical period of 1984-1992 was chosen for this environmental analysis because it contains enough years to capture some of the biological and hydrological variability in the Estuary, including the extended drought of 1987 through 1992. Using the Sacramento River Valley hydrologic classification, which applies to the analyses of Delta inflow, outflow, and exports, as well as Sacramento River flow objectives, the historical reference period consists of two wet years (1984 and 1986), three dry years (1985, 1987, and 1989), and four critical years (1988, 1990, 1991, and 1992). Using the San Joaquin Valley hydrologic classification, which applies to the analyses of San Joaquin River flow objectives, the historical reference period consists of one wet year (1986), one above normal year (1984), one dry year (1985), and six critical years (1987 through 1992).

The discussion of the environmental effects of the preferred alternative is divided into three sections: effects in the Estuary, effects in upstream areas, and effects in export areas.

A. EFFECTS IN THE ESTUARY

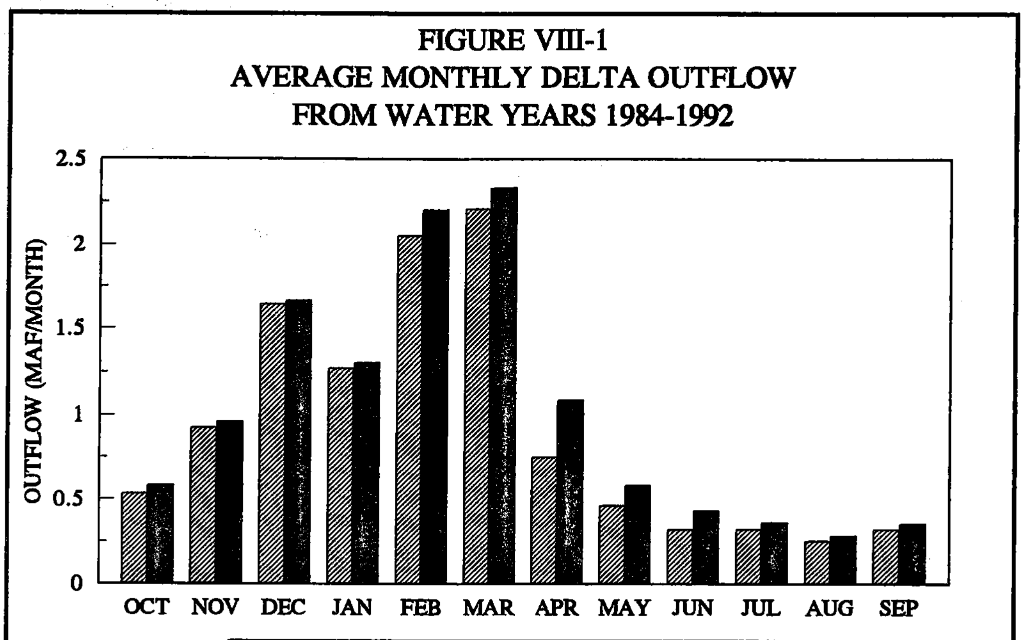
This section discusses the effects of the preferred alternative on environmental conditions within the Bay-Delta Estuary. The analysis focuses on Delta outflow, Delta exports, salinity, aquatic resources, Suisun Marsh, agricultural water supply, municipal and industrial water supply, and recreation.

For some parameters, such as Delta outflow and salinity, the preferred alternative's potential effects are obtained by directly comparing the standards to historical conditions. For other parameters, such as exports, modeled conditions of the preferred alternative from a DWRSIM operation study or other applicable model are compared to actual historical operations or to conditions obtained from a DWRSIM base case study, as described in Chapter VII. The DWR, the agency that both developed DWRSIM and is its principal user, has cautioned the SWRCB not to compare historical data to DWRSIM outputs since the model uses monthly flows and fixed assumptions (e.g., demand, Trinity operations, in-basin depletions, etc.) which in actuality vary over the period for which the operation study is run (DWR 1993). The SWRCB recognizes these conditions and has avoided direct modeled-historical data comparisons in the water supply impact analysis (Chapter VII). Nevertheless, in some cases, DWRSIM is the only available tool to predict conditions under the preferred alternative for this environmental analysis. The modeled-historical data comparisons are necessary for this purpose, albeit results must be interpreted with care and full consideration of the modeled conditions.

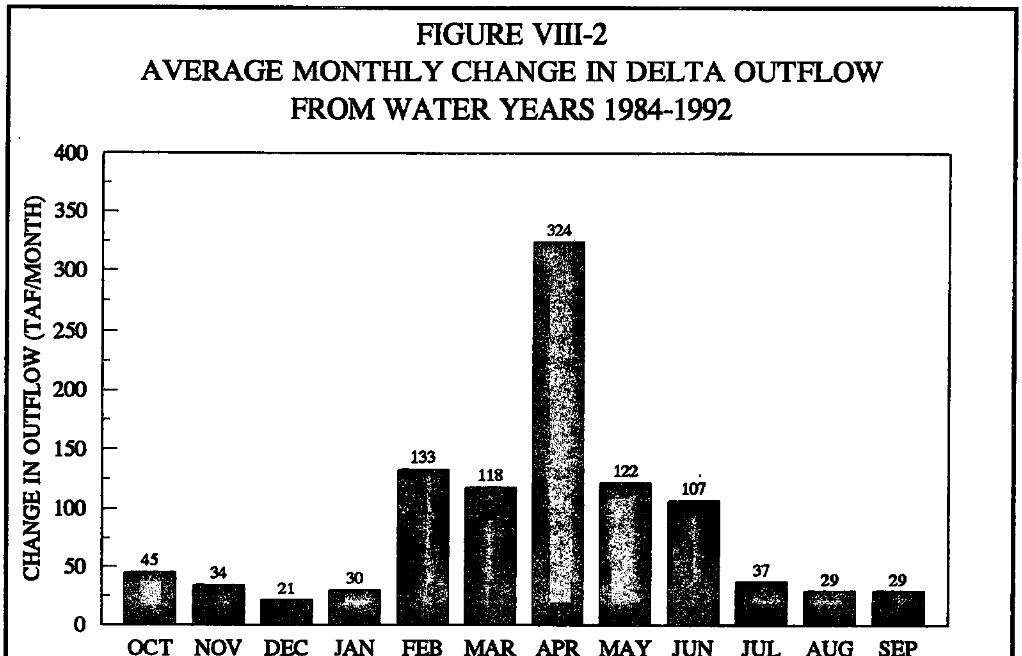
1. Delta Outflow

Delta outflow is known to be positively correlated with the population sizes of numerous aquatic species. To analyze effects of the standards on Delta outflow, historical flows are compared with those under the preferred alternative. The preferred alternative flows are obtained from the additional outflow model developed by the CCWD and discussed in Chapter VI. The model starts with historical outflows and determines the additional flows necessary to meet requirements in the preferred alternative.

As shown in Figures VIII-1 through VIII-4, average Delta outflows increase under the preferred alternative for all months and all years in the 1984-1992 period. Figure VIII-1 shows historical average monthly Delta outflows and Delta outflows under the preferred alternative. The greatest effects of the preferred alternative are seen in the spring months of February through June when average monthly Delta outflows are increased by 133 TAF, 118 TAF, 324 TAF, 122 TAF, and 107 TAF, respectively (Figure VIII-2). Figures VIII-3 and VIII-4 show that, during the critical and dry years of 1985 and 1987 through 1992, average annual outflow increases range from 723 TAF in 1985 to 1,727 TAF in 1989 (both are dry years). Over the 1984-1992 period, the average annual Delta outflow is increased by 1,029 TAF under the preferred alternative. The effects of the Delta outflow objectives on aquatic resources in the Estuary are discussed under section A.5, below.

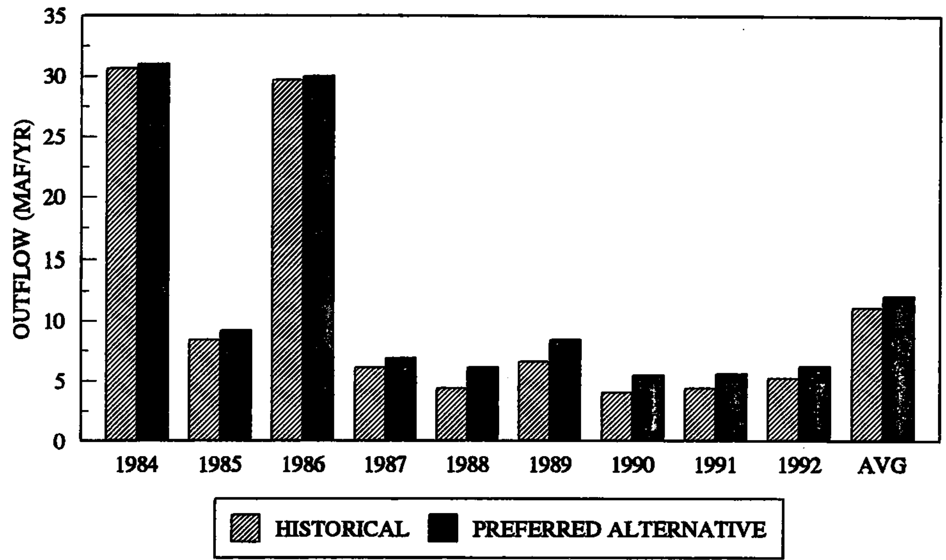


Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.



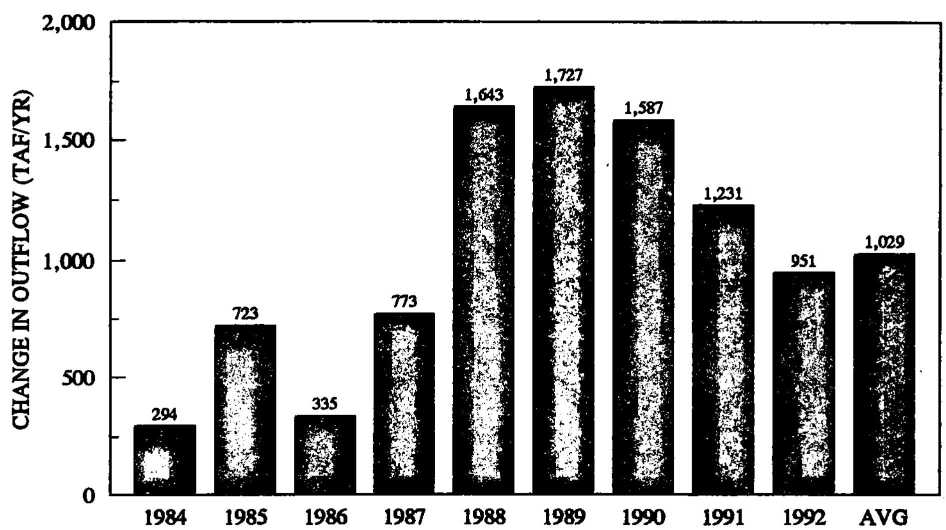
Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.
Changes shown are for the preferred alternative from historical conditions.

FIGURE VIII-3
ANNUAL DELTA OUTFLOW
FROM WATER YEARS 1984-1992



Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.

FIGURE VIII-4
ANNUAL CHANGE IN DELTA OUTFLOW
FROM WATER YEARS 1984-1992



Outflows under the preferred alternative are obtained from the CCWD's additional outflow model.

Changes shown are for the preferred alternative from historical conditions.

2. Delta Exports

Delta exports are known to affect aquatic resources adversely through entrainment by the export pumps, particularly in the spring. The preferred alternative includes restrictions on SWP and CVP pumping. These reduced exports should affect habitat conditions in the Delta and are, therefore, discussed in this chapter as well as in the water supply impact chapter (Chapter VII). Delta exports are defined in this section as exports from Banks and Tracy pumping plants. This narrow definition is used because the export restrictions in the preferred alternative apply only to these two diversions. The following discussion compares historical exports with DWRSIM-modeled exports for the preferred alternative.

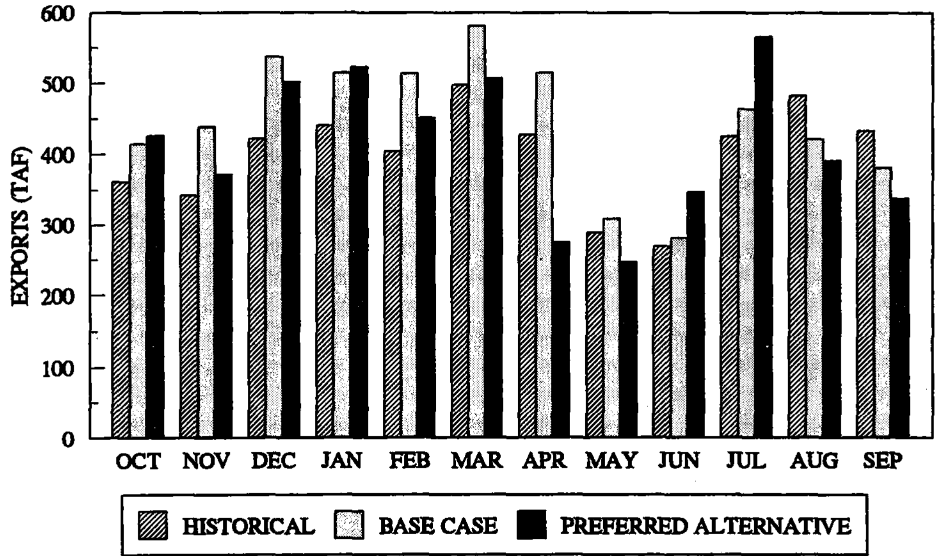
Figure VIII-5 shows average historical monthly Delta exports and those obtained from DWRSIM studies of the base case and preferred alternative; Figure VIII-6 shows the annual exports. In both figures, exports under the base case differ significantly from historical exports because of differences in demand, initial conditions, and operational rules.

Figure VIII-5 shows that average monthly exports under the preferred alternative are lower in April and May by 153 TAF and 43 TAF, respectively, and are lower in August and September by 92 TAF and 95 TAF, respectively. Reduced exports in April and May under the preferred alternative are consistent with restrictions on exports to 35 percent of Delta inflow, or 100 percent of the 3-day running average San Joaquin River flow at Vernalis, in these months. As shown in Figure VIII-6, during 1984 through 1992, exports are increased by an annual average of 147 TAF (from 4.79 MAF historically to 4.94 MAF under the preferred alternative). Annual exports are lower in 1988, 1989, and 1990 by 1.11 MAF, 695 TAF, and 1.77 MAF, respectively.

Due to fluctuations in demand, initial conditions, and operations during 1984 through 1992, this modeled-historical data comparison does not clearly illustrate the preferred alternative's impact on exports. Figures VIII-7 through VIII-10, discussed below, provide a more effective illustration of export impacts by comparing actual historical exports with the export limits in the plan. The preferred alternative includes export restrictions in terms of percent of Delta inflow exported. These types of objectives allow increased exports during periods when higher volumes of fresh water are flowing through the Delta. Correspondingly, exports are reduced as freshwater inflow to the Delta is lowered and susceptibility of fish to export losses increases.

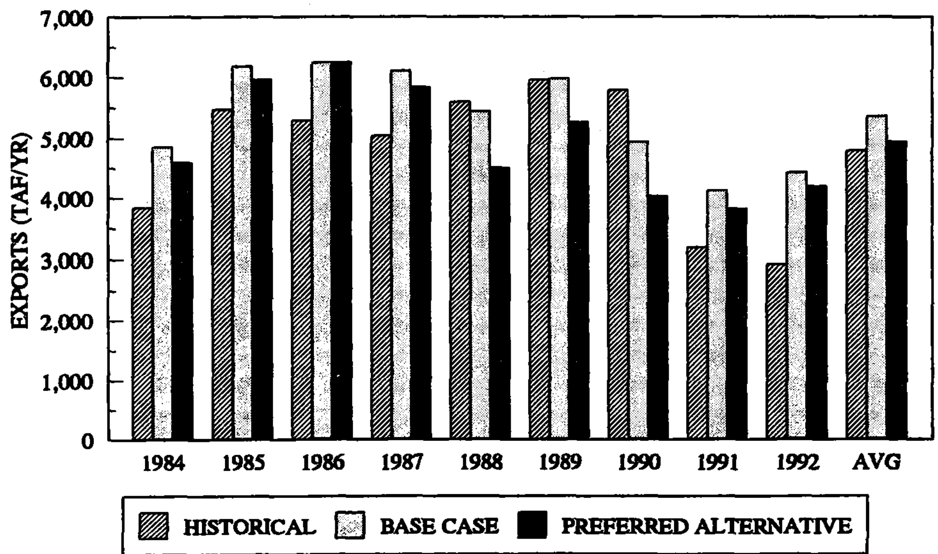
The export limit for February is based on the best available estimate of the Eight River Index for January. The Eight River Index refers to the sum of the unimpaired runoff as published in the DWR Bulletin 120 for the following locations: Sacramento River flow at Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River flow at Smartville; American River, total inflow to Folsom Reservoir; Stanislaus River, total inflow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total inflow to Exchequer Reservoir; and San Joaquin River, total inflow to Millerton Lake. If the best available estimate of the Eight River Index for January is less

FIGURE VIII-5
AVERAGE MONTHLY EXPORTS FROM WATER YEARS 1984-1992



Exports are defined as pumping at Banks and Tracy.
Exports under base case and preferred alternative are from DWRSIM studies.

FIGURE VIII-6
ANNUAL DELTA EXPORTS FROM WATER YEARS 1984-1992



Exports are defined as pumping at Banks and Tracy.
Exports under base case and preferred alternative are from DWRSIM studies.

than or equal to 1.0 MAF, the export limit for February is 45 percent of Delta inflow. If the best available estimate of the Eight River Index for January is greater than 1.5 MAF, the February export limit is 35 percent of Delta inflow. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be within the range of 35 to 45 percent. For this analysis, it was assumed that when the index is between 1.0 MAF and 1.25 MAF, the export limit is set at 45 percent of Delta inflow; when the index is greater than 1.25 MAF and less than or equal to 1.5 MAF, the export limit was assumed to be 35 percent of Delta inflow.

Figure VIII-7 shows that, during the wet years in the reference period (1984 and 1986), the export restrictions would not have had any effect on exports due to low export demands and large inflows. In dry years, as shown in Figure VIII-8, exports would have been reduced (and outflows increased) in all years in April and May, with the greatest impact in April. The export limit in February in all dry water years (1985, 1987, and 1989) would have been 45 percent. (Exports would have also been reduced in March of 1985, June of 1985 and 1987, January and February of 1989, and September of 1987.) Historical exports as percent of Delta inflow for critical water years 1988 and 1990 through 1992 are shown in Figures VIII-9 and VIII-10 with the standards. The export limit in February in two of four critical water years (1991 and 1992) is 45 percent. Major impacts on exports would have occurred in the spring months, in particular February through April. In 1988, exports would have been reduced from February through June. The effects of the export limits on aquatic resources in the Estuary are discussed under section A.5, below.

Water transfers can be used to supplement exports in order to meet future water needs. Using the assumptions and methods discussed in section G of Chapter VII, the annual capacity for water transfers under the preferred alternative during the 1984-1992 period ranges from 165 TAF in 1989, a dry water year, to 624 TAF in 1991, a critical year. The average annual transfer during this period is 437 TAF. Thus, the combined average annual exports and potential water transfer under the preferred alternative is 5.4 MAF. The effects of water transfers on aquatic resources in the Estuary are discussed in section A.5, below.

3. Salinity

Three analyses are discussed below to illustrate the preferred alternative's effect on salinity in the Estuary. The first two analyses compare the standards in the plan with historical X2 isohaline position and electrical conductivity (EC) at Vernalis, respectively. In the third analysis, EC conditions under the base case and the preferred alternative, as modeled by the DWR Delta Simulation Model (DWRDSM), are examined.

a. <u>Comparison of Standards and Historical X2 Isohaline</u>

Figures VIII-11 through VIII-15 show the average X2 isohaline positions during February through June, respectively, under historical conditions and under the standards of the preferred alternative. The average X2 positions under the preferred alternative are obtained

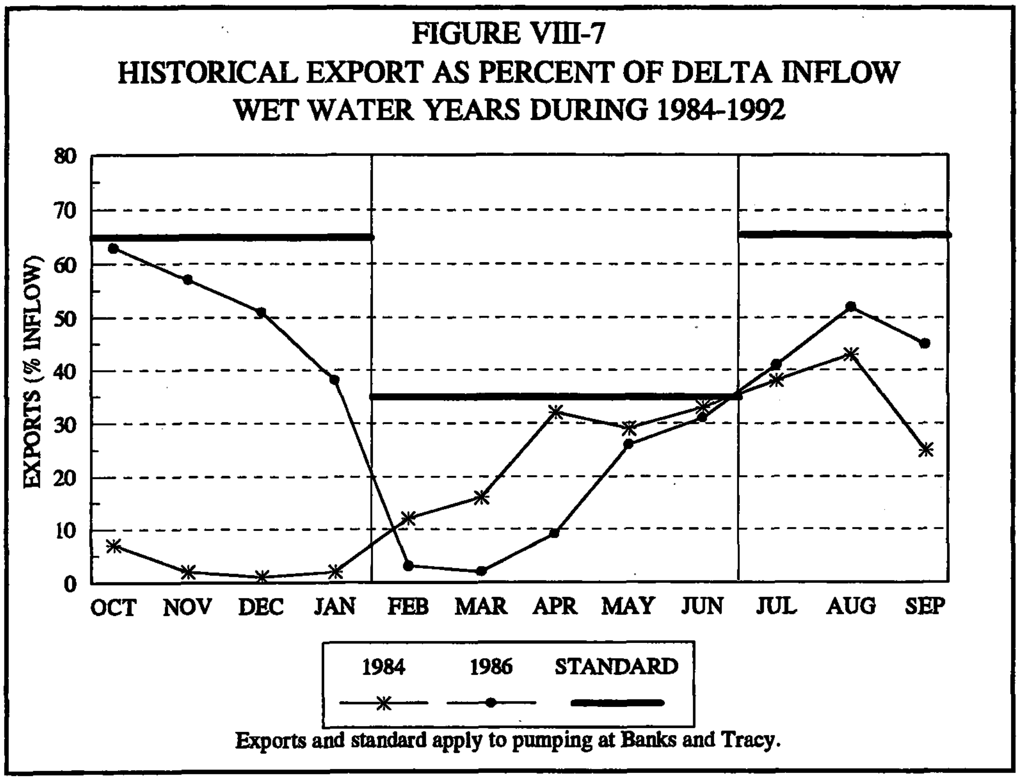


FIGURE VIII-7
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
WET WATER YEARS DURING 1984-1992
EXPORTS (% INFLOW)
0
10
20
30
40
50
60
70
80
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1984
1986
STANDARD
Exports and standard apply to pumping at Banks and Tracy.

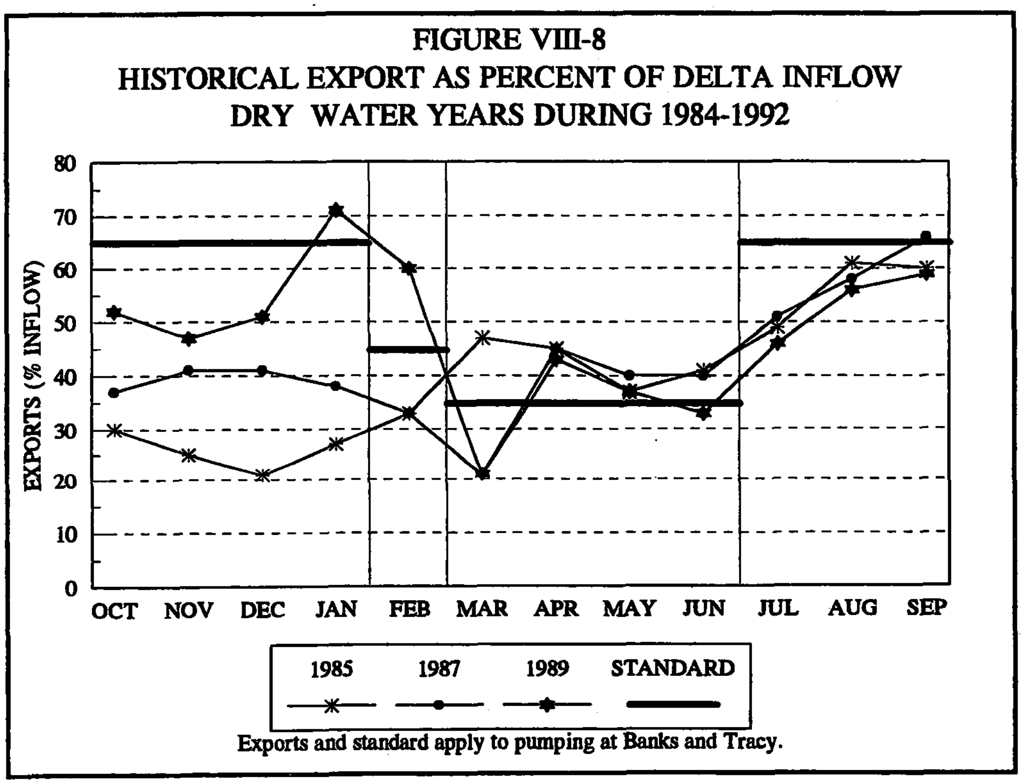
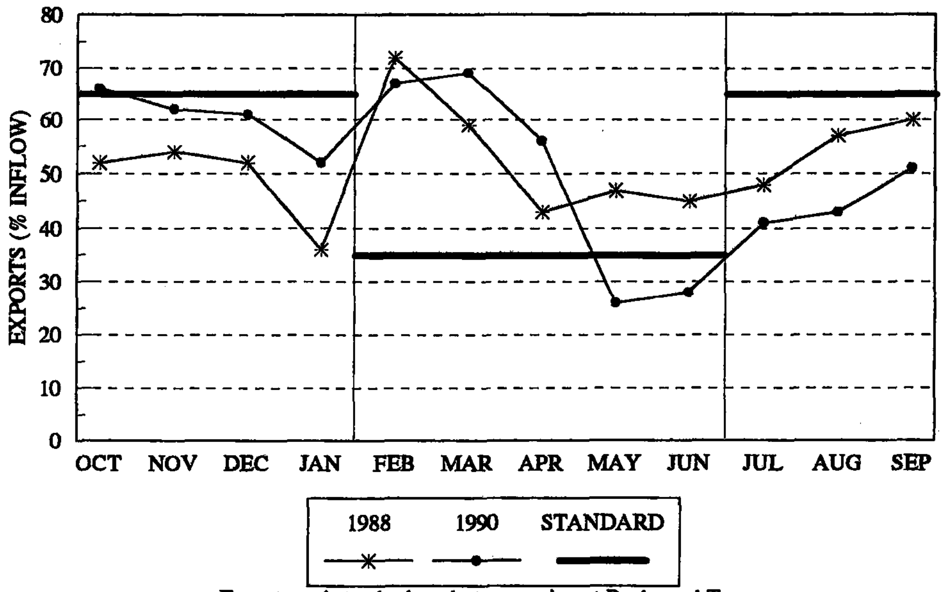


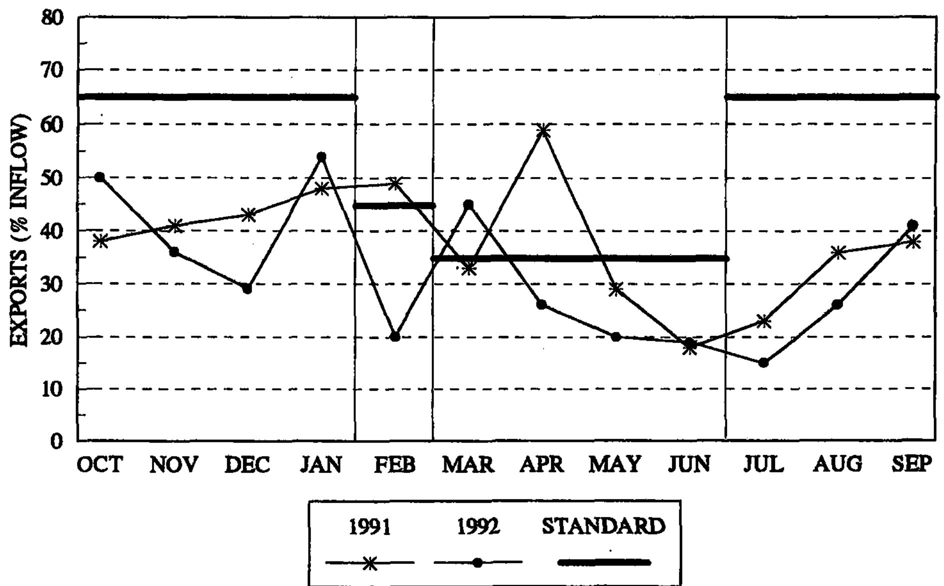
FIGURE VIII-8
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
DRY WATER YEARS DURING 1984-1992
EXPORTS (% INFLOW)
0
10
20
30
40
50
60
70
80
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1985
1987
1989
STANDARD
Exports and standard apply to pumping at Banks and Tracy.

FIGURE VIII-9
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
CRITICAL WATER YEARS 1988 AND 1990



Exports and standard apply to pumping at Banks and Tracy.

FIGURE VIII-10
HISTORICAL EXPORT AS PERCENT OF DELTA INFLOW
CRITICAL WATER YEARS 1991 AND 1992



Exports and standard apply to pumping at Banks and Tracy.

from the outflow model developed by the CCWD. By applying the additional outflows required to meet the standards in the preferred alternative to the historical X2 positions, the CCWD model projects X2 positions for the preferred alternative. Results of the CCWD model, shown in Figures VIII-11 through VIII-15, indicate that in all months the average X2 isohaline position under the preferred alternative is further downstream than historical X2 positions. In March of all years, the average X2 position is maintained downstream of the confluence; in February, May, and June, the average X2 position is maintained downstream of or near the confluence; and in April, the X2 position is near or downstream of Chipps Island. The effects of the spring Delta outflow objectives on aquatic resources in the Estuary are discussed under section A.5, below.

b. Comparison of Standards and Historical EC at Vernalis

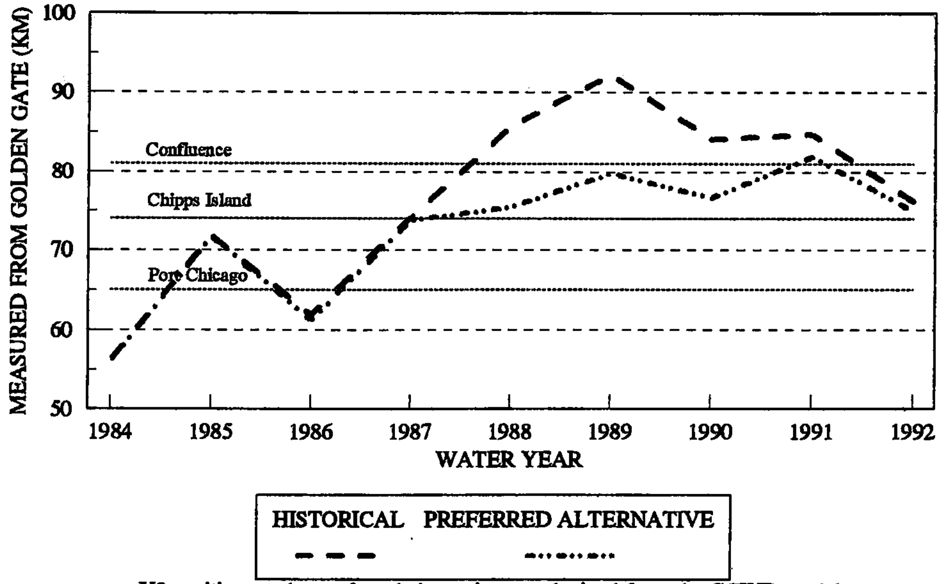
Pursuant to requirements in D-1422, during the 1984 through 1992 reference period, historical operation of New Melones Reservoir was being managed for salinity control at Vernalis. Figures VIII-16 through VIII-20 compare the average historical EC at Vernalis in 1984 through 1992 with the Vernalis agricultural salinity standards in the preferred alternative. EC standards at Vernalis are independent of water year type. For this analysis, the San Joaquin Valley 60-20-20 water year hydrologic classification index is used. The standards are not likely to have major impacts in wetter years. As shown in Figures VIII-16 and VIII-18, in 1984 (an above normal year) and 1986 (a wet year), historical salinity values measured at Vernalis are at or below the standards. Significant impacts are seen in drier years. In 1985, a dry water year, Figure VIII-17 shows that salinity levels in April through June exceeded the standard. The greatest impacts are seen in critical years 1987 through 1992, shown in Figures VIII-19 and VIII-20. In almost all critical years, salinity levels at Vernalis exceed the standards in April through August (the exceptions are April of 1987 and May of 1987, 1991, and 1992). In some critical years, the standards also require reduced salinity levels in January through March.

c. Delta Salinity Under the Preferred Alternative (DWR 1995)

Upon request by the SWRCB, the DWR has conducted hydrodynamics and water quality simulations using DWRDSM to determine the effect of the preferred alternative on water quality in the Delta. To estimate monthly average salinity in the Delta, DWRDSM (discussed in Chapter VI) uses the hydrology generated by DWRSIM studies of the base case and preferred alternative[1] as input. Thus, the modeling assumptions for DWRSIM, as discussed in Chapter VII, are also applicable to this salinity analysis. Of particular importance is the DWRSIM assumption that freshwater releases from New Melones Reservoir for salinity control would be limited to no more than 70 TAF annually. There is

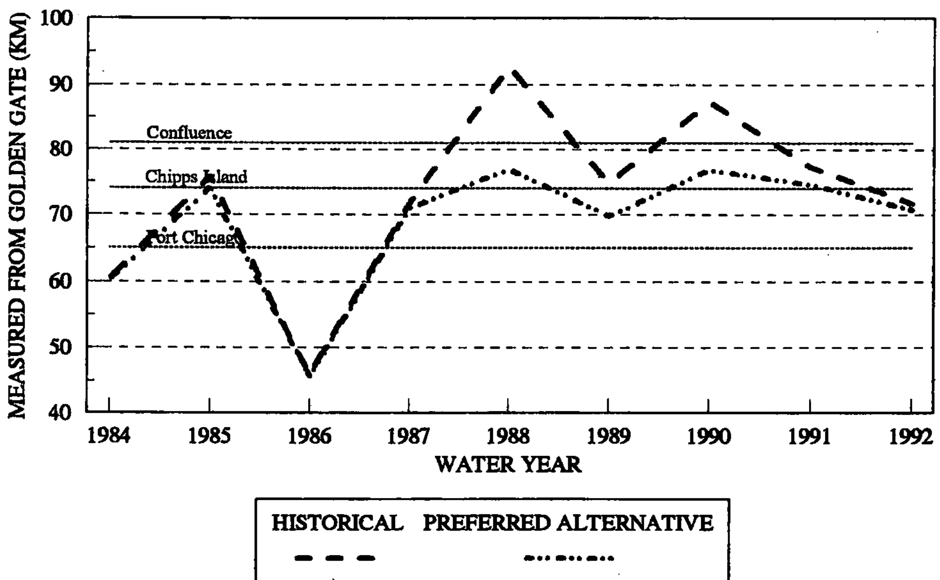
[1] Conditions under the base case and preferred alternative that were used as DWRDSM inputs are obtained from preliminary DWRSIM operation studies 1995c6b-MONTERY-412 and 1995c6b-SWRCB-409.MONT, respectively.

FIGURE VIII-11
AVERAGE X2 ISOHALINE POSITION
IN FEBRUARY OF 1984-1992



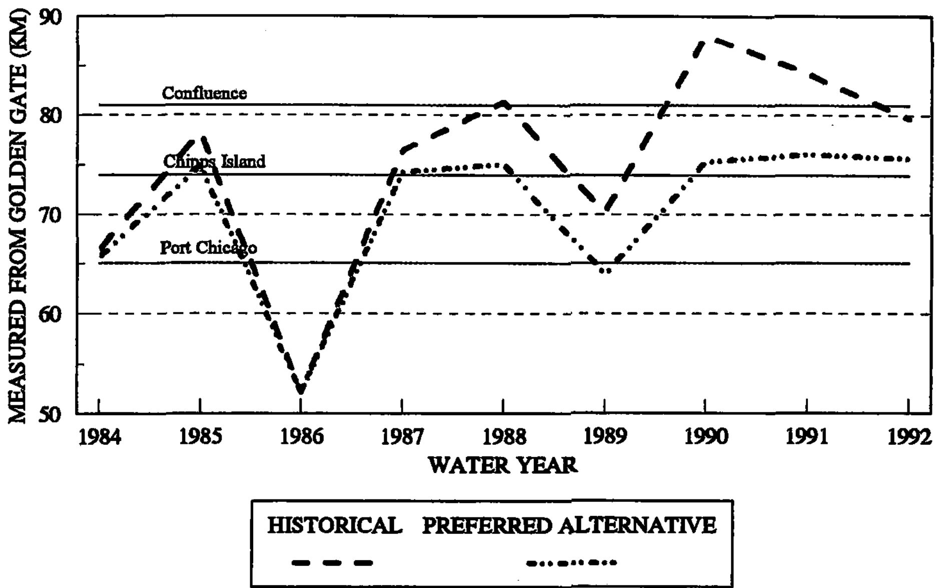
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-12
AVERAGE X2 ISOHALINE POSITION
IN MARCH OF 1984-1992



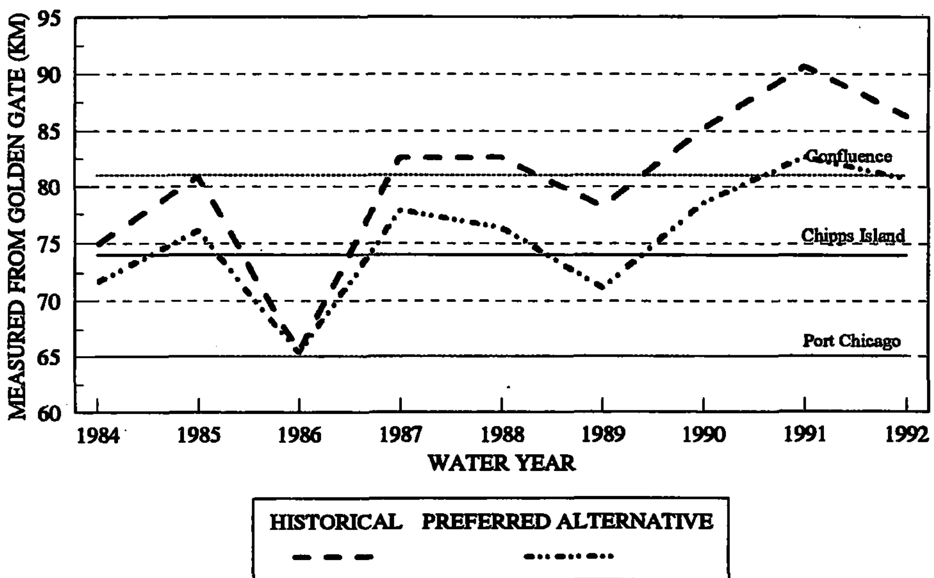
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-13
AVERAGE X2 ISOHALINE POSITION
IN APRIL OF 1984-1992



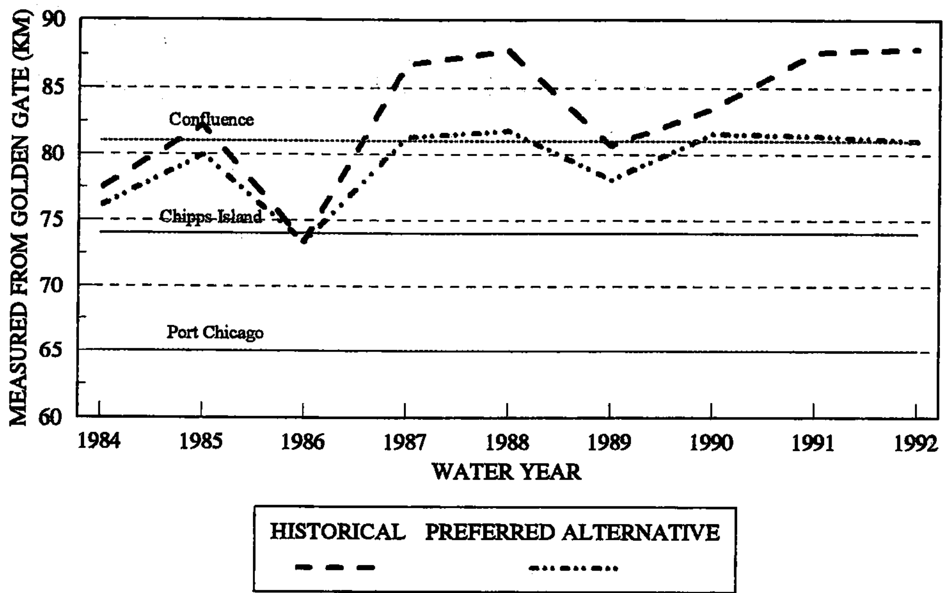
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-14
AVERAGE X2 ISOHALINE POSITION
IN MAY OF 1984-1992



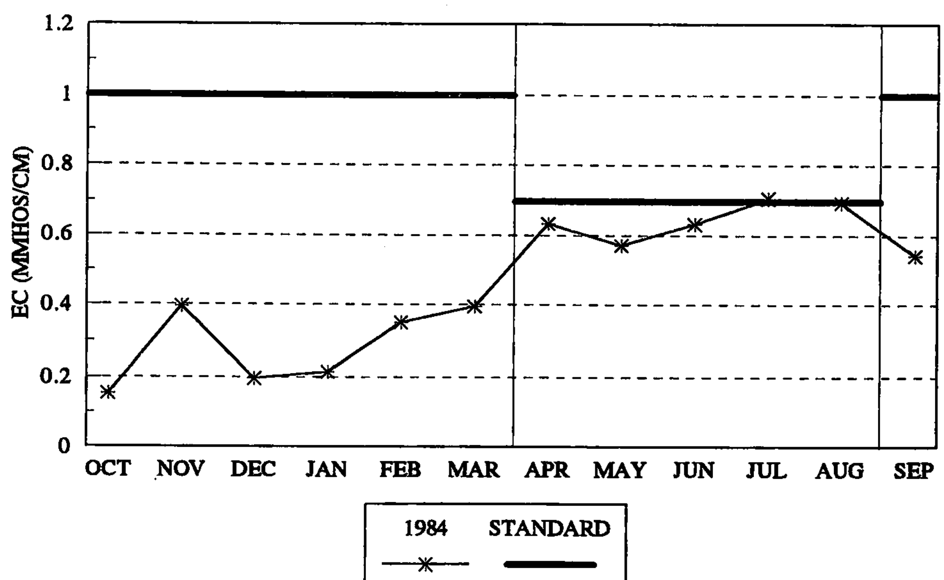
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-15
AVERAGE X2 ISOHALINE POSITION
IN JUNE OF 1984-1992



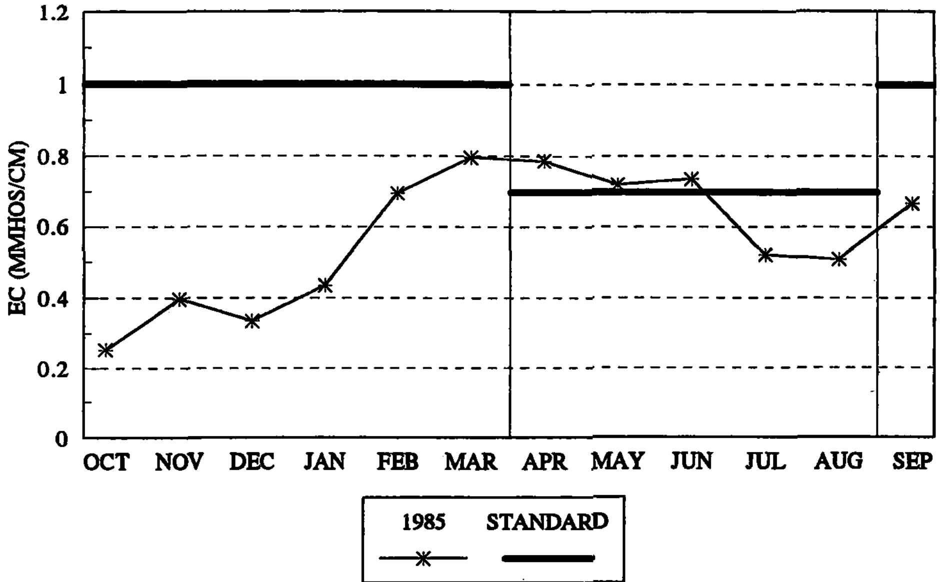
X2 positions under preferred alternative are obtained from the CCWD model.

FIGURE VIII-16
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS
FROM ABOVE NORMAL WATER YEAR 1984



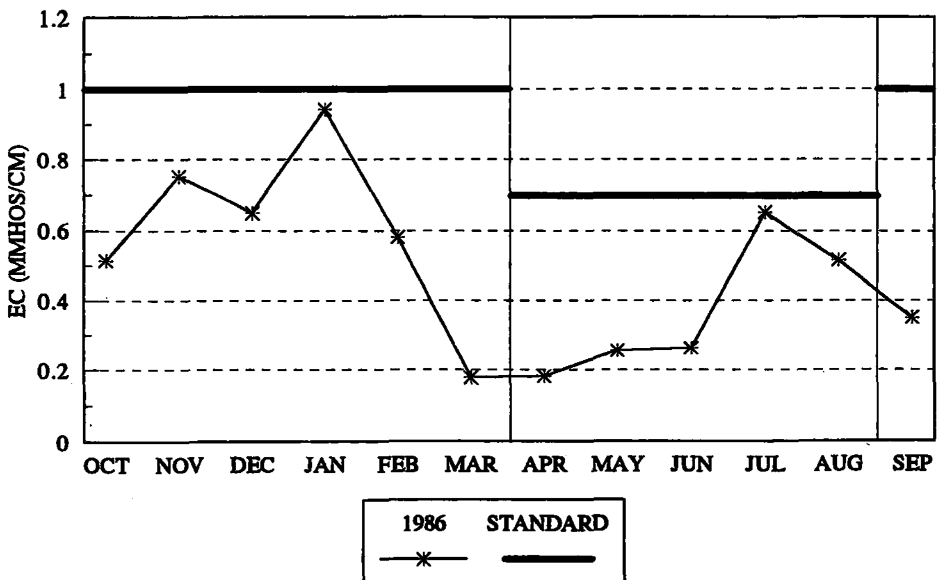
Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-17
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS
FROM DRY WATER YEAR 1985



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

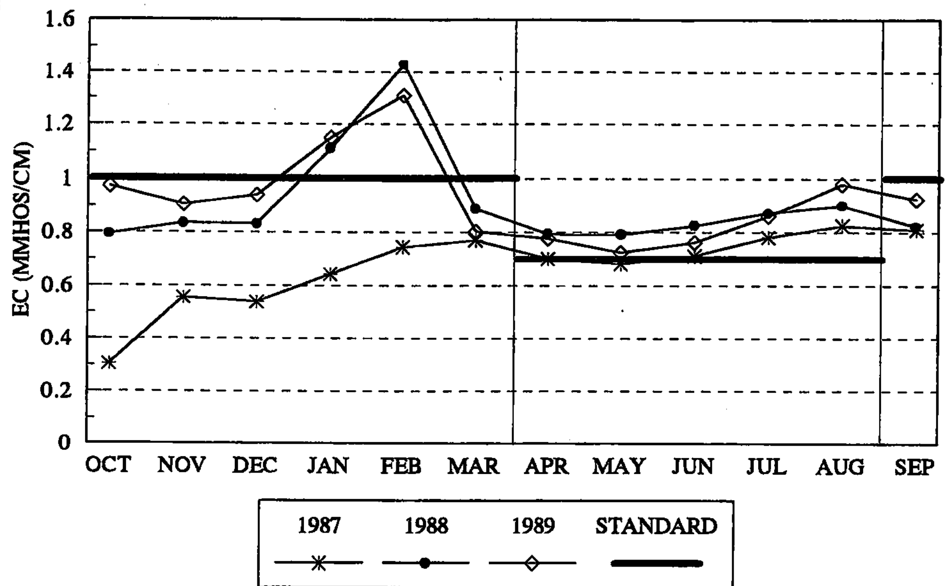
FIGURE VIII-18
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS
FROM WET WATER YEAR 1986



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-19

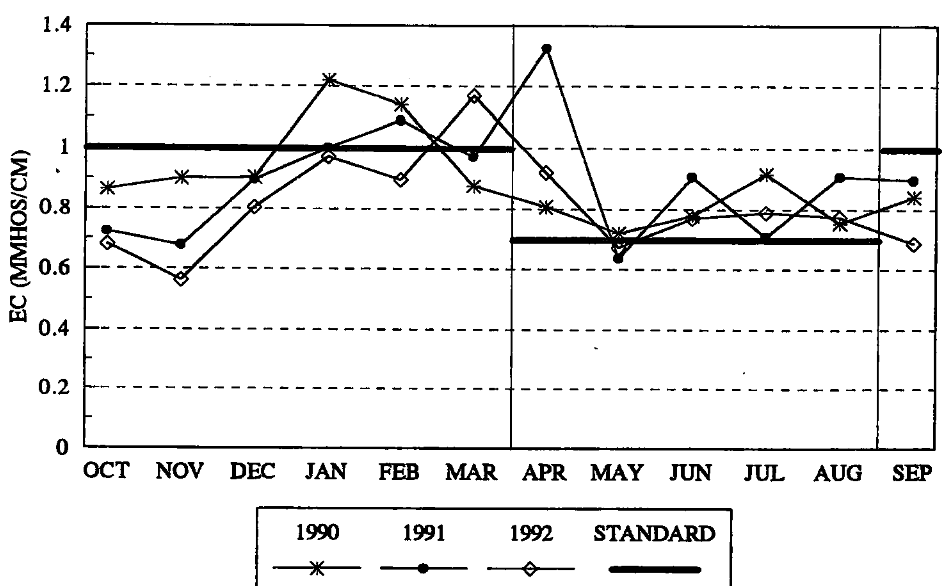
HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS FROM CRITICAL WATER YEARS 1987-1989



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

FIGURE VIII-20

HISTORICAL SAN JOAQUIN RIVER SALINITY AT VERNALIS FROM CRITICAL WATER YEARS 1990-1992



Measured as Electrical Conductivity (EC) at 25 degrees Celsius

actually no cap on the USBR responsibility to provide salinity control from New Melones, but a cap was used in the DWRSIM analysis because the SWRCB expects water quality control measures to reduce the dilution water required to meet the salinity standard. These water quality control measures are not modeled; therefore, the DWRSIM assumption represents a worst-case scenario.

The period from water years 1987 through 1992 was chosen for the salinity analysis because the greatest impacts are expected to occur in dry and critical years. Some of the modeling assumptions used to conduct the DWRDSM base case and preferred alternative simulations, and the resulting outputs, are discussed below. Additional assumptions and results are discussed in a report submitted to the SWRCB (DWR 1995).

Temporary Delta Barriers. Since 1987, three temporary rock barriers have been deployed in the Delta at the Old River head, Old River near DMC, and Middle River near Victoria Island. For planning purposes, a nominal installation and removal schedule representative of the historical pattern was devised. This installation and removal schedule was used identically in the base case and preferred alternative studies as follows:

Barrier	Installed	Removed
Middle River:	May 1	September 30
Old River head:	September 1	November 30
	May 1	May 30
Old River near DMC:	May 1	October 1

Clifton Court Forebay Operation Priority. Clifton Court Forebay is currently operated on a seasonal basis to protect water levels in the southern Delta. The priorities used by the DWR are summarized in a report submitted to the SWRCB (DWR 1995).

Delta Cross Channel Operation. The preferred alternative requires that the Delta Cross Channel be closed up to 45 days between November 1 and January 31, closed continuously between February 1 and May 20, and closed 14 days between May 21 and June 15.

Given the flexible nature of Delta Cross Channel operation under the preferred alternative in the November-January period, for modeling purposes the Delta Cross Channel was closed between November 1 and November 15, December 1 and December 15, and January 1 and January 15. The Delta Cross Channel was re-opened in the second half of each month. This nominal operation is somewhat conservative (i.e., it may over-emphasize the water quality impact of the Delta Cross Channel standard) because the preferred alternative requires the Delta Cross Channel to be closed "up to" 45 days. Presumably, the operations group will make these decisions on the basis of current water quality conditions and the presence of fish in the Sacramento River north of Walnut Grove. The May 21 through June 15 requirement, that the Delta Cross Channel be closed up to four days in a row, not including weekends, is modeled by leaving the Delta Cross Channel closed through May, and opening it thereafter.

Suisun Marsh Salinity Control Gates Operation. In recent years, the Suisun Marsh Salinity Control Gates (formerly known as the Montezuma Slough Control Structure) have been operated as a tidal pump between October and May in all water year types except wet years (Sacramento Valley 40-30-30 water year hydrologic classification). (The control gates are discussed in greater detail in section A.6 of this chapter.) Since only critical and dry years were modeled (water years 1987 through 1992), the control gates were operated in the model each year between October and May. When the control structure was not operating, all radial gates and flash boards were removed.

San Joaquin River Input Salinity. Vernalis is the upstream San Joaquin River (SJR) boundary condition of the model. As such, the boundary salinity must be provided at that location. Salinity is assumed to be an exponential function of flow by the following equation:

$$\ln EC = 10.0800014 - 0.48230 * \ln (\text{SJR flow in cfs})$$

TDS to EC conversion. Salinity output from DWRDSM was requested in EC units to be consistent with agricultural standards in the plan. The model computes salinity as TDS which, therefore, must be converted to EC. Location-specific conversion equations were used for this purpose.

Other Assumptions. The 19-year mean tide at Benicia was used; no duck club operation was simulated in Suisun Marsh; Benicia boundary salinity was calculated using the "Saldif4" program; maximum Clifton Court Forebay gate flow is 15,000 cfs; eastside stream boundary salinity was set constant at 85 ppm TDS; and Sacramento River salinity at the Sacramento boundary was set constant at 100 ppm TDS.

Salinity Output. Hydrodynamic inflows are constant within each month. Therefore, salinity approaches a steady-state condition as it is simulated within each month. For output purposes, the average monthly salinity is assumed to be the salinity on the last tidal day of the month.

Figures VIII-21 through VIII-30, prepared by the DWR, show time-series monthly average EC under the base case and the preferred alternative for water years 1987 through 1992 at the following ten standard locations, respectively: Sacramento River at Emmaton; San Joaquin River at Jersey Point; San Joaquin River at San Andreas Landing; San Joaquin River at Prisoners Point; South Fork of the Mokelumne River at Terminous; San Joaquin River at Buckley Cove; Old River near Tracy; Old River at Middle River; San Joaquin River at Brandt Bridge site; and San Joaquin River at Vernalis. Salinity output is shown in step form to emphasize that these are monthly average values resulting from steady, monthly average flow inputs. Half-month steps are shown in November, December, and January when the Delta Cross Channel is closed the first half and open the second half of the month. Solid and dashed lines at the bottom of each plot indicate the months, or portion of months, that the Delta Cross Channel is closed under the base case and the preferred alternative, respectively. Delta Cross Channel closure in the base case study only occurs for flood control when Sacramento River flow at Freeport is greater that 25,000 cfs.

The preferred alternative includes salinity standards for the western Delta from April through mid-August. As shown in Figures VIII-21 (Emmaton) and VIII-22 (Jersey Point), salinity in the western Delta is significantly reduced under the preferred alternative from the base case during these months. The average monthly salinity at Emmaton during 1987-1992 is reduced under the preferred alternative from the base case by 53 percent in April, 54 percent in May, 66 percent in June, 55 percent in July, and 15 percent in August. At Jersey Point, the average monthly salinity is reduced by 61 percent in April, 44 percent in May, 61 percent in June, 35 percent in July, and 18 percent in August.

Salinity conditions under the preferred alternative are generally in compliance with the western Delta agricultural standards. Figures VIII-21 and VIII-22 also show that: there are significant salinity decreases at Emmaton and Jersey Point in February and March; salinity at Emmaton increases in October under the preferred alternative (mainly due to reduced Sacramento River flows), and decreases during November through December (when the Delta Cross Channel closes and Sacramento River flows are increased); and salinity at Jersey Point increases in the November through January period when the Delta Cross Channel is closed the first half of the month.

The preferred alternative also includes agricultural salinity standards from April through mid-August for the interior Delta, specifically, the south fork of the Mokelumne River at Terminous, and the San Joaquin River at San Andreas Landing. Additionally, fish and wildlife objectives for salinity are established on the San Joaquin River between Jersey Point and Prisoners Point in April and May. Figures VIII-23 through VIII-25 show salinity under the preferred alternative and the base case for San Andreas, Prisoners Point, and Terminous, respectively. Salinities at San Andreas and Prisoners Point are generally lower under the preferred alternative than the base case from March through September, and are in compliance with the agricultural standards for the interior Delta. The salinity patterns at San Andreas and Prisoners Point tend to follow Jersey Point closely. However, there are greater incremental salinity increases in response to Delta Cross Channel closure. Like conditions at Jersey Point, salinity at these stations increases in the November through January period when the Delta Cross Channel is closed the first half of the month. The increase persists into February for San Andreas and Prisoners Point when the Delta Cross Channel is closed continuously. The Terminous station shows similar increases but tends to lag by one month.

Delta outflow is greater under the preferred alternative over the February through June period, resulting in generally lower spring and summer salinity at Jersey Point, San Andreas, and Prisoners Point. The increase in Delta outflow is attributable mainly to reductions in project exports. This lower salinity occurs despite continuous Delta Cross Channel closure between March and June under the preferred alternative. Salinity at Terminous remains generally higher in the spring despite higher flows under the preferred alternative, suggesting that the Delta Cross Channel has relatively greater effect there.

FIGURE VIII-21
EC FOR SACRAMENTO RIVER AT EMMATON

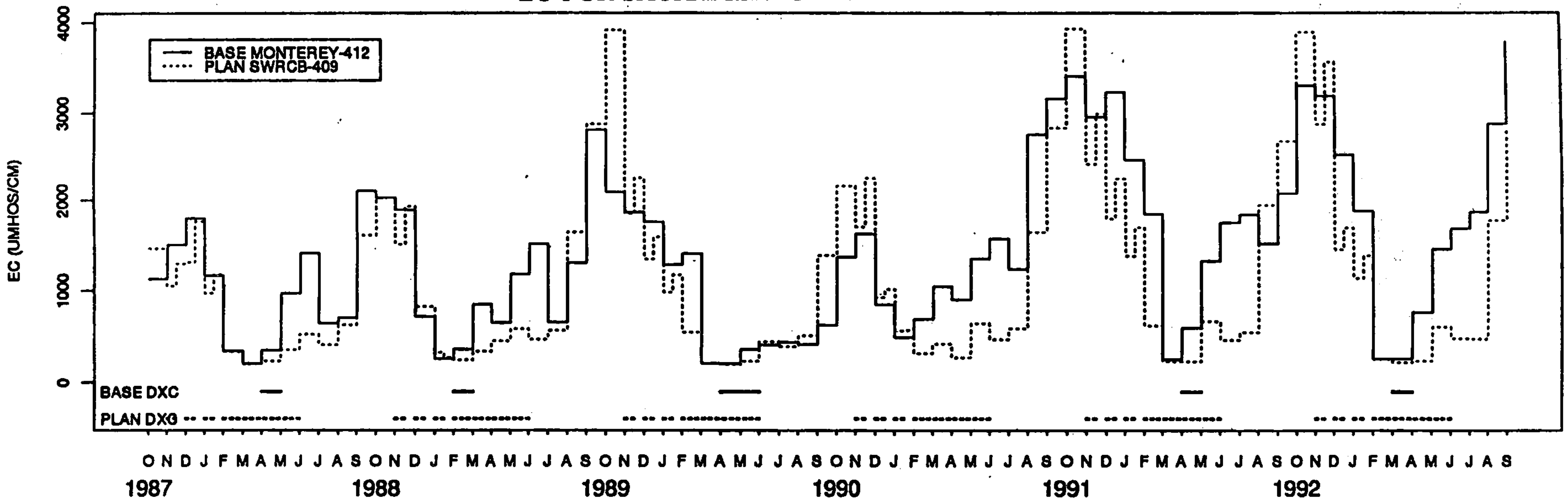
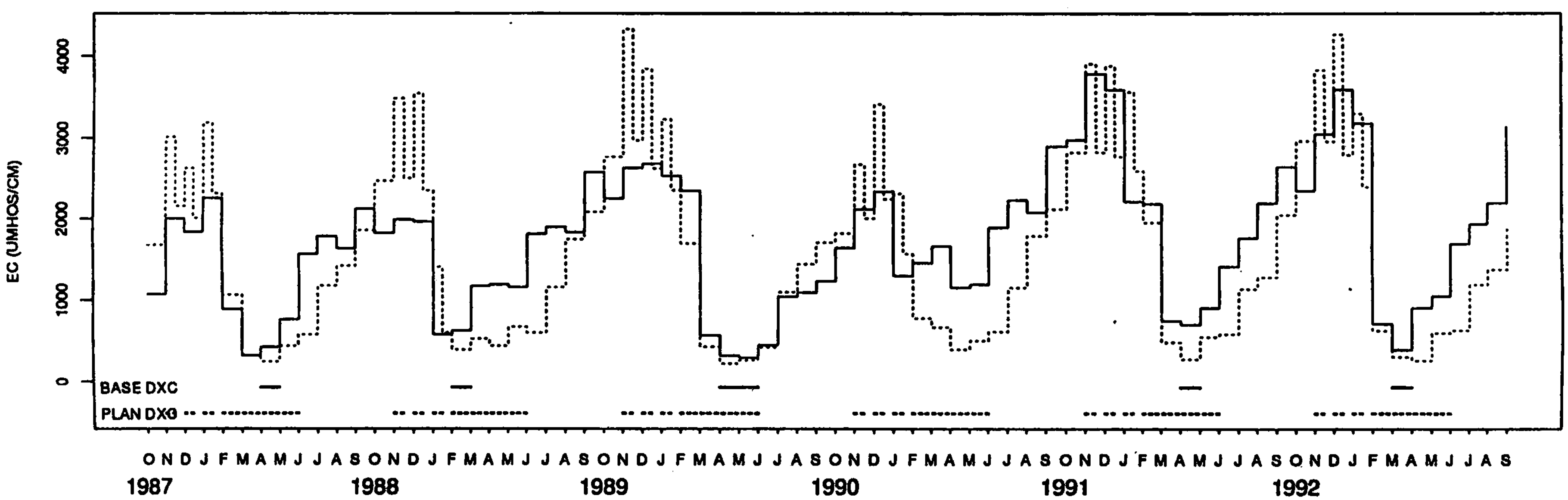


FIGURE VIII-22
EC FOR SAN JOAQUIN RIVER AT JERSEY POINT



SOURCE: DWR 1995

FIGURE VIII-23
EC FOR SAN JOAQUIN RIVER AT SAN ANDREAS LANDING

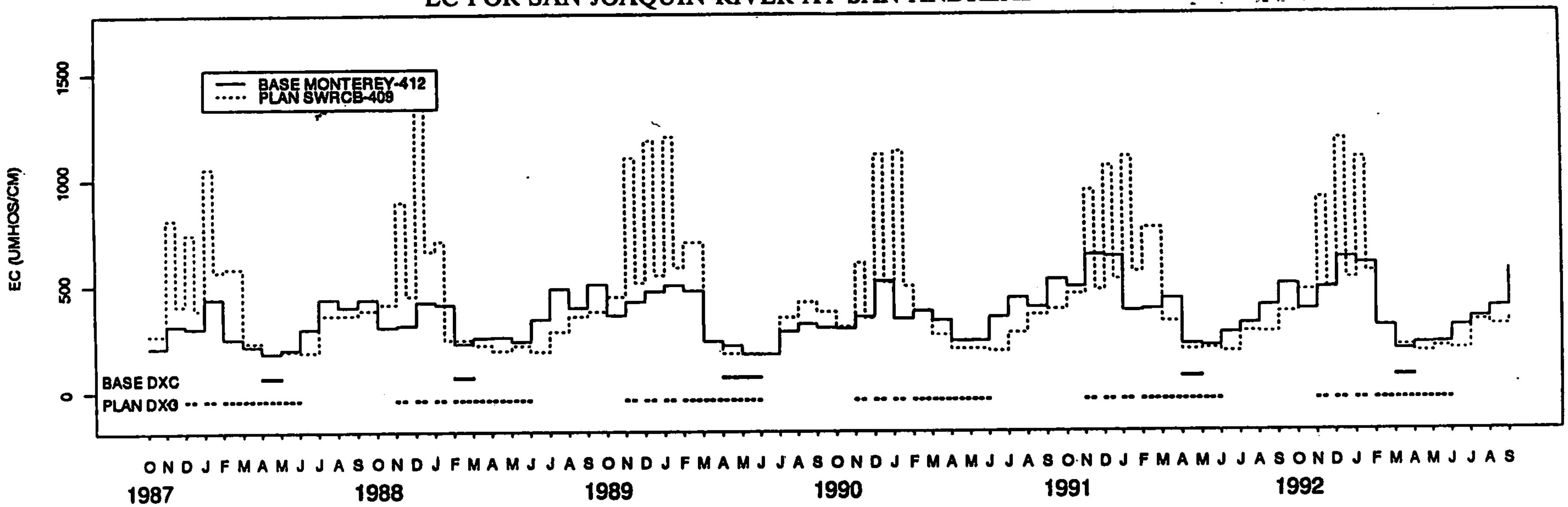
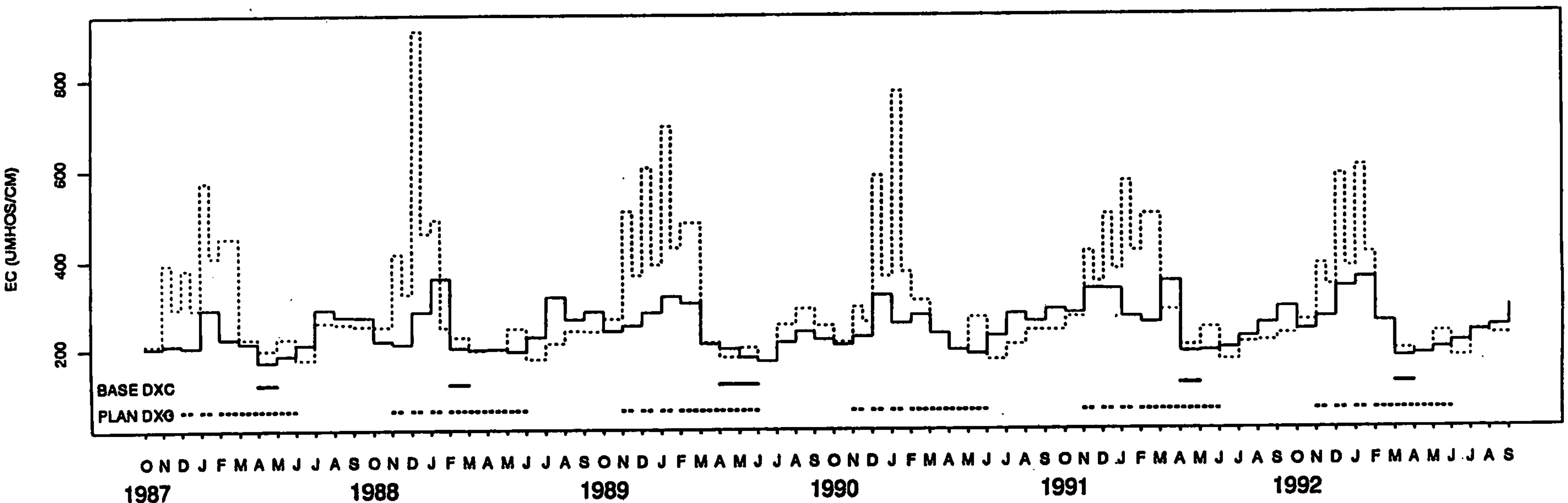


FIGURE VIII-24
EC FOR SAN JOAQUIN RIVER AT PRISONERS POINT



SOURCE: DWR 1995

FIGURE VIII-25
EC FOR SOUTH FORK OF THE MOKELUMNE RIVER AT TERMINOUS

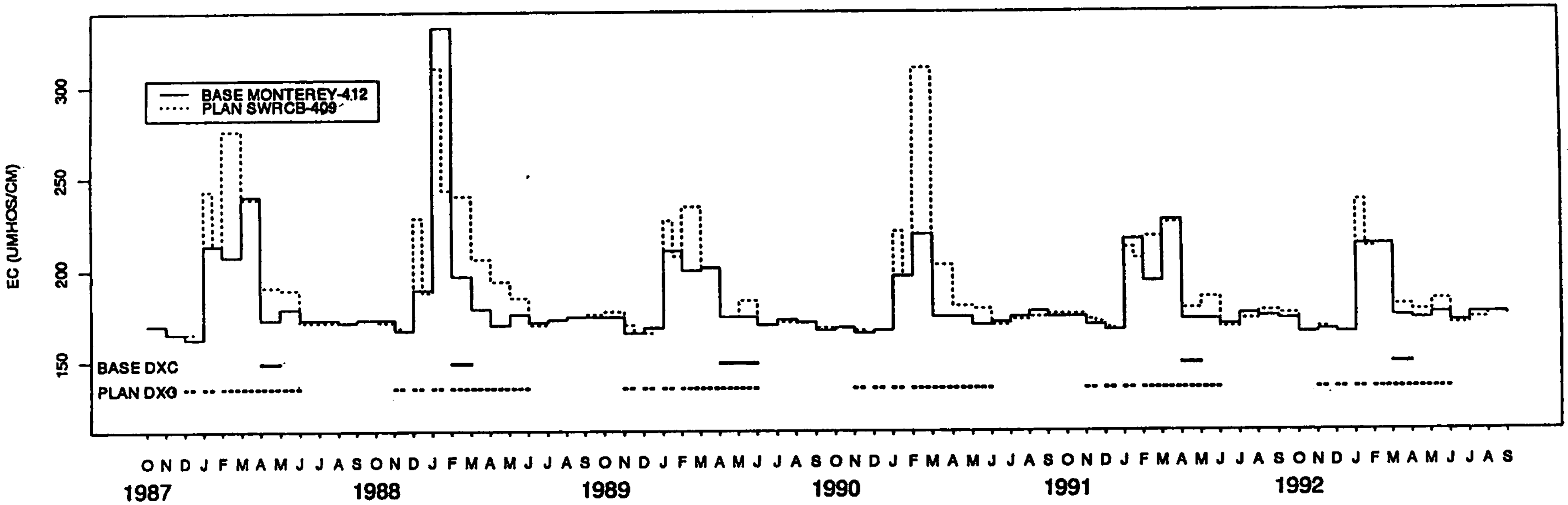
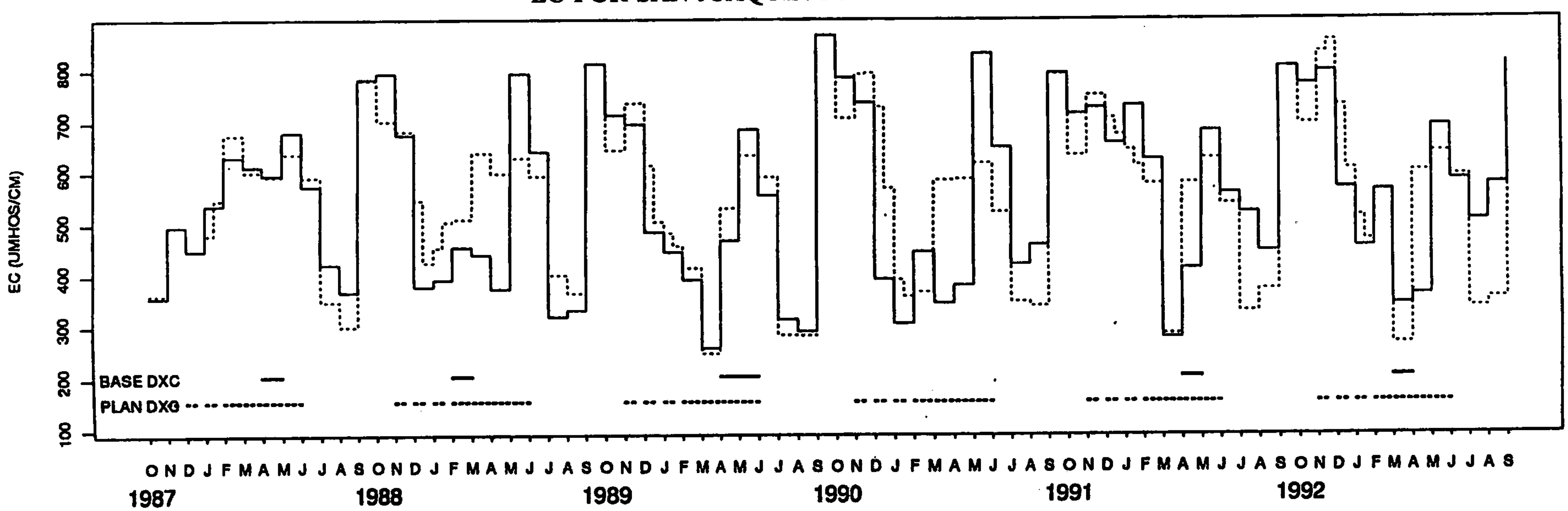


FIGURE VIII-26
EC FOR SAN JOAQUIN RIVER AT BUCKLEY COVE



SOURCE: DWR 1995

FIGURE VIII-27
EC FOR OLD RIVER NEAR TRACY

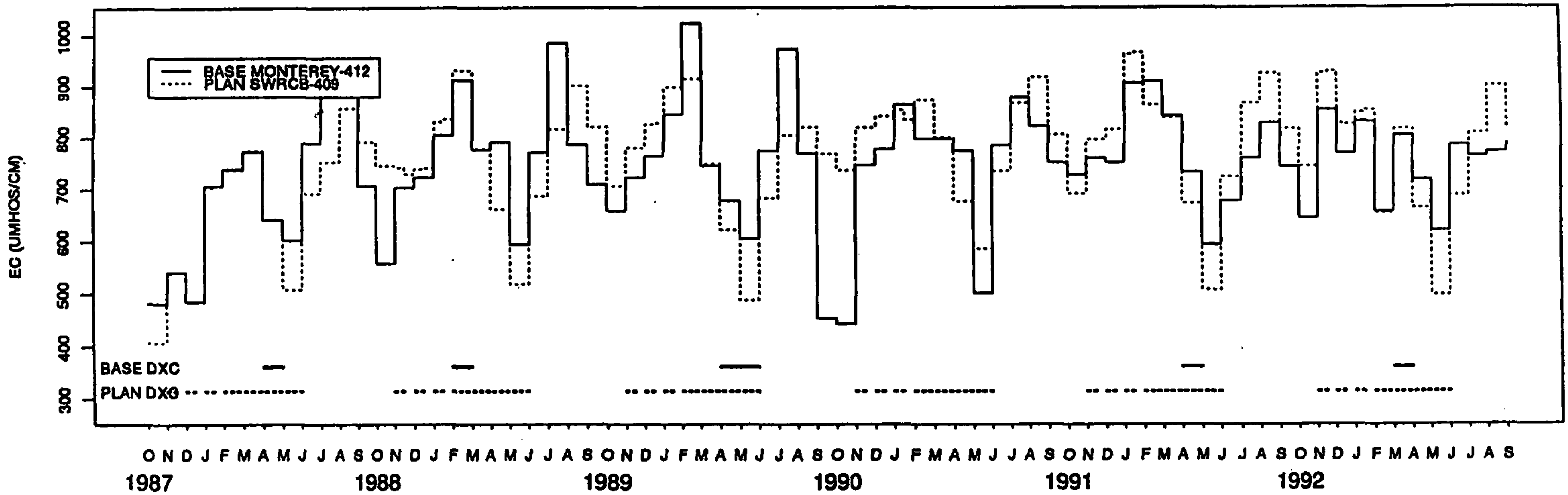
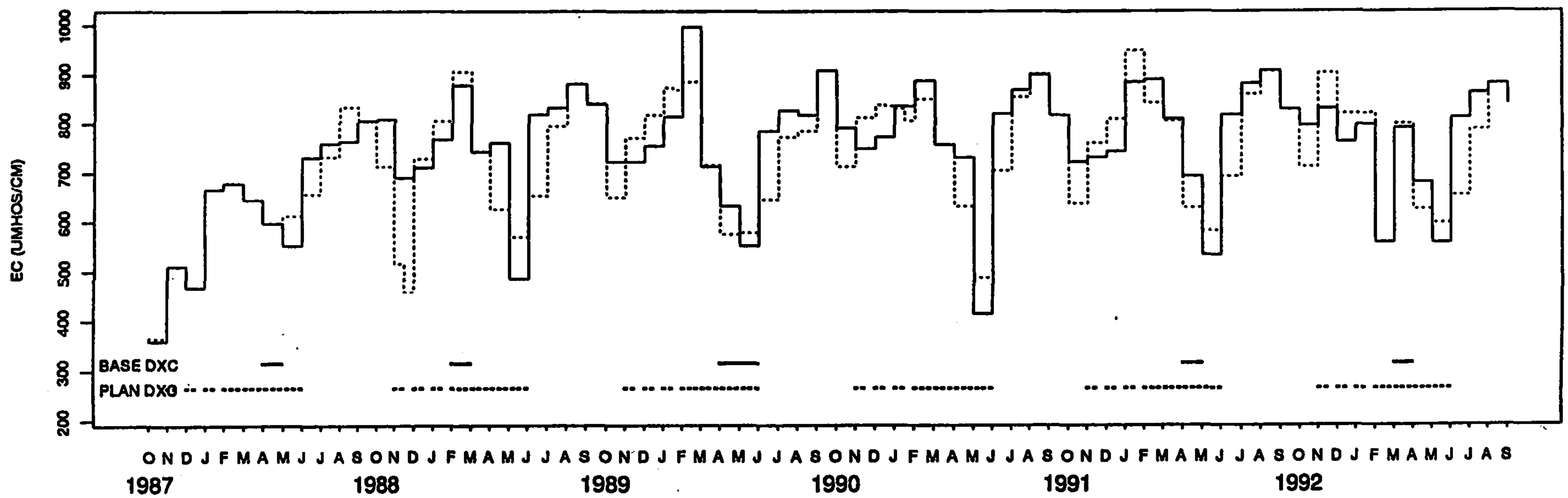


FIGURE VIII-28
EC FOR OLD RIVER AT MIDDLE RIVER



SOURCE: DWR 1995

FIGURE VIII-29
EC FOR SAN JOAQUIN RIVER AT BRANDT BRIDGE SITE

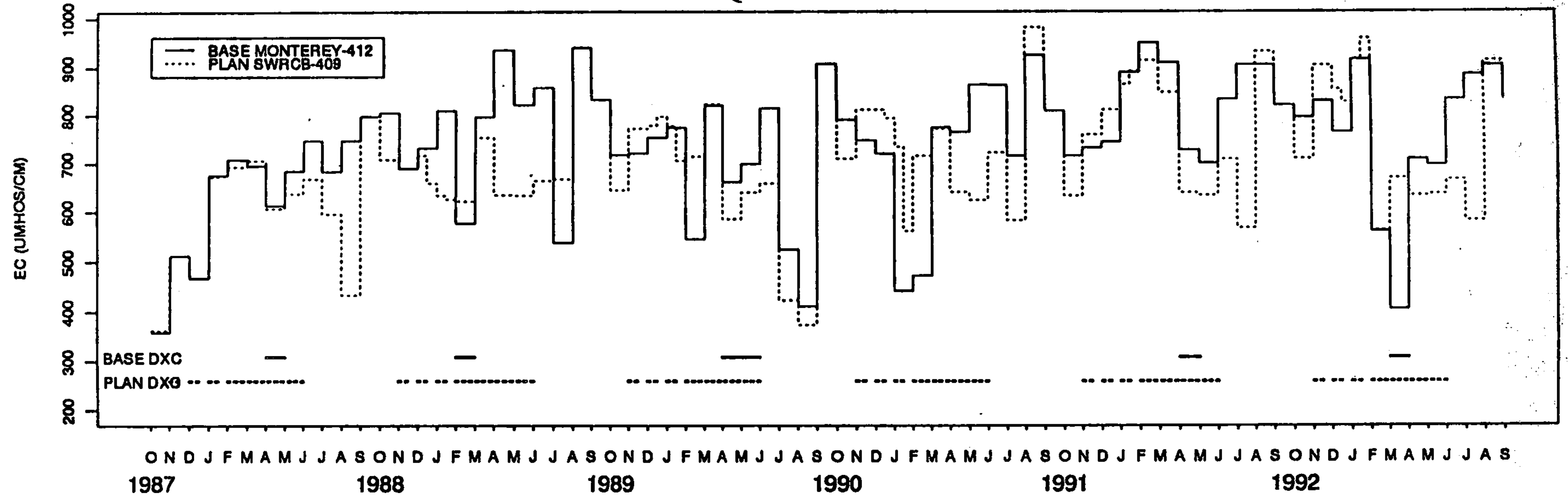
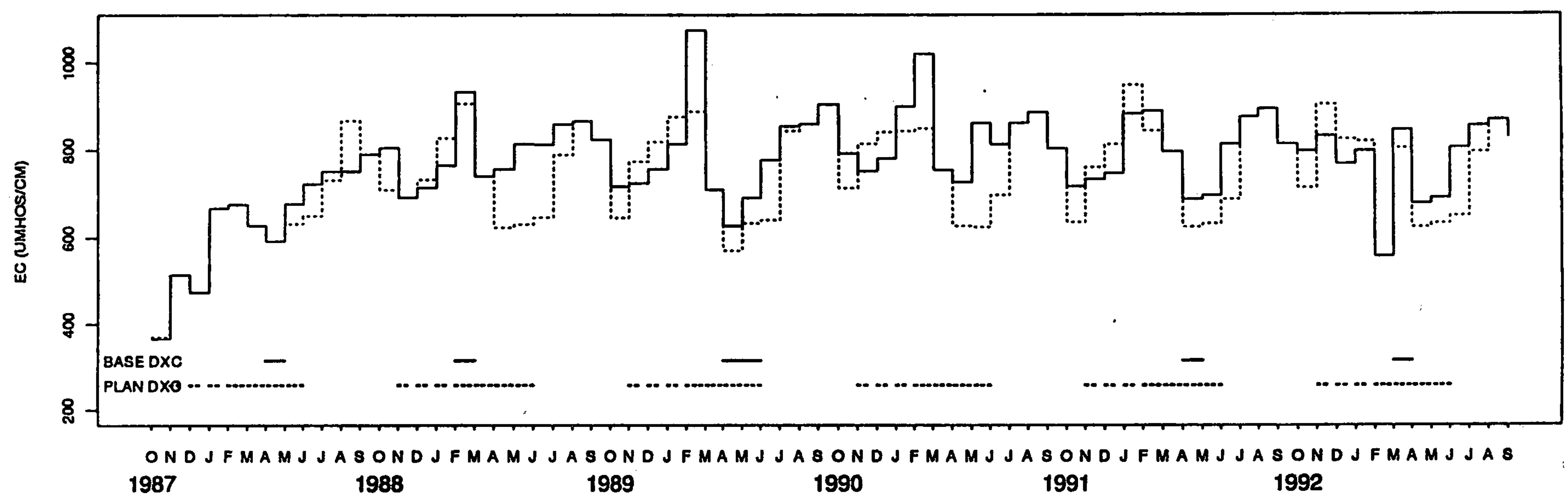


FIGURE VIII-30
EC FOR SAN JOAQUIN RIVER AT VERNALIS



SOURCE: DWR 1995

Figure VIII-26 shows salinity at Buckley Cove, on the San Joaquin River between Prisoners Point and Brandt Bridge site. Figures VIII-27 through VIII-30 show salinity under the preferred alternative and the base case at southern Delta stations for which the preferred alternative establishes year-round salinity objectives. Salinity changes in the southern Delta due to Delta Cross Channel closure are small. In general, salinity decreases under the preferred alternative from base conditions, especially from April through August. However, the 0.7 mmhos/cm standard for April through August is often exceeded in the later months (July and August) because of the 70 TAF cap on flows released from New Melones Reservoir to the San Joaquin River for water quality purposes.

Since salinity is an inverse function of flow at Vernalis, the base case versus preferred alternative differences in salinity shown in Figure VIII-30 directly reflect differences in flow. For example, November, December, and January flows are 0 to 14 percent less under the preferred alternative, resulting in 0 to 7 percent greater salinity. In general, the preferred alternative generates higher flows and lower salinities in October and April through July. Over the 1987-1992 period, average monthly salinity at Vernalis is reduced under the preferred alternative from the base case by 10 percent in April, 14 percent in May, 16 percent in June, and 3 percent in July.

Average monthly salinity at Brandt Bridge under the preferred alternative is reduced from the base case by 15 percent in April and May, 17 percent in June, 20 percent in July, and 8 percent in August. Buckley Cove generally has higher salinity in April under the preferred alternative despite higher San Joaquin River flow. This could reflect the influence of Delta Cross Channel closure. In May, larger San Joaquin River flows and reduced pumping improve salinity at Brandt Bridge and Buckley Cove under the preferred alternative. Salinity under the preferred alternative at Old River near Tracy is generally higher than the preferred alternative between September and January, and lower between March and August.

4. Water Levels

DWRDSM simulations of the base case and the preferred alternative, as discussed in section A.3, also provide means to address concerns regarding potential drawdown of water levels under the preferred alternative. According to DWRDSM modeling results (DWR 1995), significant increases in water levels are expected at Vernalis in October and April through June, as a result of the Vernalis flow requirements. On average over the 1987 through 1992 period, the average monthly Vernalis water level increases under the preferred alternative by 0.44 feet in October, by 0.71 feet in April, by 0.93 feet in May, and by 0.86 feet in June. Small decreases in water levels at Vernalis, ranging from 0.15 to 0.21 feet, are seen in November through January. Water levels also increase in February through April on the Old River near Middle River and at Tracy, and on the San Joaquin River at Brandt Bridge. DWRDSM results also show decreases in average monthly water level on the Old River near Tracy in May through October. The greatest average decrease in monthly water levels is 0.41 feet in July over the 1987 through 1992 period.

5. Aquatic Resources

The preferred alternative establishes new standards for controllable factors that both affect aquatic resources and are within the authority of the SWRCB. The preferred alternative also makes recommendations to other entities for factors within their control. The recommendations and their rationales are described in Chapter IX. The combination of new standards and recommendations to other agencies constitutes a comprehensive, multi-species management approach to the problems in the Bay-Delta Estuary. The entire package provides reasonable protection for all of the aquatic resources in the Estuary. However, not all species will receive the same level of protection, and monitoring will be needed to assess potential impacts on upstream fisheries resources.

The following discussion of the effects of the standards on aquatic resources is divided into two sections: summary of effects and aquatic resource model results.

a. Summary of Effects of Preferred Alternative on Aquatic Resources

The preferred alternative contains many of the elements found in a proposed set of standards titled, "Joint Proposal for Resolving San Francisco Bay-Delta Issues", prepared by a coalition of major agricultural and urban water users and submitted to the SWRCB at its October 1994 workshop. Consequently, much of the following description of the effects of the preferred alternative is extracted from a report prepared by this group titled, "Biological Explanation of the Joint Water Users Proposed Bay-Delta Standards" (JWU 1994).

The discussion of the effects of the preferred alternative is divided into four seasons, defined here as: spring (February through June), summer (July and August), fall (September and October), and winter (November through January).

SPRING (February-June). Spring is a critical time for most biological resources using the Estuary. During this time, many species are spawning, eggs are incubating, and juvenile fish, such as chinook salmon smolts, are emigrating through the Estuary. Because this time is so critical, a major focus of the standards is on the spring period. The greatest reduction in exports and the highest outflows are provided during this period.

Delta Outflow. The spring Delta outflow standard is complex. The standard consists of the number of days that three different flow levels are required from February through June. The flow levels are approximately the steady-state, 3-day running average flows necessary to maintain a 2 ppt isohaline (measured as 2.64 mmhos/cm EC) at: the confluence of the Sacramento and San Joaquin rivers, measured at Collinsville (7,100 cfs); Chipps Island (11,400 cfs); and Port Chicago (29,200 cfs). The number of days of a particular flow required by the standard can also be met if the daily average or 14-day average 2 ppt isohaline is at or west of the three locations specified above. The Port Chicago objectives apply only in months when the average EC at Port Chicago during the 14 days immediately prior to the first day of the month is less than or equal to 2.64 mmhos/cm.

The February through June Delta outflow standard approximately reproduces the number of days the 2 ppt isohaline would have been downstream of the three locations under various hydrologic conditions and year 1971.5 development levels. This level of development was selected since it is the mid-point of the time period, 1968-1975, that is believed to represent a reasonable level of protection. The confluence standard can be relaxed in March, upon the recommendation of the operations group established under the Framework Agreement, if the best available estimate of the Eight River Index for February is less than 500 TAF. Also, the confluence standard does not apply in May and June if the best available estimate of the Sacramento River Index for May is less than 8.1 MAF at the 90 percent exceedence level. Under this circumstance, a minimum 14-day average flow of 4,000 cfs is required in May and June.

The purpose of the Delta outflow standards are to increase outflow and restore some of the natural hydrologic patterns that historically occurred in the system and in which native fish and invertebrate species likely evolved and proliferated. The provision of late winter and spring river flow and Delta outflow promotes conditions conducive for spawning and dispersal of Delta smelt, longfin smelt, Sacramento splittail, and other estuarine and anadromous species.

As described in Chapters V and VI, a number of estuarine aquatic resources respond positively to increased spring outflow. The biological bases for this response are not well defined but are likely related to: (1) transport of eggs and larvae out of river and Delta areas and into downstream estuarine habitats; (2) nutrient transport into Suisun and Honker bays resulting in increased phytoplankton production; (3) mixing of salt and fresh water resulting in nutrient, egg, and larvae dispersal to shallow water habitats; (4) freshwater trapping in Grizzly Bay, an important nursery area; (5) reduced predation of juvenile fish due to increased dispersal to shallow water habitat and increased turbidity; and (6) intra- and inter-annual variation in outflow patterns which historically occurred in the system.

The geographic distribution of many planktonic fish eggs and larvae is influenced by the magnitude of freshwater outflow passing through the Delta. During periods of high spring freshwater outflow, the planktonic stages of these fish are distributed downstream in Suisun Bay, where their susceptibility to entrainment losses at the SWP and CVP diversions, and at other diversions within the Delta, is reduced. During years when spring outflow is low, a larger percentage of the planktonic larval fish is located within the Delta, where they are susceptible to entrainment losses and higher mortality rates (SWC 1992a).

The location of the entrapment zone downstream of the confluence of the San Joaquin and Sacramento rivers under higher outflow conditions may also be a factor causing improved survival during high outflow years. The entrapment zone is formed as fresh water flows over the more dense landward-flowing marine water, creating a circulation pattern that concentrates particles such as sediment and plankton (see section A.2.d of Chapter V). Production in the Estuary may be enhanced when the entrapment zone is located in the shallows of Suisun Bay rather than the comparatively narrow river channels upstream of the confluence.

Estuarine species respond to salinity as well as flow. Higher flows in the spring increase the volume of brackish water habitat available during a period when many euryhaline species are reproducing, which provides increased habitable space for certain species. Increased habitable space reduces densities, competition, and predation (DFG 1992).

Delta Cross Channel Gate Operation. The preferred alternative requires the Delta Cross Channel gates to be closed from February 1 through May 20 and closed for 14 days from May 21 through June 15. The purpose of this standard is to reduce the transport of emigrating salmon smolts, and eggs and larvae of other fish, into the central Delta.

The February through June period includes the peaks of both the migration season for winter- and fall-run chinook salmon smolts, and the spawning season for species such as Delta smelt, longfin smelt, Sacramento splittail, and striped bass on the Sacramento River. The diversion of smolts, eggs, and larvae out of the mainstem of the Sacramento River through the Delta Cross Channel and into the central Delta exposes them to numerous hazards, including entrainment in agricultural diversions and the export pumps, increased temperature, reduced food supply, and longer migration routes. Closing the Delta Cross Channel gates serves to reduce diversions of aquatic organisms into the central Delta, concentrate more flow in the mainstem Sacramento River, and help transport eggs, larvae, and smolts into Suisun Bay.

The Delta Cross Channel is but one of the two pathways by which salmon smolts can be diverted from the mainstem of the Sacramento River into the central Delta; the other pathway is Georgiana Slough. Georgiana Slough is a natural channel, and the Delta Cross Channel is a constructed channel. Smolts, eggs, and larvae diverted into the central Delta through Georgiana Slough encounter the same problems as smolts, eggs, and larvae diverted into the central Delta through the Delta Cross Channel. The SWRCB is not requiring installation of a barrier on Georgiana Slough, but the SWRCB recommends that the DWR and the USBR evaluate the use of a physical or acoustical barrier on Georgiana Slough. Recent prototype tests completed by Hanson Environmental, Inc. (1993) suggest that an acoustical barrier is a promising means for reducing the percentage of salmon smolts entering Georgiana Slough from the Sacramento River.

San Joaquin River Flow. The preferred alternative requires average flows ranging between 710 cfs and 3,420 cfs from February 1 through April 14 and May 16 through June 30, and average flows ranging between 3,110 and 8,620 cfs from April 15 through May 15. The required flow depends on water year type and location of the 2 ppt isohaline (a higher flow is required when 2 ppt is required to be at or west of Chipps Island). The purpose of these standards is to improve survival of salmon smolts emigrating down the San Joaquin River and to improve habitat conditions in the central and southern Delta for numerous aquatic species.

San Joaquin fall-run chinook salmon smolts migrate down the San Joaquin River principally in April and May, although some migration also occurs in June. The DFG has shown that increased flows in the San Joaquin River during the spring months is highly correlated with increased numbers of adult spawners returning two and a half years later (DFG 1987), which implies that smolt survival improves with increased spring flows. Since then, the USFWS has concluded from tagging studies in the San Joaquin River basin that smolt survival increases with increased flows and reduced exports (USFWS 1992). Results of experimental releases of tagged salmon smolts at various locations within the San Joaquin River (Dos Reis, Mossdale, Snelling, Lower Stanislaus, and Lower Tuolumne) between 1982 and 1993 suggest that smolt survival is related to the split of flows between Old River and the mainstem of the San Joaquin River. This flow split is affected by the flow at Vernalis, exports, and the status of the barrier at Old River. The likely mechanism for increased survival at higher flows is decreased migratory time through the central Delta and decreased chance of diversion off the mainstem of the San Joaquin River to the export pumps. The problem of diversion to the export pumps can also be partially addressed through construction of an Old River barrier. The SWRCB is recommending the evaluation and construction, if appropriate, of this barrier in the plan.

The volume of water required by the April 15 through May 15 pulse flow objective should be distributed over the 31-day period to coincide with fish migration, as determine by the operations group established under the Framework Agreement. Short-duration flow fluctuations, adequately separated in time, have shown to be effective in cuing smolts into outmigration. Effective planning and management of a combination of base flow and pulsed flow fluctuations can improve smolt survival efficiently.

The San Joaquin River spring flow objectives also coincide with the spawning season of a number of estuarine species, such as Delta smelt, Sacramento splittail, and striped bass. These higher flows will improve salinity conditions for spawning in the central and southern Delta, and provide transport flows out of the central Delta.

<u>Direct Export Limits</u>. The preferred alternative limits the maximum export rate from April 15 through May 15 to an amount equal to 100 percent of the 3-day running average Vernalis flow or 1,500 cfs, whichever is higher. The purpose of this standard is to limit entrainment and salvage losses of outmigrating smolts from the San Joaquin River.

A direct benefit of the standard is the reduction in numbers of species entrained into Clifton Court Forebay and into the screens, pumps, and salvage operations at SWP and CVP facilities. Spring is the period of reproduction of many aquatic vertebrates and invertebrates. Planktonic egg and larval stages are most susceptible to entrainment into the pumps because they can neither be screened nor salvaged. Spring is also the period of the outmigration of salmon smolts. The simultaneous reduction in exports with the increased flows in the San Joaquin River during the chinook salmon smolt outmigration period is especially important for improved survival of smolts from both the San Joaquin and Sacramento rivers; however, it is most critical for the San Joaquin smolts because the facilities entrain more salmon from the San Joaquin River (DWR 1992).

For the direct export limit standard to have its greatest benefit for outmigrating salmon, it should be coupled with construction of the Old River barrier. Results of coded wire tag studies indicate that outmigrating smolts are susceptible to entrainment at the pumps due to false attraction down the Old River channel near Mossdale (USFWS 1992).

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 35 percent of Delta inflow from February through June. Export pumping can be increased to 45 percent in February if the best available estimate of the Eight River Index for January is less than or equal to 1.0 MAF. If the best available estimate of the Eight River Index for January is between 1.0 MAF and 1.5 MAF, the export limit for February will be set by the operations group established under the Framework Agreement within the range of 35 percent and 45 percent. The purpose of these standards is to reduce fish, egg, and larvae entrainment and mortality at the pumps through export restrictions and intensive real-time monitoring designed to detect the presence of fish in areas adjacent to the pumps.

Relatively low export/inflow ratios are specified during the spring (≤ 35 percent) when fish, eggs, and larvae are especially vulnerable to entrainment at the pumps. The export/inflow limits during the summer, fall, and winter, which allow exports to 65 percent when fish are less vulnerable to diversion losses, were developed with consideration for balancing fish protection with water supply needs.

The development of the export/inflow concept was founded on two basic principles. First, exports may increase during periods when higher volumes of fresh water are flowing through the Delta without increasing the risk of adverse biological effects. Correspondingly, exports should decrease during those years when freshwater inflow to the Delta is decreased and a larger percentage of fish and other aquatic organisms are geographically distributed further upstream where their susceptibility to export losses is increased. Second, the percentage of water diverted in recent years, particularly during the spring, has increased substantially above diversion levels (expressed as a ratio of exports to inflow) during earlier years when aquatic resources inhabiting the Bay-Delta system were at higher population levels. The analysis in section A.2 of this chapter demonstrates that, in dry and critical years, the standard will result in lower export/inflow ratios than those which occurred in the reference period of 1984-1992, especially in the spring months.

SWP fish salvage records are available for use in evaluating the seasonal distribution in susceptibility and loss resulting from water project operations. Review of salvage data for 1980-1990 shows that the seasonal distribution of losses varies among species. Salvage data were compiled for striped bass, chinook salmon, American shad, Sacramento splittail, longfin smelt, and Delta smelt to characterize the seasonal distribution in fish losses. For these species, combined average monthly losses were greatest in April (10 percent), May

(23 percent), June (24 percent), and July (16 percent). Therefore, over 70 percent of the combined average losses for these species occurred between April and July. Average monthly losses ranged from 2 to 6 percent between August and March. In addition to salvage losses, relatively large numbers of fish eggs and larvae, which are not accounted for in salvage data, are susceptible to entrainment losses during April through June (JWU 1994). This summary of the salvage data by month does not, however, reflect the timing or loss of species of low abundance.

SUMMER (July and August). The occurrence of fish in the Bay-Delta Estuary during the summer is primarily limited to resident species, although some late spawning of striped bass, Delta smelt, and Sacramento splittail has been reported in some locations. A comparison of life stage periodicity data for several species indicates a window of inactivity during July and, in particular, August for these species. Standards for this period focus on maintenance of estuarine health and biological processes.

Delta Outflow. The preferred alternative requires the following minimum monthly average net Delta outflows for the summer period:

Table VIII-1. July and August Delta Outflow

Water Year Type	Delta Outflow (cfs)	
	July	August
Wet	8,000	4,000
Above Normal	8,000	4,000
Below Normal	6,500	4,000
Dry	5,000	3,500
Critical	4,000	3,000

The purpose of these standards is to provide outflow during summer months for maintenance of biological communities in preparation for the fall transition period, described below. The intended benefits are to sustain suitable habitat in the Delta for continued rearing of juvenile and maintenance of adult fish (Delta smelt, striped bass, and others) and to reduce seawater intrusions into the Estuary to prevent the colonization of undesirable organisms in the Delta (e.g., *Potamocorbula*, *Mya* sp., and others).

Although many of the important estuarine species of fish have spawned by June, several others, including striped bass, Delta smelt, and Sacramento splittail, have been reported to continue spawning into July. Additionally, larvae and early juveniles of Delta smelt and other species remain in the system and warrant conditions conducive to their survival. The derivation of the recommended flows is not based on the results of quantitative habitat or population studies, but rather on scientific judgment. No definitive studies have been completed to support this specific outflow proposal. The effectiveness of the recommended flows for benefitting the resource will be evaluated as part of the plan's monitoring program.

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 65 percent of Delta inflow in July and August. The purpose of this standard is to limit entrainment of organisms at the export pumps and to regulate pumping in conjunction with a real-time monitoring and response program at locations adjacent to the pumps.

July and August are a transition period during which Delta export/inflow ratios can increase, as biologically sensitive periods pass. The majority of spawning, and egg and larvae transport, is completed by July. As discussed above, review of salvage data indicates that, historically, the highest percentages of salvage occurred during the April-June period. No definitive studies or analyses were completed to support these export/inflow restrictions. The export/inflow ratios are based on shifting periods of high exports to less biologically sensitive periods.

FALL (September and October). The fall period marks the transition from the dry summer months to a period of increased rainfall with a corresponding decrease in water temperatures. Biologically, several species of fish, including fall-run chinook salmon, begin to migrate upstream into the Sacramento and San Joaquin rivers and tributaries in preparation for spawning. Adult and juvenile Delta smelt, striped bass, and adult Sacramento splittail continue to rear in portions of the Delta. Therefore, conditions promoting feeding and growth in preparation for spawning are important.

Delta Outflow. The preferred alternative requires a minimum monthly average net Delta outflow of 3,000 cfs in September and 4,000 cfs in October, except in October of critical years when the standard is 3,000 cfs. The purpose of this standard is to provide outflow for maintaining conditions conducive to growth and maintenance of resident and anadromous adult and juvenile fish populations utilizing the Bay-Delta Estuary during this period and to provide attraction flows for fall-run chinook salmon.

The intended benefits of this standard are to maintain a healthy ecosystem during this period by providing: (1) conditions which allow growth and maturation of adult fish in preparation for spawning; (2) conditions suitable for fall-run chinook salmon staging; and (3) velocity cues for upstream spawning migration of fall-run chinook salmon and longfin smelt. The standards are based on biological judgment of the life history and rearing requirements of species utilizing the Delta during this time period. No definitive studies have been conducted to determine flow magnitudes and durations.

Sacramento River Flow. The preferred alternative requires minimum monthly average flows on the Sacramento River at Rio Vista of 3,000 cfs in September and 4,000 cfs in October, except in October of critical years when the standard is 3,000 cfs. The purpose of this standard is to provide a minimum flow to attract adult salmon to the Sacramento River. Returning adult salmon rely on velocity cues for stimulating upstream migrations. Maintaining minimum Sacramento River flows will provide such cues for adult fall-run chinook salmon.

San Joaquin River Flow. The preferred alternative requires a minimum monthly average flow of 1,000 cfs in the San Joaquin River at Vernalis in October. A pulse flow of up to 28 TAF is also required in all water year types as needed to provide a monthly average flow of 2,000 cfs. The additional pulse flow is not required in a critical year following a critical year. The timing and duration of the pulse flow will be determined by the operations group established under the Framework Agreement.

The purpose of the pulse flow standard is to attract adult fall-run chinook salmon into the San Joaquin River; the purpose of the base flow standard is to provide adequate migratory conditions for adult fall-run salmon on the San Joaquin River. The pulse flow should also help to achieve the dissolved oxygen standard of 6.0 mg/l from September 1-November 30 between Stockton and Turner Cut on the San Joaquin River. The dissolved oxygen standard is intended to alleviate the dissolved oxygen sag that occurs every fall in that reach and which has been reported to block upstream migration of salmon.

Adult salmon returning to the San Joaquin River are faced with numerous channels on their migration to upstream natal spawning grounds. A pulse of water down the mainstem San Joaquin River will provide additional velocity and olfactory cues which should direct salmon to the main river and facilitate passage through the lower Delta. The month of October was chosen to coincide with the timing of adult chinook salmon arriving at the Merced River Hatchery prior to 1989, the beginning of the recent drought years (DFG 1992). Delays in upstream migration have occurred since then due to low fall flows upstream and poor water quality downstream. Migration and spawning delays constrict the time period available to produce salmon offspring. Narrowing the period can result in poor recruitment and further reduce the population (DFG 1992). Late or delayed spawning can result in poor egg quality and diminished survival to hatching. Delayed incubation and fry emergence resulting from late spawning can shift smolt outmigration further into May when water temperatures are higher and other mortality factors are greater.

The scientific basis for this standard is largely subjective, and based on biological judgment and knowledge of behavior patterns and requirements of migrating adult salmon. The amount of flow in the recommended standard represents an improvement over historical dry water year conditions.

Export/Inflow Ratio Limits. The plan limits exports to 65 percent of Delta inflow in September and October. The purpose of this standard is to limit entrainment of organisms at the export pumps, and to regulate pumping in conjunction with a real-time monitoring and response program at locations adjacent to the pumps.

The fall is a transition period during which export/inflow ratios can be higher because entrainment potential of fish is relatively low. Review of salvage data indicates that, historically, the highest percentages of salvage at the export pumps occur during the April-June period. The export/inflow ratios allow periods of higher exports during a biologically less sensitive period in exchange for lower exports during the April-June period.

WINTER (November-January). Winter is a less sensitive period for most estuarine biological resources. Certain fish species normally spawn during this period, including starry flounder and longfin smelt. While some migration occurs, this period is of lesser importance with respect to flow-related measures because the Estuary is at a natural production ebb and natural, unregulated flows through the system are sufficient for support of biological functions in most years.

Delta Outflow. The preferred alternative requires a minimum monthly average net Delta outflow in November and December of 3,500 cfs in critical years and 4,500 cfs in all other year types. In January, the minimum monthly average net Delta outflow standard is 4,500 cfs, except when the best available estimate of the Eight River Index for December is greater than 800 TAF, in which case the January standard is 6,000 cfs. The purpose of the standards are to provide net Delta outflow for continued rearing of juvenile and maintenance of adult fish, and to provide conditions conducive for maturation of adult fish in preparation for spring spawning.

There are no definitive scientific data to determine appropriate flow magnitudes and durations to produce intended benefits. The standard is based on professional judgment of the life history and rearing requirements of species utilizing the Delta during this time period. The higher flows in January, compared to those during November and December, are intended to provide conditions conducive to adult maturation and egg development, and represent a transition toward higher outflows that occur during the spring period (February-June).

Delta Cross Channel Gate Operation. The preferred alternative requires the Delta Cross Channel gates to be closed up to a total of 45 days based on real time monitoring (flows, turbidity, etc.) from November through January. Operating criteria for this standard will be developed by the operations group established under the Framework Agreement.

The purpose of this standard is to protect emigrating spring-run chinook salmon, and possibly winter-run chinook salmon, from diversion off of the mainstem of the Sacramento River and into the central Delta. The problems associated with such diversion are discussed under the spring period, above.

Sacramento River Flow. The preferred alternative requires minimum monthly average flows on the Sacramento River at Rio Vista in November and December of 3,500 cfs in critical years and 4,500 cfs in all other year types. The purpose of these standards is to contribute to the maintenance and continued rearing of resident juvenile and adult fish in the

Estuary, and to provide upstream migration cues for late fall- and winter-run adult chinook salmon and longfin smelt.

There are no definitive scientific data to determine appropriate flow magnitudes and durations to produce intended benefits. The standards are based on professional judgment and knowledge of the life history and rearing requirements of species utilizing the Delta during this time period.

Export/Inflow Ratio Limits. The preferred alternative limits export pumping to 65 percent of Delta inflow from November through January. The purpose of this standard is to limit entrainment of organisms at the export pumps.

Fish densities are typically low at the export pumps during the winter. The export/inflow ratios allow periods of higher exports during a biologically less sensitive period in exchange for lower exports during the April-June period.

b. Aquatic Resource Model Results. The previous section provides a biological rationale for, and a qualitative description of the expected benefits of, the standards in the preferred alternative. In this section, the aquatic resource models described in Chapter VI are used to provide quantitative descriptions of possible effects of certain standards in the preferred alternative. As discussed in Chapter VI, these regression equations have limited predictive capability. The regressions are only valid under the conditions in which they were derived, and conditions in the Delta are constantly changing. Nevertheless, the results are presented here for informational purposes.

The bar charts in Figures VIII-31 through VIII-41 summarize the results of the aquatic resource model calculations. Most of the figures have six bars. The six bars, in order, summarize the following information: (1) the actual monitoring aquatic resource data collected in the Delta during the historical reference period (1984-1992, except for POC and *Neomysis*, which are 1984-1989 and 1984-1990, respectively); (2) the calculated abundances (or survivals) in the reference period using actual hydrologic data; (3) the calculated abundance/survival in the reference period using DWRSIM-modeled hydrology under D-1485 conditions; (4) the calculated abundance/survival in the reference period using DWRSIM-modeled hydrology under the preferred alternative conditions; (5) the calculated abundance/survival over the 71-year DWRSIM-modeled hydrology under D-1485 conditions; and (6) the calculated abundance/survival over the 71-year (1922-1992) DWRSIM-modeled hydrology under the preferred alternative conditions. Figures VIII-39 through VIII-41 do not include the first bar described above because there are no historical wild salmon smolt survival data. (The salmon models were derived using tagged hatchery fish.). In addition, Figure VIII-39, which shows salmon survival with the Old River barrier, does not include the second bar because there was no barrier at the head of Old River during the reference period.

For purposes of discussion, the model results can be broken into three categories: (1) abundance/Delta outflow model results in Figures VIII-31 through VIII-36; (2) striped bass model results in Figures VIII-37 and VIII-38; and (3) salmon model results in Figures VIII-39 through VIII-41.

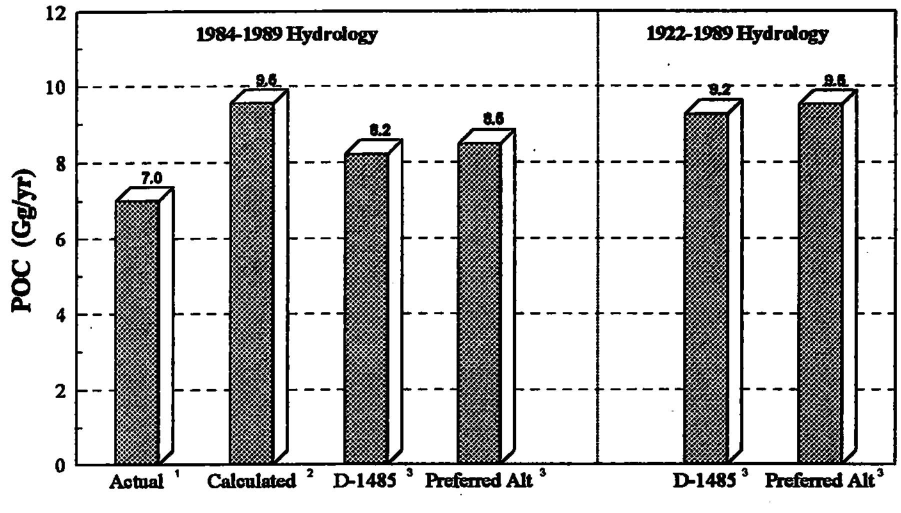
Under preferred alternative conditions, abundance/outflow model results predict that, at minimum, the existing abundances of the modeled aquatic resources would be maintained. In some cases, minor improvements may occur. A similar result is expected for most of the alternatives considered by the SWRCB, as discussed in Chapter XI. The abundance/outflow models indicate that substantial increases in abundances occur due to large storm-driven outflows, which are well outside the control of the CVP and the SWP. The additional outflow over the base case (as a result of the Delta outflow standards in the preferred and other alternatives) is adequate only to maintain existing populations of aquatic resources according to the models.

The results of the striped bass model are different than the abundance/outflow models. The striped bass model predicts that a substantial improvement in the young-of-the-year (YOY) will occur due to implementation of the standards. The YOY is principally dependent on the export and outflow conditions in the April through July period, and these months receive substantial protection in the plan. The model does not predict, however, a correspondingly substantial improvement in adult striped bass population. The adult striped bass population is principally dependent on the YOY, and on the export and outflow conditions from August through March. One of the effects of implementation of the standards will be to shift export pumping out of the spring period, which is considered most critical for estuarine protection, and into the fall and winter. The striped bass model indicates that this shift will result in the benefits of increased YOY to be largely lost, probably through increased entrainment in the fall and winter. Overall, the model results indicate that, if the plan had been in effect, with a 1995 demand level, during the reference period, striped bass populations would have declined more than they actually did. Over the 71 years of simulated hydrology, the long-term average population would have been similar to the existing population of about 600,000 striped bass.

The results of Figure VIII-38 should be viewed with caution. The figure shows that the population of adult striped bass would be greater under the 1984-1992 DWRSIM-modeled hydrology than under the 1922-1992 DWRSIM-modeled hydrology even though 1984-1992 was a dry period on average. This result is obtained because the modeled population in a particular year is dependent on the population from the previous seven years; and the actual striped bass population data from 1977-1983 were used in the 1984-1992 calculation, and the existing population of approximately 600,000 striped bass was used for the 1922-1992 calculation.

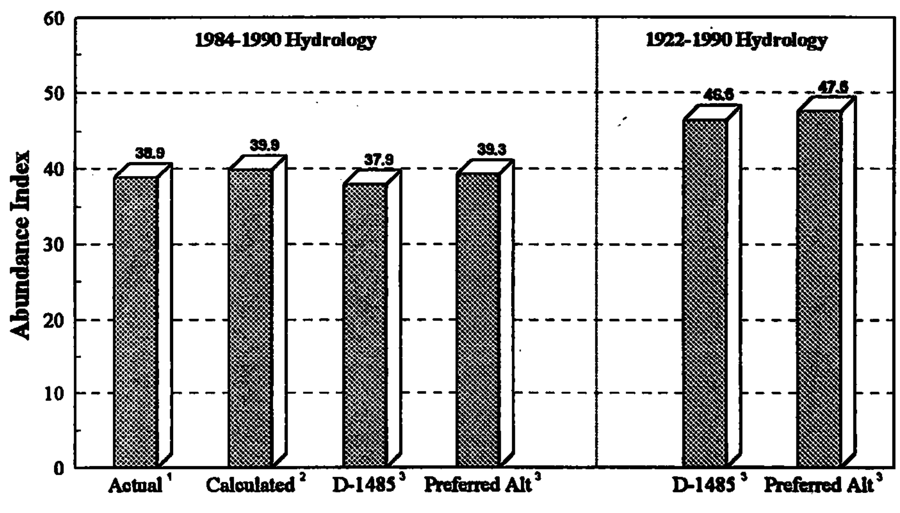
The salmon smolt survival models indicate that implementation of the standards will benefit Sacramento and San Joaquin fall-run chinook salmon smolts as they migrate through the Delta. However, as described in Chapter VI and illustrated in Figure VIII-39 through

Figure VIII-31
Particulate Organic Carbon (POC)



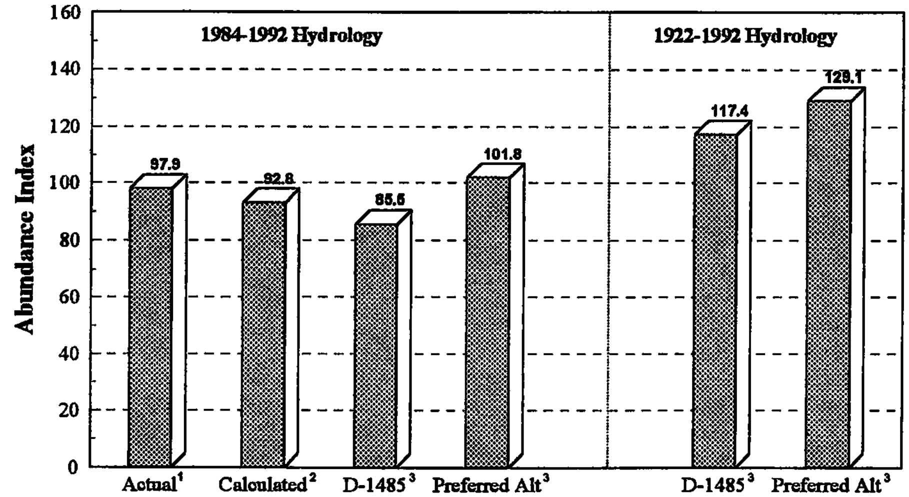
1 - Average index from empirical data provided by Jassby
2 - Average index from Jassby POC model using historical flows
3 - Average index from Jassby POC model using DWRSIM operation study flows

Figure VIII-32
Neomysis



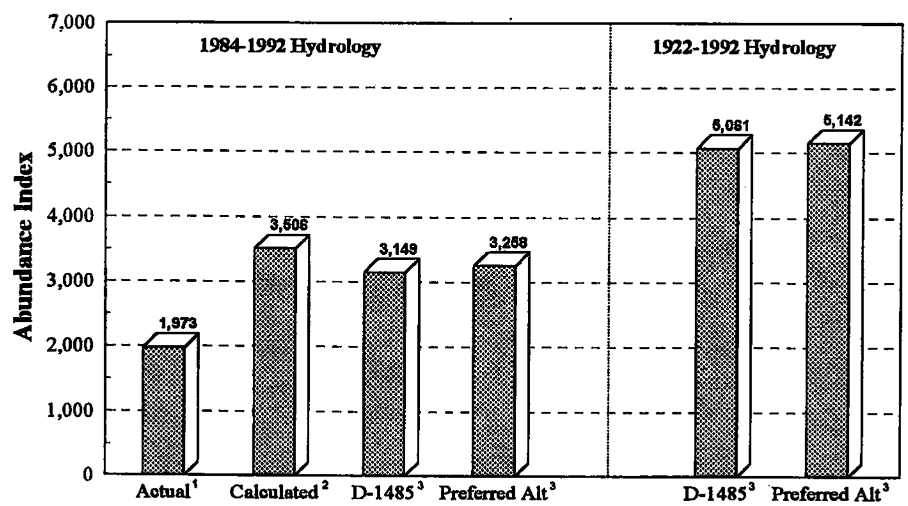
1 - Average index from empirical data provided by DFG
2 - Average index from Jassby *Neomysis* model using historical flows
3 - Average index from Jassby *Neomysis* model using DWRSIM operation study flows

Figure VIII-33
Immature *Crangon franciscorum*



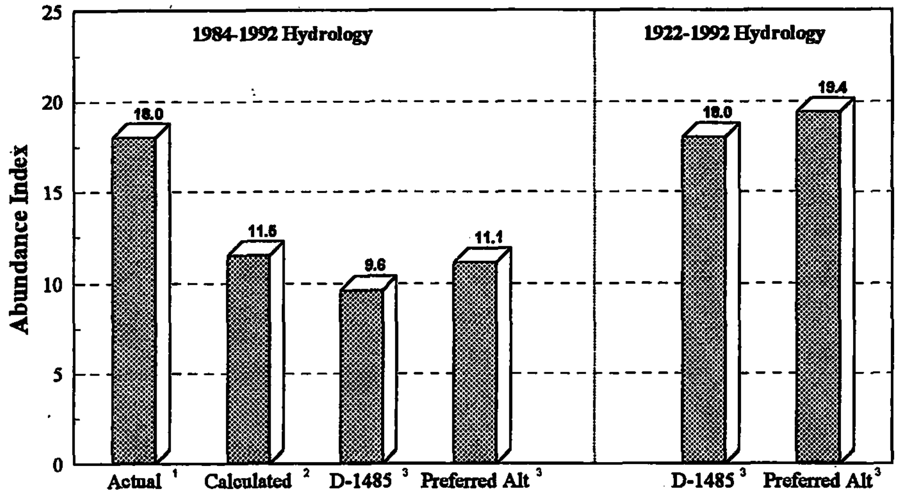
1 - Average index from empirical data provided by DFG
2 - Average index from DFG *Crangon* model using historical flows
3 - Average index from DFG *Crangon* model using DWRSIM operation study flows

Figure VIII-34
Longfin Smelt



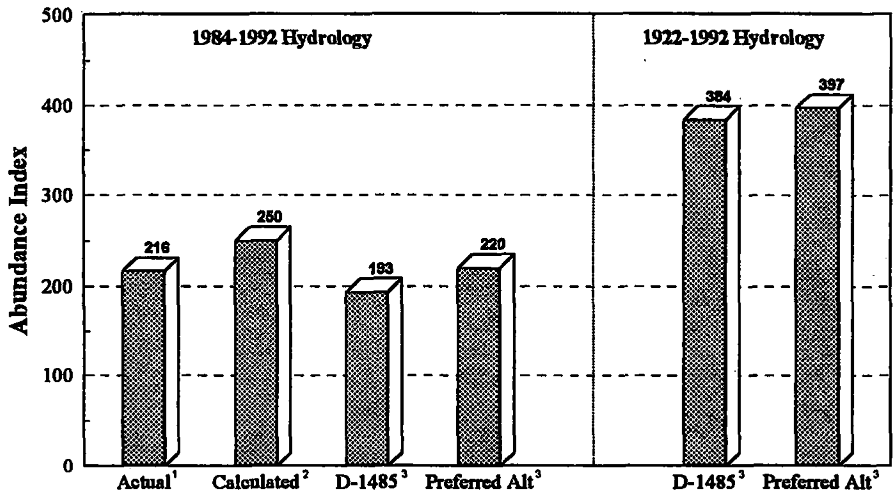
1 - Average index from empirical data provided by DFG
2 - Average index from DFG *Crangon* model using historical flows
3 - Average index from DFG *Crangon* model using DWRSIM operation study flows

Figure VIII-35
Sacramento Splittail



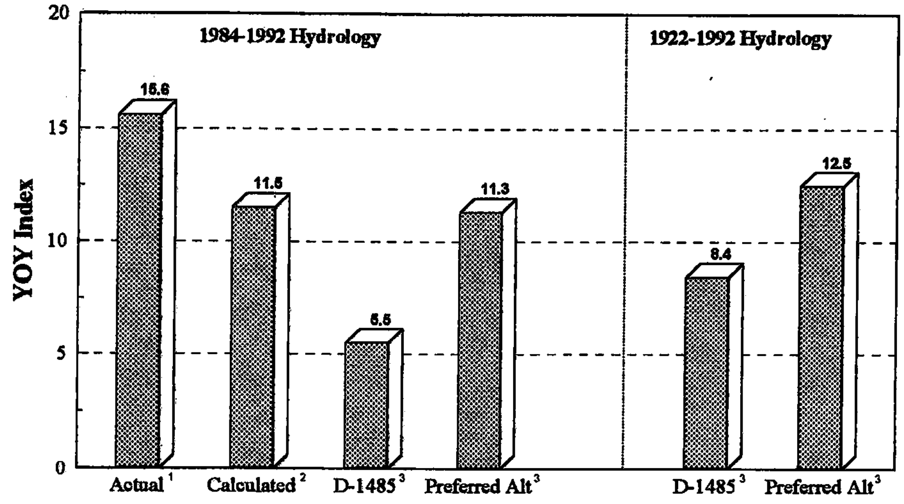
1 - Average index from empirical data provided by DFG
2 - Average index from DFG Sacramento splittail model using historical flows
3 - Average index from DFG Sacramento splittail model using DWRSIM operation study flows

Figure VIII-36
One-Year-Old Starry Flounder



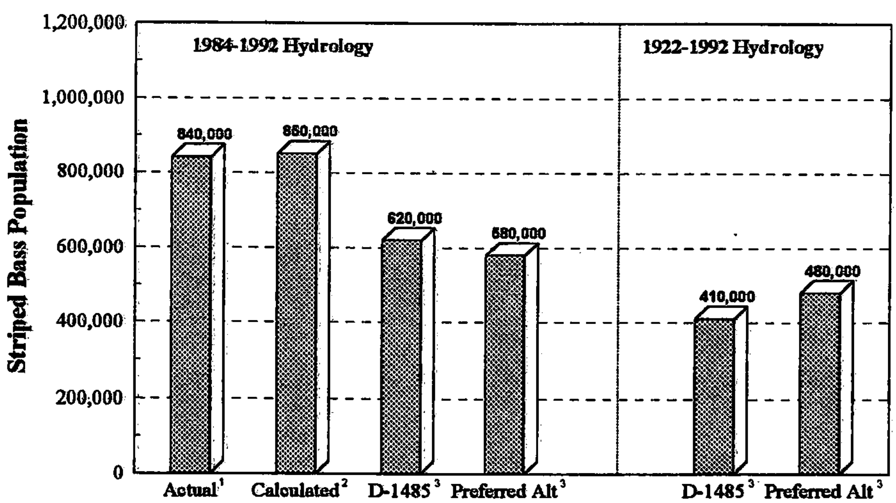
1 - Average index from empirical data provided by DFG
2 - Average index from DFG starry flounder model using historical flows
3 - Average index from DFG starry flounder model using DWRSIM operation study flows

Figure VIII-37
Striped Bass YOY Index



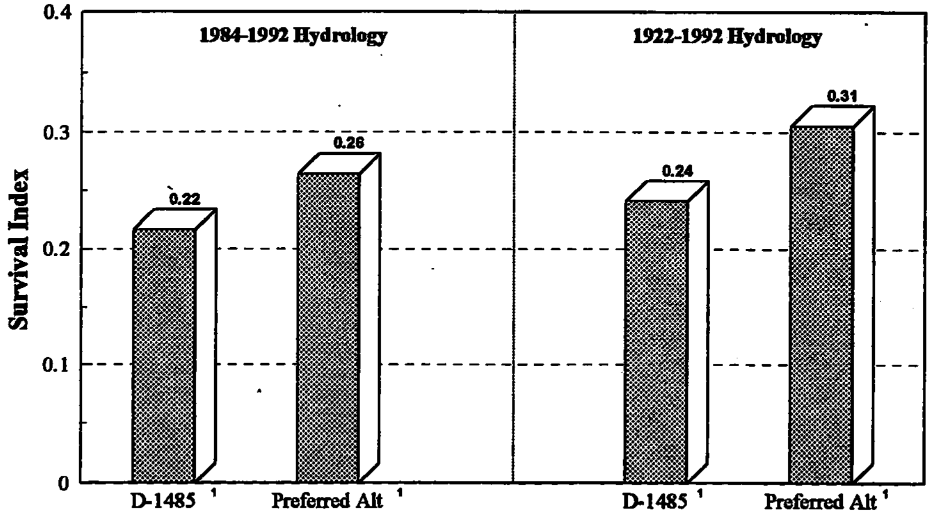
1 - Average index from empirical data provided by DFG
2 - Average index from DFG striped bass model using historical flows
3 - Average index from DFG striped bass model using DWRSIM operation study flows

Figure VIII-38
Adult Striped Bass Population



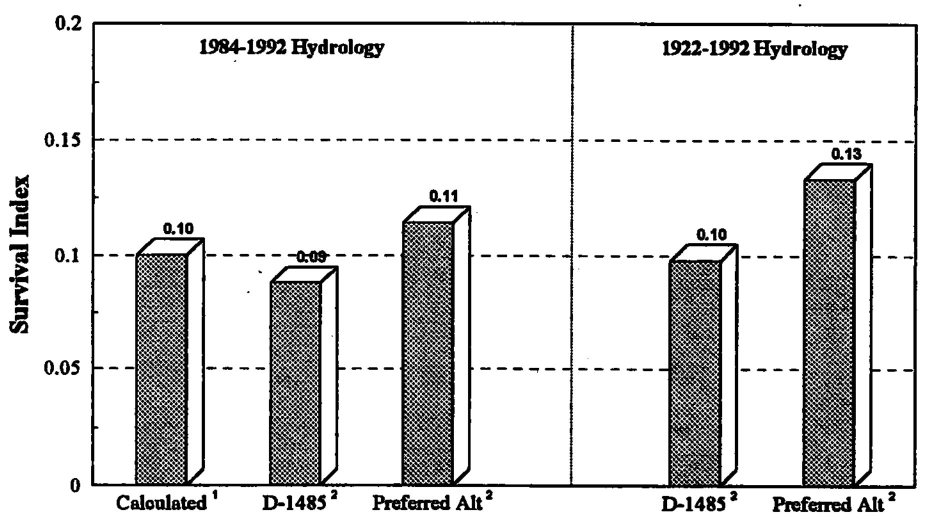
1 - Average index from empirical data provided by DFG
2 - Average index from DFG striped bass model using historical flows
3 - Average index from DFG striped bass model using DWRSIM operation study flows

Figure VIII-39
San Joaquin River Fall-Run Chinook Salmon Smolt Survival
with the Old River barrier



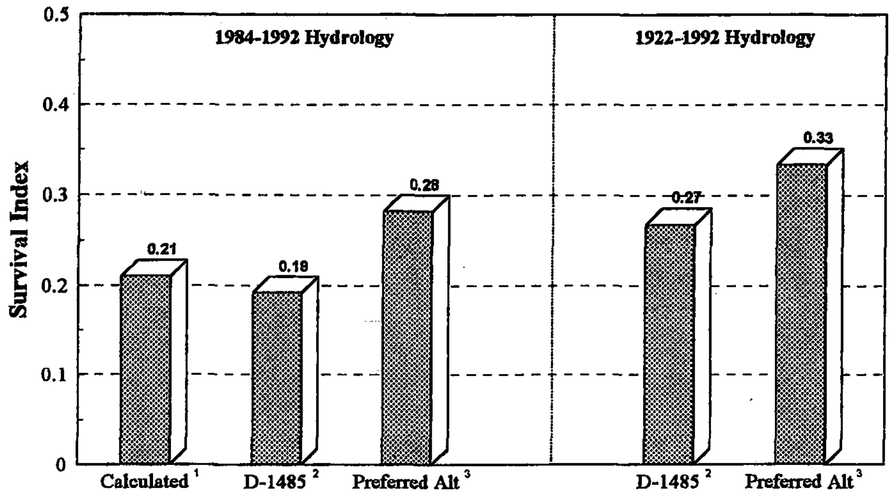
1 - Average index from USFWS salmon smolt model using DWRSIM operation study flows

Figure VIII-40
San Joaquin River Fall-Run Chinook Salmon Smolt Survival
without the Old River barrier



1 - Average index from USFWS salmon smolt model using historical flows
2 - Average index from USFWS salmon smolt model using DWRSIM operation study flows

Figure VIII-41
Sacramento River Fall-Run Chinook Salmon Smolt Survival



1 - Average index from USFWS salmon smolt model using historical flows; cross channel gates open in April, May, and June
2 - Average index from USFWS salmon smolt model using DWRSIM operation study flows; cross channel gates open in April, May, and June
3 - Average index from USFWS salmon smolt model using DWRSIM operation study flows; cross channel gates closed April thru May 20 and open May 21 thru June 30.

Figure VIII-41, the models indicate that the majority of the benefit is derived from closing the Delta Cross Channel gates on the Sacramento River and construction of a barrier at the head of Old River in the San Joaquin River basin. On the San Joaquin River, smolt survival is more than doubled by construction of the barrier.

In general, the models indicate that the survival or abundance indices of aquatic resources in the Delta would have been maintained or improved over the reference period conditions through implementation of the standards. The models' results do not predict dramatic improvements for any one species; however, the goal of the plan is to benefit many levels of the aquatic ecosystem so that conditions are improved for a broad range of species utilizing the Delta.

c. <u>Impact of Water Transfers on Aquatic Resources</u>

The SWRCB anticipates that requests for water transfers using the SWP and the CVP export facilities will occur in the future. In dry periods, the standards in the plan decrease export pumping from February through June, and water users in export areas are expected to respond by purchasing supplies and transferring them through the Delta in other times of the year. The capacity for water transfers in July through October under the standards in the plan is calculated in section G of Chapter VII, and an average annual transfer capacity of approximately 430 TAF is identified. The calculation of transfer capacity is limited to the July through October period because this is the period when transfers have historically been most common, and it is outside the most biologically sensitive period.

The impacts of increased export pumping in the late summer and early fall are generally less adverse to aquatic species than pumping in the spring. Salvage records from the SWP and CVP export facilities indicate that fish losses for striped bass, chinook salmon, American shad, Sacramento splittail, longfin smelt, and Delta smelt are considerably lower in the months from August through October than from April through July. Also, impacts to fish eggs and larvae due to entrainment at the export facilities should be minimal from July through October.

Three aquatic resource models, the POC, *Neomysis*, and striped bass models, indicate that these resources are sensitive to conditions in the July through October period. The models indicate that POC and *Neomysis* should not be adversely affected by water transfers because these models are abundance/outflow models, and outflow should not change significantly due to transfers. (Transfers are predicated on additional inflow to the Delta as necessary to meet the percent inflow export standards.) The striped bass model indicates that, with maximum transfers in July through October, the striped bass population over the 71 years of historical hydrology would decline from 480,000 to 381,000. This population is lower than the base case population of 410,000. Such a result is expected because the striped bass model is sensitive to exports throughout the year, and exports under the plan with maximum transfers from July through October exceed exports under the base case without transfers. Of course, if transfers from July through October were incorporated into the base case, the preferred alternative with transfers would provide a higher predicted striped bass population than the base case with transfers.

Even though transfers will increase exports, there are protection measures provided for aquatic resources from July through October. Limits on exports are fixed at 65 percent of inflow during this period. In addition, during this period, minimum Delta outflow objectives, varying by month and water year type, are in place, as described in section 5.a of this chapter. In September and October, there are minimum monthly average flows on the Sacramento River of 3,000 or 4,000 cfs. With cross-Delta transfers, flows in the Sacramento River would increase. There is a pulse flow requirement of up to 28 TAF on the San Joaquin River in October, as needed to provide a monthly average flow of 2,000 cfs (except in a critical year following a critical year). Transfers from the San Joaquin River basin would increase San Joaquin River flows, which would improve water quality conditions in the lower San Joaquin River.

6. Suisun Marsh

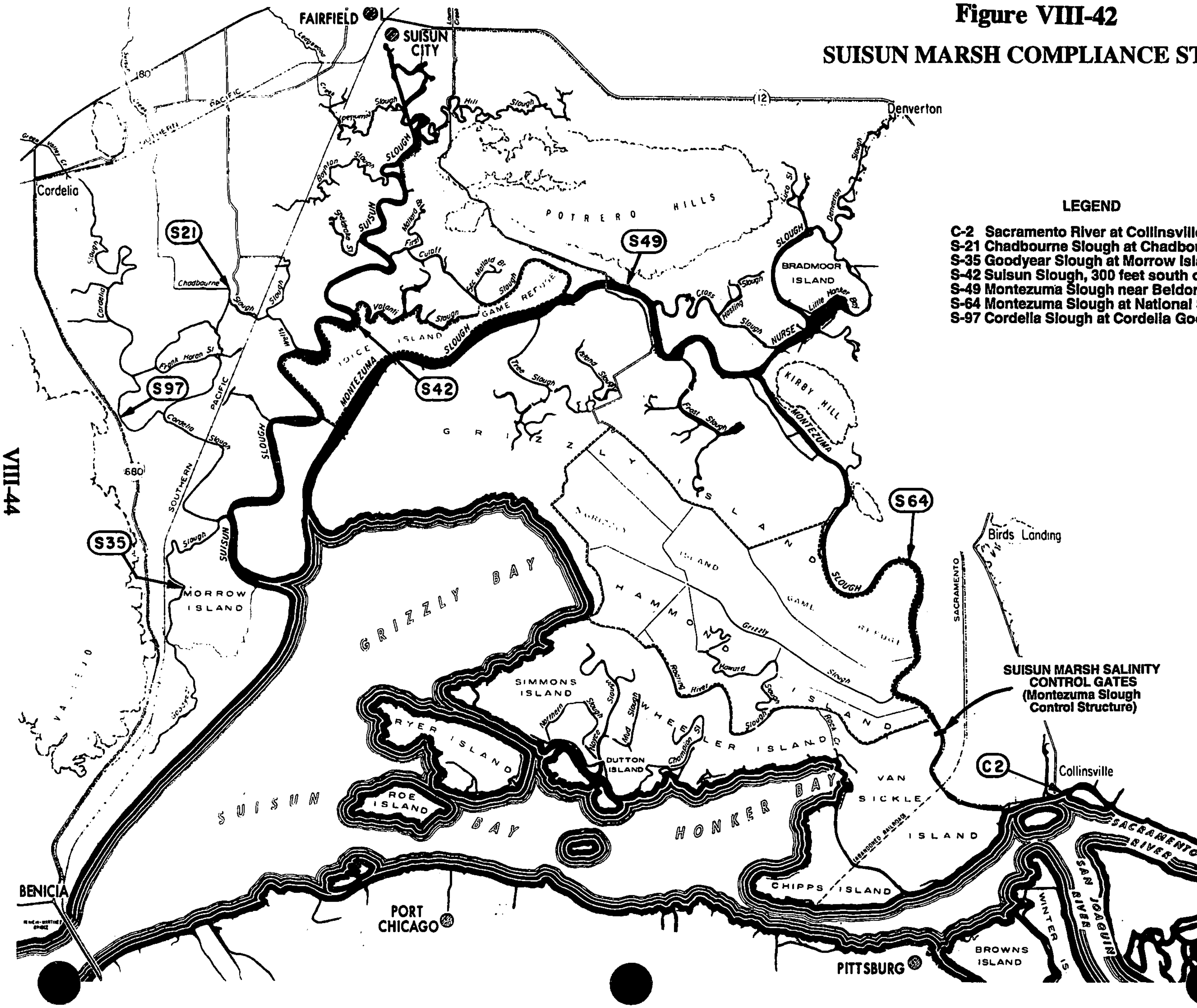
The preferred alternative includes: (1) 1978 Delta Plan standards in the eastern Suisun Marsh; (2) 1978 Delta Plan standards during normal hydrologic periods and SMPA deficiency standards in dry periods in the western marsh; and (3) a narrative standard for the tidal marshlands bordering Suisun Bay. The following discussion of the environmental effects of these standards on the Suisun Marsh is divided into three sections: background, standards, and salinity conditions.

a. Background. The 1978 Delta Plan set channel water salinity standards for the Suisun Marsh from October through May to preserve the area as a brackish water tidal marsh and to provide source water for waterfowl food plant production. Implementing the 1978 Delta Plan, D-1485 required the CVP and the SWP to develop and implement a plan, in cooperation with other agencies, which would meet all objectives by October 1, 1984. (Immediate compliance with the standards was not required because such compliance could be achieved only through large increases in outflow, then estimated at 2 MAF annually.) The USBR and the DWR later requested and received, in 1985, amendments to this requirement that changed some of the compliance locations and the compliance dates. The present compliance monitoring locations and the effective dates of compliance are listed below; the compliance monitoring stations are illustrated in Figure VIII-42.

Station ID	Location	Effective Date
C-2	Sacramento River at Collinsville	October 1, 1988
S-49	Montezuma Slough near Beldons Landing	October 1, 1988
S-64	Montezuma Slough at National Steel	October 1, 1988
S-21	Chadbourne Slough at Chadbourne Road	October 1, 1993
S-97	Cordelia Slough at Ibis Club	October 1, 1993
S-35	Goodyear Slough at Morrow Island Club	October 1, 1994
S-42	Suisun Slough at Volanti Club	October 1, 1997

Figure VIII-42

SUISUN MARSH COMPLIANCE STATIONS



LEGEND

C-2 Sacramento River at Collinsville
S-21 Chadbourne Slough at Chadbourne Road
S-35 Goodyear Slough at Morrow Island Clubhouse
S-42 Suisun Slough, 300 feet south of Volanti Slough
S-49 Montezuma Slough near Beldon Landing
S-64 Montezuma Slough at National Steel
S-97 Cordelia Slough at Cordelia Goodyear Ditch

The DWR, in cooperation with the USBR, DFG, USFWS, and SRCD, developed the "Plan of Protection for the Suisun Marsh including Environmental Impact Report" in 1984 to meet the D-1485 requirements. The Plan of Protection is a proposal for staged implementation of a combination of activities, including physical facilities, monitoring, a wetlands management program for marsh landowners, and supplemental releases from CVP and SWP reservoirs. The purpose of the staged implementation is to evaluate each action to determine the need for subsequent actions.

Phases I and II of the Plan of Protection are complete. These phases included construction of the Suisun Marsh Salinity Control Gates, which began operation in 1989. The primary goal of gate operation is to tidally pump lower salinity water through Montezuma Slough into the central marsh to reduce channel salinities during periods of low to moderate Delta outflow. Extended testing established that gate operation, in conjunction with reasonable outflow levels, results in compliance with the eastern marsh standards at stations C-2, S-49, and S-64; however, gate operation cannot consistently achieve compliance at the remaining stations in the western marsh. The planning and environmental review process to comply with the western marsh standards was initiated in June 1990. Present plans are to provide fresh water to the western marsh through augmented flow in Green Valley Creek, and possibly construction of ditches to improve flow distribution. The augmented flow would be obtained from either Lake Berryessa or the North Bay Aqueduct. The DWR and the USBR requested and received variances from the western marsh standards in the 1993-1994 and 1994-1995 control seasons to test the viability of the creek flow augmentation proposal. During the 1993-1994 control season, flow augmentation was not necessary because natural creek runoff, Delta outflow, and Suisun Marsh Salinity Control Gate operation were sufficient to meet standards. The 1994-1995 flow augmentation test is presently taking place. During the dry periods in 1984 through 1992, channel water salinities in the western Suisun Marsh exceeded the 1978 Delta Plan target salinity levels (standards were not in effect), as well as the deficiency standards defined in the SMPA.

In 1987, the DWR, USBR, DFG, and SRCD signed the SMPA. The SMPA is the contractual framework for achieving the objectives of the Plan of Protection, including controlling channel water salinity. The agreement includes normal period and deficiency period standards that are different than the standards in the 1978 Delta Plan and its required implementation, as amended. (The deficiency period is defined as either: (1) the second consecutive dry year following a critical year; (2) a dry year following a year in which the Four Basin Index was less than 11.35; or (3) a critical year following a dry or critical year.) A comparison of the SMPA-proposed standards with the 1978 Delta Plan standards is provided in Table VIII-2.

Table VIII-2. 1978 Delta Plan and SMPA Salinity Standards

Month	Mean Monthly High Tide Electrical Conductivity (mmhos/cm)		
	1978 Delta Plan	SMPA Normal	SMPA Deficiency
October	19.0	19.0	19.0
November	15.5	16.5	16.5
December	15.5	15.5	15.6
January	12.5	12.5	15.6
February	8.0	8.0	15.6
March	8.0	8.0	15.6
April	11.0	11.0	14.0
May	11.0	11.0	12.5

In 1987, the DWR, USBR, DFG, and SRCD requested that the water quality objectives in the SMPA be adopted as the marsh standards. The principal concern expressed regarding the 1978 Delta Plan standards is that they are not adjusted during dry periods. In response, the SWRCB requested, at the recommendation of the DFG, that the DWR and the USBR prepare a Biological Assessment to determine whether any flow and salinity changes that occur as a result of the actions taken pursuant to the SMPA would jeopardize any rare, threatened, or endangered species. Relevant portions of the Biological Assessment (i.e., those reflecting the current water management of the Estuary) were submitted to the SWRCB in December 1994. The SWRCB has requested the formation of a Suisun Marsh Ecological Work Group to evaluate beneficial uses and water quality objectives for the Suisun Marsh ecosystem.

During the SWRCB's current proceeding, the DWR, USBR, DFG, and SRCD again requested the SWRCB to adopt the SMPA standards (DWR 1994c, DFG 1994).

b. Standards. The 1978 Delta Plan Suisun Marsh standards, with the amended implementation under D-1485, include salinity standards at the seven compliance points listed above, and flow and salinity standards at Chipps Island from October through May. The plan changes the Suisun Marsh standards for the western marsh during year types when these standards have not yet been implemented. The discussion below describes the changes and provides the rationale for the standards in the plan.

First, the Chipps Island standards for protection of Suisun Marsh are replaced with the year-round outflow standards for general habitat protection. The outflow standards provide equivalent or better protection. Second, the eastern Suisun Marsh salinity standards (stations

C-2, S-64, and S-49) are not changed. These standards have been met since 1989, with minor exceptions, and operation of the Suisun Marsh Salinity Control gates, in combination with outflow conditions required by the plan, should be adequate to ensure continued compliance. Third, the western Suisun Marsh salinity standards (stations S-42, S-21, S-97, and S-35) are amended to include the SMPA deficiency standards. The 1978 Delta Plan standards have not been implemented in the western marsh; therefore, the implementation of the combination of 1978 Delta Plan standards in average hydrologic conditions and SMPA deficiency standards in dry conditions will provide lower salinity habitat than existing conditions. Also, there should be a natural gradient of increasing salinity from east to west which is not reflected in the existing standards, but is included in this plan when deficiency period standards are in effect. Fourth, a narrative standard for protection of tidal marshlands of Suisun Bay is added. This standard is expected to be achieved through compliance with the year-round outflow standards, but it is added to ensure that the tidal marshlands receive adequate protection.

Under the preferred alternative, there will be no decrease in protections for the Suisun Marsh beneficial uses compared with the 1984 through 1992 conditions and, as explained, there will be some improvements in protections. In the absence of any adverse effects, there is no need to wait for the DWR/USBR Biological Assessment before making these changes. If the DWR and the USBR want additional changes in the standards, their Biological Assessment will be required. Since the Suisun Marsh Biological Assessment study plan addresses implementation of SMPA standards under D-1485 conditions, a new study plan may be necessary for future standards.

c. **Salinity Conditions**. The following factors affected salinity in the Suisun Marsh from 1984 through 1992:

1. D-1485: the regulatory framework
2. SMPA: the contractual framework
3. Plan of Protection for the Suisun Marsh: facilities planning
4. Suisun Marsh Salinity Control Gates operation (beginning in 1989)
5. Delta outflow
6. Creek inflows
7. Managed wetland operations
8. Fairfield-Suisun Wastewater Treatment Plant effluent inflows
9. Precipitation/evaporation conditions
10. Tidal variations; influence of wind; barometric pressure

Of these factors, facilities planning, the operation of facilities in the marsh, and, to an extent, Delta outflow are controlled by the DWR and the USBR. Operations of the private managed wetlands in the marsh are controlled by 153 individual landowners, and the public areas are managed by the DFG. The ultimate destination and discharge of Fairfield-Suisun Wastewater Treatment Plant effluent is controlled by the Fairfield-Suisun Sewer District and the Solano Irrigation District, under permits issued by the San Francisco Bay RWQCB. Creek flows into northwestern Suisun Marsh are regulated by the management of reservoirs on Green Valley and Suisun Creek watersheds and are affected by urban development in the area. Precipitation, runoff, tidal variations, winds, barometric pressure, and evaporation are natural, uncontrollable factors.

In order to determine whether implementation of the standards will significantly change the salinity conditions in the marsh, the salinity conditions from 1984-1994 are compared to the standards (DWR 1994a). Mean monthly high tide salinity for water years 1984-1994 for eastern marsh compliance stations C-2, S-64, and S-49 and western marsh compliance stations S-21, S-97, and S-35 are presented in Figures VIII-43 and VIII-44, respectively (two pages each). Station S-42 is not included in this analysis, but the salinities at this station are very similar to the salinities at station S-21. In some cases, data are not shown for a station in a particular year because either the station was not established or the data did not meet quality assurance/quality control (QA/QC) criteria.

Mean monthly high tide salinities are presented on each bar chart, one bar per station as indicated on the legend in the upper left-hand corner of the figures. The monthly 1978 Delta Plan (solid line, indicated as D-1485) and SMPA deficiency (dashed line) standards lines are also shown on each of the six bar charts per page to facilitate comparison of the actual salinities with the 1978 Delta Plan and SMPA deficiency standards. Deficiency periods, as defined by the SMPA, occurred in 1988, 1989, 1990, 1991, and 1992.

The Suisun Marsh Salinity Control Gates began operating on October 31 of water year 1989. After gate operation began in water year 1989, salinity at the eastern marsh stations was generally below the 1978 Delta Plan standards and always below SMPA deficiency standards. Salinities at the western marsh stations were generally below 1978 Delta Plan standards and SMPA deficiency standards in wetter years or water years following wet periods, such as 1985, 1986, 1987, and 1994. However, during prolonged dry or critically dry periods, salinity in the western marsh is often above both 1978 Delta Plan standards and SMPA deficiency standards. Salinity in northwestern marsh sloughs (e.g., station S-97) is primarily affected by surface water inflows from local creeks and drainage water from the managed wetlands, and is relatively unaffected by Suisun Marsh Salinity Control Gates operations.

The DWR prepared Figures VIII-43 through VIII-51 (DWR 1994a). The bar charts in Figures VIII-43 and VIII-44 provide a graphical representation of the monthly occurrences of salinities above the standards, but they do not provide adequate information on how often and to what extent salinity at a particular station was either above or below the target salinities. Frequency-area plots are presented in Figures VIII-45 through VIII-51 for each marsh compliance station to provide an overall history of salinity with respect to the target standards. Figures VIII-45 through VIII-51 each include two plots, one for comparison with 1978 Delta Plan standards, indicated as D-1485 standards (top plot), and one for comparison with the SMPA standards (bottom plot).

Figure VIII-43

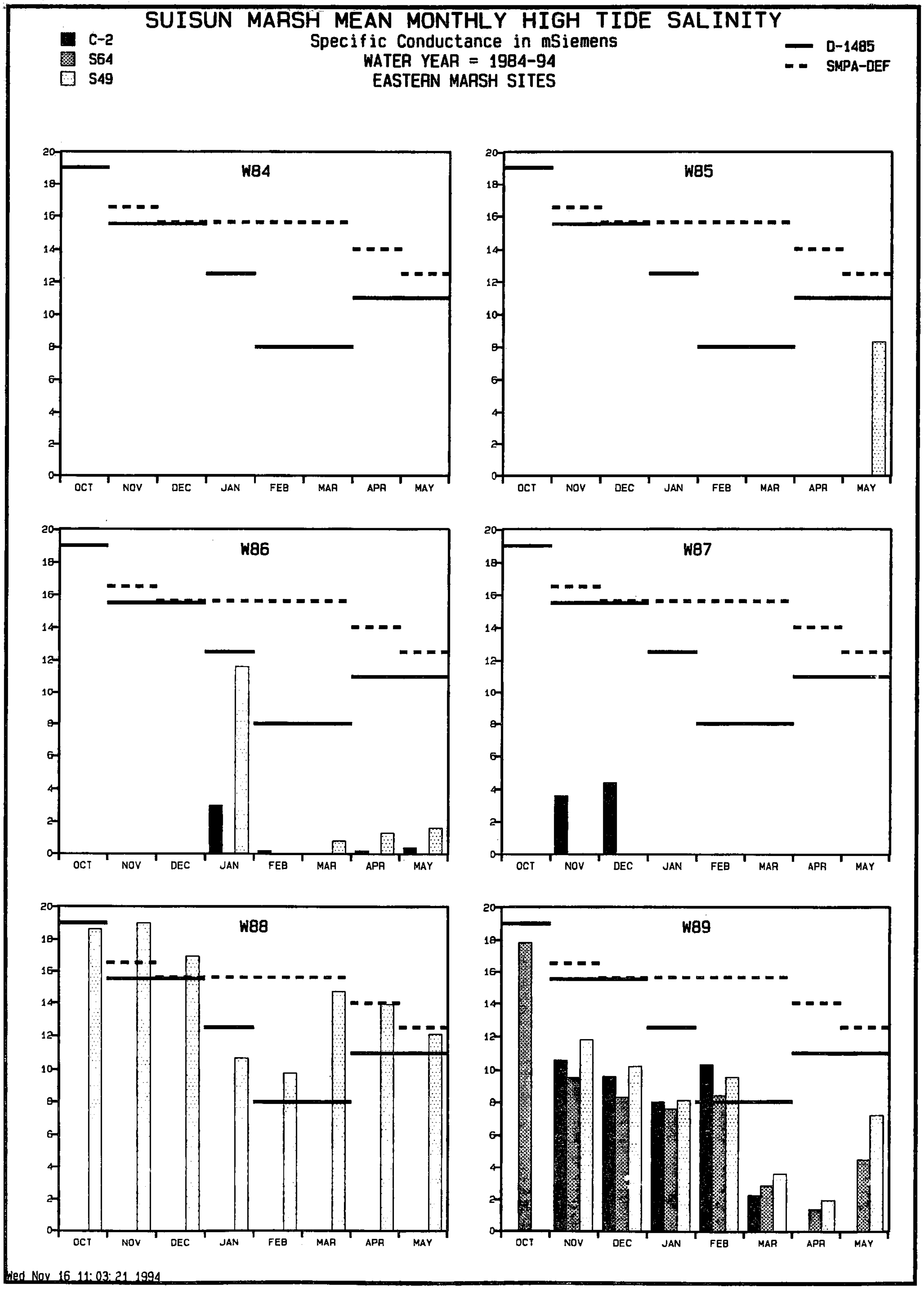


Figure VIII-43 continued

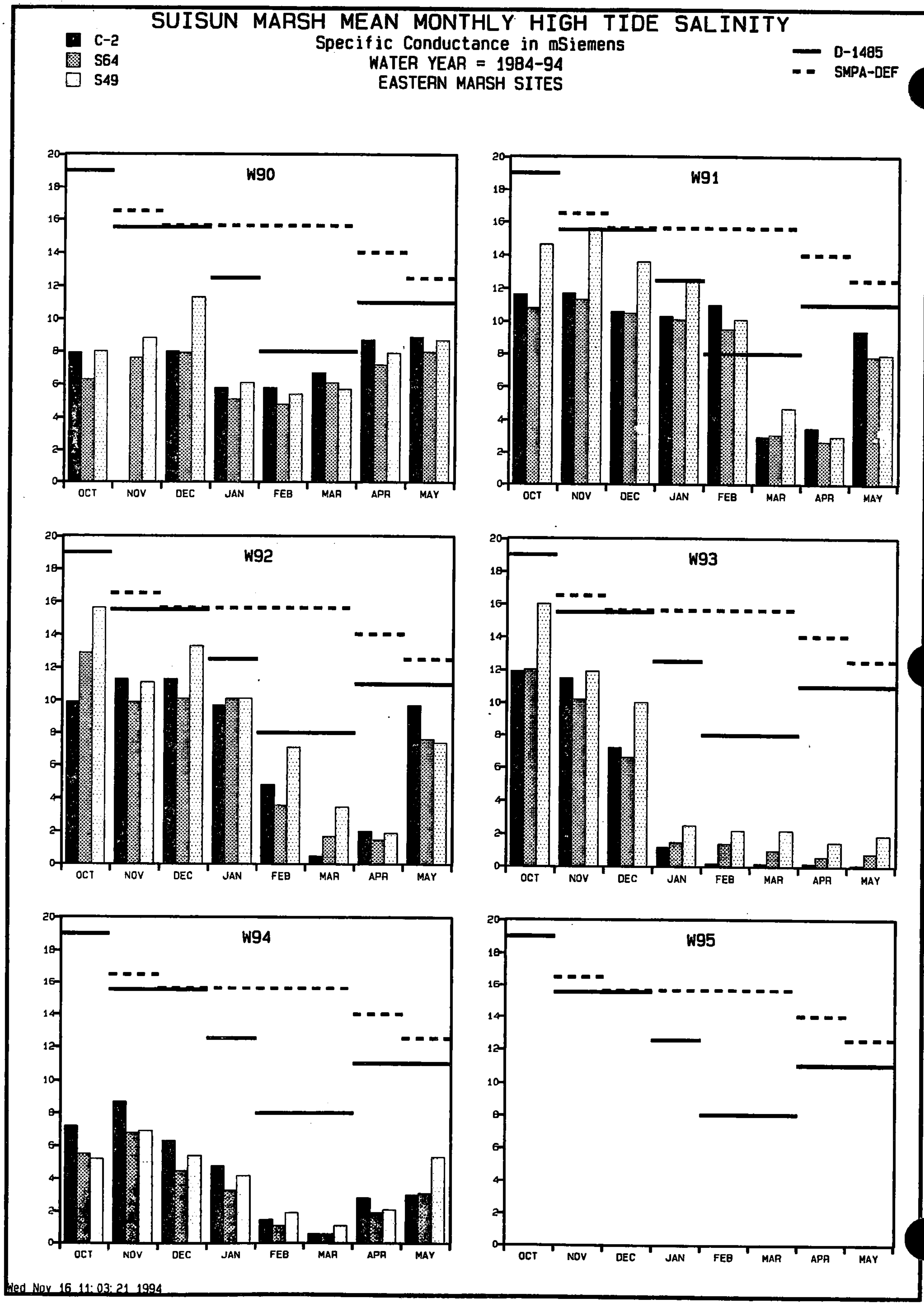


Figure VIII-44

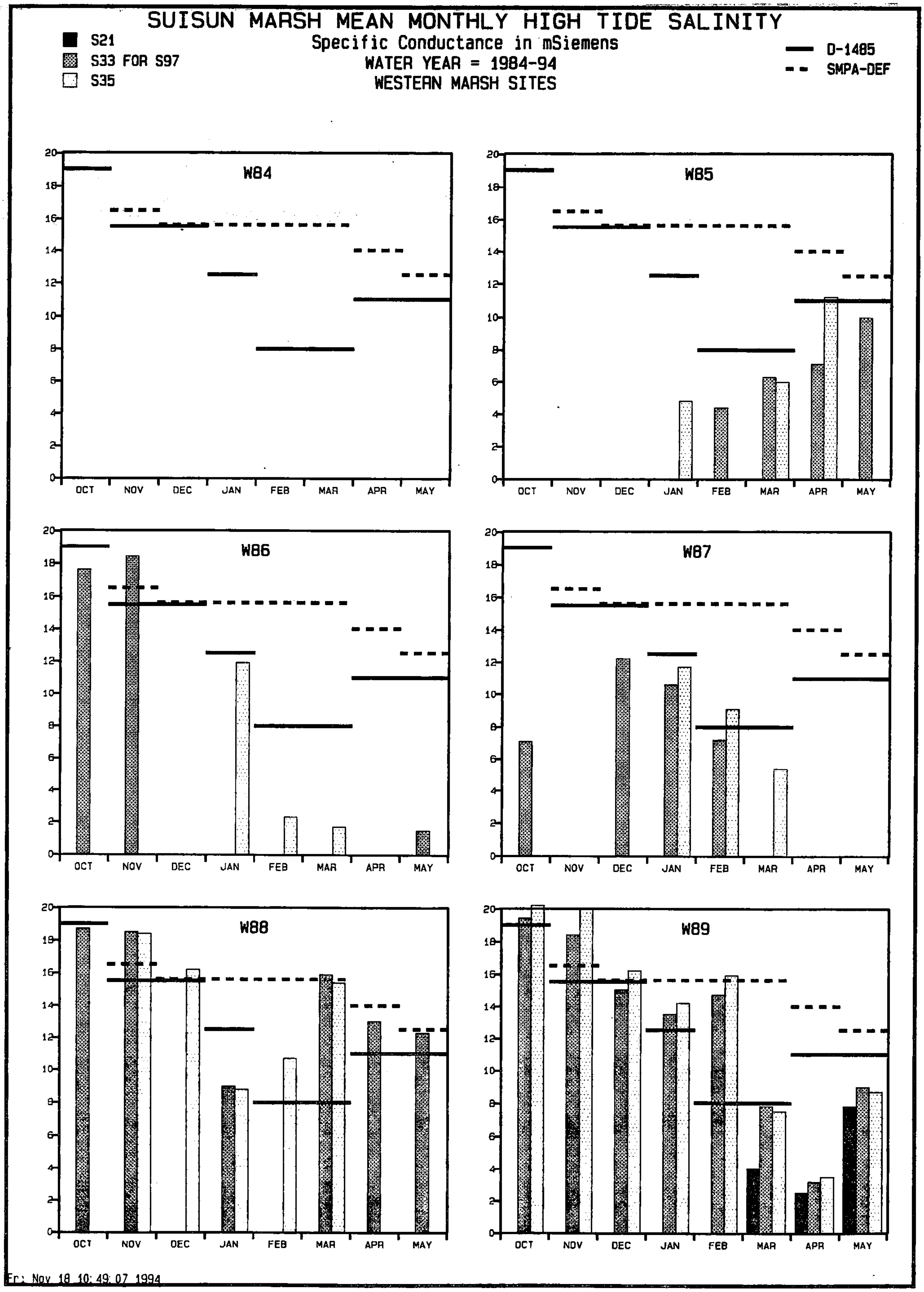


Figure VIII-44 continued

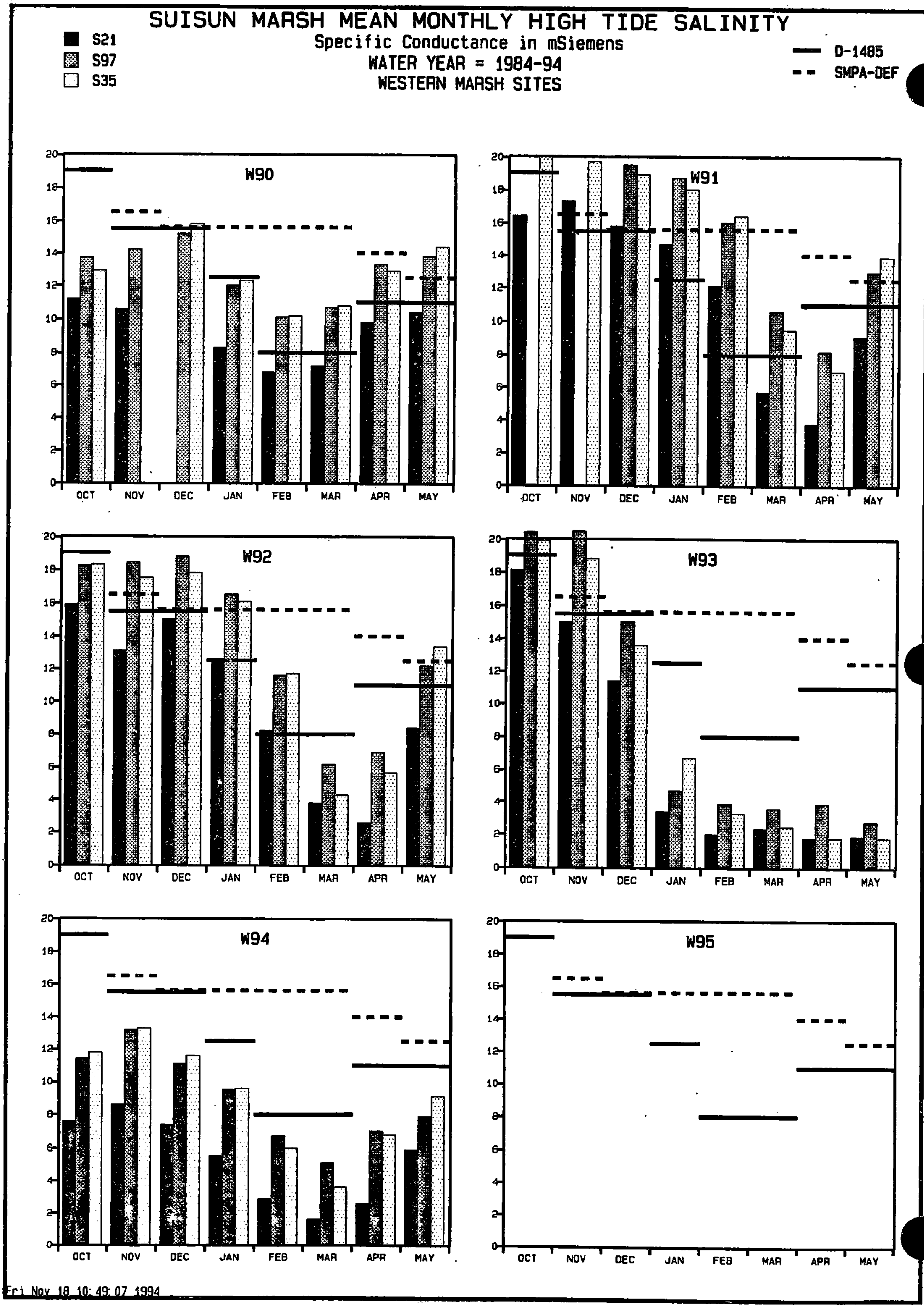


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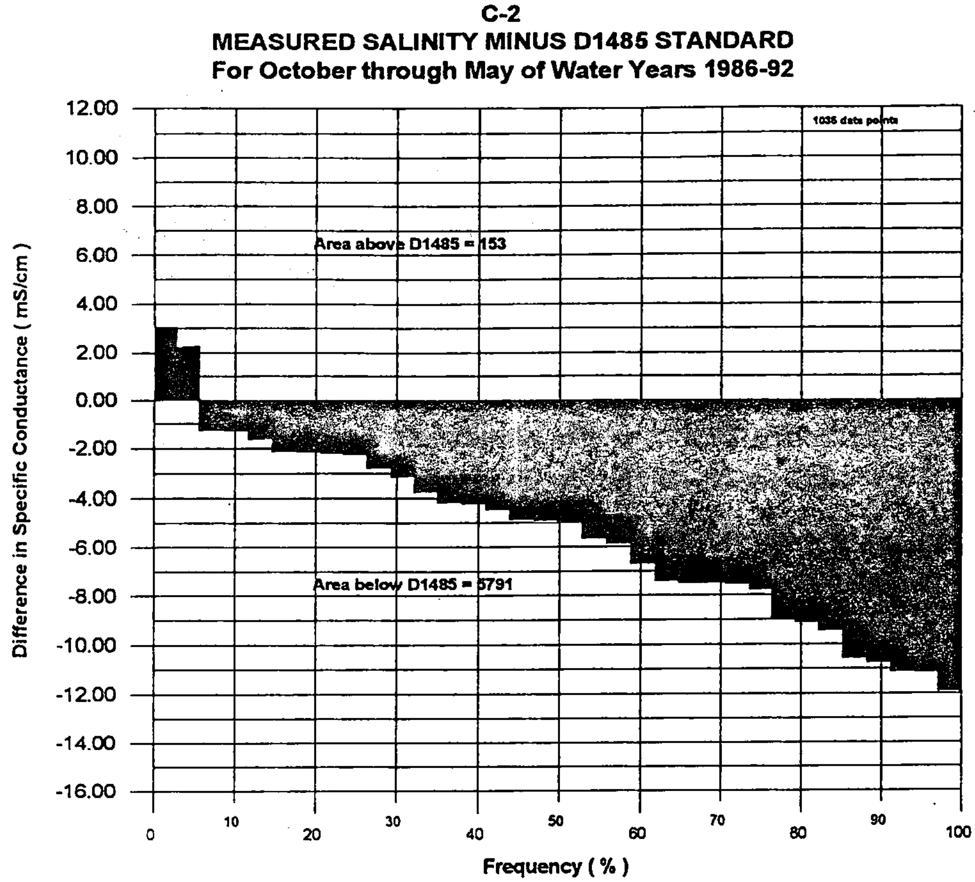
Figure VIII-45



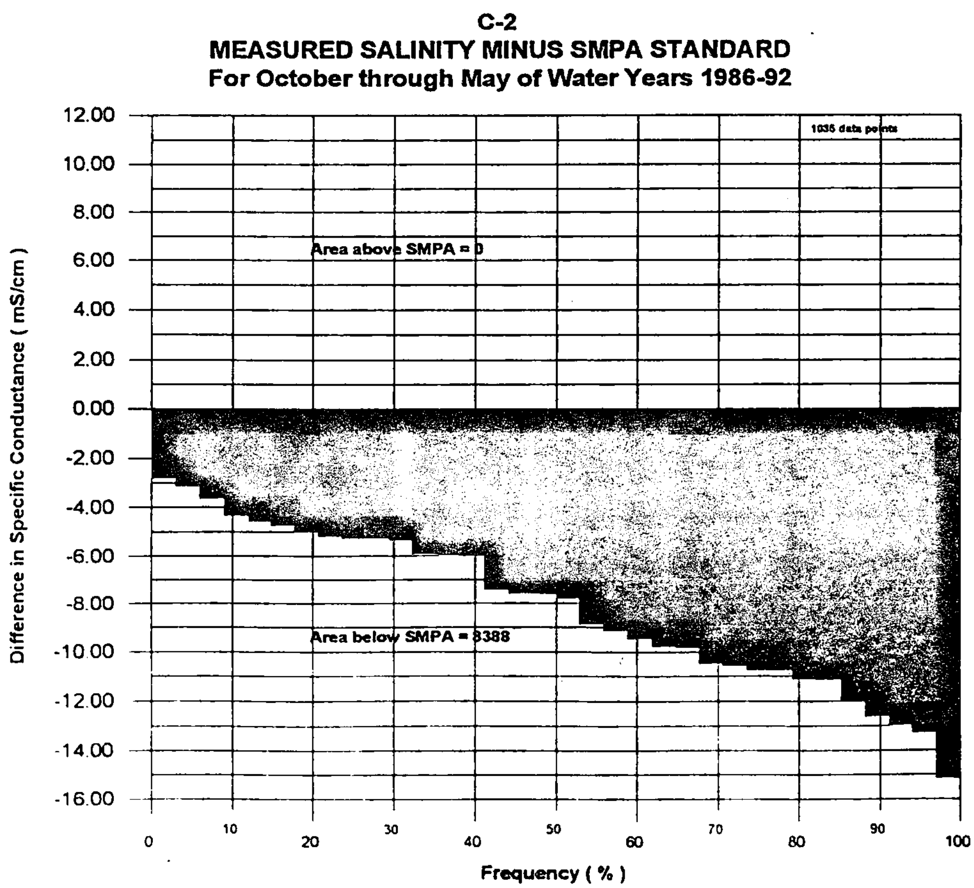
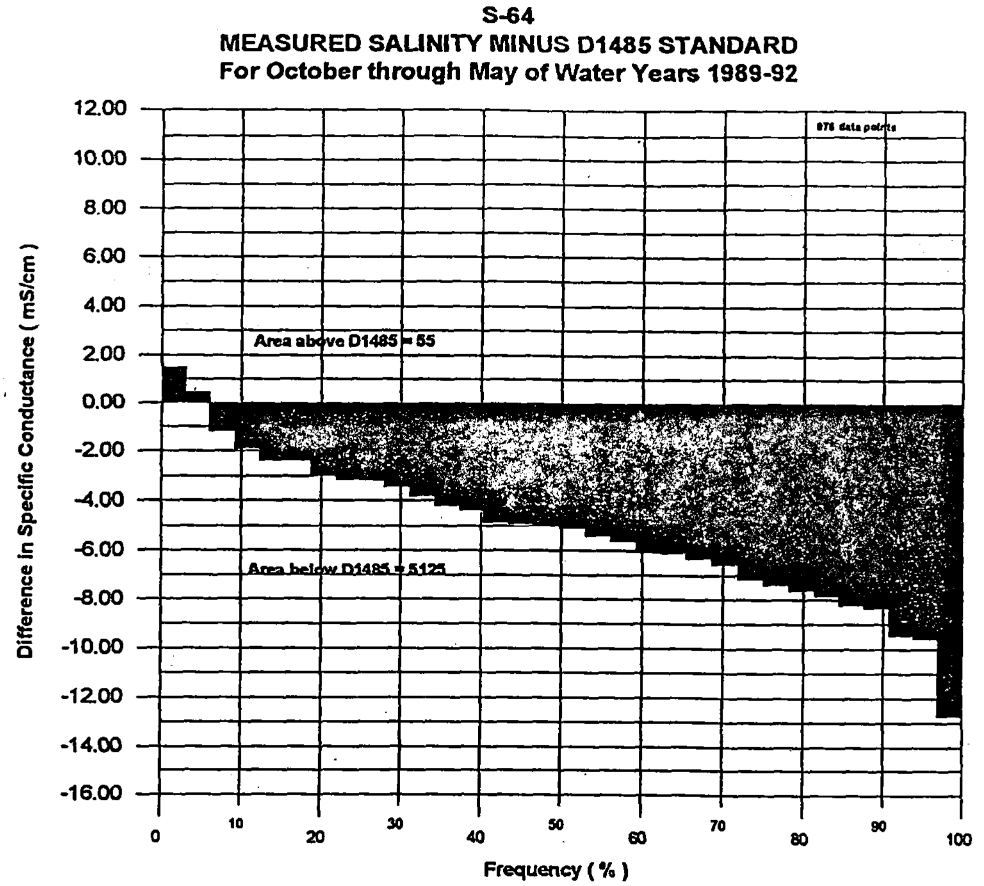


Figure VIII-46



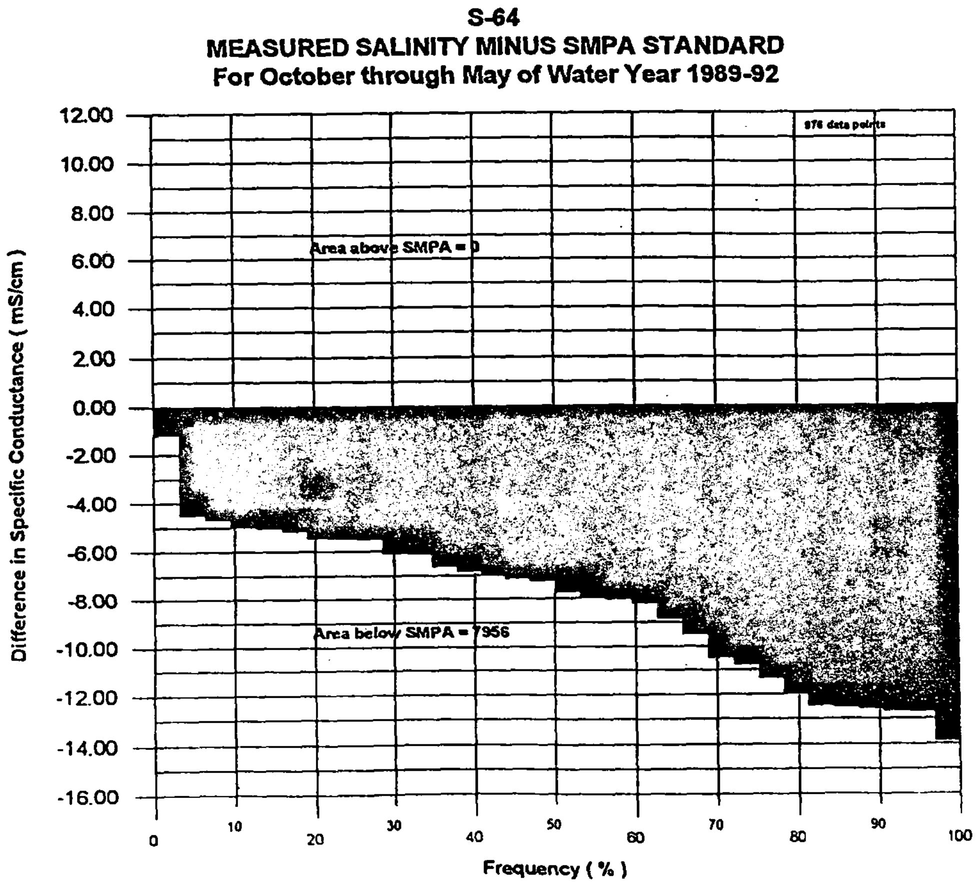
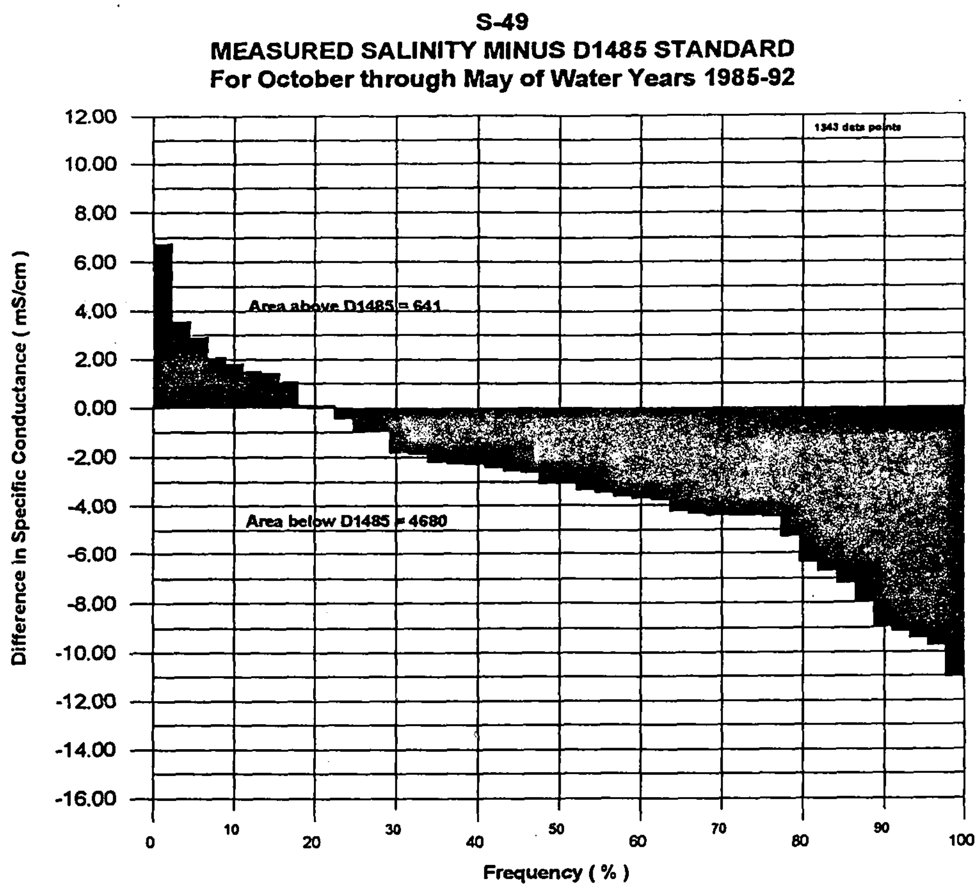


Figure VIII-47



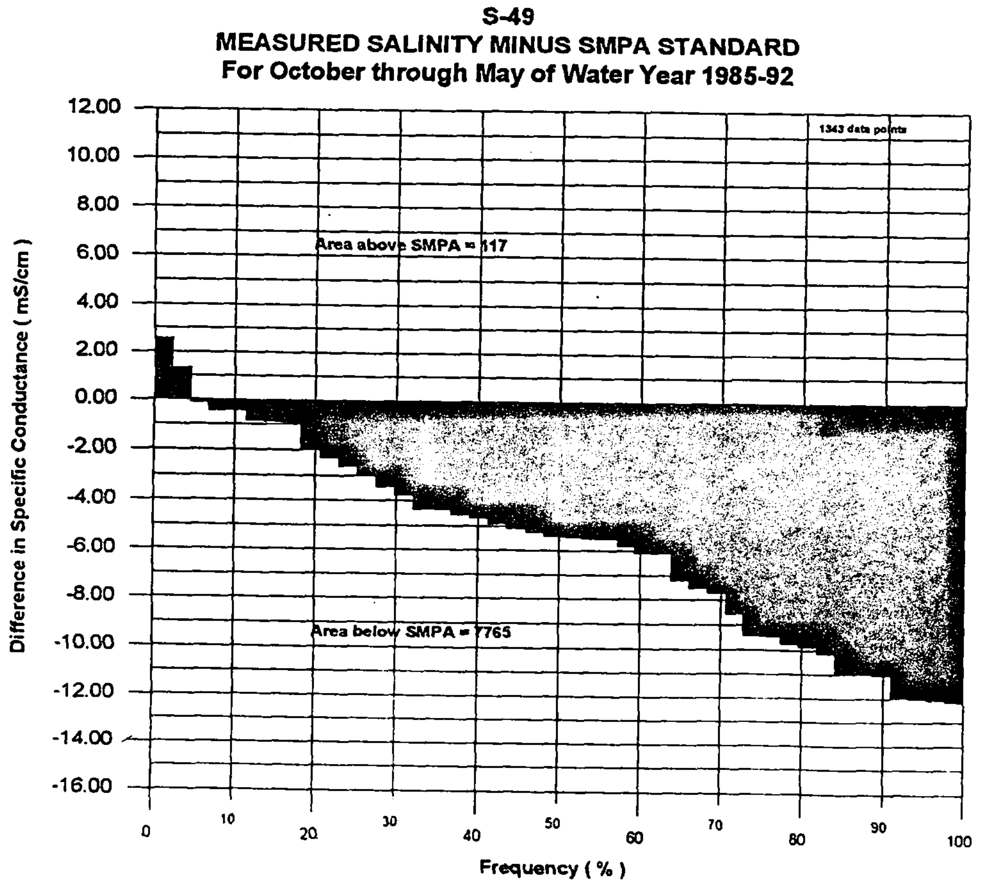
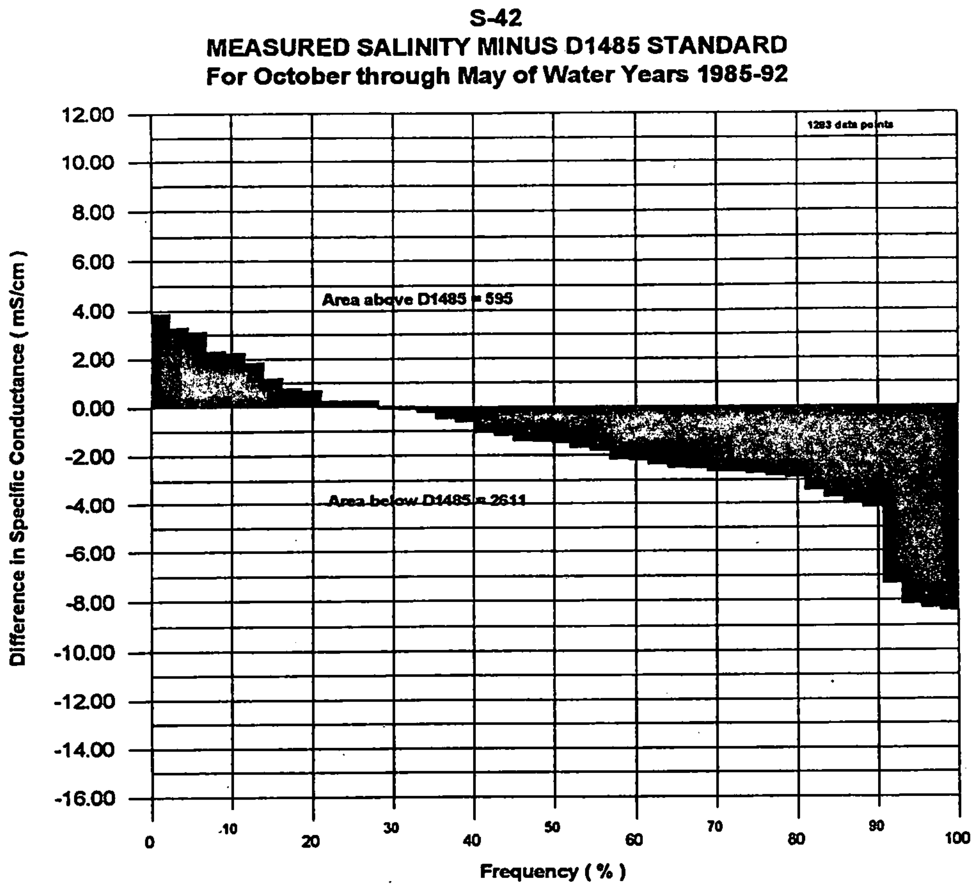


Figure VIII-48



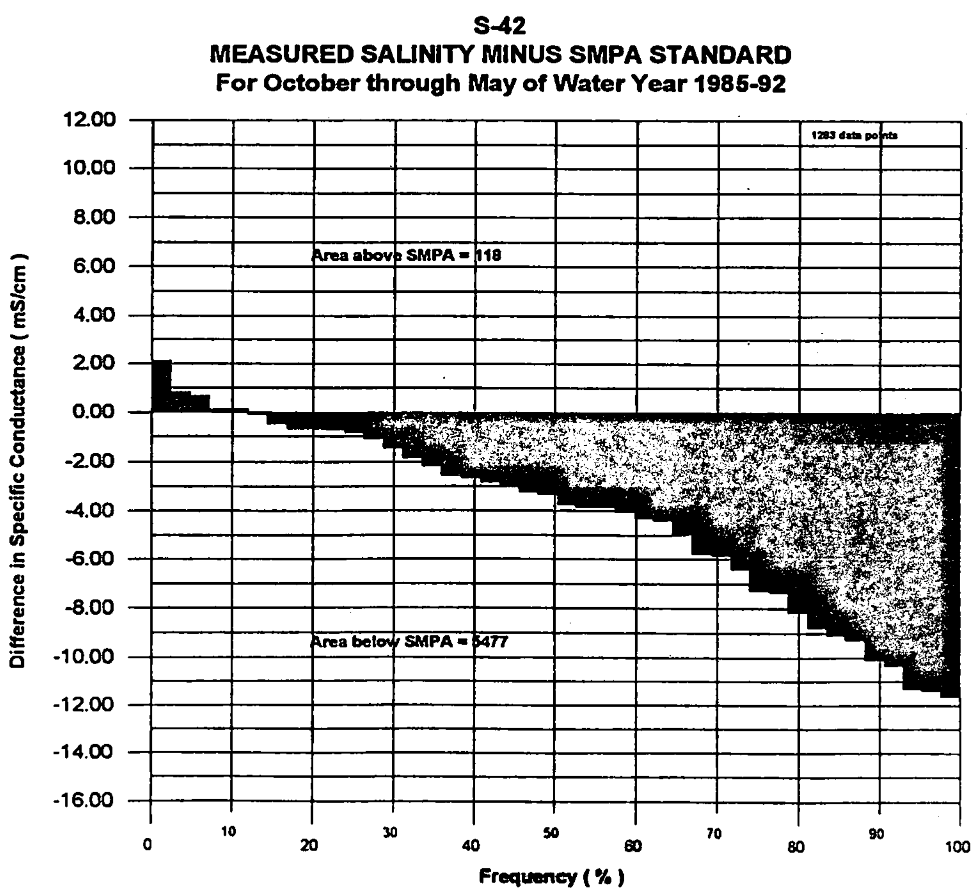
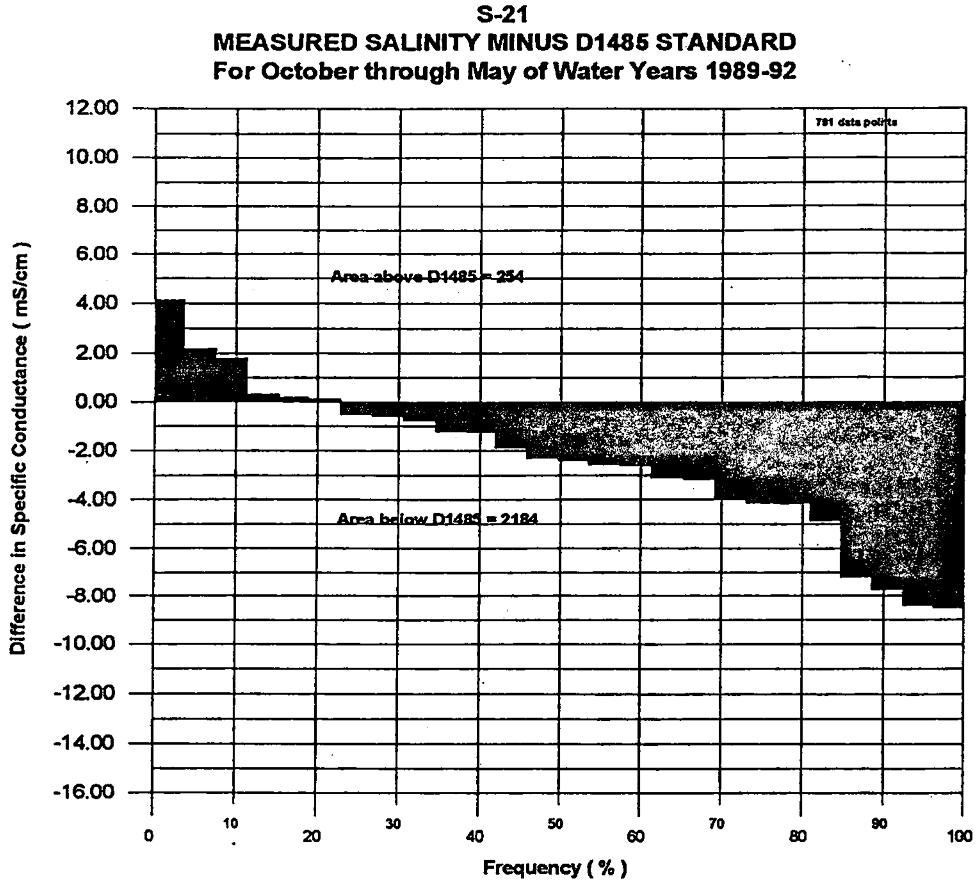


Figure VIII-49



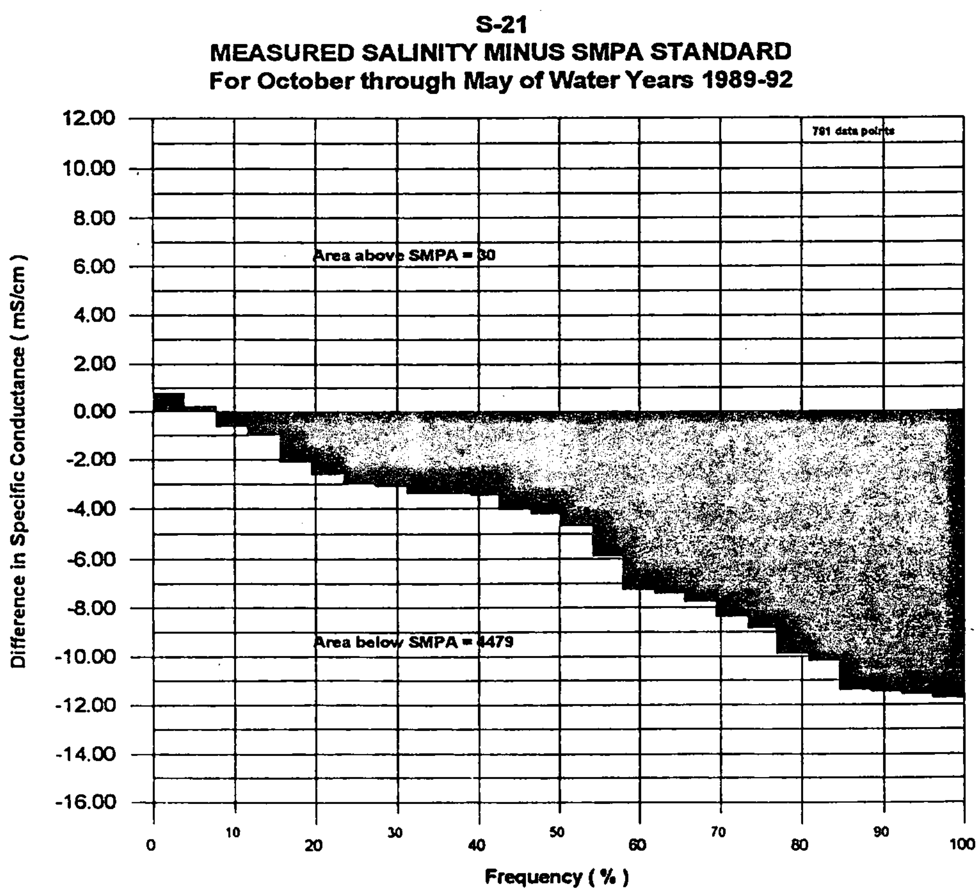
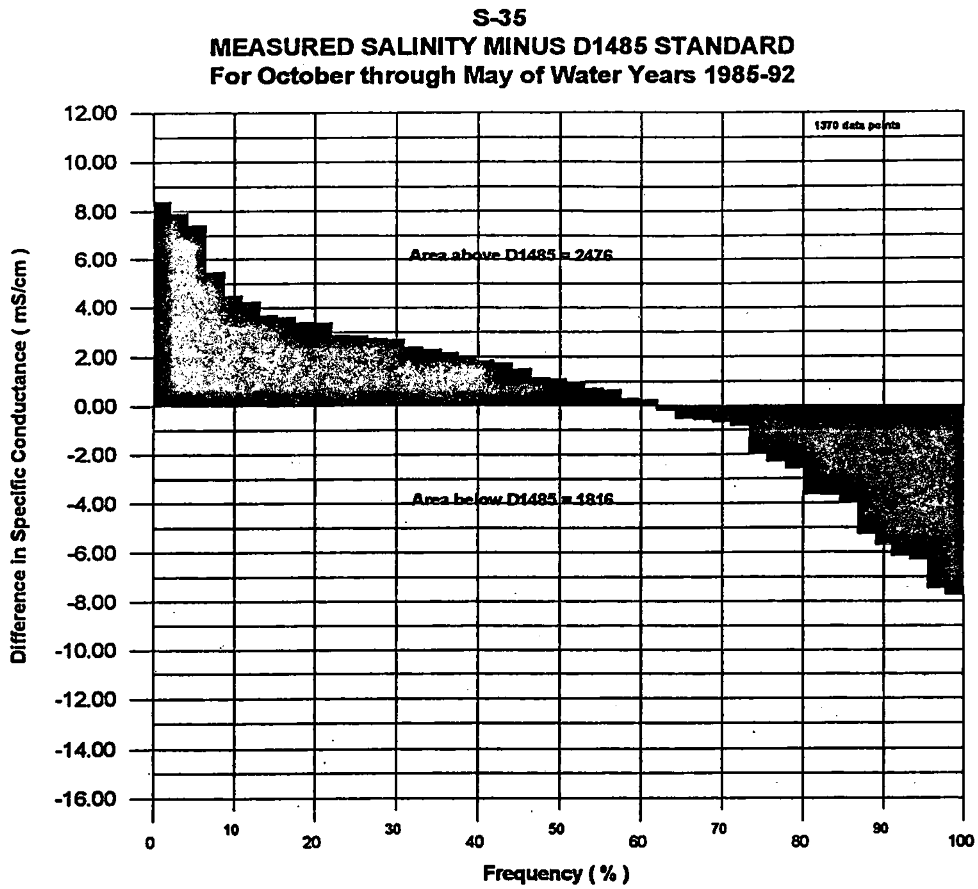


Figure VIII-50



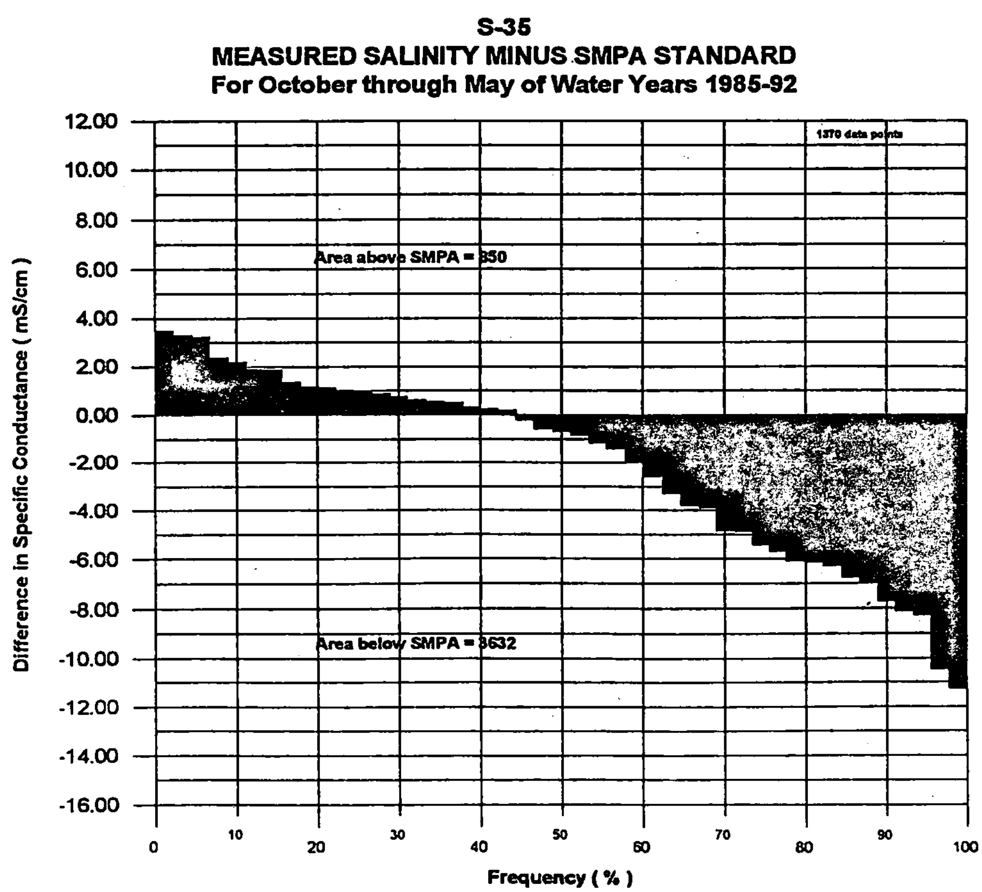
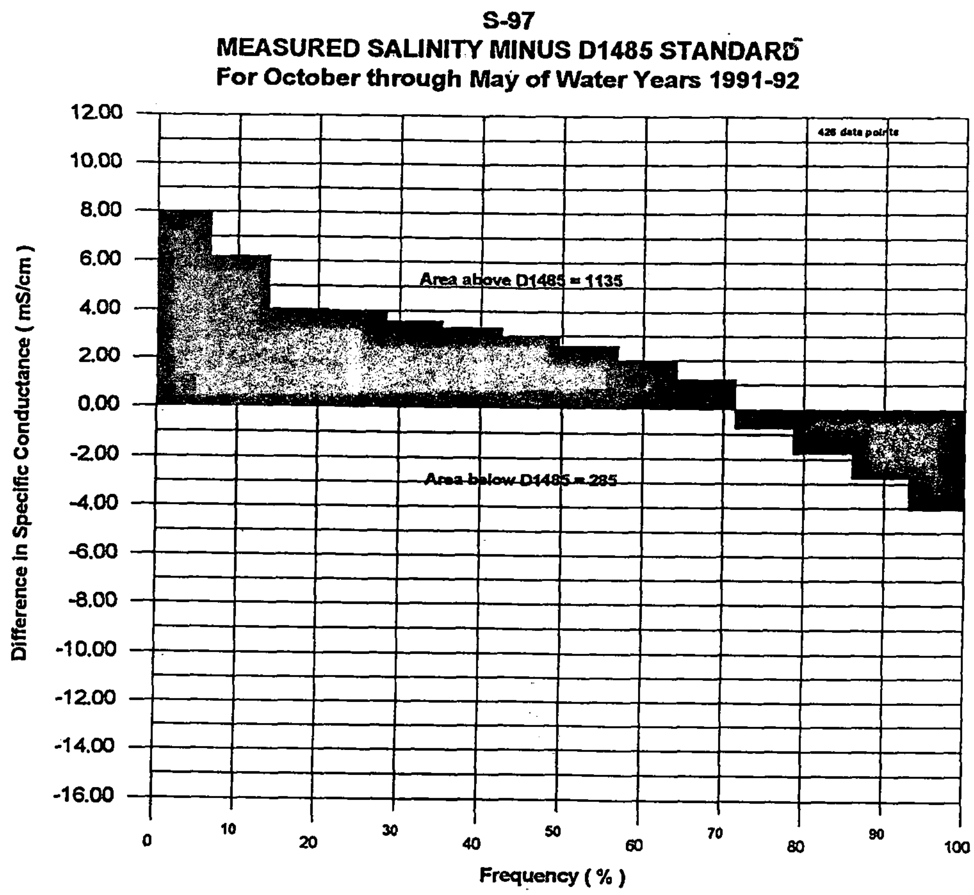
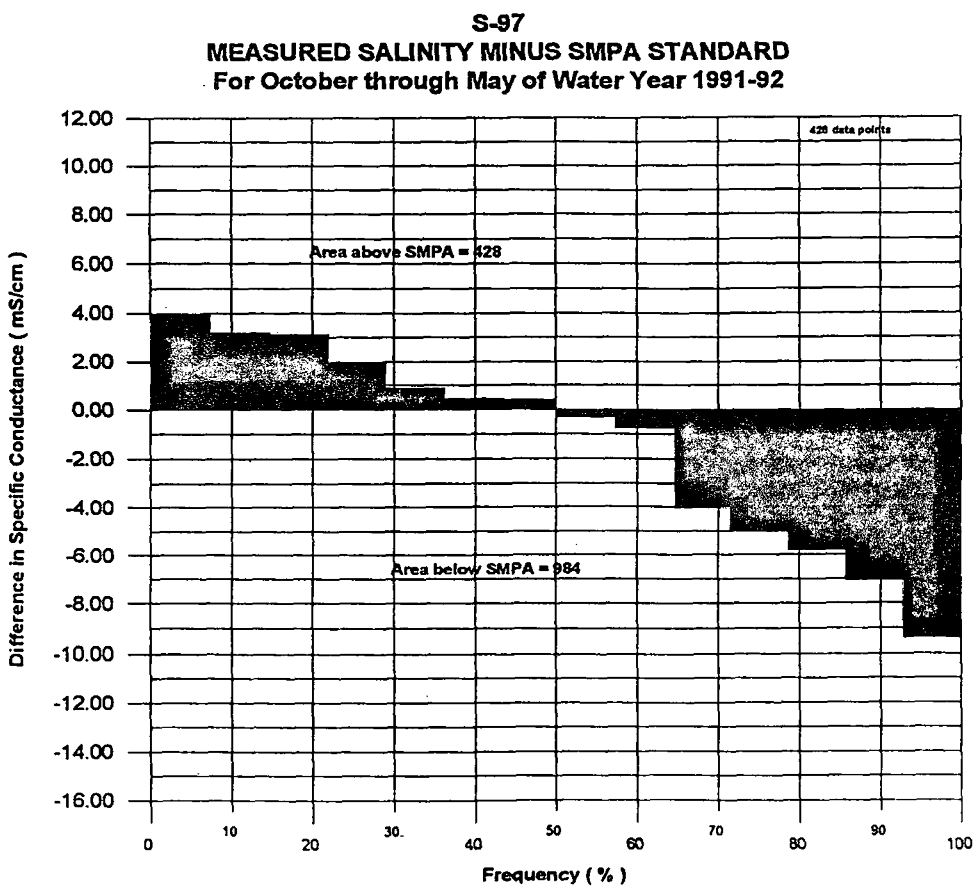


Figure VIII-51





To prepare the frequency-area plots for each location, the 1978 Delta Plan and appropriate SMPA (normal or deficiency) standards were subtracted from the respective mean monthly high tide salinity for the control season. The differences were then assigned to every day of the month and sorted from the largest positive difference (above the target standard) to the greatest negative difference (below the target standard). The sorted differences were then normalized from 1 to 100 percent and plotted. The areas above and below the zero line were calculated to indicate the relative duration and extent of salinity above and below the target standard. These areas are reported on the figures.

The areas below the target standards for eastern marsh compliance stations (C-2, S-64, and S-49) are significantly larger than the areas above. The areas for western marsh compliance stations (S-42, S-21, S-35, and S-97) below and above the target standard are either evenly balanced or greater above the target standards.

In conclusion, the implementation of the preferred alternative is expected to result in the maintenance of existing salinity conditions in the eastern marsh and result in a decrease in salinity in the western marsh. The principal environmental concern regarding the marsh is conversion of existing brackish marsh to salt marsh. Fish and wildlife agencies have also expressed concern with conversion of brackish marsh to freshwater marsh in efforts to meet internal Suisun Marsh standards. Therefore, implementation of the standards under the preferred alternative will not have a significant adverse effect on the Suisun Marsh.

7. Agricultural Supply

The SWRCB is not reviewing water quality standards for the protection of agricultural water supplies during this triennial review. Existing standards are adequate to protect the agricultural supply beneficial use.

The SWRCB has established water quality objectives in previous plans to protect Delta agriculture in three geographic areas: the western, interior, and southern Delta. The particular agricultural water quality needs in these areas were determined by analysis of predominant crops, soil type, and irrigation practices. The standards were designed to approximately replicate conditions in the Delta, with some adjustments, before the CVP and the SWP came on-line (without project conditions).

Corn is the predominant salt-sensitive crop in the western and interior portions of the Delta. In the 1978 Delta Plan, an agricultural water quality objective with a base level of 0.45 mmhos/cm EC was set based on evidence submitted by the University of California that this salinity level is necessary to maintain a 100 percent corn yield in this area. On varying dates during the irrigation season, depending on year type, this objective is adjusted to a lower quality. The adjustments, when weighted with the days at 0.45 EC, provide an average salinity throughout the irrigation season approximately equivalent to the average salinity over the irrigation season prior to construction of the projects. The agricultural water quality objectives for the interior Delta are different than the objectives in the western

Delta because water quality in the interior Delta was better during the irrigation season prior to the construction of the projects; therefore, water year type adjustments for the interior Delta are smaller.

During the time period between the 1978 Delta Plan and the 1991 Bay-Delta Plan, more information regarding the quality of water necessary to protect the agricultural beneficial use in the western and interior Delta was gathered. From 1979 to 1984, the SWRCB and the DWR cosponsored a 4-year study to establish the salt tolerance of corn grown in the Delta. The general conclusion of the study was that corn could be grown in the Delta with water supplies with a salinity level of up to 1.5 mmhos/cm EC with no loss in yield provided that controlled leaching was performed periodically to remove accumulated salts. This study did not provide information concerning the effectiveness or economics of leaching practices; therefore, the western and interior Delta standards for protection of agriculture were not changed in the 1991 Bay-Delta Plan. A study was initiated to determine the feasibility and effectiveness of leaching practices currently used in the Delta, but the full results of the study have not been submitted to the SWRCB.

For the southern Delta, the 1978 Delta Plan established objectives based on using beans and alfalfa as representative salt-sensitive crops. An objective of 0.7 mmhos/cm EC in the southern Delta protects beans during the summer irrigation season (April 1 through August 31) and an objective of 1.0 mmhos/cm EC protects alfalfa during the winter irrigation season (September 1 through March 31). Implementation of these objectives was deferred because the DWR, USBR, and SDWA were negotiating the construction of facilities to protect the agricultural productivity of the area. The negotiations were not completed, and the SWRCB proposed a staged implementation of the objectives in the 1991 Bay-Delta Plan, with final implementation to take place by 1996. The objectives in the plan do not change the objectives in the 1991 Bay-Delta Plan except the compliance date for the Old River objectives is extended by 2 years.

The new objectives for protection of fish and wildlife contained in the plan will cause a change in the salinity regime in the Estuary, as discussed in section A.3 of this chapter. During the spring, the increased outflow and San Joaquin River flows required by the plan will improve water quality throughout the Delta. These increased flows, however, may reduce the capacity to provide dilution water from New Melones Reservoir for salinity control purposes at Vernalis, as required by D-1422, depending on how the responsibility to meet the new fish and wildlife objectives are allocated. The SWRCB will address the issue of flow allocation, and its intention to implement the objectives, during the water right phase.

An assumption in the DWRSIM operation study for the preferred alternative is that only 70 TAF of water will be released from New Melones Reservoir on the Stanislaus River to control salinity at Vernalis. D-1422 contains no such limit. This constraint was incorporated into the study because the SWRCB intends to implement the Vernalis EC objective through a combination of agricultural drainage controls and freshwater releases.

The SWRCB believes that the plan will protect agricultural productivity throughout the Delta. Consequently, the plan will not have any significant environmental impact on agriculture in the Bay-Delta Estuary.

8. Municipal and Industrial Supply

The SWRCB is not reviewing water quality standards for the protection of municipal and industrial water supplies during this triennial review. Existing standards are adequate to protect the municipal and industrial supply beneficial uses.

Municipal and industrial uses are currently protected by standards that were originally adopted in the 1978 Delta Plan and were carried over unchanged into the 1991 Bay-Delta Plan. The 250 mg/l chlorides standard is based on the secondary standard for aesthetics (taste) and corrosion set by the California Department of Health Services (DHS). The 150 mg/l chlorides standard, which applies at the Contra Costa Canal Intake during a portion of the year, depending on year type, was established to protect industrial uses. Specifically, this standard was intended to protect the historical water supply of two paper manufacturers in the Antioch area. In adopting this standard, the SWRCB also recognized that the standard provides better water quality for municipal customers.

The new standards for protection of fish and wildlife contained in this plan will cause a change in the salinity regime in the Estuary, as discussed in section A.3 of this chapter. The increased outflow will improve water quality in the Delta, especially in the spring. Therefore, the municipal and industrial uses will continue to be protected by the existing standards. The plan does not have any significant environmental impact on municipal and industrial water supplies in the Estuary.

9. Recreation

The Delta supports year-round recreational uses because of its aesthetic beauty, wildlife, unique waterway system, and temperate climate. The Delta's close proximity to major population centers also contributes to its growing popularity. Recreation in the Delta, mostly water-oriented, exceeds 12 million user days annually (California Legislature 1982) and is expected to rise, particularly with increasing populations in the surrounding counties.

One of the principal recreational activities in the Delta is fishing. As discussed throughout this report, fish populations in the Delta have been declining for a number of reasons. The water quality standards, operational measures, and recommendations in the plan should stabilize or improve the fish populations in the Delta, as discussed earlier in this chapter. Recreational boating is another popular activity in the Delta. Closure of the Delta Cross Channel in some months, as required by the plan, may result in lower water levels (discussed in section A.4 of this chapter) and, thus, negatively impact recreational boating in some waterways. Overall, however, the SWRCB's action should improve recreational opportunities in the Delta, with the exception noted for closure of the Delta Cross Channel.

B. EFFECTS IN UPSTREAM AREAS

Upstream areas are defined in this analysis as the Sacramento Valley and the east side of the San Joaquin Valley. Increased outflow from the Bay-Delta Estuary will require either reduced direct diversions or releases from reservoirs in upstream areas. Therefore, significant adverse impacts are possible. The discussion below is divided into the following sections: (1) reservoir storage; (2) hydropower generation; (3) river flows; (4) land use; and (5) recreation.

1. Reservoir Storage

Section C in Chapter VII discussed in detail the preferred alternative's effect on reservoir storage in the Sacramento River basin, specifically on Clair Engle, Whiskeytown, Shasta, Folsom, and Oroville reservoirs. From 1984 through 1992, average carryover storage for these reservoirs under the preferred alternative is decreased from the base case by 150 TAF per year, as modeled by DWRSIM. This decrease is, on average, 2.7 percent of base case storage.

Section D.1 in Chapter VII discussed the preferred alternative's effect on storage in New Melones Reservoir in the San Joaquin River basin. The average reduction in New Melones carryover storage from 1984 through 1992 is 231 TAF compared to the base case, as modeled by DWRSIM. This reduction is, on average, 15 percent of base case storage.

2. Hydropower Generation

Hydropower impacts of the preferred alternative result both from shifting reservoir releases from the summer to the spring to meet higher spring outflow objectives and from reduced average storage levels. These changes reduce the ability of hydropower plants to meet peak summer loads and the plants' power generation capability (McCann et al. 1994). The preferred alternative's hydropower and cost impacts associated with reduced reservoir storage are discussed in Chapter XII.

Reduction in hydropower generation also leads to impacts on air quality due to the increased burning of fossil fuels. Common air pollutant emissions associated with the generation of electricity by fossil fuels include oxides of nitrogen (NOx), particulate matter of less than 10 microns in diameter (PM10), reactive organic gases (ROG), carbon emissions (Cx), and oxides of sulfur (SOx). Emission levels vary depending on the operating and efficiency levels of the plants (McCann et al. 1994), as well as reservoir storage and river flows. Air pollutant emission impacts of the preferred alternative have not been determined. An emission analysis was conducted for Alternative 1 (described in Chapter XI), which has greater water supply impacts than the preferred alternative. Table VIII-3 shows the net increase in emissions of NOx, SOx, PM10, ROG, and Cx under Alternative 1. Assuming a direct correlation between water supply and air quality impacts, these emissions are expected to be lower under the preferred alternative.

TABLE VIII-3
Net Increase in Air Emissions Under Alternative 1[1]
(tons per year, probability weighted[2])

YEAR	NOx	SOx	PM10	ROG	Cx
1995	231.61	80.57	7.84	5.57	42,427.35
1996	208.46	58.66	7.96	6.02	46,983.95
1997	119.35	65.03	9.29	6.83	50,543.40
1998	85.72	59.78	8.49	5.48	57,037.20
1999	103.57	40.10	8.83	6.72	52,048.45
2000	119.80	57.46	8.96	5.83	55,491.43
2001	73.60	35.42	8.69	6.37	59,980.98
2002	117.11	49.53	8.61	5.51	60,619.40
2003	90.10	46.65	9.46	6.27	65,079.93
2004	73.66	10.19	8.89	7.01	70,244.85
2005	121.24	49.17	7.80	4.47	64,360.98
2006	135.05	43.52	8.70	5.27	64,640.23
2007	234.80	62.76	11.14	4.36	57,399.48
2008	113.23	58.86	8.70	4.92	65,113.00
2009	126.14	58.42	9.15	5.01	66,983.68
2010	155.61	70.30	9.29	5.02	67,790.03
2011	129.68	52.80	8.10	3.99	66,503.55
AVG	131.69	52.90	8.82	5.57	59,602.81

1 From Table F-1 of "Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs", prepared by Richard McCann, et al., for the Association of California Water Agencies, October 7, 1994.

2 20 percent dry, 55 percent normal, and 25 percent wet years.

3. River Flows

The preferred alternative includes minimum flow requirements in September through December for the Sacramento River. These requirements are not likely to have significant impacts in upstream areas since the required flows are similar to base river flows. However, the preferred alternative has other standards (e.g., export limits, salinity standards, outflow requirements, etc.) which indirectly affect flows on the Sacramento River. Overall, the preferred alternative's effects on Sacramento River flows are expected to be similar to those on Delta outflow, discussed in section A.1 of this chapter. As Delta outflows increase under the preferred alternative for all months during 1984 through 1992, with greatest increases in spring months, Sacramento River flows are expected to increase accordingly.

The preferred alternative's effects on historical San Joaquin River flows in spring months of water years 1984 through 1992 are shown in Figures VIII-52 through VIII-60, respectively. The applicable San Joaquin River flow standard, which is dependent on the location of the isohaline, was selected using the analysis described in section A.3 of this chapter. The figures illustrate the additional water required from historical conditions to meet the minimum San Joaquin River flow standards in the preferred alternative. The greatest impacts are in the April 15 through May 15 period when additional flows are required in all years except 1986, a wet water year. To meet the minimum flow standards in the preferred alternative, average April 15 through May 15 flows must be increased by 3,319 cfs in 1984 (an above normal year); by 1,548 cfs in 1985 (a dry water year); and by 705 cfs, 972 cfs, 1,448 cfs, 1,795 cfs, 2,075 cfs, and 1,901 cfs, in the critical years of 1987 through 1992, respectively. In critical years 1991 and 1992, additional flows are also required in June.

Figure VIII-61 compares average historical San Joaquin River flows at Vernalis in October with the minimum flow standard in the preferred alternative. Under the preferred alternative, additional average monthly flows of 7 cfs and 211 cfs are required in the two most recent critical years of 1991 and 1992, respectively, to bring average monthly flows up to 1,000 cfs. The 28 TAF pulse in October would not have been required in any year in the reference period.

4. Land Use

DWRSIM does not distribute the impacts of changes in regulatory conditions among all the water users in the Central Valley. Rather, the model assumes that upstream depletions in the Sacramento and east side San Joaquin valleys are set and shortages are borne by the exporters. In order to estimate any land use changes that might occur in upstream areas, assumptions regarding the allocation of shortages among all of the water users must be made. This issue is the subject of the water right phase of these proceedings which will commence upon adoption of the plan. The assumption used throughout this report is that the CVP and the SWP are surrogates for the entire water system, and these projects bear all shortages. For the purposes of this qualitative discussion on land use, this assumption is changed to the

FIGURE VIII-52
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM ABOVE NORMAL WATER YEAR 1984

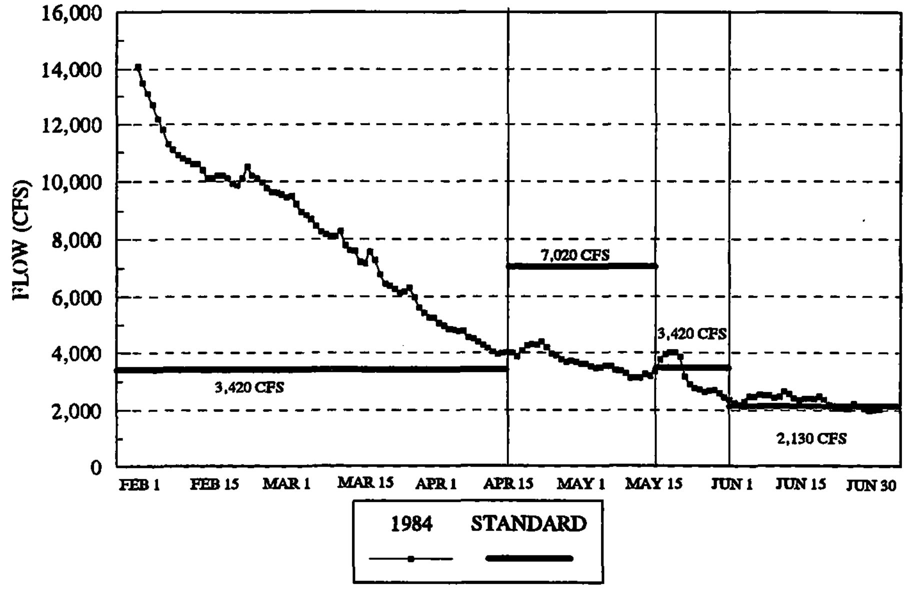


FIGURE VIII-53
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM DRY WATER YEAR 1985

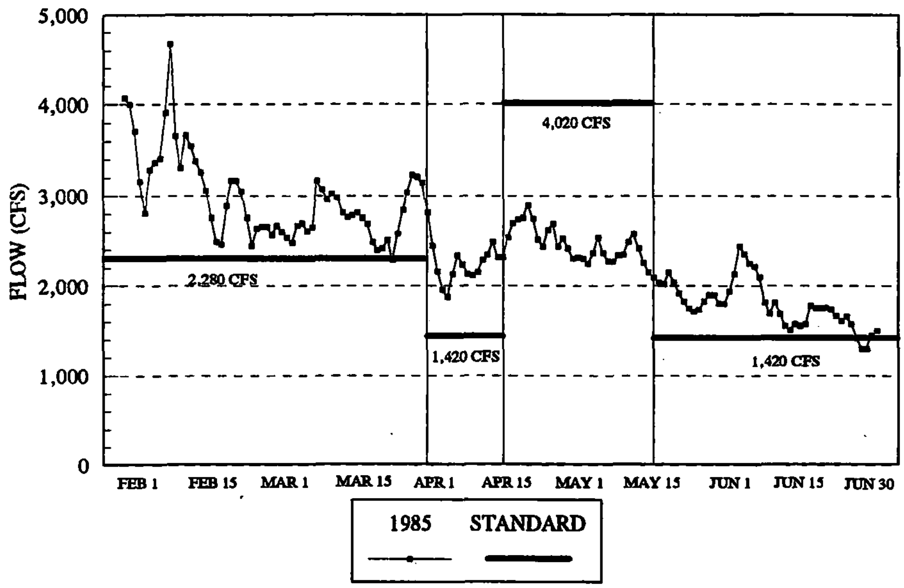


FIGURE VIII-54
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM WET WATER YEAR 1986

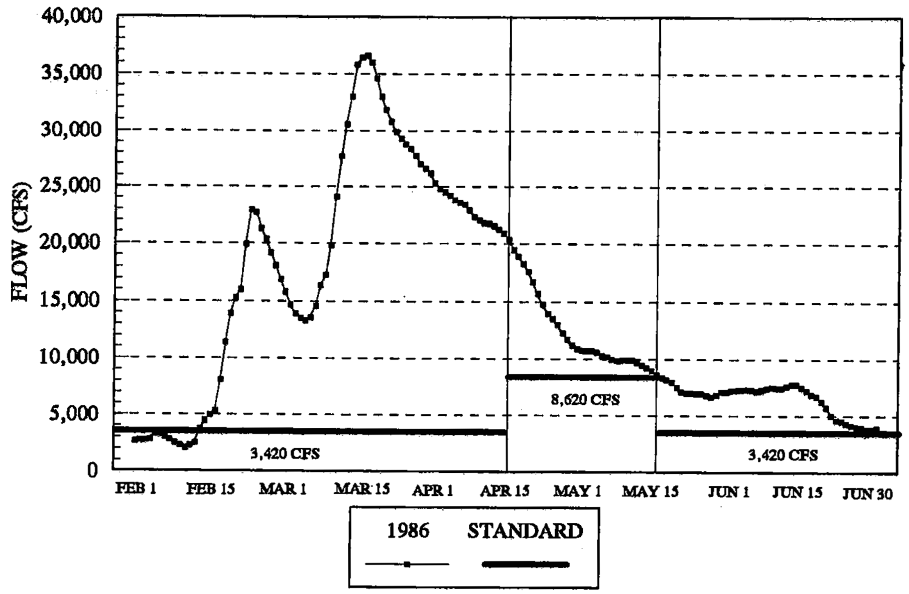


FIGURE VIII-55
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1987

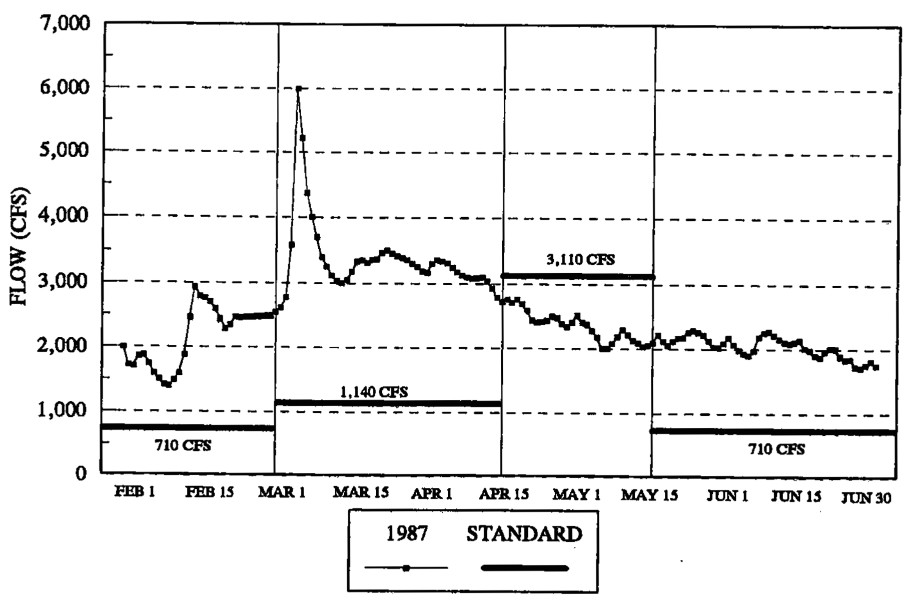


FIGURE VIII-56
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1988

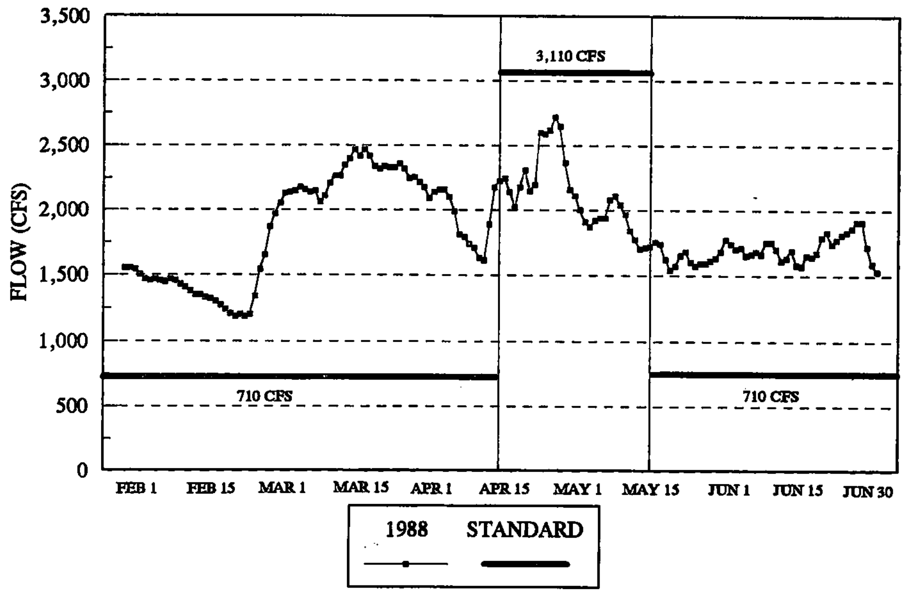


FIGURE VIII-57
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1989

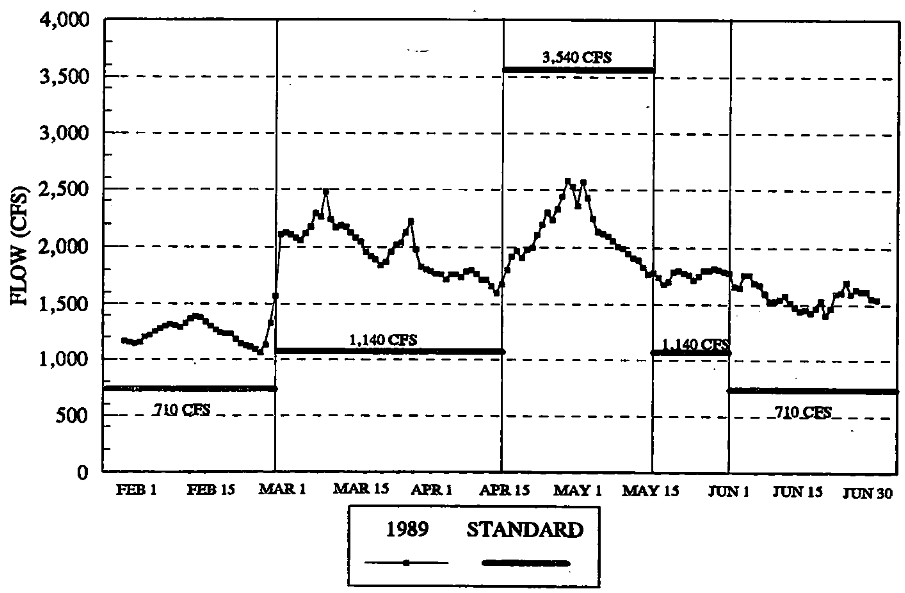


FIGURE VIII-58
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1990

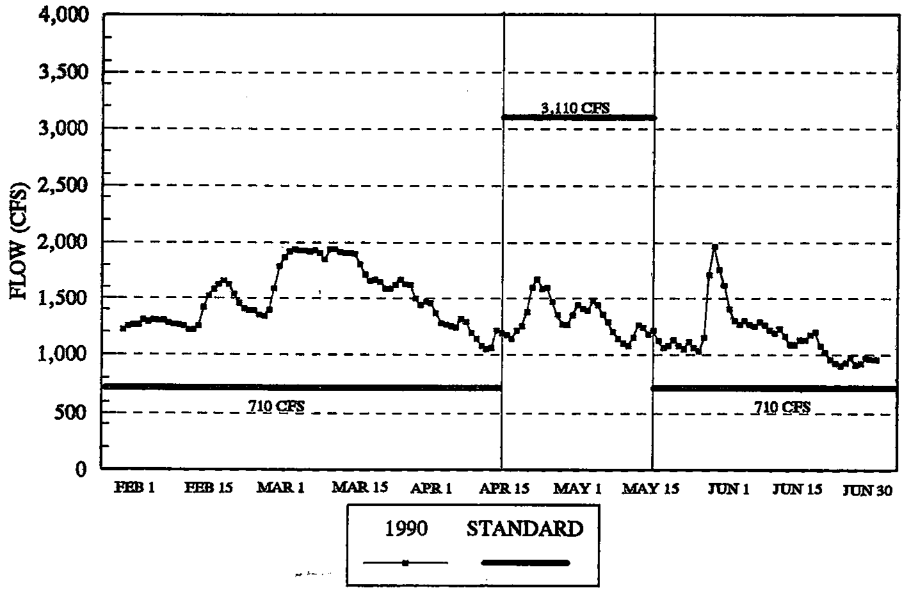


FIGURE VIII-59
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS
AT VERNALIS FROM CRITICAL WATER YEAR 1991

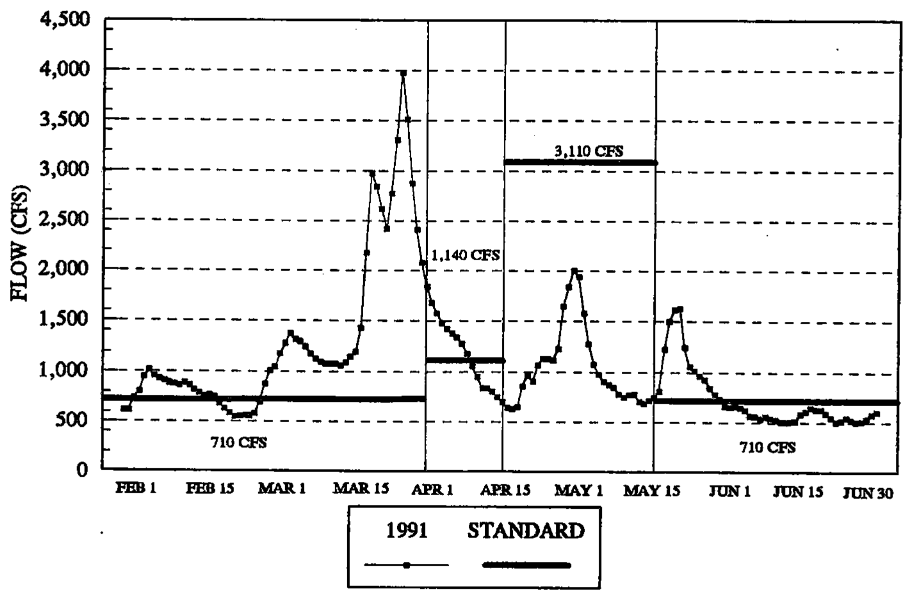


FIGURE VIII-60
HISTORICAL SAN JOAQUIN RIVER SPRING FLOWS AT VERNALIS FROM CRITICAL WATER YEAR 1992

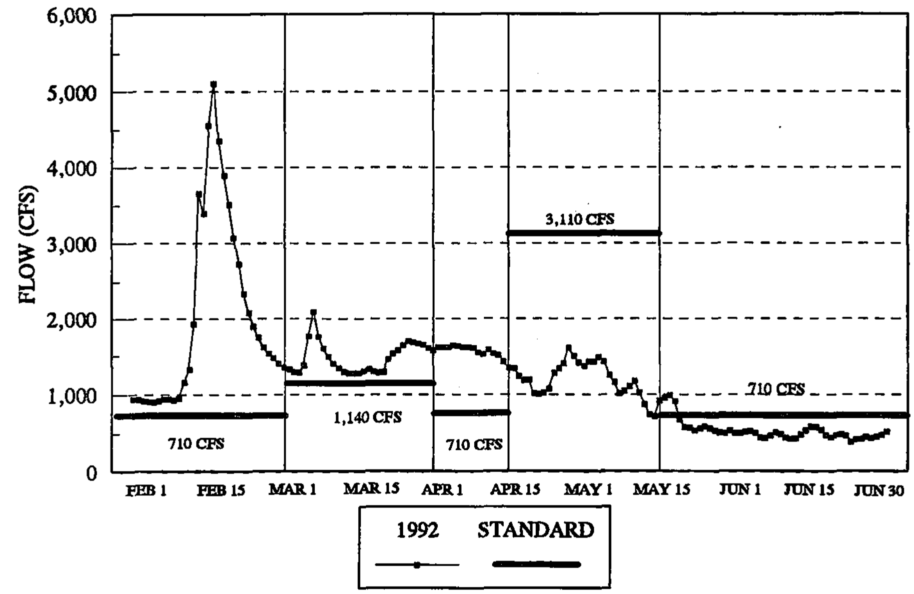
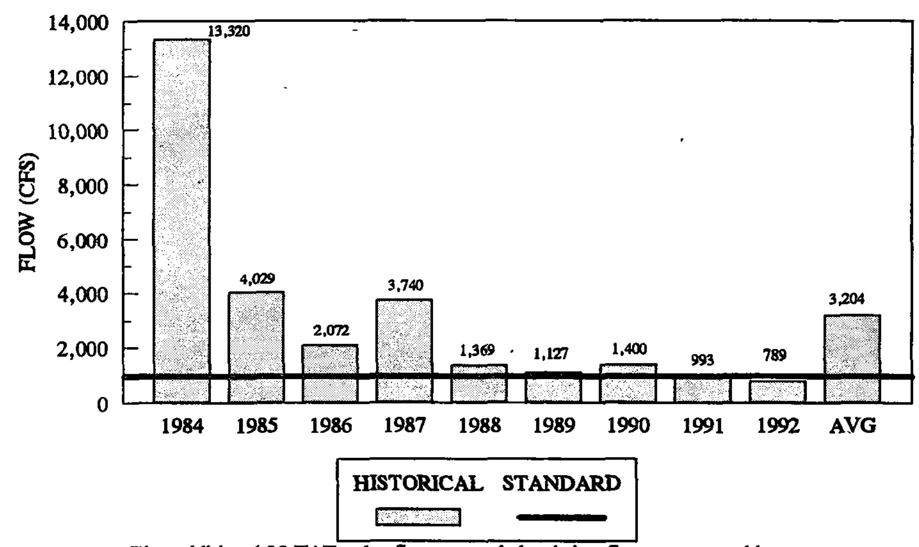


FIGURE VIII-61
AVERAGE HISTORICAL OCTOBER SAN JOAQUIN RIVER FLOWS AT VERNALIS FROM WATER YEARS 1984-1992



Plus additional 28 TAF pulse flow as needed to bring flows to a monthly average of 2000 cfs except for a critical year following a critical year.

assumption that water users in upstream areas will be required to contribute an unknown amount of water to meet Bay-Delta Estuary standards.

Land use changes that may occur as a result of the plan cannot be predicted because such changes are the result of numerous decisions made by individuals, water districts, and governmental agencies. However, the most likely land use changes as a result of implementation of the plan are agricultural land retirement and crop shifts.

A study of the response of the agricultural community to reduced water supplies was recently completed (Archibald et al. 1992). This study concluded that agricultural producers will respond to decreased surface water supplies in one of three ways: (1) obtaining alternative sources of supply to supplement reduced surface water allocations; (2) increasing water use efficiency; and (3) matching land use and cropping patterns to available water supplies through a combination of fallowing and shifts in crop type. These responses can be further broken down into long- and short-term options. The third response is relevant to this section.

In general, agricultural producers expect that, if shortages continue, marginal land will be taken out of production. The extent of reductions will depend on the costs and feasibility of alternative water supplies. The option of land retirement can be high for producers in districts with high fixed costs as these costs must be spread over remaining acres if land cannot be sold or leased to other producers.

The case study approach used by Archibald et al. (1992) also indicated that cropping patterns can change as a result of water shortages. For example, between 1989 and 1991, drought years when water shortages occurred, cotton, rice, alfalfa, and vegetable (excluding tomatoes) acreage declined while tomato acreage increased and acreage in permanent crops remained stable. These shifts exceeded normal trends, but factors other than water reductions could be responsible for these shifts.

While crop shifts are possible, there are a wide range of constraints that limit producers' abilities to shift cropping patterns in response to water shortages. These constraints include: (1) federal commodity program regulations that can encourage or discourage shifts away from program commodities such as cotton and rice; (2) multi-year supply obligations to processors of such crops as garlic, onions, processing tomatoes, and rice; (3) concern about maintaining market share in a particular commodity; (4) producer ownership of processing operations; (5) agroclimatic constraints, including soil type, temperature ranges, and pest conditions; and (6) farm management expertise, and machinery and equipment complements, required to grow a particular crop.

If the SWRCB requires upstream water users to provide some of the water necessary to meet these new standards, both crop shifts and land retirement are likely.

5. Recreation

Lakes and rivers have always been a primary focus for outdoor recreational activities. The abundance of potential recreational sites limited the need for careful planning of recreational facility development. This situation changed as a rapidly growing population sought out recreational opportunities.

Most recreational facility developments are on streams, lakes, or reservoirs operated for other purposes. Recreational activity and resources generally do not consume significant amounts, no more than 3 percent of the statewide total, of water (DWR 1994d). Consumptive use occurs when water allocated specifically for recreation, with no other benefit, is not recaptured downstream or is evaporated from a larger than normal surface area.

In general, recreational uses that could be affected by the plan can be separated into three categories, as discussed below: reservoir recreation; river recreation; and wildland recreation. Conflicts among these categories can arise in water resource planning. Minimally fluctuating reservoir levels provide optimum reservoir recreational opportunities, but higher stream flows, which deplete reservoir levels, may provide more water for wildlife areas, healthy fisheries, and rafting opportunities.

a. Reservoir Recreation. Reservoir operations for water supply are usually adequate to support established recreational activities, particularly when surface runoff from precipitation is near normal. Alterations in operations, because of drought, regulatory changes, or increasing demand, can reduce both available recreational opportunities and per capita benefits. In general, reservoir recreational benefits decrease as receding water levels reduce water surface area because: (1) recreational facilities are farther from shorelines; (2) boat ramps are less accessible; (3) boating and swimming hazards are exposed; (4) swimming area beaches become unusable; (5) fishing conditions are degraded; and (6) the aesthetic qualities of the reservoirs decrease. Recreation attendance drops substantially when water levels fall. During the 1976-1977 drought, total attendance at State and federal reservoirs in California was reduced about 30 percent, with some reservoirs experiencing declines as much as 80 percent, while attendance at a few stable reservoirs increased. A similar pattern developed during the 1987-1992 drought although there were even fewer stable reservoirs (DWR 1994d).

As discussed in section B.1 of this chapter, reservoir levels in the Sacramento and San Joaquin river basins are likely to decline under the preferred alternative. Whether declines occur, and the magnitude of the declines, will depend on management decisions made by reservoir operators responsible for meeting the new flow standards. Lower reservoir levels can have a significant impact on recreational activities.

b. River Recreation. Riverine environments offer types of recreation not available from the large water surface impoundments. Some of the recreational opportunities associated with rivers and streams are fishing, swimming, and white-water sports such as rafting, kayaking, and canoeing. In some cases, these uses can conflict. For example, peak releases in the summer from the North Fork Stanislaus River project greatly increased white-water rafting but reduced opportunities for swimming (DWR 1994d).

The change in Sacramento River and San Joaquin River flows at Freeport and Vernalis, respectively, were discussed in section B.3 of this chapter. The conclusion in that discussion is that the only significant effect on river flows is an increase over historical flows at Vernalis during the spring and fall pulse flows. While this conclusion is true at this downstream point, it may not be true immediately below rim reservoirs that may be assigned responsibility to provide the required flows. The particulars of this change in upstream flow regime will be analyzed during the water right phase.

The change in the flow regime could have an impact on rivers below rim reservoirs. Higher flows in the spring could increase opportunities for rafting and decrease swimming opportunities. The overall flow regime is intended to improve conditions for anadromous fisheries, which have substantial recreational benefit. Overall, some aspects of river recreation may be adversely affected by implementation of the standards.

c. Wildland Recreation. Many designated wildlife refuges in California are dependent on water deliberately transported to the refuges. Seasonal wetland habitat at such refuges is integral to maintenance of local wildlife and migratory waterfowl populations along the Pacific Flyway. Historically, recreational values associated with such wildlife have focused primarily on hunting, but more recently bird watching has become a significant use.

The SWRCB does not believe, and does not intend, that the standards in the plan should affect the water supplies available for wildlife refuges. Therefore, the preferred alternative should not have any significant environmental effect on wildland recreation.

6. Ground Water Pumping

Since many upstream water users will replace reduced surface water supply with ground water, any such reduction in surface water supply caused by implementation of the preferred alternative will result in increased pumping of ground water and exacerbation of the overdraft problem in California. The impacts of the preferred alternative on ground water pumping are discussed in detail in section C.1 of this chapter. To the extent that upstream users experience reduced surface water supply as result of the standards in the plan, the impacts on ground water pumping are likely to be similar to those described in section C.1.

C. EFFECTS IN EXPORT AREAS

Reduced water deliveries in export areas as a result of implementation of the preferred alternative are expected to cause significant adverse impacts. The discussion below is divided into the following sections: (1) ground water pumping; (2) land use; (3) wildlife habitat; (4) urban landscape; and (5) recreation.

1. Ground Water Pumping

In a year of average precipitation and runoff, an estimated 15 MAF of ground water is extracted and applied for agricultural, municipal, and industrial use in California at the 1990 level of development. Under the same conditions, the ground water system is recharged with over 13.5 MAF of water from rainfall, streambed seepage, and deep percolation of applied water. Therefore, the average amount of ground water extracted in the State exceeds the average recharge by about 1.3 MAF (DWR 1994d).

The reduction in surface water deliveries caused by implementation of the standards will result in increased pumping of ground water because many water users will replace their reduced surface water supply with ground water. Ground water pumping is unregulated in much of California. Consequently, water users in most export areas can drill new wells or increase their pumping capacity without encountering legal, institutional, or governmental constraints (Archibald et al. 1992). However, substitution of ground water for surface water can cause environmental impacts, such as: (a) depletion of ground water resources; (b) permanent loss of aquifer capacity; (c) surface land subsidence; (d) seawater intrusion; (e) decreased agricultural productivity; (f) water quality deterioration; and (g) increased energy consumption. Because the magnitude of these effects (which depend on water users' responses to implementation of the preferred alternative) cannot be accurately predicted, a qualitative discussion of these impacts is provided below.

a. Depletion of Ground Water Resources. The reduction in surface water supplies that will result from implementation of the standards will exacerbate the overdraft problem in California. (Overdraft is defined as the amount of ground water extracted in excess of the perennial yield.) The present level of annual overdraft in some ground water basins affected by the plan, at the 1990 level of development and assuming D-1485 regulatory conditions, is provided in Table VIII-4 (DWR 1994d).

Table VIII-4. Ground Water Overdraft by Hydrologic Region at 1990 Level of Development

Region	TAF
Central Coast	250
South Coast	20
San Joaquin	210
Tulare Lake	340

An exact estimate of the magnitude of the increased overdraft that will occur as a result of the standards is not possible because of the uncertainty of the response of individual water users. However, the worst case estimate in the short-term is that all of the reduced surface water supplies from the Delta will be replaced by increased ground water pumping, and the overdraft will increase by the magnitude of the water supply impact of the plan (discussed in Chapter VII).

b. **Permanent Loss of Aquifer Capacity**. Permanent loss of aquifer capacity occurs when fine-grained beds of clay and silt, called aquitards, compress as water is extracted. Once the aquitards are compacted, they can never hold as much water again, resulting in a permanent loss of aquifer water storage capacity. This condition has occurred in the San Jacinto and San Joaquin valleys (SWC 1992b).

c. **Surface Land Subsidence**. Consolidation of water-bearing formations causes subsidence of the land surface. Land subsidence can change canal gradients, damage buildings, and require repair of other structures (DWR 1994d). Incidents of subsidence and major geologic hazards due to ground water withdrawal in San Joaquin, San Bernardino, Riverside, and Los Angeles counties have been documented. The lowering of the land surface in the San Joaquin Valley is a result of many geologic and hydrologic processes; however, one of the primary causes is ground water extraction. The U.S. Geological Survey (USGS) reports that, prior to 1977, 5,200 square miles of the San Joaquin Valley floor area subsided by at least 1 foot, and in some areas, subsidence has been as much as 30 feet. No recent land subsidence surveys have been made, but the DWR reports that subsidence has started again in western Fresno County and may be occurring elsewhere in the San Joaquin Valley (SWC 1992c). Data collected in Westlands Water District indicate that subsidence occurred in 1990, 1991, and 1992, with the highest amount of subsidence occurring in 1991 (DWR 1994d).

Accurate prediction of subsidence is generally not possible with our present level of knowledge or current data about the extent and properties of aquifer sediments in subsidence areas. In some areas, subsidence occurs when ground water levels decline below a certain level.

d. **Sea Water Intrusion**. Declining ground water levels along the coast causes seawater to intrude into freshwater aquifers. The resulting increase in ground water salinity eliminates many of the beneficial uses of the water. The response to seawater intrusion is to either reduce pumping, close wells, or construct a seawater intrusion barrier. The latter alternative is expensive and is employed only if the ground water storage capacity is critically needed.

Los Angeles County operates seawater intrusion barrier projects in West Basin and Dominguez Gap. Los Angeles and Orange counties jointly operate a seawater intrusion barrier in Los Alamitos Gap, which straddles the border between the two counties. In most of these barriers, water from wastewater recycling facilities is injected and flows down-gradient toward the ocean, as well as inland areas, where it mixes with ground water in the aquifer and can be extracted by irrigation and municipal wells.

e. Decreased Agricultural Productivity. Reduced surface water supplies may contribute to problems of salt buildup in agricultural soils because substitute ground water supplies have higher salinity levels. Excess salinity in the plant root zone negatively affects crop plants through a reduction in the growth rate and, hence, production. Scientists generally believe that plant growth is inhibited as plants expend more energy under high salt conditions to acquire water from the soil and to make biochemical adjustments necessary to survive (SWC 1992c).

f. Water Quality Deterioration. A change in ground water gradient may accelerate movement of point and nonpoint source contaminants toward water-producing wells. This accelerated movement of contaminants is exacerbated where ground water levels have been lowered significantly because of increased extraction (DWR 1994d).

g. Increase in Energy Consumption. Increased ground water pumping will result in higher pumping lifts due to lower ground water levels and, thus, increasing energy consumption.

2. Land Use

As discussed in section B.4 of this chapter, the most likely land use changes in the export areas as a result of implementation of the standards are agricultural land retirement and crop shifts. The discussion of this issue contained in section B.4 is also relevant to the export areas and is not repeated here.

The Zilberman Rationing Model used in the economic analysis of the plan (Chapter XII) provides an estimate of the quantity of land that will be fallowed in areas subject to water supply reductions due to implementation of the standards in the plan. Assuming worst case conditions of limited transfers and no crop shifts, this model estimates that approximately 48,000 acres and 57,000 acres will be fallowed over the 71-year average hydrology and the 7-year worst case hydrology, respectively. These acreage reductions would be distributed throughout the Central Valley if water supply impacts are distributed among all water users. However, if the CVP and the SWP are held largely responsible for meeting the standards, the majority of the reductions would be borne by the projects' contractors.

The agricultural acreage reductions and crop shifts that are likely to occur in export areas as a result of implementation of the preferred alternative are a significant impact.

3. Wildlife Habitat

Presently, export water from the Bay-Delta watershed supports wildlife habitat because of both planned deliveries of export water to wildlife refuges and other habitat areas, and incidental benefits during transport, use, and discharge.

Transport, use, and discharge of water in agricultural areas creates wetland, riparian, and fish habitats (SWC 1992b). Reductions in water supply will result in increased conservation and land fallowing, which will decrease both the water quality and water quantity available for these uses. The water quality issue arises because conservation and reuse of tail and tile water tend to increase the concentrations of salt and other pollutants in the water ultimately discharged. These pollutant increases reduce the value of the discharge water to wildlife habitat. Fallowed lands also can have an impact on the environment because pre-irrigation can provide wintering habitat for waterfowl and grain crops can provide food supply for wintering waterfowl (SWC 1992d). However, fallowed land can also provide beneficial habitat for dry land species.

Water from return flows and discharges is also important in urban areas. This water creates and supports wetland and riparian habitats by establishing live streams and creating prolonged soil moisture in the upper soils in spreading basins, natural creeks, and man-made flood control channels. These habitats support the growth of wetland and riparian plants such as cattails and willows. These types of habitat are highly valuable for wildlife because they support a wide variety and abundance of fish, insects, invertebrates, birds, amphibians, and mammals. Wetland and riparian habitats are particularly important to wildlife in Southern California due to the arid nature of most of the region.

An example of the importance of runoff from urban areas and the discharge of treated effluent in creating and maintaining significant wetland habitat can be found along the Santa Ana River and at Prado Basin in Orange and Riverside counties. Prado Basin is a major flood control facility in eastern Orange County along the Santa Ana River. It impounds water during the winter for flood control. As a consequence of this temporary impoundment, extensive wetland habitat has been created in the 9,000-acre basin. There is an abundance and diversity of wildlife in the basin, including migratory waterfowl, raptors, large mammals, and spring-breeding birds. There are numerous wastewater treatment plants in the Santa Ana River watershed above Prado Basin which discharge year-round into the river and its tributaries. In addition, the watershed has changed from a predominantly agricultural area to a highly urbanized area with substantial urban runoff. At this time, the summer base flow in the Santa Ana River at Prado Basin is due entirely to discharges from the upstream wastewater treatment plants. This artificial flow in the river creates wetland conditions in Prado Basin by increasing the duration and amount of surface water and increasing soil moisture available to plants through rising ground water. The reduction in the delivery of imported water to the region could result in lower levels of runoff and wastewater discharge. Natural and man-made wetland habitats reliant on this runoff could be adversely affected because live streams may be precluded, insufficient runoff could be available to saturate the upper soils to support wetland vegetation, and significant wetland habitat dependent on this runoff could be degraded and possibly destroyed as ground water elevations dropped.

Based on these considerations, the reduction in water exports expected as a result of implementation of the preferred alternative could adversely affect wildlife habitat, depending on the actions by water users in response to water shortages. Quantification of these impacts is speculative at this time.

4. Urban Landscape

Under the preferred alternative, urban areas will receive decreased water supplies from the Delta when the plan is implemented, which can result in environmental impacts. The State Water Contractors have identified the following uses and beneficial effects of urban landscapes (SWC 1992e): aesthetics and scenic design; embellishment of private dwellings and surroundings; creation of private, domestic space; community involvement activities, as in community gardens; public amenities such as public parks, parkways, greenways, and scenic reservations; wildlife habitat; reduction in use of fossil fuels for air conditioning and heating with a concomitant reduction in production of certain pollutants; absorption of certain pollutants; reduction of water pollution in wetlands; resistance to erosion, especially in areas of steep slopes, unstable soils, and variable rainfall; as aid in flood control; and in biological conservation, including conservation of endangered species.

Because urban landscape depends on an adequate water supply for its sustenance, a reduction in that supply could adversely affect some of the beneficial effects of an urban environment. During the 1987-1992 drought in Southern California, there was a well-documented loss of ornamental trees and landscaping in Santa Barbara County that resulted in wide-ranging economic and social effects.

In the long-term, lower water supplies are likely to result in locally-mandated, more efficient management of water resources. Most of the elements of such management are contained within the Memorandum of Understanding Regarding Urban Water Conservation in California, which is discussed under section A.1 in Chapter X. With respect to urban landscape, one element of more efficient management is implementation of xeroscape programs. Expanded use of xeroscape techniques will result in a change in the urban landscape over the long-term.

5. Recreation

The principal recreational facilities in southern California associated with exports from the Delta are reservoirs operated by the DWR and the Metropolitan Water District of Southern California (MWD). The reservoirs operated by the DWR provide opportunities for swimming, boating, fishing, picnicking, and sightseeing. Reservoirs operated by the MWD and local purveyors, with the exception of Lake Mathews where public use is prohibited, provide these same opportunities, excluding swimming. Extensive recreational facilities have been constructed at many of these reservoirs, including Lake Casitas, Lake Skinner, Castaic Lake, Lake Perris, and Pyramid Lake (SWC 1992b). Implementation of the standards will not have a substantial effect on these reservoirs and their recreational use because the reservoirs are operated, in part, to provide emergency storage in the event supplies into southern California are cut. Therefore, reservoir levels should not change significantly under the regulatory conditions in the plan.

In central California, the principal recreational feature of the SWP and the CVP is San Luis Reservoir and O'Neill Forebay. This facility provides storage for water diverted from the Delta for later delivery to the San Joaquin Valley and southern California. There are extensive recreational developments and three wildlife areas around the reservoir and at O'Neill Forebay which offer camping, picnicking, sail and power boating, water skiing, wind surfing, fishing, swimming, hiking, bicycling, and waterfowl hunting. San Luis Reservoir operation will change under the conditions in the plan, as described in Chapter VII. This change may affect recreational opportunities at the reservoir.

Recreational facilities have also been developed along the California Aqueduct. Fishing is permitted in canal reaches along nearly 400 miles of the California Aqueduct, beginning at Bethany Reservoir and extending to just north of Silverwood Lake. Fish from the Delta have spread throughout the aqueduct system. Fishing opportunities should not be significantly affected by implementation of the standards because aqueduct water levels should not fluctuate appreciably.

There are also recreational facilities in export areas that are not directly related to CVP and SWP facilities but could be affected by decreased water supplies. For example, the Orange County Water District owns approximately 2,100 acres in the Prado Basin in Riverside County. The acreage includes about 600 acres of constructed ponds fed by water diverted from the Santa Ana River. The land is leased to a duck hunting and dog training concession. These recreational facilities draw approximately 50,000 participants annually. Similarly, downstream of Prado, Orange County Water District owns approximately 1,100 acres used for spreading flows of Santa Ana River and imported water. Anaheim Lake and Santa Ana River Lakes are deep spreading basins that are also leased to a fishing concession for trout fishing (WACO 1992a). A reduction in SWP exports could reduce Santa Ana River flows, thereby making less water available for these and other recreational facilities dependent on imported water supplies.

D. NEED TO DEVELOP AND USE RECYCLED WATER

1. Background

Water reclamation and reuse in California has long been supported because of the arid and semi-arid condition in the State. Reclaimed water has been intentionally used as a nonpotable water supply source in California for nearly a century. Historically, its application generally has been motivated as a cost-effective means of wastewater treatment and disposal. However, due to drought and long-term water shortages, water reclamation as a means to augment fresh water supplies has received significant emphasis in recent years, both in State policy and local water supply planning (SWRCB 1990, SWCC/BDRSWG 1991).

In July 1991, the Porter-Cologne Water Quality Control Act was amended to include among the factors to be considered in establishing water quality objectives (Water Code §13241), "the need to develop and use recycled water". The amendment also applied the existing definition of "reclaimed water" to "recycled water" and declared reclaimed or recycled water as a valuable resource. The current definition (Water Code §13050) is: "'Reclaimed water' or 'recycled water' means water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefor considered a valuable resource."

In addition, the 1991 legislation enacted the Water Recycling Act of 1991 (Water Code §13575), wherein the Legislature made the following findings and declarations:

> (a) The State of California is in a fifth year of drought, with three of the past four years being critically dry.
>
> (b) The development of traditional water resources in California has not kept pace with the state's population, which is growing at the rate of over 700,000 per year and which is anticipated to reach 36 million by the year 2010.
>
> (c) There is a need for a reliable source of water for uses not related to the supply of potable water to protect investments in agriculture, greenbelts, and recreation and to protect and enhance fisheries, wildlife habitat, and riparian areas.
>
> (d) The environmental benefits of recycled water include a reduced demand for water in the Sacramento-San Joaquin Delta which is otherwise needed to maintain water quality, reduced discharge of waste into the ocean, and the enhancement of recreation, fisheries, and wetlands.
>
> (e) The use of recycled water has proven to be safe from a public health standpoint, and the DHS is updating regulations for the use of recycled water.
>
> (f) The use of recycled water is a cost-effective, reliable method of helping to meet California's water supply needs.
>
> (g) The development of the infrastructure to distribute recycled water will provide jobs and enhance the economy of the state.

The Water Recycling Act of 1991 also established a statewide goal to recycle a total of 700 TAF of water per year by the year 2000 and 1.0 MAF of water per year by the year 2010.

In September 1991, the State Water Conservation Coalition Reclamation/Re-Use Task Force (formed by the Committee for Water Policy Consensus and the Southern California Water Committee) and the Bay-Delta Reclamation Sub-Work Group (formed by the SWRCB and chaired by the DWR) submitted a joint report to the SWRCB for consideration in its Bay-Delta Water Rights process. The report (SWCC/BDRSWG 1991), which presented the results of a study on water recycling, estimated the potential for reclamation by the year 2000, and addressed various issues which posed constraints to water reclamation.

Subsequently, in July 1993, Senate Concurrent Resolution 17 was passed which requested the DWR, in consultation with other appropriate agencies, to provide suggestions that will help the State meet or exceed the statewide recycling goals of the Water Recycling Act of 1991. In response to this request, the DWR, with the cooperation of the USEPA, USBR, Contra Costa Sanitary District, and San Diego County Water Authority, released a report titled, "Meeting the Goals of the Water Recycling Act of 1991: An Attainable Future", in May 1994.

Most recently, on June 1, 1994, the SWRCB, DWR, DHS, California Conference of Directors of Environmental Health, USEPA, USBR, and the WateReuse Association of California adopted a joint statement of support for water reclamation. In this statement, these agencies resolved that they will cooperate to develop specific policies and resource commitments that will enable the State to meet the Legislature's water reclamation goals and to help satisfy the State's overall water needs. This statement reported that the amount of water reclaimed in California had increased from 165 TAF per year in 1977 to over 380 TAF per year in 1993.

2. Potential for Reclaiming Water

In July 1993, the WateReuse Association of California released a report, based on a survey of California water and wastewater agencies, on the potential for future water recycling (WRAC 1993). The survey results indicated that water recycling projects being planned by water and sanitary districts and municipalities will substantially increase water reclamation in the State. While the WateReuse Association's 1993 survey report states that achieving the goals of the Water Recycling Act of 1991 are within reach and, in fact, the 2010 goal can be exceeded by over 30 percent if the survey respondents accomplish their own predictions, the SWRCB's Office of Water Recycling believes that this is an optimistic projection of water reclamation potential in light of limited funding for reclamation projects. The Office of Water Recycling concludes that, based on the survey report's projection of $2 billion to add 600 TAF per year, between $3 billion and $4 billion will be required for capital facilities to meet the 1.0 MAF per year goal for the year 2010. Therefore, to achieve the State's goals for water reclamation, substantial financial assistance will be needed (SWRCB 1994).

For purposes of assessing the potential of wastewater reclamation to reduce demands on other fresh water supplies, the quantities of fresh water displaced by reclamation should be considered rather than the quantities of reclaimed water deliveries. Fresh water displaced refers to the amount of fresh water that would otherwise be used to meet present or future non-potable demands if reclaimed water were not available. Reclaimed water deliveries include deliveries that serve all beneficial uses, including those that displace fresh water and other uses that would not, under most circumstances, have received fresh water if reclaimed water were not available (SWCC/BDRSWG 1991). Therefore, the amount of fresh water displaced by reclaimed water is considered the contribution of wastewater recycling to the State's future water supply (DWR 1994d).

While reclaimed water generally replaces fresh water, this replacement does not always result in an actual augmentation to the State's overall water supply. For example, wastewater discharged to streams or percolation ponds is available for indirect reuse through downstream diversions or groundwater pumping. Planned reuse directly from a wastewater treatment plant may be merely substituting for an unplanned reuse of the same effluent taking place downstream (SWRCB 1990).

The total annual fresh water that was or will be displaced by reclaimed water for the years 1990, 2000, 2010, and 2020 is estimated at 235, 453, 561, and 676 TAF, respectively. The source of most of this reclaimed water is wastewater discharged into the ocean from California's coastal cities. Smaller amounts could come from reclaiming brackish ground water and desalination of ocean water. Currently, most of the ground water reclamation programs under consideration (excluding contaminant remediation) are located in southern California. Ground water reclamation programs are designed to recover degraded ground water, which commonly has high TDS and nitrate levels. To be used, this water must either be treated, blended with higher quality water, or applied untreated for landscape irrigation. The total annual contribution of ground water reclamation by the year 2000 is likely to be about 90 TAF. Because of its high cost and uncertain success, desalting brackish agricultural water and ocean water currently is considered to be a minor possible option for augmenting the State's future water supply (DWR 1994d).

Numerous constraints to fully implementing all potential wastewater reclamation options exist, including: funding of reclamation facilities (as noted above), distances to potential applications, regulatory requirements, acceptance by health authorities and the public, and water quality, including salinity (DWR 1994d). The relatively poor quality of reclaimed water can significantly constrain water reclamation efforts and affect the quantity of fresh water displaced. For irrigation and industrial uses, the quantity of reclaimed water delivered will generally be greater than the quantity of fresh water displaced due to the differences in water quality between fresh water and reclaimed water. Reclaimed water contains higher concentrations of TDS, salts, and hardness than fresh water. Therefore, when irrigating, approximately 10 percent more reclaimed water needs to be applied to ensure that the salts are leached from the plants' root zones. In industrial applications, such as cooling tower supply, the greater hardness requires reclaimed water to be used for fewer cycles to prevent scaling and damage to the equipment (SWCC/BDRSWG 1991).

3. Relevance of Water Reclamation to Bay-Delta Standards

In testimony received by the SWRCB during Bay-Delta water rights hearings in 1992, the quality of reclaimed water and its source water was emphasized. To maximize the use of reclaimed water, the reclaimed water quality must be acceptable for its end use. Therefore, water reclamation is limited by the quality (i.e., salt content measured as TDS) of the fresh water supply and the intended market for the reclaimed water.

Most uses of reclaimed water can be served when the TDS is no greater than 800 mg/l. Certain types of salt-sensitive landscaping and agriculture are unable to tolerate irrigation with reclaimed water high in TDS. Normal urban water use generally adds about 300 mg/l TDS to the potable water supply (SDCWA 1992, MWD 1992). Therefore, to achieve an acceptable TDS level of 800 mg/l in reclaimed water, which will allow for a full range of beneficial uses that could be served with reclaimed water, a source water low in TDS (i.e., no more than 500 mg/l) is needed. For the urban areas of Southern California, where most water reclamation efforts in the State are taking place, this means that a reliable supply of imported water that is low in TDS is required.

Within the San Diego County Water Authority (SDCWA) service area, an average of 90 percent of the water supply is imported. This supply consists primarily of imported Colorado River water which typically has TDS levels of 600-750 mg/l. When Colorado River water is reclaimed, TDS increases to 900-1,050 mg/l after only one reuse. For example, during 1991, the SDCWA received 100 percent Colorado River water due to drought conditions. This imported water supply, which had a TDS level that reached 657 mg/l, resulted in reclaimed water from the Fallbrook Sanitary District Reclamation Facility that averaged 905 mg/l TDS and peaked at over 1,000 mg/l TDS (SDCWA 1992). These levels exceed the recommended and upper maximum contaminant levels for TDS of 500 mg/l and 1,000 mg/l, respectively, established as secondary drinking water standards by the DHS (CCR § 64473). TDS levels this high may restrict the use of reclaimed water for several purposes, including groundwater recharge to a drinking water supply and irrigated agriculture.

The Colorado River Basin Salinity Control Forum (CRBSCF), which is comprised of the seven states in the basin, recommended salinity criteria for three locations near key diversions on the Colorado River in its triennial review of Colorado River salinity criteria (CRSCF 1993). These criteria, which were first established in 1975, are 723, 747, and 879 mg/l flow-weighted annual salinity below Hoover Dam, below Parker Dam, and at Imperial Dam, respectively. These criteria were selected to maintain salinity levels to offset the effects of water resource development in the Colorado River basin since 1972. Periodic increases in salinity above the criteria as a result of reservoir conditions or natural variations in flow are considered to be in compliance with the criteria. Natural variations in runoff can cause a fluctuation in average annual salinity concentrations of about 450 mg/l at Imperial Dam. The CRBSCF report states that implementation of the criteria will prevent, by the year 2015, a salinity concentration increase of approximately 140 mg/l at Imperial Dam. In March 1993, the SWRCB approved the 1993 triennial review of the Colorado River salinity criteria and plan of implementation as presented in the CRBSCF report (SWRCB Resolution No. 94-28).

The SDCWA maintains that, if their water supply continues to consist primarily of Colorado River water, whose TDS levels are expected to increase unless salinity control measures are implemented, the TDS levels in reclaimed water will substantially limit the application of reclaimed water as a resource in San Diego County. To maximize the development of reclaimed water supplies in the county, a minimum amount of SWP water, which is relatively lower in TDS, is required for blending with Colorado River water supplies. The SDCWA has estimated that their future imported water supplies must contain 50 percent SWP water to meet their reclaimed water projections for the year 2000. A 50 percent blend of SWP water results in a TDS of 500 mg/l in the total imported water supply. Considering an increase of approximately 300 mg/l TDS due to normal municipal uses, the 50 percent SWP contribution to the imported water supply ultimately will achieve TDS levels of about 800 mg/l. Reclaimed water of this quality will serve a full range of uses for reclaimed water and, ultimately, reduce dependence on SWP water (SDCWA 1992).

The Water Advisory Committee of Orange County (WACO), which represents leaders in water reclamation and reuse in the State, and the MWD also testified that, to continue to operate wastewater reclamation projects effectively, a reliable imported supply of SWP water is needed. They also stated that the higher salt content Colorado River water is not suitable as a substitute for SWP supplies and, furthermore, may not be available in the future (WACO 1992b, MWD 1992). The WACO and the Santa Ana Watershed Project Authority (SAWPA) stated that the Santa Ana River watershed system in Orange County, and the SWP itself, were planned and built for the introduction of low salinity SWP supplies into the headwaters of the river system (WACO/SAWPA 1992). Like the SDCWA, the MWD testified that, to meet its projected total use of reclaimed water by the year 2010, adequate supplies of Delta water must be available (MWD 1992).

Although one might expect that reductions in imported water from the Delta should encourage water reclamation efforts in State and federal water project service areas, previous evidence brought before the SWRCB suggests that the poor quality of alternative water sources compared to Delta water may actually decrease the potential for water reclamation in certain areas of the State. Reductions in imported Delta water will probably encourage wastewater reclamation in some areas and impede it in others, depending on factors such as the quantity and quality of all water supply sources available, the level of treatment achieved, and the potential for various uses of reclaimed water.

The amount of water taken from the Delta may not be reduced by increases in water reclamation because the majority of reclamation projects are being built in areas experiencing increases in population and water demand. Reclaimed water will be used to offset future demand so that increased diversion from the Delta can be minimized; however, reclamation projects will probably not result in a substantial reduction in the need for imported water from the Delta (SWCC/BDRSWG 1991).

E. IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

Most of the environmental impacts identified in this report are reversible. The principal hydrologic effect of implementation of the preferred alternative will be to change Delta outflow, reservoir levels, and deliveries to export areas. These parameters presently fluctuate a great deal due to the variable hydrology in the Central Valley. If the standards are implemented and then rescinded at a future date, the hydrology will be dependent on the regulatory conditions in effect at that time. However, there are three irreversible impacts that might occur as a result of this situation: land use changes, fossil fuel combustion, and land subsidence. These irreversible changes are discussed below.

The most likely land use change that might occur as a result of the standards is accelerated agricultural land retirement. Without a firm agricultural water supply, the conversion of this land to some other use may occur, especially if the land is adjacent to an urban area. The extent to which this land use change will actually occur is dependent on decisions by local authorities.

The second irreversible impact is increased fossil fuel combustion. The dedication of additional water to the environment will decrease the availability of water in some upstream reservoirs for summer peak power generation, as discussed in both section B.1 of this chapter and in Chapter XII. In addition, the development of replacement water through ground water pumping and reclamation is power intensive. As discussed in section B.2 of this chapter, fossil fuel combustion will likely be an element in replacing lost power and meeting new power requirements as a result of the plan.

The third irreversible impact is land subsidence. As discussed in section C.1 of this chapter, implementation of the standards is likely to result in increased ground water pumping which can cause land subsidence. Land subsidence can damage surface structures, and it can result in permanent loss of aquifer capacity.

These commitments of resources are justified in light of the enhanced protection that the plan provides to aquatic habitat-related beneficial uses in the Estuary. If the plan is not adopted and implemented, there may be further declines in fresh- and brackish-water aquatic and terrestrial habitats in the Delta, resulting in the potential listing of additional species under the federal and State ESAs.

F. GROWTH-INDUCING EFFECTS

The preferred alternative will reduce the amount of water available to water utilities in areas served by the CVP, the SWP, and other parties charged by the SWRCB in the upcoming water rights proceeding with responsibility for meeting the requirements of the plan. To the extent that historic patterns are any indication of future trends, reduced water availability is unlikely to affect growth in these areas.

Growth patterns have historically been influenced by market conditions far more than by any other factor. Water shortages have rarely done more than slow the progress of adequately financed development proposals. Growth moratoriums have occasionally been imposed due to inadequate water supplies. El Dorado County, for example, imposed a building moratorium due to a temporary supply shortage (Rudy Limon, El Dorado County Counsel, pers. comm., October 19, 1994). But, in most cases, enough water has been found to sustain most economically viable growth. Because the costs of water supply augmentation projects can usually be spread over a large user base, the cost of new supplies has seldom been high enough to significantly reduce the profitability of new development projects.

Land fallowed in response to irrigation water cutbacks could become available for other uses, including development. The fact that fallowed farmland will probably drop in price could also increase its attractiveness for non-agricultural uses. Because development is primarily driven by demand, however, the availability of fallowed land is not expected to result in significant new growth. Without a tangible demand for new housing, an increase in the amount of available, affordable land will not stimulate the construction of new housing.

G. NEED FOR DEVELOPING HOUSING

The preferred alternative would have no direct effects on housing demand, but could alter demand indirectly by affecting economic conditions. One economic effect of implementation of the standards that could affect housing demand is job losses in agricultural areas where irrigation water supplies would be reduced. Demand would decrease in the affected areas, and increase in the regions to which displaced workers migrate.

Although the standards are expected to cause some job losses in the agricultural sector, the number of workers to be displaced will be too few to cause a significant change in the demand for housing. (The employment impacts of the standards are discussed in Chapter XII.) Nor are the standards expected to significantly affect the economy of the State as a whole (see Chapter XII). Decreased water supplies may increase costs for some businesses in some areas of the State. In most cases, however, these increases will be small relative to other factors affecting businesses. By providing a measure of certainty about future water supplies, Bay-Delta standards could have a stabilizing effect on the State's economy. Also offsetting the negative economic impacts of the standards on some businesses is a quality of life improvement that will result from improved water quality in the Bay-Delta Estuary (Sanders et al. 1990). This improvement could indirectly benefit the State's economy by, for example, keeping some trained, productive residents from moving to other states in pursuit of higher incomes.

H. RELATIONSHIP BETWEEN SHORT-TERM USES AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The principal issue associated with the relationship between short-term uses and the maintenance of long-term productivity is ground water overdraft. As discussed in sections B.6 and C.1 of this chapter, implementation of the standards will aggravate ground water overdraft problems. Additionally, changes in the use of water may well occur, from agricultural uses to municipal uses, or from one type of agricultural use or crop to another, in the short- and long-term.

The standards have the potential to affect water levels in reservoirs, flows in the rivers, water management operations, and the quantity of water deliveries to various districts in the short- and long-term. Surface water is, however, renewable from precipitation. Also, the plan will be reviewed every 3 years to evaluate the effectiveness of the standards and the water supply needs of the State.

The plan will provide better protection to aquatic habitat-related beneficial uses in the Estuary. Long-term increases in fresh- and brackish-water aquatic and terrestrial habitats in the Delta will result. If the plan does not go forward, there will probably be further declines in those resources and additional species may be listed under the federal and State ESAs.

I. CUMULATIVE IMPACTS

Cumulative impacts are defined in the CEQA Guidelines as two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant impacts (CEQA Guidelines §15355).

In this case, the principal impacts of implementation of the standards can be traced to the loss of water to areas upstream of the Delta or in export areas. Therefore, significant cumulative impacts are impacts of other projects or activities that also reduce the water available to upstream and export areas. Such projects or activities include: (1) Mono Lake Water Right Decision 1631; (2) the CVPIA; (3) the federal ESA; (4) the reallocation of Colorado River water; (5) the proceedings of the Federal Energy Regulatory Commission (FERC); and (6) other SWRCB water right proceedings. These projects are discussed below.

1. Mono Lake Water Right Decision 1631

Mono Lake Water Right Decision 1631 was adopted by the SWRCB on September 28, 1994. The decision reallocates water in the Mono Lake Basin from consumptive use by the Los Angeles Department of Water and Power (LADWP) to protection of public trust resources.

LADWP diverts water in the Mono Basin from Lee Vining Creek, Walker Creek, Parker Creek, and Rush Creek. The water is then exported from the Mono Basin through the Mono Craters Tunnel approximately 11 miles to the upper Owens River. The Mono Basin water commingles with water in the upper Owens River and flows into the Los Angeles Aqueduct from which it is distributed for a variety of municipal uses in the City of Los Angeles.

Decision 1631 sets a target elevation of 6,391 feet for Mono Lake and it establishes minimum flow requirements for the creeks flowing into Mono Lake. The decision prohibits diversion from the basin until the lake level rises above 6,377 feet. Limited diversion is allowed after that event, and less restrictive diversions are allowed after the lake rises to the final target elevation, which is expected to occur in about 20 years. Hydrologic modeling of the standards in the decision project that Los Angeles will be able to divert an average annual amount of approximately 12.3 TAF over the next 20 years. The long-term average annual exports once the lake reaches an elevation of 6,391 feet are projected to increase to approximately 30.8 TAF. From 1974 to 1989, the City of Los Angeles diverted an average of 83 TAF annually from the Mono Basin.

2. CVPIA

The CVPIA reauthorizes the U.S. Department of the Interior's CVP. It includes fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic uses, and fish and wildlife enhancement as a purpose equal to power generation. The CVPIA identifies the following three specific measures which are likely to reduce the amount of water available for irrigation and municipal use in the Central Valley and export areas:

1. The CVPIA dedicates 800 TAF of CVP yield in all normal years for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized in the Act. Under dry year conditions, the dedication is reduced to 600 TAF.

2. The CVPIA requires the Secretary of the Interior to provide, either directly or through contractual agreements with appropriate parties, firm water supplies of suitable quality to maintain and improve wetland habitat areas on: units of the National Wildlife Refuge System in the Central Valley of California; the Gray Lodge, Los Banos, Volta, North Grasslands, and Mendota state wildlife management areas; and the Grasslands Resources Conservation District in the Central Valley of California. The amount of water that will be dedicated to this activity has not yet been firmly established.

3. The CVPIA provides that, by September 30, 1996, the Secretary of the Interior shall complete the Trinity River Flow Evaluation Study currently being conducted by the USFWS to develop recommendations regarding permanent instream flow requirements and Trinity River Division operating criteria and procedures for the restoration and maintenance of the Trinity River fishery. If the Secretary of the Interior and the Hoopa Valley tribe agree on these recommendations, they will be implemented; otherwise, the existing fishery releases of 340 TAF will remain in effect unless increased by an act of Congress, appropriate judicial decree, or agreement between the Secretary and the Hoopa Valley tribe.

3. Federal ESA

Requirements established under the federal ESA for protection of winter-run chinook salmon and Delta smelt, referred to as biological opinions, controlled many of the operational decisions of the CVP and the SWP in the Bay-Delta Estuary in the last 2 years. On December 15, 1994, federal and State agencies signed the Principles for Agreement in which the federal government agreed to accept the requirements in the preferred alternative for the next 3 years, after which the requirements may be revised. Accordingly, the biological opinion for Delta smelt has been redrafted and is largely consistent with the requirements in the plan. The biological opinion for winter-run chinook salmon has not been promulgated, but it is anticipated to also be consistent with the requirements in the plan.

Delta operations can be affected by the federal ESA in the future. If the requirements in the plan do not stabilize populations of endangered species in the Delta, more restrictive ESA requirements may be established after the 3-year agreement cited above has expired. Additional species could also be listed in the future. For example, the Sacramento splittail is being considered for listing, and discussions have been held on listings for other species such as the spring-run chinook salmon, sturgeon, longfin smelt, and steelhead trout. The agreement states that if additional water is required for protection of newly-listed species then water will be provided by the federal government on a willing seller basis. After the agreement expires, the ESA could have substantial, though unquantifiable, cumulative impacts on Delta water supplies.

4. Reallocation of Colorado River Water

During the past decade, the MWD has operated the Colorado River Aqueduct at or near capacity of about 1.2 MAF annually. Currently, however, the DWR estimates that the MWD's contractual supplies and firm rights to Colorado River water amount to only about 724 TAF (DWR 1994d). At the recent SWRCB Mono Lake hearings, the MWD testified that, notwithstanding the quantity of its firm water rights, the MWD intends to take all appropriate steps to maintain Colorado River deliveries at 1.2 MAF in the future (MWD 1993). The MWD believes that this can be accomplished through: (1) the use of water apportioned to, but unused by, Arizona and Nevada; (2) access to surplus water when available; and (3) implementation of water transfer programs in cooperation with the California agricultural districts which use Colorado River water and possibly with the other basin states.

The MWD cites its recent successful negotiations regarding water transfer programs as providing assurance that it will be able to rely on full deliveries of Colorado River water in the future. These negotiations have resulted in a major water conservation program in the service area of the Imperial Irrigation District and agreements with landowners and lessees in the Palo Verde Irrigation District on a land fallowing program.

If the MWD is required to reduce its diversions from the Colorado River, such reductions will exacerbate the effects of the water supply reductions caused by the plan in the MWD's service area.

5. FERC Proceedings

The FERC is evaluating and modifying existing terms for protection of fish and wildlife in licenses for hydroelectric generation projects. Pending FERC decisions on the Mokelumne and Tuolumne rivers may impose additional water supply impacts for water users in these systems.

6. SWRCB Water Right Proceedings

The SWRCB occasionally reopens water right permits to review flow requirements for protection of resources within the subject stream systems. As result of these water right proceedings, the SWRCB may require additional flows for protection of fish and wildlife. The implementation of these water right decisions in combination with the plan may impose additional water supply impacts for water users in these systems. The SWRCB is currently conducting water right proceedings on the Mokelumne and Yuba rivers.

Literature Cited in Chapter VIII

Archibald, S., T. Kuhnle, R. Marsh, M. Renwick, and B. Thompson. 1992. An economic analysis of water availability in California Central Valley agriculture. Phase II draft report prepared by Center for Economic Policy Research, Stanford University, California. District responses and adjustments to water availability 4:1-41.

BioSystems Analysis, Inc. 1992. Water temperature control in the Sacramento-San Joaquin Bay/Delta toward a reasonable strategy. Draft report. March 1992. Prepared for U.S. Environmental Protection Agency. 48 pp.

California Legislature. 1982. Delta dilemma. Assembly Office of Research.

CRBSCF. 1993. Water quality standards for salinity, Colorado River system. 1993 Review. Final Report. Colorado River Basin Salinity Control Forum. October 1993.

DFG. 1987. Delta outflow effects on the abundance and distribution of San Francisco Bay fish and invertebrates, 1980-1985. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1987 Water Quality/Water Rights Proceeding on the San Francisco Bay/Sacramento-San Joaquin Delta. (WRINT-DFG-60)

DFG. 1992. Estuary Dependent Species. Entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta. 97 pp. (WRINT-DFG-6)

DFG. 1994. Memorandum from Perry Herrgesell to Tom Howard. October 19, 1994. 2 pp.

DWR. 1992. Biological assessment. Effects of Central Valley Project and State Water Project Delta operations on winter-run chinook salmon. 137 pp.

DWR. 1993. Comments of the California Department of Water Resources on State Water Resources Control Board Draft D-1630. California Department of Water Resources.

DWR. 1994a. Summary of salinity conditions in Suisun Marsh during water years 1984-1992. November 23, 1994.

DWR. 1994b. Comments of the DWR at the Third Public Workshop for the Review of Standards for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. California Department of Water Resources.

DWR. 1994c. Comments of the Department of Water Resources at the fifth workshop of the State Water Resources Control Board on Bay-Delta standards. Presented by David B. Anderson, September 1, 1994. 9 pp.

DWR. 1994d. California water plan update. Bulletin 160-93. California Department of Water Resources. October 1994. Volume I. 397 pp. Volume II. 315 pp.

DWR. 1995. DWRDSM Study: Draft Water Quality Control Plan. Memorandum from Francis Chung of the California Department of Water Resources to Tom Howard of the State Water Resources Control Board. April 20, 1995. 22 pp. plus attachments.

Hanson Environmental, Inc. 1993. Demonstration project to evaluate the effectiveness of an acoustic (underwater sound) behavioral barrier in guiding juvenile chinook salmon at Georgiana Slough: Results of 1993 Phase I field tests. Prepared for San Luis and Delta-Mendota Water Authority, State Water Contractors, California Department of Water Resources, and U.S. Bureau of Reclamation. December 1993. 24 pp. plus figures and appendices.

JWU. 1994. Biological explanation of the Joint Water Users proposed Bay-Delta standards. California Urban Water Agencies, San Luis and Delta-Mendota Water Authority, Kern County Water Agency, and Tulare Lake Basin Water Storage District. November 3, 1994.

McCann, R., D. Mitchell, and L. House. 1994. Impact of Bay-Delta water quality standards on California's electric utility costs. Prepared by M. Cubed for the Association of California Water Agencies. October 7, 1994. 15 pp.

MWD. 1992. Efforts to conserve, manage, reuse and obtain additional water supplies for Metropolitan Water District of Southern California service area. Submitted by the Metropolitan Water District of Southern California during proceedings for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Rights Phase. (WRINT-SWC-10)

MWD. 1993. Testimony of Timothy Huges Quinn, Director, SWP and Conservation District, the Metropolitan Water District of Southern California. Record of the Proceedings, D-1631. October 20, 1993.

Sanders, L., R. Walsh, and J. Loomis. 1990. Toward empirical estimation of the total value of protecting rivers. Water Resources Research 26(7):1345-1357.

SDCWA. 1992. Importance of State Project water to San Diego County water reclamation development. Submitted by the San Diego County Water Authority during proceedings for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Rights Phase. (WRINT-SDIEGO-3)

SWC. 1992a. Recommended elements of a management program for Bay/Delta fish populations. Prepared by C.H. Hanson. June 1992. 69 pp. (WRINT-SWC-1)

SWC. 1992b. Significant environmental impacts of reduced SWP deliveries to the Metropolitan Water District of Southern California service area. State Water Contractors. 11 pp. (WRINT-SWC-17)

SWC. 1992c. Economic impacts of the 1991 California drought on San Joaquin valley agriculture and related industries. Prepared by Northwest Economic Associates for State Water Contractors. 40 pp. (WRINT-SWC-60)

SWC. 1992d. Testimony and exhibits of Tulare Lake Basin water storage district concerning agricultural water use. Testimony by Joseph B. Summers. 7 pp.

SWC. 1992e. The ecological importance of urban vegetation. June 1992. 4 pp. (WRINT-SWC-15)

SWCC/BDRSWG. 1991. Water recycling 2000. California's plan for the future. Joint report prepared by the State Water Conservation Coalition Reclamation/Reuse Task Force and the Bay Delta Reclamation Sub-Work Group (chaired by the California Department of Water Resources). September 1991. 96 pp.

SWRCB. 1990. California municipal wastewater reclamation in 1987. State Water Resources Control Board. Office of Water Recycling. June 1990. 65 pp.

SWRCB. 1994. Memorandum from Marc Del Piero, Member of the State Water Resources Control Board, to Steve Kasower, Division of Local Assistance, California Department of Water Resources. June 1, 1994.

USFWS. 1992. Measures to improve the protection of chinook salmon in the Sacramento/San Joaquin River Delta. Expert testimony of U.S. Fish and Wildlife Service on chinook salmon technical information for State Water Resources Control Board water rights phase of the Bay/Delta Estuary Proceedings. July 1992. 61 pp. (WRINT-USFWS-7)

WACO. 1992a. Testimony of the Water Advisory Committee of Orange County. pp. 5-7. (WRINT-WACO-3)

WACO. 1992b. Policy statement concerning consideration by the State Water Resources Control Board of possible interim water rights actions. June/July 1992. Submitted by the Water Advisory Committee of Orange County during proceedings for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Rights Phase. (WRINT-WACO-2)

WACO/SAWPA. 1992. Joint opening statement of the Water Advisory Committee of Orange County and the Santa Ana Watershed Project Authority before the State Water Resources Control Board. June 22, 1992. Submitted during proceedings for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary Water Rights Phase. (WRINT-WACO-5)

WRAC. 1993. Future water recycling potential, '93 survey. WateReuse Association of California. July 1993.

CHAPTER IX. RECOMMENDED ACTIONS

The SWRCB intends to implement the objectives in the draft plan, to the extent feasible, through amendments to the water right permits of water right holders in the Central Valley. The SWRCB realizes, however, that some of the objectives cannot reasonably be achieved through water right permit changes exclusively and that the aquatic resource values of the Bay-Delta Estuary are dependent on many factors beyond the regulatory authority of the SWRCB, as described in Chapter V. Therefore, the SWRCB is making the following recommendations to other parties in order to ensure that all water quality objectives are achieved and the aquatic resources of the Bay-Delta Estuary are protected through a comprehensive, ecosystem-based approach.

The recommendations are divided into two categories: recommendations to achieve water quality objectives and recommendations to improve estuarine habitat.

A. RECOMMENDATIONS TO ACHIEVE WATER QUALITY OBJECTIVES

The four water quality objectives that will require action by other entities to ensure that they are met are: (1) San Joaquin river dissolved oxygen objective; (2) narrative objective for salmon protection; (3) narrative objective for brackish tidal marshes of Suisun Bay; and (4) southern Delta agricultural salinity objectives.

1. San Joaquin River Dissolved Oxygen Objective

Factors which contribute to low levels of dissolved oxygen in the lower San Joaquin River include: the Stockton Wastewater Treatment Plant; upstream sources of biochemical oxygen demand (BOD); the deepened Stockton ship channel; the commercial use of the dead-end portion of the ship channel; the enlarged turning basin at the Port of Stockton; and low river flows in the fall. Feasible measures to implement the dissolved oxygen objective in this plan include: (1) regulating the effluent discharged from the Stockton Wastewater Treatment Plant and other upstream discharges that contribute to the BOD load; (2) providing adequate flows in the San Joaquin River; and (3) installing barriers at locations (e.g., head of Old River) to increase flows in the river past Stockton. Wastewater discharges to the river are currently regulated by the Central Valley RWQCB. The RWQCB is requiring the City of Stockton to make improvements in its wastewater treatment plant to achieve reduced BOD loadings. This plan's objectives for flows in the San Joaquin River at Vernalis are expected to contribute to achieving the dissolved oxygen objective and additional flow-related measures will be considered by the SWRCB during the water rights proceeding. The DWR and the USBR are evaluating the effectiveness of a barrier at the head of Old River, as described more fully in section B.5 of this chapter.

2. Narrative Objective for Salmon Protection

It is uncertain whether implementation of the numeric objectives in this plan alone will result in achieving the narrative objective for salmon protection. Therefore, in addition to the timely completion of a water rights proceeding to implement river flow and operational requirements which will help protect salmon migration through the Bay-Delta Estuary, other measures may be necessary to achieve the objective of doubling the natural production of chinook salmon from average 1967-1991 levels. This narrative objective is consistent with the anadromous fish doubling goals of the CVPIA; thus, prompt and efficient actions taken to implement this CVPIA goal, in concert with other recommended actions in this plan, are important to achieving the narrative salmon protection objective. Monitoring results will be considered in the ongoing review to evaluate achievement of this objective and the development of numeric objectives to replace it.

3. Narrative Objective for Brackish Tidal Marshes of Suisun Bay

Implementation of the numeric objectives in this plan, particularly the Delta outflow objectives, will likely result in achieving the narrative objective for the brackish tidal marshes of Suisun Bay. However, because the extent of the effectiveness of the numeric objectives in providing water quality conditions necessary to achieve a brackish marsh throughout all elevations of tidal marsh bordering Suisun Bay is still uncertain, additional measures by other agencies are recommended under section B.14 of this chapter, including the formation of a Suisun Marsh Ecological Work Group. Among the actions indicated in section B.14, the work group will identify specific measures to implement the narrative objective and make recommendations to the SWRCB in the ongoing review to evaluate achievement of this objective and the development of numeric objectives to replace it.

4. Southern Delta Agricultural Salinity Objectives

The draft plan contains objectives for salinity levels in the southern Delta. Objectives to protect these beneficial uses previously have been implemented largely through releases of fresh water from New Melones Reservoir. The fresh water releases help compensate for diversions of fresh water that have left mainly salty return flows in the San Joaquin River. While fresh water releases should continue, they do not prevent salts from entering the river. Return flows and drainage from agricultural operations add salts to the San Joaquin River. Also, there has not been enough fresh water available in every year to meet the water quality objectives. Therefore, actions are needed to reduce the amounts of salts in the San Joaquin River during periods when higher levels of salt would violate the objectives.

The following measures have the potential to reduce the salt loads entering the river and to help meet the salinity objectives in the southern Delta. These measures, excluding out-of-valley disposal of salts, have been recommended by the San Joaquin Valley Drainage Program. The measures are described in the September 1990 report, titled "A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San

Joaquin Valley". An implementation program for these measures is described in a 1991 document, titled "A Strategy for Implementation of the Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley". Some of these measures currently are underway. The SWRCB recommends that the agencies that have agreed to implement the following activities move forward with their commitments.

a. Source Control. In the 1991 Bay-Delta Plan, the SWRCB asked the Central Valley RWQCB to develop and adopt a salt-load reduction program that would reduce annual salt loads discharged to the San Joaquin River by at least 10 percent. The Central Valley RWQCB has been working with agricultural water users to implement source control programs that reduce the discharge of salts to the San Joaquin River resulting from the application of irrigation water. Source control programs include farm-by-farm irrigation audits, technical assistance and consultation with growers, and land retirement as appropriate. However, to date this program has not resulted in the achievement of the objectives.

The failure to meet the water quality objectives is due, in part, to two factors. First, less water has been delivered to San Joaquin Valley irrigators in recent years, so the salts from return flows are more concentrated. The reduction in water deliveries is due both to drought conditions reducing the available water and to restrictions under the ESA on pumping water from the southern Delta export pumps. Second, the USBR, under the CVPIA, section 3406(d), increased its deliveries of water to wetlands in the San Joaquin Valley. In the past two years drainage from the wetlands increased the salt loading to the river by 20 percent, because the wetlands are low-lying areas that received salty runoff historically and can add substantial amounts of naturally occurring salts to water when they are flooded (Dennis Westcot, Central Valley RWQCB, pers. comm., November 2, 1994).

The SWRCB recommends that the Central Valley RWQCB continue its efforts to achieve additional source control of salts draining from agricultural land in the San Joaquin Valley. The U.S. Soil Conservation Service (SCS) and the DWR also will provide technical support. USBR, DWR, SCS, and SWRCB have committed to provide support for demonstration projects. The DFA will conduct research to help select irrigation methods and crops for water and salt management.

Land retirement with cessation of irrigation should be used as a source control measure in areas which either overlay shallow ground water with elevated levels of selenium, have soils that are difficult to drain, have low economic returns, or contribute disproportionately to drainage problems. Water Code section 14900 authorizes the DWR to purchase land suitable for retirement using funds obtained from selling the irrigation water supply of the retired lands. Additional activities related to land retirement include monitoring the hydrologic and social effects of discontinuing irrigation (DWR), technical assistance to facilitate land use changes (USBR), hydrologic analyses (USGS), assistance in evaluating land reserve/retirement options under the USDA conservation reserve program (SCS), and evaluation of the potential use of retired land for use as wildlife habitat (DFG and USFWS). If there are transfers of water or water rights which require SWRCB approval, the SWRCB will be involved. Under its water right authority, the SWRCB also could require cessation of water use on specific lands if it finds that use of water on these lands is unreasonable.

b. Drainage Reuse. Reuse of drainage water on progressively more salt-tolerant plants will reduce the volume of drainage water and concentrate the salts to facilitate disposal. Demonstration projects are underway to develop reuse technologies, and treatment and disposal technologies, for the remaining solids or liquids. The DWR is funding research on the impacts of reuse on wildlife; the DFG is conducting field studies of potential impacts on wildlife; the DFG and the USFWS should evaluate the potential impacts of agroforestry plantation on wildlife; the DFA and the SCS should continue testing and demonstration of agroforestry and the use of halophyte plants; the DFA should coordinate the demonstration projects and provide quality control; the SCS should assist farmers to plan, design, and manage drainage reuse programs; the USGS should provide technical assistance and analysis regarding ground water and effluent storage to effect reuse of drainage water.

c. Evaporation Systems. Evaporation ponds for storage and evaporation of drainage water after reuse on salt-tolerant plants accomplish the final segregation and containment of salts. Construction of evaporation ponds will require site specific planning and linkage with other actions, including reuse and treatment. Any evaporation system should include safeguards for wildlife.

The DWR and the USFWS should fund studies of impacts on wildlife; the DFG and the USFWS should conduct the studies; the DWR should support demonstration projects of evaporation pond design improvements; the DFG should continue to coordinate work with the Central Valley RWQCB, which is responsible for ensuring that ponds conform to the applicable water quality control plan; the USBR should fund demonstration projects for new or improved evaporation pond technologies; the SCS should work with farmers to develop and evaluate pond design and management criteria. The SWRCB recommends that the DWR, the USFWS, and the DFG include, as part of their programs, field testing and demonstration projects to avoid or minimize wildlife hazards.

d. Ground Water Management. In some places near-surface water tables can be lowered by pumping ground water from deep wells in a semi-confined aquifer. This can be an effective interim and possibly long-term measure for management of agricultural drainage problems where ground water in the root zone of crops creates problems requiring drainage. For the best results, this measure requires a planned, sustained, and coordinated approach in which the right volume of extraction takes place in the right location. Also, the extracted water should be suitable for irrigation or wildlife habitat. Several activities are planned. The planned activities include developing a monitoring program (DWR), detailed hydrologic analyses to implement demonstration projects to test ground water management (USGS); development and demonstration of on-farm high water table management (SCS), and the use of water transfers to encourage ground water management (USBR).

e. **Institutional Measures**. Several institutional measures could help reduce drainage problems. These include the use of tiered water pricing where advantageous, water marketing, improved scheduling of water deliveries, and formation of regional drainage management organizations. The DWR should encourage and support methods such as tiered water pricing and water marketing; the USBR should seek to initiate trial arrangements for funding drainage projects; the USFWS should draft and propose comprehensive legislation to authorize and fund the San Joaquin Valley Drainage Program's drainage management plan. The SWRCB will participate in a study of the use of an environmental recovery fund and price controls in water markets.

f. **Discharges to the San Joaquin River**. Controlled and limited discharges of agricultural drainage water to the San Joaquin River must occur in a manner that meets water quality objectives. This may be best accomplished by coordinating the release of drainage water with higher flows in the river during the winter and spring periods when more dilution water is available. Adequate coordination may require the execution of agreements with dischargers, waste discharge requirements that restrict the discharge of drainage water to the river, or time-specific waste discharge prohibitions. Furthermore, the actions of dischargers in isolating and transporting agricultural drainage water must contribute to the needs of fish and wildlife.

The agencies committed to implementing actions related to the drainage water discharge to the San Joaquin River should continue or initiate the activities identified by the San Joaquin Valley Drainage Program. These activities include: completion of the five-year interagency effort by the San Joaquin River Management Program (established and funded by the State Legislature, and led by the DWR) to develop a plan which includes management of agricultural drainage to the river; the DWR and the USBR real-time salt monitoring program for the river (with the cooperation of the Central Valley RWQCB); the USGS investigations of surface water and ground water interaction to evaluate the quantity, quality, and timing of ground water contributions to the river; the DFG and the USFWS monitoring of the effects of implementing discharge controls to the river on fish and wildlife; and the USBR planning for the San Luis Unit which could contribute substitute water supply and provide water control facilities needed to convey drainage water to the San Joaquin River downstream of the confluence with the Merced River. The SWRCB, with the support and cooperation of appropriate entities, is willing to investigate the concept of a discharger with high productivity soils purchasing another discharger's waste load allocation, once developed, in the San Joaquin River basin.

In addition to the planned measures identified by the San Joaquin Valley Drainage Program, these agencies and the affected water districts should consider taking advantage of winter flood flows to remove salts from low-lying areas in the San Joaquin Valley, either as part of a flood control program or pursuant to a permit from the SWRCB to appropriate water during high flow events. Also, the operators of wetlands receiving new water from the USBR under the CVPIA should participate in real-time management of their discharges to ensure that they do not cause violation of water quality objectives. If funding is needed for further work on salt discharge management, the Central Valley RWQCB could seek a grant under Clean Water Act section 319(h).

g. Out-of-Valley Disposal of Salts. Inadequate drainage, and accumulating salts and trace elements, are increasingly persistent problems in many parts of the San Joaquin Valley. These drainage problems threaten water quality, agriculture, fish and wildlife, and public health. Ultimately, it will be necessary for the in-basin management of salts to be supplemented by the disposal of salts outside of the San Joaquin Valley for protection of these beneficial uses to continue.

The USBR should reevaluate alternatives for completing a drain to discharge salts from agricultural drainage outside of the San Joaquin Valley and pursue appropriate permits. This evaluation should include the development of information on the potential effects on fish and wildlife habitat and populations in the receiving waters, and the physical and economic feasibility of the various alternatives.

B. RECOMMENDATIONS TO IMPROVE HABITAT CONDITIONS

The parties have recommended actions in addition to setting and implementing water quality objectives that the SWRCB or other agencies should take to protect the fish and wildlife uses of the Bay-Delta Estuary. The SWRCB intends to conduct proceedings to consider implementing measures discussed below that are within its jurisdiction. The SWRCB also recommends that other agencies and entities consider taking certain actions under their authorities. This section describes measures that the SWRCB believes should be considered and specifies the agencies that should take the actions.

The funding of these activities is expected to require a substantial financial commitment. Approximately 60 million dollars per year over the next three years should be allocated for this purpose. A portion of the funds needed for these activities will come from a prioritization of existing programs. Additional funds will be secured through a combination of federal and State appropriations, user fees, and other sources, as required. The water user community has agreed, through the December 15, 1994 "Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government", to make available, by February 15,1994, an initial financial commitment of $10 million annually for three years. An open process including water user groups, State and federal agencies, and environmental interests will determine priorities and financial commitments for the implementation of these activities. The SWRCB expects that the detailed process for prioritizing and funding these activities will be developed before March 31, 1995.

The recommendations discussed in this section, together with the objectives and the implementation measures to meet the objectives, are a part of a comprehensive plan of protection for the Bay-Delta Estuary's fish and wildlife resources. Because these measures will require the commitment of many agencies and entities, a comprehensive plan should be a multi-agency effort. The SWRCB is committed to investigating the measures within its authority and to conducting proceedings if it appears fruitful to do so, but the efforts of other agencies are also required.

1. Unscreened Water Diversions

Unscreened water diversions for agricultural, municipal, and industrial uses present a known threat to fish populations. Studies as early as the early and middle 1970's showed that large numbers of egg and larval striped bass and significant numbers of chinook salmon were entrained by agricultural diversions in the Sacramento River watershed. More recent studies confirm that large numbers of fish continue to be entrained.

More than 300 unscreened diversions on the Sacramento River between Redding and Sacramento divert approximately 1.2 MAF of water per year. In the Delta, about 1,800 unscreened agricultural diversions divert over 2 MAF of water per year according to the NMFS.

Diversions into conduits with a capacity in excess of 250 cfs must be screened if the DFG determines that a screen is necessary to prevent fish from passing into the conduit. (Fish & G. Code §5981) The DFG may install a screen on a conduit smaller than 250 cfs, and the owner of the conduit must allow the DFG the right of access to the conduit and screen. (Fish & G. Code §6024) Further, DFG can obtain injunctive relief against a diverter's operation of a diversion in a manner that results in the killing of endangered species. (Department of Fish and Game v. Anderson-Cottonwood Irr. Dist.(1992) 11 Cal.Rptr.2d 222, 8 Cal.App.4th 1554) Likewise, federal agencies enforcing the federal ESA can obtain an injunction prohibiting the take of an endangered species in the course of pumping water. (United States of America v. Glenn-Colusa Irrigation District (1992) 788 F.Supp. 1126)

Currently, the NMFS is considering a requirement for screens on Sacramento River diversions. The use of screens on water diversions that need screening would aid in the survival of salmon upstream of the Delta, and incidentally could increase the number of salmon passing through the Delta. Additionally, the need for screens in the Delta should be evaluated.

The SWRCB recommends that the NMFS continue its work in the Sacramento River and that the NMFS, the USFWS, and the DFG also institute a program to evaluate water diversions within the Delta. In the Sacramento and San Joaquin rivers and in the Delta, these agencies should assess whether (1) changes in the timing of diversions could be made to avoid peak concentrations of fish and (2) changes in management of water uses would be feasible to avoid entraining large numbers of fish. In evaluating the diversions, these agencies should (1) decide where screens are needed, (2) consider whether diversion points should be relocated or consolidated to reduce entrainment, and (3) give their recommendations on changes in points of diversion to the SWRCB for consideration in a water right proceeding. The SWRCB will provide available information to these agencies to facilitate their locating diversions and contacting diverters. The SWRCB may conduct inspections of diversion facilities in cases where the other agencies are unable to obtain access.

The program should include collection of data regarding the size and approach velocity of diversions and the proximity of fish to the diversions when they are operating. The agencies should develop (1) performance criteria for diversions by June 1996, (2) testing specifications to show whether or not diversions are having an unreasonable effect on fish by June 1996, (3) incentives by June 1996 to encourage diverters to consolidate and relocate diversions to the least environmentally sensitive locations, (4) a program by June 1997 for notifying diverters of requirements for their diversions and of a time schedule for completing the requirements, (5) requirements to install devices at the highest priority diversions by June 1999 and at selected lower priority diversions by June 2004, (6) a monitoring program to inspect the devices upon their installation and periodically thereafter.

2. Improve Fish Survival at the SWP and the CVP Export Facilities

Despite the presence of screens at the diversion facilities of the SWP and the CVP, substantial fish mortality occurs with operation of the facilities. At the SWP facilities, the water and fish first enter the Clifton Court Forebay. There, predatory fish consume many of the smaller fish. Next, the water is drawn into the pumps through fish screens. Fish are salvaged from the screens, trucked to another location in the Delta, and released. Many fish do not survive the salvage operation. When the fish are released, they are again subject to predation as they regain their orientation in the water. The CVP does not use a forebay, but predatory fish nevertheless consume smaller fish near the intake. The screens at the CVP diversion should be updated and improved to ensure that fewer fish are entrained. Better fish survival at the export facilities could make it feasible to increase the maximum export rates and reduce outflow requirements, allowing a greater volume of exports than will be possible under this plan.

The SWRCB recommends that the DWR and the USBR in consultation with the DFG, the USFWS, and the NMFS implement all feasible measures and programs to reduce the mortality of fish salvaged at the facilities, including improvements in the screening efficiency at the export facilities, improved fish salvage and handling, changes in facility operations, and predator management programs at both the SWP and the CVP intakes to reduce predation losses. With respect to the entrainment of fish, the SWRCB recommends that the DWR and the USBR develop programs to (1) monitor entrainment on a real-time basis to identify periods of peak susceptibility of various species to entrainment and (2) coordinate operations of the two diversions to reduce the combined losses at the two facilities. The SWRCB will consider requiring implementation of these measures and programs in a water right proceeding that will follow adoption of this plan.

3. Regulation of Fishing

Current levels of legal sport fishing and commercial fish harvests may be contributing to reduced fish populations. Therefore, the effects of sport fishing and commercial harvest should be reviewed and appropriate measures should be taken to ensure that genetic pools are maintained.

The SWRCB recommends that the DFG, the Fish and Game Commission, the Pacific Fisheries Management Council, and the NMFS take the following actions within their respective authorities and jointly:

(a) Develop and implement a fisheries management program to provide short-term protection for aquatic species of concern through seasonal and area closures, gear restrictions to reduce capture and mortality of sub-legal fish, and other appropriate means.

(b) Review and modify if necessary existing harvest regulations to ensure that they adequately protect aquatic species. The agencies should consider implementing a regular periodic review of these regulations at least every two years.

(c) Seek changes in trawling methods used by the commercial shrimp industry to reduce the incidental take of other fish species. The changes could be effected either through an agreement with the industry or through regulations.

4. Illegal Fishing

Annually, about 500,000 undersized striped bass and an uncounted number of salmon are taken illegally. The DFG has estimated that sport fishing regulations have been violated at a rate in excess of 65% in the Delta. In 1992, the DFG and the DWR agreed to a three-year program to increase enforcement efforts and deter illegal take of Delta fishery resources. Their goal is to reduce violations by 20% in the Delta.

The SWRCB recommends that the DWR and the DFG continue the enforcement program and expand it to provide more enforcement. Sources of additional funding should be explored. Additionally, the DFG should explore the feasibility of developing and implementing an educational program to curb poaching of fishery resources, and should implement such a program if feasible.

5. The Use of Barriers in the Delta

The USBR maintains a gate at the entrance of the Delta Cross Channel, and opens and closes the gate to meet standards adopted by both the SWRCB and other agencies. The gate's operation affects export rates, entrainment rates of fish at the export pumps, flooding in the central Delta, and water quality in the central Delta. Based on tests conducted in the past few years, the use of additional gates or barriers in some Delta channels shows promise for helping to improve the survival of certain fish species, especially migrating salmon and steelhead. Some reservations have been expressed, however, as to the effect of the barriers on Delta smelt and on water quality in the central Delta. Apparently further study and testing is needed before it can be finally determined that barriers should be used, so this plan does not include an objective for the installation and operation of barriers. Therefore, the SWRCB recommends that the DWR and the USBR, in consultation with the DFG, the USFWS, and the NMFS, (1) test the use of barriers at the head of Old River and at other strategic locations within the lower San Joaquin River and Delta as a means of improving survival of migrating chinook salmon and steelhead and (2) evaluate the advisability of closing Georgiana Slough by using either a physical barrier or an acoustical barrier. The tests should also determine whether the barriers will have adverse effects on other species, including Delta smelt. If the barriers are effective and will neither harm the Delta smelt nor have other significant adverse effects on the environment, the DWR and the USBR should consider using them.

If the use of barriers changes the location or method of meeting a water quality objective, the DWR or the USBR could request a change in this water quality control plan. With adequate documentation, such a request could be processed at a triennial review of this plan, or sooner if necessary.

6. Control the Introduction of Exotic Species

Numerous fish and invertebrate species have been intentionally and accidentally introduced into the Bay-Delta Estuary. Accidental introductions of species have occurred primarily through the discharge of ballast waters from international shipping traffic. The introduction of exotic species apparently has caused major changes in the composition of aquatic resources in the Bay-Delta Estuary.

The impacts of introduced species relative to other factors in the decline of Bay-Delta fish populations is not clear. Therefore, a program should be developed to gather, compile, and analyze information on the biological needs of the introduced species and their interrelationships with native species. With this information, responsible agencies can decide whether they could substantially benefit native fisheries by putting resources into control or eradication measures.

Measures should be taken to limit the accidental future introduction of non-indigenous species. The federal Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990, at 16 U.S.C. §§4701 to 4751, includes comprehensive provisions for regulating the introduction of non-indigenous species, including: (1) regulating the discharge of ballast water from ships; (2) establishing of a task force, chaired by the Director of the USFWS and the Under Secretary of Commerce for Oceans and Atmosphere, which is to implement a program to prevent the introduction and dispersal of aquatic nuisance species, to monitor, control and study such species, and to disseminate related information; and (3) technical and financial assistance to eliminate the environmental, public health, and safety risks associated with aquatic nuisance species.

In 1992, the California Legislature enacted Fish and Game Code sections 6430-6439. These sections: (1) declare that the State's fishery resources are threatened by the introduction of non-indigenous aquatic organisms and that ballast water is a possible source of disease-causing bacteria and viruses; (2) provide for the DFG's adoption of State policy regarding the discharge of ballast water and sediment; and (3) require the use of a ballast water control report form to monitor compliance with State policy.

The SWRCB recommends that the DFG, the USFWS, and the NMFS pursue programs to determine the impacts of introduced species on Bay-Delta fisheries and the potential benefits of control measures. These agencies should consider information and analysis provided by other public and private entities who have an interest in finding ways to preserve and enhance native species in the Bay-Delta. These agencies should determine where ballast water can be released without posing a threat of infestation or spread of aquatic nuisance species and should limit the release of ballast water to those areas. If new laws are needed, these agencies should draft and propose legislation.

The DFG also should consider preparing a comprehensive management plan as described in the federal law, to obtain federal assistance in dealing with the introduced species. Additionally, the California Fish and Game Commission should deny all requests for introduction of new aquatic species into the watershed of the Bay-Delta Estuary unless it finds, based on strong, reliable evidence, that an introduction will not have deleterious effects on indigenous species.

7. Improve Hatchery Programs for Species of Concern

It is important that the genetic variability of wild fish stocks be retained. Because hatchery fish share a limited gene pool, reliance solely on hatcheries to maintain populations of a given species could result in extinction or loss of vigor.

Hatchery production of various fish species that use the Delta is important for mitigating the loss of stream spawning and rearing habitat and to provide short-term support for various species until other programs to improve fish survival within the watershed of the Bay-Delta are implemented. Hatcheries appear particularly important to rebuild depleted stocks and to maintain populations during dry and critically dry years. Hatchery production should complement and not substitute for improvements in natural production and survival of fish species. Hatchery management practices should take into account the need for genetic diversity, the maintenance of the integrity of different runs of salmon, diet and pre-release conditioning, the locations where the fish will be released, and other factors affecting survival.

The Coleman National Fish Hatchery, operated by the USFWS on Battle Creek tributary to the Sacramento River, requires substantial maintenance and repair and should be extensively rehabilitated. The hatchery is an important factor in maintaining the fall-run chinook salmon and steelhead populations, and also has been used experimentally in recent years to propagate winter-run chinook salmon. Additional hatchery capacity is needed for winter-run and spring-run chinook salmon and other salmonids. A hatchery has been proposed for this purpose on the Sacramento River adjacent to Keswick Dam. A hatchery also is needed in the San Joaquin River drainage to replace losses of salmon and steelhead. These fisheries have suffered substantial declines in the San Joaquin drainage, probably due to instream flow conditions, habitat quality, entrainment at water diversions, operation of reservoirs, and elevated temperatures during spawning, egg incubation, rearing and emigration. These adverse conditions require improvement, and measures that can be expected to improve these conditions are discussed elsewhere in this plan. A hatchery should be designed and managed to rebuild the salmon and steelhead stocks to complement other measures that will improve the habitat conditions in the San Joaquin River drainage.

The SWRCB recommends that the DFG, the NMFS, and the USFWS carefully examine and periodically reexamine the role and contribution of hatchery production for various fish species including chinook salmon, steelhead, striped bass, and other fish species including experimental hatchery programs for Delta smelt. The SWRCB also recommends that these agencies evaluate strategies for improving the survival of hatchery fish, both before and after release, including timing releases relative to the presence or absence of other species, the use of multiple release points, and the size and life stage of fish to be released. The SWRCB also recommends that these agencies, together with the USBR, take steps to rehabilitate the Coleman Fish Hatchery and to construct both the Keswick Hatchery and a hatchery in the San Joaquin River watershed.

8. Minimize Losses of Salmon and Steelhead Due to Flow Fluctuations

Because of the construction of dams on most of the rivers tributary to the Delta, releases of water from the dams can influence the locations where salmon and steelhead spawn. Higher flows in the reaches below a dam can lead to spawning at locations in the riverbed that may be dewatered by later downward fluctuations before the eggs hatch. Reductions in flow can strand fry in side channels and shallow backwaters that are isolated from the main river channel. While short-term increases in flow from storms often cannot be avoided, flow fluctuations because of scheduled releases can be managed to reduce adverse impacts on downstream fisheries.

The SWRCB recommends that the DFG, the USFWS, and the NMFS evaluate the releases from the impoundments upstream of the Delta and make recommendations where appropriate for changes in the operations of those impoundments to minimize adverse fishery impacts caused by flow fluctuations. These agencies should consider factors that include the allowable size of flow reductions, appropriate ramping rates for increasing or decreasing flows, and flood control operations. Where appropriate, these agencies should seek agreements from the dam operators or make recommendations to the SWRCB for necessary changes in the water rights of these facilities.

9. Expand the Gravel Replacement and Maintenance Programs Downstream from Dams in the Tributaries to the Delta

The construction of dams on the major tributaries of the Delta blocks the movement of gravel eroding from upstream areas. Salmonids spawn in gravel in the river beds. The lack of suitable spawning habitat can limit the success of salmonid reproduction. Programs exist to replace gravels and improve the spawning habitat on some rivers. The programs for the Sacramento and San Joaquin river systems should be expanded.

The SWRCB recommends that the DWR, the USBR, and other agencies that currently conduct gravel replacement and spawning habitat improvement programs on the Sacramento and San Joaquin river systems increase their efforts in the reaches where salmonids are likely to spawn.

10. Evaluate the Benefits and Costs Associated with Alternative Water Conveyance and Storage Facilities Including Changes in the Points of Diversion of the SWP and the CVP in the Delta

The current water diversion facilities of the CVP and the SWP in the southern Delta adversely impact fish populations. These facilities or alternative facilities are needed to meet water supply demands in areas south and west of the Delta. Various alternatives have been identified to minimize fisheries impacts while meeting water supply demands. The proposed alternatives include construction of a water diversion intake on the Sacramento River equipped with state-of-the-art fish screens, isolated and through-Delta water conveyance facilities, and new water storage within and south of the Delta. The feasibility, biological impacts and benefits, and likely operational criteria for each of these alternatives should be evaluated.

Consistent with the Framework Agreement regarding a long-term Bay-Delta Estuary solution, the agreement's signatory agencies should: (1) evaluate the feasibility, biological impacts and benefits, and likely operational criteria of various alternatives to the current water diversion facilities in the southern Delta; and (2) based on the evaluation, develop a project that will meet the dual goals of minimizing impacts to aquatic resources while providing a reasonable supply of water for export.

11. Develop an Experimental Study Program to Study the Effects of Pulse Flows on Fish Eggs and Larvae

The magnitude of freshwater outflow passing through the Delta affects the geographic distribution of many planktonic fish eggs and larvae. The egg and larval stages of many fish species occur in the Delta during a relatively short period of time in the spring (April - June). When there is high freshwater outflow, the planktonic eggs and larvae are moved downstream into Suisun Bay where they are less susceptible to entrainment at the SWP and the CVP diversions and at other diversion points within the Delta. Absent high outflows, the larvae tend to remain in the Delta.

Short-term artificial increases in freshwater flows (pulse flows) can be used to move the eggs and larvae into Suisun Bay. To improve the efficiency of water used for this purpose, it would be helpful to experimentally quantify the magnitude and duration of pulse flows needed to move a substantial proportion of fish eggs and larvae into Suisun Bay. Any experiment also should determine whether short-term pulse flows have a lasting benefit or whether, when outflows are reduced after a pulse flow, the larval fish are drawn back into interior Delta areas.

The SWRCB recommends that the DWR and the USBR conduct experiments to investigate and evaluate the biological benefits of pulse flows to move planktonic fish eggs and larvae into Suisun Bay. Flows should be released from both the Sacramento and San Joaquin rivers, and real-time biological monitoring should be used to determine the most favorable times for the pulse flows and the effects of the pulse flows on the eggs and larvae. These experiments should be conducted as soon as feasible, taking into account base flows and availability of water supplies. If results were obtained soon enough, they could be used to refine potential pulse flow requirements in a water right decision implementing this water quality control plan.

12. Habitat Restoration

Most of the historical fish and wildlife habitat in the Delta and throughout the Central Valley has been eliminated or disturbed. The construction of dams for water storage on nearly all of the Bay-Delta Estuary's tributary streams and the conversion of natural habitat to croplands eliminated significant amounts of habitat for species in the Central Valley. In the Delta, less than 100,000 acres of the total 738,000 acres remains as marsh, riparian, and upland habitat. The remainder of the area is highly altered due to conversion to agricultural land, industrial and urban development, and actions for flood control and navigation, such as dredging channels and riprapping banks. Furthermore, many of the alterations that have already occurred require extensive ongoing maintenance, which also disrupts fish and wildlife habitat. Restoration of fish and wildlife habitat in and upstream of the Delta would benefit many species of the Bay-Delta Estuary.

State and federal agencies should require, to the extent of their authority, habitat restoration in the Delta and upstream of the Delta as a condition of approving projects. For example, the Delta Protection Commission, in all of its actions under the Delta Protection Act of 1992 (Public Resources Code section 29700 et seq.) which provides for the coordination of local land use decisions in the Delta, should consider the need to restore and preserve marsh, riparian, and upland habitat in the Delta. The DFG, when it considers approving stream alterations, and the DFG, USFWS, and NMFS, when they consider projects that affect endangered species, should consider habitat requirements. The U.S. Army Corps of Engineers should consider habitat requirements in connection with applications for permits under Clean Water Act section 404. The Federal Emergency Management Agency should consider habitat requirements in establishing flood insurance requirements and levee standards. Within their authorities, these agencies should provide for: (1) levee setback requirements; (2) improvements in the productivity of aquatic areas throughout the Central Valley; (3) reductions in the depth of selected Delta channels, by using either dredge material from navigational channels or natural infill, to restore more productive shallows and shoals; (4) conversion of low-lying Delta islands to habitat areas; and (5) other habitat enhancement measures. The SWRCB will consider habitat requirements where needed to meet water quality standards under the Clean Water Act when approving section 401 certifications. Additionally, responsible governmental agencies and private parties should institute programs to increase riverine cover in the Bay-Delta Estuary watershed, if demonstrated to be effective in lowering water temperatures by providing shading.

13. Temperature Control

Water temperature is a key factor influencing spawning, egg incubation, and juvenile rearing of chinook salmon and steelhead throughout the rivers of the Central Valley. Seasonal changes in ambient air temperature, the temperature of water released from rim reservoirs, and agricultural drainage return flows are the most important factors influencing temperature within the spawning and rearing areas of chinook salmon and steelhead.

Vertical stratification in water temperatures within rim reservoirs offers the opportunity for releases of relatively cold water during the late spring, summer and fall when water temperatures may otherwise be elevated to levels that are detrimental to growth and survival of various life stages of both chinook salmon and steelhead. A proposal for construction of a temperature curtain at Shasta Reservoir has been made, which would permit the selective withdrawal of water from various locations within the water column while continuing to generate hydroelectric power. The SWRCB recommends that the USBR completes this project as soon as possible. The SWRCB further recommends that the operators of other rim reservoirs evaluate the temperature impact of their operations and take actions to correct any significant, negative temperature effects. The SWRCB will consider incorporating appropriate temperature standards into the water right permits of rim reservoir operators, as a means of making the most efficient use of the available water supply.

The Central Valley RWQCB should evaluate best management practices that could be implemented to reduce the impact of agricultural drainage return flows on the temperature of Central Valley rivers.

14. Suisun Marsh Improvements

The objectives for Suisun Marsh regulate salinity in the channels. The purpose of these objectives is to make irrigation water available for the managed wetlands in Suisun Marsh that will bring soil salinity into the range capable of supporting the plants characteristic of a brackish marsh. Four entities, the DWR, the USBR, the DFG, and the SRCD, negotiated and signed the SMPA, which proposes changes in the salinity objectives for Suisun Marsh in certain dry years. The SMPA objectives, like the objectives adopted in 1978, would regulate channel water salinity. The soil water salinity is not directly regulated, and depends upon the irrigation practices used by the various property owners of the managed wetlands in the Suisun Marsh. To provide more consistent protection for the managed wetlands in Suisun Marsh and the species these wetlands support, management practices should be used that will promote adequate soil salinity levels. With more uniform water distribution, it may be possible to protect the beneficial uses of water more efficiently than under current practices.

The DWR, the USBR, the DFG, and the SRCD should: (1) continue the actions, including facility plans, identified for implementation of the SMPA; (2) conduct a study to determine the relationship between channel water salinity and soil water salinity under alternative management practices (including an assessment of whether the current channel water salinity objectives are needed to support the beneficial uses and whether different water quality objectives, including soil water salinity objectives, would provide equivalent or better protection for the beneficial uses if favorable management practices also are used); and (3) employ, together with the property owners in the Suisun Marsh, a watermaster to direct the timing and amounts of water diverted in the Marsh to ensure that the water is used efficiently and the protection of beneficial uses is maximized. Additionally, pursuant to Public Resources Code section 9962, the SRCD should oversee and enforce water management plans for achieving water quality objectives for salinity in the Suisun Marsh. If possible, the watermaster should be employed under the provisions of Part 4, Division 2 of the Water Code (Wat. C. §§4000-4407), under which the parties could negotiate an agreement that includes the property owners in the Marsh. The agreement should determine the rights to the use of water from the channels of the Suisun Marsh among the various claimants, and should specify rules for managing the water in the marsh to maximize the salinity control benefits of the water. To be valid, the agreement would have to be recorded in the office of the county recorder for Solano County, in which the Suisun Marsh is situated. Alternatively or conjunctively, the parties to the SMPA and the San Francisco Bay Conservation and Development Commission should establish a Suisun Marsh water master to help implement water management plans on private seasonal wetlands (i.e., managed diked wetlands).

Additionally, the DWR should convene a Suisun Marsh Ecological Work Group, consisting of representatives of the SWRCB, San Francisco Bay RWQCB, DWR, DFG, USBR, USEPA, USFWS, NMFS, USEPA, National Biological Survey, San Francisco Bay Conservation and Development Commission, SRCD, Ducks Unlimited, California Waterfowl Association, National Audubon Society, California Native Plant Society, and other interested parties. Topics that the Ecological Work Group should consider include: (1) evaluate the beneficial uses and water quality objectives for the Suisun Bay and Suisun Marsh ecosystem; (2) assess the effects on Suisun Bay and Suisun Marsh of the water quality objectives in this plan and the federal Endangered Species Act biological opinions; (3) identify specific measures to implement the narrative objective for tidal brackish marshes of Suisun Bay and make recommendations to the SWRCB regarding achievement of the objective and development of numeric objectives to replace it; (4) identify and analyze specific public interest values and water quality needs to preserve and protect the Suisun Bay/Suisun Marsh ecosystem; (5) identify studies to be conducted that will help determine the types of actions necessary to protect the Suisun Bay area, including Suisun Marsh; (6) perform studies to evaluate the effect of deep water channel dredging on Suisun Marsh channel water salinity; (7) perform studies to evaluate the impacts of urbanization in the Suisun Marsh on the Marsh ecosystem; and (8) develop a sliding scale between the normal and deficiency objectives for the western Suisun Marsh.

In evaluating, and in developing numeric objectives for, the narrative objective for the tidal marshes of Suisun Bay, the work group should consider the habitat value of these wetlands, including their importance as reproductive habitat for fish and other organisms. In addition, the work group should consider not only species listed under the federal ESA (such as the salt marsh harvest mouse and the California clapper rail), but also other species that are vulnerable to increasing salinity in the tidal marshes contiguous with Suisun Bay. These species include candidate species (Mason's lilaeopsis, delta tule pea, Suisun Slough thistle, Suisun aster, soft-haired bird's beak, Suisun song sparrow, California black rail, tri-colored blackbird, saltmarsh common yellowthroat, Suisun ornate shrew, and southwestern pond turtle) and other vulnerable species (tules, bulrush, river otter, beaver, nesting snowy egret, nesting black-crowned night heron, marsh wren, American bittern, Virginia rail, sora, common moorhen, and ducklings of breeding ducks such as mallard, gadwall, and cinnamon teal).

CHAPTER X. MITIGATION AND UNAVOIDABLE SIGNIFICANT IMPACTS

This water quality control plan will be implemented primarily through the adoption of a water right decision and to a lesser extent through the actions of other agencies. Because implementation actions will not be fully formulated and established in this plan, the SWRCB cannot mitigate for the potential significant impacts of this plan through regulatory actions incorporated into the plan. Such regulatory actions must wait until the plan is implemented through a water right decision. It is possible, however, to discuss some of the options available to the SWRCB to mitigate the potential adverse impacts of this decision, including policy recommendations to other agencies.

The SWRCB has developed the standards and recommendations in this preferred alternative by balancing all of the uses of water in the Estuary, thereby minimizing the adverse impacts on any one beneficial use. This plan increases the protection provided to fish and wildlife uses of the Estuary while maintaining existing water quality protections for other uses of water in the Estuary. Therefore, there are no significant adverse environmental impacts in the Estuary due to this plan. However, the higher level of protection for the fish and wildlife beneficial uses of water from the Estuary will result in decreased water availability in export areas and changes in reservoir levels and river flows in upstream areas. Consequently, mitigation measures likely to be implemented by other agencies will focus on actions that encourage the efficient use of available water supplies through conservation, conjunctive use, reclamation, mitigation funding, water transfers, combined points of diversion, offstream storage projects, the South Delta Program, purchase of Delta Islands, and the long-term Delta solution. The following sections discuss these measures.

A. CONSERVATION

The history and the measures associated with urban and agricultural water conservation are different. Therefore, urban and agricultural water conservation are discussed separately.

1. Urban Water Conservation

In 1988, during the Bay-Delta Proceedings, interested parties gave the SWRCB widely divergent estimates of water conservation potential in California. To resolve these differences, urban water agencies, environmental groups, and State agencies actively participated in a three-year effort which culminated in the publication of a Memorandum of Understanding Regarding Urban Water Conservation in California. This memorandum identified 16 Best Management Practices (BMPs) for urban water conservation; it committed the signatories to implementing the BMPs; and it established the California Urban Water Conservation Council to both oversee implementation of the existing BMPs and evaluate new BMPs. Over 100 water agencies, plus over 50 public advocacy groups and other interested parties, have signed the memorandum. A summary description of the 16 BMPs is provided below. A more detailed description can be found in the memorandum.

1. Interior and Exterior Water Audits and Incentive Programs for Single Family Residential, Multi-Family Residential and Governmental/Institutional Customers

2. New and Retrofit Plumbing

3. Distribution System Water Audits, Leak Detection and Repair

4. Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections

5. Large Landscape Water Audits and Incentives

6. Landscape Water Conservation Requirements for New and Existing Commercial, Industrial, Institutional, Governmental, and Multi-Family Developments

7. Public Information

8. School Education

9. Commercial and Industrial Water Conservation

10. New Commercial and Industrial Water Use Review

11. Conservation Pricing

12. Landscape Water Conservation for New and Existing Single Family Homes

13. Water Waste Prohibition

14. Water Conservation Coordinator

15. Financial Incentives

16. Ultra-Low Flush Toilet Replacement Programs

Water conservation will play a significant role in managing California's urban water needs. The widespread acceptance of urban BMPs in California ensures that their implementation will be the industry standard for water conservation programs. However, the SWRCB recognizes that, as water use continues to become more efficient, agencies will lose flexibility in dealing with shortages.

Recommendation. The SWRCB recommends that all urban users of water originating in the Bay-Delta watershed sign the Memorandum of Understanding Regarding Urban Water Conservation in California. In addition, the DWR, in cooperation with the California Urban Water Conservation Council, should continue to identify additional BMPs that can reduce urban water use.

2. Agricultural Water Conservation

There are three principal pieces of legislation that encourage agricultural water conservation: the California Agricultural Water Management Planning Act of 1986 (Stats. 1986, C. 954, Water Code §10800 et seq.), the federal Reclamation Reform Act of 1982, and the Agricultural Water Suppliers Efficient Water Management Practices (EWMPs) Act (Stats. 1990, C. 739, Water Code §10900 et seq.). This legislation is discussed below.

The California Agricultural Water Management Practices Act requires all agricultural water suppliers delivering over 50 TAF of water per year to prepare an Information Report and identify whether the district has a significant opportunity to conserve water or reduce the quantity of saline or toxic drainage water through improved irrigation water management. The legislation affected the 80 largest agricultural water purveyors in California. The districts that have a significant opportunity to conserve water or reduce drainage are required to prepare Water Management Plans.

The Reclamation Reform Act of 1982 requires federal water contractors to prepare Water Conservation Plans. In California, the USBR's Mid-Pacific Region developed a set of Guidelines to Prepare Water Conservation Plans and required all federal water contractors serving over 2,000 acres to submit water conservation plans. The CVPIA required the USBR's Mid-Pacific Region to revise its existing guidelines for reviewing conservation plans to include, but not be limited to, BMPs and Efficient Water Management Practices (EWMPs) developed in California.

The EWMPs Act charged the DWR to establish an advisory committee consisting of members of the agricultural community, University of California, DFG, environmental and public interest groups, and other interested parties to develop a list of EWMPs for agricultural water users. Approximately 22 practices are under consideration. The University of California at Davis surveyed 23 of the 79 agricultural water agencies affected by the act to assess what practices similar to EWMPs are currently in place. The results of that survey are displayed in the table below.

Table X-1. Summary of current efficient water management practices.

	Practice	Currently in Place (%)
	Irrigation Management	
1.	Improve water measurement and accounting	70
2.	Conduct irrigation efficiency studies	43
3.	Provide farmers with "normal-year" and "real time" irrigation, scheduling and crop evapotranspiration ET information	52
4.	Monitor surface water qualities and quantities	52 & 100 respectively
5.	Monitor soil moisture	13
6.	Promote efficient pre-irrigation techniques	17
7.	Monitor soil salinity	26
8.	Provide on-farm irrigation system evaluations	35
9.	Monitor quantity and quality of drainage waters	39 & 52 respectively
10.	Monitor ground water elevations and qualities	83 & 42 respectively
11.	Evaluate and improve water user pump efficiencies	39
12.	Designate a water conservation coordinator	48
	Physical Improvement	
13.	Improve the condition and type of flow measuring devices	61
14.	Automate canal structures	35
15.	Line or pipe ditches and canals	22
16.	Modify distribution facilities to increase the flexibility of water deliveries	43
17.	Construct or line regulatory reservoirs	26
18.	Construct District tailwater reuse systems	39
19.	Develop recharge basins	35
20.	Improve on-farm irrigation and drainage systems	43
21.	Evaluate efficiencies of District pumps	57
22.	Provide educational seminars	57
	Institutional Adjustments	
23.	Improve communication and cooperative work among district, farmers, and other agencies	65
24.	Change the water fee structure in order to provide incentives for more efficient use of water and drainage reduction	43
25.	Increase flexibility in water ordering and delivery	65
26.	Conduct public information programs	48
27.	Facilitate financing capital improvements for District and on-farm irrigation systems	43
28.	Increase conjunctive use of ground water and surface water	22
29.	Facilitate, where appropriate, alternative land uses	4

The Advisory Committee on the Efficient Water Management Practices Act is working to develop a process for agricultural water management plans for implementation of EWMPs within the framework of rights and duties imposed by existing law. Water management plans will identify water conservation opportunities and set a schedule for implementation. It is difficult to assess the impact of EWMPs at the present time. Calculation of water savings resulting from implementation of EWMPs will require a detailed planning process by each individual district, including analysis of technical feasibility, social and district economic criteria, and legal feasibility of each practice.

In addition to the legislative programs discussed above, agricultural water conservation is also encouraged through the San Joaquin Valley Drainage Program (SJVDP), which was established as a joint Federal and State effort in 1984. The SJVDP published its recommended plan in September 1990 (SJVDP 1990). The recommended plan should guide management of the agricultural drainage problem, and one of the major elements of the plan is increased conservation efforts. In December 1991, eight State and Federal agencies, including the SWRCB, signed a Memorandum of Understanding to coordinate activities implementing the plan.

Recommendation. The SWRCB recommends that all agricultural water users receiving water from the Bay-Delta watershed implement water conservation measures to the maximum extent practicable. Reasonable conservation measures have been formulated under the Efficient Water Management Practices Act, and reasonable conservation goals in the San Joaquin Valley can be found in the SJVDP report. Implementation of this recommendation is not intended to take precedence over implementation of conjunctive use programs, as described in the next section.

B. GROUND WATER MANAGEMENT

Ground water basin management is defined as: protection of natural recharge and use of intentional recharge; planned variation in amount and location of extraction over time; use of ground water storage conjunctively with surface water from local and imported sources; and, protection and planned maintenance of ground water quality (DWR 1994). Because ground water will be used to replace much of the shortfall in surface water supplies, limitations on Delta exports will exacerbate ground water overdraft in regions receiving a portion of their supplies from the Delta. Effective ground water management can minimize overdraft problems and provide sustainable water supplies.

Management of ground water in California has generally been considered a local responsibility. This view is strongly held by landowners and has been upheld by the Legislature which has enacted a number of statutes establishing local ground water agencies. State agencies have encouraged local agencies to develop effective ground water management programs to maximize their overall water supply and to avoid lengthy and expensive lawsuits resulting in adjudicated basins.

The Water Code provides some limited authority to deal with ground water through a number of types of local water agencies and districts, formed either by general or special legislation. Thirteen ground water basins have been adjudicated and are operated in accordance with court settlements, eight ground water management agencies have been authorized by the State Legislature, and three water districts have special authority from the Legislature to levy a pump tax. A fourteenth watershed has been adjudicated in federal court, but water users are not limited in their ground water extraction (DWR 1994). In 1992, the Water Code was amended (Water Code section 10750, et seq.) to provide authority and define procedures to allow certain local agencies to produce and implement a ground water management plan. To date, more than 30 local agencies have expressed interest in using this part of the Water Code to adopt a ground water management program. A number of those agencies have adopted resolutions of intent in accordance with Water Code section 10750 to adopt a ground water management plan. The Legislature has also enacted several specific statutes establishing ground water management agencies that can regulate the amount of ground water that is extracted and limit its place of use within the district's boundaries. Eight ground water management agencies have been formed by such special legislation (DWR 1994).

Conjunctive use is an essential element of ground water management. Conjunctive use programs are designed to increase the total useable water supply by jointly managing surface and ground water supplies as a single source. The basin is recharged, both directly and indirectly, in years of above average precipitation so that ground water can be extracted in years of below average precipitation when surface water supplies are below normal. There are some instances, however, where conjunctive use is employed for annual regulation of supplies. These programs involve recharge with surface water or reclaimed water supplies and same-year extraction for use. An example of a large scale conjunctive use program is the Kern Water Bank which could be developed to store as much as one MAF and contribute as much as 140 TAF per year to the SWP in drought years (DWR 1994).

In the future, conjunctive use projects are expected to increase and become more comprehensive because of the need for more water and the higher cost of new surface water facilities. Conjunctive use programs generally promise to be less costly than new traditional surface water projects because they increase the efficiency of water supply systems and cause fewer negative environmental impacts than new surface water reservoirs (DWR 1994).

Recommendation. The SWRCB recommends that all water supply agencies receiving water from the Delta establish aggressive groundwater management programs at the local and regional levels. The programs should be focused on solutions to clearly identified problems, such as overdraft or seasonal availability of surface water supplies, so as to optimize the use of surface and ground water resources.

Local agencies should adopt programs for ground water management with the following goals:

- Identify and protect major natural recharge areas. Develop managed recharge programs where feasible.

- Optimize use of ground water storage conjunctively with surface water from local, including recycled water, and imported sources. Local agencies should manage conjunctive use programs to maximize use of ground water during dry periods and recharge the ground water during wet periods.

- Monitor ground water quality and make public information available on areas where constituents exceed allowable limits and on trends in the chemical contents of ground water.

- Develop ground water basin management plans that not only manage supply, but also address overdraft, increasing salinity, chemical contamination, and subsidence

C. WATER TRANSFERS

Currently, water transfers are the most promising way of closing the gap between water demands and dependable water supplies over the next ten years. There are fewer environmental impacts associated with transfers than with construction of conventional projects, and although difficult to implement, transfers can be implemented more quickly and usually at less cost than construction of additional facilities. Unfortunately, water transfers are not available on a statewide basis because some regions of the State are physically isolated from water conveyance facilities.

Under existing law, holders of both pre-1914 and modern appropriative water rights can transfer water. Holders of pre-1914 appropriative rights may transfer water without seeking approval of the SWRCB, provided others are not injured. Holders of modern appropriative rights may transfer water, but the SWRCB must approve any transfer requiring a change in terms and conditions of the water right permit or license, such as place of use, purpose of use, or point of diversion. Water held pursuant to riparian rights is transferrable if the new use will preserve or enhance public trust uses (Water Code §1707). Also, there is a recent practice in which downstream appropriators contract with riparians to leave water in a stream for potential downstream diversion under the appropriator's water right. Water obtained pursuant to a water supply contract is also transferable. However, most water supply contracts require the consent of the entity delivering the water.

Transfers of ground water, and ground water substitution arrangements whereby ground water is pumped as a substitute for transferred surface water, are in some cases subject to statutory restrictions designed to protect ground water basins against long-term overdraft and to preserve local control of ground water management.

Short-term (one year or less) temporary transfers of water under Water Code section 1725 et seq. are exempt from compliance with CEQA, provided SWRCB approval is obtained. The SWRCB must find no injury to any other legal users of the water and no unreasonable effect on fish, wildlife, or other instream beneficial uses. CEQA compliance is required for long-term transfers. Because of complex environmental problems in the Delta, the SWRCB has announced that it will not approve long-term transfers that increase Delta pumping until completion of an environmental evaluation of the cumulative impacts. If the parties to a transfer intend to use facilities belonging to the SWP, the CVP, or other entity for transporting the water, they must make arrangements with the owner of the facility. In addition, permits from fish and wildlife agencies may be required if a proposed transfer will affect threatened or endangered species.

The CVPIA also contains provisions intended to increase the use of water transfers by providing that all individuals and districts receiving CVP water (including that under water right settlement and exchange contracts) may transfer it to any other entity for any project or purpose recognized as a beneficial use under State law. The Secretary of the Interior must approve all transfers. The approval of the affected district is required for any transfer involving over 20 percent of the CVP water subject to long-term contract with the district. Section 3405(a)(1) also sets forth a number of conditions on the transfers, including conditions designed to protect the CVP's ability to deliver contractually obligated water or meet fish and wildlife obligations because of limitations in conveyance or pumping capacity. The conditions also require transfers to be consistent with State law, including CEQA. Transfers are deemed to be a beneficial use by the transferor, and are only permitted if they will have no significant long-term adverse impact on ground water conditions within the transferor district, and will have no unreasonable impact on the water supply, operations, or financial condition of the district.

Recommendation. The SWRCB recognizes that the adoption of new, more restrictive standards for protection of fish and wildlife will reduce the capacity for water transfers through the Delta. Nonetheless, the SWRCB believes that water transfers, with appropriate safeguards against adverse environmental and third party impacts, are an important tool for solving some of California's water supply and allocation problems. The SWRCB expeditiously processes requests for water transfers, and it will continue to do so. Upon adoption of this plan, the SWRCB will reconsider its announcement that it will not approve long-term transfers that increase Delta pumping until completion of an environmental evaluation of the cumulative impacts. The SWRCB encourages other agencies with regulatory authority over water transfers to develop mechanisms for rapid processing of water transfer requests.

D. RECLAMATION

A discussion of both water reclamation issues relevant to this plan and the effect of this plan on water reclamation potential is provided in Chapter VIII.D of this report.

Recommendation. The SWRCB urges all water users in the State to maximize their production and use of reclaimed water. Urban water agencies should evaluate the installation of nonpotable water distribution pipelines to use reclaimed water for irrigation of parks, greenbelts, golf courses, and other landscaping irrigation in new developments.

E. MITIGATION FUND

Mitigation funds paid by water users in the Bay-Delta Estuary are a mechanism to limit the water supply impact of new Bay-Delta standards to individual water users (Fullerton 1994, CUWA 1994). A water supply impact threshold could be established beyond which compliance with Bay-Delta standards would be achieved with purchased water paid for by a fund established for this purpose and supported by payments from users of water from the Bay-Delta watershed. A supply impact cap would ensure that the environmental objectives of new Bay-Delta standards would be achieved while minimizing the uncertainty of water supply reliability and preventing severe economic impacts caused by water shortages.

CUWA has proposed that a mitigation fund would acquire the necessary water by two means: (1) purchasing water from willing sellers upstream of the Delta; and (2) paying export users to reduce their deliveries to meet export constraints. Using voluntary purchases to obtain supplies to meet Bay-Delta standards has several potential advantages. First, it ensures that water users avoid excessive reductions that would bring unreasonable costs to their customer base. Second, market forces would determine the source of supplies above the cap, reducing the negative impacts of forced reductions.

Relying on market forces to obtain additional supplies would lower overall costs to the State's economy because the water contributing least to the State's economic production would be the first sold for environmental restoration. A mitigation fund also would reduce third party or community impacts arising from supply reductions. Unlike regulatory reductions of water supplies, voluntary purchases leave the seller with monetary compensation for the reduction in water use. The seller can reinvest these revenues in other agricultural enterprises or in capital outlays such as water conservation.

A mitigation fund can also be used to mitigate the environmental effects of water storage, direct diversion and exports through construction of projects. These projects would include rehabilitation and construction of temperature control devices, rehabilitation and construction of fish screens, replenishment of spawning gravel, construction of Delta channel fish barriers, and other mitigation and monitoring projects identified by fishery agencies and other fishery experts. The CVPIA established a restoration fund for purposes of this nature.

Recommendation. The SWRCB encourages urban, agricultural, and environmental groups to develop a legislative proposal to authorize a mitigation fund for the Delta. Such a fund should incorporate a mitigation credits program, which will allow a water user to meet some or all of its obligations by substituting another resource deemed equivalent.

F. COMBINED USE OF CVP AND SWP POINTS OF DIVERSION IN THE DELTA

Currently, a water imbalance exists in the two projects. The CVP has an excess water supply north of the Delta, but it doesn't have sufficient conveyance capacity to transport it to its ultimate place of use south of the Delta. The SWP on the other hand has surplus capacity in its conveyance facilities but an insufficient upstream water supply. Therefore, the excess capacity in the SWP facilities could be used to transport more CVP water to the San Joaquin Valley without impairing the SWP, and a share of the CVP water supply could be sold to the SWP for use in its service area. The CVP has limited rights under its water rights permits to use the SWP diversion facilities in the Delta. D-1485 authorizes the CVP to use SWP facilities to make up deficiencies caused by the export restrictions in May and June established by the decision. The SWP water rights do not identify the CVP export facilities as an authorized point of diversion or rediversion.

In addition to the water supply issues, combined use of CVP and SWP points of diversion and rediversion have the potential to decrease fishery impacts. The two diversions are at different locations and different fish species are entrained at the diversions at different times. A combined point of diversion would allow pumping to shift between diversion points based on the density of fish near the diversion points.

The USBR has petitioned the SWRCB to add the Clifton Court Forebay as a point of diversion and rediversion in the water right permits of the CVP and to remove the 4,600 cfs rate of diversion restriction on pumping through the Delta Mendota Canal. To date, the SWRCB has not acted on this petition.

Recommendation. The SWRCB will consider authorizing combined use of the CVP and the SWP points of diversion and rediversion in the Delta during a separate proceeding following adoption of the plan.

G. OFFSTREAM STORAGE PROJECTS

Enhanced water supply reliability in the future can be achieved, in part, by construction of additional offstream storage. There are several major offstream storage projects presently under consideration or development: Los Banos Grandes Reservoir, Domenigoni Valley Reservoir, Los Vaqueros Reservoir, Delta Wetlands, and Mandeville Island. Los Banos Grandes Reservoir, a proposed feature of the SWP, would be located south of San Luis Reservoir, and it could provide 0.3 MAF of average and 0.26 MAF of drought year net water supplies under D-1485 conditions. Domenigoni Valley Reservoir, proposed for construction by the Metropolitan Water District, could provide 0.26 MAF of drought year net water supplies (DWR 1994). Los Vaqueros Reservoir, which will be used to improve water quality in the Contra Costa Water District and provide emergency storage, has received all necessary environmental and water rights permits and currently is under construction. Delta Wetlands is a proposed storage project in the Delta with a capacity of approximately 238 TAF. Surplus flows would be diverted onto two islands, Bacon Island and Webb Tract, and subsequently wheeled through the SWP or CVP export pumps or released to meet Delta outflow requirements. Recently, a water right application for a similar project was filed to impound 330 TAF on Mandeville Island.

Recommendation. The DWR should evaluate the feasibility of the Los Banos Grandes project under the new regulatory conditions imposed by the plan. The Metropolitan Water District should move forward with its planned construction of Domenigoni Valley Reservoir. The SWRCB, as lead agency, will continue to process the water right applications for the Delta Wetlands and Mandeville Island Projects.

H. SOUTH DELTA PROGRAM

The South Delta Program is being undertaken by the DWR to increase the yield and flexibility of operation of the SWP. The principal features of the South Delta Program can be divided into five components: (1) construct and operate a new intake structure at the SWP Clifton Court Forebay; (2) perform channel dredging along a reach of Old River just north of Clifton Court Forebay to improve channel capacity; (3) increase diversions into Clifton Court up to a maximum of 20,430 acre-feet per day on a monthly averaged basis; (4) construct and operate a barrier seasonally in both the spring and fall to improve fishery conditions for salmon migrating along the San Joaquin River; and (5) construct and operate three flow control structures to improve existing water level and circulation patterns for agricultural users in the southern Delta. This program could augment SWP supplies by about 60 TAF per year (DWR 1994).

Recommendation. The DWR should evaluate the feasibility of the South Delta Program under the new regulatory conditions imposed by this plan.

I. PURCHASE OF DELTA ISLANDS

Delta soils fall into two general categories: peat soils in the western and interior Delta and mineral soils in the other parts of the Delta. In areas where peat soils predominate, substantial subsidence of land elevations has occurred because exposure of peat soils to oxygen and higher temperatures causes the soil to oxidize into a gas. This process is accelerated by agricultural activity.

Recommendation. The DWR, the USBR, and other interested parties should evaluate the feasibility of purchasing the Delta Islands with the most serious land subsidence problems and converting the land use to some function that would minimize subsidence and reduce water use. Water freed up by this project could be available for export.

J. LONG-TERM DELTA SOLUTION

In an April 1992 water policy speech, Governor Wilson stated that the Delta was broken and he outlined the steps necessary to move forward with a solution. One of the principal elements of his policy was the formation of a Bay-Delta Oversight Council which would establish criteria for a comprehensive study of Delta solutions, conduct the study, and make recommendations to the Governor's Water Policy Council. Recently, several federal agencies and the State of California signed a Framework Agreement which expanded on this concept by establishing a joint State/federal process to develop long-term solutions to the Delta problems. This process is still in an early stage and no long-term recommendation has been made.

Recommendation. The SWRCB recognizes that a long-term solution to the Delta problems is necessary to ensure water supply reliability and full protection of the beneficial uses of the waters of the Bay-Delta Estuary. The SWRCB will provide support to the joint State/federal solution finding process. Upon completion of the process, the SWRCB will evaluate its water quality standards to ensure that they are consistent with the proposed solution.

K. UNAVOIDABLE SIGNIFICANT IMPACTS

The mitigation measures discussed in this chapter are largely outside the control of the SWRCB, and the majority of the measures are moving forward regardless of the SWRCB's action because they have been planned for some time.

The SWRCB does not believe that the significant impacts identified in Chapter XIV of this report are fully mitigated by these proposals. The significant impacts identified in Chapter XIV are unavoidable.

Literature Cited in Chapter X

SJVDP. 1990. A management plan for agricultural subsurface drainage and related problems on the westside San Joaquin valley. 183 pp.

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

Fullerton, D. Letter from NHI to Tom Howard, SWRCB, with attachments. May 25, 1994. 18 pp.

CUWA. 1994. Proposals for a coordinated estuarine protection program for the San Francisco Bay-Sacramento and San Joaquin River Delta Estuary. August 1994.

CHAPTER XI. ANALYSIS OF ALTERNATIVE STANDARDS

A. DESCRIPTION OF ALTERNATIVES

This section describes alternative sets of fish and wildlife standards considered for adoption by the SWRCB. The standards for protection of agricultural and municipal beneficial uses are not being reviewed during this triennial review; therefore, the standards for protection of these beneficial uses are the same in all alternatives.

The SWRCB solicited alternative sets of fish and wildlife standards for its consideration at workshops on July 13-14, September 1, and October 19, 1994. Complete regulatory alternatives submitted include proposals by the USEPA, the DFG, David Schuster and Chuck Hanson, the Bay Institute, Jones and Stokes, and SWRCB staff, and a joint proposal by major agricultural and urban water agencies. (David Schuster and Chuck Hanson participated in the formulation of the joint proposal, which supersedes their individual proposals. SWRCB staff's proposal was not a formal recommendation to the SWRCB, but rather an attempt to ensure that a range of alternatives was evaluated.) Discussions with the federal agencies indicated that the NMFS may adopt a biological opinion for winter-run chinook salmon that imposes additional standards in the Estuary, and these draft standards were combined with the USEPA alternative to prepare an alternative characterized as the Club FED alternative.

DWRSIM operation studies were run for all of these proposals, five of which are analyzed in this report: the USEPA, the DFG, SWRCB staff, and the Club FED alternatives, and a modified version of the joint proposal (preferred alternative). The modified version was endorsed by representatives of the State and federal governments and urban, agricultural, and environmental interests, as documented in the "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government".

The complete regulatory alternatives proposed by the participants include similar features. These similarities occur because the same principles are employed by all of the participants in formulating their alternatives. These principles include: (1) additional outflow in the Spring period (February through June) for general estuarine protection; (2) additional flow on the San Joaquin River during the peak salmon outmigration period; (3) export constraints to reduce entrainment; and (4) operation of barriers to reduce diversion of smolts and eggs from the main stems of the Sacramento and San Joaquin rivers. While the principles are the same, both the amount of water dedicated to these principles and the regulatory parameters used to address these principles are different. For example, outflow can be expressed as either flow or salinity in the western Delta, and export limits can be fixed or variable (QWEST, percent inflow, or restricted diversions below a particular outflow).

In most cases the alternatives suggested to the SWRCB include recommended actions that are beyond the scope of this plan. For example, all of the groups recommended that a barrier be installed at the head of Old River in the spring to reduce diversion of outmigrating salmon on the San Joaquin River to the export pumps. These recommendations are not included here, but they are discussed in Chapter IX.

1. Base Case or "No Action" Alternative

The base case used in Chapter VII for the water supply impact analysis of the preferred alternative is assumed to be the "no action" alternative in this chapter. This base case consists of D-1485 conditions, modified to account for upstream requirements on the Sacramento River imposed by the NMFS to protect winter-run chinook salmon. This base is chosen for the reasons discussed in Chapter VII, one of which is that it represents the SWRCB's current regulatory requirements that impact Bay-Delta water supplies. The conditions which define the base case for DWRSIM studies are discussed in section VII.A. Alternatives 1 through 5 are discussed below in terms of changes and additions to these base case conditions.

2. Alternative 1

Alternative 1 is the USEPA's final water quality standards for the Estuary, which were published in the Federal Register in January 1995 (60 FR 4664-4709). This alternative includes four sets of standards to be added to the flow and export standards for protection of fish and wildlife in D-1485 and the water quality standards in the 1991 Bay-Delta Plan: (1) estuarine habitat criteria (X2 isohaline standard); (2) fish migration criteria (salmon smolt survival standard); (3) fish spawning criteria for the lower San Joaquin River (salinity standard); and (4) narrative criteria for the Suisun Marsh.

a. Estuarine Habitat Criteria (X2 Isohaline Standard). For protection of the estuarine habitat and other designated fish and wildlife uses in the estuary, the USEPA adopted a set of criteria that the agency believes provides the same degree of protection as would have existed under the 1968 "level of development" (Herbold 1994). The criteria specify the number of days when the near-bottom salinity at Roe Island, Chipps Island and the confluence of the Sacramento and San Joaquin rivers must not exceed 2 ppt. (The USEPA defines "level of development" as the existing water diversion and storage facilities in the targeted period (Seraydarian 1994). However, the USEPA's standards exceed the targeted level of development in very dry periods because they require 150 days at the confluence. Also, the standards are less than the targeted level of development in wetter periods. In actuality, the standards replicate the number of days the 2 ppt isohaline would have been downstream of Chipps and Roe islands under various hydrologic conditions during the historical reference period, not the hydrology of the targeted reference period. The distinction is important because very different water supply impacts at the same historical reference period would have been obtained if the USEPA had selected a different isohaline or different compliance locations.)

The USEPA developed its estuarine habitat criteria by using a logistic equation to define a sliding scale for the number of days the 2 ppt isohaline was downstream of Roe and Chipps islands under 1968 conditions. The criteria are then calculated on a monthly basis from February through June based on the previous month's unimpaired flow index (PMI) for the Sacramento River and San Joaquin River basins. The criteria include a "trigger" for the Roe Island standards to be required for any given month only if the 14-day average salinity at Roe Island falls below 2 ppt on any of the last 14 days of the previous month. Lastly, the 2 ppt criteria are required at the confluence of the Sacramento and San Joaquin rivers from February 1 through June 30 for all year types.

The USEPA believes that the SWRCB could adopt an implementation program that allows compliance with the criteria in any one of three ways: (1) the daily salinity value meets the requirement; (2) the 14-day average salinity meets the requirement; or (3) the daily outflow is equivalent to the salinity requirement (Seraydarian 1994). In the third method, the equivalent outflow is approximately 7,100 cfs for the confluence, 11,400 cfs for Chipps Island, and 29,200 cfs for Roe Island.

The estuarine habitat criteria are modeled in DWRSIM as described below:

i) Salinity at the confluence of the Sacramento and San Joaquin Rivers must not exceed 2 ppt from February 1 through June 30.

ii) Salinity at Roe Island (when triggered) and Chipps Island must not exceed 2 ppt for a specific number of days each month from February through June. The specific number of days for each month is computed by the following formula (Herbold 1994):

$$NDR = TND * \left(1 - \frac{1}{1+e^{K}}\right) \qquad K = A + B * \ln(PMI)$$

where A and B are determined by Table XI-1 for each location, and

NDR	=	number of days required in the month
TND	=	total number of days in the month
PMI	=	previous month's eight river index

The eight river index is defined as the sum of the unimpaired runoff for the following locations: (1) Sacramento River flow at Bend Bridge, near Red Bluff; (2) Feather River, total inflow to Oroville Reservoir; (3) Yuba River flow at Smartville; (4) American River, total inflow to Folsom Reservoir; (5) Stanislaus River, total inflow to New Melones; (6) Tuolumne River, total inflow to Don Pedro; (7) Merced River, total inflow to Exchequer; and (8) San Joaquin River, total inflow to Millerton Lake. Table XI-2 contains calculated required number of compliance days, using the above equations, for a range of PMI values.

TABLE XI-1 A & B Values for Calculating K				
MONTH	CHIPPS ISLAND		ROE ISLAND (if triggered)	
	A	B	A	B
FEB	--	--	-14.36	2.068
MAR	-105.16	15.943	-20.79	2.741
APR	-47.17	6.441	-28.73	3.783
MAY	-94.93	13.662	-54.22	6.571
JUN	-81.00	9.961	--	--

TABLE XI-2 Number of Days when Salinity Must Not Exceed 2 ppt									
PMI (TAF)	CHIPPS ISLAND					ROE ISLAND (if triggered)			
	FEB	MAR	APR	MAY	JUN	FEB	MAR	APR	MAY
250	0	0	0	0	0	1	0	0	0
500	28	0	0	0	0	5	1	0	0
750	28	18	0	0	0	9	2	1	0
1000	28	31	2	0	0	13	4	2	0
1250	28	31	7	0	0	17	7	4	0
1500	28	31	15	0	0	19	10	8	0
1750	28	31	21	0	0	21	13	11	0
2000	28	31	26	1	0	22	16	15	0
2500	28	31	29	16	1	24	20	21	2
3000	28	31	29	29	7	25	24	25	5
4000	28	31	30	31	25	26	27	28	18
5000	28	31	30	31	29	27	29	29	26
6000	28	31	30	31	30	28	30	30	29

b. Fish Migration Criteria (Salmon Smolt Survival Standard). To protect salmon smolts and other migratory species in the estuary, the USEPA has adopted salmon smolt survival criteria consisting of two sets of index values: the Sacramento River Salmon Index (SRSI) and the San Joaquin River Salmon Index (SJRI).

USFWS studies have shown that closure of the Delta Cross Channel gates is the most important controllable factor in the survival of smolts on the Sacramento River (USFWS 1992). Accordingly, the USEPA's target index values approximate experimental salmon survival index values observed in Sacramento releases during periods when the gates are closed, which is approximately double the historical survival measured at times when the gates are open. The criteria for the Sacramento River system are as follows:

i) At temperatures < 61 °F: SRSI = 1.35

ii) At temperatures ≥ 61 °F and ≤ 72 °F: SRSI = 6.96 - 0.092*Temperature (°F)

iii) At temperatures > 72 °F: SRSI = 0.34 (the measured index approaches zero, but the USEPA believes that this value is appropriate in order to encourage efforts to protect salmon during periods of high temperatures)

The USEPA expects target index values to be attained through measures to be identified in the USFWS Sacramento salmon smolt survival model. The model relates the salmon survival index to four factors: temperature at Freeport, exports, proportion of water diverted into the Delta Cross Channel at Walnut Grove, and proportion of water remaining in the Sacramento River at Walnut Grove.

For the San Joaquin River system, the USEPA derived the target values from the modeled values associated with protective measures recommended by the USFWS (USFWS 1992), revised to provide additional protection in drier years. The USEPA believes that its criteria will increase wet year survival by a factor of 1.8 and dry year survival by a factor of four. The resulting San Joaquin salmon smolt survival criteria are based on the 60-20-20 San Joaquin Water Year Index (SJWYI) in MAF, and are as follows:

i) In years with SJWYI > 2.5: SJRI = (-0.012) + 0.184*SJWYI

ii) In other years: SJRI = 0.205 + 0.0975*SJWYI

The USEPA expects the revised USFWS San Joaquin salmon smolt survival model to be used in identifying measures to attain the above criteria. This model relates the survival of San Joaquin smolts migrating through the Delta to four factors: San Joaquin River flow at Vernalis, proportion of flow diverted from the mainstem San Joaquin River, exports, and temperature at Jersey Point. The salmon smolt criteria are modeled in DWRSIM as described below:

i) The Delta Cross Channel gates are closed from April 1 through June 30.

ii) Minimum flow requirements and export restrictions must be maintained as specified in Table XI-3. These values have been estimated by the USEPA to be necessary to achieve the survival index standard, based on the USFWS smolt survival model.

c. Fish Spawning Criteria for the Lower San Joaquin River (Salinity Standard). To address increased salinity levels caused by agricultural return flows in the San Joaquin Valley, the USEPA also adopted fish spawning criteria for the lower San Joaquin River. These salinity standards are intended to reduce the impacts of salt loadings on spawning habitat for sensitive species, including striped bass and Sacramento splittail, and protect other fish and wildlife uses of the lower San Joaquin River from Jersey Point to Vernalis. The criteria include the following requirements from April 1 through May 31:

i) In wet, above normal and below normal years, the 14-day running average of the mean daily EC must not exceed 0.44 mmhos/cm in the reach from Jersey Point to Vernalis.

ii) In dry and critical years, the 0.44 mmhos/cm EC standard is required in the reach from Jersey Point to Prisoner's Point.

These standards were not incorporated into the DWRSIM operation study.

d. Narrative Criterion for Suisun Marsh. To protect the tidal wetlands surrounding Suisun Bay, the USEPA adopted a narrative criterion that requires water quality conditions sufficient to support high plant diversity and diverse wildlife habitat and prevent conversion of brackish marsh to salt marsh. This standard was not incorporated into the DWRSIM operation study.

3. Alternative 2

Alternative 2 was developed by SWRCB staff from various recommendations received from workshop participants. This alternative includes flow, export and operational requirements to replace those for protection of fish and wildlife in the 1978 Delta Plan and D-1485.

a. Flow Standards. For protection of chinook salmon during the peak of smolt outmigration, flows on the San Joaquin River at Vernalis for four weeks from April 17 through May 14 must be at least 8,000 cfs in wet years, 7,000 cfs in above normal years, 6,000 cfs in below normal years, 5,000 cfs in dry years, and 4,000 cfs in critical years. To attract adult migrating chinook salmon into the San Joaquin River and its tributaries, flows on the San Joaquin River must be at least 2,000 cfs from October 18 through October 31.

b. Export Standards. During the spring pulse flow period from April 17 through May 14, exports must not exceed 1,500 cfs. Maximum exports for the rest of April through June are

TABLE XI-3 Salmon Smolt Criteria for DWRSIM		
PARAMETER	**SJWYI[1] (MAF)**	**CRITERION (cfs)**
EXPORTS (cfs) 4/1 - 4/15 and 5/16 - 5/31	≤ 2.5	1191.13 + 964.08*SJWYI
	>2.5 and <3.8	13.79 + 1432.41*SJWYI
	≥ 3.8	6,000
EXPORTS (cfs) 4/15 - 5/15	All Values	1,500
EXPORTS (cfs) 6/1 to 6/30	≤ 2.8	4,000
	> 2.8 and < 3.8	13.79 + 1432.41*SJWYI
	≥ 3.8	6,000
VERNALIS FLOW (cfs) 4/15 - 5/15	≤ 2.5	832.52 + 1749.08*SJWYI
	>2.5 and <4.2	-1972.43 + 2864.82*SJWYI
	≥ 4.2	10,000

[1] Where SJWYI = the 60-20-20 San Joaquin Water Year Index in MAF

set at 4,000 cfs in critical years, 5,000 cfs in dry years, and 6,000 cfs in below normal, above normal, and wet years. In July, exports must not exceed 9,200 cfs. These fixed export constraints in April through July are eliminated when the Delta Outflow Index exceeds 50,000 cfs. Additionally, total CVP and SWP exports must be less than 30 percent of Delta inflow from February 1 through June 30, and 60 percent of Delta inflow from July 1 through January 30.

c. Operations. The Delta Cross Channel gates must be closed from February 1 through April 30, and they are operated on a real-time basis from November 1 through January 31 and May 1 through June 30. For modeling purposes the gates are assumed to be closed throughout the period.

e. X2 Isohaline Standard. This requirement is based on the California Urban Water Agencies' (CUWA's) proposed estuarine habitat standard (CUWA 1994). The standard is derived using the same methodology as used by the USEPA, but the standard replicates the number of days the 2 ppt isohaline was downstream of the three locations under conditions that existed in year 1971.5 instead of year 1968. Additionally, the number of days the 2 ppt isohaline must be downstream of the confluence is derived using the sliding scale methodology instead of the USEPA's recommendation that the 2 ppt isohaline be downstream of the confluence at all times from February through June.

Compliance with the standard can be achieved by meeting at least one of three alternative criteria at each of three locations for the number of days during each month of February through June, as determined from the eight river index, defined on page XI-3, for the previous month (PMI):

- i) Average daily salinity at the compliance point; or
- ii) 14-day average salinity at the compliance point; or
- iii) Maintenance of Delta outflow calculated to maintain desired salinity at steady-state.

Table XI-4 contains calculated required number of compliance days for a range of PMI values.

4. Alternative 3

The DFG developed three sets of alternative Bay-Delta standards in 1992, and it recommended that the SWRCB consider adoption of one of the alternatives during the SWRCB's draft D-1630 proceedings (DFG 1992). During the SWRCB's hearings to develop alternatives for this plan, the DFG recommended that the SWRCB consider alternative B in the above reference. This alternative is extracted from that source.

The DFG developed these standards by examining the needs of fall-run chinook salmon, winter-run chinook salmon, striped bass and a series of estuarine species. These standards

TABLE XI-4: Number of Days When Salinity Must Not Exceed 2 ppt

PMI (TAF)	CONFLUENCE					CHIPPS ISLAND					ROE ISLAND				
	FEB	MAR	APR	MAY	JUN	FEB	MAR	APR	MAY	JUN	FEB	MAR	APR	MAY	JUN
250	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0
750	28	8	0	0	0	28	0	0	0	0	8	2	0	0	0
1000	28	31	0	0	0	28	12	2	0	0	12	4	0	0	0
1250	28	31	24	0	0	28	31	6	0	0	15	6	1	0	0
1500	28	31	30	31	0	28	31	13	0	0	18	9	1	0	0
1750	28	31	30	31	0	28	31	20	0	0	20	12	2	0	0
2000	28	31	30	31	0	28	31	25	1	0	21	15	4	0	0
2500	28	31	30	31	5	28	31	29	11	1	23	19	8	1	0
3000	28	31	30	31	25	28	31	30	27	4	25	23	12	4	0
4000	28	31	30	31	30	28	31	30	31	23	26	27	20	15	0
5000	28	31	30	31	30	28	31	30	31	29	27	28	25	25	4
6000	28	31	30	31	30	28	31	30	31	30	27	29	27	29	16
7000	28	31	30	31	30	28	31	30	31	30	27	30	28	30	26
8000	28	31	30	31	30	28	31	30	31	30	27	30	29	31	29
9000	28	31	30	31	30	28	31	30	31	30	28	30	29	31	30
10000	28	31	30	31	30	28	31	30	31	30	28	31	30	31	30

would replace the flow and operational constraints for protection of fish and wildlife in D-1485.

a. Flow Standards. For protection of fall-run chinook salmon, average Sacramento River flows at Rio Vista should exceed 4,000 cfs from April 1 through June 30; and average San Joaquin River flows at Vernalis from April 15 through May 15 should be greater than: 10,000 cfs in wet years; 8,000 cfs in above normal years; 6,000 cfs in below normal years; 4,000 cfs in dry years; and 2,000 cfs in critical years. For protection of striped bass eggs and larvae, the minimum daily flow on the Sacramento River at Freeport should exceed 13,000 cfs.

b. Export Standards. During the spring pulse flow on the San Joaquin River from April 15 through May 15, limit exports to the following: 6,000 cfs in wet years; 5,000 cfs in above normal years; 4,000 cfs in below normal years; 3,000 cfs in dry years; and 2,000 cfs in critical years. For April through July, maximum average monthly exports must be maintained as follows: 6,400 cfs in wet years; 5,400 cfs in above normal years; 4,400 cfs in below normal years; 3,400 cfs in dry years; and 1,600 cfs in critical years. For August through March, maximum average monthly exports must be maintained as follows: 7,900 cfs in wet years; 7,100 cfs in above normal years; 6,500 cfs in below normal years; 6,000 cfs in dry years; and 5,000 cfs in critical years.

The DFG also proposes that exports in excess of 1,500 cfs and diversion to storage be prohibited unless the outflows in Table XI-5 are met.

c. QWEST Standards. QWEST must be greater than zero cfs from February 1 through June 30. From April 15 through May 31, QWEST must be at least 1,500 cfs, 2,000 cfs, 2,500 cfs, and 3,000 cfs in dry, below normal, above normal, and wet years, respectively. QWEST must be greater than 1,000 cfs for the rest of the April 1 through June 30 period.

d. Operations Standards. The Delta Cross Channel gates should be closed from February 1 through June 30.

e. Outflow Standards. In critically dry years, the Delta Outflow Index must be greater than 8,700 cfs, 7,800 cfs, 7,000 cfs, 6,200 cfs, 5,600 cfs, and 5,000 cfs in February, March, April, May, June, and July, respectively. For protection of striped bass, the outflow standards in Table XI-6 must be met in the fall.

5. Alternative 4

This alternative adds requirements to the USEPA's standards described in Alternative 1 (described in section XI.A.2). These additional requirements are proposed by the NMFS for the protection of winter-run chinook salmon.

TABLE XI-5 Outflow Below Which 1,500 cfs Export Restriction and Diversion Prohibition Apply				
MONTH	DELTA OUTFLOW INDEX			
	WET	ABOVE NORMAL	BELOW NORMAL	DRY
FEB	50,000	50,000	22,000	19,200
MAR	45,000	50,000	15,400	15,000
APR	18,000	13,600	9,500	9,500
MAY	24,400	15,000	9,500	9,500
JUN	17,500	12,000	8,600	7,900
JUL	12,500	9,900	8,300	7,600
OCT	14,200			
NOV	16,300	12,900	9,500	
DEC	28,000	27,000	26,000	20,000

TABLE XI-6 14-Day Running Average Delta Outflow Requirement					
YEAR TYPE	AUG	SEP	OCT	NOV	DEC
Wet	5,800	7,300	7,300	7,300	7,300
Above Normal	5,600	4,200	4,500	4,500	5,400
Below Normal	5,300	4,200	4,500	4,500	4,900
Dry	5,000	4,000	4,500	4,500	4,700
Critical	3,300	3,000	3,600	3,600	4,700

a. <u>QWEST Standards</u>. QWEST must be greater than -2000 cfs from November 1 through January 31. In the months of February through April, QWEST must be at least 2000 cfs for 6 weeks, with exact dates to be determined through monitoring, and greater than 0 cfs for the rest of the February 1 through April 30 period. For modeling purposes, QWEST requirements are assumed to be -2000 cfs in November through January, 0 cfs in February, 2000 cfs in March, and 1000 cfs in April.

b. <u>Operations</u>. The Delta Cross Channel gates must be closed from February 1 through June 30, and they are operated on a real-time basis for 45-day closure based upon monitoring during November 1 through January 31. In modeling the latter, the gates are assumed to be closed 15 days in each of the three months, for a total of 45 days.

6. Alternative 5

Alternative 5, which incorporates the "Principles for Agreement on Bay-Delta Standards between the State of California and the Federal Government," is the consensus proposal by major agricultural and urban water users, and is the SWRCB's preferred alternative. The fish and wildlife standards, modeling assumptions, and potential impacts of the preferred alternative are described in detail earlier in this report and are not repeated here. For additional information on the standards, modeling assumptions and water supply impacts, and environmental impacts, refer to Chapters II, VII and VIII, respectively.

B. WATER SUPPLY IMPACTS OF ALTERNATIVES

This section compares the water supply impacts of alternative sets of fish and wildlife standards considered for adoption by the SWRCB. The analysis focuses on the water supply impacts, and not on their distribution to responsible water users. The SWP and the CVP serve as surrogates in the modeling studies in order to determine the overall water supply impacts of each alternative. Following adoption of the draft plan, the SWRCB will initiate a water right proceeding to identify responsible water users and allocate responsibility.

Water supply impacts are determined by comparing DWRSIM studies for each alternative with the base case described in section VII.A. Complete characterization of the water supply impacts requires consideration of three parameters: total exports, Sacramento River Basin storage changes, and San Joaquin River Basin water supply impacts. Table XI-7 summarizes the water supply impacts of the alternatives relative to the base case.

1. Exports

For this analysis, exports are defined as SWP exports at Banks Pumping Plant, CVP exports at Tracy Pumping Plant, Contra Costa Canal exports, North Bay Aqueduct exports, and diversions by the City of Vallejo. Water supply impacts discussed below for both the 71-year hydrology and critically dry period do not include adjustments due to additional flows in excess of New Melones releases required to meet flow requirements in the San

TABLE XI-7 Summary of Comparative Water Supply Impacts Relative to Base Case (TAF/yr)				
Proposed Fish & Wildlife Standards	**Critical Dry Period Average (May 1928-Oct 1934)[2]**	**71-Year Average (1922-1992)[3]**	**Average Annual Carryover Storage in Sacramento River Basin[1]**	**Average Annual Carryover Storage in New Melones Reservoir**
Alternative 1	-1079	-495	-175	-730
Alternative 2	-1389	-573	-253	-680
Alternative 3	-2428	-2893	1244	-320
Alternative 4	-1411	-865	-61	-730
Alternative 5	-987	-300	17	-666

1. Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville reservoirs, with total storage capacity of 11.7 MAF.
2. Change in total exports (Banks, Tracy, Contra Costa and North Bay/Vallejo diversions) from base case plus adjustments due to upstream reservoir storage used (Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones) and additional flows in excess of New Melones releases required to meet flow requirements in the San Joaquin River at Vernalis.
3. Change in total exports (Banks, Tracy, Contra Costa and North Bay/Vallejo diversions) from base case plus adjustments due to additional flows in excess of New Melones releases required to meet flow requirements in the San Joaquin River at Vernalis.

Joaquin River at Vernalis. Critical period impacts also do not include adjustments due to Sacramento River Basin reservoir storage used.

Figure XI-1 shows the average annual exports for the 71-year hydrology under the base case and all alternatives. The figure shows the highest, lowest and average annual exports for each set of standards. Average annual exports for the base case are 6.1 MAF. Alternative 3 has the lowest average annual exports at 3.2 MAF. For other alternatives, annual exports range from 5.3 MAF (under Alternative 4) to 5.9 MAF (under Alternative 5). Figure XI-2 shows the maximum, minimum, and average changes in exports under each alternative from that of the base case. Exports are reduced from 230 TAF (under Alternative 5) to 2.9 MAF (under Alternative 3), with maximum annual reductions of 1.4 MAF, 1.6 MAF, 4.1 MAF, 2.3 MAF, and 1.1 MAF under Alternatives 1 through 5, respectively.

Figure XI-3 shows the average annual exports during the critically dry period of May 1928 through October 1934 for the base case and all alternatives, and Figure XI-4 shows the corresponding export reduction for each alternative from the base case. In the base case, the average annual exports are 5.2 MAF. Average annual exports for the alternatives range from 2.4 MAF (under Alternative 3) to 4.3 MAF (under Alternative 5). Average impacts range from 830 TAF (Alternative 5) to 2.7 MAF (Alternative 3) per year on average.

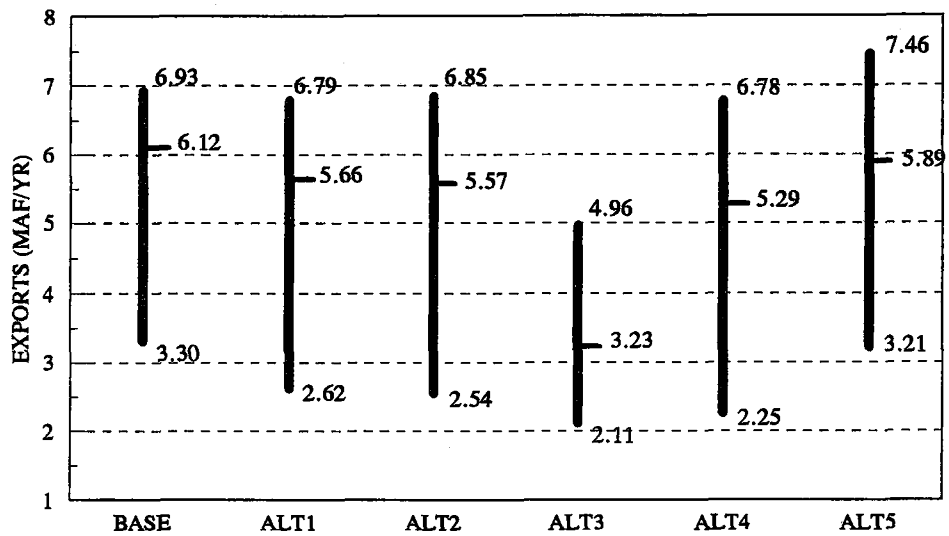
2. Sacramento River Basin Storage Impact

To evaluate potential impacts on reservoir storage in the Sacramento River Basin, combined storage in Clair Engle, Whiskeytown, Shasta, Oroville and Folsom reservoirs under the various alternatives is compared with that under the base case.

For the 71-year hydrology, Figure XI-5 shows carryover (end-of-September) storage under the base case and all alternatives. Change in storage from the base case for each alternative is shown in Figure XI-6. For Alternatives 1, 2, and 4 the reductions in carryover storage from the base case are 175 TAF, 253 TAF, and 61 TAF, respectively. Under Alternative 3, exports are restricted until reservoir inflows reach designated levels. This restriction results in an increase in carryover storage of 1.24 MAF. Alternative 5 also results in an increased carryover storage of 17 TAF from the base case.

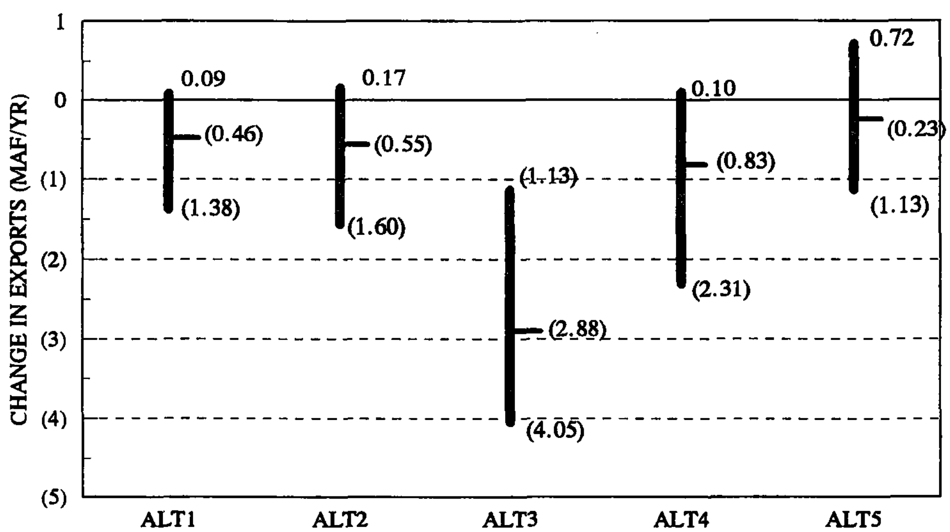
For the critically dry period of May 1928 through October 1934, the combined impact on upstream reservoir storage in the Sacramento River Basin and on New Melones Reservoir storage in the San Joaquin River Basin is characterized as the change in upstream storage during this period (derived by subtracting storage at the end of the critical period from storage at the beginning of the period, dividing by 6.5 for an annual average, and subtracting losses due to evaporation). The changes in upstream storage for the base case and all alternatives are shown in Figure XI-7. Figure XI-8 shows the net change in annual upstream storage used under Alternatives 1 through 5 from the base case.

FIGURE XI-1
AVERAGE ANNUAL EXPORTS
OVER 71-YEAR HYDROLOGY



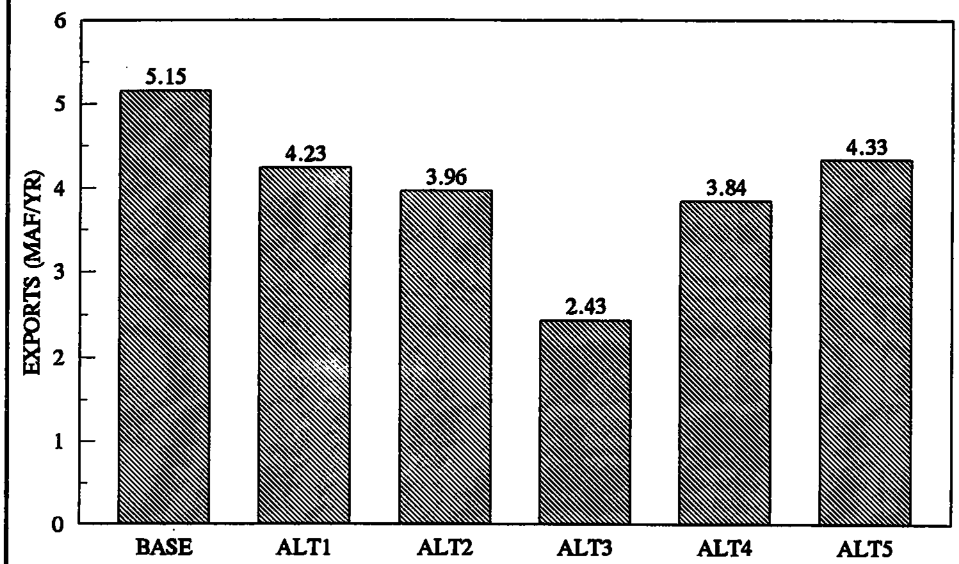
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo
Top of bar = maximum, bottom of bar = minimum, marker = average

FIGURE XI-2
AVERAGE ANNUAL CHANGE IN EXPORTS FROM BASE CASE
OVER 71-YEAR HYDROLOGY



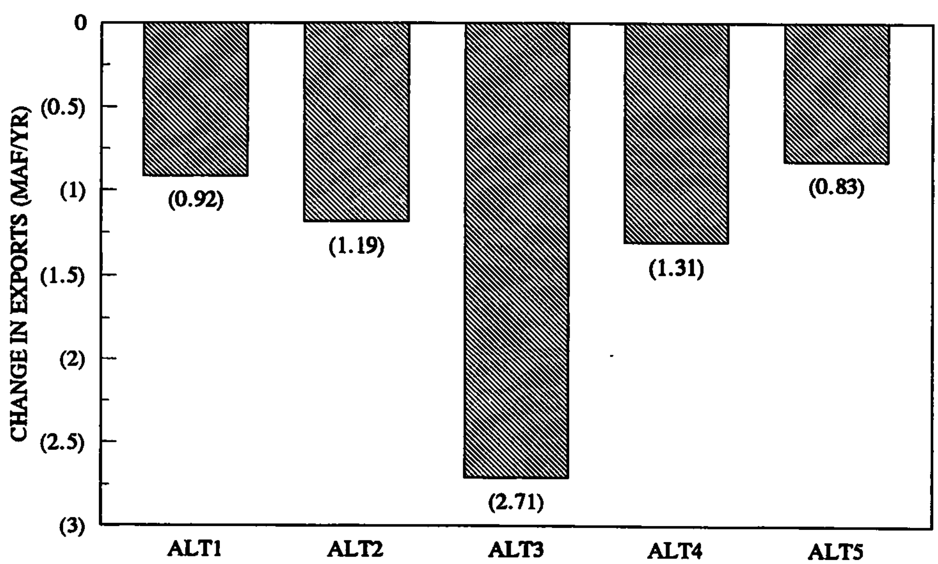
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo
Top of bar = minimum, bottom of bar = maximum, marker = average

FIGURE XI-3
AVERAGE ANNUAL EXPORTS
FROM MAY 1928 - OCTOBER 1934



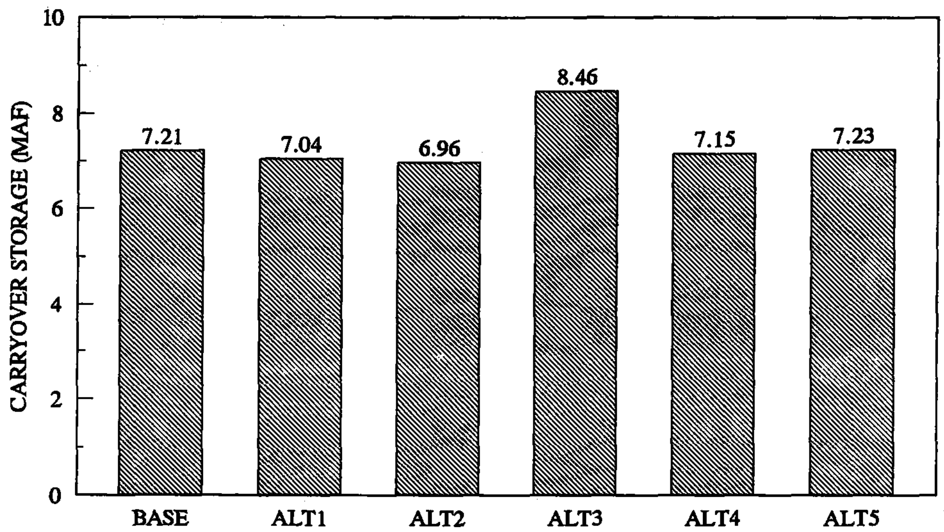
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo

FIGURE XI-4
AVERAGE ANNUAL CHANGE IN EXPORTS FROM BASE CASE
FROM MAY 1928 - OCTOBER 1934



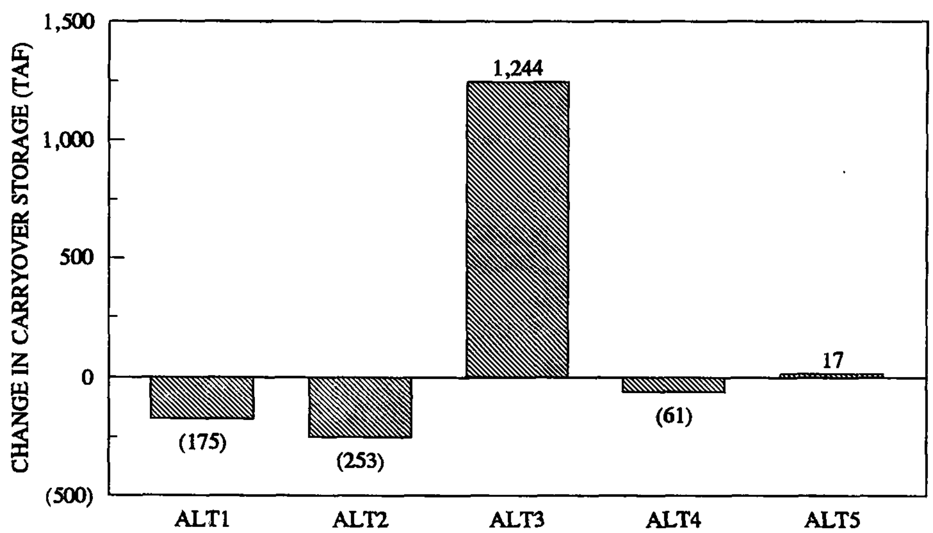
Exports include Banks, Tracy, Contra Costa and North Bay/Vallejo

FIGURE XI-5
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE IN SACRAMENTO RIVER BASIN RESERVOIRS



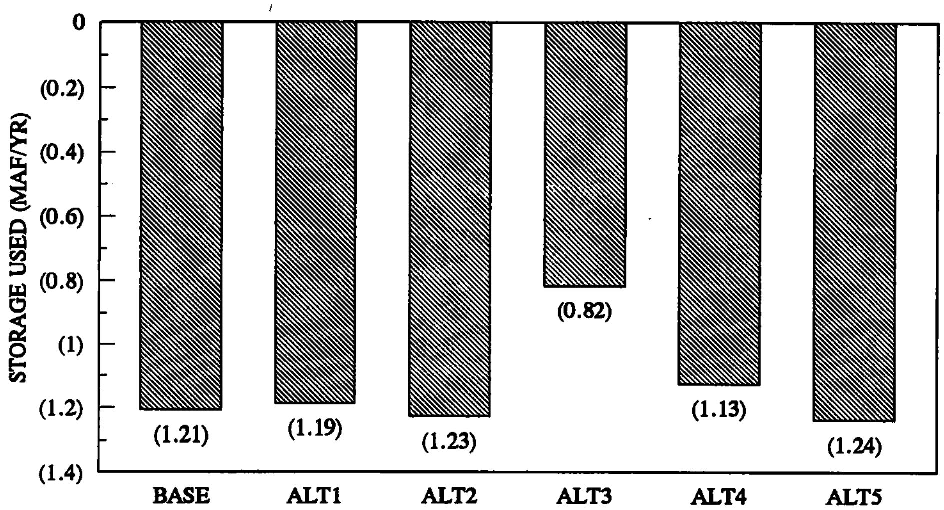
Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville Reservoirs
Average carryover storage over 71-year hydrology

FIGURE XI-6
AVERAGE CHANGE IN END-OF-SEPTEMBER STORAGE IN SACRAMENTO RIVER BASIN RESERVOIRS



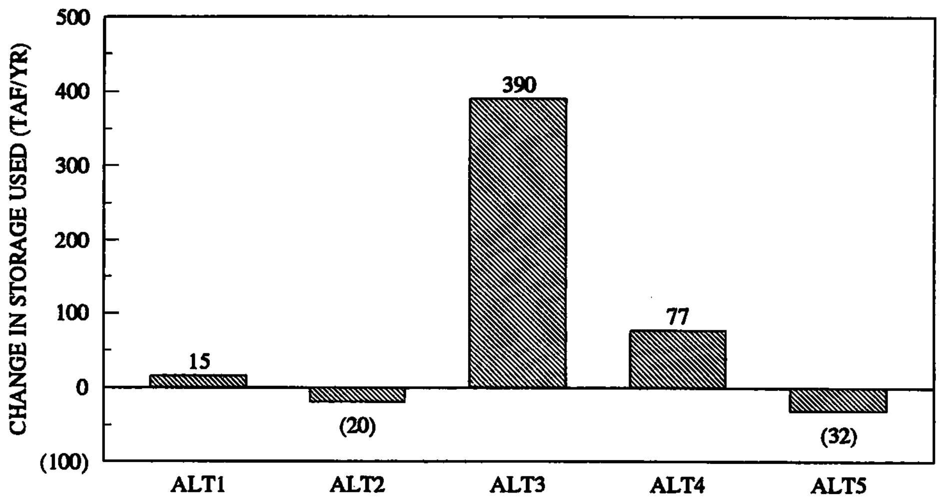
Average change in carryover storage from base case over 71-year hydrology
Includes Clair Engle, Whiskeytown, Shasta, Folsom and Oroville Reservoirs

FIGURE XI-7
AVERAGE ANNUAL UPSTREAM STORAGE USED FROM MAY 1928 - OCTOBER 1934



Includes Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones.
Average annual storage used = (May 1928 storage - October 1934 storage)/6.5 yrs with adjustment for evaporation.

FIGURE XI-8
AVERAGE ANNUAL CHANGE IN UPSTREAM STORAGE USED FROM MAY 1928 - OCTOBER 1934



Includes Clair Engle, Whiskeytown, Shasta, Folsom, Oroville and New Melones.
Annual storage used =(May 1928 storage - October 1934 storage)/6.5 years - evap
Change in net storage used from base case.

3. San Joaquin River Basin Impact

As discussed in Section VII.D, water supply impacts of the new flow standards at Vernalis are characterized by two limiting cases. The first limiting case assumes that water necessary to achieve the standards is obtained by reducing storage in San Joaquin Valley reservoirs, represented in DWRSIM studies by New Melones Reservoir. The second limiting case assumes that the water is obtained by reducing deliveries to customers, while increasing San Joaquin River flows. In actuality, water users are likely to meet the requirements through a combination of these two measures. The water supply impact in the first limiting case is determined by the change in New Melones storage from the base case. The water supply impact in the second case is determined by comparing the additional flow required on the San Joaquin River at Vernalis between the base case and the alternatives.

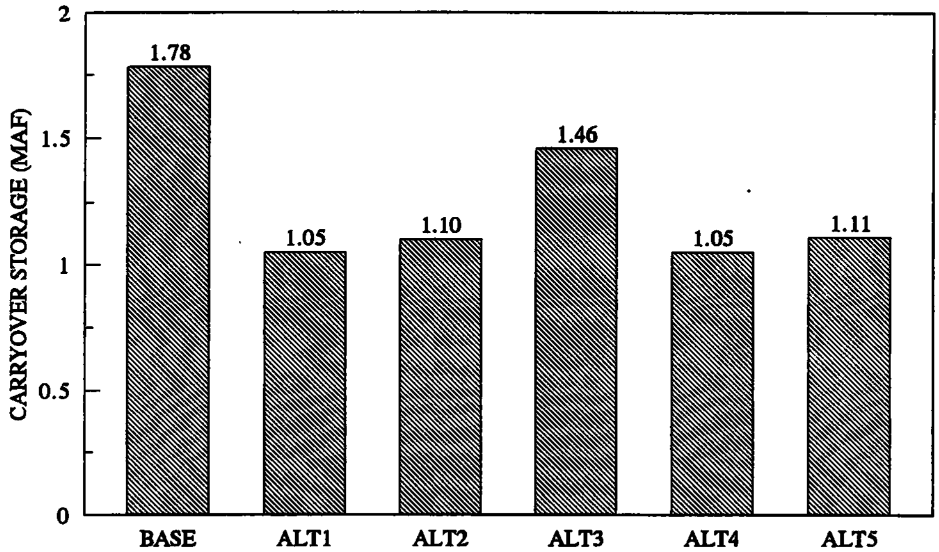
a. New Melones Reservoir Storage. Figure XI-9 shows carryover storage in New Melones under the base case and various alternatives. Figure XI-10 shows the changes in storage from the base case for the alternatives. Impacts on New Melones carryover storage under Alternatives 1 through 5 are 727 TAF, 672 TAF, 311 TAF, 727 TAF, and 666 TAF, respectively.

These impacts do not include adjustments due to additional flows in excess of New Melones releases required to meet the new flow requirements. This excess water from unspecified sources is required when New Melones reaches minimum operating storage. Water in excess of New Melones releases is required under Alternative 1 in 11 years (1927-1935, 1964 and 1992), resulting in an additional average annual impact of 35 TAF/yr over the 71-year hydrology; under Alternative 2 in 8 years (1928-1934 and 1992), with an average annual impact of 23 TAF/yr; under Alternative 3 in 7 years (1928-34), with an average annual impact of 13 TAF/yr; under Alternative 4 in 11 years (1927-1935, 1964 and 1992), with an average annual impact of 35 TAF/yr; and under Alternative 5 in 20 years (1926-1935, 1948-1949, 1963-1964, 1966, and 1974-1978), with an average annual impact of 71 TAF.

b. San Joaquin River Flow. All of the alternatives require minimum flows in the San Joaquin River at Vernalis in April and May for salmon smolts outmigration. Alternatives 2 and 5 require additional flows in October. Alternative 5 also includes minimum flow requirements at Vernalis in February, March and June. The flow requirements in Alternatives 1 and 4 are identical, and, thus, their impacts are the same.

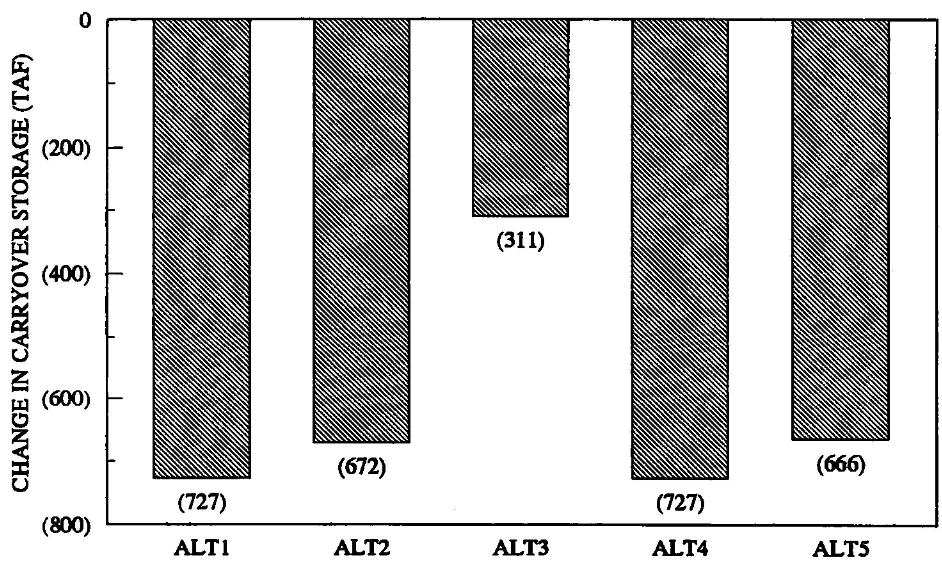
As shown in Figure XI-11, under Alternatives 1 through 5, the average annual additional San Joaquin River flows provided are 267 TAF, 232 TAF, 171 TAF, 267 TAF, and 266 TAF, respectively. Figure XI-12 shows the average monthly additional flows from the base case for the various alternatives in February through July. In November through January, and in August and September, the additional Vernalis flows provided are similar between all five alternatives. Under Alternatives 2 and 5, additional Vernalis flows of 10.4 TAF and 16.3 TAF, respectively, are provided to meet the October minimum flow requirements.

FIGURE XI-9
AVERAGE END-OF-SEPTEMBER CARRYOVER STORAGE IN NEW MELONES RESERVOIR



Average carryover storage over 71-year hydrology

FIGURE XI-10
AVERAGE CHANGE IN CARRYOVER STORAGE FROM BASE CASE IN NEW MELONES RESERVOIR



Average change in carryover storage over 71-year hydrology

FIGURE XI-11
AVERAGE ANNUAL ADDITIONAL SAN JOAQUIN RIVER FLOW AT VERNALIS FROM BASE CASE

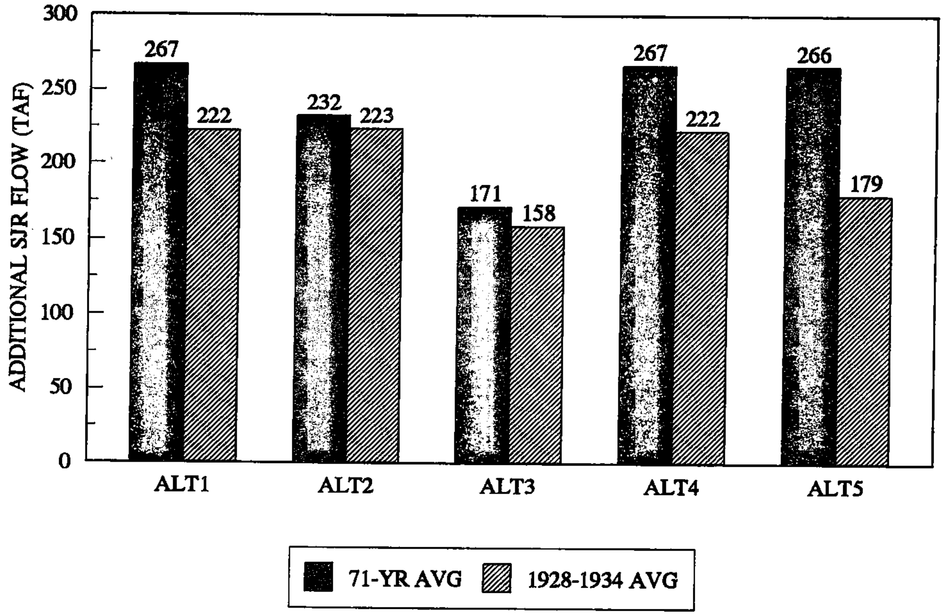
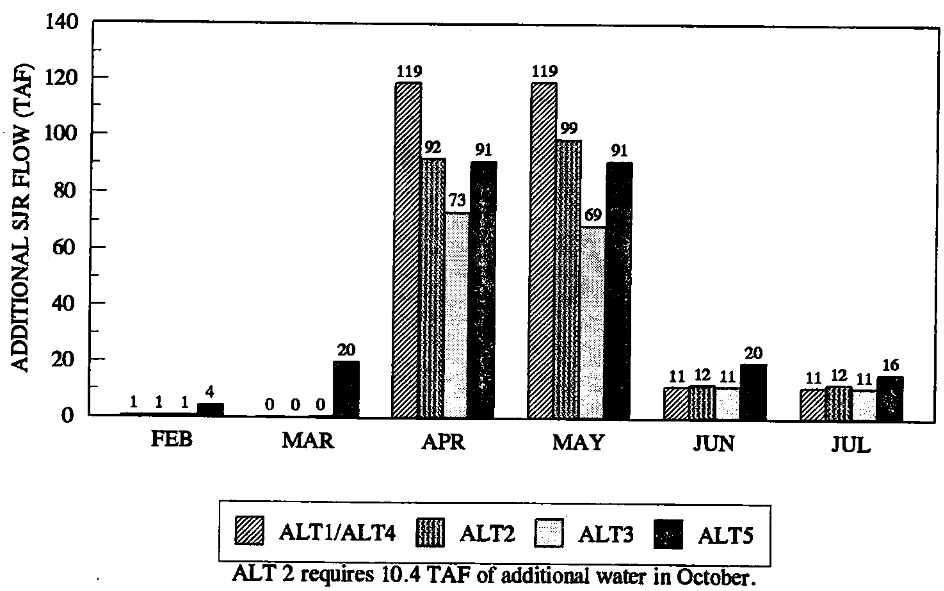


FIGURE XI-12
AVERAGE MONTHLY ADDITIONAL SAN JOAQUIN RIVER FLOW FROM BASE CASE OVER 71-YEAR HYDROLOGY



ALT 2 requires 10.4 TAF of additional water in October.
ALT5 requires 16.3 TAF of additional water in October.

C. IMPACTS OF ALTERNATIVES ON AQUATIC RESOURCES

Major factors affecting aquatic resources in the Bay-Delta Estuary are reasonably well established, and although the alternatives analyzed by the SWRCB are different, they all address these major factors. Similar elements found in all of the alternatives include: (1) increased outflow, especially in the spring, for general estuarine protection; (2) export restrictions, especially in the spring, to minimize entrainment; (3) higher San Joaquin River flows during the most important salmon smolt outmigration period to improve smolt survival; and (4) barrier operation or construction to minimize straying from historic migratory routes.

A major difference among the alternatives is the period of the year over which regulatory controls are proposed. Alternatives 1 and 4 establish standards for the February through June, and October through June periods, respectively, while alternatives 2, 3, and 5 establish flow and operational requirements throughout the year. The SWRCB believes that operational requirements are needed throughout the year to ensure adequate protection for the Estuary.

In general, the condition of aquatic resources in the Estuary improves as the hydrologic regime moves toward unimpaired conditions. (Such movement, however, comes at the expense of the consumptive uses of the waters of the Estuary.) Therefore, assuming similarly crafted standards, the water supply impacts of a set of alternative standards can provide a reasonable surrogate for the biological benefits of the alternatives at the present level of understanding. This simplistic approach cannot be used in this case because the alternatives are comprised of different elements.

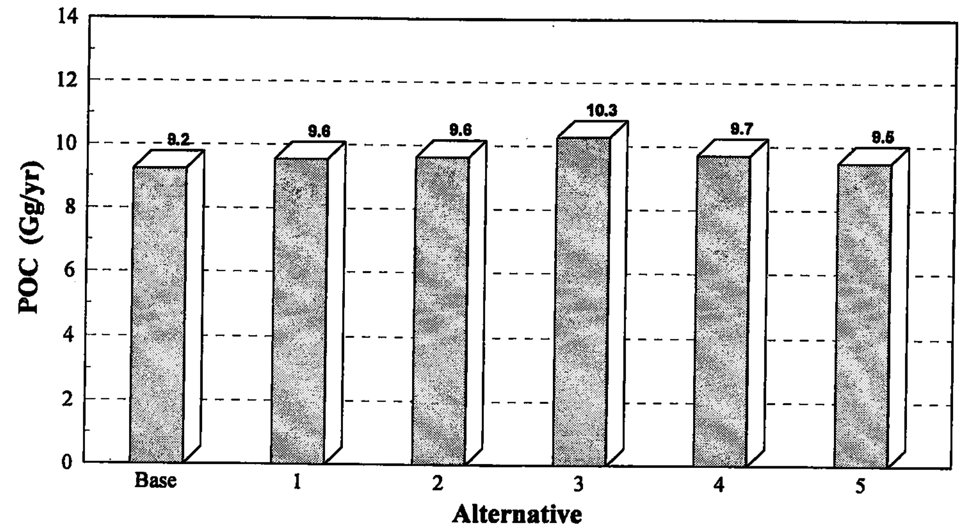
The effects of each of the alternatives on aquatic resources (POC, *Crangon franciscorum*, Neomysis, longfin smelt, starry flounder, splittail, striped bass, and chinook salmon) are summarized in this section using the aquatic resource models described in Chapter VI and the DWRSIM-modeled 71-year hydrology. For purposes of discussion, the model results can be broken into three categories: (1) the abundance/outflow model results in Figures XI-13 through XI-18; (2) the striped bass model results in Figures XI-19 and XI-20; and (3) the salmon model results in Figures XI-21 through XI-23.

The abundance/outflow model results predict that none of the alternatives will result in major increases in the targeted resources. This result is expected because the abundance/outflow models predict that substantial increases in abundances occur due to large storm-driven outflows, which are well outside both the control of the CVP and the SWP, and the range of outflows required in these alternatives.

The striped bass model predicts that Alternative 3 will provide a substantial increase in both the young-of-the-year and the adult population. The model predicts that the other alternatives will improve the YOY index, but the adult population under these alternatives will not change markedly from the existing population of approximately 600,000 striped bass. The YOY is principally dependent on the export and outflow conditions in the April through July

Figure XI - 13

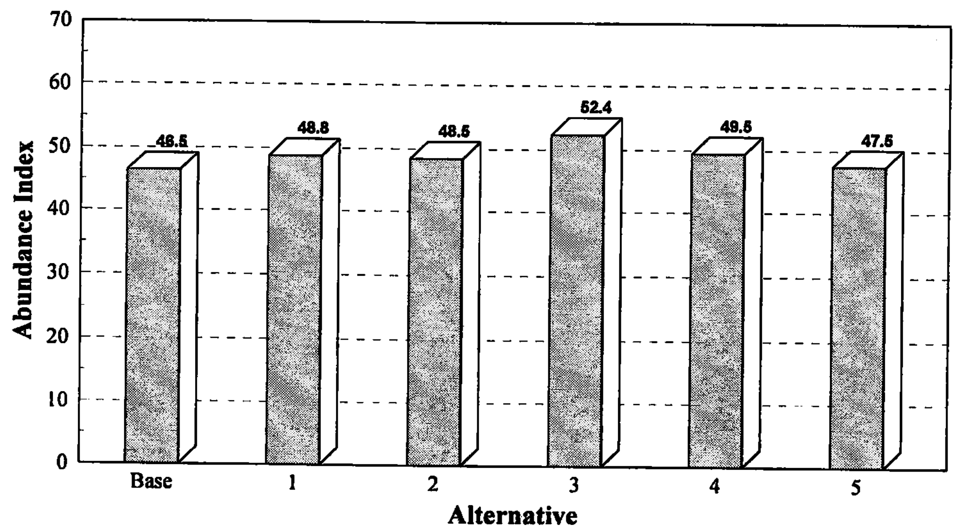
Particulate Organic Carbon (POC)



Abundance index values are obtained using the modified Jassby model and DWRSIM model output for 1922-1992.

Figure XI - 14

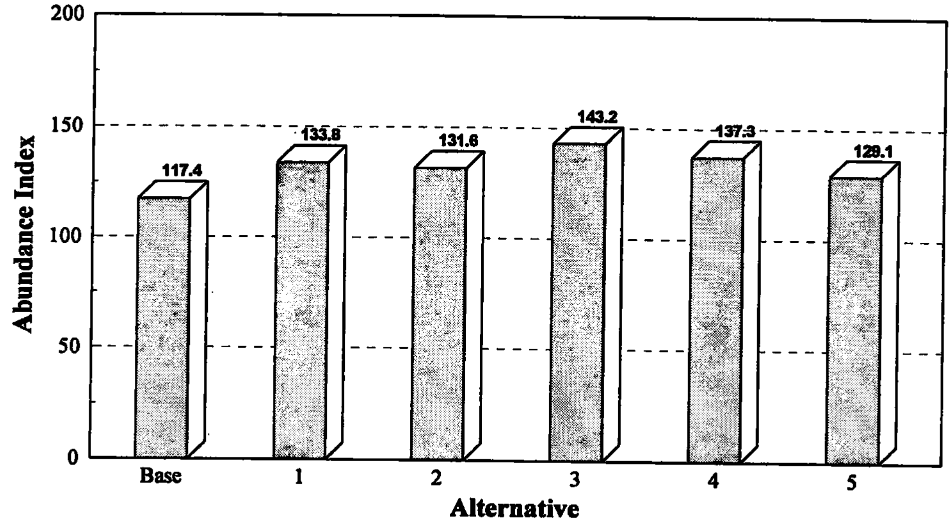
Neomysis



Abundance index values are obtained using the modified Jassby model and DWRSIM model output for 1922-1992.

Figure XI - 15

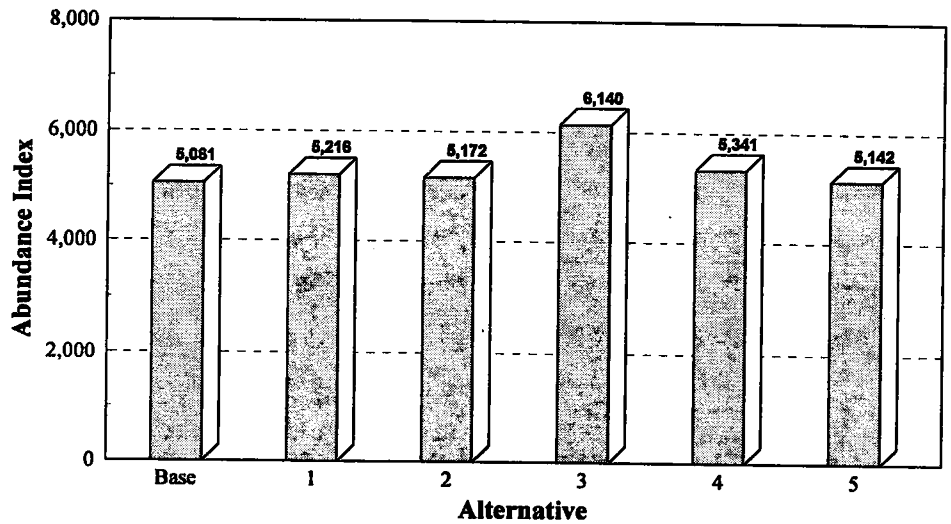
Immature *Crangon franciscorum*



Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.

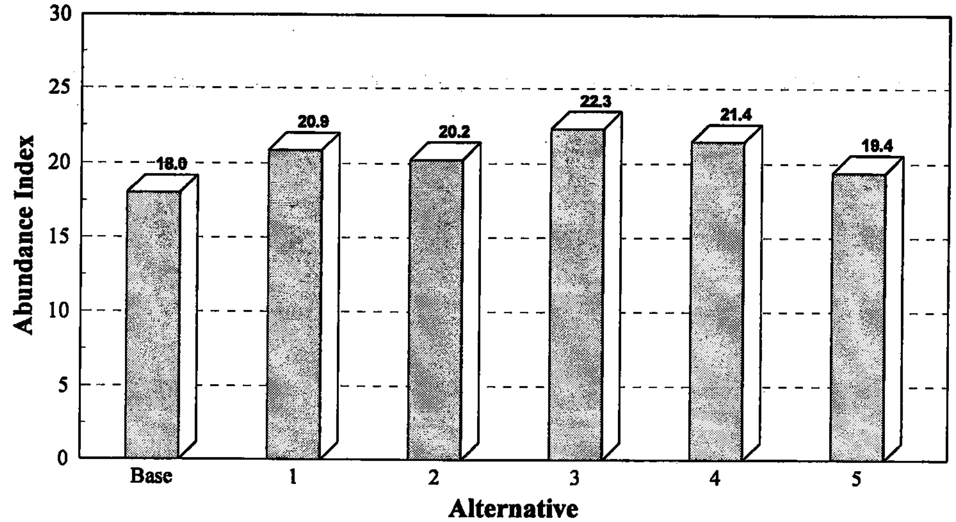
Figure XI - 16

Longfin Smelt



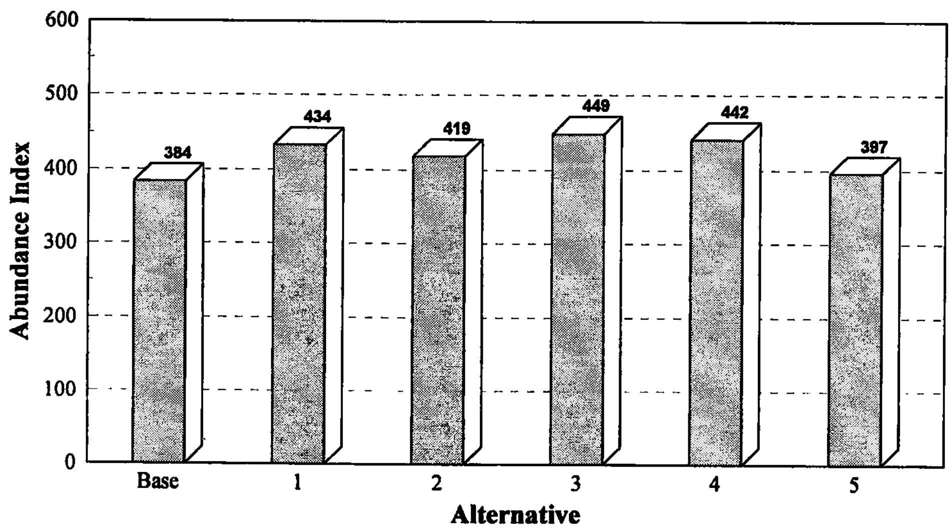
Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.

Figure XI - 17
Sacramento Splittail



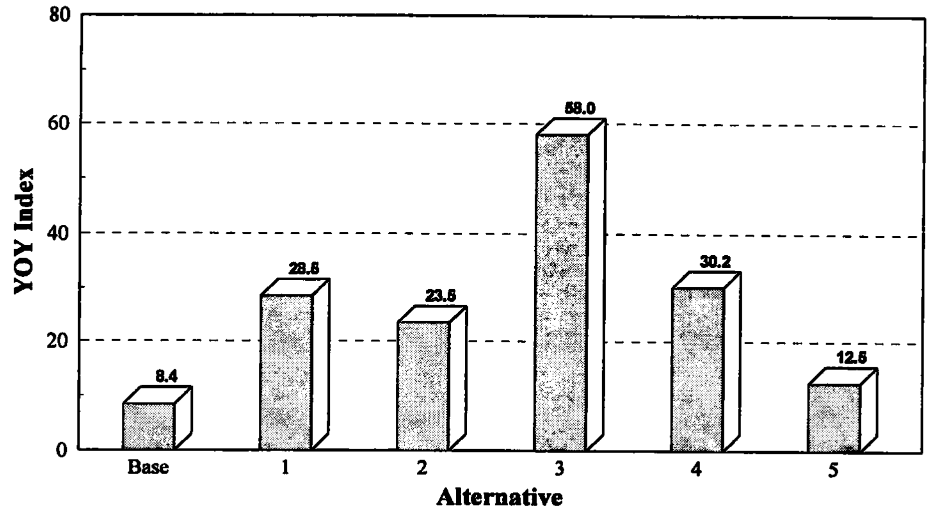
Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.

Figure XI - 18
One-Year-Old Starry Flounder



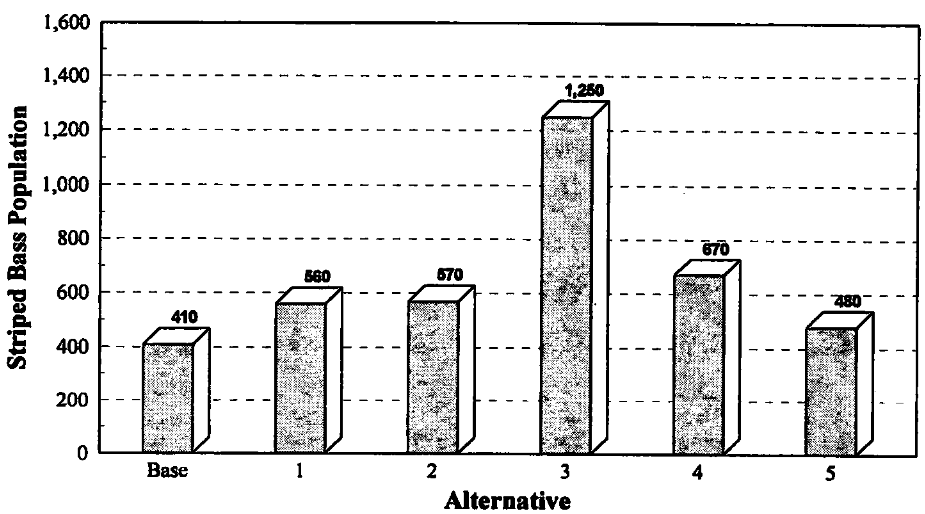
Abundance index values are obtained using the DFG model and DWRSIM model output for 1922-1992.

Figure XI - 19
Striped Bass YOY Index



Abundance index values are obtained using the DFG striped bass model and DWRSIM model output for 1922-1992.

Figure XI - 20
Adult Striped Bass Population



Abundance index values are obtained using the DFG striped bass model and DWRSIM model output for 1922-1992.

period, and these months receive substantial protection in all of the alternatives. The adult striped bass population is principally dependent on the YOY and export and outflow conditions from August through March. All of the alternatives, with the exception of Alternative 3, tend to shift export pumping out of the spring period, which is considered most critical for estuarine protection, and into the fall and winter. The striped bass model indicates that this shift will cause the benefits of increased YOY in the alternatives to be largely lost, probably through increased entrainment in the fall and winter.

The fall-run chinook salmon models predict increases in smolt survival during migration through the Delta for all of the alternatives. On the San Joaquin River, smolt survival for all of the alternatives more than doubles due to construction of the Old River barrier. The high flows at Vernalis combined with the export constraints of 1,500 cfs in Alternatives 1 and 4 cause these alternatives to have the highest predicted smolt survivals on the San Joaquin River. On the Sacramento River, the smolt survival increases are largely driven by the closure of the Delta Cross Channel gates. The model covers the period from April through June, and it predicts increased survival when the Delta Cross Channel gates are closed, as described in Chapter VI. Alternatives 1 through 4 require the gates to be closed throughout this period, and consequently these alternatives have very similar predicted survival indices. Alternative 5 requires the gates to be closed from February 1 through May 20 and for four days a week from May 21 through June 15. The base case assumes that the gates are open throughout the April to June period. Therefore, the base case and Alternative 5 have the lowest smolt survivals.

D. RATIONALE FOR SELECTION OF PREFERRED ALTERNATIVE

The first step in setting objectives for the aquatic resources of the Bay-Delta Estuary is to develop a scientific understanding of the factors that have contributed to the decline of these resources and are subject to regulation. As discussed in section C of this chapter, all of the alternatives share similar elements, which are based on this scientific understanding. The principal elements consist of: (1) higher outflows in the February through June period for general estuarine protection; (2) higher flows in the San Joaquin River in the spring to improve migratory conditions for chinook salmon, and improve habitat conditions in the south Delta; (3) fixed or variable export constraints to reduce entrainment; and (4) construction and operation of barriers to minimize the movement of eggs, larvae, and smolts towards the export pumps.

The second step in setting objectives is to determine the level of protection that will ensure reasonable protection of the beneficial uses (aquatic resources) and will prevent nuisance. This step requires the SWRCB to consider the competing demands for the available water supply. Unlike objectives for parameters such as toxics, dissolved oxygen, or temperature, factors such as flow and export rates do not have identifiable threshold levels that limit the beneficial uses' viability. Instead, the available information indicates that a continuum of protection exists. (This statement is illustrated by the description of the aquatic resource models in Chapter VI.) Higher flows and lower exports provide greater protection for aquatic resources. Apparently, the maximum level of protection requires unimpaired flow conditions and elimination of exports, although natural conditions are not always optimal for all the species present in the Delta.

In the SWRCB's judgement, the set of objectives in Alternative 5 provides the most reasonable protection for the aquatic resources among the alternatives considered. This alternative includes the elements identified above, and it includes flow requirements and export constraints throughout the year. The SWRCB believes that low flows and entrainment to the export pumps are problems throughout the year.

The following four factors were important elements in the SWRCB's determination that Alternative 5 provides the most reasonable level of protection. First, the urban and agricultural sectors of the State are dependent on water supplies from the Bay-Delta Estuary watershed. Their uses are competing beneficial uses for the water supplies used by the aquatic resources. Second, the SWRCB will periodically review these objectives to determine whether the standards have stabilized and enhanced the condition of aquatic resources, as expected. This review will be based on information obtained through the extensive monitoring program in the Bay-Delta Estuary required by the SWRCB. Third, the objectives in this plan are only one part of the overall program to improve aquatic resource conditions. Substantial improvement will also be provided through implementation of the recommendations in the draft plan and through the long-term planning process for the Bay-Delta Estuary established in the Framework Agreement. Fourth, these standards were developed and agreed to by representatives of the urban, agricultural (principally urban and agricultural water exporters), and environmental communities together with State and federal fishery and water agencies. This agreement was signed on December 15, 1994, and marks a turning point in resolving the contentious issues that have surrounded the establishment of Bay-Delta standards.

Literature Cited in Chapter XI

CUWA. 1994. Recommendations to the State Water Resources Control Board for a Coordinated Estuarine Protection Program for the San Francisco Bay-Sacramento and San Joaquin River Delta Estuary (August 25, 1994). California Urban Water Agencies. 59 pp.

DFG. 1992. Summary and Recommendations for the Department of Fish and Game's Testimony on the Sacramento-San Joaquin Estuary. Department of Fish and Game. 31 pp. (WRINT-DFG-8)

Herbold, B. 1994. Letter from Bruce Herbold of the U.S. Environmental Protection Agency to George Barnes, California Department of Water Resources. June 10, 1994.

Seraydarian, H. 1994. Letter from Harry Seraydarian of the U.S. Environmental Protection Agency to Wayne White, U.S. Fish and Wildlife Service. August 31,1994

USFWS. 1992. Abundance and Survival of Juvenile chinook Salmon in the Sacramento-San Joaquin Estuary, 1991 Annual Progress Report (June 1992). United States Fish and Wildlife Service. (WRINT-USFWS-9)

CHAPTER XII. ECONOMIC IMPACTS OF THE PREFERRED ALTERNATIVE

A. OVERVIEW

The proposed standards will reduce the amount of water pumped from the Delta by the SWP and the CVP below the amount permitted under D-1485. In addition, the standards will reduce the amount of water that can be diverted from tributaries of the San Joaquin River. These water supply impacts are discussed in detail in Chapter VII. Water deliveries to SWP contractors are also affected by the Monterey Agreement. Among the provisions of this agreement, made in December 1995, is a change in the way that deliveries are curtailed in dry years. In general, deliveries to agricultural contractors are cut back less and deliveries to urban contractors are cut back more than under the operating agreements previously in force.

The economic impacts presented in this chapter are based on a comparison of water deliveries under the preferred alternative and operations under the Monterey Agreement to deliveries under D-1485 and the operating agreement existing until December 1995. Because provisions of the ESA currently limit deliveries to below those permitted under D-1485, the economic impacts presented here are larger than those that would result from implementation of the plan given actual current conditions.

The economic impact of implementation of the draft plan on agriculture may vary substantially depending on the extent that water can be transferred between users and on the extent that growers are able to respond to reduced availability of surface water by changing crops and pumping groundwater. Under the most pessimistic scenario examined in this analysis, where water transfers are limited and growers are unable to change crops, losses in producers' net income average $14 million annually. However, with more water transfers and greater flexibility in plantings, losses could be lower than half this figure.

Total job displacement resulting from reduced agricultural production averages about 1,000 jobs under the most pessimistic scenario. Although this job displacement may cause individual hardship, it is small in comparison to total employment in the area and is likely to be absorbed by general economic growth.

Impacts on urban water users depend on utilities' ability to secure supplies of transferred water. If all of the water supplies are replaced by transferred water, the total cost to utilities will average $5 million annually. Payments to growers for transferred water will offset the income losses from reductions in water deliveries to agriculture. However, if water utilities respond to the standards by imposing rationing on their customers, the resulting shortage costs are estimated to be in the region of $33 million annually.

Detailed benefits of the preferred alternative could not be estimated because of resource constraints and uncertainty regarding water users' response to the draft plan. Moreover, the effect of regulatory action on fish populations is not known with certainty. However, a review of the literature covering the economic value of resources similar to the Bay-Delta system shows that the benefits of protection are potentially significant.

B. IMPACTS ON AGRICULTURE

1. Introduction

The proposed standards will reduce the amount of water delivered to growers by the SWP and the CVP and by irrigation districts on the east side of the San Joaquin valley. Growers will likely fallow acreage and change crops in response to reduced deliveries of water. In many cases, growers will be able to pump additional groundwater, use water transferred from other areas, use what water they have on high-valued crops, and improve their irrigation systems; these actions will offset the impacts of reduced deliveries. Nevertheless, agricultural production will be reduced because less water will be available overall. Growers' income will be reduced, both because production will be reduced and because groundwater and transferred water will be more expensive than project water. Reduced production will also result in job losses in agriculture and other industries in the areas affected by the reduced deliveries. These impacts are discussed in section D of this chapter.

The cost that the standards will impose on growers is measured as the impact of the standards on producers' net income. Producers' net income is defined as crop production receipts less operating costs. Operating costs include labor, fuel, seed, chemicals, and groundwater pumping. In other words, producers' net income is the return to land, improvements, management, and business risk. Because producers' net income includes the return to land and improvements, impacts on producers' net income include impacts on land values.

Impacts on gross crop production are also presented. These figures do not represent the impact on agriculture because about half of gross production receipts is spent on operating costs, which fall as production is curtailed. However, impacts on gross production are useful for comparison with production trends in recent years.

The economic analysis of the preferred alternative was done by estimating water supplies in 21 regions in the Central Valley under D-1485 and two alternative standards for which information was available in mid-October 1994. Economic models were used to estimate agricultural production in each region with these water supplies. When water deliveries under the preferred alternative became available, agricultural production under this alternative was estimated by interpolation. The economic impacts of the preferred alternative were estimated from the difference between agricultural production under D-1485 and agricultural production under the preferred alternative.

2. Water Supplies

a. Project Deliveries. The economic analysis was based on estimates of water deliveries to SWP contractors and CVP regions obtained from DWRSIM modeling studies. More information on the use of DWRSIM is in Chapters VI and VII. Water deliveries were estimated for 71 years of historical hydrology under D-1485 and the alternative standards under consideration by the SWRCB. Deliveries to CVP contractors were estimated from the DWRSIM output using a model of the control rules of the CVP developed by Larry Dale Associates in cooperation with Westlands Water District (Dale 1994).

b. Eastside Districts. No models of reservoir operations on the Merced and Tuolumne rivers are available. Consequently, it is uncertain how the requirements for additional flows in the San Joaquin River will affect deliveries to growers in irrigation districts diverting water from these rivers. For the purposes of this analysis, it was assumed that these eastside districts have no flexibility in operating their reservoirs and must reduce deliveries to growers by an amount equal to their contribution to the additional flow. Since some changes in reservoir operations are in fact possible, this assumption has the effect of exaggerating the economic impacts of the standards.

c. Other Local Supplies. Data compiled by the USBR were used to estimate local supplies in each region. Actual local supplies for the period of 1985-1992 were used to estimate local supplies that would be expected in the 71 years of DWRSIM deliveries. Throughout this analysis, it was assumed that, except for the eastside districts, availability of water from local supplies was not affected by the standards.

d. Groundwater. Groundwater use varies from year to year depending on the availability of surface water. Data compiled by the USBR for the period of 1985-1992 were used to establish a relationship between groundwater use and deliveries of surface water in each region. This relationship was used to estimate average groundwater use in each year with water deliveries under D-1485.

3. Assumptions and Methodology

a. General. The extent of the economic impacts of the standards depends largely on the ability of growers to use groundwater and transferred water and to change crops and irrigation systems. This ability is not known with certainty; consequently, impacts were estimated under a number of scenarios which embody various assumptions on the response of the agricultural sector to reduced water deliveries. All of the scenarios embodied the assumption that growers were not able to respond to reduced availability of water by changing their irrigation systems. Because this assumption removes one of the ways that growers can respond to water cutbacks, it tends to overestimate the economic impacts of the standards.

b. Year Types. It is impractical to do an analysis of economic impacts in every year for which simulated water deliveries are available. For the purposes of this economic analysis, the years were grouped into three year types, based on water deliveries. Because economic impacts depend on water deliveries rather than hydrologic conditions, this grouping is a better basis for economic analysis than a grouping based on hydrologic conditions. The low-delivery years are the seven years of lowest water deliveries under a particular standard. In this context, water deliveries means the total of CVP deliveries, SWP deliveries, and local supplies. The high-delivery years are the 36 years with the highest water deliveries, and the medium-delivery years are the remaining 28 years. The grouping is done independently for each standard. For example, the seven low-delivery years under D-1485 are not the same years as the seven low-delivery years under any of the alternative proposed standards.

c. Groundwater Use. The effect of the standards on groundwater use is complex and only partially predictable. In the short run, growers with access to groundwater are likely to partially substitute groundwater for project deliveries. However, with continued groundwater use, it is likely that groundwater will become less easily available. Water levels will fall as a result of increased pumping. Costs will increase and, in some areas, groundwater may become less available because of water quality problems or other physical limitation. It is also possible that concern over depletion of groundwater may lead to restrictions on pumping.

Two alternatives on groundwater use were considered in the analysis. In the first, groundwater use is assumed to increase with water shortages in the same way as it has in recent years. The relationship between water deliveries and groundwater use discussed in section 2.d of this chapter was used to estimate groundwater use in each region under the reduced deliveries following the implementation of the standards. This alternative represents the likely short-term response of growers to reduced deliveries of project water.

In the second alternative, groundwater use is restricted to current amounts, but with higher costs resulting from several years of increased pumping. Because reduced deliveries are likely to result in increased groundwater use for several years, this represents a lower limit on the ability of growers to substitute groundwater for project water and so will tend to exaggerate the economic impacts of the standards.

d. Water Transfers. The extent to which growers are able to use water transferred from other areas is of crucial importance in this analysis. Reductions in water deliveries to growers of high-valued vegetable and tree crops, or growers in areas with favorable soil and climatic conditions, will have large economic impacts. These impacts will be mitigated significantly if these growers can use water transferred from growers of low-valued crops or growers in less productive areas.

The extent to which water transfers will increase as a result of the standards is uncertain. Growers of high valued crops will have a strong incentive to secure water to replace that lost from cutbacks. State policy encourages transfers which do not adversely affect legal users of water and do not unreasonably affect fish and wildlife. However, transfers may be limited the availability of facilities to transfer the water. Transfers are discussed in Chapter X, section C.

Two alternatives were considered on the extent of water transfers following the introduction of the standards. In the first alternative, cropping patterns are estimated, assuming water can be transferred freely within each of the 21 regions, but not between regions. Since transfers between regions take place, this alternative understates the extent of transfers actually occurring. Moreover, transfers are likely to increase after the introduction of the standards, since reduced water deliveries will increase incentives to transfer water. Because transfers will mitigate economic impacts, this alternative will tend to exaggerate the economic impacts of the standards.

In the second alternative, the San Joaquin Valley was divided into two regions and it was assumed that water can be transferred freely within each of these regions, but not between the two regions. The first region consisted of the eastside districts supplied by the San Joaquin River and its tributaries; the second region was the remainder of the San Joaquin Valley. This alternative illustrates an example of how economic impacts can be mitigated by transfers.

Neither of these alternatives contain trades from the Sacramento Valley to the San Joaquin Valley. Such transfers have occurred in the past and are expected to occur in the future. These transfers would mitigate the economic impact of the standards, because water, generally, is more available, and has less economic value, in the Sacramento Valley. The ability of water users to transfer water across the Delta will be subject to maintenance of the new water quality standards.

e. Crop Changes. Two alternatives on the way in which growers adjust their crop mix in response to water shortages were used in this analysis. In the first alternative, it is assumed that the only possible response to reduced water availability is to fallow some acreage. A rationing model developed by Zilberman (Dale 1994) was used to estimate how cropping patterns would respond to reductions in water deliveries under this alternative. In this model, crops are ranked within regions in order of their return to each acre-foot of irrigation water. As water supplies are reduced, crops are taken out of production in order of their net returns to water.

This model embodies the assumption that growers are always able to fallow their least-profitable crops. This is obviously a simplification of growers' actual response to reduced deliveries. In many cases, low-valued crops are planted in rotation with higher-valued crops for agronomic reasons, such as replenishment of soil nutrients or pest control. However, crop rotations are not fixed. It is likely that in years of extreme water shortages, growers use what water they have on their higher valued crops, while in years with more moderate water shortages, the need to maintain rotations has some affect on plantings.

The rationing model also embodies the tacit assumption that water can be transferred freely within each region. This assumption is a reasonable approximation of current practices. The regions in the model correspond roughly to irrigation districts or groups of irrigation districts. Trades or sales of water between growers within the same irrigation district are very common. Exchanges between irrigation districts are less common, but still fairly frequent.

In the second alternative, it was assumed that growers are able to respond to reduced water deliveries by changing crops in a way to maximize their profits under reduced water availability. The Central Valley Agricultural Production Model (CVAPM) developed by the

University of California, the DWR, and the USBR (Dale 1994) was used to estimate agricultural production in each region with the water available in each year type.

This model assumes that growers continually adjust production levels in an effort to maximize their returns on investment. In practice, growers' flexibility is limited in the short run. Consequently, production levels indicated by the model are a long-run response to changing conditions. As used in this analysis, the model implicitly assumes that growers adjust their production levels to average water supplies in the three year types. However, water supplies vary from year to year, so there will not actually be a movement toward the production levels that are optimum for supplies in the three year types. The actual long-run response to the standards will be an adjustment to lower, but variable, water availability. As a result, the model will tend to underestimate economic impacts because a complete long-run response to average supplies in each year type is never achieved.

f. Scenarios Used in Analysis. Four scenarios were developed by combining the alternatives on crop changes, groundwater use, and water transfers. Economic impacts were estimated for these scenarios. The less restrictive alternative on groundwater use was combined with the less flexible alternative on crop changes to give a "Non-Adaptive Scenario". This scenario restricts growers' ability to respond to reduced water deliveries by changing crops but allows them to pump additional groundwater. This scenario is intended to represent the immediate economic impacts of the standards; however, it overestimates economic impacts because even in the short run, some changes in crops are possible.

A second scenario was formed by combining the flexible alternative on crop changes with the more restrictive alternative on groundwater use. This "Adaptive Scenario" gives an indication of the economic impacts occurring after growers have had time to adapt to reduced project deliveries. The more restrictive alternative on groundwater use was used in this scenario because the high levels of pumping implied by the current relationship between groundwater use and deliveries of surface water cannot continue indefinitely.

Each of these two combined scenarios on crop changes and groundwater use was combined with the two alternatives on water transfers to give a total of four scenarios for which impacts were estimated. These scenarios are summarized in Table XII-1.

Table XII-1. Scenarios Used in Estimation of Economic Impacts

Alternative on crop changes and groundwater use	Alternative on Water Transfers: Within regions only	Alternative on Water Transfers: Within groups of regions
Non-adaptive No changes in crops, increased groundwater available.	*Scenario 1.* Gives an overestimate of immediate impacts of standards.	*Scenario 2.* Gives an underestimate of immediate impacts of standards. Extent of underestimation depends on how restrictive assumption on crop changes is offset by unrestrictive assumption on transfers.
Adaptive Crop changes, groundwater use restricted to current amounts.	*Scenario 3.* May give an overestimate of impacts occurring after growers have had some time to adapt because transfers are limited and growers are assumed not to change irrigation systems.	*Scenario 4.* Gives an underestimate of impacts occurring after growers have had some time to adapt.

4. Results

The cost to the agricultural sector of the SWRCB's preferred alternative may vary substantially depending on the ability of growers to change crops and use transferred water. Under Scenario 1, the most restrictive scenario, losses in net income average $14 million per year (Table XII-2). Losses are mitigated substantially by water transfers and the ability to change crops. Under Scenario 2, where water can be transferred freely within the two San Joaquin valley regions, losses are only $7 million. Transfers within the San Joaquin Valley are unlikely to be as high as implied in this scenario. However, transfers between regions are likely to increase following the introduction of the standards. Under Scenario 1, at least two-thirds of the losses in net income occur in western Fresno County. Water is very valuable in this area, particularly in low-delivery years. Growers in this area will have strong incentive to seek transfers from areas where water has less value, such as western Merced and Stanislaus counties. In addition, transfers from the Sacramento Valley to the San Joaquin Valley are likely to increase because of reduced project deliveries.

Table XII-2. Impacts on Agriculture of the Preferred Alternative

	Loss in crop production (million $/year)				Loss in producers' income (million $/year)			
	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years
Scenario 1	49	21	9	18	30	16	9	14
Scenario 2	8	9	4	6	7	7	6	7
Scenario 3	45	39	22	31	9	3	4	4
Scenario 4	-3	-19	-10	-13	0	-3	-1	-2

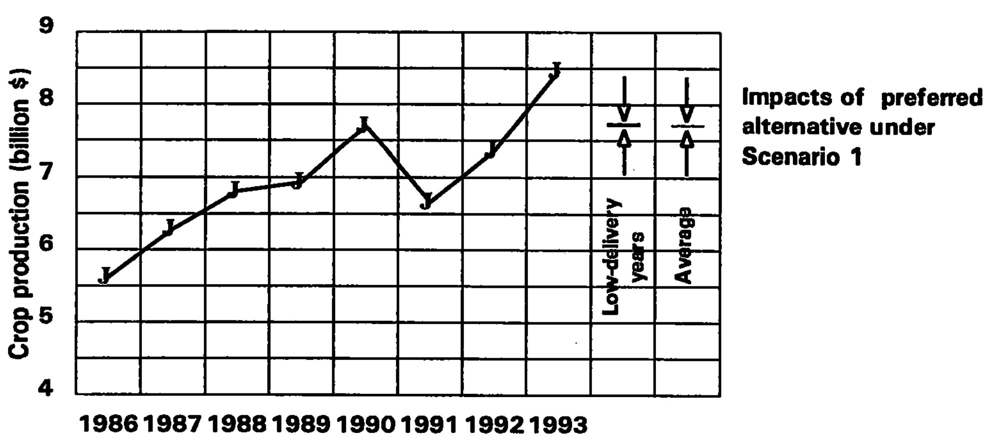
The ability to change crops also reduces impacts. Under Scenario 3, losses in net income are $4 million, showing that the gains from crop changes outweigh the losses from the more restrictive assumption on groundwater use. Under Scenario 4 there is a slight gain in net income, indicating that the gains from crop changes and extensive transfers outweigh the effects of the standards.

Economic impacts are substantially higher in dry years. Under Scenario 1, losses in the years of lowest deliveries average $30 million. This loss falls to $7 million under Scenario 2 and $9 million under Scenario 3.

All of these impacts show the effect of a change from deliveries under D-1485 and the former operating agreement of the State Water Project to deliveries under the preferred alternative and the Monterey Agreement. Because the Monterey Agreement gives agricultural water users more water in drier years, impacts will be greater if measured using D-1485 and the Monterey Agreement as a base. As noted earlier, estimates of economic impacts are based on economic analysis done using information available in October 1994. Consequently, no analysis could be made of the impact of the increase in water deliveries occurring as a result of the Monterey Agreement. However, the results suggest that in the absence of changes in water quality standards, the Monterey Agreement will result in an increase in net income of $5–10 million in low-delivery years and up to $5 million in medium-delivery years. The Monterey Agreement will have no effect in high delivery years. Thus, impacts measured using D-1485 and the Monterey Agreement as a base will be $5–10 million greater in low-delivery years and up to $5 million greater in medium-delivery years than the figures presented in Table XII-2.

Losses in crop production range widely, depending on year type and assumption on transfers and crop changes. However, these losses are within the range of the normal fluctuation in agricultural production in the last several years. Between 1986 and 1990, crop production in the eight San Joaquin Valley counties increased by an average of $520 million annually (Figure XII-1). Under Scenario 1, the loss in low-delivery years resulting from the preferred alternative is $49 million but averages only $18 million.

Figure XII-1. Recent Crop Production and Impacts of Preferred Alternative



C. IMPACTS ON URBAN WATER USERS

1. Introduction

The proposed standards will reduce deliveries of SWP and CVP water to water wholesaling agencies. The water deliveries affected will be SWP deliveries to the Metropolitan Water District of Southern California (MWD) and SWP and CVP deliveries to the Santa Clara Valley Water District (SCVWD). Opportunities for developing new water supplies are very limited. Consequently, these agencies and retail water utilities that they serve are likely to respond by arranging transfers of water from agricultural users, increasing use of recycled water, reducing water use by more extensive conservation programs, and perhaps imposing rationing on their customers.

Because of resource constraints, this analysis does not examine the extent to which water utilities might increase use of recycled water and reduce water demand further by conservation programs. Consequently, economic impacts were estimated under the assumption that the only options available to water utilities are additional water transfers and rationing. To the extent possible, wholesaling agencies and water utilities will try to avoid rationing by arranging water transfers, since the cost of transferred water is far lower than the shortage costs that occur as a result of water rationing. However, transfers are limited by the factors discussed in Chapter X, section C and lack of physical transfer capacity at the time of year when the water can be used by water utilities. The SCVWD is particularly limited by a lack of physical transfer capacity.

Modeling results reported by the USEPA (USEPA 1994) indicate that significant transfer capacity exists in the SWP system in late summer. In order to make use of this capacity, the MWD and the SCVWD would need to increase storage near their service areas, since the transfer capacity is not available at the same time as the transferred water could be used. The SCVWD's storage capacity is currently limited. The MWD is in the process of increasing its storage capacity.

Because the extent to which water agencies will be able to replace project deliveries with transferred water is unknown, economic impacts of two scenarios were estimated. In one scenario, it is assumed that the entire reduction in water project deliveries is replaced by water transfers. The value of the impacts was estimated as the cost of the replacement water. Estimates of the cost per acre-foot of replacement water were developed in consultation with planning staff of the MWD and the SCVWD. The cost of transfers to the MWD was estimated as $200 per acre-foot, and the cost of transfers to the SCVWD was estimated as ranging from $250–350 per acre-foot.

In a second scenario, it is assumed that no additional water transfers can be made so that reduced deliveries result in water rationing. The value of impacts was estimated as the shortage costs resulting from this rationing. Shortage costs were estimated using a cost function developed by Larry Dale Associates (Dale 1994). The function is as follows: for shortages of up to 10 percent, shortage costs are $1,400 per acre-foot; for shortages of 10 to 20 percent, shortage costs are $1,700 per acre-foot; and for shortages over 20 percent, shortage costs are $2,000 per acre-foot.

2. Results

Under the transfer scenario the total cost of transferred water averages $5 million annually; costs average $30 million in the seven low-delivery years. The total amount of water transferred to both service areas averages 23,000 acre-feet over all year types and averages 130,000 acre-feet in low-delivery years. More details are given in Table XII-3. A study of SWP operations (Dale 1994) indicated that sufficient capacity exists to make these transfers. However, for several reasons, transfers may be limited to less than these amounts. For example, in dry years, less water may be available for transfers.

Because water utilities have good access to credit and can borrow to cover high costs occurring in dry years, the average costs over all years are the relevant measure of costs to utilities. Under the transfer scenario, the average cost of transferred water to the MWD is less than two tenths of one percent of the total retail cost of water delivered to urban users in southern California. The average cost of transferred water to the SCVWD is about three tenths of one percent of the total retail cost of water delivered to the south San Francisco Bay Area.

Table XII-3. Impacts of Preferred Alternative on Urban Water Users

	Seven low-delivery years	71-year average
Metropolitan Water District		
Reduction in deliveries (acre-feet)	105,000	15,000
Cost of transfers ($ million)	21	3
Additional shortage costs if no additional transfers possible ($ million)	147	21
Santa Clara Valley Water District		
Reduction in deliveries (acre-feet)	25,000	8,000
Cost of transfers ($ million)	9	2
Additional shortage costs if no additional transfers possible ($ million)	43	12

Under the second scenario with no additional transfers, shortage costs in both agencies' service areas were estimated as averaging $190 million in the low-delivery years (Table XII-3). These costs are additional to shortage costs occurring under baseline conditions. Over all years, shortage costs average $33 million annually.

Shortage costs represent the value lost to consumers as a result of reducing water use below desired levels, rather than out-of pocket expenses for increased water bills. Shortage costs are a measure of value of the cost and inconvenience to consumers of reducing water use in response to rationing and price increases. These costs reflect the following responses. Some consumers will pay more rather than reduce their use, some consumers will reduce their water use by purchasing water-saving devices, and some consumers will choose to bear the inconvenience of using less water.

These impacts represent the combined effect of the introduction of the standards and the change in SWP operation specified in the Monterey Agreement. Because the Monterey Agreement will reduce deliveries to urban contractors in dry years, impacts will be smaller than those presented in Table XII-3 if the Monterey Agreement is included in the base. In the case of MWD, about 30 percent of the impacts in the seven low-delivery years result from the Monterey agreement. For SCVWD, about 40 percent of the impacts in the seven low-delivery years result from the Monterey agreement.

D. IMPACTS ON REGIONAL ECONOMIES

1. Extent of Impacts

a. General. Reductions in water deliveries to agriculture will affect all sectors of the economy. When farm production falls as a result of reduced water availability, growers will hire fewer seasonal workers and may lay off some year-round workers. Until they find other jobs, consumer spending by these workers is likely to fall, affecting retailers and other businesses in the area. In addition, growers will reduce purchases of equipment, materials, and services from local businesses, reducing jobs and income with these suppliers.

Job and income losses resulting from the preferred alternative were estimated using input-output analysis, a widely-used economic technique. The procedure is described in section D.2 of this chapter. Input-output analysis usually overestimates indirect job and income losses. One of the fundamental assumptions in input-output analysis is that trading patterns between industries are fixed. This assumption implies that suppliers always cut production and lay off workers in proportion to the amount of product supplied to farms or other industries reducing production. In reality, businesses are always adapting to changing conditions. When a farm cuts back production, some suppliers will be able to make up part of their losses in business by finding new markets in other areas. Growth in other parts of the local economy will often provide opportunities for these firms. For these and other reasons, job and income losses estimated using input-output analysis should be treated as upper limits on the actual losses expected.

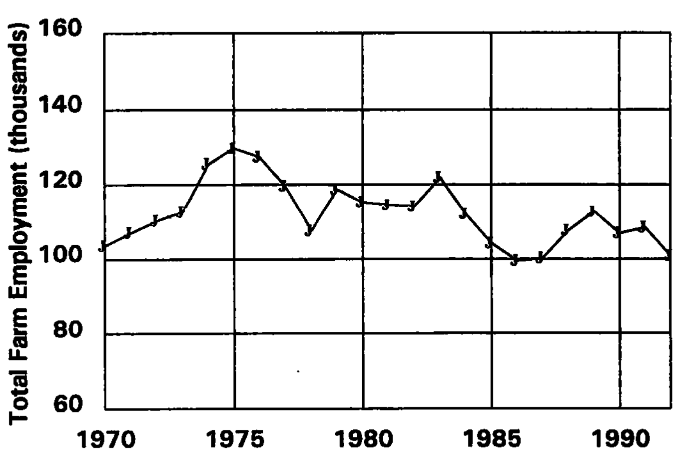
b. Employment Impacts. The effect of the preferred alternative on employment may vary substantially, depending on the extent to which growers change crops or use groundwater and transferred water. Under Scenario 1, where crop changes and access to transferred water are limited, the number of jobs displaced in the agricultural sector is estimated to average about 230 over all years, but climbs to about 640 in low-delivery years (Table XII-4). However, under Scenario 2, where water can be transferred throughout the San Joaquin Valley, job displacement is significantly lower, particularly in low-delivery years. Short-term job impacts are likely to be higher than the displacements shown for Scenario 2. However, Scenario 2 gives an indication of the potential effect of water transfers on job impacts.

Table XII-4. Regional Employment Impacts of the Preferred Alternative

	Direct job displacement				Indirect job displacement			
	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years
Impacts of reduced deliveries to agriculture								
Scenario 1	640	270	120	230	900	380	170	320
Scenario 2	100	120	50	80	140	170	70	110
Scenario 3	590	510	290	400	830	710	410	560
Scenario 4	-40	-250	-130	-170	-60	-350	-180	-240
Impacts of transfers to urban users								
Hay and grains only	160	—	—	30	220	—	—	40
Hay, grains, field crops	420	—	—	80	590	—	—	110

This job displacement is within recent fluctuations in farm employment. Farm employment in the San Joaquin Valley has gradually drifted downward since the mid-1970s, fluctuating by an average of 5,600 each year since 1975 (Figure XII-2). The job displacement under Scenario 1 in low-delivery years—the most severe condition—is about three-quarters of the drop in farm employment between 1980 and 1981.

Figure XII-2. Farm Employment, San Joaquin Valley



It should be emphasized that these displaced jobs do not represent a permanent job loss to the region. Regional job markets are affected by growth in all sectors of the economy and migration to and from the area. Moreover, the agricultural labor force is very mobile with a high proportion of seasonal workers. A job displacement in agriculture is likely to result in a slight decrease in net migration into the area and a change in seasonal movements of workers. As a result, the effect of the standards on the number of unemployed farm workers in the area will be smaller than the job displacement indicated by this analysis, and will gradually decline as migration patterns change and the rest of the economy grows.

Job displacements in other sectors of the economy range up to 560 when averaged over all years. In the low-delivery years, indirect job displacements range up to 900. Although these job losses will cause individual hardship, they are small in comparison to total employment in the San Joaquin Valley. Total employment in the eight San Joaquin counties is just over 1,000,000. The region added an average of 23,000 jobs annually between 1980 and 1990. The area has lost jobs in recent years, but job growth is likely to resume as California's economy recovers, absorbing this job displacement.

c. **Income Impacts.** Income losses also give an indication of the extent of impacts on the region's economy. Income losses are estimated using input-output analysis and like the estimates of employment impacts, should be treated as upper limits. Income losses as estimated by input-output analysis will occur only if displaced workers are unable to find other jobs and businesses supplying growers and their employees have very limited ability to find new markets.

In low-delivery years, the estimated losses in personal income resulting from the SWRCB preferred alternative range up to $40 million depending on transfers, groundwater use, and the ability of growers to change crops (See Table XII-5). These income losses are small in comparison to total personal income in the region. Between 1980 and 1990, personal income in the San Joaquin Valley counties increased from $14.4 billion to $21.0 billion when measured in constant 1992 dollars.

Table XII-5. Regional Income Impacts of the Preferred Alternative

	Total job displacement				Loss in personal income (million $/year)			
	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years	Low-delivery years	Medium-delivery years	High-delivery years	Average over all years
Impacts of reduced deliveries to agriculture								
Scenario 1	1,540	650	290	550	41	21	12	19
Scenario 2	240	290	120	190	11	13	8	10
Scenario 3	1,420	1,220	700	960	33	28	16	23
Scenario 4	-100	-600	-310	-410	-2	-14	-7	-9
Impacts of transfers to urban users								
Hay and grains only	380	—	—	70	—	—	—	—
Hay, grains, field crops	1,010	—	—	190	—	—	—	—

d. Impacts on Industries Processing and Using Farm Products. The impacts discussed in the preceding section are limited to impacts resulting from losses in farm jobs and reduced purchases by growers. In addition to these impacts, there will be impacts on industries processing, distributing, and using farm products. If these industries reduce their output, there will be additional indirect impacts.

Not enough information was available to allow estimates of these impacts to be made. Reduced availability of locally-produced farm products will affect every industry differently. In some industries, such as fruit and vegetable canning and drying, there is a strong linkage between production and availability of locally-produced materials. These industries may be forced to reduce their output if local farm production is reduced. However, in many industries, such as bakery products, production is driven by other factors, such as markets in nearby urban areas. Output in these industries is less likely to be affected by changes in local farm production.

Reduced production of grains and alfalfa is likely to affect the dairy industry. Alfalfa, a high water use crop, will likely be grown in lesser amounts in the San Joaquin Valley. Reductions in alfalfa production could have an impact on the dairy industry, which relies heavily on alfalfa as a food source. The remainder of this subsection is based on comments submitted by Western United Dairymen (Northwest Economic Associates 1994). The accuracy of this information has not been verified by SWRCB staff.

Most of the alfalfa consumed in California is produced in the state. California alfalfa production in 1992 was 6.4 million tons, of which 41 percent was produced in the northern San Joaquin and Sacramento valleys, 18 percent in the southern San Joaquin Valley, and 41 percent in southern California. Because of high transportation costs, alfalfa is used primarily in the region it is produced.

Dairy cows account for about 50 percent of total state alfalfa consumption. About 25 percent of the state's dairies are located in the southern San Joaquin Valley, producing approximately 35 percent of the state's milk. These dairies are likely to be most affected by the proposed standards.

The primary impact on the southern San Joaquin dairies of reduced alfalfa acreage would be higher costs to transport alfalfa from more distant locations. In addition, the acreage reductions could increase alfalfa prices.

Northwest Economic Associates estimated the acreage reductions, price increases and additional transportation costs that would result from various levels of water shortage. Dairy industry cost increases are measured as the increased delivered costs of alfalfa that must be purchased to make up for regional shortfalls. These estimates were made independently of the estimates of changes in acreage described in section B of this chapter. According to this analysis, dairy industry costs would increase by $5.5 million at water shortages of 30 percent, and $13.8 million at water shortages of 50 percent. These costs represent 0.2 and 0.5 percent of total industry revenues, respectively. The costs would be split between the dairy industry and consumers in an unknown manner, depending on whether the dairy industry is able to pass on increased costs by raising prices.

e. Impacts of Transfers to Urban Use. Transfers of water to urban use may have economic impacts in the areas from which the water is transferred. To the extent that transfers depend on land fallowing, these impacts will depend on the crops fallowed by the transferring growers. Impacts will generally be lowest if grains and pasture are fallowed to release water for transfer, and higher if field crops or vegetables are fallowed. Regional impacts will be offset by funds received for water transfers. If growers use these funds to make improvement to their operations, this spending will offset the impacts of crop fallowing.

Growers are likely to fallow their lowest valued crops when releasing water for transfer. The direct and indirect job impacts of the transfer discussed in section C of this chapter are shown in Table XI-4. If there are no offsetting job gains from spending of transfer funds, job displacement in low-delivery years are estimated as about 400 jobs when the fallowing is confined to hay and grains, and about 1,000 jobs when the fallowing is evenly divided between hay, grains, and field crops. Job displacement from water transfers is insignificant when averaged over all year types. The effect of this job displacement on local labor markets will depend on how the fallowed acreage is distributed. However, if the fallowed acreage is distributed throughout the Central Valley, job impacts on labor markets will be insignificant even in low-delivery years.

2. Details of Estimation Methods

Wage losses in agriculture were estimated from changes in agricultural production using a ratio of labor costs to sales derived from statistics published in the *1987 Census of Agriculture* (U.S. Department of Commerce 1989). Payroll-to-receipts ratios ranged from 12 percent for farms primarily growing cash grains (SIC 011) to 31 percent for farms primarily growing vegetables, fruits, and tree nuts (SIC 017, 018). This analysis used the ratio for general crop farms (SIC 019), which was 20 percent. Employee benefits in agriculture are lower than in other industries, so wages represent nearly all of labor costs. Wages were estimated as 90 percent of labor costs. The number of year-round equivalent direct jobs displaced was estimated from the wage loss using average weekly earnings for crop production workers in the San Joaquin Valley (Employment Development Department no date).

Impacts on farm income were estimated by multiplying impacts on total crop production by the ratio of farm income and agricultural production for the San Joaquin Valley in the years 1986–1992. Farm income consists of agricultural wages and salaries plus income of farm proprietors. The ratio was estimated from crop production as reported by the California Department of Food and Agriculture and farm income as estimated by the U.S. Bureau of Economic Analysis.

The regional effects of reduced farm production were estimated using input-output analysis. Multipliers were estimated using the Implan system (1991 database), developed by the Minnesota Implan Group, Stillwater, Minnesota. The job multiplier for the region consisting of the eight San Joaquin Valley counties was estimated as 2.4 and the income multiplier was estimated as 2.7.

The job multiplier gives an estimate of the total number of jobs supported by each job in crop production. The multiplier includes the job in crop production. Thus, the multiplier for the San Joaquin Valley indicates that each job in crop production supports 1.4 jobs with suppliers and in businesses serving employees of farms and businesses supplying farms. The indirect job displacement shown in Table XI-4 was estimated using this figure.

The income multiplier gives an estimate of the total amount of income in the region created by each dollar in income in agriculture. Again, since the multiplier includes the income in agriculture, the multiplier for the San Joaquin Valley indicates that every million dollars in wages and salaries and proprietors' income in agriculture supports $1.7 million in personal income in the rest of the economy.

E. IMPACTS ON HYDROELECTRIC POWER PRODUCTION

1. Introduction

Hydroelectric power generation plants provide approximately 24 percent of California's electricity generating capacity. The system provides inexpensive peak power production. It is particularly valuable since it can be turned on and off to match daily load swings. Also, it displaces fossil-fuel generation in urban areas during the hottest part of the day, decreasing air pollution.

The proposed water quality standards will affect hydropower by requiring additional reservoir releases during the spring. As a result, hydroelectric power production will be shifted from the summer, when it is most valuable, to spring. The costs of lost summertime hydropower will be borne by the municipal utilities that purchase their lowest cost power from the Western Area Power Administration (WAPA).

The standards will also increase peak loads on the systems of the Pacific Gas and Electric Company and Southern California Edison. Energy use during the summer months is likely to increase as growers respond to reduced deliveries of SWP and CVP water by increasing groundwater pumping. The costs of increased agricultural pumping will be incurred by agricultural energy customers. These costs are included in the impacts discussed in section B of this chapter.

In addition, decreases in hydroelectric generation during the summer can be expected to increase generation from less efficient thermal power plants, increasing air pollution. The costs of increased air pollution will likely be borne by residents located near PG&E's natural-gas fired power plants.

The following analysis of the impact of the plan on hydroelectric power generation was provided by the Association of California Water Agencies (ACWA) and the WAPA (Beck 1994 and WAPA 1995). Costs represent increased CVP capacity costs, increased groundwater pumping costs, and increased air pollution costs.

2. Effect on CVP Hydroelectric Capacity Requirements

In the process of storing and transporting water for delivery to agricultural and municipal water users, the CVP both produces and consumes hydroelectric power. The hydropower produced is sold to municipal and agricultural customers by the WAPA. The CVP's hydroelectric facilities include Shasta Dam and Folsom Dam in northern California. The CVP hydrosystem capacity is approximately 1,800 megawatts (MW).

The objectives in the plan will result in shifting water releases, and CVP hydropower generation, to the winter and spring months at the expense of summer power generation. This shift will cost WAPA and its customers about $25 million annually from a long-term or regional perspective when compared to D-1485. This cost represents the value of lost summer hydroelectric capacity, offset by revenue generated by selling surplus capacity during the non-summer period, and energy savings from decreased project pumping. The loss of summertime hydropower capacity and energy will be borne by municipal utilities that purchase their lowest cost power from the WAPA.

Capacity is the amount of resources necessary to meet demand at any time. When the capacity of a resource is reduced, for example due to less storage in reservoirs, the utility must either purchase or build replacement capacity. Increased capacity costs for the CVP equal the amount of summer hydroelectric capacity that is lost relative to the base case. Capacity purchases are usually made on an annual rather than monthly basis. As a result, surplus capacity will be available for sale during certain times of the year.

The CVPIA created the CVP Restoration Fund, which provides for payment of up to $50 million annually for enhancements of the CVP project. Payment into the fund is allocated among power and water customers. To the extent that contributions from water users are reduced due to reduced water deliveries, the CVPIA requires that power customers increase their contributions to make up the difference. Reductions in water deliveries could result in additional payments of $1.8 to $3.0 million annually to the fund by power customers. This cost is a transfer from water customers to power customers.

In addition to the impacts associated with changes in energy production, there are also secondary effects associated with each alternative. These include the drawdown of New Melones Reservoir which could prevent that project from providing reserves to the CVP system, and reduced operational flexibility of the CVP hydroelectric facilities resulting in a long-term reduction in competitiveness of the project. (R.W.Beck, 1994)

3. Increased Groundwater Pumping

Reductions in water deliveries will likely translate into increased groundwater pumping, increasing agriculture's demand for energy, especially during the summer months. Agriculture demands about three percent of the load in the PG&E and SCE territories (McCann et. al 1994). Upwards of 70 percent of this load is related to groundwater pumping. An estimate of increased groundwater pumping was made by M. Cubed (McCann et. al 1994). That estimate was made independently of the cost estimates appearing in the section B of this chapter. The value of increased capacity required for agricultural pumping, according to M. Cubed, would be between $16.0 million and $16.5 million for the 1995 - 2000 period. Most of this cost would be incurred by agricultural energy customers (McCann et. al 1994).

4. Air Quality

The shifting of energy from the summer to other times of the year and the added capacity required for agricultural groundwater pumping could impact air quality. Decreases in hydroelectric generation during the summer can be expected to increase generation from less efficient thermal power plants.

For all three alternatives, the annualized costs are about $2.5 million per year for the 1995-2000 period. These costs are based on standard unit emission costs used by the California Energy Commission. The costs of increased air pollution will likely be borne by residents located near PG&E's natural-gas fired power plants, such as those in Pittsburg, Antioch, Moss Landing, Morro Bay, and Hunters Point. (McCann et. al 1994)

F. BENEFITS

The preferred alternative is capable of producing a wide range of benefits. Due to information limitations, however, the specific economic values of those benefits could not be estimated. In lieu of specific estimates, this section will qualitatively describe the preferred alternative's benefits, and, by way of illustrating the likely magnitude of those benefits, summarize the findings reached in other, related studies.

The preferred alternative's benefits range from those that would accrue to those who use Bay-Delta resources directly (such as commercial and recreational anglers), while others would accrue to people who do not even visit the Bay-Delta. Estimating the value of some of these benefits is a relatively simple matter of recording their effects on market transactions. Increased income from improved commercial fishing harvests can be measured in this way (provided that changes in fish populations are known). Other categories of benefits have little or no effect on markets. Hunting, fishing, and hiking are examples of active use benefits which can only be partially estimated by observing market behavior. Passive use values are held by people who may never use a good they value. People who may never visit the Sacramento-San Joaquin Delta, for example, might be willing to pay to improve conditions there. Passive use values include: (a) the satisfaction of knowing that certain valuable environmental qualities remain unthreatened (existence value); (b) preserving the option to make future use of qualities such as these (option value); and (c) knowing that qualities such as these will be available to future generations (bequest value).

The techniques used for estimating the value of benefits which have little or no effect on private markets yield values which are functionally equivalent to market prices, and which are sufficiently accurate for use in the public policy decision-making process (Arrow et al. 1993; Carson et al. 1994; Mitchell and Carson 1989; Madriaga and McConnell 1987; Cummings et al., 1986). The two techniques most widely used for this purpose are the travel cost and the contingent valuation methods.

The baseline conditions used to estimate the impacts on urban and agricultural water users, discussed earlier in this chapter, are those allowable under the standards contained in D-1485. Due to various endangered species requirements, exports are currently well below those permitted under D-1485. As a result, environmental conditions are currently better than they would be if exports were to increase to full D-1485 levels. For the recent 1984-1992 period, the preferred alternative would result in average annual exports that are slightly higher than historical levels. Of greater importance, however, would be the significant increases in Delta outflows that would be realized under the preferred alternative. Delta outflows have long been considered to be essential to the maintenance of aquatic and estuarine habitats in the Bay-Delta system. Despite the fact that exports are not now at D-1485 levels, the appropriate comparison is between the standards contained in D-1485 and the proposed regulatory requirements. For that reason, the analysis in this section reflects a difference between a future under D-1485 conditions and a future with the preferred alternative in place.

If current water quality and habitat conditions in the Bay-Delta system are not permitted to degenerate, conditions for hunting, fishing, boating, water skiing, and wildlife viewing would also be preserved. Passive use values, possibly including the potentially large value associated with avoiding species endangerment or extinction, will also be realized. By way of illustrating the potential magnitude of some of the values the preferred alternative would produce, representative benefit estimates, from existing economic studies, are displayed in Table XII-6.

Although values specific to the Bay-Delta system cannot be extracted from most of these studies, the values they contain do establish that the overall benefits of the preferred alternative could be well in excess of its costs. The reason is that passive use values for a natural resource tend to rise sharply with increasing scarcity. Estuaries are becoming increasingly rare. Because it is the largest estuary on the west coast of the Americas (USEPA 1994), the loss of estuarine values in the Bay-Delta would greatly increase the scarcity of such resources. Economic studies of other bay and estuary systems have demonstrated the relatively high passive use values associated with rare resources such as the Bay-Delta (Hayes et al. 1992; Bockstael et al. 1988). A study of the value of preserving Narragansett Bay, for example, showed that the active use benefits of preservation were less than the costs of providing those benefits. When passive use values were included, however, the benefits significantly exceeded the costs (Hayes et al. 1992).

If an estuary protection program benefits special status species, passive use values can be even higher than they would otherwise be (see the following entries in Table XII-6: Boyle and Bishop 1987; Stevens et al. 1991; Hagen et al 1992; Rubin et al 1991; Bowker and Stoll 1988; Rockel and Kealy 1991). Although the Bay-Delta system does support special status fish species, the effects of the preferred alternative on those species is uncertain. If the preferred alternative were to prevent additional rare and endangered species listings, it could provide additional benefits in the form of avoided costs. Listing the spring-run chinook salmon, for example, could lead to potentially significant costs. Perhaps the highest of these costs would be the possible (although not certain) shutdown of the commercial and recreational salmon fisheries. Because the relative role of the many environmental variables affecting salmon populations is poorly understood, however, the effects of regulatory actions on those populations cannot be accurately predicted.

Perhaps the most important use values supported by the Bay-Delta system are commercial and recreational fishing. The fish species with the highest value to the sport and commercial fishing industries is salmon. Roughly equal in importance to salmon for recreational anglers is striped bass. The California inland river, Delta, San Francisco Bay, and offshore fisheries also include sturgeon, shad, white catfish, bay shrimp, and starry flounder. According to Dumas et al (1993), anglers from central and northern California took almost 2.5 million saltwater fishing trips during the 1985-1986 season. On 38 percent of those trips, the quarry was either salmon, striped bass, or a combination of species, which included salmon or bass.

Anglers, like most recreators, are willing to pay more for the recreational experience than the costs they actually incur (see, for example, Loomis and Cooper 1990). Actual expenditures are not included in the benefit estimate because they constitute a transfer: if the opportunity to fish

Table XII-6: Benefit Estimates from the Bay-Delta and Similar Resources

Study	Setting and Data Source	Value/Good	Estimated Net Monetary Value	Baseline year
Carson & Mitchell 1993	A nation-wide CVM survey. Active & passive use values included.	(1) Improving national water quality to "boatable" levels (2) Improving national water quality to "swimmable" levels	(1) $106 - $141 per household per year (2) $89 - $116 per household per year	1990
Whittington et al. 1994	A CVM survey of 5 Texas counties. Active and Passive Use values included.	Improving water quality in Galveston Bay	$5-$13 per household per month	1993 (?)
Bockstael & McConnell 1988	Various use, travel cost, & CVM surveys of users of Chesapeake Bay	(1) Use/nonuse value of increase in water quality to swimmable level (2) 20% increase in water quality to Beach users (3) 20% increase in water quality to boaters	(1) $5-$224 per household per year (2) $1.14-$99.79 per household per year (3) $0.37-18.01 per boater per year	(1) 1984 (2) 1987 (3) 1987
Hayes, et al. 1992; Hayes 1987	A CVM survey of a sample of Rhode Island households	Swimmable and shellfishable water quality in Narragansett Bay, RI. Includes active and passive use values.	About $200 per household per year for swimmable water quality; about $200 per household per year for shellfishable water quality.	1984
Loomis & Creel 1992		(1) Wildlife viewing in the San Joaquin Valley (2) Waterfowl hunting in the San Joaquin Valley	(1) $128 per household per year (2) $159 per household per year	unknown
Walsh et al. 1992	Based on 120 outdoor recreation studies covering the whole U.S. between 1968-1988	(1) Swimming (2) Camping (3) Picnicking (4) Motorized Boating (5) Non-motorized Boating (6) Migratory Waterfowl Hunting (7) Non-consumptive Fish & Wildlife use (viewing)	(1) $15.54 - $30.40 per recreation day (2) $15.52 - $23.48 per recreation day (3) $7.37 - $27.29 per recreation day (4) $11.25 - $51.87 per recreation day (5) $17.61 - $79.75 per recreation day (6) $24.13 - $47.15 per recreation day (7) $17.69 - $26.71 per recreation day	3rd Quarter 1987
Jones & Stokes 1993, Appendix X	A CVM of California. Active & passive use values included.	Maintenance of specific water levels in Mono Lake.	$0.62 per additional foot per English-speaking household per year (6,377-6,390 feet).	unknown
Loomis 1987	A CVM of California. Active & passive use values included.	Maintenance of specific water levels in Mono Lake.	$42.71 - $94.68 per household per year for a level that will preserve wildlife & tufa.	unknown
Mannesto & Loomis 1991	A CVM survey of boaters on the Sacramento-San Joaquin Delta	Value of wetlands in the Delta to Boaters	$ 37.85 - $69.80 annually to maintain current conditions; $33.14 - $59.27 annually for additional wetland area	unknown
Boyle & Bishop 1987	A CVM of Wisconsin Taxpayers	Value of preventing the extinction of the bald eagle & the striped shiner	A median annual WTP of $4.92 - $24.63 per taxpayer for the eagle and $1.00 for the shiner	1985
Stevens et al. 1991	A CVM of Mass. and of New England re: endangered ssp. Validity of this use of CVM is questioned	Existence value of Atlantic salmon in Mass., and of the bald eagle, wild turkey and coyote in New England	avg. annual WTP per respondent of $7.93 for salmon, of $19.28 for eagle, of $11.86 for turkey, of $5.35 for coyote	unknown
Hagen et al 1992	A nationwide CVM (1,000 household sample)	active & passive use values of the northern spotted owl	$47.93 - $144.28 per household per year	unknown
Rubin et al 1991	A CVM of Washington State Residents	active & passive use values of the northern spotted owl	An avg. household willingness to pay of $34.84 per year.	unknown
Bowker & Stoll, 1988	A CVM of users of the Arkansas Nat. Wildlife Refuge, & a national sample of non-users	non-use values for the whooping crane	$21 - $132 per household per year	unknown
Rockel & Kealy 1991	Pooled TCM based on results of a national survey	all non-consumptive recreational uses of wildlife	$198 - $3,731 per trip	1980

were to become unavailable, the affected anglers would spend their recreation dollars in other ways. Recreational fishing benefits, therefore, are measured in terms of *net* willingness to pay (full willingness to pay, minus actual expenditures). This value is referred to as "consumers' surplus". It is this value that would be lost to society if the recreational opportunity were to disappear.

The selected alternative could benefit the commercial fishing industry by increasing the harvests of some or all commercial species. The value of the commercial fishery in California peaked in 1988 at about $200 million. By 1992, that figure had dropped to about $130 million. The value of the salmon harvest declined from $41.9 to $4.4 million over the same period (California Department of Finance 1987-1993). The dressed weight of the chinook salmon harvest dropped from 7,397,000 to 1,604,000 pounds between 1986 and 1992 (Dumas et al. 1993). The decline of the commercial catch has coincided with the drought, culminating in the closures of some fisheries in 1992 and 1993.

Although the economic effects of a known change in salmon populations could be estimated with acceptable accuracy (USEPA 1994), the physical and biological impacts of the preferred alternative on that fishery cannot be estimated accurately. The salmon population impact estimates appearing in this Section were derived from models which calculate salmon smolt survival based primarily on Delta flow dynamics. Actual adult population sizes also depend upon other important variables. Among those variables are the following:

(1) The relationship between smolt survival and the size of the adult population. Evidence of a significant positive relationship is lacking.

(2) Pumping, riparian land uses, and discharges along inland rivers and creeks can have significant impacts on salmon survival.

(3) Ocean temperatures, currents, and related conditions can, by affecting the food supply available to marine salmon populations, lead to substantial changes in population size. El Niño events, for example, have dramatic population effects.

Even if changes in salmon populations could be accurately predicted, uncertainties concerning future fishery regulatory actions would significantly affect fisheries benefits. The action which will have the most influence over the magnitude of those benefits is the chinook salmon escapement goal, set by the Pacific Fisheries Management Council (PFMC). The escapement goal determines how many adult salmon should return to spawn, following the commercial and recreational harvests. An increase in the salmon escapement goal could diminish or negate any commercial or recreation benefits that would otherwise result from increased salmon populations (these foregone benefits would be at least partially offset, however, by an increase in the non-use benefits associated with a larger salmon population).

As part of its Bay-Delta standard-setting process, the USEPA analyzed the fisheries benefits its standards were expected to produce (the USEPA's standards are identical to the SWRCB's Bay-Delta Alternative 1). In order to estimate the value of those benefits, however, it was necessary to make a number of assumptions to cover the gaps in our knowledge of the physical and biological processes affecting fisheries populations. The SWRCB has determined, however, that those uncertainties are too great to justify an attempt to estimate the economic value of the preferred alternative's fisheries benefits.

Literature Cited in Chapter XII

Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner, H. Schuman (Contingent valuation panel, appointed by the U.S. Office of General Counsel). 1993. Report of the NOAA Panel on Contingent Valuation. 64 pp.

Beck, R. W. 1994 Impacts of Bay-Delta Water Quality Standards on CVP Power Production. Prepared for the Western Area Power Administration.

Bockstael, N., and K. McConnell. 1988. Benefits from improvements in Chesapeake Bay Water Quality. Volume II of Benefit analysis using indirect or imputed market methods. University of Maryland, College Park, Maryland. Prepared for the Office of Policy Analysis, Office of Policy and Resource Management, U.S. Environmental Protection Agency. EPA Contract No. CR-811043-01-0

Bowker, J. and J. Stoll. 1988. Use of dichotomous choice nonmarket methods to value the whooping crane resource. American Journal of Agricultural Economics 70:372-381.

Boyle, K., and R. Bishop. 1987. Valuing wildlife in benefit-cost analyses: a case study involving endangered species.

California Department of Finance. 1987 through 1993 [individual volumes published annually]. California Statistical Abstract. Sacramento, CA.

Carson, R., N. Flores, K. Martin, and J. Wright. 1994. Contingent valuation and revealed preference methodologies: comparing the estimates for quasi-public goods. Unpublished draft. 47 pp.

Carson R. and R. Mitchell. 1993. The value of clean water: the public's willingness to pay for boatable, swimmable quality water. Water resources research 29(7): 2445-2454.

Cummings, R., D. Brookshire, and W. Schulze. 1986. Valuing environmental goods: An Assessment of the Contingent Valuation Method. Totowa, N.J.: Rowman and Allanheld. 270 pp.

Dale, L. (Larry Dale Associates, Point Richmond, California). 1994. Personal communication.

Dumas, C. 1993. EPA CVP Improvement Act Study--Environmental Benefits. University of California, Berkeley. Department of Agricultural and Natural Resources Economics.

Employment Development Department. No date. California Agricultural Employment and Earnings Bulletin, Annual Averages 1992.

Hagen, D., J. Vincent, and P. Welle. 1992. Benefits of preserving old-growth forests and the spotted owl. Contemporary policy issues 10(2):13:26.

Hayes, K. 1987. An analysis of the benefits of improving water quality in Narragansett Bay: an application of the contengent valuation method. Masters Thesis, Resource Economics, University of Rhode Island.

Hayes, K., T. Tyrrell, and G. Anderson. 1992. Estimating the benefits of water quality improvements in the upper Narragansett Bay. Marine Resource Economics 7:75-85.

Howard, T. (Division of Water Rights, SWRCB). 1994. Memorandum to George Barnes (Modeling Support Branch, Department of Water Resources) requesting DWRSIM runs on the SWRCB staff's proposed Bay-Delta Water Quality Standards.

Jones and Stokes Associates. 1993. Draft environmental impact report for the review of the Mono Basin water rights of the City of Los Angeles. Prepared for the California State Water Resources Control Board, Division of Water Rights, Sacramento, CA.

Loomis, J. 1987. An economic evaluation of public trust resources of Mono Lake. University of California at Davis, Institute of Ecology. Report #30.

Loomis, J. and M. Creel. 1992. Recreation benefits of increased flows in California's San Joaquin and Stanislaus rivers. Rivers 3(1): 1-13.

Loomis, J. and Joseph Cooper. 1990. Economic benefits of instream flow to fisheries: a case study of California's Feather River. Rivers 1(1):23-30.

Madriaga, B. and K. McConnell. 1987. Exploring existing value. Water Resources Research 23(5):936-942.

Mannesto, G. and J. Loomis. 1991. Evaluation of mail and in-person contingent valuation surveys: results of a study of recreational boaters. Journal of Environmental Management. 32:177-190.

McCann, R., D. Mitchell, and L. House. 1994 Impact of Bay-Delta Water Quality Standards on California's Electric Utility Costs. Prepared for the Association of California Water Agencies by M. Cubed, Sacramento.

Mitchell, R. and R. Carson. 1989. Using Surveys to Value Public Goods: the Contingent Valuation Method. Washington D.C.: Resources for the Future. 463 pp.

Northwest Economic Associates. August 1994. The Economic Impacts of the Proposed Federal Bay/Delta Standards on the California Dairy Industry. Prepared for Western United Dairymen.

Rockel, M. and M. Kealy. 1991. The value of non-consumptive wildlife recreation in the United States. Land Economics 67(4):422-434.

Rubin J., G. Helfand, and J. Loomis. 1991. A benefit-cost analysis of the northern spotted owl. Journal of Forestry 89. December 1991. Pp. 25-30.

Stevens, T., J. Echeverria, R. Glass, T. Hager, and T. More. 1991. Measuring the existence value of wildlife: what do CVM estimates really show? Land economics 67(4):390-400.

U.S. Department of Commerce, Bureau of the Census. 1989. 1987 Census of Agriculture, Geographic Area Series, Report AC-87-A-5.

USEPA. 1994. Regulatory impact assessment of the final water quality standards for the San Francisco Bay/Delta and critical habitat requirements for the delta smelt. San Francisco, CA. With technical assistance from Jones and Stokes Associates, Inc. (JSA 94-130).

Walsh, R., D. Johnson, and J. McKean. 1992. Benefit transfer of outdoor recreation studies. Water Resources Research 28(3): 707-713.

WAPA. 1995. Letter from WAPA to SWRCB dated March 8, 1995.

Whittington, D., G. Cassidy., D. Amaral, E. McClelland, H. Wang, C. Poulos. 1994. The Economic Value of Improving the Environmental Quality of Galveston Bay. A Report to the Galveston Bay National Estuary Program. Department of Environmental Sciences and Engineering, University of North Carolina, Chapel Hill.

CHAPTER XIII. EFFECTS OF PREFERRED ALTERNATIVE ON SPECIAL STATUS SPECIES

The proposed standards are designed to improve overall habitat conditions throughout the Bay-Delta Estuary, including habitat conditions for rare, threatened, and endangered species. This chapter provides both a description of relevant special status species and the effects of the proposed project on these species. The species list was provided by the DFG as part of the California ESA informal consultation process.

The special status species are discussed in three sections. Section I includes species that were identified as occurring within the counties that intersect with the legal boundaries of the Estuary, but inhabit areas outside of the Estuary and will not be adversely affected by the project. Section II includes species that inhabit areas within the Estuary that may be affected by the project, but the species are not likely to be adversely affected by the project. Section III includes species that inhabit areas in the Estuary that may be affected by the project and potentially could be adversely affected by the project. Species discussed include State and federal special status birds, mammals, fish, amphibians, reptiles, plants, and invertebrates. The descriptions of the habitats and the potential impacts of project operations on special status species were compiled from information provided by the DFG, DWR, USFWS, and various publications.

Impacts to special-status species are a component of the environmental impacts analysis and were considered in analyzing potential environmental impacts of the preferred alternative.

SECTION I

The following are special status species that were identified as occurring within the counties that intersect with the legal boundaries of the Estuary, but inhabit areas outside of the Estuary and will not be adversely affected by the project.

BIRDS

Swainson's Hawk
Buteo swainsoni
CA Threatened

Swainson's hawks breed in California and spend the winter in South America as far south as Argentina. Their diet consists of the California vole and a variety of birds and insects. The hawks nest near riparian systems of the Central Valley or use lone trees or groves of trees in agricultural fields. Suitable foraging areas include native grasslands or lightly-grazed pastures, alfalfa and other hay crops, and certain grain and row crops. Unsuitable foraging habitat includes row crops in which prey are scarce or unavailable due to the density of the vegetative cover, such as vineyards, orchards, rice, and cotton crops (DFG 1992).

The proposed standards are not likely to adversely affect the nesting or foraging habitat of the Swainson's hawk.

Greater Sandhill Crane
Grus canadensis tabida
CA Threatened

Greater sandhill cranes nest in Lassen, Modoc, Plumas, Shasta, Sierra, and Siskiyou counties. The cranes winter in the Central Valley in the Butte Sink area and the Sacramento-San Joaquin Delta near Lodi in San Joaquin County. Wintering grounds include areas with favorable roost sites and an abundance of cereal grain crops. Irrigated pastures are chosen for feeding and resting areas. Their diet includes roots, tubers, grains, toads, frogs, eggs, young birds, small mammals, and various invertebrates (DFG 1992).

The proposed standards are not likely to adversely affect the greater sandhill crane.

Western Yellowbilled Cuckoo
Coccyzus americanus occidentalis
CA Endangered
FED Candidate

The western yellowbilled cuckoo typically nests in willow trees along the north, central, and southern coast, in the Klamath-Modoc region, the Sacramento and San Joaquin valleys, the southern Sierra Nevada, Mojave Desert, and lower Colorado River. The cuckoo has nested in walnut and almond orchards in California, but its natural nesting habitat is in deciduous riparian forest and woodlands of cottonwood-tree willow composition. The major threat to the cuckoo is the loss and degradation of its riparian habitat (DFG 1992).

The proposed standards are not likely to adversely affect the western yellowbilled cuckoo.

MAMMALS

San Joaquin Kit Fox
Vulpes macrotis mutica
CA Threatened
FED Endangered

The historic range of the San Joaquin kit fox included most of the San Joaquin Valley from the vicinity of Tracy south to Kern County. Kit foxes occur in the remaining native vegetation associations of the valley floor and surrounding foothills. Depending on the extent of agricultural development, distribution is spotty within this broad range. In addition, smaller less dense populations may be found further north and in the narrow corridor between Interstate 5 and the Interior Coast Range from Los Banos to Contra Costa County.

In addition to habitat loss from agriculture, oil, residential and public works development, kit foxes are subject to disease, predation, roadkill, shooting, trapping, and rodenticide mortality (DFG 1992).

The proposed standards are not likely to adversely affect the San Joaquin kit fox.

Riparian Brush Rabbit
Sylvilagus bachmani riparius
CA Candidate For Listing as Endangered
FED Category 1 Candidate Species (Taxa for which the USFWS has sufficient biological information to support a proposal to list as endangered or threatened)

The riparian brush rabbit is currently found only at Caswell Memorial State Park (CMSP) on the Stanislaus River at the southern edge of San Joaquin County (DFG 1993). The entire population is restricted to 261 acres of remaining native riparian forest running in a strip along the Stanislaus River (DFG 1992).

The proposed standards are not likely to adversely affect the riparian brush rabbit.

Riparian Woodrat
Neotoma fuscipes riparia
FED Candidate

Historically, the riparian woodrat occupied the native riparian forests along the northern portion of the San Joaquin River and its tributaries, from Stanislaus County to the Delta. This habitat had a brushy understory associated with the forest and adjacent upland areas suitable for cover and retreat from annual floods. The historic ranges of the riparian brush rabbit and the riparian woodrat were nearly identical. Currently, the riparian woodrat and the riparian brush rabbit are known to occur only in CMSP, San Joaquin County, along the Stanislaus River.

The riparian woodrat is declining in population size and appears to be in jeopardy due to loss of habitat. This loss is primarily due to the completion of dams on the main tributaries to the lower San Joaquin River system which has reduced the frequency and severity of flooding. Prior to construction of dams and levees, much of the land that periodically flooded was used as pasture and was uneven in topography with some ground remaining above typical flood levels. These higher areas contained numerous patches of shrubs and trees and probably provided refuge during flooding events. Virtually all areas outside of flood-control levees now have been cleared, leveled, and planted as orchards, vineyards, or annual row crops.

Because the riparian woodrat only lives in the CMSP, the proposed standards are not likely to adversely affect this species.

AMPHIBIANS

California Tiger Salamander

Ambystoma californiense

FED Category 2 Candidate Species (Taxa for which existing information may warrant listing, but for which substantial biological information to support a proposed rule is lacking)

California tiger salamanders occur in the Central Valley from Butte County south to Kern County and in coastal grasslands from the vicinity of San Francisco Bay south at least to Santa Barbara County. One isolated population is known to exist at Grass Lake in Siskiyou County.

Tiger salamanders are most commonly found in annual grassland habitat, but also occur in grassy understory of valley-foothill hardwood habitats and, uncommonly, along stream courses. They occur mostly below 1,000 feet.

The adults spend most of the year in subterranean refugia, especially rodent burrows. The first rains of November usually initiate adult migration to breeding ponds where they remain a few days to several weeks after breeding is completed. Breeding and egg-laying normally occur from December through February. Females lay numerous eggs on both submerged and emergent vegetation and on submerged debris. Aquatic larvae seek cover in turbid water, clumps of vegetation, and other submerged debris. Post-metamorphic juveniles retreat to mammal burrows after spending a few hours of the day in mud cracks near water or tunnels constructed in soft soil.

Tiger salamanders breed and lay eggs primarily in vernal pools and other temporary ponds. They sometimes use permanent man-made ponds if predatory fishes are absent. Streams are rarely used for reproduction. Land under cultivation is unsuitable for these salamanders and major waterways that are swift and deep are not suitable for breeding habitat.

California tiger salamander habitat is not present in the tidal wetlands of Suisun Marsh. The tidal sloughs and permanent and seasonal wetlands all support fish and this salamander does not coexist with fish (DFG unpublished report; DWR 1994).

The proposed standards are not likely to adversely affect the California tiger salamander.

Western Spadefoot Toad
Scaphiophus hammondi
FED Category 2 Candidate Species

The western spadefoot toad occupies valley and foothill grasslands, open chaparral, and pine oak woodlands where temporary pools are present. Open grasslands with shallow temporary pools are considered to be ideal habitat. The western spadefoot toad is found throughout the Central Valley and surrounding foothills from near sea level to the 4,500-foot elevation. Individuals have been observed in the Sacramento Valley to the northeast of the Delta near Sloughhouse and to the northwest near Dunnigan. The nearest documented population to the Suisun Marsh is at the Jepson Prairie Preserve (DWR 1994).

Potential habitat for the western spadefoot toad is not present in the areas of Suisun Marsh influenced by tidal channels. This species is not expected to be adversely affected by the proposed standards.

Red-Legged Frog
Rana aurora draytonii
FED Category 2 Candidate Species, Proposed Endangered

Historically, the red-legged frog extended from the vicinity of Pt. Reyes National Seashore, Marin County, and from about Redding, south to Baja California, Mexico. Its habitat consists of quiet, permanent pools of streams, marshes, and occasionally ponds, and they prefer shorelines with extensive vegetation. This highly aquatic species stays within streamside habitats. The frogs have a period of inactivity from late summer to early winter.

Breeding takes place from January to July with a peak in February in the south, and in March to July in the north. Eggs are laid typically on vertical emergent vegetation such as bulrushes and cattails. Tadpoles require 11-20 weeks to reach metamorphosis. Adult frogs are nocturnal and are closely associated with dense, shrubby, or emergent riparian vegetation associated with deep, still or slow-moving water. Reduction in population levels are due to habitat loss, introduction of exotic predatory species (such as crayfish, largemouth bass, and catfish), and habitat fragmentation (Jennings et al. 1992).

Because the red-legged frog requires freshwater riparian vegetation and the proposed standards are not likely to reduce this type of habitat, the proposed standards are not likely to adversely affect this species.

REPTILES

Giant Garter Snake
Thamnophis couchi gigas
CA Threatened
FED Threatened

The giant garter snake historically occurred in the San Joaquin Valley from Sacramento and Antioch southward to Buena Vista Lake, Kern County. It appears that this snake has been extirpated from Buena Vista Lake and the Tulare Lake basin. The present known distribution extends from near Chico, Butte County, to the vicinity of Burrel, Fresno County. It is one of the most aquatic garter snakes and is usually found in areas of freshwater marsh and low-gradient streams, although it has adapted to artificial habitats such as drainage canals and irrigation ditches, especially those associated with rice farming.

The primary threat to the species is urbanization, such as housing, business, industrial and recreational developments, which often leads to the destruction of wetlands and channelization of streams. Other impacts of urbanization include pollution, destruction of food sources, and predation by native and introduced species (DFG 1992).

The proposed standards are not likely to adversely affect the giant garter snake.

PLANTS

Salt Marsh Bird's Beak
Cordylanthus maritimus maritimus
CA Endangered
FED Candidate

Salt marsh bird's beak grows in the higher reaches of coastal salt marshes, where it receives inundation only at higher tides. Salt marsh bird's beak presently occurs only in scattered sites at fewer than ten remnant salt marshes in San Diego, Orange, Ventura, Santa Barbara, and San Luis Obispo counties (DFG 1992). Because the salt marsh bird's beak is not found within the project area, the proposed standards are not likely to adversely affect this species.

Delta Button Celery
Eryngium racemosum
CA Endangered
FED Candidate

Delta button celery occurs generally on clay soils in lowland areas of riparian and floodplain habitat. Historically, it occurred in Calaveras, Merced, Stanislaus, and San Joaquin counties. Presently, it occurs primarily in Merced County along the San Joaquin River (DFG 1992).

The proposed standards are not likely to adversely affect the Delta button celery.

Contra Costa Wallflower
Erysimum capitatum var. *angustatum*
CA Endangered
FED Endangered

The Contra Costa wallflower habitat is stabilized sand dunes that are densely covered with herbs, grasses, and shrubs. Only two populations remain, both at the 70-acre Antioch Dunes along the San Joaquin River near Antioch in Contra Costa County (DFG 1992).

The proposed standards are not likely to adversely affect the Contra Costa wallflower.

Antioch Dunes Evening Primrose
Oenothera deltoides howellii
CA Endangered
FED Endangered

The Antioch dunes evening primrose grows in loose sand and semi-stabilized dunes in a small area along the San Joaquin River near Antioch in Contra Costa County, in the same area as the Contra Costa wallflower.

The proposed standards are not likely to adversely affect the Antioch dunes evening primrose.

Pitkin Marsh Indian Paintbrush
Castilleja uliginosa
CA Endangered
FED Endangered

The Pitkin Marsh Indian paintbrush historically was restricted to the wet marsh habitat of upper Pitkin Marsh in Sonoma County (DFG 1992). Loss of marsh habitat has greatly reduced the distribution of this species. Since the late 1970's, only a single plant remains in the wild. Pitkin Marsh Indian paintbrush requires two plants for pollination, so the single known plant cannot reproduce. Because the private landowner on whose property this plant is found will not allow the DFG to manage and monitor the plant, this last plant may be gone.

The proposed standards will not adversely affect the Pitkin Marsh Indian paintbrush.

San Joaquin Salt Bush
Atriplex joaquiniana
FED Category 2 Candidate Species

The San Joaquin salt bush is an annual herb from the goosefoot family (Chenopodiaceae). The San Joaquin salt bush is typically found in chenopod scrub type habitat. Salt bushes and greasewood frequently dominate this habitat type. This plant species is found in fine-textured, alkaline, and/or saline soils in areas of impeded drainage occurring in meadows, seeps, valley and foothill grasslands. The San Joaquin salt bush blooms from April through September. The geographic distribution of the San Joaquin salt bush is in the southern Sacramento Valley, San Joaquin Valley, and the eastern slopes of the inner south coast range. The San Joaquin salt bush may be found in Alameda, Contra Costa, Colusa, Fresno, Glenn, Merced, Napa, Sacramento, San Benito, Santa Clara, San Joaquin, Solano, Tulare, and Yolo counties.

The California Native Plant Society (CNPS) has categorized this plant as rare. A rare listing means that the plant is not presently threatened with extinction, but it may become endangered if its present environment worsens. Currently, the San Joaquin salt bush is threatened by grazing, agriculture, and development.

Due to its habitat requirements, the proposed standards are not likely to adversely affect the San Joaquin salt bush.

California Beaked-Rush
Rhynchospora californica
FED Category 2 Candidate Species

The California beaked-rush is a perennial rhizomatous herb from the sedge family (Cyperaceae). The California beaked-rush is a rare plant occurring in freshwater meadows, seeps, marshes or swamps, in areas from sea level to treeline and on many different substrates. It is adapted to seasonally or permanently saturated soils. It may be surrounded by grasslands, forests, or shrublands. The California beaked-rush blooms from May through July. It is found in southern northwest Sonoma County, the northern and central Sierra Nevada foothills of Butte and Mariposa counties, and the northern San Francisco Bay area.

The CNPS has categorized this plant as rare. Currently the California beaked-rush is threatened by marsh habitat loss.

The California beaked-rush is not likely to occur in the areas affected by the proposed project; therefore, the proposed standards are not likely to adversely affect this plant.

Heartscale
Atriplex cordulata
FED Category 2 Candidate Species

Heartscale, or heartleaf saltbush, grows in alkaline or saline soils and is found in alkali grasslands, alkaline seasonal wetlands, and valley sink scrub vegetation communities. It is most commonly associated with barren, sparsely vegetated sites. It is found in the Sacramento and San Joaquin Valley at elevations less than 200 meters. It has been reported in Tulare, Fresno, Madera, Merced, Stanislaus, San Joaquin, Contra Costa, Solano, and Glenn counties. The closest known populations to the project are west of the Clifton Court Forebay in Contra Costa County. The decline of this species is related to urbanization and agricultural development (DWR 1994).

Heartscale does not occur in areas that will affected by the proposed project; therefore, the proposed standards are not likely to adversely affect this species.

Tiburon Indian Paintbrush
Castilleja affinis neglecta
FED Category 1 Candidate Species

The Tiburon Indian paintbrush is endemic to serpentine-derived soils and south to west-facing slopes within native bunchgrass communities. It occurs at American Canyon in Napa County and at three sites on the Tiburon Peninsula in Marin County (DFG 1992). It is threatened by urban development and mining activities. There is no suitable habitat for this species in the wetlands of Suisun Marsh (DWR 1994).

The Tiburon Indian paintbrush does not occur in the areas that will be affected by the proposed project; therefore, the proposed standards will not adversely affect this species.

Contra Costa Buckwheat
Eriogonum truncatum
FED Category 2 Candidate Species

Contra Costa buckwheat was last seen in 1940 and because recent attempts to rediscover it have been unsuccessful, it is presumed to be extinct. Historic populations ranged from 350 to 1600 feet in elevation (DWR 1994).

The proposed standards will not adversely affect the Contra Costa buckwheat.

Legenere
Legenere limosa
FED Category 2 Candidate Species

Legenere is categorized as Rare by the CNPS. It is found in the bed of vernal pools and in open wet meadows at elevations less than 450 feet. It has been documented in Lake, Napa, Placer, Sacramento, Solano, Sonoma, and Stanislaus counties. The closest known population to the Estuary is north of Suisun Marsh wetlands (DWR 1994).

The proposed standards will not affect vernal pools; therefore, the proposed standards will not adversely affect the legenere.

INSECTS AND OTHER INVERTEBRATES

Lange's Metalmark Butterfly
Apodemia mormo langei
FED Endangered

The Lange's metalmark butterfly is known only from Contra Costa County, where it inhabits the relict Antioch Dunes on the south bank of the San Joaquin River, near its confluence with the Sacramento River. Historically, its range may have included the entire extent of a now-destroyed 500-acre dune system. It is believed that this system was part of a prehistoric desert which extended into California's Central Valley. Its current range comprises only about 15 acres of the remaining dunes.

Lange's metalmark butterfly inhabits stabilized sand dunes and all developmental stages are closely associated with its larval host plant, naked buckwheat. The butterfly eggs are deposited only on this plant. The single greatest threat to the species is habitat destruction (Miriam Green Associates 1993).

The proposed standards will not affect the Antioch Dunes and, therefore, will not adversely affect the Lange's metalmark butterfly.

Sacramento Anthicid Beetle
Anthicus sacramento
FED Category 2 Candidate Species

The Sacramento anthicid beetle has been found in five locations in Sacramento, Solano, Butte, and Glenn counties. The Sacramento anthicid beetle occupies accumulations of loose sand where larvae probably feed on vegetable detritus. The need for loose sand is apparently critical. The loose sand apparently provides a substrate from which wind-deposited food is gleaned and the shifting sands protect the anthicids from terrestrial predators.

Historically, agricultural and economic development activities (land reclamation, flood control, water management, and sand mining) have been responsible for habitat destruction. In general, larger dune systems are continually shifted and reformed by winds, erosion, and new sand deposition. They are constantly renewing suitable microhabitats. Once limited in size and isolated, new dune formation ceases. As the existing dunes are stabilized by encroaching vegetation, new unstabilized formations no longer replace them. In addition, predation by the introduced Argentine ant is considered to represent a significant threat to the species (Miriam Green Associates 1993).

The proposed standards are not likely to affect the habitat of the Sacramento anthicid beetle and, therefore, will not adversely affect this species.

Delta Green Ground Beetle
Elaphrus viridis
CA Endangered
FED Threatened

The only known habitat for the Delta green ground beetle is in Olcott Lake in the Jepson Prairie Preserve in Solano County (Nature Conservancy 1992).

The proposed standards will not affect the habitat of the Delta green ground beetle and, therefore, will not adversely affect this species.

Longhorn Fairy Shrimp
Branchinecta longiantenna
FED Endangered

The longhorn fairy shrimp is reported from 18 pools in three widely-spaced locations along the eastern margin of the Coast Range between Contra Costa and San Luis Obispo counties, and in two locations near Brushy Peak.

The longhorn fairy shrimp inhabits two quite different vernal pools: (1) small clear-water depression pools in sandstone outcrops; and (2) clear to moderately turbid, clay and grass-bottomed pools in shallow swales of short grass, or grass and low shrub vegetation of near-desert conditions.

Fairy shrimp typically complete their life cycle in approximately 2 months. Nearly all fairy shrimp feed upon algae, bacteria, protozoa, rotifers, and bits of detritus. Eggs are either dropped at the bottom of the pond or remain attached to the female until she dies and sinks. The thick-shelled eggs are very tolerant of adverse conditions and hatch when the vernal swale/pool fills again with runoff.

Habitat of the longhorn fairy shrimp may have always been somewhat limited (Miriam Green Associates 1993).

The proposed standards will not affect vernal pools and, therefore, will not adversely affect the longhorn fairy shrimp.

Conservancy Fairy Shrimp
Branchinecta conservatio
FED Endangered

The range of the conservancy fairy shrimp includes the entire Central Valley in highly turbid, ephemeral water located in swales and vernal pools. These vernal swales and pools are created by winter and spring runoff into depressions lined with hardpan clay and may last for several months before drying out. Pools inhabited by the conservancy fairy shrimp are typically large but range in size from 0.37 acres to 10 acres.

Fairy shrimp typically complete their life cycle in approximately 2 months. Nearly all fairy shrimp feed upon algae, bacteria, protozoa, rotifers, and bits of detritus. Eggs are either dropped at the bottom of the pond or remain attached to the female until she dies and sinks. The thick-shelled eggs are very tolerant of adverse conditions and hatch when the vernal swale/pool fills again with runoff.

Much of the suitable habitat for the Conservancy fairy shrimp has probably been lost to agricultural and other development activities since the 1800's. The restriction of the species to small, widely scattered locations renders individual populations extremely vulnerable to localized disturbance (Miriam Green Associates 1993).

The proposed standards will not affect vernal pools; therefore, the Conservancy fairy shrimp will not be adversely affected.

Vernal Pool Fairy Shrimp
Branchinecta lynchi
FED Threatened

The range of the vernal pool fairy shrimp is from the Vina Plains of Tehama County through most of the length of the Central Valley, along the eastern margin of the Central Coast mountains region, to the mountain grasslands north of Santa Barbara. Several disjunct populations are located on the Santa Rosa Plateau and in Skunk Hollow near Ranch California in Riverside County.

Vernal pool fairy shrimp inhabit two quite different pools: (1) small, usually less than 20 inches diameter, clear-water depression pools in sandstone outcrops; and (2) the more common "grassed swale, earth slump or basalt-flow depression pools in unplowed grasslands", from approximately 200 square feet to more than 25 acres.

Although this species ranges over a broad area, locations are rather scattered and the species is not abundant anywhere. Habitat requirements and the currently documented range suggests that the species once was probably widely distributed in grassland ephemeral pools throughout the Central Valley and in the margins of bordering mountain ranges. Much suitable habitat has been lost to agricultural and other development activities since the 1800's. At the time Europeans arrived in California, there were approximately 6 million acres of vernal pools in the Central Valley. By 1970, approximately 5.4 million acres had been destroyed. Vernal pool habitat continues to decline at a rate of 2 to 3 percent per year (Miriam Green Associates 1993).

The proposed standards will not affect vernal pools; therefore, they will not adversely affect the vernal pool fairy shrimp.

California Linderiella
Linderiella occidentalis
FED Category 1 Candidate Species, Proposed Endangered

The California linderiella is reported to occur from the east side of the Central Valley from east of Red Bluff to east of Madera at elevations between 131 to 551 feet. The species is found in the Sacramento area and from Boggs Lake north of San Francisco Bay in Lake County, and possibly south to Riverside County.

California linderiella inhabits three different types of seasonal pools, which may fill and redry one or more times during any given year depending on the seasonal nature of precipitation and drought: (1) pools in grass-bottomed swales in old alluvial soils underlain by hardpan, containing clear to tea-colored water; (2) mud-bottomed pools with lightly turbid water; or (3) clear water depression pools in sandstone or old lava flows. Pool size varies from about 1 square meter to the 99-acre Boggs Lake (Miriam Green Associates 1993).

The proposed standards will not affect the habitat utilized by California linderiella; therefore, they will not adversely affect this species.

Vernal Pool Tadpole Shrimp
Lepidurus packardi
FED Endangered

The vernal pool tadpole shrimp is found at 14 vernal pool complexes in the Sacramento Valley from the Vina Plains in Butte County, south to the Sacramento area in Sacramento County, and west to the Jepson Prairie region of Solano County. The vernal pool tadpole shrimp is found in pools most commonly located in grass-bottomed swales of unplowed grasslands in old alluvial soils underlain by hardpan, or in mud-bottomed pools containing highly turbid water. Pool sizes vary from approximately 50 square feet to 9 acres.

The proposed standards will not affect vernal pools; therefore, they will not adversely affect the vernal pool tadpole shrimp.

SECTION II

The following special status species inhabit areas within the Estuary that may be affected by the proposed standards, but the species will not likely to be adversely affected by the proposed standards.

BIRDS

Bald Eagle
Haliaeetus leucocephalus
CA Endangered
FED Endangered

The bald eagle winters near lakes, reservoirs, river systems, some rangeland, and coastal wetlands. The breeding range is mainly in mountainous habitats near reservoirs, lakes, and rivers in the northern one-third of the State. The birds are opportunistic in foraging, usually feeding on fish or waterfowl, but capable of preying on other small animals. They often eat carrion. The bald eagle is a rare winter visitor to Suisun Marsh (DFG 1992).

The proposed standards include standards that are intended to improve the habitat for estuarine species; therefore, the proposed standards will not adversely affect the bald eagle.

California Brown Pelican
Pelecanus occidentalis californicus
CA Endangered
FED Endangered

The California brown pelican breeds from the Channel Islands of southern California southward into Mexico. Between breeding seasons, pelicans range as far north as British Columbia, Canada and as far south as Central America. In California, the pelican eats surface schooling fishes such as the Pacific mackerel, Pacific sardine, and northern anchovy. The population segment of interest and concern to the DFG is the Southern California Bight population (DFG 1992).

The proposed standards are not likely to adversely affect the California brown pelican.

American Peregrine Falcon
Falco peregrinus anatum
CA Endangered
FED Endangered

The American peregrine falcon migration and wintering habitat includes most of California, except desert areas. These habitats are varied, including wetlands, woodlands, cities, agricultural areas, and coastal habitats. The California breeding range, which has been expanding, now includes the Channel Islands, the coast of southern and central California, the inland north coastal mountains, the Klamath and Cascade ranges, and the Sierra Nevada. Nesting sites are typically on ledges of large cliff faces, but some pairs nest on city buildings and bridges. The peregrine falcon feeds on birds that are caught in flight. They are a rare winter visitor to Suisun Marsh (DFG 1992).

Winter foraging habitat for the species is present along tidal sloughs and in the seasonal wetlands of the Suisun Marsh area where waterfowl are present in high densities during October through May. The Delta and Suisun Marsh are used only irregularly by a small number of these raptors. The Estuary harbors an estimated 10-20 wintering American peregrine falcons. There are four nesting pairs known to occur near Central San Francisco, San Pablo, and Suisun bays; however, as of January 1992, none of these pairs were successfully reproducing (DWR 1994).

The proposed standards are not expected to result in a loss of habitat, nesting areas, or winter foraging habitat for this bird. Therefore, the proposed standards are not likely to adversely affect the American peregrine falcon.

California Least Tern
Sterna antillarum browni
CA Endangered
FED Endangered

The California least tern winters somewhere in Latin America, but the winter range and habitats are unknown. The nesting range is along the Pacific coast from southern Baja California to San Francisco Bay. Terns usually arrive in California in April and depart in August. They nest in colonies on bare or sparsely vegetated flat substrates near the coast. The historical nesting habitats of this species have been largely eliminated by development and recreational use. Typical nesting sites are now on isolated or specially protected sand beaches or on natural or man-made open areas in remnant coastal wetlands. These sites are typically near estuaries, bays, or harbors were small fish are abundant. Adverse impacts include wetland development, introduced predators, unnaturally heavy predation by native species, human disturbance, and off-road vehicles. El Niño ocean conditions may diminish the tern's coastal fish food supplies and reduce breeding success (DFG 1992).

The proposed standards are not likely to adversely affect the California least tern's nesting or foraging habitat.

Salt Marsh Common Yellowthroat
Geothlypis trichas sinuosa
CA - Under consideration for designation as a Species of Special Concern
FED Category 2 Candidate Species

The salt marsh yellowthroat, a subspecies of the common yellowthroat, can be found year-round in the San Francisco Bay region. This particular subspecies only inhabits (breeds in) San Francisco Bay, Tomales Bay, and Carquinez/Suisun Bay in central California. Some birds may winter further south. Probably less than 200 pairs remained in 1978, and further reductions have probably occurred. This species principally breeds and winters in brackish to saline emergent wetland habitats. The plant communities preferred by yellowthroats for breeding include brackish marsh, freshwater marsh, and woody swamp areas with dense tangled vegetation for constant concealment. The birds are most often observed in coyote bush or emergent tule and cattail stands close to the water.

The yellowthroat eats insects, especially larvae. Declines of this species are also related to reductions in the vegetation associated with brackish water such as the tidal wetlands. Birds wintering in Bay salt marshes annually disperse from brackish/freshwater breeding sites when they become unsuitable due to seasonal vegetational die-offs.

Losses of tidal salt, brackish, and freshwater marshes around the Estuary have drastically reduced both breeding and wintering habitat for this bird. The distribution and abundance of its habitat has been so reduced or altered in quality that it is estimated that a population decrease of 80-95 percent has occurred. The continuous corridors of salt marshes grading upstream into adjacent brackish/freshwater wetlands, which historically existed around the Bay, have been fragmented through creation of salt ponds, stream alterations, agricultural conversion, and more recently, urban development. This has made successful dispersion of fledglings and seasonal movements by adults difficult. Reduction in freshwater inflow from adjacent creeks and rivers are also believed to negatively affect the population through reduced abundance of marsh vegetation and insects.

Current threats to the subspecies include loss of freshwater marshes, continued degradation of salt marshes by erosion, introduced salt marsh vegetation and predators, loss of breeding areas to flood control practices, urban encroachment, and rising sea level.

It is uncertain whether the salt marsh yellowthroat occurs in Suisun Marsh, although suitable habitat does exist. Reductions in freshwater inflow to estuarine marshes are believed to negatively affect the salt marsh yellowthroat through reduced abundance of vegetation and insects. The intent of the salinity standards proposed for Suisun Marsh is to maintain the historic brackish conditions in this region. Therefore, the proposed standards are not likely to adversely affect the salt marsh yellowthroat.

Aleutian Canada Goose
Branta canadensis leucopareia
FED Threatened

This subspecies of Canada goose breeds in the Aleutian Islands. Its main wintering grounds are in the Central Valley of California. This goose generally leaves the Aleutians in late-September for its southward migration. Following stops along the Oregon coast and the California coast above Crescent City, it arrives in the Central Valley from October to November. The geese use the Sacramento Valley marsh and agricultural areas in early winter. In December and January, Aleutians are typically found using suitable habitat in the upper San Joaquin Valley near Los Banos and south of Modesto. Use of Suisun Marsh by these birds is sporadic. Preferred foraging areas include lightly grazed pasture lands. Aleutians feed on green shoots and seeds of cultivated grains as well as wild grass and forbs. The return migration to the north occurs from late-February through April.

The Aleutian Canada goose was originally listed as endangered by the USFWS due to its severely depleted population. Nest predation in breeding areas was the principal cause. The sport hunting harvest of this reduced population exacerbated the decline. Recovery efforts focused on removal of predators from the breeding islands and hunting restrictions. The population has now rebounded from an estimated wintering population of 800 in the mid-1970's to over 5,000 currently. As a result, the USFWS has recently down-listed this subspecies to threatened. Continued maintenance of suitable wintering habitat, including managed marsh and suitable agricultural lands, such as small grains and pasture, is important for the continuing recovery of this species.

The Aleutian Canada goose infrequently utilizes the areas that will be affected by the proposed project. The proposed standards include standards for the managed marsh in Suisun Marsh which are intended to maintain and improve habitat conditions, in part, for waterfowl. The proposed standards are not likely to adversely affect the Aleutian Canada goose.

Western Snowy Plover
Charadrius alexandrinus nivosus
FED Threatened

The western snowy plover is found along the Pacific coast from northern Mexico to Washington, and inland in the Central Valley of California, the Salton Sea, and Mono Lake. The snowy plover is commonly found from September through March on sandy beaches and bayshore sand flats. It is uncommon to fairly common all year long on salt pond dikes around San Francisco Bay, where nesting occurs. Recent surveys along the coast of northern California document fewer than 100 pairs nesting between Marin County and the Oregon border.

The western snowy plover prefers the dry sand and upper sand flats of open beaches backed by sand dunes and bordered by marsh or brackish lagoons. Nesting is typically solitary and occurs on flat sand and shell mix, with no vegetative cover, and a good supply of amphipods and ground beetles for food.

Most prime nesting habitat, in low dunes, is subject to human disturbance and, consequently, populations have dwindled. The plovers have partially compensated for this loss by shifting their breeding activities in several areas, including San Francisco Bay, to include nesting on salt pond dikes, bare flats, or sand fills (WESCO 1989).

The proposed standards are not likely to adversely affect the nesting or foraging habitat of the western snowy plover.

Tricolored Blackbird
Agelaius tricolor
FED Candidate

The historical breeding range of the tricolored blackbird in California included the Sacramento and San Joaquin valleys and low foothills of the Sierra Nevada from Shasta County to Kern County and along the coast from Sonoma County south to the Mexican border. Although tricolored blackbird populations have declined throughout their range, they continue to breed in the Central Valley up to the low foothills in coastal areas from Sonoma County south to Baja California, and on the Modoc Plateau south to the Honey Lake Valley, Lassen County. A statewide survey conducted during 1968-1972 indicated that 78 percent of the 168 colonies located were in highly agricultural portions of the Central Valley. Populations in this region may have declined by 50 percent from the 1940's.

Tricolored blackbirds nest in dense colonies in the vicinity of fresh water, especially in marshy areas with heavy growths of cattails (*Typha* spp.) and tules (*Scirpus* spp.). In addition to these preferred nesting substrates, tricolored blackbirds also nest in other vegetation, such as willows (*Salix* spp.), thistles (*Centaurea* spp.), mustard (*Brassica* spp.), nettles (*Urtica* spp), blackberries (*Rubus* spp.), salt cedar (*Tamarix* spp.), giant cane (*Arundo donax*), wild grapes (*Vitus* spp.), and wild roses (*Rosa* spp.). Proximity to productive foraging grounds, such as flooded fields, margins of ponds, and grassy fields, is also important in nest site selection.

Within established nesting areas, tricolored blackbirds are extremely sensitive to predators, and even relatively minor disturbances can cause abandonment of entire colonies. Historical literature describes predation by mammals as a cause of major nesting failures. Other observers have also reported massive tricolored blackbird nesting failures due to bird and mammal predators, poisoning, and human disturbance.

The proposed standards are not likely to affect freshwater marshy habitat which may serve as the nesting habitat for the tricolored blackbird; therefore, the proposed standards are not likely to adversely affect the tricolored blackbird.

Loggerhead Shrike
Lanius ludovicianus
FED Category 2 Candidate Species

Typical loggerhead shrike nesting habitat is an open field with a few trees, open woodlands, or scrub. They breed over most of North America from central Canada south to southern Mexico. The loggerhead shrike winters throughout most of the breeding range, but retreats somewhat from Canada. The loggerhead shrike feeds mostly on large insects and other land invertebrates, and also on mice, birds, lizards, and carrion. Its survival is jeopardized by habitat destruction and exposure to pesticides, and possibly from impact with cars on roads within nesting and hunting territories (Erlich et al. 1992).

The loggerhead shrike has been observed in the eastern and western Suisun Marsh. They utilize a number of different habitat types in the marsh including open fields, wetlands, uplands, and open woodlands (Brenda Grewell, DWR, pers. comm., December 1994).

The proposed standards are not likely to adversely affect the habitat or prey of the loggerhead shrike.

FISH

Sacramento Perch
Archoplites interruptus
FED Category 2 Candidate Species

The Sacramento perch is the only native Centrarchid west the Rocky Mountains. This species was once abundant in natural lakes, sloughs, and slow moving rivers of central California. The perch has been largely extirpated from the Delta, but surveys conducted by the DFG caught five Sacramento perch in Suisun Marsh from 1974 to 1979. In July of 1992, a DFG fishery biologist identified a Sacramento perch caught by an angler near Westgate Landing on the south fork of the Mokelumne River. Currently, in California, a viable native population of Sacramento perch exists in Clear Lake, Lake County. Introductions of Sacramento perch have occurred throughout the State in isolated farm ponds and reservoirs.

Sacramento perch can tolerate a wide range of water conditions, such as salinities of up to 17 ppt and water temperatures that exceed 77°F. This adaptation is thought to have evolved in response to historical environmental fluctuations resulting from periods of flooding and drought. Throughout the Central Valley, the Sacramento perch inhabited sloughs, slow-moving rivers, and lakes that contained areas dominated by rooted emergent and submerged vegetation, which is critical for spawning and nursery habitat of young fish.

The decline of the Sacramento perch has been linked to several factors: competition with introduced species for food and spawning resources, predation by introduced species on eggs and young fish, and habitat alterations. The Sacramento perch's main competition comes from introduced species within its own family, such as black crappie, largemouth bass, smallmouth bass, and bluegill. Competition may have forced the less aggressive Sacramento perch to utilize areas that are less suitable for spawning and feeding. When the perch is forced out of preferred habitats into areas that are less desirable, their reproductive success is limited. In Clear Lake, the Sacramento perch reproduction may be successful only when the population of black crappie is low. Moyle (1976) also reported that catfish and carp have been observed moving across spawning beds of the Sacramento perch eating deposited eggs. The introduction of these and other non-native species happened almost simultaneously with the occurrence of major habitat alterations in the Delta. Reduction in suitable habitat has occurred since the late-1800's when changes in the upstream hydraulic operations (dams, water diversions, and mining) altered the flow patterns of the Delta and its tributary streams. Construction of levees led to the loss of vast amounts of suitable spawning and nursery habitat in the Delta. Rip-rapping of channel and slough edges in the Delta further reduces the remaining habitat.

Stocking of Sacramento perch is currently limited to farm ponds and impoundments. Introductions into impoundments where other Centrarchid species are present have failed, and when stocked into impoundments where no other fish exist, they over-populate and growth becomes stunted (Moyle 1976).

The proposed standards are not likely to adversely affect the Sacramento perch.

Tidewater goby
Eucyclogobius newberryi
FED Endangered

The tidewater goby is endemic to California and is distributed in brackish water habitats along the California coast. This goby is found in shallow lagoons and lower stream reaches where the water is brackish to fresh and 25-100 centimeters (cm) deep. The substrate usually consists of sand and mud, with abundant emergent and submerged vegetation. In the San Francisco Bay and associated streams, nine of ten previously identified populations have disappeared and a survey of streams of the Bay drainage failed to record any populations. Severe salinity changes, and tidal and flow fluctuations, have a detrimental effect on the survival of tidewater gobies (Moyle et al 1989).

The tidewater goby utilizes the small estuaries associated with coastal streams and are, therefore, dependent on sufficient inflow from the coastal streams to sustain the brackish conditions. While the proposed standards may improve some brackish water habitats in the

Estuary during the spring, it is not likely that the habitat of the tidewater goby will be affected; therefore, the proposed standards are not likely to adversely affect the tidewater goby.

REPTILES

Northwestern Pond Turtle

Clemmys marmorata marmorata
FED Category 2 Candidate Species

The western pond turtle includes two subspecies, the northwestern and the southwestern pond turtle. The northwestern pond turtle occurs from the vicinity of the American River northward to the Columbia River. Within the Estuary, the northwestern pond turtle is found north of San Francisco Bay, while the southwestern pond turtle is found south of San Francisco Bay. These turtles, which are found in water that ranges from fresh to brackish to seawater, inhabits marshes, ponds, and small lakes with abundant vegetation, creeks, slow-moving streams, sloughs with riparian habitat, and irrigation ditches with emergent vegetation. Habitat requirements include well-vegetated backwater areas with logs for basking and open sunny slopes away from riparian zones for egg deposition. Western pond turtles nest up to 400 meters from and 60-90 meters above stream banks on sand banks along the courses of large rivers, or on hillsides in foothill regions. The turtles mate in April and May, and eggs are laid from June through August. The hatchlings overwinter in nests and emerge in March or April. Sexual maturity in pond turtles is thought to occur at about eight years and they may live for 30 to 40 years (DWR 1994, Jennings et al. 1992).

The continuing loss of suitable nesting habitat may result in inadequate reproduction rates in some areas. Extensive water diversion for agriculture and other purposes has led to the reduction of western pond turtle numbers in California. Dredging also destroys suitable habitat, as does the construction of dams and reservoirs.

The northwestern pond turtle can tolerate a wide range of salinities, and their nesting and basking habitat will not be affected by the proposed standards; therefore, the proposed standards will not adversely affect the northwestern pond turtle.

Southwestern Pond Turtle

Clemmys marmorata pallida
FED Candidate

The southwestern pond turtle occurs in coastal drainages from the vicinity of Monterey south to northwestern Baja California Norte in the vicinity of the Sierra San Pedro Martir. Turtles that occur in the Central Valley from south of the American River to the vicinity of Tejon Pass were described as representing an area of intergradation of the two subspecies of western pond turtles (Jennings et al. 1992).

The pond turtle is considered to be thoroughly aquatic in its habitat preference. It selects quieter pools and backwaters in swifter streams. It is more common in areas with muddy or rocky bottoms that are overgrown with aquatic vegetation such as cattails, watercress, or water lilies. They use mudbanks, logs, and cattail mats for basking. Pond turtles seek deep water with masses of waterlogged leaves and brush for escape cover.

The southwestern pond turtle is the most carnivorous member of the genus *Clemmys*. Food consists of aquatic plants, such as yellow pond lily pads, insects, aquatic invertebrates, fish, frogs, snakes, birds, mammals, and carrion. Pond turtles hibernate in winter. The exact extent of the hibernation period varies with season, altitude, and latitude. It is active in March in southern California. Pond turtles hibernate in the mud of stream or pond bottoms. Nesting in central California takes place in late-April and May. Nesting sites are usually located in a sunny place near a pond, stream, or river, but nesting sites may also be in an open field or hillside hundreds of yards from water (DWR 1994).

The southwestern subspecies has declined in abundance due to the loss of aquatic habitat resulting from agricultural development, water diversions, stream channelization, and urbanization.

The southwestern pond turtle can tolerate a wide range of salinities, and their nesting and basking habitat will not be affected by the proposed standards; therefore, the proposed standards will not adversely affect the southwestern pond turtle.

PLANTS

California Hibiscus
Hibiscus lasiocarpus
FED Category 2 Candidate Species

The habitat of the California hibiscus includes river banks and freshwater marsh. The range extends along Butte Creek and the Sacramento River and adjoining sloughs from Butte County to the Delta and to San Joaquin County. The species is common in the south and central Delta: Middle River islands, Woodward Canal, West Canal, Old River near Coney Island, Grant Line Canal, and Bacon Island. In the Delta, it is confined to freshwater marsh habitat on remnant berm islands. It is associated with tules, willows, buttonwillow, and other marsh and riparian species on heavy silt, clay, or peat soils (DWR 1992).

Its range has been diminished by channelization and draining of wetlands. In the southern Delta, levee maintenance, bank erosion, and island submergence have led to the loss of some populations of California hibiscus. Increases in channel water salinity may also pose a threat to this freshwater species. Competition from an invasive introduced iris may displace the hibiscus. The scarcity of remaining habitat prompted the special status (DWR 1992a).

The proposed standards are not likely to increase channel water salinity in the range of the California hibiscus; therefore, the proposed standards are not likely to adversely affect this plant.

Contra Costa Goldfields
Lasthenia conjugens
FED Category 1 Candidate Species

Contra Costa goldfields grows in shallow vernal pools in valley grasslands at elevations less than 300 feet. The historic distribution of the species included: coastal California from Point Arena in Mendocino County south to Santa Barbara; southern San Francisco Bay and around the base of the Diablo Range in Contra Costa County; and the inner coast range around San Pablo Bay, Suisun Bay, and the western Delta. Its current range is limited to Napa and Solano counties. Many historic habitats have been eliminated by urban development and grazing.

Contra Costa goldfields is present in the greater Suisun Marsh area in areas above the influence of tidal channels (DWR 1994); therefore, the proposed standards are not likely to adversely affect the Contra Costa goldfields.

Suisun Slough Thistle
Cirsium hydrophilum var. *hydrophilum*
FED Category 2 Candidate Species

The Suisun Slough thistle is a spiny, biennial herb, 1-1.5 meters tall, with pale lavender-rose flowers. DWR staff has observed and mapped the distribution of this species at two locations in Suisun Marsh in 1991-1994 (DWR 1994). The habitat of the thistle apparently consists of salt to brackish wetlands periodically inundated during high tides. Little else is known concerning the distribution and habitat requirements of this species. Like other candidate and listed species, the variety probably has suffered major population declines because of widespread habitat modification throughout its historic range, the Suisun Marsh.

The proposed standards are not likely to adversely affect the Suisun Slough thistle.

INSECTS

Valley Elderberry Longhorn Beetle
Desmocerus californicus dimorphus
FED Threatened

The range of the Valley Elderberry longhorn beetle extends throughout the Central Valley from Redding to Bakersfield. The beetle is found on elderberry shrubs, associated with riparian vegetation. Specific drainages in which the beetles are located include: the

American, Calaveras, Cosumnes, Feather, Merced, Sacramento, Stanislaus, Tuolumne, and San Joaquin rivers.

All stages of the Valley Elderberry longhorn beetle life cycle are associated with elderberry. Adults lay eggs on the plants and the larvae bore into the plant. After pupation, new adults emerge and use the elderberry for resting, foraging, and mating.

Destruction of riparian habitat is generally accepted as the greatest threat to the species. It has been estimated that approximately 90 percent of California riparian systems have been destroyed since the mid-1800's. Elderberries typically grow on high river terraces (Miriam Green Associates 1993). The proposed standards are not likely to adversely affect the elderberry and, therefore, are not likely to adversely affect the Valley Elderberry longhorn beetle.

SECTION III

The following are special status species that inhabit areas in the Estuary, that may be affected by the project, and potentially, could be adversely affected by the project.

BIRDS

California Black Rail
Laterallus jamaicensis coturniculus
CA Threatened
FED Category 1 Candidate Species

The California black rail is a rare, year-long resident of tidal salt, brackish, and freshwater marshes in the Bay-Delta Estuary, Morro Bay, the Salton Sea, and the lower Colorado River area. Historically a local resident in coastal lowland marshes from Santa Barbara County to San Diego, it still winters there, although rarely. Significant loss of saltwater, brackish and freshwater wetland habitats has contributed to reduced populations. Extreme high tides in tidal marshes and water level fluctuations in freshwater marshes have disrupted nesting attempts. Loss of high marsh vegetation around San Francisco Bay has also eliminated the species as a breeder in the South Bay.

Black rails usually frequent upper marsh zones during extreme high tides. They may depend on the zone where the upper marsh vegetation intergrades with peripheral, upland, or freshwater marsh vegetation for cover. Black rails are carnivorous. They glean and peck for a variety of arthropods (e.g., isopods and insects) from the surface of mud and vegetation.

Black rails occur most commonly in tidal salt marshes dominated by pickleweed, or brackish marshes supporting bulrushes in association with pickleweed. Where black rails occur in exclusively freshwater marshes, bulrushes and cattails are usually present. Rail nests are concealed in dense marsh vegetation, such as pickleweed, near the upper limits of tidal flooding and consist of a loosely-made, deep cup which may be at ground level or elevated several inches high.

Rails are generally found only in tidal marshes containing higher elevation zones. They are present in small numbers in narrow tidal marshes along major sloughs and are absent from nontidal marshes. The black rail is apparently critically dependent on a very narrow, high-marsh zone not subject to extreme and frequent tidal action, where insect abundances are greatest, and where some freshwater influences may exist. The presence of weedy vegetation on dikes adjacent to North Bay marshes provides additional transitional upland cover during extreme high tides. Generally, tidal marshes in the North Bay are at a higher elevation, while South Bay marshes lack any broad, high marsh or transition zones and experience a more extreme fluctuation in tidal height. In the nonbreeding season, black rails disperse widely and relatively greater use of the south Bay has been observed, especially by juvenile rails (SFEP 1992).

Current causes of black rail mortality include shortage of well-developed, high-marsh habitat, contributing to exposure during extreme high tides and subsequent predation by harriers, egrets, herons, short-eared owls, and feral cats. The recently established population of introduced red foxes in the south Bay may also prey on black rails during high tide events in this region. Predation by Norway rats on rail eggs may also occur during nesting. Contaminants such as mercury were detected in clapper rail eggs, near San Francisco Bay, in 1986-1987 at sufficient levels to affect nesting success which could also be adversely affecting the California black rail.

Impact of Proposed Standards. The California black rail occurs in the freshwater tidal marshes in the Delta, eastern and western Suisun Marsh, and salt marshes around San Pablo Bay. California black rails inhabit areas influenced by channel salinity and in areas which are more saline than conditions will be in areas of Suisun Marsh, under the proposed standards. The proposed standards will improve freshwater outflow conditions in the Estuary in the spring which should preserve a gradient of freshwater to brackish to saltwater marsh in the unmanaged tidal marshes. In the managed marsh, the conditions should remain the same in the eastern marsh and become slightly more fresh in the western marsh (see section A.5 of Chapter VII). Because the primary limiting factor adversely affecting the black rail is the scarcity of undiked high marsh habitat, and because the proposed standards and resulting channel salinities are not likely limit their potential habitat, the proposed standards are not likely to adversely affect the California black rail.

California Clapper Rail
Rallus longirostris obsoletus
CA Endangered
FED Endangered

The California clapper rail is a coot-sized bird with adults averaging 14-16½ inches. The original range of the rail included Humboldt and Morro bays, as well as salt marshes in the San Francisco and San Pablo bays, Napa Marsh, Bolinas and Tomales bays, and Elkhorn Slough. Development by diking and filling of rail habitat has reduced its range, but the principal cause of its current decline is predation by the introduced red fox. Rail populations have declined dramatically, especially in the South Bay due to red fox predation. Internal Suisun Marsh sloughs and tidal marshes are used by the clapper rail. California clapper rails are present in tidal marshes along the Grizzly Bay and western Suisun Bay shoreline, Suisun Slough, Cutoff Slough and Hill Slough.

Generally, four features characterize preferred habitat for this subspecies: (1) marshes supporting an extensive system of tidal sloughs, providing direct tidal circulation throughout the site; (2) predominant coverage by pickleweed with extensive stands of Pacific cordgrass in the lower elevation marsh zone; (3) high marsh cover consisting of tall stands of pickleweed, gumplant, and wrack; and (4) abundant invertebrate populations. Lower rail densities in the more brackish marshes of San Pablo Bay and Napa Marsh may be related to variations in freshwater outflow and resulting changes in vegetation (SFEP 1992).

The total clapper rail population was first estimated in the early-1970's at 4,200-6,000 individuals. Based on surveys during 1981-1987, the population was estimated to be about 1,500 individuals, with the difference due to more accurate survey techniques rather than a population reduction. In 1988, the population estimate was about 700 individuals; only 300-500 rails were estimated to exist in 1990-1991. The species may be on the verge of extinction.

Concurrent with this declining population in rails has been the dramatic population increase of introduced red foxes, particularly along the east shore of the South Bay. Other threats to clapper rails include predation of eggs, young, and adults by Norway rats, raccoons, striped skunks, and feral cats. In addition, extremely high tides and the lack of high marsh/transition zone habitat has led to predation on adults by norther harriers, barn owls, short-eared owls, and red-tailed hawks. Also, during 1986-1987, mercury was detected in San Francisco Bay clapper rail eggs at levels sufficient to cause embryotoxic effects in mallard ducks. Sewage effluent is also reducing salt marsh habitat in the South Bay by conversion to brackish marsh (SFEP 1992).

Impact of Proposed Standards. The proposed standards could improve freshwater outflow conditions in the Estuary which should preserve a gradient of freshwater to brackish to saltwater marsh in the unmanaged tidal marshes. Conversion of salt marsh to brackish marsh or fresh marsh is not expected. In the managed marsh, the conditions should remain the same in the eastern marsh and may become slightly more fresh in the western marsh (see section A.5 of Chapter VII). The proposed increases in freshwater outflow are within the historical ranges of salinities experienced in the recent past and are not expected to adversely affect the California clapper rail.

Suisun Song Sparrow
Melospiza melodia maxillaris
CA - Considered for possible listing as Threatened
FED Category 2 Candidate Species

The Suisun song sparrow is a small, non-migratory bird endemic to the brackish tidal marshes of Suisun Bay and vicinity in Solano and Contra Costa counties, and the southwestern tip of Sacramento County. This subspecies of song sparrow is typically found in high densities in tidally-influenced vegetation, where pairs forage only short distances and stay close to small, defended territories throughout their lifetimes. Territories are typically associated with tidal sloughs, creeks, or the bayshore. Tidal marsh vegetation, comprised primarily of bulrush and cattail, provides appropriate escape and nesting habitat. Mud flats at the base of this dense vegetation are used extensively for feeding.

Song sparrows typically do not leave the cover of vegetation, eating at the base of the vegetation when mud is exposed at low tide. They only inhabit vegetation where there is room to walk between stalks on the mud. They cannot live where vegetation is too dense or where tidal flow is impeded at all, such as behind mosquito ditches and dikes or where water flow is controlled. Environmental disturbances can fragment habitat. Maintaining or rebuilding levees in the few remaining tidal areas can have a further fragmenting effect.

Young only disperse a short distance from their birthplace. A median juvenile dispersal distance from hatching to breeding site is 607 feet for the song sparrows in San Pablo Bay. They also do not take extended flights over unfamiliar, unsuitable habitat. Therefore, fragmentation of their historic habitat greatly limits breeding among subpopulations (SFEP 1992).

Both adults and young are vulnerable to predation during higher high tides which flood their territories forcing the birds into upland areas. Although formerly occurring in great numbers throughout the tidal marsh, Suisun song sparrows are now restricted to disconnected fragments and narrow strips of optimal habitat. They presently exist at 8 percent of their former numbers, and optimal habitat exists at less than 10 percent of that historically available. The song sparrow faces genetic isolation of subpopulations due to habitat fragmentation.

Historically, the Suisun song sparrow was considered to be an abundant permanent resident of marshes surrounding San Francisco Bay. Destruction and conversion of tidal salt and brackish marshes, particularly in the South and Suisun bays, has greatly reduced the numbers of, and the habitat availability for, this bird. Threats to remnant Suisun song sparrow populations include the fragmented condition of remaining optimal habitat, toxic substance discharges and accidental oil spills into the Bay, and vegetation removal in higher marsh and levee areas. In addition, there is a lack of high marsh nesting cover, resulting in increased vulnerability to high tides and predation by Norway rats and diurnal raptors. Other threats include: ongoing commercial and residential development adjacent to tidal wetlands, which increases the potential for pollution; increased human disturbance; and predation by feral animals. Long-term changes in channel salinity resulting from changes in Delta outflow could result in changes in the vegetation composition of the tidal wetland used by this species (SFEP 1992).

Impact of Proposed Standards. Suisun song sparrows are endemic to the brackish tidal marshes of Suisun Marsh. The birds are physiologically adapted to allow direct consumption of brackish water and are dependent on water in the brackish salinity range. This adaptation to salinity serves to isolate the subspecies from upland subspecies which tolerate only fresh water. Increases in salinity could adversely affect the Suisun song sparrow, as they cannot survive on seawater. A goal of the proposed salinity standards for the Suisun Marsh is to maintain a natural gradient of brackish channel water conditions throughout marsh. The proposed standards should protect channel salinity conditions required by the Suisun song sparrow; therefore, the proposed standards are not likely to adversely affect this species (DWR 1994).

MAMMALS

Salt Marsh Wandering Shrew
Sorex vagrans halicoetes
FED Candidate

Populations of the salt marsh wandering shrew are restricted to salt marshes of San Francisco Bay. Field surveys have been conducted in San Pablo Marsh, Richmond, and Contra Costa County. Suitable habitat is medium-high marsh, about 6-8 feet above sea level, and it extends to lower marsh areas not regularly flooded by tidewater. Suitable areas with this expanse of marsh typically have an abundance of stranded driftwood and other detritus scattered in pickleweed which ordinarily reaches 1-2 feet in height. Under these pieces of wood, moisture is retained fairly well into the autumnal dry period and amphipods, isopods, and other invertebrates are common in most seasons of the year. Nesting and resting cover for shrews is provided by the same driftwood and plant material. The season for births runs from late-February to early-June, with a small amount of breeding occurring in September (Johnston and Rudd 1957).

Most suitable habitat for the salt marsh wandering shrew has been lost to development. This shrew, which prefers a low, dense cover of pickleweed, occurs in low densities.

Impact of Proposed Standards. The proposed standards could improve freshwater outflow conditions in the Estuary in the spring, which should preserve a gradient of freshwater to brackish to saltwater marsh in the unmanaged tidal marshes of the Estuary. In the managed marsh, the conditions should remain the same in the eastern marsh and may become slightly more fresh in the western marsh (see section A.5 of Chapter VIII). The proposed increases in freshwater outflow are within the historical ranges of salinities experienced in the past and are not expected to adversely affect the salt marsh wandering shrew.

Suisun Ornate Shrew
Sorex ornatus sinuosus
CA Species of Special Concern
FED Category 1 Candidate Species

The Suisun ornate shrew is endemic to tidal marshes along the northern shoreline of San Pablo and Suisun bays, from Sonoma Creek eastward to Collinsville. This subspecies inhabits the middle-to-higher marsh elevations where driftwood and litter provide nesting and foraging sites. Suisun ornate shrews occupy a smaller area and more restricted habitat than the endangered salt marsh harvest mouse, discussed below. Few remaining tidal marshes in the Estuary have intact adjacent upland areas where shrews can seek shelter during extreme high tides. It appears that shrews prefer tidal over diked wetlands, but recent findings of salt marsh harvest mice in diked wetlands suggest this habitat may also provide some suitable cover for shrews. Physical structure and species composition of the plant community is probably also important for adequate shrew habitat. The remaining tidal marshes of San Pablo and Suisun bays are broken into small isolated units which rarely have a complete elevational gradient of marshland vegetation (SFEP 1992).

Like the other marsh species endemic to Suisun Marsh, the current distribution of the Suisun ornate shrew has been greatly reduced over the past century by widespread destruction of the peripheral halophyte zone of tidal marshes. Within the historic distribution of this shrew, approximately 58,800 acres of diked marshes are present. Less than two dozen marshes within its range may still provide potential habitat for the species. More extensive habitat currently remains in Suisun Marsh than in San Pablo Marsh. Based on their restricted distribution and shortage of habitat, this species is considered Highest Priority Species of Special Concern by the DFG.

Impact of Proposed Standards. The proposed standards could improve freshwater outflow conditions in the Estuary in the spring, which should preserve a gradient of fresh to brackish to saltwater marsh in the unmanaged tidal marshes. In the managed marsh, the conditions should remain the same in the eastern marsh and may become slightly more fresh in the western marsh (see section A.5 of Chapter VIII). The proposed increases in freshwater outflow are within the historical ranges of salinities experienced in the past and are not expected to adversely affect the Suisun ornate shrew.

Salt Marsh Harvest Mouse
Reithrodontomys raviventris
CA Endangered
FED Endangered

Two subspecies of the salt marsh harvest mouse are endemic to the salt and brackish marshes bordering the San Francisco Bay region. Generally, habitat suitable for the Suisun ornate shrew is also suitable for the salt marsh harvest mouse. The preferred habitat is the mid-to-higher elevation tidal wetlands and adjacent transition zones which provide essential refugia during extreme high tides. These marshes are typically dominated by pickleweed, but a diverse mixture of annual and perennial herbaceous vegetation often characterizes the transitional habitat frequented by the species. Salt marsh harvest mice will also move from tidal and diked marshes into adjacent grasslands in the late spring for limited periods of time.

The northern subspecies, *Reithrodontomys ravivetris halicoetes*, inhabits wetlands bordering San Pablo and Suisun bays, while the southern subspecies, *R. r. raviventris*, occurs in Central and South San Francisco Bay. The mouse is crepuscular and partially diurnal in its activity and generally has a very calm temperament. This behavior might explain the mouse's requirements for dense cover. Dense salt marshes of pickleweed (*Salicornia* sp.), gumplant (*Grindelia* sp.), and fat hen (*Atriplex* sp.) are characteristic of the principal habitat of the mouse and cover appears to be a major factor affecting utilization. The mouse cannot live on a diet consisting exclusively of pickleweed and salt grass (*Distichlis* sp.). The mouse requires a more varied diet, including green and dry plant stems and leaves and plant seeds provided by areas supporting diverse habitat matrices.

Most salt marsh harvest mice are captured in dense, diverse marsh habitats. Sparse cover in poor condition provides poor mouse habitat. Major exceptions appear to be during high water outflows and high tides in tidal areas, and when duck clubs are flooded for hunting or other management purposes. During these times, mice seek refuge in more upland areas or on adjacent levees and for short periods of time on emergent vegetation. These refugia are generally densely vegetated and provide escape cover. In areas managed for waterfowl, dikes with dense vegetation provide refugia for the mouse when these areas are normally flooded from October through June.

Originally found throughout the extensive marshes once bordering the San Francisco Bay east to the vicinity of Collinsville, the salt marsh harvest mouse is now restricted to scattered populations within its original range. Based on historic vegetative composition and tidal elevations, it is estimated that there has been about a 95 percent historical decline in these wetlands, primarily through conversion to salt evaporation ponds and agricultural land (SFEP 1992). Diking of tidal marshes also has greatly reduced the availability of high marsh and transition zone habitat during high tides. This loss of habitat is most serious in the South Bay, where the marshes are narrower and more highly fragmented, the tidal amplitudes are higher, and there has been greater land subsidence from groundwater extraction.

Though poorly documented, it is estimated that about 6,000 acres of diked salt marsh is currently available for the northern subspecies of the mouse, primarily in Suisun Marsh. As a mitigation element of the 1986 Suisun Marsh Protection Plan, the DFG is developing about 1,000 acres of habitat within the Suisun Marsh to be dedicated to the salt marsh harvest mouse (SFEP 1992). Detailed management for the 1,000 acres, and monitoring of this habitat and salt marsh harvest mouse populations, is required in the plan.

Impact of Proposed Standards. The proposed standards could improve freshwater outflow conditions in the Estuary in the spring which should preserve a gradient of freshwater to brackish to saltwater marsh in the unmanaged tidal marshes. In the managed marsh, the conditions should remain the same in the eastern marsh and may become slightly more fresh in the western marsh (see section A.5 of Chapter VIII). The proposed increases in freshwater outflow are within the historical ranges of salinities experienced in the past and are not expected to adversely affect the salt marsh harvest mouse.

FISH

Winter-run Chinook Salmon
Onchorhynchus tshawytscha
CA Endangered
FED Endangered

The State and federally-listed endangered Sacramento winter-run chinook salmon is a unique population of chinook salmon in the Sacramento River system. The winter-run chinook salmon is one of four recognized chinook salmon races in California. It is distinguishable from the other three Sacramento chinook runs by the timing of its upstream migration and spawning season. Adult winter-run salmon pass through the Bay and migrate upstream through the Delta principally from mid-November through mid-June. Spawning occurs from mid-April to mid-August, peaking in late-June or early-July. Winter-run fry begin migrating from spawning areas in early-September and may enter the Estuary soon afterwards, especially when fall storms cause high Sacramento River flows. Peak outmigration through the Delta appears to occur during February and March. In some years, seaward migration can last into May (DFG 1992).

The NMFS listed winter-run chinook salmon as threatened under emergency provisions of the federal ESA in August 1989. The species was formally listed as federally threatened in November 1990. The State of California listed winter-run chinook salmon as endangered in 1989 under provisions of the California ESA. On June 19, 1992, the NMFS proposed that the winter-run chinook salmon be reclassified as an endangered species pursuant to the federal ESA. On August 14, 1992, the NMFS proposed critical habitat for the winter-run chinook salmon from Keswick Dam (Sacramento River Mile 302) to the Golden Gate Bridge. On February 12, 1993, the NMFS prepared a Biological Opinion addressing operations of the CVP and the SWP, and recommended reasonable and prudent alternatives (DFG unpublished report).

Prior to construction of Shasta Dam in 1945, winter-run chinook salmon were reported to spawn in the upper reaches of the Little Sacramento, McCloud, and lower Pit rivers. Specific data relative to the historic run sizes of winter-run chinook salmon prior to 1967 are sparse and mostly anecdotal. Numerous fishery researchers have cited Slater (1963) to indicate that the winter-run chinook salmon population may have been fairly small and limited to the spring-fed areas of the McCloud River before the construction of Shasta Dam. However, recent DFG research in California State Archives has cited several fisheries chronicles that indicate the winter-run chinook salmon population may have been much larger than previously thought. According to these qualitative and anecdotal accounts, the winter-run chinook salmon reproduced in the McCloud, Pit, and Little Sacramento rivers, and may have numbered over 200,000. Construction of Shasta Dam blocked access to all of the winter-run chinook salmon's historic spawning grounds.

The subsequent decline of winter-run chinook salmon has been attributed, in part, to the operation of Red Bluff Diversion Dam, which prevented or delayed access to the favorable spawning ground below Keswick Dam in summer and early-fall. Another factor contributing to the decline is unsuitable water temperatures in the upper river. This condition occurs when the water levels are low in Shasta Reservoir and the ability to access cold hypolimnitic water is limited by the dam's spill gate and powerhouse penstock design. The volume of available cold water within the reservoir is also limited. Other mortality factors in upstream areas include toxic discharge from Iron Mountain Mine, entrainment at poorly screened diversions, and stranding of juveniles during major flow fluctuations in the rearing area.

Completion of the Red Bluff Diversion Dam in 1966 enabled accurate estimates of all salmon runs to the upper Sacramento River based on fish counts at the fish ladders. These annual fish counts document the dramatic decline of the winter-run chinook salmon population. The estimated number of winter-run chinook salmon passing the dam from 1967-1969 averaged 86,509. During 1989, 1990, 1991, and 1992, the spawning escapement of winter-run past the dam was estimated at 547, 441, 191, and 1,180 adults, respectively. In 1994, the estimated escapement was 189 adults. Due to the lack of fish passage facilities at Keswick Dam, adults tend to migrate to and hold in deep pools between Red Bluff Diversion Dam and Keswick before initiating spawning activities.

Since the construction of Shasta and Keswick dams, winter-run chinook salmon spawning has primarily occurred between Red Bluff Diversion Dam and Keswick Dam. Aerial surveys of spawning redds have been conducted annually by the DFG since 1987. These surveys have shown that the majority of winter-run chinook salmon spawning in the upper Sacramento River has occurred between the Anderson-Cottonwood Irrigation District (ACID) dam at River Mile 298 and the upper Anderson Bridge at River Mile 284. However, significant numbers of winter-run chinook salmon may also spawn below Red Bluff (River Mile 245) in some years. In 1988, for example, winter-run chinook salmon redds were observed as far downstream as Woodson Bridge (River Mile 218).

Winter-run chinook salmon eggs hatch after an incubation period of about 40-60 days, depending on ambient water temperatures. Maximum survival of incubating eggs and pre-emergent fry occurs at water temperatures between 40°F and 56°F. Mortality of eggs and pre-emergent fry commences at 57.5°F and reaches 100 percent at 62°F. Other potential sources of mortality during the incubation period include redd de-watering, insufficient oxygenation, physical disturbance, and water-borne contaminants.

The pre-emergent fry remain in the redd and absorb the yolk stored in their yolk-sac as they grow into fry. This period of larval incubation lasts approximately 2 to 4 weeks, depending on water temperatures. Emergence of the fry from the gravel begins during late-June and continues through September. The fry seek out shallow, nearshore areas with slow current and good cover, and begin feeding on small terrestrial and aquatic insects, and aquatic crustaceans. As they grow to 50 to 75 mm in length, the juvenile salmon move out into deeper, swifter water, but continue to use available cover to minimize the risk of predation and reduce energy expenditure.

The emigration of juvenile winter-run chinook salmon from the upper Sacramento River is highly dependent on stream flow conditions and water year type. Once fry have emerged, storm events may cause emigration pulses. Emigration past Red Bluff may begin as early as late-July or August, generally peaks in September, and can continue until mid-March in drier years. Emigration past Glenn Colusa Irrigation District (GCID) at River Mile 206 is monitored daily by the DFG with a rotary screw trap in the GCID oxbow. DFG trap data show that juvenile winter-run chinook salmon emigration past GCID begins as early as mid-July and may continue through April. Data combined from 1981-1992 trapping and seining efforts show that winter-run chinook salmon outmigrants occur from Keswick to Princeton between early-July and early-May.

The timing and dynamics of rearing and downstream migration are more ambiguous in the lower Sacramento River and the Delta. A recent review of chinook salmon data from the IEP Bay Study and other Bay-Delta investigations was conducted by the DFG for occurrence, distribution, and seasonality of winter-run chinook salmon. This review showed that winter-run chinook salmon were captured as early as September at Clarksburg in 1973 and as late as June at Carquinez Strait. Another document reports high winter-run chinook salmon catches in Montezuma Slough (western Delta) during a major flow event in late November of 1981. Mid-water trawl sampling by the DFG identified winter-run chinook salmon juveniles in the northern Delta on November 9, 1992. Available information suggests that the peak period of winter-run emigration through the Delta extends from late-January through April, but early high flows in November or December may bring juveniles into the lower Sacramento River and Delta much earlier.

Relatively little information is available on how conditions in the Estuary affect winter-run chinook salmon. The majority of research on Delta water quality and hydrodynamic conditions affecting chinook salmon have been conducted with fall-run chinook salmon.

Much of this information can be applied to the winter-run. The principal factors affecting fall-run smolt survival in the Delta are temperature, exports, and diversion off the mainstem Sacramento River into the central Delta. Although winter-run smolts generally migrate through the Estuary earlier in the year than fall-run smolts, when it is very unlikely that Delta waters would be detrimentally warm, elevated water temperature can be a factor in the fall and late-spring. Spring temperatures may also be important to winter-run adults.

Like fall-run chinook salmon, any winter-run smolts diverted into the central Delta are expected to have reduced survival as a result of a longer migration route, exposure to increased predation, higher water temperatures, a greater number of agricultural diversions, and greater exposure to the effects of the CVP and SWP export facilities. Due to periodic closure of the Delta Cross Channel gates during higher levels of runoff in late-winter and early-spring, typically a smaller proportion of winter-run smolts are diverted from the mainstem Sacramento River into the central Delta through the Delta Cross Channel. Although experimental evidence is inconclusive as to whether juvenile salmon are diverted in proportion to the diversion of flow through the Delta Cross Channel, Georgiana Slough, and Montezuma Slough, study results support the conclusion that when the Delta Cross Channel gates are closed, a smaller proportion of juvenile salmon are diverted into the central Delta than when the gates are open.

A review of recent fish salvage records from the CVP and the SWP indicates that about 80 percent of the outmigrant juvenile winter-run chinook salmon are salvaged prior to April 1. Extensive sampling in the Sacramento River below Sacramento and adjacent channels during the winter/spring of 1992-1993 indicated the presence of winter-run-sized juvenile salmon from December 7, 1992 through April 28, 1993, with a major peak occurrence around mid-March and a second, smaller peak in early April. Outmigrants in 1992-1993 undoubtedly extended before and after the December 7 through April 28 period because the sampling captures only a small percentage of emigrants.

Scale analysis performed by the DFG provides some additional information regarding the freshwater and estuarine life history of winter-run chinook salmon. Back-calculated length at saltwater entry suggests that the average size of a winter-run chinook salmon smolt is approximately 118 mm while fall-run size at saltwater entry averages 85 mm. In combination with growth data used to determine the spatial and temporal distribution of winter-run chinook salmon, this back-calculated size at saltwater entry supports the January through April period of peak Delta emigration. This evidence suggests that winter-run chinook salmon are residing in fresh and estuarine waters for 5 to 9 months prior to actively emigrating as smolts to the ocean. This period of in-river and Delta residence exceeds that of fall-run chinook salmon by 2 to 4 months.

Little information is available on how conditions in the Suisun Bay area affect winter-run chinook salmon. For instance, the extent to which winter-run smolts use Montezuma Slough as opposed to the Sacramento River during their downstream migration through the Suisun Bay area is unknown. Smolts migrating through Montezuma Slough are exposed to potentially higher rates of entrainment due to unscreened diversions from Montezuma Slough serving managed wetlands when compared to a mainstem Sacramento River route through Suisun Bay. Operation of the Suisun Marsh Salinity Control Gates during extended low Delta outflow increases the percentage of Delta outflow entering Montezuma Slough and may increase the percentage of smolts migrating through Montezuma Slough (DFG unpublished report).

The NMFS proposed several reasonable and prudent alternatives for the Delta operations as well as those operations specified for the upstream areas. The 1993 Biological Opinion specified that: (1) the Delta Cross Channel gates be closed from February 1 through April 30; (2) based on real-time monitoring, the Delta Cross Channel gates should be operated to minimize diversion of juvenile winter-run between October 1 and January 31; (3) the 14-day running average QWEST must be zero from February 1 through April 30; and (4) the 14-day running average QWEST must be greater than -2,000 cfs from November 1 through January 31 (DWR 1992).

Impact of Proposed Standards. Delta conditions will be influenced by the proposed standards and, therefore, will affect the survival of winter-run chinook salmon smolts migrating through the Delta. The effect of the standards on winter-run chinook salmon smolts can only be surmised based on what is known about fall-run chinook salmon smolts. Measures that prevent the diversion of the smolts into the central Delta may increase their survival. These measures would include the closure of the Delta Cross Channel gates between the months of February through April, the peak of the outmigration. Closure of the gates during other times should provide additional protection to smolts outmigrating on either side of the peak period. An acoustical barrier on Georgiana Slough may further reduce diversion of smolts into the central Delta.

The preferred alternative specifies standards that are intended to protect a number of different species. The proposed standards to be implemented between February 1 and April 30, a period that overlaps with the timing of the outmigration of winter-run chinook smolts, could benefit winter-run smolts. These standards include: (1) closure of the Delta Cross Channel gates from February 1 through May 20; (2) maximum exports of 1,500 cfs or 100 percent of the 3-day running average San Joaquin River flow at Vernalis, whichever is greater, from April 15 through May 15 (time period may vary); (3) maximum exports of 35 percent of Delta inflow from February through June (February exports may vary from 35-45 percent depending on the January Eight River Index); (4) San Joaquin River pulse flows of 3,110 cfs to 8,620 cfs from April 15 through May 15 (time period may vary), and base flows of 710 cfs to 3,420 cfs from February 1 through April 14, depending on water year type; and (5) Delta outflow standards from February 1 through June 30, ranging from 4,000 to 8,000 cfs.

Implementation of the proposed standards should improve conditions for winter-run chinook salmon migration through the Delta compared to D-1485 conditions. D-1485 has no export limits between November and April, and the Delta Cross Channel gates are required to be closed between January 1 and April 15 only when the Delta Outflow Index is greater than 12,000 cfs.

Delta Smelt
Hypomesus transpacificus
CA Threatened
FED Threatened

The Delta smelt is one of two native resident species of smelt in the Bay-Delta Estuary. A recent decline in its abundance has caused the Delta smelt to be listed as a threatened species under both the California ESA and the federal ESA.

The Delta smelt is a small, slender-bodied fish, with a typical adult size of 2.2 to 2.8 inches, which is found only in the Bay-Delta Estuary. Most of the year, the population is found in the San Joaquin River below Mossdale, in the Sacramento River below Isleton, and in the Suisun Bay area. Delta smelt have been found at salinities as great as 10 ppt, or approximately 15 mmhos/cm EC, but most of the population occurs at less than 2 ppt, or 3 mmhos/cm EC. They school in open surface waters.

Delta smelt appear to be opportunistic feeders on planktonic copepods, mostly the native *Eurytemora affinis*, and on the introduced *Pseudodiaptomus forbesi* in years when it occurs in high abundance. Also included in the diet are cladocerans, amphipods, and insect larvae. When the population moves downstream to Suisun Bay, the opossum shrimp, *Neomysis*, becomes an important food item.

Delta smelt are euryhaline, and much of the year are most abundant in low salinity areas, most often just upstream of the area where incoming salt and outflowing fresh water mix. It is theorized that this mixing effect allows organisms which swim poorly, such as zooplankton and larval fish, to remain in the area of low salinity rather than being flushed out to sea. Hence, Delta smelt spend their live from the larval period to pre-spawning adulthood in the Delta and brackish areas downstream, particularly the Suisun Bay region. Surveys by the IEP San Francisco Bay-Delta Outflow Study, which has sampled fish in the Estuary from San Francisco Bay to the western Delta since 1980, indicate that the Delta smelt population thins out in San Pablo Bay and is virtually non-existent in San Francisco Bay. The summer-fall geographical distribution is strongly influenced by Delta outflow. As outflow increases, more of the population occurs in Suisun and San Pablo bays. During periods of low outflows, the population is farther upstream.

As spawning approaches in the late-winter and spring, Delta smelt adults migrate to fresh water. The spawning season varies from year to year and may occur from winter (December) to summer (July). Gravid adults have been collected from December to April, although ripe Delta smelt are most common in February and March. In 1989 and 1990, Wang (1991) estimated that spawning had taken place from mid-February to late-June or early-July, with peak spawning occurring in late-April and early-May.

The majority of spawning occurs from February through June in the dead-end sloughs, in the shallow edge-waters of Delta channels, in Montezuma Slough near Suisun Bay, and in the Sacramento River upstream of Rio Vista. Spawning location appears to vary widely from year to year. Sampling of larval smelt in the Delta suggests spawning has occurred in the Sacramento River, Barker Slough, Linsdey Slough, Cache Slough, Georgiana Slough, Prospect Slough, Beaver Slough, Hog Slough, Sycamore Slough, San Joaquin River off Bradford Island including Fisherman's Cut, False River along the shore zone of Frank's Tract and Webb's Tract, and possibly other areas. Delta smelt also may spawn north of Suisun Bay in Montezuma and Suisun sloughs and their tributaries.

Spawning occurs in fresh water at temperatures of 7-15° Celsius. Females produce 1,400-2,900 demersal adhesive eggs on rock, gravel, tree roots, and submerged vegetation. After hatching, larvae drift downstream to the mixing, or entrapment, zone. Growth is rapid, with juveniles reaching 1.6-2 inches long by August. Adult lengths are reached when fish are 6 to 9 months old. Delta smelt are a short-lived species; most die after spawning at 1 year of age, but some survive to 2 years (Stevens et al. 1990).

During the 1980's, the Delta smelt population decreased substantially and has remained low. In the past, Delta smelt populations have declined but always recovered the following year. The population reductions began in the southern and eastern Delta during the 1970's, prior to the overall population decline of the 1980's.

Data indicate that abundance of a Delta smelt year class largely depends on environmental conditions affecting survival of eggs and young fish, rather than the abundance of adult spawners. However, to investigate the cause of the population decline, the DFG evaluated the following factors: Delta outflows, water diversions, food supply, reverse flows, water temperatures, and water transparency. The analysis was unable to point to any one environmental factor as controlling Delta smelt population abundance.

The pelagic larvae and juveniles feed on zooplankton. When the low salinity habitat is located in Suisun Bay, where there is extensive shallow-water habitat within the euphotic zone (depths less than four meters), high densities of phytoplankton and zooplankton may accumulate. However, since an invasion of the Asian clam (*Potamocorbula amurensis*) in 1986, phytoplankton abundance has dropped dramatically. When the 2 ppt isohaline is contained within Suisun Bay, young Delta smelt are dispersed more widely throughout a large expanse of shallow water and marsh habitat than when the 2 ppt isohaline is upstream in the deeper Delta channels. Dispersion in areas downstream from Collinsville reduces their susceptibility to entrainment in Delta water diversions and distributes juvenile Delta smelt among the extensive, protective, and highly productive shoal regions of Suisun Bay. In contrast, when located upstream, the low salinity habitat becomes confined in the deeper river channels which are smaller in total surface area, contain fewer shoal areas, and are less productive.

To determine the distribution and timing of Delta smelt movements throughout the Estuary, the DFG conducted a series of surveys intended to provide crucial information on all life stages of Delta smelt from newly-hatched larva to adult. These surveys included tow-net surveys conducted from June through August, egg and larva surveys conducted in the late-winter through summer, and mid-water trawl surveys conducted in the fall and winter.

The larval surveys conducted by the DFG were initially designed to monitor striped bass eggs and larvae in the Estuary. Because early life stages of Delta smelt are similar to striped bass after hatching, this survey gives a good overview of larval distribution and can be used to identify general spawning areas.

The summer tow-net abundance index is thought to be one of the more representative indices because data have been collected over a wide geographic area (from San Pablo Bay upstream through most of the Delta) for the longest period of time (since 1959). The summer tow-net survey determines abundance and distribution of juvenile Delta smelt and provides data on the recruitment potential of the species. Except for two years since 1983 (1986 and 1993), this index has remained at consistently lower levels than experienced previously.

An abundance index is used to estimate a proportion of the population because sampling an entire population is nearly impossible and a mark-recapture study using Delta smelt cannot be done because the fish is too fragile. An index has no unit of measurement. By systematically sampling specific locations throughout the Estuary and using the same amount of sampling effort (i.e., same net, same technique), that proportion may be compared through time. Changes in the value of the annual abundance index are assumed to represent annual changes in the population. Therefore, an assessment of whether the population has increased or decreased can be made. It indicates that the smelt population has varied dramatically from year to year but declined to low values in the early 1980's and has remained at a severely low level with the exception of a small increase in 1986 and 1993. Only three times before this decline did the index fall below 10 during the 31 year record, and these low values were only for one year at a time.

The fall mid-water trawl survey, conducted during September through October, covers the entire range of Delta smelt distribution and provides one of the two best measures of late juveniles and adult Delta smelt in a large geographic area (San Pablo Bay upstream to Rio Vista on the Sacramento River and Stockton on the San Joaquin River). The mid-water trawl provides an indication of the abundance of the adult population. The mid-water trawl provides a better measure of abundance because it samples pre-spawning adult Delta smelt. An index based on pre-spawning adults, rather than on juveniles which are vulnerable to high mortality, provides a better estimate of Delta smelt stock and recruitment.

Delta smelt were once the most common pelagic fish in the upper Estuary, as indicated by its abundance in DFG trawl catches. Delta smelt abundance from year to year has fluctuated greatly in the past but, between 1982 and 1992, their populations were consistently low. In 1993, numbers increased considerably, apparently in response to a wet winter and spring. During the period of 1982-1992, most of the population was confined to the Sacramento River channel between Collinsville and Rio Vista. The actual size of the population is unknown. However, the pelagic life style of Delta smelt, short life span, spawning habits, and relatively low fecundity indicate that a fairly substantial population probably is necessary to keep the species from becoming extinct.

The Delta Native Fish Recovery Team, formed to respond to the issues surrounding the listing of the Delta smelt, tentatively identified the following reasons for the decline in Delta smelt in order of importance: (1) reduction in Delta outflows; (2) entrainment losses to water diversions; (3) high outflows; (4) changes in food organisms; (5) toxic substances; (6) disease, competition, and predation; and (7) loss of genetic integrity. The reasons for the decline are probably multiple and synergistic.

The USFWS has proposed critical habitat of Delta smelt to include all of Suisun Bay and the Delta. The declaration of critical habitat means that all habitat-altering activities taking place within the region have to be analyzed as to their effect on Delta smelt and then modified if their effect is likely to be significant. Critical habitat for Delta smelt are those specific areas within a geographic area occupied by the species, in which are found physical or biological features: (1) essential to the conservation of the species; and (2) which may require special management considerations or protection (USFWS 1994). Critical habitat for the Delta smelt focuses on habitat conditions required during specific life stages such as spawning, larval and juvenile transport, rearing, and adult migration.

Critical habitat designations alert federal and State agencies, other organizations, and the public to the importance of a geographical area in the conservation of a listed species. Designation of the critical habitat for Delta smelt can provide additional protection with regard to activities that require federal agency action. Based primarily on information gathered by the DFG and researchers at the University of California at Davis, the USFWS proposed the following critical habitat for Delta smelt: "Areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bay); the length of Montezuma Slough and the existing contiguous waters contained within the Delta, as defined by section 12220 of the State of California's Water Code (a complex of bays, dead-end sloughs, channels typically less than 4 meters deep, marshlands, etc. as follows: bounded by a line beginning at the Carquinez Bridge which crosses the Carquinez Strait thence northeasterly along the western and northern shoreline of Suisun Bay, including Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; thence upstream to the intersection of Montezuma Slough with the western boundary of the Delta as delineated in section 12220 of the Water Code; thence following a boundary and including all contiguous water bodies contained within the statutory definition of the Delta, to its intersection with the San Joaquin River at it confluence with Suisun Bay; thence westerly along the south shore of Suisun Bay to the Carquinez Bridge" (USFWS 1994).

Impact of Proposed Standards. The conclusion of the USFWS is that restoration of the Delta smelt to a sustainable population size is likely to require maintenance of the low salinity habitat in Suisun Bay and maintenance of net seaward flows in the lower San Joaquin River during the period when larvae are present (USFWS 1994 and 1995).

The proposed standards are intended to protect a number of different species in the Estuary. The salinity, flow, and operational standards implemented between February 1 and June 30 could benefit the Delta smelt. These proposed standards include: (1) the Delta outflow standards from February through June; (2) closure of the Delta Cross Channel gates from February through May 20 and partial closure from May 21 through June 15; (3) maximum exports of 1,500 cfs or the flow at Vernalis, whichever is greater, from April 15 through May 15; (4) maximum exports between 35 and 45 percent in February, and 35 percent in March through June; and (5) San Joaquin pulse flows of 3,110 cfs to 8,620 cfs from April 15 through May 15, and base flows of 710 cfs to 3,420 cfs from February through April 14 and from May 16 through June, depending on water year type.

The proposed conditions during the spring months may benefit Delta smelt in comparison to the conditions under D-1485. D-1485 has significantly lower outflow requirements and less restrictive export limits.

Sacramento Splittail
Pogonichthys macrolepidotus
FED Proposed Threatened

The Sacramento splittail is a native minnow that commonly reaches 12 to 16 inches in length and lives mostly in the slow-moving stretches of the Sacramento River up to the Red Bluff Diversion Dam, in the Delta, and in the Napa and Suisun marshes. They have been found in Suisun Bay, San Pablo Bay, and Carquinez Strait. Splittail may be evenly distributed in the Delta; however, a 1987 DFG study found them most abundant in the northern and western Delta on flooded island areas in association with other native species.

Sacramento splittail are tolerant of brackish water, being caught at salinities as high as 10-12 ppt, or 15-18 mmhos/cm EC. During spring, they congregate in dead-end sloughs of the marsh areas of the Delta, and Napa and Suisun marshes, to spawn over beds of aquatic or flooded terrestrial vegetation. They have been observed to migrate up the Sacramento River and spawn at Miller Park.

Currently, the Sacramento splittail population lives largely in the shallow, low salinity habitat of Suisun Bay and Suisun Marsh but, in early spring, adults migrate upstream through the Delta to spawn near the mouths of the rivers along the Delta's eastern edge. Although this migration pattern predominates for most of the splittail, lower concentrations of the species can be found in most locations in the Delta throughout the year. In recent years, fewer numbers of newly-spawned splittail have moved across the Delta, back to Suisun Bay. The scarcity of shallow habitats upstream and the increase of salinity in Suisun Bay and Suisun Marsh have greatly restricted the habitat required by this species.

Sacramento splittail recruitment is correlated with annual Delta outflow. Years of higher outflow may provide better cues to direct successful migration upstream by adults, larger areas of flooded vegetation on which the adults can spawn, higher flows to transport the newly-spawned young downstream, and larger areas of suitable habitat in Suisun Bay and Suisun Marsh (Federal Register Vol. 59 No. 4).

Impact of Proposed Standards. The proposed standards are likely to improve the estuarine habitat for Sacramento splittail. The outflow standards between February and June, export limitations, and the San Joaquin River pulse flows should increase the amount of annual outflow in the spring and, therefore, improve splittail recruitment.

Although the proposed conditions during the spring months may benefit the Sacramento splittail, but the effect of the conditions in the Delta during the other months of the year is unknown.

Spring-Run Chinook Salmon
Onchorhynchus tshawytscha
(May be petitioned for listing)

Spring-run chinook salmon were once the most abundant race of salmon in California's Central Valley, and one of the largest runs on the Pacific coast. Large spring-run populations occupied 26 streams in the Sacramento-San Joaquin drainage, principally in the middle reaches of the San Joaquin, Feather, Upper Sacramento, McCloud and Pit rivers and their tributaries. By 1992, however, wild spring-run populations were less than 0.5 percent of the historic runs which numbered up to a million fish (NHI 1994).

Overall population trends for spring run chinook salmon have been documented as declining for many decades. More than 20 historically large populations of spring-run salmon have been extirpated or reduced nearly to zero since 1940. The remnant wild spring-runs on Mill, Deer, Butte, and Big Chico creeks have exhibited statistically significant declines over the same period.

Four tributaries to the Sacramento River, Mill, Deer, Chico, and Butte creeks, consistently support annual spawning populations of spring-run chinook salmon. Several other tributaries occasionally have spring-run salmon present or have recently supported small numbers of them. These tributaries include Antelope, Battle, Beegun, Clear, and South Fork Cottonwood creeks. Historically, spring-run salmon occupied the headwaters of all major river systems in California where natural barriers were absent. Spring-run salmon are known to have occurred in the San Joaquin, Merced (near Yosemite), Stanislaus, Tuolumne, Mokelumne, American, Yuba, Feather, McCloud, Pit, and upper Sacramento rivers. Most of the former spring-run habitat was eliminated by water development and dam construction, preventing access to the headwater areas. It is estimated that nearly 85 percent of the former salmon habitat was lost by 1928, primarily spring-run headwater habitat (NHI 1994).

Spring-run chinook salmon were heavily exploited by the early gill-net fishery in the Sacramento-San Joaquin Delta. A large canning industry, although short-lived, targeted spring-run salmon because of their superior condition when captured during their annual spawning run. Early reports by the California Fish Commissioners reported annual gill-net landings in excess of 700,000 spring-run salmon. Before completion of Friant Dam, nearly 50,000 spring-run salmon were counted on the San Joaquin River. As in the San Joaquin drainage, the Sacramento River populations were dramatically reduced following the construction of barrier dams in the 1940's. The most critical barriers were the closures of Shasta Dam on the Sacramento River in 1945 and Friant Dam on the San Joaquin River in 1948. The spring-run chinook salmon became extinct in the San Joaquin drainage and in the mainstem Sacramento River. Spring-run stocks are now limited to spawning in Mill and Deer creeks and possibly Big Chico, Butte and several other east valley creeks (NHI 1994). Spring-run salmon in the Feather and Sacramento rivers have become hybridized with fall-run salmon because of their forced coexistence below major reservoirs.

The majority of adult spring-run chinook salmon migrate into the Bay-Delta Estuary from mid-March though June. Some evidence from tagging studies indicates freshwater entry into the lower river may actually begin in mid-February. Both spring- and winter-runs migrate coincidentally, with each race segregating into separate holding and spawning areas apparently influenced by suitable water temperatures for spawning and reproductive success. No winter-run salmon migrate into Mill, Deer, Chico, or Butte creeks where summertime water temperatures are adequate for holding adults but lethal to incubating salmon eggs.

Spring-run spawning times have been poorly documented and reported as occurring at a variety of times. The most thorough record appears in the reports from the Baird Hatchery on the McCloud River. Adult spring-run salmon begin entering tributaries in early-March, continuing though April, and peaking in May. The upstream movement concludes by the end of June effectively isolating spring-run salmon in the headwater holding and spawning areas. Spawning takes place from mid-August to the first week in October. Recent spawning stock surveys in Deer Creek have confirmed that the onset of spawning begins in late-August and continues into early-October. There appears to be some variation in spawning times within different drainages, possibly related to water temperatures. Those populations spawning at higher elevations such as Mill and Deer creeks spawn approximately 3 weeks earlier than those in Butte and Chico creeks, where spawning activity is first noted in mid-September. Within Deer Creek, spawning begins first at upstream areas and occurs progressively later at lower elevations.

Additional complexity and variability of spring-run life history results from the different emergence times within different drainages. Early migration extending from early-December through June appears to be the dominate time of juvenile emigration in Butte and Chico creeks. However, some yearling salmon have been collected in January and February, which indicates some unknown portion of the juveniles oversummer in the creeks to outmigrate in the following fall. Conversely, yearling emigration from mid-October through March predominates in Mill and Deer creeks. The fall migration out of the drainage appears to respond to seasonal runoff events. Early season storms stimulate early outmigration (NHI 1994).

Impact of Proposed Standards. Spring-run chinook salmon smolt survival may well be influenced by Delta conditions during the outmigration period, primarily November through January. How the spring-run smolts are affected can only be surmised based on what is known about the influence of Delta conditions on fall-run chinook smolts. Measures that prevent the diversion of the smolts into the central Delta and provide a net seaward outflow may increase spring-run smolt survival through the Delta. The operation measures that would create such conditions include the closure of the Delta Cross Channel gates, limits on export pumping, and minimum Delta outflows.

During the November through January period, the proposed measures that will provide protection for spring-run chinook salmon include: (1) minimum Delta outflows based on water year type; (2) closure of the Delta Cross Channel gates up to a total of 45 days based on monitoring (flows, turbidity, etc.); (3) minimum Sacramento River flows at Rio Vista based on water year type; and (4) a limit on export pumping of less than 65 percent of Delta inflow.

Green Sturgeon
Acipenser medirostris
FED Recommended for Category 2 Candidate Species

Green sturgeon have been taken in salt water from Ensenada, Mexico to the Bering Sea and Japan. They are found in the lower reaches of large rivers from the Sacramento-San Joaquin Delta northward, including the Eel, Mad, Klamath, and Smith rivers. Although spawning has not been confirmed in the Delta, juveniles are common in freshwater areas, especially in the summer. The diet of green sturgeon appears to consist primarily of neomysids and amphipods (Moyle 1976).

Impact of Proposed Standards. It is not clear what conditions are detrimental to the green sturgeon or whether the proposed standards would improve conditions for this species. The proposed standards are not likely to adversely affect the green sturgeon.

Longfin Smelt
Spirinchus thaleichthys
FED Recommended for Category 2 Candidate Species, Petitioned for Listing

The longfin smelt occurs from the Bay-Delta Estuary in California to Prince William Sound in Alaska. Longfin smelt is an euryhaline species with a 2-year life cycle. Spawning occurs in fresh water over sandy-gravel substrates, rocks, or aquatic plants. Spawning may take place as early as November and extend into June, although the peak spawning period is from February to April. After hatching, larvae move up into surface water and are transported downstream into brackish-water nursery areas. Delta outflow into Suisun and San Pablo bays has been positively correlated with longfin smelt recruitment because higher outflow increases larval dispersal and the area available for rearing. The longfin smelt diet consists of neomysids, although copepods and other crustaceans also are eaten. Longfin smelt are preyed upon by fishes, birds, and marine mammals (Federal Register Vol. 59 No. 4).

In the Bay-Delta Estuary, the decline in longfin smelt abundance is associated with freshwater diversion from the Delta. Longfin smelt may be particularly sensitive to adverse habitat alterations because their 2-year life cycle increases their likelihood of extinction after consecutive periods of reproductive failure due to drought or other factors. Relatively brief periods of reproductive failure could lead to extirpations (Federal Register Vol. 59 No. 4).

Although the southernmost populations of longfin smelt are declining, little or no population trend data are available for estuaries in Oregon and Washington. The listing of a Bay-Delta Estuary population segment is also not warranted at this time because that population does not seem to be biologically significant to the species as a whole, and may not be reproductively isolated (Federal Register Vol. 59 No. 4).

Impact of Proposed Standards. The proposed standards may improve conditions for longfin smelt. The standards that may improve the estuarine habitat for longfin smelt include the Delta outflow standard, export limitations, and San Joaquin River pulse flows. Between February and June, the outflow standard should benefit the longfin smelt by providing transport flows for eggs and larvae downstream to low salinity habitat. The abundance of longfin smelt is correlated with outflow during the months of December through May. Conditions from December through February may affect the longfin smelt.

PLANTS

Delta Tule Pea
Lathers jepsonii jepsonii
FED Category 2 Candidate Species

This climbing perennial herb was distributed historically throughout many Bay area marshlands, with additional populations known from San Benito, Fresno, and Tulare counties. Because of widespread habitat losses from the filling and diking of wetlands, its current distribution is largely restricted to fresh and brackish tidal wetlands bordering San Pablo and Suisun bays and tidal wetlands in the Delta.

Delta tule pea is found along the water side or crest of river and canal banks in brackish and freshwater marshes and riparian woodlands on drier ground at or above the zone of tidal influence. It is common among tule stands in the western Suisun Marsh where it occasionally forms dense tangled masses (DWR 1992a). This subspecies has been found trailing through tule stands along the Suisun Slough in the western portion of the Suisun Marsh. Populations of the Delta tule pea noted during field surveys in Suisun Marsh were confined to the edges and water side of levees (sometimes the crests) of tidally influenced streams.

Drainage of marshy areas and salinity changes are considered endangerment factors.

Impact of Proposed Standards. The proposed standards will maintain a continuum of fresh to brackish marsh in Suisun Marsh and the unmanaged tidal wetlands; therefore, the proposed standards are not likely to adversely affect the Delta tule pea.

Suisun Marsh Aster
Aster chilensis var. *lentus*
FED Category 2 Candidate Species

This robust, perennial herb, 1-2 meters tall, is known from various areas throughout Suisun Marsh and the Delta. It typically occurs along tidal sloughs in salt to brackish marshes.

The Suisun Marsh aster is located in Suisun Slough, Hill Slough, and other western Suisun Marsh waterways. These populations are often dense, but highly restricted to the narrow band of tule alongside the streams. One population was noted on the land side of a levee bordering Suisun Slough; however, these plants were closely associated with a small drainage ditch which eventually drained into Suisun Slough. All of the observed populations observed in the Suisun Marsh were tidally influenced.

Impact of Proposed Standards. The proposed standards will maintain a continuum of fresh to brackish marsh in Suisun Marsh and the unmanaged tidal wetlands; therefore, the proposed standards are not likely to adversely affect the Suisun Marsh aster.

Mason's Lilaeopsis
Lilaeopsis masonii
CA Rare
FED Category 2 Candidate Species

Mason's lilaeopsis is a member of the carrot family (Apiaceae), the fourth largest family of flowering plants in California. It is a low-growing perennial that appears grass-like at a distance.

Mason's lilaeopsis is know to be located in 39 sites according to the California Natural Diversity Data Base, maintained by the DFG. The overall distribution of the plant includes Contra Costa, Napa, Solano, Sacramento, and San Joaquin counties. The plant is restricted to the tidal zone and grows in disturbed muddy banks and flats, and occasionally on rotting wood. Measurements taken of populations on exposed banks indicate that they occur in the zone between 16 and 36 inches above the high and low tide equilibrium point (i.e., above the zero flood level). The highest densities of plants were found to occur at 30 to 32 inches above tidal equilibrium.

The formation of habitat is primarily due to natural disturbance of riparian or marsh vegetation as a result of bank failure and erosion. The plants appear to colonize new habitat both vegetatively and by seed deposition. Entire plants of Mason's lilaeopsis have been observed floating in the sloughs, suggesting that vegetative reproduction and the formation of clonal populations may be important in colonization. The rhizomatous nature of Mason's lilaeopsis allows it to reproduce vegetatively. It is likely that some populations are composed mostly of clones from individuals that initially colonized the habitat.

The plants grow successfully in the shade of riparian shrubs, such as willows, and in full sunlight. No correlation between riparian or marsh species and Mason's lilaeopsis was observed. The associated species were a function of local habitat conditions. Highly-disturbed, steeply-sloping levees supported herbaceous perennial associates. Older levees with more gentle slopes and small islands supported riparian shrubs, and non-leveed areas consisted primarily of tule and cattail marshlands. Mason's lilaeopsis was not observed in association with rock revetment.

The habitat of Mason's lilaeopsis is generally considered transient. The rate of habitat formation, colonization, and eventually loss varies as a function of bank stability. Steep levee banks are unstable and the viability of a population of Mason's lilaeopsis may be as short as 1 year after colonization. More stable situations, such as those on riparian islands, may support a population for over 20 years, based on historical information obtained from topographic maps of islands in the sloughs. In summer, habitat viability is directly related to the level of human development, with leveed banks having low viability.

While little data are available on channel water salinity requirements, evidence suggests populations of Mason's lilaeopsis are restricted to the fresher portion of the Napa River and locations west of Martinez in the Suisun Bay area and the Delta. Threats to this species are primarily related to dredging, levee construction, and riprapping (DFG unpublished report).

Impact of Proposed Standards. The proposed standards will maintain a continuum of fresh to brackish marsh in Suisun Marsh and the unmanaged tidal wetlands; therefore, the proposed standards are not likely to adversely affect the Mason's lilaeopsis.

Soft Haired Bird's-beak
Cordylanthus mollis mollis
FED Category 1 Candidate Species

This annual herb is endemic to higher elevations of tidal marshes fringing the shorelines of San Pablo and Suisun bays. The soft haired bird's-beak grows in the upland transition border or the upper level of the high tide. It is found in tidal marshes at the north end of the San Francisco Bay and in the Suisun Marsh. While relatively small (25-40 cm high), its distinctive gray-green and hairy vegetation contrasts with associated salt marsh vegetation. Recent known locations are limited to several areas in Napa Marsh, South Hampton Bay, the confluence of Cutoff Slough and Montezuma Slough (west of Beldons Landing) in Suisun Marsh, and several locations along the northern Contra Costa County shoreline.

Two locations of the species (near Napa River and Montezuma Slough) are in a diverse association of species and are tidally inundated. Most of the sites appear to be tidally influenced. The soft haired bird's-beak is not likely to occur in pure stands of pickleweed at the lowest elevations; rather, the combination of saltgrass and pickleweed at higher elevations are more suitable.

Impact of Proposed Standards. The proposed standards will maintain a continuum of fresh to brackish marsh in Suisun Marsh and the unmanaged tidal wetlands; therefore, the proposed standards are not likely to adversely affect the soft-haired bird's beak.

Hispid Bird's-beak
Cordylanthus mollis hispidus
FED Category 2 Candidate Species

The hispid bird's-beak is a small (15-20 cm high) leafy annual herb. It grows on saline flats in association with pickleweed and/or saltgrass. Known from only a few populations, the subspecies extends from the Sacramento-San Joaquin Delta and southern Sacramento Valley south through the San Joaquin Valley to Kern County.

It seems probable that any *Cordylanthus* populations found in tidal wetlands in Suisun Marsh more likely would be the subspecies *C. m. mollis* (DFG unpublished report).

Impact of Proposed Standards. The proposed standards will maintain a continuum of fresh to brackish marsh in Suisun Marsh and the unmanaged tidal wetlands; therefore, the proposed standards are not likely to adversely affect the hispid bird's-beak.

Literature Cited in Chapter XIII

Bay Institute of San Francisco, The. 1994. Comments of the Bay Institute of San Francisco on proposed USEPA rule: Water quality standards for surface waters of the Sacramento River, San Joaquin River and San Francisco Bay and Delta. March 10, 1994.

DFG. 1992. Annual report on the status of California State listed threatened and endangered animals and plants. California Department of Fish and Game. 203 pp.

DFG. 1993. Status review of the riparian brush rabbit (*Sylvilagus bachmani riparius*) in California. Report to the Fish and Game Commission. Nongame Bird and Mammal Section Report 93-12. December, 1993. 23 pp. plus attachments.

DFG. 1994. Unpublished Report. Contact person: Frank Wernett, Bay-Delta Division, Stockton, California.

DWR. 1992a. Biological assessment. Effects of Central Valley Project and State Water Project Delta operations on winter-run chinook salmon. October 1992. 136 pp. plus appendices.

DWR. 1992b. Biological assessment for South Delta Temporary Barriers Project. Biological assessment for USFWS Section 7 endangered species permit. California Department of Water Resources, Office of Environmental Services. February 1992.

DWR. 1994. Summary of sensitive plant and wildlife resources in Suisun Marsh during water years 1984-1994. Environmental Services Office, Department of Water Resources. December 1994. 107 pp.

Erlich, P., D. Dobkin, and D. Wheye. 1992. Birds in jeopardy. The imperiled and extinct birds of the United States and Canada, including Hawaii and Puerto Rico. Stanford University Press, Stanford, California.

Jennings, M., M. Hayes, and D. Holland. 1992. A petition to the USFWS to place the California red-legged frog (*Rana aurora draytonii*) and the western pond turtle (*Clemmys marmorata*) on the list of endangered and threatened wildlife and plants. January 15, 1992.

Johnston, R. and R. Rudd. 1957. Breeding of the salt marsh shrew. Journal of Mammology 38(2):57-163.

Miriam Green Associates. 1993. Phase I report - Sensitive species, Interim South Delta Project. Prepared for USBR and DWR. February 12, 1993.

Moyle, P. 1976. Inland fishes of California. University of California Press. ISBN 0-520-02975-5. 405 pp.

Moyle, P., J. Williams, and E. Wikramanayake. 1989. Fish species of special concern of California. Final report submitted to the DFG. Contract No. 7337. October 1979. 222 pp.

Nature Conservancy, The. 1992. Jepson Prairie Preserve handbook. Second edition Jepson Prairie Docent Program.

NHI. 1994. Comments and recommendations to the State Water Resources Control Board regarding review of standards for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. July 13, 1994 workshop. 23 pp. plus attachments.

SFEP. 1992. Status and trends report on wildlife of the San Francisco Estuary. Prepared by the USFWS for the San Francisco Estuary Project under EPA Cooperative Agreement CE-009519-01-0. January 1992. 283 pp. plus appendices.

Slater, D. 1963. Winter-run chinook in the Sacramento River, CA, with notes on water temperature requirements at spawning. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries No. 461. 9 pp.

Stevens, D., S. Miller, and B. Bolster. 1990. Report to the Fish and Game Commission: A status review of the delta smelt, *Hypomesus transpacificus* in California. California Department of Fish and Game Candidate Species Status Report 90-2. 149 pp.

USFWS. 1994. Biological opinion on the effects of 1994 Central Valley Project and State Water Project impacts on delta smelt. U.S. Fish and Wildlife Service. 68 pp.

USFWS. 1995. Formal Consultation and Conference on Effects of Long-term Operation of the Central Valley Project and State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat and Proposed Threatened Sacramento Splittail. U.S. Fish and Wildlife Service. 72 pp.

Wang, J. 1991. Early life stages and early life history of the Delta smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin estuary, with comparison of early life stages of the longfin smelt, *Spirinchus thaleichthys*. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Tech. Report 28. 18 pp. plus appendices.

WESCO. 1989. Biological assessment for the proposed shorelands project, Hayward, Alameda County, California. Prepared by Western Ecological Services Company, and revised by Thomas Reid Associates, for the U.S. ACOE. August 1989.

CHAPTER XIV. ENVIRONMENTAL CHECKLIST

Legend: Y=yes ?=maybe N=no

1. EARTH. Will the proposal result in:	
a. Unstable earth conditions or in changes in geologic substructures?	N
b. Disruptions, displacements, compaction, or overcovering of the soil?	N
c. Change in topography or ground surface relief features?	?
d. The destruction, covering, or modification of any unique geologic or physical features?	N
e. Any increase in wind or water erosion of soils, either on or off the site?	?
f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition, or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet, or lake?	N
g. Exposure of people or property to geologic hazards such as earthquakes, landslides, mudslides, ground failure, or similar hazards?	N
2. AIR. Will the proposal result in:	
a. Substantial air emissions or deterioration of ambient air quality?	?
b. The creation of objectionable odors?	N
c. Alteration of air movement, moisture, or temperature, or any change in climate, either locally or regionally?	N
3. WATER. Will the proposal result in:	
a. Changes in currents, or the course or direction of water movements, in either marine or fresh waters?	Y
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface runoff?	N
c. Alterations in the course or flow of flood waters?	N
d. Change in the amount of surface water in any water body?	Y
e. Discharge into surface waters, or in any alteration of surface water quality including but not limited to temperature, dissolved oxygen, or turbidity?	Y
f. Alteration of the direction or rate of flow of ground water?	Y
g. Change in quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	Y
h. Substantial reduction in the amount of water otherwise available for public water supplies?	Y
i. Exposure of people or property to water–related hazards such as flooding or tidal waves?	N

ENVIRONMENTAL CHECKLIST (CONTINUED)

Legend: Y=yes ?=maybe N=no

4. PLANT LIFE. Will the proposal result in:	
a. Change in the diversity of species, or number of any species, of plants (including trees, shrubs, grass, crops, and aquatic plants)?	?
b. Reduction of the numbers of any unique, rare, threatened, or endangered species of plants?	?
c. Introduction of new species of plants into an area, or in a barrier to the normal replenishment of existing species?	N
d. Reduction of acreage of any agricultural crop?	Y
5. ANIMAL LIFE. Will the proposal result in:	
a. Change in the diversity of species, or numbers of any species, of animals (birds, land animals including reptiles, fish and shellfish, benthic organisms, or insects)?	?
b. Reduction of the numbers of any unique, threatened, or endangered species?	?
c. Introduction of new species of animals into an area, or result in a barrier to the migration or movement of animals?	N
d. Deterioration to existing fish or wildlife habitat?	N
6. NOISE. Will the proposal result in:	
a. Increases in existing noise levels?	N
b. Exposure of people to severe noise levels?	N
7. LIGHT AND GLARE. Will the proposal produce new light or glare?	N
8. LAND USE. Will the proposal result in a substantial alteration of the present or planned use of an area?	Y
9. NATURAL RESOURCES. Will the proposal result in an increase in the rate of use of any natural resources?	Y
10. RISK OF UPSET. Will the proposal involve:	
a. A risk of an explosion or the release of hazardous substances (including, but not limited to, oil, pesticides, chemicals, or radiation) in the event of an accident or upset condition?	N
b. Possible interference with an emergency response plan or an emergency evacuation plan?	N
11. POPULATION. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?	?
12. HOUSING. Will the proposal affect existing housing, or create a demand for additional housing?	N
13. TRANSPORTATION AND CIRCULATION. Will the proposal result in:	
a. Generation of substantial additional vehicular movement?	N
b. Effects on existing parking facilities, or demand for new parking?	N
c. Substantial effect on existing transportation systems?	N
d. Alterations to present patterns of circulation or movement of people and/or goods?	N

ENVIRONMENTAL CHECKLIST (CONTINUED)

Legend: Y=yes ?=maybe N=no

e. Alterations to waterborne, air, or rail traffic?	Y
f. Increase in traffic hazards to motor vehicles, bicyclists, or pedestrians?	N
14. PUBLIC SERVICES. Will the proposal have an effect upon, or result in a need for, new or altered governmental services in any of the following areas:	
a. Fire protection?	N
b. Police protection?	N
c. Schools?	N
d. Parks or other recreational facilities?	?
f. Maintenance of public facilities, including roads?	N
g. Other governmental services?	N
15. ENERGY. Will the proposal result in:	
a. Use of substantial amounts of fuel or energy?	?
b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?	?
16. UTILITIES. Will the proposal result in a need for new systems, or substantital alterations to the following utilities:	
a. Sewerage?	N
b. Water?	?
c. Electricity?	?
d. Natural gas?	N
e. Telephone?	N
17. HUMAN HEALTH. Will the proposal result in:	
a. Creation of any health hazard or potential health hazard (excluding mental health)?	N
b. Exposure of people to potential health hazards?	N
18. AESTHETICS. Will the proposal result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view?	?
19. RECREATION. Will the proposal result in an impact upon the quality or quantity of existing recreational opportunities?	Y
20. CULTURAL RESOURCES.	
a. Will the proposal result in the alteration or the destruction of a prehistoric or historic archaeological site?	N
b. Will the proposal result in adverse physical or aesthetic effects to a prehistoric or historic building, structure, or object?	N
c. Does the proposal have the potential to cause a physical change which would affect unique ethnic cultural values?	N
d. Will the proposal restrict existing religious or sacred uses within the potential impact area?	N

Legend: Y=yes ?=maybe N=no

21. MANDATORY FINDINGS OF SIGNIFICANCE.

a. Does the proposal have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self–sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare, threatened, or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory? ?

b. Does the project have the potential to achieve short–term, to the disadvantage of long–term, environmental goals? ?

c. Does the project have impacts which are individually limited, but cumulatively considerable? ?

d. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly? Y

DETERMINATION

On the basis of this initial evaluation, I find that the proposed project could have a significant effect on the environment.

Gerald E. Johns
Signature

5/12/95
Date

Environmental Program Manager II
Title

for the State Water Resources Control Board

ENVIRONMENTAL CHECKLIST
Responses to "Yes" and "Maybe" answers:

1. **EARTH.** Will the proposal result in:

c. Change in topography or ground surface relief features? "Maybe"

The project may result in changes in agricultural practices in certain areas which could possibly change the topography or ground surface relief features. Increased groundwater withdrawals or overdraft may result in local occurrences of land subsidence.

e. Any increase in wind or water erosion of soils, either on or off the site? "Maybe"

Reductions and greater fluctuations of reservoir pool levels may increase wind and water erosion around the rims of reservoirs. Also, the project may result in an increase in the abandonment of agricultural areas which may increase wind erosion of soils.

2. **AIR.** Will the proposal result in:

a. Substantial air emissions or deterioration of ambient air quality? "Maybe"

The project will result in a decrease in the availability of water for hydroelectric power generation which may result in the need for alternative electrical power generation from the combustion fossil fuels. This could result in the deterioration of local ambient air quality.

3. **WATER.** Will the proposal result in:

a. Changes in currents, or the course or direction of water movements, in either marine or fresh waters? "Yes"

The project will result in changes in the magnitude and timing of freshwater outflow in the Delta which may result in changes in the course or direction of water movements. In rivers, the project could affect flows as a result of changes in reservoir operation, changes in runoff, return flows, wastewater discharge, or drainage to the rivers.

d. Change in the amount of surface water in any water body? "Yes"

The project will result in changes in the levels of the reservoirs and rivers both upstream of the Delta and in export areas.

e. Discharge into surface waters, or in any alteration of surface water quality including but not limited to temperature, dissolved oxygen, or turbidity? "Yes"

The project will result in alterations of surface water quality parameters such as temperature, dissolved oxygen, turbidity, and salinity in the rivers and in the Delta by changing the magnitude of flows at different times of the year. In addition, there is the possibility that the project will result in higher levels of total dissolved solids in surface waters in the export areas due to decreased availability of higher quality Delta water for blending with local lower quality water.

f. Alteration of the direction or rate of flow of ground water? "Yes"

The project will result in a reduction in the amount of surface water applied in some areas of the State, thus, resulting in less percolation to the ground water table. This will result in a change of direction or rate of flow of ground water.

g. Change in quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations? "Yes"

The project will result in changes in the quantity of ground water through an increase in groundwater withdrawals.

h. Substantial reduction in the amount of water otherwise available for public water supplies? "Yes"

There will be a decrease in water available for export from the Delta, the amount depending on water year type. The agencies that export water will need to determine how that water will be distributed. Generally, more water is exported for irrigation than for municipal use. It is likely that municipal water supplies will be met first and that irrigation supplies will be reduced.

4. **PLANT LIFE.** Will the proposal result in:

a. Change in the diversity of species, or number of any species, of plants (including trees, shrubs, grass, crops, and aquatic plants)? "Maybe"

The project may result in a change in the types of crops grown in some parts of the State.

b. Reduction of the numbers of any unique, rare, threatened, or endangered species of plants? "Maybe"

The project will reduce water supplies to export areas, depending on water year type, which may affect water supplies to water districts in the export areas. The decisions of local water agencies will determine local water management and operations and, therefore, whether or not the habitat of special-status plant species in the export areas will be affected.

d. Reduction of acreage of any agricultural crop? "Yes"

The project will result in the reduction in the acreage of some agricultural crops in parts of the State.

5. **ANIMAL LIFE.** Will the proposal result in:

a. Change in the diversity of species, or numbers of any species, of animals (birds, land animals including reptiles, fish and shellfish, benthic organisms, or insects)? "Maybe"

The project will reduce water supplies to export areas, depending on water year type, which may affect water supplies to water districts in the export areas. The decisions of local water agencies will determine local water management and operations and, therefore, whether or not the diversity and numbers of animals in the export areas will be adversely affected.

b. Reduction of the numbers of any unique, threatened, or endangered species? "Maybe"

The project will reduce water supplies to export areas, depending on water year type, which may affect water supplies to water districts in the export areas. The decisions of local water agencies will determine local water management and operations and, therefore, whether or not the habitat of special-status animal species in the export areas will be affected.

8. **LAND USE.** Will the proposal result in a substantial alteration of the present or planned use of an area? "Yes"

The project will result in an alteration of agricultural areas.

9. **NATURAL RESOURCES.** Will the proposal result in an increase in the rate of use of any natural resources? "Yes"

The project will result in an increase in the release of stored water from upstream reservoirs, an increase in the use of ground water, and, possibly, an increase in the burning of fossil fuels for power generation.

11. **POPULATION.** Will the proposal alter the location, distribution, density, or growth rate of the human population of an area? "Maybe"

If the project results in a change in distribution of municipal water supplies, it could result in changes in the location, density, or growth rate of the human population in the areas where such a change in water supply may occur.

13. **TRANSPORTATION.** Will the proposal result in:

e. Alterations to waterborne, air, or rail traffic? "Yes"

The project requires the closure of a Delta channel during specified times. When the channel is closed, waterborne traffic will be altered.

14. **PUBLIC SERVICES.** Will the proposal have an effect upon, or result in a need for, new or altered governmental services in any of the following areas:

d. Parks or other recreational facilities? "Maybe"

The project: (1) will result in a change in the water levels of upstream reservoirs and flow in the rivers which may affect parks or other recreational facilities; (2) may affect water supplies that provide water to parks and other recreational facilities; and (3) may affect the use of recreational facilities utilized by those participating in sport fisheries.

15. **ENERGY.** Will the proposal result in:

a. Use of substantial amounts of fuel or energy? "Maybe"

The project will result in a decrease in the availability of water for hydroelectric power generation which may result in the need for alternative electrical power generation from the combustion fossil fuels. In addition, although reduced exports will reduce energy demand for export pumping, increased pumping of ground water to replace reduced surface water supplies may result in increased local demands for electricity.

b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy? "Maybe"

The project will result in a decrease in the availability of water for hydroelectric power generation which may result in the need for alternative electrical power generation, including the development of new sources of electricity. In addition, the project will result in increased groundwater withdrawals which may result in increased demand upon existing sources of energy for groundwater pumping.

16. UTILITIES. Will the proposal result in a need for new systems, or substantial alterations to the following utilities:

b. Water? "Maybe"

The project will result in a change in the amount or allocation of water supplies; therefore, it may result in the need to alter the water distribution system, or result in the need for new systems in the areas where such a change may occur.

c. Electricity? "Maybe"

If the project results in a change in the operation scheme of some multi-purpose reservoirs, it may result in a change in the timing or amount of hydro-electric power generated. The result will require a re-operation or changes in management of the electrical utilities or an augmentation of electrical supplies. Increased pumping of ground water to replace reduced surface water supplies may result in increased local demands for electricity. However, the project also will result in decreased exports which will lower energy requirements to export water.

18. AESTHETICS. Will the proposal result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to public view? "Maybe"

The project may result in changes of the operations of upstream reservoirs which may cause the water levels to be lower for longer periods, reducing the aesthetic values of the reservoir. The project may also result in reduced water availability for irrigation of landscaping in export areas which could reduce the aesthetic qualities of those areas.

19. RECREATION. Will the proposal result in an impact upon the quality or quantity of existing recreational opportunities? "Yes"

The project will restrict recreational access to some waterways through Delta Cross Channel gate closure and may: (1) result in a change in the water levels of upstream reservoirs which may affect the quality of or access to recreational facilities or opportunities; and (2) affect sport fisheries both in upstream areas and in the Delta. (See also 14. d.)

21. MANDATORY FINDINGS OF SIGNIFICANCE.

a. Does the proposal have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare, threatened, or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory? "Maybe"

The project will reduce water supplies to export areas, depending on water year type, which may affect water supplies to water districts in the export areas. The decisions of local water agencies will determine local water management and operations and, therefore, whether or not the proposal has the potential to adversely affect plants or animals in the export areas.

b. Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals? "Maybe"

The project will result in increased groundwater withdrawals to replace decreased water supplies. This may result in environmental problems related to groundwater overdraft in the long-term. Additionally, changes in the use of water may occur, such as shifts in crops or land use.

c. Does the project have impacts which are individually limited, but cumulatively considerable? "Maybe"

The project will have an effect on the water supplies in some upstream and export areas; however, how significant those cumulative effects will be will vary by water year type, area, water right type, and water management strategies.

d. Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly? "Yes"

The project will have an effect on water supplies in some parts of the State. This will have a direct or indirect effect on people involved directly or indirectly in agriculture, and, to some degree, those dependent on municipal supplies.

The SWRCB will decide the exact measures needed to implement the Bay-Delta Plan in a future water rights proceeding that includes the water users in the watershed of the Bay-Delta Estuary, and will consider actions to mitigate any significant environmental effects that will occur as a result of those implementation measures at that time. The SWRCB separated this action from the future implementation of the plan upon the direction of the Court of Appeal in previous Bay-Delta litigation. In that case, the SWRCB combined its water quality and water rights proceedings, and implemented the plan immediately. The Court of Appeal stated that combining the proceedings caused the SWRCB to compromise its water quality role by defining the water quality objectives in terms of the water rights to be amended. The Court advised the SWRCB against this procedure. (U.S. v. State Water Resources Control Board (1986) 227 Cal.Rptr. 161, 180)

Because the plan does not, in itself, mandate any implementation, no significant environmental effects will occur until a further action has been taken that implements the plan. To the extent that the DWR and the USBR already are implementing some of the new objectives in the plan, they are doing so because of their obligations under the federal ESA, which predate the adoption of the plan. Therefore, the plan and its implementation may not have additional environmental effects since most of the environmental effects identified below will have already occurred by the time the plan is implemented. The discussion below makes the theoretical assumption that the existing physical environment is the environment that would exist in the absence of the intervening regulatory actions by other agencies. In effect, it provides a cumulative assessment of the likely impacts of implementing the water quality objectives in the plan instead of implementing the operating standards in D-1485. D-1485 was the primary regulatory control over flow, operations, and salinity levels in the Bay-Delta Estuary until about 1991, when other regulatory actions were commenced under the federal ESA.

The plan increases the protection provided to fish and wildlife uses of the Estuary while maintaining existing water quality protections for other uses of water in the Estuary. Therefore, there will be no significant adverse effects to biological resources in the Estuary due to the plan. Implementation of these protections would shift some water supplies from consumptive uses throughout the State to fish and wildlife uses in the Estuary, resulting in decreased water availability to water users responsible for meeting the objectives and changes in reservoir levels and river flows in upstream areas. Consequently, implementation could cause significant or potentially significant adverse environmental effects through reductions in water supply and changes in flow patterns. These environmental effects, including possible mitigation measures and findings, are discussed below. The notations in brackets refer to the environmental checklist items which identify these environmental effects.

a. Adverse Environmental Effects Primarily Due to Reduced Water Supplies

(1) Water Supplies. Implementation of the plan could have the potential to result in significant cumulative effects on water supplies in some upstream and export areas [21.c]. Increases in the rate of use of stored water from upstream reservoirs would occur [9]. Substantial reduction in the amount of water otherwise available for public water supplies would occur [3.h]. The occurrence and extent of these effects would depend on water year type, area, water right type, and water management strategies. Also, there could be a need for new systems or substantial alterations to existing water facilities to address changes in the amount or allocation of water supplies [16.b].

(2) Water Quality. Higher levels of total dissolved solids could occur in surface waters in export areas due to decreased availability of water for blending with local lower quality water [3.e].

(3) Ground Water. Changes in quantity of ground waters, either through direct additions or withdrawals, would occur [3.g]. Increases in the rate of use of ground water would occur [9]. Alteration of the direction and rate of the flow of ground water would occur as a result of less percolation to the ground water table due to reductions in surface water applied in some areas [3.f]. Changes in topography or ground surface relief features could occur as a result of local land subsidence due to increased groundwater withdrawals or overdraft [1.c].

(4) Agriculture. Reduction of acreage of agricultural crops would occur in some areas [4.d]. Substantial alteration of the present or planned use of some agricultural areas would occur [8]. Changes in the types of agricultural crops could occur [4.a]. Changes in topography or ground surface relief features could occur as a result of changes in agricultural practices in certain areas [1.c]. Increases in wind erosion of soils could occur if abandoned agricultural areas increase [1.e].

(5) Short-term Gain/Long-term Loss. Implementation of the plan could have the potential to achieve short-term environmental goals to the disadvantage of long-term goals such as minimizing environmental problems related to groundwater overdraft, and shifts in crops or land use [12.b].

(6) Biological Resources. Implementation of the plan could have the potential to affect adversely plants or animals in the export areas [21.a]. Changes in the diversity of species, or number of any species, of animals could occur [5.a]. Reduction of the numbers of any unique, rare, threatened, or endangered species of plants and animals could occur [4.b, 5.b]. The occurrence and extent of these effects would depend on water year type and local water management and operations in response to reduced water supplies.

(7) Parks and Recreation. Effects on parks or other recreational facilities could occur through reductions in water supplies to these areas [14.d].

(8) Human Populations. Implementation of the plan has the potential to affect adversely, directly and indirectly, people involved in agriculture or dependent on municipal supplies through reduced water supplies in some parts of the State [21.d]. Alterations in the location, distribution, density, or growth rate of the human population of an area could occur if changes in the distribution of municipal water supplies occurs as a result of changed water supplies [11].

(9) Aesthetics. Creation of an aesthetically offensive site open to public view could occur if water availability for landscape irrigation is reduced [18].

Mitigation Measures and Findings. It is essential that the SWRCB now adopt a water quality control plan to serve as a basis for future regulatory measures that will protect the fish and wildlife uses of the Estuary. The plan is an essential early step in establishing adequate protections for the Estuary.

This report, in Chapter X, lists the following mitigation measures that could mitigate the effects of implementing the plan. When the SWRCB implements the plan through a water right decision, it will consider specific actions within its authority that may help carry out the following mitigation measures. The implementation measures are of a nature that they must be adopted under other proceedings. The water rights measures cannot be adopted under the authority to adopt a water quality control plan. The SWRCB's authority to mitigate the effects of implementing the plan is the SWRCB's water rights authority. Therefore, the SWRCB cannot legally, at this time, either implement the plan or mitigate the environmental effects of implementation. Consequently, adoption of the mitigation measures identified in the environmental report is infeasible at this time. These legal considerations also will delay any significant effects resulting from adoption of the plan and these legal considerations outweigh the potential significant environmental effects of the plan. Adoption of the plan without adopting mitigation measures does not preclude mitigation, but merely delays it until the future proceeding, which may directly result in the significant environmental effects listed above.

Actions which could mitigate or avoid the significant effects on the environment are primarily within the responsibility and jurisdiction of local water purveyors and managers and have been, or can and should be, adopted by those entities. The decisions made by local water purveyors when they allocate remaining water supplies will determine whether the adverse effects occur. If they use the following mitigation measures effectively, they may be able to reduce the adverse effects to a level of insignificance.

(1) Urban Water Conservation (including the 16 Best Management Practices for urban water conservation established in the Memorandum of Understanding Regarding Urban Water Conservation in California)

(2) Agricultural Water Conservation (including water conservation measures formulated under the Efficient Water Management Practices Act of 1990 and conservation goals established by the San Joaquin Valley Drainage program)

(3) Ground Water Management (including conjunctive use programs)

(4) Water Transfers

(5) Reclamation (including reclaimed water use for irrigation of agricultural crops, parks, greenbelts, golf courses, and landscape)

(6) Mitigation Fund (including a mitigation credits program)

(7) Combined Use of CVP and SWP Points of Diversion in the Delta

(8) Offstream Storage Projects (including Los Banos Grandes Reservoir, Domenigoni Valley Reservoir, Los Vaqueros Reservoir, Delta Wetlands, and Mandeville Island)

(9) South Delta Program (undertaken by the DWR)

(10) Purchase of Delta Islands (where land subsidence is a serious problem)

(11) Long-term Delta Solution (joint federal-State effort)

b. <u>Environmental Effects Primarily Due to Changes in Flow Patterns</u>

(1) <u>Water Flows</u>. Changes in currents, or the course or direction of water movements of marine and fresh waters would occur as a result of changes in the magnitude and timing of freshwater outflow in the Delta. River flows could be affected as a result of changes in reservoir operation, runoff, return flows, wastewater discharge, or drainage to the rivers [3.a].

(2) <u>Water Quality</u>. Alteration of surface water quality parameters, including temperature, dissolved oxygen, and turbidity, would occur in the rivers and the Delta by changing the magnitude of flows at different times of the year [3.e].

(3) <u>Energy</u>. Substantial air emissions or deterioration of ambient air quality could occur as a result of electrical power generation from fossil fuel combustion that could make up for hydroelectric power generation losses incurred due to

decreased water availability in peak generating periods [2.a]. Use of substantial amounts of fuel or energy could occur [15.a], including an increase in the rate of use of fossil fuels for power generation [9]. Substantial increase in demand upon existing sources of energy for increased ground water pumping, or requirements for the developing new sources of energy to replace any reductions in hydroelectric power generation, could occur [15.b]. Need for new systems or substantial alterations to existing electricity facilities could occur [16.c].

(4) Parks and Recreation. Effects on parks or other recreational facilities could occur through changes in water levels of upstream reservoirs and flows in rivers, and uses of recreational facilities by sport fishery participants [14.d]. Impacts upon the quality or quantity of existing recreational opportunities would occur through closure of the Delta Cross Channel gates which would restrict recreational access to some waterways in the Delta; other aspects of the proposal could affect sport fisheries [19].

(5) Aesthetics. Changes in the amount of surface water in reservoirs would occur in the upstream and export areas [3.d]. Creation of an aesthetically offensive site open to public view could occur if changes in reservoir operations cause water levels to be lower for longer periods [18].

(6) Traffic. Alterations to waterborne traffic would occur due to closure of the Delta Cross Channel gates intended to protect fish migration [13.e].

Mitigation Measures and Findings. These environmental effects could only be avoided by not implementing the plan, except that a boat lock could be constructed at the Delta Cross Channel to mitigate for effects on boating traffic. Boating interests may consider such a facility. However, the environmental effects of such a facility and its cost could preclude its construction.

Because the SWRCB is required by law to adopt a plan which will ensure the reasonable protection of beneficial uses and the prevention of nuisance, it is infeasible not to adopt the plan. (See Water Code section 13241.) It is the intent of the SWRCB to avoid, to the extent feasible, any adverse environmental effects of implementation of the plan. Therefore, the benefits of providing protection for fish and wildlife uses in the Estuary outweigh any significant adverse environmental effect that could occur due to implementation of the plan.