TURLOCK IRRIGATION DISTRICT
MODESTO IRRIGATION DISTRICT

P. O. Box 949
Turlock, California 95381
209-883-8300 (FAX 209-656-2180)

March 24, 2005

Honorable Magalie R. Salas
Secretary, Federal Energy Regulatory Commission
888 First Street, N. E.
Washington, D. C 20426

Re: Turlock and Modesto Irrigation Districts - Project No. 2299 -- 2005 Summary Report pursuant to Paragraph (G) of the Order issued July 31, 1996

Dear Secretary Salas:

Enclosed pursuant to Paragraph (G) of the Order Amending License and Dismissing Rehearing Requests, issued July 31, 1996 license for Project No. 2299 is the 2005 Summary Report for the Lower Tuolumne River. If you have any questions, please contact Tim Ford at 209-883-8275.

Respectfully submitted,

MODESTO IRRIGATION DISTRICT	TURLOCK IRRIGATION DISTRICT
Allen Short	Larry Weis
Allen Short	Larry Weis
General Manager	General Manager

TJF
Enclosures

cc: George Taylor – FERC, Washington DC (w/enclosures)
Philip Scordelis – FERC, San Francisco CA (w/enclosures)
William Madden, Esq. - TID/MID (w/enclosures)
Bill Loudermilk - CDFG
Deborah Giglio - USFWS
Donn Furman - CCSF
Allison Boucher - FOTT
Patrick Koepele - TRPT

This Page Intentionally Left Blank

United States of America
Before the
Federal Energy Regulatory Commission

2005 Ten Year Summary Report

pursuant to

Paragraph (G) of the 1996 FERC Order
issued July 31, 1996

Turlock Irrigation District
and
Modesto Irrigation District

Don Pedro Project
FERC Project No. 2299-024

April 1, 2005

This Page Intentionally Left Blank

EXECUTIVE SUMMARY

The Don Pedro Project (FERC Project No. 2299-024) is a multi-purpose reservoir on the lower Tuolumne River that is licensed to the Turlock Irrigation District and Modesto Irrigation District (Districts) and completed in 1971. Beginning in 1994, Federal Energy Regulatory Commission (FERC) mediated negotiations resulted in the 1995 FERC Settlement Agreement (1995 FSA) pursuant to Article 39 of the license concerning Fall-run Chinook salmon (*Oncorhyncus tshawytscha*) in the lower Tuolumne River. The 1995 FSA contained (1) significant changes to the Article 37 flows and the Article 58 monitoring program, (2) restrictions on flow ramping rates, and (3) implementation of non-flow mitigative measures. Following a Biological Opinion from the USFWS and FERC EIS documents, the FERC issued a July 31, 1996 Order amending Articles 37 and 58 of the license and providing for other aspects of the 1995 FSA.

As required by Ordering Paragraph (G) of the 1996 FERC Order, this report summarizes all fishery studies, river-wide monitoring, and non-flow mitigation measures conducted since 1996. This report also describes aspects of the 1995 FSA that were not included in the 1996 FERC Order and additional measures implemented by the Districts and other parties related to the recovery of Tuolumne River Chinook salmon.

Fishery Flows. As required by Ordering Paragraph (D) of the 1996 FERC Order, the Districts have provided the instream flows agreed to in the 1995 FSA flow schedule and which was incorporated as an amendment to Article 37 of the License by the 1996 FERC Order. Except during operational emergencies and flood-related operations, the Districts normally add a buffer to the required flows to ensure compliance with the required minimum flows.

Flow Fluctuation Studies. As required by FERC Ordering Paragraph (G), this report summarizes the results of studies related to the effects of flow release fluctuations on the salmon resources in the lower Tuolumne River. The participants in the 1995 FSA recognized that flow reductions can cause stranding and entrapment of fry and juvenile salmon. However, the Districts had changed their method of operation well before the 1995 FSA and have not released large hydropower peaking flow fluctuations to the river since the issuance of FERC's 1996 Order. In addition to a 3-year intensive stranding assessment (1998–2000), the Districts filed a comprehensive report to FERC in 2001 that: reviewed the results of stranding assessments conducted between 1986 and 2000; evaluated the effectiveness of the 1995 FSA ramping rates; documented conditions under which stranding may occur; and identified potential areas for floodplain improvements. The review of the long-term stranding survey data indicated several factors may contribute to the magnitude of juvenile stranding, including: (1) salmon density, (2) extent of flow reduction and the minimum flow in the fluctuation cycle (which determines the amount of potential stranding area exposed), (3) ramping rate, and (4) physical characteristics of sites in terms of slope and substrate categories. The review indicated the highest potential for stranding occurred between 1,100–3,100 cfs, which corresponds to the lowest broad floodplain inundation zone in several areas of the primary spawning reach (RM 36.5–50.7). There has been no major problem identified with incidental fish losses resulting from necessary flow changes for flood management, pulse flow, and base flow requirements in the Districts' operations in the post-FSA period (1995–2004).

Non-Flow Measures (Habitat Restoration Projects). Section 12 of the 1995 FSA directed the parties to the agreement to identify and strive to implement ten priority habitat restoration projects (including a minimum of two salmon predator pond isolation projects) by the year 2005, with the understanding that the parties would help seek additional funding. The Habitat Restoration Plan for the Lower Tuolumne River was completed in 2000 and the Tuolumne River Technical Advisory Committee (TRTAC) selected ten priority projects, including several large-scale channel restoration projects. In addition to coordinated habitat restoration projects by others, two of the ten priority projects identified by the TRTAC have been implemented, including one major predator isolation project (SRP 9) and one large channel and floodplain restoration project (7/11 Reach). Of the remaining eight TRTAC projects, up to five projects are ready for implementation to begin in 2005 subject to final funding and permit approvals. The restoration program has been highly successful in obtaining major funding from other sources, resulting to date in over $33 million dollars to complement the $1 million contributed by the Districts and the City and County of San Francisco (CCSF) under Section 12 of the 1995 FSA. An estimated additional $7.5 million in outside funding would be needed to complete implementation of the two TRTAC-selected habitat restoration projects that are not yet fully funded.

Riverwide Fishery and Habitat Studies. As required under Ordering paragraph (F) of the 1996 FERC Order, the Districts have conducted or supported riverwide monitoring since 1996 for the following elements:

1. *Spawning escapement estimates.* CDFG has conducted Fall-run Chinook spawning surveys on the Tuolumne River since 1971, as required by the fish study program for the Don Pedro Project. The Tuolumne River Chinook population has experienced recent periods of environmental stress, including changes in oceanic cycles and productivity, the severe six-year California drought from 1987–1992, and a more recent dry period from 2001–2004. Escapement recently peaked in 2000 at 17,900 spawners following a series of wet and above normal water years, including the largest flood flow releases in the history of the Don Pedro Project in 1997. Average Fall-run Chinook salmon escapement from 1996–2004 was 7,500, which was slightly higher than the long-term average escapement of 6,700 documented since the completion of Don Pedro Dam (1971–2004).

2. *Quality and condition of spawning habitat.* Previous studies of lower Tuolumne River salmon habitat conducted by the Districts have attributed low salmonid survival-to-emergence to poor spawning gravel quality, which has resulted from deposition of fine sediment. The 1997 flood event deposited large amounts of fine sediment in the Tuolumne River, so the TRTAC began to develop: an overall sediment management plan for the river; methods for assessing salmon spawning gravel quality from

permeability measurements; and a sampling design for assessing the effects of management actions on gravel quality. Fine sediment is the focus of two of the ten priority projects selected by the TRTAC. Several activities are planned to improve the overall quality of spawning gravels for Tuolumne River salmonids, including construction of a sedimentation pond on Gasburg Creek (a tributary source of fine sediment near La Grange), addition of clean gravels to the channel, and the mechanical cleaning of gravel.

3. *Relative fry density with respect to female spawners.* Based on reviews of historical information, the Districts filed a report to FERC in 1996 that concluded that regular seining surveys were not able to practically provide information on survival-to-emergence success in specific reaches or riffles. Nevertheless, the annual reports submitted to FERC have presented analyses of riverwide average and peak fry densities and estimated female spawners. A multi-year analysis (1986–2003) of peak and average fry density from January through March vs. female spawner counts from the prior fall run indicates a positive correlation between the two factors.

4. *Fry distribution and survival.* The Districts have conducted regular seining surveys from 1986–2004, beginning in January and continuing through May of each year at several sites within the Tuolumne River and additional sites in the San Joaquin River. Annual seine reports contain salmon density by location, by river section, as well as comparisons of riverwide and section density as indices of abundance. Screw trapping done prior to April in 1998-2002 provided additional abundance information. No practical means of providing direct estimates of fry survival has been identified to date.

5. *Juvenile distribution and temperature relationships.* As stated above, the Districts have conducted regular seining surveys from 1986–2004. In accordance with Article 58 of the 1996 FERC Order, the Districts have monitored water temperatures within the lower Tuolumne River, but there is little evidence that juvenile distribution within the river is well correlated with water temperature due to predominantly low ambient air temperatures in the March through May period. Daily average water temperatures at the USGS La Grange gage generally ranges from 10–13 deg C, but water temperatures from spring to fall generally increase, subject to flow rates and ambient air temperature, with distance downstream of the La Grange powerhouse. By June, relatively few juveniles have remained in the river. However, the increased summer flows in the post-FSA period have provided a longer reach of suitable temperatures.

6. *Smolt survival.* Since 1986, about 1.7 million smolts mostly reared in the Merced River Hatchery, were marked with coded wire tags (CWTs) and released in the Tuolumne River to study long-term variations in riverwide outmigration survival. In addition to CWT releases conducted prior to the 1996 FERC Order (1986, 1987, 1990, 1994, 1995), the TRTAC sponsored studies from 1996–2002 and other smaller releases to study reach-specific survival in association with planned restoration

projects. Efforts to design a robust survival monitoring program to date have met limited success. Resulting survival indices have been variable (0.1 to > 1.0), showing weak relationships with increases from low flows (<1,000 cfs) to flood flows of more than 4,000 cfs. Reach-specific survival studies at medium flows (1,300-3,700 cfs) found very high survival in the upper spawning reach and generally lower survival downstream. Tests over smaller reaches such as habitat restoration projects were not successful. Because of the difficulties in measuring smolt survival using paired CWT or multiple mark-recapture (MMR) releases, and because of genetic issues regarding the use of large hatchery releases, these studies were terminated. There is consideration through the CALFED program of further assessing smolt survival through predation rate or predator abundance monitoring.

Programmatic Goals under the 1995 FSA. Section 8 of the 1995 FSA set forth three programmatic goals using an adaptive management strategy initially centered on flow enhancement, habitat restoration, and increases in smolt survival, using measures that were deemed to have high probabilities of success. The three programmatic goals are discussed below.

1. *Increase Naturally Occurring Salmon Populations.* Escapement levels from 1996–2004 appear to have increased relative to the long-term average from 1971–2004. Salmon population modeling suggests that average escapements would have been 37% higher had the 1996 FERC Order flows been provided from 1971-2004 than those provided under the pre-1995 flow schedules, barring population level impacts from out-of-basin factors. However, these population assessments must be considered provisional, because the planned habitat restoration projects are not 100% complete and most of the projects that have been implemented are too recent to have had demonstrable effects on the underlying stock-recruitment relationship of the Tuolumne River.

2. *Protect any remaining genetic distinction.* Preliminary studies of Central Valley Chinook salmon genetics have revealed differences between seasonal runs, but little divergence among fall-run stocks of different streams. Evidence suggests that even if there were any genetically distinct sub-populations, past hatchery planting programs probably led to significant gene flow among the populations. Nevertheless, under Section 8 of the 1995 FSA, all parties agreed to protect any remaining genetic distinction of Tuolumne River Chinook salmon. Because the continued use of study fish from non-Tuolumne stock in Tuolumne River studies would violate that goal, the Districts do not support future smolt survival studies that use non-Tuolumne-origin salmon.

3. *Increase salmon habitat in the Tuolumne River.* The Districts have worked with the TRTAC to develop non-flow measures to support the recovery of Tuolumne River Chinook salmon, including monitoring specific aspects of salmon biology, developing a geomorphic process-based restoration plan for the 52 miles of the river downstream

of La Grange Dam, planning and implementing ten habitat restoration projects as required by the Section 12 of 1995 FSA. Despite losses in available riffle habitat within the primary spawning reach (RM 36.5–51.7) following the large 1997 flood event which saw peak flows of near 60,000 cfs, redd superimposition and salmon population model results suggests that the underlying stock-recruit relationship has largely recovered from this impact. Annual surveys at recently completed gravel augmentation projects near Old La Grange Bridge (RM 50) and within the former gravel mining reach of the river (RM 34.3–40.3) have demonstrated increases in spawning utilization at these sites. Absent out-of-basin factors such as Delta mortality and ocean harvest, the results of monitoring and studies to date indicate that long-term escapement has the potential to increase by a factor of two to three following the completion of the planned restoration projects.

Comparative Goals under the 1995 FSA. During the discussions that resulted in the 1995 FSA, the participants acknowledged that many of the factors which affect salmon were beyond their control so numerical goals (e.g., doubling the number of returning adult spawners) were not adopted. The following three comparative goals were adopted in Section 9 of the 1995 FSA:

1. *Improvements in smolt survival and successful escapement in the Tuolumne River.* As stated above, efforts to design a robust survival monitoring program to date have met limited success with only weak relationships between smolt survival and flow or other factors such as habitat restoration (e.g., the completed predator isolation projects). By comparison of invertebrate food supplies before and after the implementation of the 1995 FSA, the increased instream flows and other restoration actions carried out since the implementation of the 1995 FSA have improved conditions for rearing salmonids. Although annual seining surveys are generally considered unsuitable for assessing absolute juvenile production, the surveys suggest that the average density of juveniles has increased in the years following the 1995 FSA. These results are supported by annual rotary screw trap (RST) monitoring conducted from 1995–1997, 1999–2000, and 2002–2004.

   In terms of successful escapement, high inter-annual variations in escapement due to environmental factors outside of the Districts control make assessment of improvements highly sensitive to whether the averaging interval includes environmental extremes which are associated with exceptionally high or low escapements. For this reason, tends in long-term escapement of fall-run Chinook salmon was assessed using model simulations. Model results suggest average escapement levels would have been 37% higher had the 1996 FERC Order flows been provided from 1971–2004 than those provided under the pre-1995 flow schedules barring population level impacts from out-of-basin factors.

2. *Increase in naturally reproducing Chinook salmon in this subbasin.* Continued releases of hatchery-reared salmon may compromise the achievement of the Section 8

goal to increase naturally reproducing Chinook salmon in this subbasin. Numbers of adult salmon returning to the Tuolumne River and the San Joaquin system as a whole have fluctuated widely throughout the period of record. As stated above, average Fall-run Chinook salmon escapement from 1996–2004 was 7,500, which was slightly higher than the long-term average escapement of 6,700 documented since the completion of Don Pedro Dam (1971–2004). However, non-Tuolumne-origin, hatchery salmon has comprised an increasing proportion of the total on the Tuolumne River since the beginning of smolt survival evaluations in 1986.

3. *Population Resiliency.* Participants to the 1995 FSA agreed that barring events outside the control of the Districts, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested. Given that population recovery rates are affected by annual runoff, Delta exports, and other environmental factors (which are outside the control of the Districts), the population resiliency goal of the 1995 FSA was interpreted to call for an increase in minimum escapement levels, which would presumably provide larger parent stocks to enhance recovery after declines. The revised Article 37 flow schedules were designed to improve smolt production and outmigration survival, especially in dry years. Population modeling results suggest that increased minimum flows under the 1995 FSA recommended minimum flow schedule would have increased salmon numbers during past population crises in late 1970s and early 1990s. Although some evidence suggests that the San Joaquin system as a whole may have been less productive for salmon in recent times, this is likely due to impaired survival through the Delta related to export, salvage, predation and other factors outside of the Districts' control.

Achievement of the 1995 FSA Goals. As stated in Ordering paragraph (G) of the 1996 FERC Order, achievement of the 1995 FSA goals requires the evaluation of trends established over several years. The Districts have made good faith efforts to meet both the programmatic and comparative goals of the 1995 FSA with only limited time to assess long-term trends resulting from actions taken since the 1996 FERC Order. Although monitoring and studies conducted to date identify improved conditions for Tuolumne River Chinook salmon, participants in the development of the 1995 FSA recognized that the Tuolumne River salmon population responded not only to activities within the basin, but also to factors downstream in the San Joaquin River, Delta, and ocean.

1. *Factors outside the Control of the Districts.* Under FSA Section 10, the parties agreed that examples of factors outside the control of the Districts included Delta export operations, water quality, commercial and sport salmon harvest, land use activities on non-District owned lands within the Tuolumne River riparian corridor, and riparian diversions below La Grange Dam. Of these factors, Delta export likely remains the single largest stressor on Tuolumne River Chinook salmon with both direct effects due to entrainment in the State and Federal pumps and predation in the State's Clifton Court Forebay, and indirect effects related to predation and poor water quality (i.e.,

DO impairment) for migrating salmon. Delta Export rates have grown in recent decades and are usually over 6,000 cfs almost year-round, often exceeding 10,000 cfs and only occasionally falling below the combined outflow of the entire San Joaquin basin tributaries. Smolt survival through the Delta ranged from about 2% to 19% from 2000 to 2004 during the April-May period of additional salmon protective measures such as increased tributary outflows (i.e., Pulse flows, VAMP) and the temporary Head of Old River Barrier intended to reduce entrainment. A permanent operable fish control structure at the head of Old River, once complete and operating, will offer relatively greater protection to Tuolumne River salmon fry, juvenile, and smolts from direct and indirect mortality factors related to Delta export operations.

2. *Factors within the Control of the Districts.* Examples of factors within the control of the Districts included Don Pedro Dam operations (including decisions on the delivery, distribution, and transfer of water within and outside of the Districts) and river flows at La Grange Dam (except during flood control operations), and land use activities on District-owned lands within the Tuolumne River corridor. The Districts have endeavored in good faith to manage Don Pedro Project operations and river flows at La Grange Dam to fully comply with the requirements of the 1995 FSA and the 1996 FERC Order. Land use activities on District-owned lands within the Tuolumne River riparian corridor have not adversely impacted Tuolumne River fishery resources.

Continuation of the Tuolumne River Fish Management Program through Relicensing. The Districts recommend continuation of certain features of the Tuolumne River fish management program and the implementation of additional non-flow measures to increase salmon production on a long-term basis. The Tuolumne River fish management program has implemented the flow and non-flow measures identified in the 1995 FSA with corresponding improvements in physical and biological community indicators. As provided under the adaptive management strategy for the recovery of the Tuolumne River Chinook salmon population under Section 8 of the 1995 FSA, if the initial measures implemented have led to acceptable population increases, then additional measures of "some risk" could be implemented to improve success of the program. Additional measures include increasing salmon spawning habitat utilization through temporary spawning barriers as well as reductions in predation of smolts in Tuolumne River.

This Page Intentionally Left Blank

Table of Contents

Appendices

A. Don Pedro Project Fish Flow Procedure
B. Summary Reports, Annual Report contents, TRTAC materials and Actions documented in Lower Tuolumne River Annual Reports to FERC (1996–2004)
C. Don Pedro Project License Articles 39 and 58 Technical Report List by Topic (1992–2004)
D. Salmonid Habitat Maps for the Lower Tuolumne River
E. Stranding Survey Data (1996–2002)
F. Lower Tuolumne GIS Mapping Products (CD-ROM)

List of Tables

List of Figures

List of Acronyms and Abbreviations

Acronym or Abbreviation	Definition
AF	acre-feet, a measure of water volume
AFRP	Anadromous Fish Restoration Program (part of USFWS)
AMF	Adaptive Management Forum
AT	air temperature
BAWSCA	Bay Area Water Supply and Conservation Agency
CALFED	now known as California Bay-Delta Authority
CALFED	California and Federal Agencies Bay-Delta Program
CBDA	California Bay-Delta Authority
CCSF	City and County of San Francisco
CDEC	California Data Exchange Center
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CDRR	combined differential recovery rate
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CRRF	California Rivers Restoration Fund
CSBP	California Stream Rapid Bioassessment Protocol
CSPA	California Sportfishing Protection Alliance
CVP	Central Valley Project
CWA	Clean Water Act
CWT	coded wire tag
CY	cubic yard
D50	Grain diameter at which 50 % of the particle size distribution lies above and below.
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DWR	Department of Water Resources
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EPT	Ephemeroptera, Plecoptera, Trichoptera - insect orders
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FL	fork length
FOT (or FOTT)	Friends of the Tuolumne
FR	Federal Register
FSA	Don Pedro Project 1995 FERC Settlement Agreement

Acronym or Abbreviation	Definition
ft	Feet
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HORB	Head of Old River Barrier
HRI	harvest rate index
HRP	Habitat Restoration Plan
IEP	Interagency Ecological Program
IFIM	Instream flow incremental methodology
LWD	Large Woody Debris
m	Meter
mg/L	milligram per Liter
MID	Modesto Irrigation District
mm	millimeter
MSL	Mean Sea Level
M&T	McBain and Trush (consultants)
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NHI	Natural Heritage Institute
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
ORNL	Oak Ridge National Laboratory
PFMC	Pacific Fishery Management Council
QA/QC	Quality assurance/quality control
R (letter and/or #)	a specific riffle (location identifier, e.g. RA7 is Riffle A7)
RM	River mile
ROW	Right of way
RST	rotary screw trap
RWQCB	Regional Water Quality Control Board
SJR	San Joaquin River
SJRA	San Joaquin River Agreement
SJRMP	San Joaquin River Management Program
SPCA	S. P. Cramer and Associates (consultants)
spp.	Species
SRP	Special Run/Pool (mined area of river - usually with a #, e.g. SRP 9)
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWS	Stillwater Sciences (consultants)
T&E	Threatened and Endangered
TID	Turlock Irrigation District

Acronym or Abbreviation	Definition
TRE	Tuolumne River Expeditions
TRPT	Tuolumne River Preservation Trust (also as Tuolumne River Trust)
TRTAC	Tuolumne River Technical Advisory Committee
USACE	U.S. Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan
WT	water temperature
WY	Water Year
Yd	Yard

Glossary

Keyword	Definition
alluvial	Having originated through the transport by and deposition from running water.
anadromous fish	Fish that spawn in freshwater, migrate to the ocean or estuaries to grow and mature, and return to freshwater to reproduce. Salmon, steelhead, and shad are examples.
channel	Natural or artificial waterway of perceptible extent that periodically or continuously contains moving water.
bankfull discharge	Discharge that just overtops a river or stream channel banks onto the adjacent floodplain. Bankfull discharge occurs approximately every 1 to 2 years (with a median value of 1.5 years) and is generally considered to be the primary channel-forming discharge.
cobble	Substrate particles 64-256 mm in diameter. Often subclassified as small (64-128 mm) and large (128-256 mm) cobble.
endangered species act (ESA)	Federal act of 1973, as amended, 16 U.S.C. Sections 1531-1543; California act of 1984, as amended, Fish and Game Codes Sections 2050-2098.
federally listed	Species formally listed as a threatened or endangered species under the federal Endangered Species Act; designations are made by the U.S. Fish and Wildlife Service or National Marine Fisheries Service.
fine sediment	Substrate particles smaller than 2 mm.
geographic information system (GIS)	A computer system capable of storing and manipulating spatial data. A geographic information system has four major components: a data input subsystem, a data storage and retrieval subsystem, a data manipulation and analysis subsystem, and a data reporting subsystem.
gravel	Substrate particles between 2 and 64 mm in diameter.
point bar	Mesohabitat classification within alternate bar morphology comprised of depositional features lying exposed above the water surface along the inner radius of channel bends.
pool	Mesohabitat classification within alternate bar morphology comprised of scour areas with reduced water velocity, smooth water surface and greater depths than surrounding areas.
rearing habitat	Areas in rivers or streams where juvenile fish find food and cover in which to live and grow.
riffle	Mesohabitat classification within alternate bar morphology comprised of depositional features below the water surface with increased water velocity, turbulence and dissolved oxygen.
riparian vegetation	Vegetation growing on or near the banks of a stream or other body of water in soils that exhibit some wetness characteristics during some portion of the growing season.

Keyword	**Definition**
riparian zone	Those terrestrial areas where the vegetation and microclimate conditions are products of the combined presence and influence of perennial and/or intermittent water, associated with high water tables and soils that exhibit some wetness characteristics. Normally used to refer to the zone within which plants grow rooted in the water table of rivers, streams, lakes, ponds, reservoirs, springs, marshes, seeps, bogs, and wet meadows.
salmonids	Fish of the family Salmonidae, including salmon, trout, chars, whitefish, ciscoes, and grayling.
sediment	Fragments of rock, soil, and organic material transported and deposited in beds by wind, water, or other natural phenomena.
silt	Substrate particles 0.004-0.062 mm in diameter.
special run pool	Mesohabitat classification for pool areas within a river created by former in-channel aggregate extraction pits
thalweg	The deepest point of a stream along any channel cross-section.

1 PURPOSE OF REPORT

This report by the Turlock Irrigation District and Modesto Irrigation District (Districts or Licensees) for the Don Pedro Project, FERC Project No. 2299, describes and summarizes the results of all fishery studies and monitoring conducted and all non-flow mitigation measures and monitoring studies related thereto implemented by the Licensees pursuant to the Commission's Order Amending License and Dismissing Rehearing Requests, issued July 31, 1996. This report is intended to fully comply with Ordering Paragraph (G) of the 1996 Order. Towards that end, the categories of information relative to the lower Tuolumne River specifically identified in the Order to be filed by April 1, 2005 are addressed in the following areas of this report:

- Identify the non-flow mitigative measures implemented – Section 3.3
- Results of monitoring related to the non-flow mitigative measures – Section 3.4
- Results of fishery and habitat studies – Section 3.5
- Results and discussion of monitoring studies related to the effects of flow release fluctuations on the salmon resources – Section 3.5.2.6

This report is also intended to report on those aspects of the 1995 FERC Settlement Agreement (FSA) among Turlock Irrigation District (TID), Modesto Irrigation District (MID), City and County of San Francisco (CCSF), California Department of Fish and Game (CDFG), United States Fish and Wildlife Service (USFWS), California Sports Fishing Protection Alliance (CSPA), Friends of the Tuolumne (FOT), Tuolumne River Expeditions (TRE), Tuolumne River Trust (TRT) , FERC staff, and San Francisco Bay Area Water Users Association (currently Bay Area Water Supply and Conservation Agency), that were not included in the 1996 Order, and such additional related studies and monitoring conducted by the Licensees.

This Page Intentionally Left Blank

2 INTRODUCTION

Don Pedro Project No. 2299 replaced the original Old Don Pedro Dam (Table 2-1). Article 37 of the Federal Power Commission license established the minimum flow requirements for the first 20 years of project operation. Article 39 of the license required the Licensees (1) to "… make necessary studies aimed at assuring the continuation and maintenance of the fishery…" by the end of that first 20-year period and (2) to develop a program for conducting and funding the studies.

Table 2-1. Major dates in Tuolumne River water development and FERC process

Year	Event
1871	Wheaton Dam completed in the vicinity of the present day La Grange Dam
1887	Turlock Irrigation District and Modesto Irrigation District established.
1893	La Grange Dam Completed (replaced privately owned Wheaton Dam)
1913	Raker Act (38 Stat. 242) passed by Congress – authorized CCSF to construct Hetch Hetchy Reservoir in Yosemite National Park
1923	City and County of San Francisco's Hetch Hetchy Reservoir Completed TID-MID's Old Don Pedro Reservoir Completed
1964	FERC issues License for New Don Pedro Project
1966	TID-MID accept FERC License (50-year license term starts running)
1967	TID/MID/CDFG Article 39 Study Program approved by the FERC
1971	New Don Pedro Project completed TID/MID/CDFG Cooperative Cost Sharing Agreement under Article 39
1986	TID/ MID/CDFG/USFWS enter into Amended Fish Study Agreement
1987	FERC Order approving 1986 Amended Fish Study Agreement (38 FERC ¶61,097)
1992	TID-MID's Article 39 Twenty-Year Fish Study Report filed with the FERC
1995	Mediated FERC Settlement Agreement (1995 FSA)
1996	FERC Order approving 1995 FSA
2005	TID/MID submit 10-Year Summary Report under 1996 FERC Order
2011	Formal FERC Relicensing Process begins
2016	Don Pedro Project FERC License Renewal Date

The Article 39 Study Program was filed by the Licensees in 1967 and approved by FERC in 1968. The Don Pedro Project was completed and operation began by the Licensees in March 1971. That same year the study program was revised to reflect minor program changes and current cost estimates. The revised program was incorporated into a cooperative agreement between the Districts and CDFG and approved by FERC in 1972.

The Article 39 Study Program was amended substantially in 1986 and approved in Article 58 of the FERC Order of February 1987. The Licensees filed their 8-volume 20-year report in May 1992 - a more detailed review of the history briefly summarized above was contained therein.

2.1 1995 FERC Settlement Agreement (FSA) and 1996 FERC Order

Pursuant to Article 39 of the license, the FERC began a proceeding in December 1992. That process led to FERC-mediated negotiations resulting in the 1995 FSA which contained (1) significant changes to the Article 37 flows and the Article 58 monitoring program, (2) restrictions on flow ramping rates, and (3) implementation of non-flow mitigative measures. The FERC, following a Biological Opinion from the FWS and FERC Draft and Final EIS documents, issued a July 31, 1996 Order amending Articles 37 and 58 as proposed by the FSA. The first annual report pursuant to the amended Article 58 and the FSA was submitted to FERC in March 1997. That 7-volume report included supplements to some of the 1992 Article 39 Report Appendices, remaining Article 58 reports completed since 1991 under the 1986 study plan, and other reports that were completed after the 1992 report was filed.

The FSA defined goals and a consensus strategy for improving the health of the Tuolumne River Chinook salmon population. Section 8 of the FSA identified the following three programmatic goals that the strategy for recovering the population attempted to achieve:

- Increase naturally occurring salmon populations
- Protect any remaining genetic distinction
- Increase salmon habitat in the Tuolumne River

It was agreed that both instream flow and non-flow measures would be employed as part of the strategy, and that adaptive management would be a key part of the strategy.

During the discussions that resulted in the FSA, the participants acknowledged that many of the factors which affect salmon are beyond their control so numerical goals were not adopted (e.g., doubling the number of returning adult spawners). Instead, the following three comparative goals were defined in Section 9 of the FSA:

- Improvements in smolt survival and successful escapement in the Tuolumne River
- Increase in naturally reproducing Chinook salmon in this subbasin
- Barring events outside the control of the agreement participants to the settlement, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested.

As part of the adaptive management strategy, it was agreed that the success of the flow and non-flow measures defined in the agreement would be monitored and evaluated. If a consensus could be reached as to the results of the evaluation, the measures would be fine-tuned or terminated, or alternative measures would be defined and implemented. A detailed review is conducted annually and an annual report has been filed by the Districts with the FERC by April 1 of each year.

A review of salmon runs between 1953 and 1994 in the Tuolumne River and other San Joaquin tributaries indicated a cyclical pattern to spawning escapements, with wide inter-annual variation in the population of adults returning to spawn both in the Tuolumne and the other San Joaquin tributaries. The pattern of escapements demonstrated the capacity of the Tuolumne River salmon population to rebound from dramatic population declines, highlighting the resiliency of the population. Despite this population resiliency, the Districts recognized the importance of reducing the magnitude of spawning population variation. By reducing the extent of declines in escapements during periods of environmental stress, the Districts hoped to facilitate faster population recoveries and to increase total production.

Participants in the development of the FSA recognized that the Tuolumne River salmon population responded not only to activities within the Tuolumne River basin, but also to factors downstream in the estuary and ocean. Under FSA Section 10, the parties agreed that examples of factors outside the control of the Districts included Delta export operations, commercial and sport salmon harvest, land use activities on non-District owned lands within the Tuolumne River riparian corridor, and riparian diversions below La Grange Dam. Examples of factors within the control of the Districts included Don Pedro Dam operations (including decisions on the delivery, distribution, and transfer of water within and outside of the Districts) and river flows at La Grange Dam (except during flood control operations), and land use activities on District-owned lands within the Tuolumne River riparian corridor. In the event the goals were not achieved because of factors within the control of the Districts, the Districts agreed to implement additional non-flow measures, but if the goals were not achieved because of factors outside of the Districts' control, then no additional measures were to be required.

The Districts, with the filing of this report to satisfy Ordering Paragraph (G), have successfully implemented the fish management program and faithfully executed the requirements of the 1995 FSA and the 1996 FERC Order.

2.2 San Joaquin River System and Water Development

The Tuolumne River is part of the San Joaquin River system in the Central Valley of California. The primary rivers draining the Central Valley are the Sacramento and San Joaquin that flow through the Sacramento-San Joaquin Delta to the San Francisco Bay before entering the Pacific Ocean. The southern portion of the San Joaquin Valley is the enclosed Tulare Basin - in wet years there can be some overflow from the Kings River northward into the San Joaquin system. Figure 2-1 shows the location of the San Joaquin River system through the Delta to the ocean.

The runoff of the San Joaquin River system is substantially smaller than the Sacramento River Basin. The San Joaquin River flow into the Delta at Vernalis is relatively small, averages approximately 3.7 million AF/yr, as compared to the average annual flow of the Sacramento

River into the Delta at Freeport of approximately 16.8 million AF/yr. The proportion of actual average inflows to the Delta from 1956 to 1970, before completion of the Don Pedro Project, was 82.6% from the Sacramento River system, 4.8% from the "eastside tributaries" to the Delta (Mokelumne, Cosumnes, and Calaveras rivers), and 12.6% from the San Joaquin River system.

An analysis of the computed unimpaired flow for the larger Sierra Nevada rivers of the San Joaquin River basin indicates that the Upper San Joaquin River above Friant Dam comprises on average 31% of the combined unimpaired flow, the Merced River comprises 17%, the Tuolumne River constitutes 32%, and the Stanislaus River accounts for 20%. The Merced Irrigation District's New Exchequer Dam (FERC Project No. 2176) regulates flows on the Merced River and the Districts' Don Pedro Project (FERC Project 2299) regulates flows on the Lower Tuolumne River. The majority (51%) of the four basin unimpaired flow within the San Joaquin basin is regulated by the USBR as part of the Central Valley Project (CVP), with Friant Dam on the Upper San Joaquin River and New Melones Dam on the Stanislaus River. The Central Valley Project began pumping from the Old River channel of the San Joaquin River in the south Delta in 1951 and the State Water Project began diverting water from the south Delta in 1968.

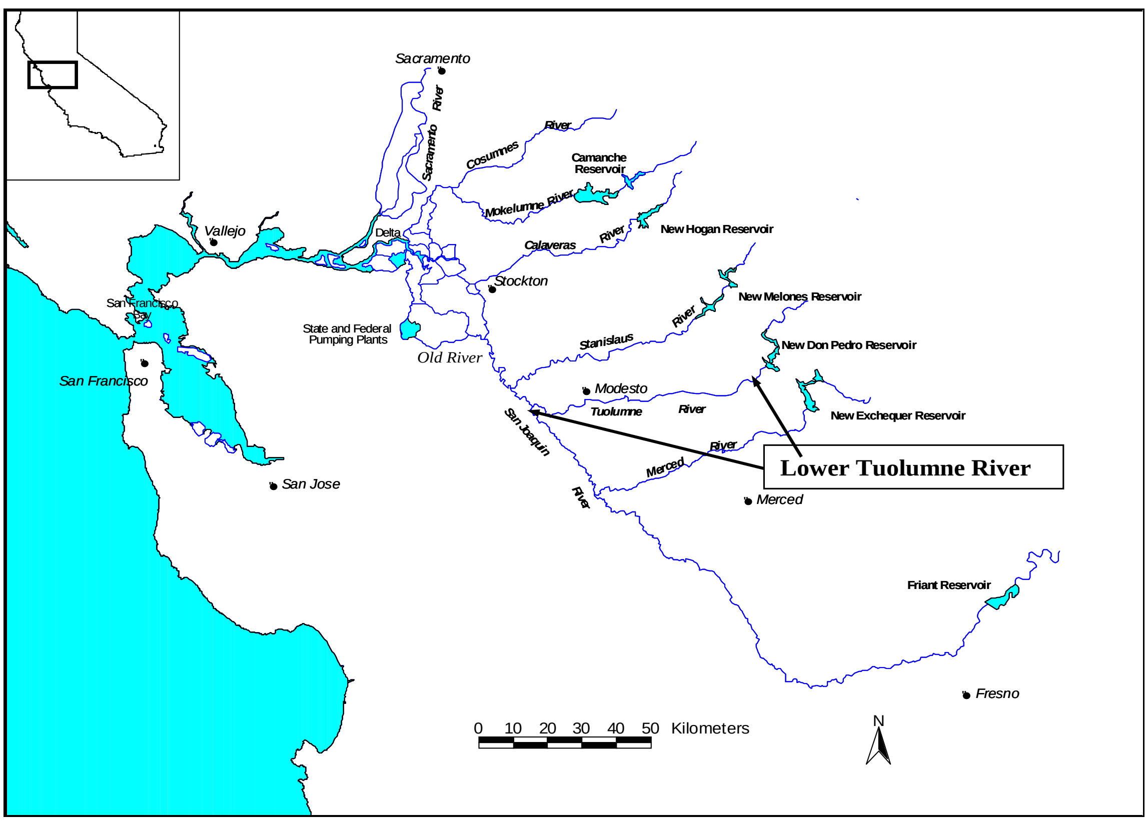


Figure 2.2-1. Location map for San Joaquin River system, Sacramento-San Joaquin Delta, and San Francisco Bay in central California.

2.3 Tuolumne River basin water development

The Tuolumne River drains a 1,960-square mile (5,080-square kilometer) watershed on the western slope of the Sierra Nevada Range and is the largest of three major tributaries to the San Joaquin River. The river originates in Yosemite National Park and flows southwest to its confluence with the San Joaquin River, approximately 10 miles west of the city of Modesto (at San Joaquin River RM 83.7). Deep canyons and mountainous terrain characterize the river's upper watershed. Downstream of the Sierra Nevada, the river flows through a gently sloping alluvial valley of agricultural and urban environments.

Inflows to the Don Pedro Project are regulated by the upstream Hetch Hetchy system, a series of reservoirs and diversion conduits that is owned and operated by the City and County of San Francisco (CCSF) and that provides much of the drinking water supply for 2.3 million people within the greater San Francisco Bay Area. Hetch Hetchy Reservoir, built by CCSF in 1923, is the uppermost reservoir on the mainstem Tuolumne and has a capacity of 360,000 acre-feet after being enlarged in 1938. Smaller reservoirs on Eleanor Creek (1918) and Cherry Creek (1955), tributaries below Hetch Hetchy, have capacities of 27,000 acre-feet and 268,000 acre-feet, respectively. San Francisco diverts an average of about 250,000 acre-feet per year from the upper watershed for use in the San Francisco Bay area. Together, the CCSF and TID-MID reservoir systems are operated to meet water rights in the Tuolumne Basin, to satisfy flood control agreements with the U.S. Army Corps of Engineers (USACE), and to comply with the Raker Act of 1913.

La Grange Dam, downstream of Don Pedro Reservoir, was constructed in 1893, replacing the smaller Wheaton Dam constructed in 1871 by the Tuolumne Water Company. La Grange Dam currently serves as a diversion dam for the Districts, diverting an average of 900,000 acre-feet per year into two canals. About 600,000 acre-feet per year are supplied to the Turlock Irrigation District south of the river and to the town of La Grange. The other 300,000 acre-feet per year supplies the Modesto Irrigation District and the city of Modesto north of the river. The smaller Wheaton Dam, constructed in 1871 by the Tuolumne Water Company at the same location, was replaced by the La Grange Dam. Don Pedro Reservoir, first constructed for irrigation storage on the Tuolumne River near the base of the mountains by the Districts in 1923, was enlarged from an original capacity of 290,000 acre-feet to a capacity of 2.03 million acre-feet in 1971.

Within the alluvial valley of the lower Tuolumne River below La Grange Dam, the river can be divided into two geomorphic reaches that are defined by channel slope and bed composition. The gravel-bedded reach extends from La Grange Dam (RM 52) to RM 24.0. The sand-bedded reach extends from RM 24.0 to the confluence with the San Joaquin River (RM 0) (Figure 2.3-1). The flow of the lower Tuolumne River is regulated primarily to satisfy instream flow requirements under the FERC license, flood management requirements, and agreements, such as the San Joaquin River Agreement. Local rainfall runoff, tributary inflow (primarily from Dry Creek at Modesto), returns flows from agriculture, and groundwater accretion also contribute to the flows of the lower Tuolumne River below La Grange Dam.

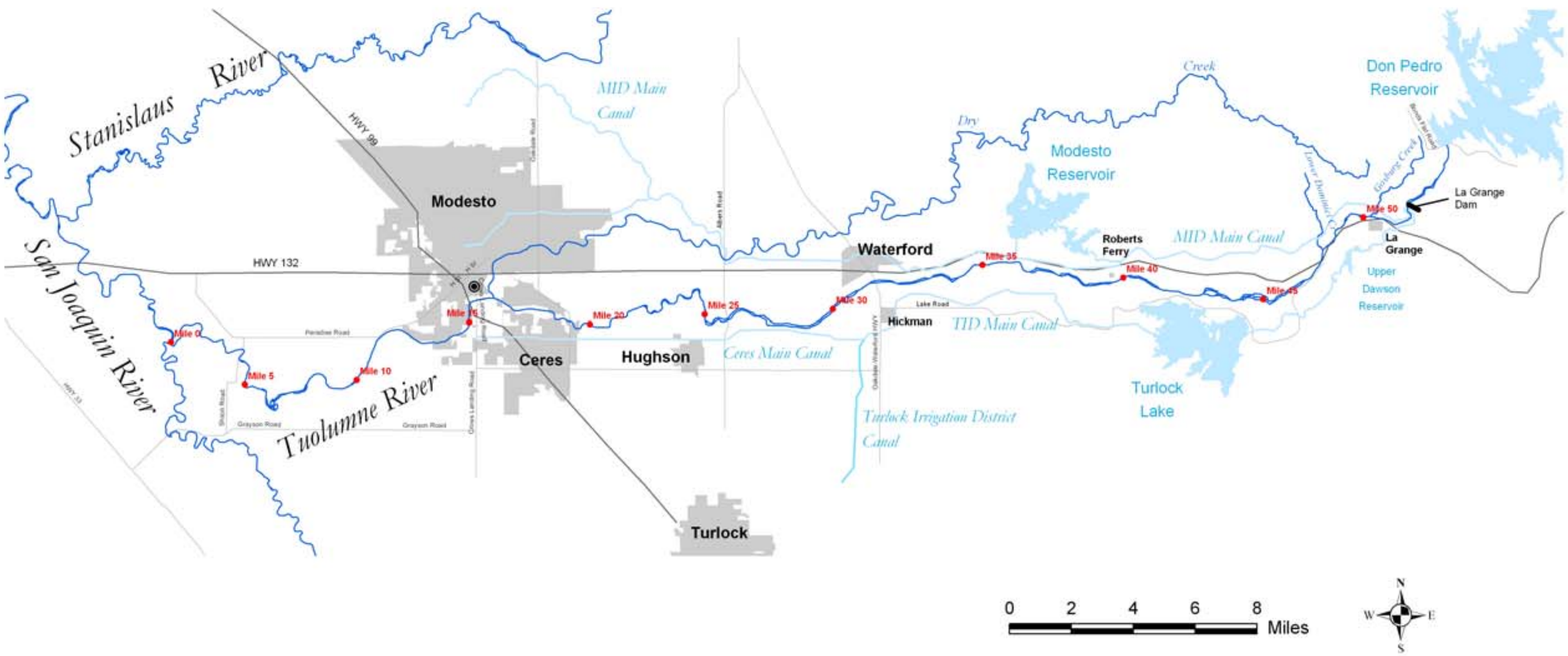


Figure 2.3-1. Map of Lower Tuolumne River

2.4 Summary of Tuolumne River Chinook salmon life history

Chinook salmon runs are present in the Sacramento-San Joaquin river systems, including other major tributaries of the San Joaquin River. However, all runs were extirpated from the San Joaquin River above its confluence with the Merced River by operation of the Friant Division of the USBR's Central Valley Project. The Tuolumne River supports a population of fall-run Chinook salmon (*Oncorhyncus tshawytscha*) that spend a part of their life cycle in the river (Fig.2-3). Once leaving the river, they encounter conditions shared with the other San Joaquin tributaries (Fig. 2-4).

Adult salmon typically enter the Tuolumne River to spawn from October through December, with spawning activity usually peaking in November. The age of return for adult salmon generally ranges from 2 to 5 years, with the majority of returning females being 3-year olds. Abundance varies by year-class depending on juvenile survival, ocean harvest, and other factors. Most spawning occurs upstream of RM 30 near Waterford and is heavily concentrated in the reach upstream of RM 46 near La Grange. The period of fry emergence varies, depending upon the timing of adult arrival and incubation temperature. It typically extends from January through March but has been documented to occur as early as December and as late as May. Young salmon leave the river as fry, juveniles, subyearlings (smolts), or yearlings. Large numbers leave the river as fry (<50 mm), particularly during years with higher winter flows, to enter the San Joaquin River and Delta. Subyearlings emigrate from February through May, with most smolts being >70 mm and migrating from March through May. A few salmon may over-summer in the river and emigrate during the late fall or early winter. The relative importance of these life history strategies in contributing to recruits is not well understood, but it generally appears that fry and subyearlings have better survival in wetter years.

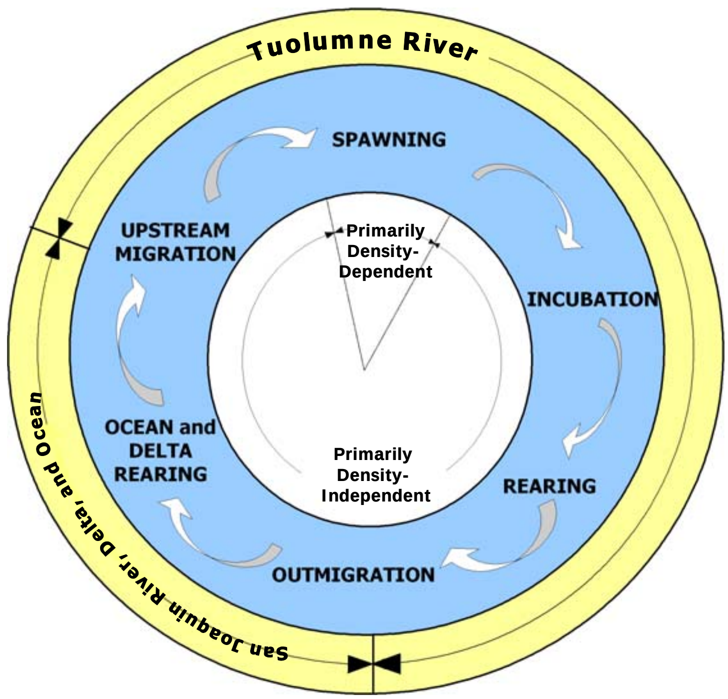


Figure 2.4-1. Schematic of Tuolumne River Chinook salmon life cycle
(Courtesy of Sapna Khandwala, Stillwater Sciences)

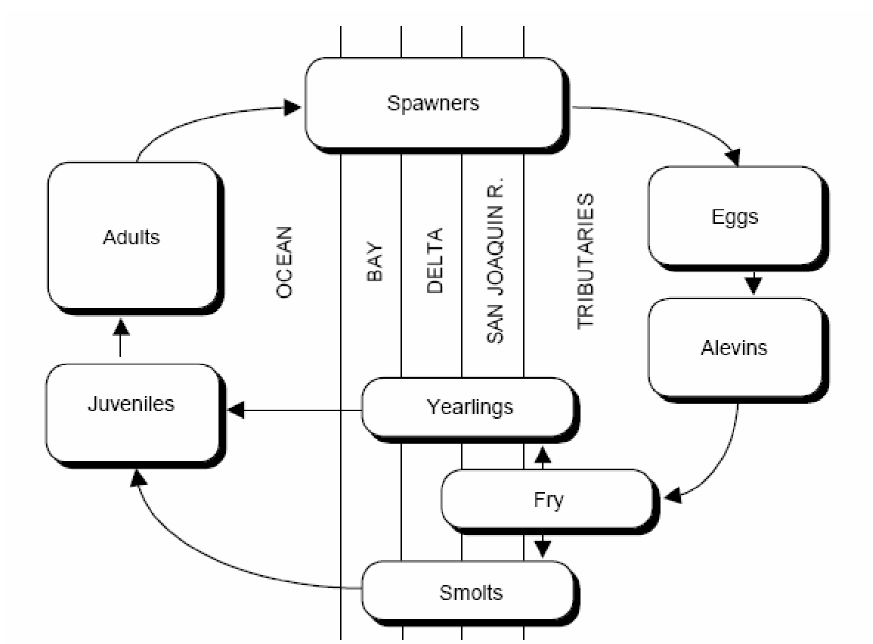


Figure 2.4-2. Schematic life history of San Joaquin fall-run Chinook salmon. (from Baker and Morhardt, 2001).

2.5 Major Factors affecting Tuolumne Salmon Populations

The conditions affecting salmon runs in the Tuolumne River include many factors from the river to the Pacific Ocean. The Stanislaus and Merced Rivers share many of these factors that likewise affect their salmon populations. The primary factors are considered to be flow, habitat modification, delta mortality, harvest, and ocean conditions; however, other factors, such as water quality, may have synergistic or cumulative effects that are poorly understood. The environment for Tuolumne salmon has changed considerably over the years and many factors throughout their life history contribute to the population status.

Water Management - Historical flows in the San Joaquin system were dominated by large winter runoff events followed by a prolonged snowmelt period in spring to early summer. Early water development in the San Joaquin watershed has reduced volumes and altered flow patterns entering the Delta. Much of the water in the San Joaquin River system is either used consumptively within the basin for agriculture and urban needs or is exported (e.g. CCSF Aqueduct to the Bay Area and Friant-Kern Canal to the Tulare Basin). This pattern of consumptive use and export differs significantly from the Sacramento River system, where water is imported from the Trinity River and a large amount of the Sacramento basin's runoff is delivered to the Delta where it is exported to large areas of Western and Southern San Joaquin Valley and Southern California.

River Habitat Modification – All major San Joaquin Rivers have been subject to significant habitat alteration. Dams on all the major San Joaquin system rivers prevent recruitment of gravel from upper watersheds to downstream spawning areas. The major dams also trap fine sediments from the upper watershed, but the continuation of fine sediment loads from sources downstream of the dams (e.g, tributaries, sheet erosion) have generally increased the proportion of fine sediment stored in channels, to the detriment of salmon egg incubation and fry emergence. Intensive gold dredging in the first half of the 1900s completely altered the channel and floodplain in most of the primary spawning reaches, including about 12 miles of the most important spawning habitat in the Tuolumne River. Subsequent in-channel sand and gravel (aggregate) mining created large pits that converted intact river channels into slow flowing lake environments for many miles of river channels (about 8 miles of the Tuolumne) and greatly reduced salmonid habitat. Aggregate mining shifted to floodplains and terraces and created large pits that now constrict rivers between berms that are ruptured periodically during floods. Many miles of river edge have been lined with riprap by agencies or landowners to stabilize banks, further reducing favorable salmon habitat. Field and project levees for flood protection have reduced flood inundation areas that are generally associated with increased productivity. The degree of levees and riprap increases from the tributaries down the San Joaquin River leading into the Delta. Broader systemwide impacts include the reduction and clearing of floodplain riparian vegetation and the conversion of natural environments to agricultural and urban uses.

Riparian Diversions – Many unscreened riparian pump diversions exist throughout the migration route and rearing areas of salmon from the Tuolumne into the Delta, but the effects are generally unknown. There are four large agricultural pumping diversions directly from the San Joaquin River between the Merced River and the Delta. The lowermost (Banta-Carbona diversion) has a recently installed $9.8 million screening facility and bypass, but others are not screened.

Delta and Bay Development - Agricultural development in the Delta began on islands in the 1850s. Islands were cleared of tule marsh vegetation and channels were dredged to build and maintain levees to block tidal flooding of the developed agricultural islands. These tidal areas were important as rearing habitat and as sources of food production. Because of the levees, salmon now must rear mainly in less productive channels, where predation mortality is likely higher. Bay marshlands were similarly diminished and also subject to more urban/industrial development. Current agricultural water diversions onto Delta islands are considered entrainment threats for juvenile salmonids, though it is unclear if the cumulative mortality associated with numerous small diversions has a population level effect (Brown 1982, Cook et al. 1998, Pickard 1982). A deepwater ship channel was developed between the Bay and Stockton that further modified the Delta environment for San Joaquin salmon.

State and Federal Delta Water Export - Salmon are vulnerable to export effects during upstream passage through the Delta as spawners, during emigration as smolts or yearlings, and as fry rearing in the Delta. The federal Central Valley Project Tracy Pumping Station (completed in 1951) and the California State Water Project Harvey O. Banks Pumping Plant (completed in 1968) withdraw large volumes of water from the Old River channel of the San Joaquin River in the south Delta. Migrating juveniles from the San Joaquin River system go directly to the pumping facilities by entering Old River below Mossdale. Others may reach the export facilities by going down channels west of Stockton (e.g. Turner Cut, Columbia Cut, Middle River). The percentage of salmon reaching the export facilities is a function of the percentage of the water in the San Joaquin passing through Old River, which is in turn is affected by the volume of export water pumped relative to the volume of flow in the San Joaquin River (Baker and Morhardt 2001). At times the south Delta exports equal or exceed the entire San Joaquin River flow, which can cause reverse flows in channels leading to the export facilities, thereby increasing the entrainment risk of salmon in the pumping facilities. Although both projects are equipped with fish screens and salvage facilities, direct mortalities to fry and juvenile salmon are high (CDFG 1987). That mortality occurs from predation (particularly in Clifton Court Forebay of the State Water Project), entrainment, physical damage and stress during salvage operations, and predation at release points for salvaged fish near the downstream edge of the Delta. Indirect mortality due to the pumping operation (e.g. increased travel time and predation exposure) may also be a factor.

Water quality issues – Several issues related to water quality are present in the entire system. Suitable water temperatures are important to survival of all life stages. Low dissolved oxygen levels in the deepwater ship channel area in Stockton may result in an intermittent migration barrier to adult salmon, which may lead to higher straying rates, increased pre-spawning mortality affecting the Stanislaus, Tuolumne, and Merced runs, or delayed spawning that could have negative effects on the timing and survival of fry and juveniles. Other problems related to contaminants (e.g., pesticides, etc.) or elevated levels of selenium and other natural compounds may reduce food resources or otherwise negatively affect survival.

Hatcheries – The effect of hatchery salmon on Tuolumne populations is unknown at present, although contributions to the run are evidenced by tagged/marked fish. The proportion of hatchery salmon should be diminishing soon as a result of ending large Tuolumne study releases in 2002. The number of unmarked hatchery fish is unknown, but potentially may be significant at times. Potential deleterious effects include genetic impacts, reduced naturally spawning population productivity, and resource competition in freshwater, estuarine, and ocean environments.

Harvest - The commercial and recreational catch of salmon directly reduce the numbers of fish returning to spawn. The ocean harvest and the Central Valley Harvest Rate Index have been excessive (>70%) in many years, supported largely by major hatchery operations in the Sacramento system. Additional inland harvest occurs, mostly in the Bay and Delta, but also in the San Joaquin River system prior to the mid-October angling closure in the tributaries.

Poaching – There is little specific information available, but anecdotal evidence suggests that it may be significant for adult salmon at times within the San Joaquin tributaries.

Ocean Conditions – Variations in northeastern Pacific Ocean productivity can have major effects of growth and survival of salmon, but these marine effects are not specifically considered in this report. The Pacific Decadal Oscillation and shorter term El Niño/Southern Oscillation, both appear to change ocean productivity through complex processes. The mechanisms of how salmon populations are affected are not well understood, but ocean survival may be largely subject to events in the first year after ocean entry where predation may contribute to significant natural mortality.

This Page Intentionally Left Blank

3 PROGRAM ACTIVITIES AND ACCOMPLISHMENTS

The 1995 FSA defined goals and a consensus strategy for improving the health of the Tuolumne River Chinook salmon population. Section 8 of the 1995 FSA defined the following three programmatic goals that the consensus strategy for recovering the Tuolumne River salmon population attempts to achieve:

1. Increase naturally occurring salmon populations
2. Protect any remaining genetic distinction
3. Increase salmon habitat in the Tuolumne River

It was agreed that both instream flow and non-flow measures would be employed as part of the strategy, and that adaptive management would be a key part of the strategy. Participants in the 1995 FSA process also recognized that many factors that affect the Tuolumne River Chinook salmon population were beyond the control of the 1995 FSA signatories. Consequently, Section 9 of the 1995 FSA defined the following three comparative (as opposed to numeric) goals:

1. Improvements in smolt survival and successful escapement in the Tuolumne River
2. Increase in naturally reproducing Chinook salmon in this subbasin
3. Barring events outside the control of the agreement participants to the settlement, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested.

To implement the Section 8 adaptive management strategy and achieve the Section 9 goals, the 1995 FSA and the 1996 Order established a fish management program for the Lower Tuolumne River to be administered by the Districts. The program consists of the following elements described in the following sections:

- Program Administration & Coordination
- Instream Flow Management
- Non-Flow Measures (Habitat Restoration Projects)
- Restoration Project Monitoring
- Riverwide Monitoring

3.1 Program Administration & Coordination

The Districts, as the Licensees, are responsible for administering and coordinating the Lower Tuolumne River fish management program to implement and comply with the 1995 FSA and 1996 Order. TID is the Don Pedro Project Manager and has committed several positions to the fish management program. The program is administered by TID's assistant general manager for water resources and regulatory affairs in close coordination with MID. A TID department manager is the Tuolumne River Habitat Restoration Program Manager who administers all non-flow mitigation measures. A different TID department manager administers all Tuolumne River fishery studies and supervises the Districts' aquatic biologist. Tim Ford, the Districts' aquatic biologist, has held that position since 1981 and is a recognized expert on Tuolumne River and San Joaquin Basin salmonid issues. Stillwater Sciences (Berkeley, CA) and McBain & Trush (Arcata, CA) are the Districts' primary fisheries and river geomorphology consultants. HDR Engineering is the design engineer and Hart Restoration is the revegetation consultant on the Districts' major riparian habitat restoration projects. In accordance with Section 20 of the 1995 FSA, CCSF has provided $70,000 per year for ten years to fund a full time CDFG biologist position devoted to the Tuolumne River.

The Districts are also responsible for program administration and administrative support to the Tuolumne River Technical Advisory Committee (TRTAC), which was established under Section 14 of the 1995 FSA. The TRTAC superseded the 1986 Study Program Agreement's Technical Committee, consisting of the Districts, CDFG, and USFWS, which functioned well because committee members recognized the need to modify flow schedules and study plans to meet changing circumstances and the need to make those modifications within well-defined flow and funding parameters in the agreement. The 1986 Technical Committee applied an adaptive management approach to the allocation of instream flows and the design, coordination, and allocation of funding for fish studies and monitoring activities. That experience carried over to the expanded TRTAC.

The TRTAC has been a key element in implementing the 1995 FSA and the 1996 Order. The TRTAC has been responsible for coordinating the Article 58 monitoring activities, analyzing the results of monitoring and studies, facilitating data exchange among participants, developing adaptive management strategies, and identifying and selecting non-flow measures. The TRTAC members also have provided input into the flow schedule decisions by the Districts, CDFG, and USFWS under Article 37. The TRTAC has done much to foster and maintain an open dialogue among the TRTAC participants and good faith problem solving of issues.

TRTAC meetings have been held at least quarterly during the months of March, June, September, and December. The following topics are normally discussed at those meetings:

Table 3.1-1. Quarterly TRTAC Meeting topics

Meeting Date	Topics
March TRTAC meeting	1. Review and comment on the proposed fish flow schedule for the new fish flow year, which starts on April 15. 2. Review fall spawning survey results and seine results
June TRTAC meeting	1. Discuss any True-ups to the fish flow schedule. 2. Review information on the spring field studies
September TRTAC meeting	1. Discuss final flow volume and fall pulse. 2. Review results of summer field work
December TRTAC meeting	1. Discuss annual report content 2. Receive preliminary fall escapement numbers.

In addition to the regularly scheduled quarterly TRTAC meetings, additional TRTAC subgroup meetings are convened as needed to address problems that arise during the year. A monitoring subgroup was formed in 1998 to devote additional time on various detailed issues of concerns. One major task of the subgroup was to analyze the results of the trawl recoveries at Mossdale during smolt survival index studies performed under the 1987 and 1996 Orders. Telephone conferences and e-mail communications between TRTAC meetings have also been utilized to obtain TRTAC member input on time-sensitive matters as needed. All 1995 FSA signatories have participated in TRTAC meetings except CSPA and TRE, which hold separate meetings under Section 17 of the 1995 FSA. Since 1998, NOAA Fisheries has also been a regular participant in TRTAC meetings and activities.

Section 14 of the 1995 Agreement also established a Management Committee comprised of management representatives of MID, TID, CDFG, USFWS, and CCSF. Because the TRTAC members have endeavored to reach consensus on issues at the TRTAC level, no issues to date have been elevated to the Management Committee by the TRTAC.

In summary, the Districts, their biologists and consultants have devoted over two decades of full time research and monitoring efforts to ensure the lower Tuolumne River fish management program maintains a healthy salmon population and supporting ecosystem and meets the regulatory requirements of the FERC License.

3.2 Instream Flow Management

Several criteria and operating procedures determine flows in the Lower Tuolumne River below La Grange Dam. The FERC instream flow requirements, described in Section 3.2.1, constitute the fundamental framework for setting flows in the river. During the spring pulse flow period, additional flow may be required under the State Water Resources Control Board-approved San Joaquin River Agreement/VAMP studies, described in Section 3.2.2. USACE flood management requirements can also trigger additional releases, as described in Section

3.2.3. Finally, the 1995 FSA defined a series of cooperative actions to obtain additional flows in the Tuolumne River; Section 3.2.4 describes the status of those actions.

3.2.1 Establishment of FERC fish flows

Minimum instream flow requirements under the original Article 37 varied between 40,123 AF (Water Year 1988-1989) and 123,210 AF per water year. The FERC authorized suspension of the instream flow requirement for Water Year 1976-1977, the driest water year of record. Under the original Article 37, each year's minimum instream flow started on October 1 and was determined by the inflow into Don Pedro Reservoir during the immediately preceding water year, ending on September 30. There were only two set flow schedules – Schedule A (normal year) and Schedule B (dry year) – along with a methodology to determine required instream flows during critical water years. While rather simple to determine the required instream flow schedule, one AF of inflow could shift whether a normal versus dry year schedule applied, inflow is influenced by CCSF's Hetch Hetchy Project operations, and the methodology did not taken into consideration the amount of runoff produced during the then current water year when the actually releases would be made. Variations in the actual daily schedule were made upon agreement of the Districts and CDFG.

Under the 1995 Agreement and 1996 Order, instream flow requirements now vary from a minimum floor of 94,000 AF to a maximum of 300,923 AF (Table 3.2.1-1).

Table 3.2.1-1. Minimum Flow Releases based from 1996 FERC Order

Water Year Type	% Occurrence	Oct. 1–15 (cfs)	Attraction Pulse Flow (acre-feet)	Outmigration Pulse Flow (acre-feet)	Oct. 16–May 31 (cfs)	June 1–Sept. 30 (cfs)	Total Flow (acre-feet)
Critical and Below Normal	6.4	100	None	11,091	150	50	94,000
Median Critical	8.0	100	None	20,091	150	50	103,000
Intermediate Critical/Dry	6.1	150	None	32,619	150	50	117,016
Median Dry	10.8	150	None	37,060	150	75	127,507
Intermediate Dry/Below Normal	9.1	180	1,676	35,920	180	75	142,502
Median Below Normal	10.3	200	1,736	60,027	175	75	165,002
Intermediate Below Normal/Above Normal	15.5	300	5,950	89,882	300	250	300,923
Median Above Normal	5.1	300	5,950	89,882	300	250	300,923
Intermediate Above Normal/Wet	15.4	300	5,950	89,882	300	250	300,923
Median Wet/Maximum	13.3	300	5,950	9,882	300	250	300,923

Section 11 of the 1995 Agreement as adopted by the 1996 Order made the following significant changes in setting minimum instream flows:

- Ten water year classifications with prescribed flow schedules were established – two different schedules for each of the five water year types – Critical, Dry, Below Normal, Above Normal, and Wet.
- An absolute fish flow floor of 94,000 AF was established.
- One flow schedule of 300,923 AF was established for Above Normal and Wet water years – the 49.3% wetter water years.
- Water year classifications would be determined using the San Joaquin Basin 60-20-20 Index and the CDWR San Joaquin Valley unimpaired runoff forecasts, which are readily available over the Internet as well as published in the various reports of CDWR Bulletin 120-3-[year], Water Conditions in California.
- Additional water would be added to applicable flow schedule should the San Joaquin Basin Index fall between the designated water year classifications – that additional water became known as "Interpolation Water."
- The new fish flow year starts on April 15 of each year, approximately the time that spring outmigration pulse flows commence.
- Additional blocks of water would be provided for fall attraction flows in Below Normal, Above Normal, and Wet water years and spring outmigration pulse flows would be provided in all water years.
- Negative and positive True-ups to the fish flow schedule would be made during the fish flow year to reflect changes in the CDWR forecasted runoff.
- Fish flow schedule changes, the allocation of Interpolation Water, and True-ups are subject to agreement among the Districts, CDFG, and USFWS.

The flow schedule determination process thus became much more dynamic but within the fixed parameters established by the 1996 Order. The 1996 Order also provided the needed flexibility to adjust and integrate the Tuolumne FERC fish flows with fish flows from the New Melones Project operated by the USBR on the Stanislaus River and from the New Exchequer Project (FERC Project No. 2179) operated by the Merced Irrigation District on the Merced River to meet fish flow objectives for the San Joaquin River Basin.

3.2.1.1 Water Year Classification

The minimum instream flows for fishery purposes for the Don Pedro Project are determined using the following Water Year Classification table and Flow Schedule table in Article 37 of the 1996 Order. In general, the current water year's calculated San Joaquin Basin 60-20-20 Index is used to determine the applicable FERC water year classification, which is then applied to the Flow Schedule table to determine the amount of water to be released for fish purposes during the fish flow year (April 15 through April 14). The Flow Schedule consists of two components: a base flow that will change in rate (cfs) depending on the time of year and pulse flows for the spring and fall periods.

Table 3.2.1.1-1. Water Year Classification

Water Year Classification	Cumulative Occurrence	Freq.	60-20-20 Index (1906-1995)	60-20-20 Index (1906–2004)
Critical Water Year and Below	<6.4	6.4	<1,500 TAF	<1,476 TAF
Median Critical Water Year	6.4-14.4	8.0	1,500	1,476
Inter. C-D Water Year	14.4-<20.5	6.1	2,000	2,002
Median Dry	20.5-<31.3	10.8	2,200	2,187
Intermediate D-BN	31.1-<40.4	9.1	2,400	2,403
Median Below Normal	40.4-<50.7	10.3	2,700	2,698
Intermediate BN-AN	50.7-<66.2	15.5	3,100	3,139
Median Above Normal	66.2-71.3	5.1	3,100	3,669
Intermediate AN-W	71.3-<86.7	15.4	3,100	3,898
Median Wet/Maximum	86.7-100	13.3	3,100	4,593

The 1996 FERC Order in essence establishes two different fish flow schedule tracks – the Wetter Water Year Track and the Drier Water Year Track. The Wetter Water Year Track consists of the 49.3% wettest water year types (Intermediate Below Normal-Above Normal and above) and is generally characterized by the following:

- Four Water Year Classifications – two each for Above Normal and Wet water years – with the same fish flow schedule of 300,923 AF.
- Minimum base flows are set.
- Fall Attraction Pulse Flow amount is fixed but needs to be shaped.
- Spring Outmigration Pulse Flow amount is fixed but needs to be shaped and integrated with any required VAMP flows.

The Drier Water Year Track consists of the 50.7% drier water year types and is generally characterized by the following:

- Six Water Year Classifications – two each for Critical, Dry, and Below Normal water years – with fish flow schedules varying from a floor of 94,000 AF in a Critical Water

Year or drier to 165,002 AF in a Median Below Normal Water Year.

- Potential Interpolation Water amounts to be added when 60-20-20 Index falls between Water Year Classifications, which can be used to increase base flows or pulse flows.

- Negative and positive True-ups to the fish flow schedule during the fish flow year resulting from changes in the forecasted runoff.

- Fall Attraction Pulse Flow amounts in Below Normal water years (i.e., Intermediate Dry-Below Normal and Median Below Normal) are fixed but need to be shaped.

- Spring Outmigration Pulse Flow amounts are fixed but need to be shaped and integrated with any required VAMP flows.

Each year the California Department of Water Resources (CDWR) makes a runoff forecast of the unimpaired flow of the San Joaquin River Basin System, which includes the unimpaired flows of the Stanislaus, Tuolumne, Merced and San Joaquin watersheds expressed in thousands of AF (TAF) of water. These data are converted into CDWR's San Joaquin Valley Water Year Hydrologic Index, also known as the San Joaquin Basin 60-20-20 Index, which classifies water years (October 1 through September 30) into five basic types – Critical, Dry, Below Normal, Above Normal, and Wet. The 60-20-20 Index consists of 60% of the current water year's April through July San Joaquin Valley unimpaired runoff, 20% of the current water year's October through March unimpaired runoff, and 20% of the previous water year's Index, all expressed in the tens of thousands of AF. Article 37 further refined those five water year types into ten water year types reflected in the above tables. Licensees use the numbers from the CDWR forecast to calculate the Index to the nearest thousand AF. The CDWR Index is only calculated to the nearest tens of thousands of AF and the more precise calculation is needed in order to comply with Article 37, i.e., the calculation of the breakpoint between each of the drier seven water year types requires the current water year's index to be calculated to the nearest thousand AF.

3.2.1.2 Fish Flow Procedural Steps

The process to determine the new fish flow schedule begins each year with the CDWR February 1 San Joaquin Valley unimpaired runoff forecast and proceeds through a step-wise progression to the following January. Input from the Federal and State fish agencies and from the other TRTAC participants are solicited at each step. However, the decisions regarding the final flow schedule are made by the Districts, CDFG, and FWS as provided in the license. The Districts are participants in the VAMP approved by the SWRCB and require the spring outmigration flows under the 1996 Order to be integrated and coordinated on a San Joaquin River Basin-wide basis.

Under VAMP, the Article 37 fish flow water, including the spring outmigration pulse flow water, is considered part of the San Joaquin River base flows. However, as occurred in 2002 and 2004, the 12 days following the April 1 CDWR runoff forecast can turn dry thereby significantly reducing the applicable 60-20-20 index number and correspondingly reducing the amount of Article 37 water and the SJR base flow. The Districts need to maintain flexibility to quickly address any significant reductions in the projected runoff so as to avoid significant negative True-ups to the Article 37 fish flow schedule later in the fish flow year. Because this actually occurred in 2002, both CDFG and USFWS have recognized the potential problem and have been responsive to the Districts' need to quickly adjust the Article 37 water amount in this very short time period. Table 3.2.1.2-1 and Figure 3.2.1.2-1 summarize the process.

Table 3.2.1.2-1. Don Pedro Project Fish Flow Procedural Steps

Step	Date	Task
1	February	CDWR February 1 runoff forecast
2	March	CDWR March 1 runoff forecast. TID calculates preliminary San Joaquin Basin Index. If SJB Index is Intermediate BN-AN or wetter, then 300,923 AF allocated. If SJB is drier than Intermediate BN-AN, then Interpolation Water is calculated.
3	March	TID-MID develop Preliminary Flow Schedule based upon Step #2 and distributes to CDFG, USFWS, and other TRTAC participants and the VAMP technical team for review and comment.
4	March 15	CDFG is to submit proposed fish flow schedule to TID, MID, and USFWS for review and comment.
5	March	At March TRTAC meeting, fish flow schedules are discussed in detail.
6	April	CDWR April 1 runoff forecast. TID recalculates SJB Index number.
	April 10	Final fish flow schedule must be agreed upon by the Licensees, CDFG, and USFWS. If no agreement, then Default Flow Schedule is implemented.
	April 13	Possible start for Tuolumne River VAMP flows.
	April 15	**Start of new FERC Flow Schedule, Start of new Fish Flow Year (April 15 through April 14), VAMP pulse flow period is April 15 to May 15.**
7	May	CDWR May 1 runoff forecast.
	May	CDWR updates May 1 runoff forecast. TID updates SJB Index to see if runoff is on tract with April 1 forecast.
	May-June	TID, MID, CDFG, and USFWS, with input from other TRTAC participants, may agree upon interim true-ups and determine allocation of any "excess" fish flow water over the balance of the Fish Flow Year ending April 14. Can be discussed at June TRTAC meeting.
	June 1	**Start of Summer flows under Fish Flow Schedule.**
	June	June TRTAC meeting.
8	June	TID reports on the Spring Pulse Flow.
9	August	TID receives CDWR's final unimpaired runoff numbers.
10	August	TID calculates the Fish Flow Schedule true-up, if any. TID, MID, CDFG, and USFWS, with input from other TRTAC participants, determine how any positive or negative true-up will be allocated over the balance of the Fish Flow Year ending April 14.
	September	At September TRTAC meeting, if fall attraction pulse flow water is available, then the timing and duration of the fall pulse flow is discussed. If not finalized during August, how any positive or negative true-up would be allocated over the balance of the Fish Flow Year would also be discussed.
	October 1	**New Water Year starts and Fall flows start under Fish Flow Schedule.**
11	October	TID updates San Joaquin Basin Index and water year type frequency distribution.
12	October	TID consults with CDFG and USFWS on fall attraction pulse flow if applicable under the Fish Flow Schedule. TRTAC input was given at the September TRTAC meeting.
13	January	TID reports on the fall attraction pulse flow and Article 38's 45-day period.

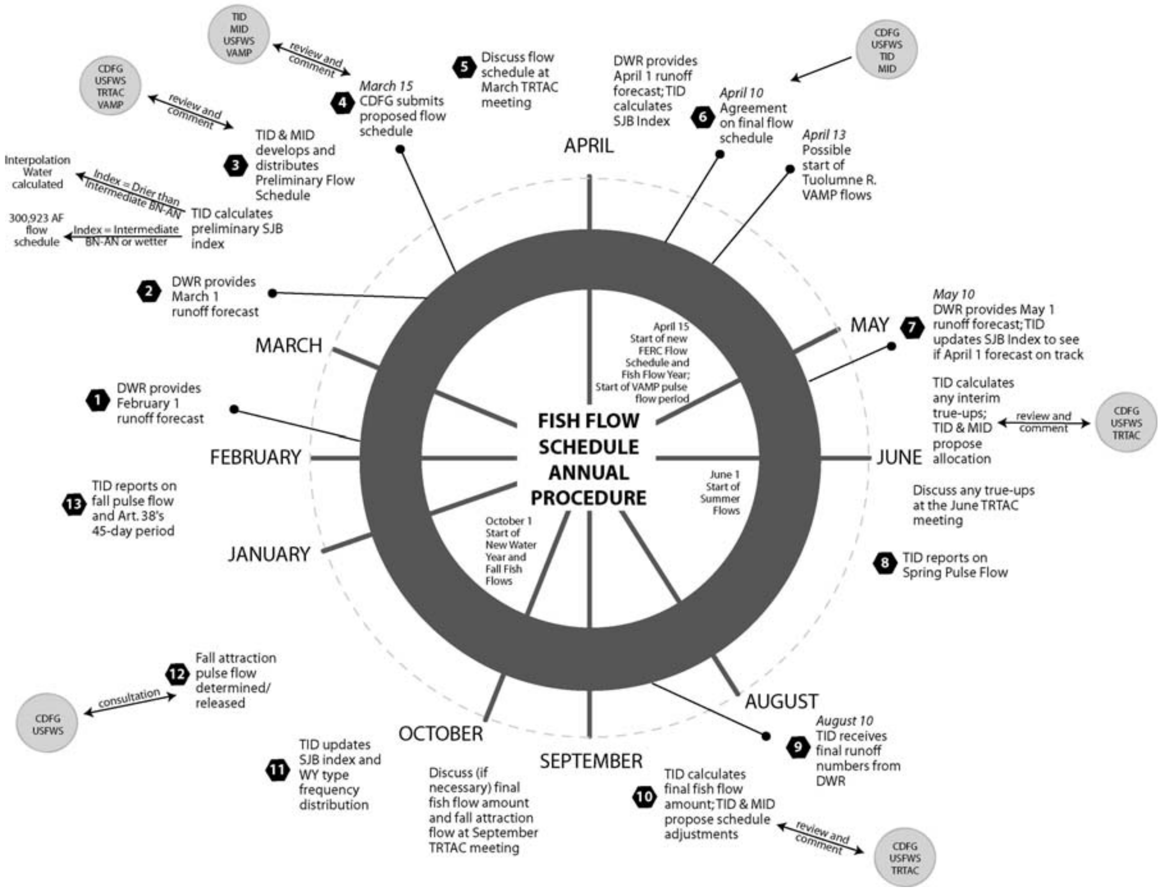


Figure 3.2.1.2-1. Don Pedro Project Fish Flow Procedure

3.2.1.3 Annual Flow Volumes since the 1996 FERC Order

The fish flow procedure described above and in detail in Appendix A of this report has been followed each year since the 1996 Order pursuant to the provisions of the amended Article 37. Flows below La Grange Dam are recorded at the USGS Gage No. 11289650, which is maintained and operated by the USGS. Meeting the required FERC minimum flow is the Districts' top Don Pedro Project operational priority. Except for operational emergencies and flood-related operations, the Districts normally add a buffer to the base flow rate to ensure meeting the required FERC minimum flow. While very infrequent, the USGS has re-rated the La Grange gage (11289650) so that the official river flow is rated downward even more than the amount of the buffer. The Districts practice is to immediately respond by increasing flow releases as needed upon notification of the re-rating. However, as USGS has a practice of retroactively applying the new rating, this can result in periods where the retroactively revised USGS flow is less than the required minimum flow that the Districts were trying to meet on a real-time basis. The Districts provide a written report, including pre-and post-rating flow records, to FERC in these instances and as well as in the event of an operational emergency that causes the flow to be temporarily less than required. Figure 3.2.1.3-1 and Table 3.2.1.3-1 below show the daily flow requirements and annual release volumes for the Don Pedro Project since the 1996 FERC Order.

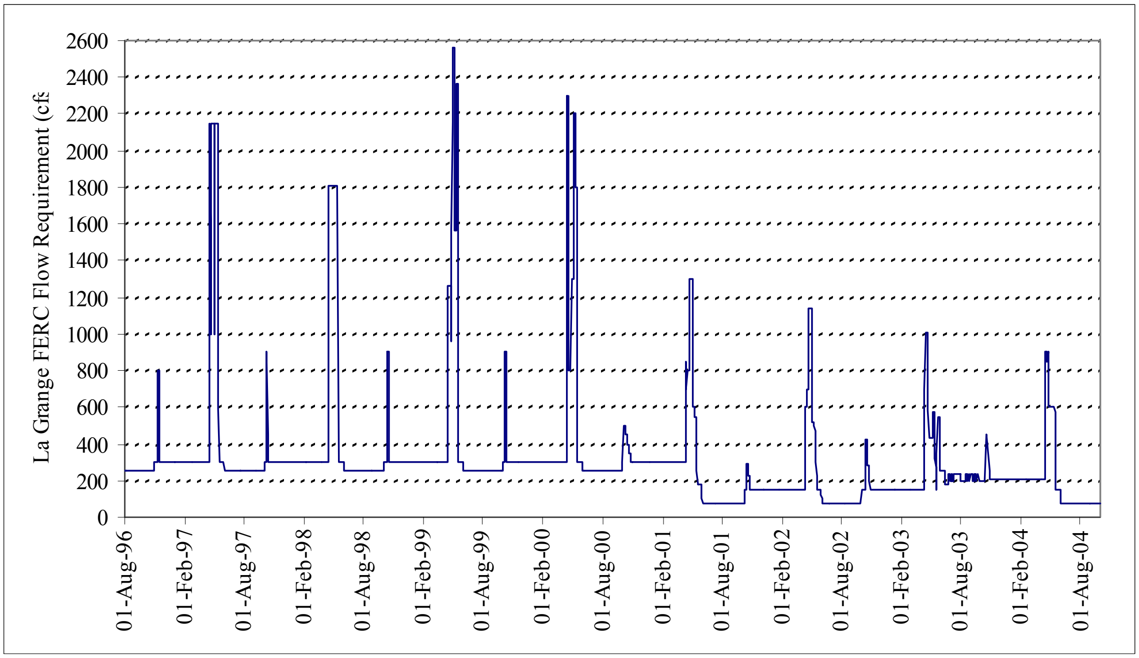


Figure 3.2.1.3-1 1996 FERC Order actual daily fish flow schedule from August 1, 1996 through Water Year 2004

Table 3.2.1.3-1 lists in columns the following: (1) The annual fish flow year for which the data represent from April 15 of one year to April 14 of the next year; (2) Initial volume of Article 37 water required based on the CDWR April 1 50% exceedence forecast or 300,923 acre-feet, the maximum required amount, which ever was greater; (3) the final calculated volume of water required under the amended Article 37; (4) the amount of Tuolumne river flow contribution to the VAMP spring pulse flow (Section 3.2.2); (5) the estimated annual total of flood management water released to the Tuolumne River at La Grange; (6) the final Article 37 Water Year Classification for the given Fish Flow Year; and (7) the final detailed San Joaquin Basin 60-20-20 Index as calculated by the Licensees from the CDWR runoff data.

Table 3.2.1.2-1. Annual Tuolumne River Required Flow Volumes in Acre-Feet and Basin Indices.

1	2	3	4	5	6	7
Article 37 Fish Flow Year (4/15-4/14)	**Initial Article 37 Annual Volume based on April 1 50% exceedance forecast**	**Final Article 37 Required annual Volume at La Grange**	**Annual VAMP Spring Pulse Flow Contribution**	**Estimated Flood Management Flow Annual Volume at La Grange**	**Final Article 37 Water Year Classification**	**Final Detailed San Joaquin Basin 60-20-20 Index**
1996-1997	*	300,923	No VAMP	1,800,000	Intermediate AN-W	4,119,611
1997-1998	300,923	300,923	No VAMP	850,000	Intermediate AN-W	4,130,248
1998-1999	300,923	300,923	No VAMP	1,350,000	Median Wet/Max	5,655,738
1999–2000	300,923	300,923	21,300	390,000	Intermediate BN-AN	3,590,923
2000–2001	300,923	300,923	25,900	80,000	Intermediate BN-AN	3,381,658
2001–2002	129,121	128,683	14,060	0	Median Dry	2,206,766
2002–2003	147,763	136,726	0	0	Median Dry	2,342,915
2003–2004	126,064	196,128	9,729	50,000	Median Below Normal	2,816,111
2004–2005	150,689	128,970	11,051	incomplete	Median Dry	2,211,624

* Partial year- FERC Order Issued July 31, 1996

3.2.2 The San Joaquin River Agreement/Vernalis Adaptive Management Program

The State Water Resources Control Board (SWRCB) has a long and contentious history in the development of State water quality standards in accordance with Federal requirements to protect fish and wildlife and other beneficial uses for water of the San Francisco Bay-Delta Estuary (Bay-Delta). In 1995, the SWRCB adopted a final Water Quality Control Plan (WQCP) for the Bay-Delta. As required by California law (Water Code § 13050), all water quality plans are required to include an implementation program, including measures over which the SWRCB has direct authority, such as its ability to deny or condition water rights diversions and use. The SWRCB conducted a water rights proceeding from 1998 through 1999 to develop a program to implement the Bay-Delta water quality objectives. That proceeding produced Decision 1641, a revised version of which was issued on March 15, 2000.

The San Joaquin River Agreement (SJRA) (signed in February 1998) and the Vernalis Adaptive Management Plan (VAMP) are cornerstones of a history-making commitment incorporated by the SWRCB into D-1641 to implement the 1995 WQCP. Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and Federal, State, and local governmental interests. CDFG and USFWS were signatories to the SJRA.

VAMP was initiated in 2000 as part of SWRCB Decision 1641. It is a large-scale, long-term (12-year) management program designed to protect juvenile Chinook salmon outmigrating from the Tuolumne, Merced, and Stanislaus Rivers through the Sacramento-San Joaquin Delta. VAMP is also a scientific experiment designed to assess salmon survival rates in response to modifications in San Joaquin River flows, SWP/CVP exports, and the installation of the Head of Old River barrier (HORB). When closed, the HORB shunts most San Joaquin Basin (including Tuolumne) smolts away from a direct path to the SWP/CVP export pumps, thereby improving smolt survival. The Districts have supported the construction of a permanent operable Head of Old River Barrier that could extend the seasonal period of salmon protective measures.

Specific experimental objectives of VAMP include quantification of juvenile salmon smolt survival under different sets of San Joaquin River flow rates and SWP/CVP export pumping rates as shown in the following Table:

Table 3.2.2-1. VAMP Vernalis Flow & Delta Export Targets

Forecasted Existing Flow (cfs)	**VAMP Target Flow (cfs)**	**Delta Export Target Rates (cfs)**
< 1,999	2,000 [non-VAMP flow objective]	1,500 [non-VAMP flow objective]
2,000 to 3,199	3,200	1,500
3,200 to 4,440	4,450	1,500
4,500 to 5,699	5,700	2,250
5,700 to 7,000	7,000	1,500 or 3,000
Greater than 7,000	Provide stable flow to the extent possible	

Note: Based on Table 2-1 from SJRGA's 2004 Annual Technical Report

Vernalis defines the southern boundary of the jurisdictional Delta (Cal. Water Code § 12220), and it is the location of a USGS flow gauge (USGS 11303500) that helps to define Delta inflows from the San Joaquin River basin. The annual target flows at Vernalis are met by coordinated upstream releases that augment base flows on the San Joaquin River according to allocation criteria in the SJRA. Under the SJRA, the following San Joaquin River Group Authority (SJRGA) agencies have agreed to provide the supplemental water needed to achieve the VAMP target flows, limited to a maximum of 110,000 AF: TID, MID, MerID, Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), and the San Joaquin River Exchange Contractors (SJRECWA).

The Merced Irrigation District (MerID) supplemental water is provided on the Merced River from storage in the New Exchequer Project and is measured at the Merced River at Cressey gage (USGS 11271290). The Oakdale Irrigation District (OID) and South San Joaquin Irrigation District (SSJID) supplemental water is provided on the Stanislaus River through diversion reductions and is measured below Goodwin Dam (USGS 11302000). The San Joaquin River Exchange Contractors Water Authority supplemental water is provided via Salt Slough, West Delta Drain, Boundary Drain and/or Orestimba Creek through system operation. TID/MID supplemental water is provided on the Tuolumne River from storage in the Don Pedro Project and is measured at the La Grange gage (USGS 11289650), the same gage used to measure FERC flows.

Coordinating the timing and amount of supplemental water from each applicable SJRGA agency in relationship to existing San Joaquin River base flows is a complicated task. The Hydrological Group, of which the Districts are active members, of the San Joaquin River Technical Committee (SJRTC) was established to forecast hydrologic conditions and to plan, coordinate, schedule and implement the flows required to meet the test flow target in the San Joaquin River near Vernalis. The Hydrology Group is also charged with exchanging information relevant to the forecasted flows and coordinating with others in the SJRTC, in particular the Biology Group, who are responsible for planning and implementing the salmon smolt survival study. TID and MID are also active members of the Biology Group.

CDFG, USFWS, and the Districts are active participants in the VAMP process, which facilitates the Article 37 flow allocation approval process and the integration of the Tuolumne River spring outmigration pulses with the supplemental water provided by the SJRGA agencies as part of VAMP. Section 3.2.1 of this Report describes how the TRTAC process is integrated with the VAMP process in determining how the Article 37 spring outmigration pulse flow water is used. It is important to note that the 1996 FERC Order provides the flexibility to shape, integrate, and adjust the Don Pedro Project's Article 37 flows with the larger San Joaquin Basin spring flow and SWP/CVP export operations.

The SJRGA prepares an annual technical report filed with the SWRCB, which includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of SJRA supplemental water; installation, operation, and monitoring of the temporary springtime HORB; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Results of the VAMP evaluations are reviewed in Section 44.4.1.4 of this report.

3.2.3 Flood management flows

The U.S. Army Corps of Engineers (USACE) defined the flood management operating criteria for Don Pedro Reservoir in the 1972 USACE Flood Control Manual for the Don Pedro Project. Generally, the flow at La Grange must be managed to maintain seasonal flood storage space in Don Pedro Reservoir, yet not exceed 9,000 cfs as measured at the USGS gage at Ninth Street in Modesto (USGS 11290000), located just below the confluence of Dry Creek. The USACE requires a rain flood storage reservation of 340,000 acre-feet, corresponding to a reservoir elevation of 801.9 feet (28.1 feet below the maximum reservoir elevation of 830 feet), between October 7 and April 27. In years with above average snowpack, additional USACE snowmelt parameters may apply to the reservoir storage criteria.

The USACE maximum discharge of 9,000 cfs in Modesto is designed to limit flood damage in the lower Tuolumne River. Maintaining flood flows below the 9,000 cfs target at Modesto can be challenging because of accretionary flows between La Grange Dam and Modesto. Dry Creek, the largest unregulated tributary of the lower Tuolumne River, is a low elevation watershed that is subject to significant short-term rainflood flow events of 5,000 cfs or higher. Flood management operations must also account for such flashy accretionary flows and reduce La Grange releases as necessary to prevent the total flow at Modesto from exceeding 9,000 cfs. The flood control manual also requires that flows be decreased no more than 1,000 cfs per 2-hour period, which is equal to the lowest hourly ramp down rate of 500 cfs per hour defined in FSA Section 16.

It takes about 24 hours for flows overtopping La Grange Dam to reach the Ninth Street gage, 36 miles downstream. Because of this lag time, Don Pedro Project operators managing flood management releases must anticipate high flows from Dry Creek a day in advance. CDWR maintains a telemetered gage on Dry Creek in Modesto, but it is only 6 miles upstream of the Ninth Street gage. To obtain an earlier warning of Dry Creek flows, the Districts installed a telemetered flow gage in 1996 on Dry Creek at Crabtree Road, northwest of La Grange. The flows measured at the Crabtree Road gage also take about 24 hours to reach the river gage in Modesto. This is a significant tool for flood management operations because it provides an indication of the magnitude of the discharge that the Dry Creek watershed will contribute to the mainstem Tuolumne River. Because additional runoff enters Dry Creek below the Crabtree Road gage, the gage cannot provide a completely accurate prediction of the impacts of Dry Creek flows on the Tuolumne River at Modesto; nevertheless, the gage is a valuable aid to operators who are required to limit river flow at Modesto to 9,000 cfs.

Flood management flows are generally released (1) when the Don Pedro Reservoir level is approaching the flood reservation elevation and runoff projections indicate that the flood reservation space could be encroached or (2) when the flood reservation space is encroached and the USACE determines an acceptable reservoir release schedule to reduce storage. Figure 3.2.3-1 shows the Don Pedro reservoir storage relative to the USACE flood reservation space over the 1996–2004 water years. Figure 3.2.3-2 shows the flow at La Grange over the same time period. Flood management flows were released in water years 1996–2001 and in 2004. The January 1997 flood is discussed in more detail in Section 4.4.6 of this report. Section 3.2.4 also describes the Districts' and CCSF's unsuccessful request to the USACE to modify the flood control rules, in accordance with FSA Section 11.

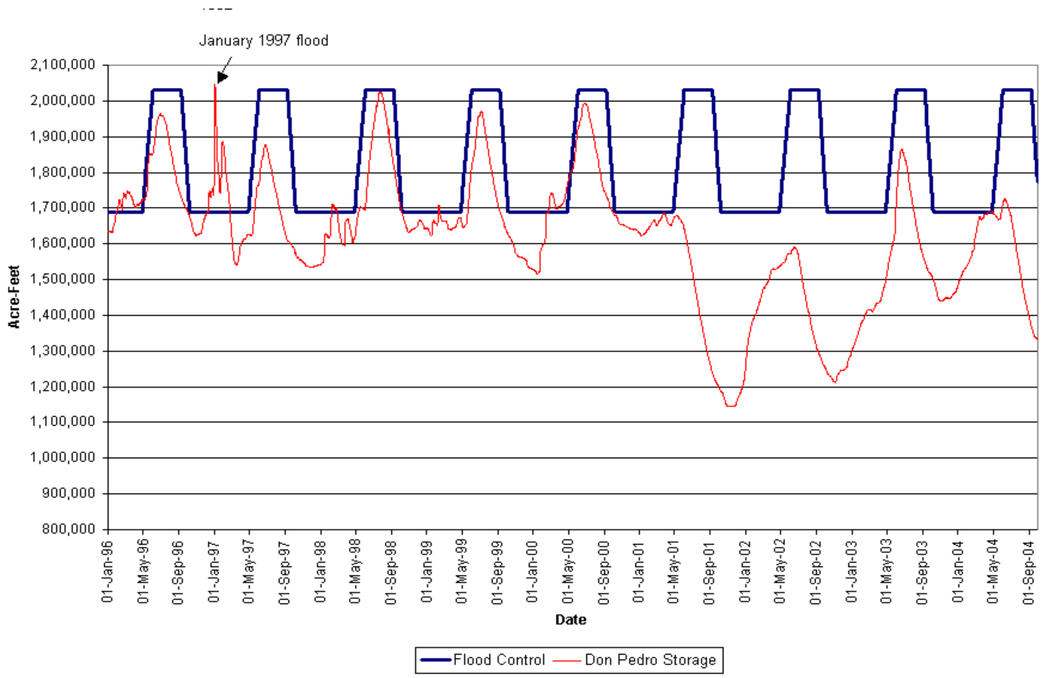


Figure 3.2.3-1 Don Pedro storage and USACE flood reservation space for WY 1996–2004

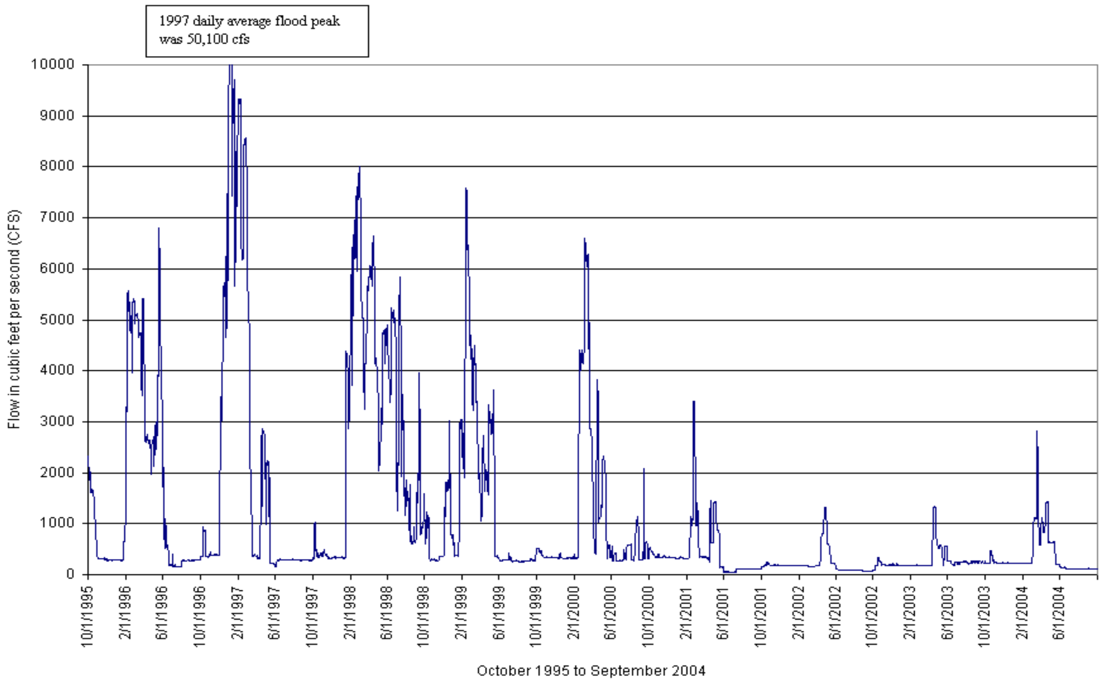


Figure 3.2.3-2 Daily average flow at La Grange for WY 1996–2004

3.2.4 Cooperative efforts to obtain additional flows in the Tuolumne River

Section 11 of the 1995 FSA directs signatories to cooperate to secure additional flows for the Tuolumne River, and it defines a series of actions for signatories to pursue. This section identifies the seven actions defined in Section 11 and describes the status of each:

1. **The Districts/CCSF will request Army Corps modification of flood control rules.**

   A letter requesting a meeting was sent to the U.S. Army Corps of Engineers (USACE), dated September 5, 1996. A meeting between the Districts, City and County of San Francisco, and USACE was held on October 2, 1996. The USACE reported in an October 18, 1997 letter they would review the proposed Don Pedro Project flood control manual modifications and respond within six months on that review. The massive January 1997 flood changed circumstances significantly and the USACE identified certain issues in its April 11, 1997 letter (above correspondence filed in our annual "1998 FERC Report"). The Statewide response to the 1997 flood included review of flood management in the Central Valley of California. The USACE completed: (1) the Modesto Community Assessment Study in September 1997 and (2) the Tuolumne River Reconnaissance Study (Section 905(b) Analysis) in October 1998. The USACE began a Tuolumne River Feasibility Study in 1999. The USACE and the State

Reclamation Board conducted the multi-year Sacramento and San Joaquin River Basins Comprehensive Study, resulting in an interim report in December 2002. These review processes consider structural and non-structural solutions. Purchase/easement of some flood-prone lands and better flood-proofing of some key facilities to accommodate higher flows have occurred.

The Districts continue to recommend they be allowed to release up to 15,000 cfs at La Grange with a maximum allowable flow of 20,000 cfs below Dry Creek at Modesto, instead of the present 9,000 cfs limit at Modesto. However, the USACE has not implemented any flood control operational changes for the Tuolumne and San Joaquin Rivers and has not approved any changes in the Don Pedro Project flood control rules.

2. **Water transfer agreements will be subject to freeing water from other committed uses.**

   No transfers have occurred.

3. **FWS and CDFG will have an option to purchase up to 20% of any water sold by the Districts to CCSF.**

   No water sales to CCSF have occurred.

4. **FWS will seek funds for water purchase from the Districts.**

   The San Joaquin River Agreement (see Section 3.2.2) is a conditional water purchase by USBR to increase flow for VAMP during the spring outmigration pulse flow period. There has been no other formal proposal made to the Districts to purchase water, and the Districts have not indicated that any other water is available for sale.

5. **TID will promote the proposed Turlock Area Drinking Water Project with diversion site between RM 19–26.**

   TID has promoted and is continuing to promote the proposed Turlock Drinking Water Project with the cities and other public purveyors of drinking water within TID. TID demonstrated its commitment to the project by spending approximately $1 million of its own funds to design, purchase, and install an infiltration gallery/intake at river mile 26 in 2001 in conjunction with the construction of the SRP 9 riparian habitat restoration project. It would not have been feasible to install the infiltration gallery after the SRP 9 project had been completed. The infiltration gallery/intake would be the facility through which TID could withdraw water for irrigation and/or for the Drinking Water Project. The cities are again reconsidering the project but it has not been a high priority with them.

6. **TID will conduct feasibility and cost analyses of withdrawing water for irrigation at the proposed Drinking Water Project diversion point as part of their EIR for that project. CDFG and FWS will determine if they will fund all or part of the design and construction of facilities. The parties are not obligated to fund these facilities.**

   A preliminary draft EIR for the Drinking Water Project had been prepared and circulated for comment but was not finalized because of a lack of interest to proceed on the part of the cities and other public purveyors of drinking water within TID. TID sent a January 5, 2004 letter to CDFG and FWS identifying the costs of facilities (pump station, pipeline, outlet structure) in order to operate the infiltration gallery/intake as an irrigation diversion facility. CDFG responded in a November 30, 2004 letter that did not identify any funding; FWS has not yet responded.

7. **Participants will work cooperatively to conserve water to allow water to be carried over from one year to the next year.**

   The April 1, 2003 CDWR runoff forecast and resulting San Joaquin River 60-20-20 Basin Index prescribed an initial Article 37 fish flow of 126,064 AF for the fish flow year, April 15, 2003, through April 14, 2004. The projected runoff increased when wetter than average conditions occurred during April – May 2003 and, with True-ups, the final Article 37 fish flow became a Median Below Normal water year with 196,128 AF, or an increase of more than 60,000 AF over the April 15 fish flow amount. Thus, an opportunity was presented for the TRTAC to consider carrying over up to 5,000 AF beyond October 1, 2003, for use until October 1, 2004. Given that the prior two water years were two water year classifications drier at Medium Dry, the Districts suggested to the TRTAC to consider carrying over up to 5,000 AF.[1] However, the TRTAC decided with concurrence by the Districts, CDFG, and USFWS, to use all of the additional True-up water to adaptively manage and augment summer 2003 flows. See Annual Report 2003-4. Thus the carryover provision has not been implemented to date because consensus could not be reached in the TRTAC as described above.

3.3 Non-Flow Measures (Habitat Restoration Projects)

Section 12 of the 1995 FSA directed the TRTAC to identify ten top-priority habitat restoration projects (including a minimum of two salmon predator pond isolation projects), with the objective of implementing the priority projects by the year 2005 and the provision that other parties would help seek additional funding. The 1995 FSA required up to $1 million from the Districts and CCSF for the non-flow measures. The 1995 FSA further

[1] The 2004-2005 fish flow year did turn out to be another drier Median Dry water year.

identified that implementation methods should include gravel cleaning, gravel additions, gravel replacement, placement of boulders, restoring floodplain, land acquisition, riparian restoration, among other methods. Other measures, including sediment source control, predator control, turbidity enhancement, reduced poaching, fish screens or guidance systems, and grazing management would be evaluated and potentially included among the priority projects.

The TRTAC chose to have an inventory and assessment made of the entire 52-mile lower river corridor to initiate the non-flow measure program. The overriding guidance document resulting from that effort was the Habitat Restoration Plan for the Lower Tuolumne River Corridor (Restoration Plan) by McBain & Trush (2000). The Restoration Plan advanced a novel approach in river restoration by identifying the inherent capabilities of the river system as well as mitigation measures that would most effectively maintain or restore habitat conditions most favorable for the species of concern. The Restoration Plan integrated the insights and expertise of physical and biological scientists in an ecosystem level analysis where hydrology, geomorphic processes, and biological responses are linked. In this ecosystem model, the magnitude, timing, and spatial distribution of watershed inputs (e.g., water, sediment, and nutrients) is influenced by natural and anthropogenic disturbance. Alterations in watershed inputs alter important geomorphic processes (e.g., sediment transport and channel migration). These processes construct geomorphic attributes that determine habitat structure, complexity, and connectivity. Species abundance and population dynamics, community composition, and trophic structure may be directly affected by these habitat attributes. The Restoration Plan was highly successful in identifying and prioritizing a number of restoration opportunities.

The completed Restoration Plan separated the river into seven segments based on habitat features and geomorphology. Within each segment the types of restoration project best suited to the habitat and natural processes were identified, including 14 high-priority restoration projects to improve salmon habitat and reduce predation losses. Several of these projects would restore “Special” Run/Pools (SRPs – mined lake-like river reaches) to riverine habitat as well as projects responding to impacts of the 1997 flood that occurred in the midst of the development of the Restoration Plan. Following is a discussion of the 10 TRTAC-identified priority projects, which can be broken into three broad classes based on the project goals and type of restoration activity, and a brief discussion of additional habitat restoration project being lead by others, which also use the Restoration Plan as the guidance document:

- **Channel and Riparian Restoration** - The channel restoration type of project is identified as the Gravel Mining Reach from RM 40.3 to RM 34.3 where terrace aggregate mining is currently active. The restoration work involves channel reconstruction, setting back existing dikes between the mining pits and the river to widen the floodway, reconstruction of riffle pool sequences to increase spawning and rearing area, and planting riparian forest on the newly created floodway benches. These are considered large-scale projects given the 6.2-mile length of the river and the magnitude of the materials used for the restoration construction. The Gravel Mining Reach was divided into four stand alone projects (Phases I-IV).

- **Predator Isolation** - These projects are focused on reducing predator habitat and improving the survival of fry and smolts as they rear and swim through these predator habitat areas. Inchannel mining created the SRPs, therefore the primary restoration activity is filling the former mined area and recreating riverine habitat more suitable for juvenile salmonid rearing and outmigration survival. Newly created floodway benches are replanted with trees and understory riparian species. There were four SRP projects initially identified in the Restoration Plan and the two SRPS at the lowest point of the SRP reach were selected as priority projects (SRP 9 and SRP 10).

- **Sediment Management** - The third class of projects involve sediment management ranging from cleaning fine sediments deposited in existing riffles, reducing transport of fine sediments into the principle spawning areas between Basso Bridge and La Grange, and gravel additions or infusions to create more riffles and to provide improved continuity of sediment transport for the long term maintenance of natural fluvial process in segments of the river. There were four sediment management projects identified by the TRTAC.

Due to the scope of these projects and the many steps and entities involved, there have been only two fully completed through 2004, at a combined cost of about $10 million (Table 3.3-1). However, there are up to five more projects potentially ready for implementation to begin in 2005. An estimated additional $7.5 million would be needed to complete the two projects that are not presently fully funded. The specified total FSA Section 12 funding amount of $1 million had been almost entirely spent through 2004. Project locations are shown in Figure 3.3-1.

Table 3.3 -1. Status of ten priority TRTAC habitat restoration projects

Priority Projects		**River Mile Location**	**Approx. River Mile Length**	**Funding and Potential Construction Activity Schedule**				**Status and additional funding needed**	
				2005	**2006**	**2007**	**(Funding millions)**		
Channel and Riparian Restoration Projects									
1	Gravel Mining Reach Phase I	37.7-40.3	2.6				$7.135	**Completed in 2003**	
2	Gravel Mining Reach Phase II	36.6-37.7	1.1	F			$6.455		
3	Gravel Mining Reach Phase III	35.2-36.6	1.4	D	F		$11.397		
4	Gravel Mining Reach Phase IV	34.2-35.2	1.0			**X**		Additional Required (1999 est.)	$3.340
Predator Isolation Projects									
5	Special Run-Pool 9	25.8-26.0	0.2				$2.653	**Completed in 2001**	
6	Special Run-Pool 10	25.0-25.4	0.4	D	**X**		$0.544	Additional Required:	$4.200
Sediment Management Projects									
7	Riffle Cleaning (Fine sediment)	40-52	several sites	F	F		$1.028		
8	Gasburg Creek basin (Fine sediment)	near 50.3	off river	F	F		Included above		
9	Gravel augmentation (Coarse sediment)	40-52	several sites	F	F	F	$4.552	Scope/budget being reviewed by CBDA	
10	River Mile 43 (Coarse sediment)	42.8-43.2	0.4	F			$0.300		
						Total:	***$34.064***	***Total:***	***$7.54***

Key: F = fully funded; D = design only funded; X = potential construction

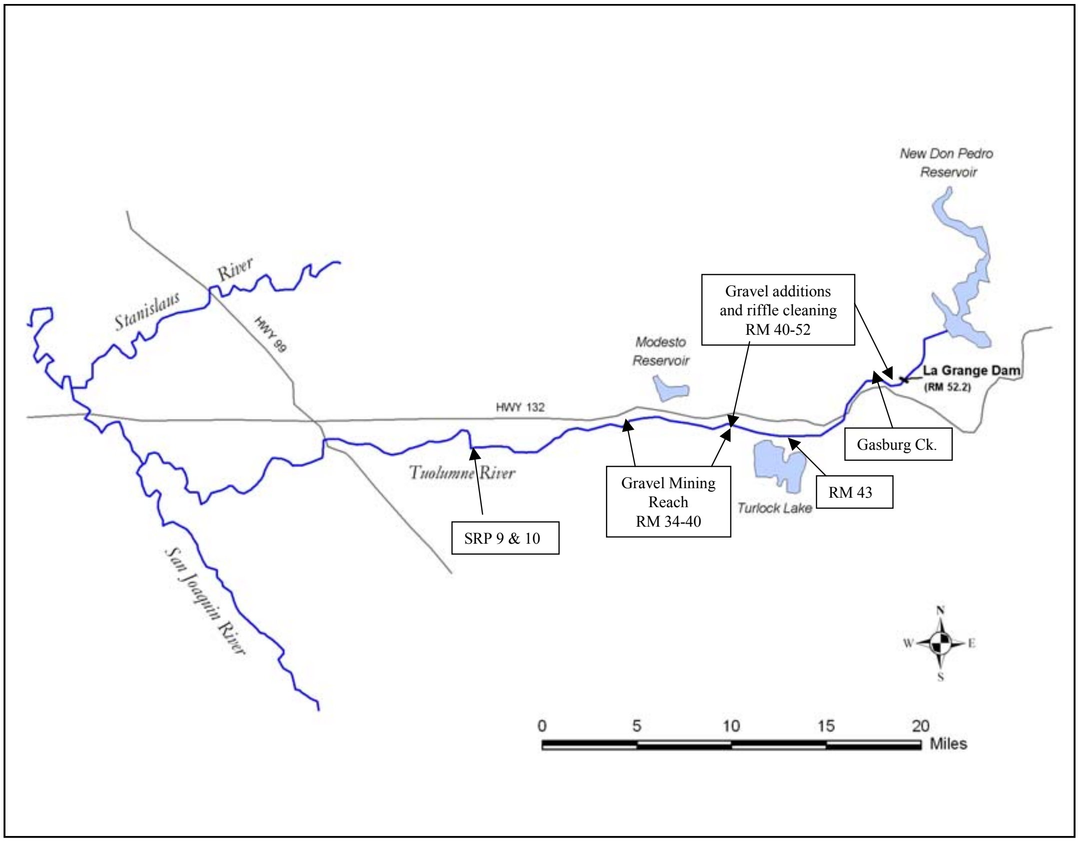


Figure 3.3 –1. Location map of TRTAC habitat restoration projects.

A tiered Environmental Assessment and Initial Study/Mitigated Negative Declaration were jointly produced in 1998 by TID and the USFWS (funded by the 1995 FSA and AFRP) for the four projects of the Gravel Mining Reach and SRPs 9 and 10. The complexity of the design and implementation of the first SRP project and Gravel Mining Reach project led to the development of a Design Manual in February 2004 to memorialize the process of taking recommendations from the Restoration Plan to large-scale implementation. A Coarse Sediment Management Plan was completed by McBain & Trush in July 2004 to provide design and implementation guidance for the gravel addition projects identified in the Restoration Plan.

3.3.1 Channel and riparian restoration

Impetus for channel and riparian restoration in the Gravel Mining Reach comes primarily from recurring failure of berms or dikes separating off-channel aggregate extraction pits, accentuated by damage during the 1997 flood. The January 1997 flood releases from Don Pedro Reservoir and spillway peaked at nearly 60,000 cfs. Flood damage occurred to the channel and berm/levee system and to riparian aggregate mining features. Damage included multiple aggregate mining pit berm failures, complete channel capture through certain aggregate mining pits, and substantial degradation to salmon habitat (loss of riffles, channel downcutting and fine sediment introduction from the settling ponds).

The proposed long-term solution is to restore a riparian floodway with a minimum width of 500 ft to 600 ft to safely convey discharges of at least 15,000 cfs with fully grown riparian vegetation and a reasonable safety factor. The restoration revegetates floodplains with native riparian series, similar to the revegetation plans for the SRP projects. The 330 acres of existing off-channel aggregate extraction pits will be reduced to 270 acres.

Objectives for the Channel and Riparian Restoration Projects in the Gravel Mining Reach include:

- Restore a floodway width that will safely convey floods of at least 15,000 cfs.
- Remove floodway “bottlenecks” created by encroachment of inadequate mining pit berms (e.g., berm failure above a certain discharge threshold) into the floodway.
- Protect aggregate extraction operations, bridges, and other human structures from future flood damage.
- Improve salmon spawning and rearing habitats by restoring an alternate bar (pool-riffle) morphology, restoring spawning habitat within the meandering channel, and filling in-channel mining pits.
- Prevent salmon mortality that results from connection between the Tuolumne River and off-channel mining pits.
- Restore native riparian communities on appropriate geomorphic surfaces (i.e., active channel, floodplains, and terraces) within the restored floodway.
- Allow the channel to migrate within the restored floodway to improve and maintain riparian and salmonid habitats.
- Restore habitats for special status species (e.g., egrets, ospreys, herons).

3.3.1.1 Gravel mining reach phase I (7/11 segment)

This segment extends along the 7/11 aggregate extraction area upstream of Roberts Ferry bridge (RM 40.3) downstream to the M.J. Ruddy property line below the 7/11 plant site (RM 37.7). Project construction involved a total of 454,000 yd^3 of materials moved within the entire 7/11 Materials mining sites from upstream of Roberts Ferry Bridge to downstream of the site of the processing plant. The source and construction sites were connected by off-highway haul roads associated with 7/11 Materials aggregate operations. Maximum haul distance was 2.5 miles from the source site to the downstream end of the 7/11 Segment. A total of 87.4 Acres was acquired for the project with 31.4 planted to new riparian forest. The floodway width was increased to 450 to 500 ft providing flood capacity to convey at least 15,000 cfs. A total of 1.1 acres of exotic vegetation was removed.

Project Status: The 7\11 Segment restoration construction was completed in March 2003 with maintenance of the revegetation plantings conducted through September 2004. Figure 3.3.1.1-1 shows a view looking downstream from Roberts Ferry Bridge.

Figure 3.3.1.1–1. Part of completed 7/11 project below Roberts Ferry Bridge

3.3.1.2 Gravel mining reach phase II (MJ Ruddy segment)

This segment is located between the property line upstream of Ruddy's orchard (RM 37.7) downstream to the haul road bridge for Santa Fe Aggregates at (RM 36.6). Construction in the M.J. Ruddy segment will require importing an estimated 465,000 yd^3 of aggregate and topsoil material. There potentially are local sources depending on the status of mining on both the Ruddy and Warner properties that would greatly reduce the need to haul materials a greater distance. Approximately 36.4 acres of floodplain will be created or modified to increase the floodway capacity, and native riparian habitat will be increased from 18.6 acres to 42.2 acres. A total of 1.6 acres of native vegetation (narrow-leaf willow) will be removed as part of channel relocation and/or to acquire revegetation materials.

Project Status: The Project has been fully funded in the amount of $7,737,000. The design work is complete, ROW acquisition is underway, and construction in anticipated to begin in the spring of 2005 with revegetation in the fall of 2005. Maintenance of the revegetation planting will extend through September 2006.

3.3.1.3 Gravel mining reach phase III (Warner-Deardorff segment)

The Warner/Deardorff segment extends from the Santa Fe Aggregates conveyor bridge (RM 36.6) downstream to the entrance to Dan Casey Slough (RM 35.2). Construction in this segment should not require material importation because historic floodplains on the Deardorff parcel will be lowered and the remainder of the Tulare Pond deepened. This phase will also create approximately 63.6 acres of floodplain. Native riparian vegetation will increase from 56.9 acres to 67.5 acres. A total of 9.0 acres of narrow-leaf willow will either be disturbed or removed as part of channel and dike relocation and/or to acquire revegetation materials.

Project Status: The Project has been fully funded with $518,670 from the US Fish & Wildlife AFRP and $10,800,000 from the CBDA. The design and permitting of the MJ Ruddy and Warner Deardorff segments has been done as one project under the Districts' contribution for the MJ Ruddy Segment. The design work is 90% complete; ROW acquisition will commence after completion of the MJ Ruddy ROW acquisition, and construction is anticipated to begin in the spring of 2006 with revegetation in the fall of 2006. Maintenance of the revegetation planting will extend through September 2007.

3.3.1.4 Gravel mining reach phase IV (Reed segment)

The Reed segment is defined by the entrance to Dan Casey Slough on the upstream end (RM 35.2), and the upstream extent of the Reed Mitigation restoration project on the downstream end (RM 34.3). In a manner similar to Phase III, the Reed segment restoration was originally intended to use on-site materials for channel and floodplain reconstruction to avoid the need for imported materials. Extensive mining at the site in recent years may now require importation of materials to complete the restoration. Restoration will create approximately 48.2 acres of floodplain. Native riparian vegetation will be increased from 35.9 acres to 47.5 acres. A total of 2.9 acres of native vegetation (narrow-leaf willow) would be removed as part of channel relocation and/or to acquire revegetation materials.

Project Status: While the Reed Segment has been identified as the fourth project in the Mining Reach there has been no funding by the State, Federal, or District pledged or awarded for the project at this time. In 1999 the estimated cost for this project was $3,340,000. The funding Agencies have asked to review the budget and project monitoring reports of the first three segments completed before considering funding for the Reed Segment.

3.3.2 Predator isolation (Special Run Pools)

Each special run pool (SRP) has the potential to reduce Chinook salmon survival because the unnaturally wide channel and deep-water conditions offer more favorable habitats to non-native largemouth and smallmouth bass, and the native Sacramento pikeminnow, all of which prey on juvenile Chinook salmon. These projects will restore a natural two-stage channel morphology and alternate bar sequence scaled to the present and future flow regime, facilitate sediment transport and routing, restore Chinook salmon rearing habitat, reduce predation and predator opportunity time, and increase riparian vegetation. SRPs 5, 6, 9, and 10 were initially identified as potential restoration projects.

SRP 9 and SRP 10 were chosen as the priority projects because they were the furthest downstream and are a short distance from to each other for comparative monitoring programs (Fig. 3.3.2-1). Restoration of SRP 9 in conjunction with SRP 10 was intended to restore bedload transport continuity through this reach, which can be used by the river to build and maintain dynamic gravel bars, and thus improve Chinook salmon spawning and rearing habitat.

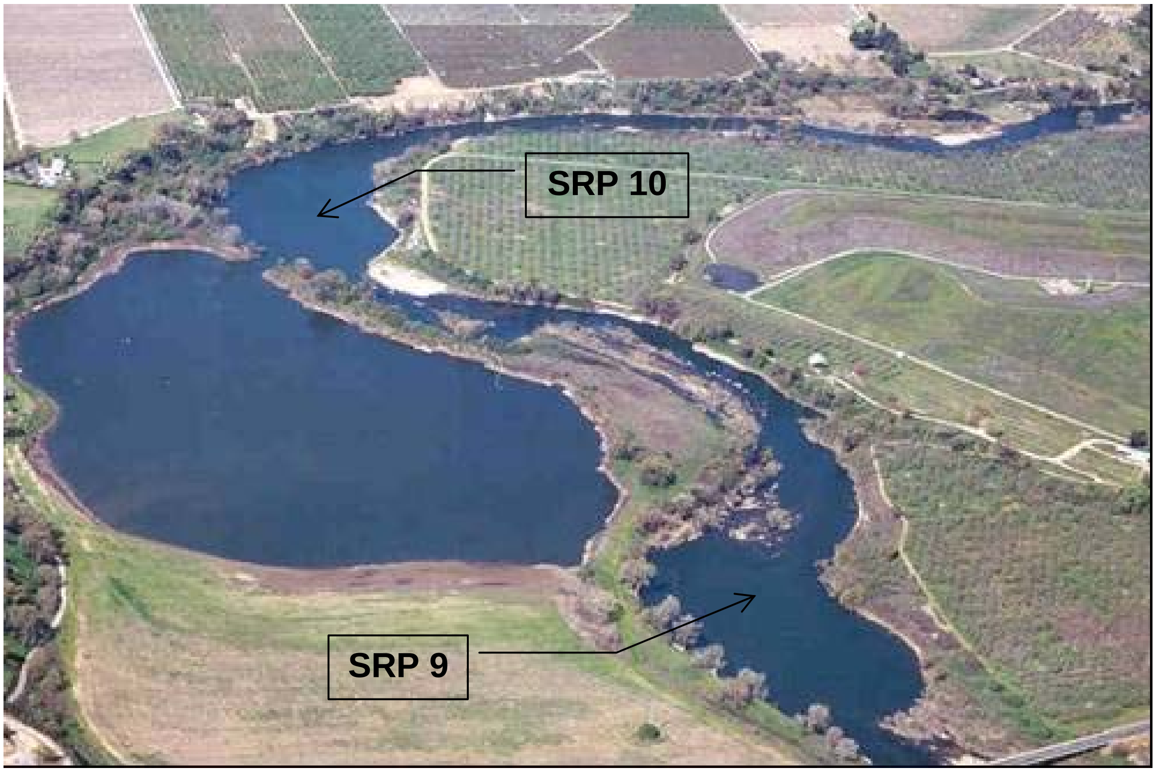


Figure 3.3.2-1 Pre-project aerial view of SRP 9 and SRP 10 sites

Objectives for the Predator Isolation Projects at SRP 9 and SRP 10 include:

- Reduce habitat favored by predatory fish species, and replace with high quality Chinook salmon habitat.
- Restore channel and planform morphology scaled to contemporary and future sediment and hydrologic regimes.
- Restore sediment transport continuity and eliminate bedload impedance reaches.
- Revegetate reconstructed floodplains and terraces with native woody riparian species, planted on surfaces designed to inundate at discharges appropriate for each species/series life cycles.

3.3.2.1 SRP 9 (and SRP 10 embankment repair)

SRP 9 is located immediately downstream of Fox Grove County Park, 10 miles east of Modesto, and extends from RM 25.6 to 25.9. Aggregate extraction at SRP 9 created a 400 ft wide by 6 ft to 19 ft deep pit, and eliminated floodplains on the north and south banks.

The project involved filling in most of the pit, and re-establishing an alternate bar morphology through the reach. The upstream boundary of the SRP 9 pit (RM 25.9) is a riffle that acts as the project entrance control, and was not disturbed during construction. The downstream boundary is the riffle crest at the outlet of SRP 9. A single thread channel and floodplain was restored through the SRP 9 segment requiring 144,000 cubic yards of imported fill material filling the pool along the north and south banks to reclaim 4.5 acres of floodplain. Two forms of bio-engineered bank stabilization were installed along approximately 500 ft of the north bank downstream at the exit riffle on the outside of the meander to increase bank stability. The low water channel width was reduced to 90 to 100 ft. The SRP 9 Project included repairing a breach in the dike between SRP 10 and the south terrace mining pit pond adjacent to both SRP 9 & SRP 10. This was done as part of the SRP 9 project because construction was easier and it eliminated a large source of bass in the pond from entering the river long before SRP 10 could be restored. The initial design called for overbank flows to occur at 4,500 cfs. This was reduced to 1,500 cfs to reduce the materials required to construct the project when the initial bids came in above budget.

Project Status: The restoration construction was completed October 2001 and the revegetation planting was completed in December 2001 (Figure 3.3.2.1-1). Maintenance of the revegetation planting went through December 2003.

Figure 3.3.2.1-1. View of completed SRP 9 project

3.3.2.2 SRP 10

SRP 10 is located one mile downstream of Fox Grove County Park, 9 miles east of Modesto, and extends from RM 25.2 to 25.6. Aggregate extraction at SRP 10 created a 400 ft wide by 10 ft to 36 ft deep in-channel pit, and eliminated the large point bar and floodplains on the north bank. Restoring SRP 10 in conjunction with SRP 9 will restore bedload transport continuity through this reach, which can be used by the river to build and maintain dynamic gravel bars (available for Chinook habitat).

The proposed treatment will fill the pit and re-establish an alternate bar morphology north of the pit through a segment of the adjacent orchard. This is consistent with designing projects to fit the contemporary flow regime. The material from the orchard will be used as the fill for the pit, eliminating the need to import material for the project. This will create several benches in the old pit area that inundate at different flows allowing a diverse riparian forest area to be recreated. The low water channel in SRP 10 will be reduced to 90 to 100 ft wide. Monitoring data and habitat modeling from the constructed SRP 9 have been used to apply adaptive management techniques to the final design for SRP 10. It is estimated that 144,000 cubic yards of material will be moved to fill in the old mining pit and 4.5 acres of new floodplain will be created.

Project Status: This project has been divided into two phases. Phase I involved design, ROW appraisals, and permits that has been funded by CBDA in the amount of $543,350. The design is 85% complete. Phase II has not been funded and will involve ROW acquisition, construction, and revegetation at an estimated cost of $4,250,000.

3.3.3 Sediment management

Early construction of dams in the late 1800s on the Tuolumne, Stanislaus, and Merced Rivers restricted access to upstream gravels while still permitting spawning downstream. On the Tuolumne River, the blockage occurred in 1871 with the completion of a private dam by Milton A. Wheaton in the vicinity of the present La Grange Dam. With this dam, which was eventually replaced by La Grange Dam in 1893 (RM 52.0) and the upstream Old Don Pedro Dam in 1923, recruitment of coarse sediment (gravel and cobble) to the Tuolumne River channel downstream of La Grange Dam was effectively cut off. Because the few small tributaries entering the Tuolumne River downstream of La Grange contribute virtually no coarse sediment, coarse sediment supply downstream of La Grange Dam is currently limited to sediments stored in contemporary channel, floodplain, and terrace deposits, or bank erosion of dredger tailings. In the absence of an upstream source, high flow events have selectively transported medium-sized particles (gravels) from the bed surface, leaving behind large cobbles and boulders that can armor the bed surface layer. Additionally, fine sediment (sand and silt) input and storage into the Tuolumne River was found to be high in studies prior to 1995. Massive incision of the Don Pedro spillway during the 1997 flood peak generated many hundred thousand cubic yards of rubble and sand, much of which was deposited in LaGrange Reservoir. Some of the coarse sand, however, was transported through LaGrange Reservoir to the lower Tuolumne River, depositing on floodplains and in channel in the spawning reach. These fine sediments reduce egg-to-emergence survival of salmonid embryos in the gravels.

Chinook salmon depend on an adequate quantity of high quality coarse sediment deposits for spawning and rearing, and require a significant portion of these deposits to be of gravel and small cobble size classes with relatively low proportions of fine sediment. The Sediment Management Plan outlines actions to improve spawning production that focus on increasing coarse sediment supply and increasing spawning gravel quality while also reducing fine sediment supply to the spawning areas.

Sediment Management Project Objectives include:

- Implement actions to reduce fine sediment storage in the mainstem Tuolumne River.
- Implement remedial actions to prevent further extensive fine sediment input into the Tuolumne River from Gasburg Creek (located near the upstream end of the spawning reaches).
- Increase coarse sediment storage in the channel with a large “transfusion” of coarse sediment to provide alluvial deposits immediately available for Chinook salmon spawning, and for eventual downstream transport and redeposition.
- Maintain this restored coarse sediment storage by periodic augmentation of coarse sediment supply equal to the rate of downstream sediment transport.

3.3.3.1 Riffle cleaning project

The Districts previously evaluated several methodologies for gravel cleaning to improve the survival to emergence associated with the existing gravel quality of the spawning riffles (TID/MID 1992, Appendix 2). As part of the CBDA funded Fine Sediment Project, a riffle cleaning project has been planned to be implemented in summer 2005. The objectives of this project are to: (1) quantify the relationship between substrate permeability and chinook salmon survival-to-emergence and (2) reduce the volume of sand stored in the mainstem channel and, hence, increase substrate permeability. The approach for reducing the volume of sand stored in the Tuolumne River is based on evaluating the volume of sand storage in pools, assessing the efficacy of various pool and riffle cleaning methods (funded under a pre FSA project), and implementing five riffle-cleaning projects. The project implemented a field experiment to quantify the relationship between permeability and salmon survival-to-emergence. The results are to provide guidance on the level of gravel cleaning the project should work towards. Sand storage in riffles throughout the spawning reach has been assessed by the TRTAC monitoring program

Project Status: The project has been funded by CBDA in the amount of $404,230. The survival to emergence study and pool sand volume assessment has been conducted. The methods and equipment for cleaning sand is currently under evaluation. It is anticipated sand cleaning work will be conducted in the summer of 2005.

3.3.3.2 Gasburg Creek sedimentation basin

There are three elements to the Gasburg Creek sediment management project. The first was to conduct a reconnaissance-level assessment of the Gasburg Creek watershed to evaluate the contribution of sediment from Gasburg Creek to the Tuolumne River, identify major sediment sources within the Gasburg Creek watershed, and provide recommendations for reducing sediment delivery from the watershed. The study found two locations within the basin where remedial action is recommended to reduce the amount of sediment to be handled in the Sedimentation basin.

Gasburg Creek flows through an inactive sand mine near the confluence with the Tuolumne River and the California Department of Fish & Game (CDFG) La Grange office. The channel was highly disturbed by mining activities, which reconfigured the creek, dumped fill and asphalt into the creek, and removed all riparian vegetation. This second element of the project includes channel restoration design and implementation for a 300-foot reach of the creek downstream of the sedimentation basin.

The construction of a sedimentation basin on lower Gasburg Creek is the third element of this project, with the objective to immediately reduce the volume of sand contributed to the mainstem spawning reach. The location chosen for the sedimentation basin on the creek is adjacent to the toe of the Modesto Irrigation District canal. Project designs and construction cost estimates for this sedimentation basin have been completed by McBain & Trush in coordination with the CDFG. Implementation would occur in cooperation with CDFG (which occupies the property) and the California Department of Water Resources (CDWR) (which owns the property).

Project Status: The project has been funded by CBDA in the amount of $590,880. The watershed assessment and design work are complete. Construction of the sedimentation basin is scheduled for the summer of 2005.

3.3.3.3 Coarse sediment management plan gravel augmentation project

On the Tuolumne River, gravel and cobble are needed to restore degraded sections of river to more productive conditions, and to increase salmon spawning habitat. Recent spawning habitat assessments have indicated Chinook salmon spawning habitat has decreased as a result of the 1997 flood, and spawning gravel restoration is needed to sustain the salmon population. The Gravel Augmentation Project is implementation of restoration in the priority areas identified in the “Coarse Sediment Management Plan” (CSMP). Two important restoration goals in this project are to:

- Continue with large-scale sediment augmentation by placing large volumes of spawning gravel-sized material in the upper gravel-bedded reaches below La Grange Reservoir, to increase spawning habitat availability and improve geomorphic conditions.

- Develop project implementation, monitoring, and adaptive management plans that will facilitate a long-term sediment augmentation program on the Tuolumne River.

The project entails placement of 300,000 cubic yards of screened aggregate to increase salmon spawning habitat by reducing the gradient of existing riffles and by the addition of aggregate in alternate bars within the long runs between existing riffles to further increase available spawning habitat. The project design and implementation process are intended to include protection of existing *O mykiss* habitat while expanding salmon spawning habitat with the aggregate infusion. The CSMP had to be completed with the *O mykiss* protection measures incorporated before the design work on this project could proceed.

As originally funded, the project included acquisition of off-site remnant dredger tailings from two properties near Basso Bridge. That aggregate was to have been processed for the project and the associated mining reclamation plan would have created wetland habitat near the river. Public opposition to the proposed mining and the difficulty associated with the Districts obtaining mining permits for the two off-site source areas made this portion of the project very difficult to implement in a timely manner. The project is under amendment to delete this portion of the work and use the funds to acquire the needed processed aggregate from existing commercial sources.

Project status: The project has been funded for $4,400,000. The design and permitting work has started. The scope of the project is being amended to move funds originally slated for developing the mining operation near La Grange to purchasing of the required aggregate through existing commercially permitted sources. This change will result in 30% more aggregate being available for initial placement in the river. Placement of the aggregate can only be done in the summer period when salmon are not present. It is anticipated the placement will take three years, starting in the summer of 2005.

3.3.3.4 River Mile 43 (Bobcat Flat/Dredger Tailings Reach Phase III)

The impacts from gold dredging, combined with flow and sediment regulation, have cumulatively degraded habitat that was once highly conducive to salmon production into a degraded condition that contributes a disproportionately small proportion of the productive potential of the gravel-bedded reach of the Tuolumne River. Once healthy salmon habitat now receives considerably less spawning use than spawning riffles upstream of the Dredger Tailing Reach. This problem was caused by dredge mining converting the channel morphology from a natural pool-riffle sequence to a "lake-cascade" morphology. This conversion removed the numerous low gradient riffles highly conducive to Chinook salmon spawning and rearing habitat to a smaller number of high gradient riffles that were separated by long backwater pools. Many of these high gradient riffles are greater than 1% slope during spawning flows (<300 cfs), creating velocities higher than that preferred by spawning salmon over much of the riffle surface. The conversion to steep riffles by dredge mining resulted in a dramatic decrease in Chinook spawning habitat because the steep riffles reduced the number and surface area of spawnable habitat due to higher gradient, higher velocities, and reduced number of riffles and the aerial extent of the remaining riffles.

The project is designed to demonstrate how to increase available spawning areas in the Dredger reach of the river. Reversing the impacts of the dredge mining require conversion from the "lake-cascade" morphology back to a more natural pool riffle morphology. This can be accomplished by redistributing the elevation drop in the short steep riffles to create low gradient riffles with a slope less than 0.2%. Adding aggregate in the long lake areas to create new bars and riffle areas can create similar conditions. Reducing the riffle slopes will not only improve the hydraulic conditions within each riffle to increase spawning habitat, but it will also greatly increase the total amount of potential spawning habitat by increasing the riffle surface area.

The project involves implementing two gravel addition treatments at RM 43 to reduce the gradient at two riffles and to create a new riffle in between. Approximately 10,000 cubic yards of screened aggregate will be placed in the river. The project includes creation of a high flow bypass channel on the adjacent floodplain as the way to generate the aggregate required for the project. The floodplain work is part of a larger riparian reforestation project conducted by the landowner and TRTAC member, the Friends of The Tuolumne.

Project status: The RM 43 work is fully funded by the California Department of Water Resources (4 Pumps Project mitigation funds) in the amount of $300,000. The design work has been completed. The process for obtaining the permits required to construct the project has started. It is anticipated that inchannel restoration could start in the summer of 2005.

3.3.4 Habitat restoration projects by others

In addition to the 10 projects identified by the TRTAC there are many other entities presently involved with restoration activities along the Tuolumne River, including the Friends of the Tuolumne (FOT), Tuolumne River Trust (TRT), National Resource Conservation Service NRCS), East Stanislaus Resource Conservation District (ESRCD), USFWS, CDFG, Stanislaus County, and the Cities of Waterford, Ceres and Modesto. These parties have also been working cooperatively as the Tuolumne River Coalition to help obtain funding for project implementation, including floodplain acquisition or easements and floodplain and riparian habitat restoration. All entities are using the Restoration Plan as a guidance document for restoration aspects of their projects.

3.3.4.1 FSA Section 19 funding for riparian habitat and recreation

The $500,000 in funding required by FSA Section 19 from CCSF was provided to the ESRCD to administer. That funding has been allocated to riparian and recreation projects near Waterford (several floodplain parcels) and on the river downstream of Modesto. At the end of 2004, about $350,000 of the $500,000 had been spent.

3.3.4.2 CDFG spawning habitat enhancement

The CDFG placed about 27,000 cubic yards of gravel into the river near La Grange from 1999–2003 to create more spawning area to help offset the losses due to the 1997 flood.

CDFG also has recently received funding to purchase 41.6 acres of floodplain between La Grange and Basso Bridge, adjoining lands owned by Stanislaus County.

3.3.4.3 Tuolumne River Regional Parkway

The City of Modesto has begun development and implementation of the Tuolumne River Regional Parkway, centered in the City of Modesto. The park will be located mostly on the north bank, from RM 12.5 to RM 19.3. This project includes revision of the Joint Powers Authority General Plan, development of the Gateway Parcel located downtown Modesto near the Ninth St. Bridge, and potentially extensive restoration of riparian zones.

3.3.4.4 Grayson River Ranch Project

The FOT, TRT, NRCS, and ESRCD have been involved in some large floodplain restoration projects west of Modesto, including the Grayson River Ranch project, which is a 140 acre floodplain parcel on the south bank of the Tuolumne River between river miles 5 and 6. In response to severe flooding in 1997 and frequent past flooding, the property owners applied for and received a “perpetual conservation easement” for their property. The NRCS administers easement agreements in cooperation with the ESRCD, linking with various local, state, federal, and non-profit partners for funding and restoration coordination (McBain and Trush 2000).

3.3.4.5 Big Bend Floodplain Restoration Project

Additionally, the TRT, in partnership with the NRCS, the California Department of Water Resources (DWR), the National Oceanic and Atmospheric Administration (NOAA), and the ESRCD have acquired approximately 250 acres of property on both sides of the Tuolumne River from river mile (RM) 5.8 to 7.4 (“Big Bend”), approximately 5.5 miles west of the city of Modesto. The following project objectives drove the design and implementation of the project:

1. Facilitate protection of a contiguous habitat corridor along the lower Tuolumne River;
2. Improve channel-floodplain connectivity to improve natural regeneration of native riparian species, allow inundation at a greater frequency, and improve spawning habitat for Sacramento splittail and rearing habitat for juvenile Chinook salmon and steelhead trout;
3. Preserve existing riparian vegetation and plant native riparian vegetation within the floodplain appropriate to each species’ life history requirements;
4. Remove invasive exotic hardwood and herbaceous vegetation; and
5. Preserve flood conveyance channel capacity and reduce risk of flood damage.

Funding covered purchase of the site as an easement, restoration design, permitting, a portion of the implementation cost, and three years of post-implementation monitoring. Project design for both grading and revegetation was completed in 2004. Current funding for implementation covers grading (minimal) on the entire site and revegetation of two of the ten fields (approximately 60 acres) on the site. Implementation began in November 2004 with notching of berms surrounding the agricultural floodplain fields; planting of woody vegetation on the north side of the river was completed in Fall 2004. Planting of woody vegetation on the south side of the river began in February 2005 and is almost complete. Herbaceous vegetation will be planted in 2006. Three years of post-implementation monitoring are also included in the project, including monitoring of (1) floodplain inundation extent and duration, (2) fish utilization of the floodplain during high flows, and (3) establishment of riparian vegetation for both horticultural revegetation and natural recruitment.

3.3.4.6 Bobcat Flat Project

Further upstream in the dredger tailings reach, CBDA has funded a proposal by FOT to acquire about 250 acres of river and floodplain habitat at Bobcat Flat (RM 42.4–44.6). A restoration plan is currently being developed (TRTAC River Mile 43 Project is within this area). The goal is to enhance natural floodplain function at the parcel, which has approximately 2 miles of river frontage (McBain and Trush 2000).

3.3.4.7 Other local conservation projects along the Tuolumne

Additional conservation easements on other floodplain parcels involving hundreds of acres have been acquired or proposed. The USFWS San Joaquin River National Wildlife Refuge, located near the confluence of the Tuolumne River with the San Joaquin River, has acquired lands, including the lower 1.3 miles along the north bank of the Tuolumne River. Riparian restoration is planned for part of several areas along the river:

- City of Ceres - 38 acres of floodplain on the south bank at RM 20
- Stanislaus County – parklands owned near La Grange and the Riverdale Park near Modesto.

3.4 Restoration Project Monitoring

Site-specific monitoring related to the implementation of the completed restoration projects offers the opportunity to address river-wide objectives at a site-specific scale. Several field investigations, modeling efforts, and other analyses have been conducted for the restoration projects to quantify or describe: (1) pre- and post-NDPP coarse sediment supply to the lower river, (2) existing channel morphology and bed texture, (3) bedload transport rates under existing and post-augmentation conditions, (4) existing fine sediment storage in the mainstem channel bed, (5) existing habitat conditions for salmonid spawning, (6) salmonid spawning distribution and habitat utilization. In addition to the 1995 FSA Section 13 requirements for river-wide monitoring, the Restoration Plan includes project-specific monitoring to address specific objectives of individual restoration projects. Project-specific monitoring plans are designed to assess:

1. whether the physical features were constructed as designed,
2. geomorphic and riparian vegetation responses to channel and floodplain reconstruction during high and low flows, and
3. changes in habitat suitability and utilization by target fish species.

Below follows a preliminary summary of pre-project monitoring assessments as well as post-project monitoring for the 7/11 Reach and SRP 9 sites, including as-built topographic and bathymetric surveys, habitat mapping, fish population monitoring, and habitat suitability modeling. A monitoring update report is in preparation.

3.4.1 Physical assessments

Following the overall guidance of the Restoration Plan, species abundance and population dynamics, community composition, and trophic structure may be directly affected by physical habitat attributes. The following physical assessments were performed as part of the restoration projects completed to date.

3.4.1.1 Geomorphic studies

Existing channel morphology was documented under the CSMP (McBain & Trush 2004b) using channel cross section surveys (n=42) and longitudinal profiles. Several indicators, based on the contemporary channel morphology, identify that the channel downstream of La Grange Dam is coarse sediment supply deficit and that this condition can reduce both the productivity and capacity of salmonid spawning habitat. First, channel cross section surveys indicate that the channel is overly wide in many reaches, lacks adequate bankfull channel confinement, and has not readjusted its cross sectional dimensions to the contemporary high flow regime. Second, field surveys conducted by McBain and Trush have identified numerous sites where lateral bars, riffles, or other sediment storage features have been reduced in volume. Third, long scour pools and in-channel mining pits known as “Special Run Pools” cumulatively comprise nearly five miles of river channel in the dominant spawning reaches upstream of Roberts Ferry Bridge. These sections of channel trap all sediment routed to them, provide little or no high quality salmonid habitat, and provide more suitable habitat for non-native piscivores that prey on juvenile salmonids. Finally, a large number of riffles throughout the gravel-bedded zone has been progressively reduced in size or completely eliminated by a single or numerous large floods. Between 1988 and 1999–2001 (following the 1997 flood), riffle area in the study reach was reduced by 16% from 1.57 million ft^2 to 1.32 million ft^2.

3.4.1.2 Coarse sediment

Coarse sediment supply

Since construction of large storage reservoirs on the Tuolumne River, the majority of sediment supply from the upper watershed has been eliminated. The primary exception to this was the January 1997 flood spill, which required the opening of the Don Pedro Dam spillway. The major release of water through the spillway eroded and moved approximately 500,000 cu yds of topsoil mixed with crushed and scoured bedrock to La Grange Reservoir and over La Grange Dam into the lower Tuolumne River (McBain and Trush 2000). Small tributaries downstream of La Grange Dam do not supply significant volumes of coarse sediment to the mainstem river.

Contemporary coarse sediment transport rates and thresholds

Tracer rock experiments and numerical modeling conducted during the CSMP (McBain & Trush 2004b) were used to estimate the flow required to mobilize the riverbed in the spawning reach. Three tracer rock monitoring sites were established in April 2001, and a fourth was added in 2002. Additional tracer rock monitoring sites were established in the 7/11 Mining Reach as part of the post-construction monitoring for the 7/11 Mining Reach restoration project. Based on these tracer rock experiments, coarse bed particles in most reaches do not appear to be significantly mobilized by flows up to 6,880 cfs. Bed mobility modeling was conducted at the Ruddy 4-Pumps Restoration site and predicted bed mobility at discharges of 9,800 cfs, 7,050 cfs, and 8,250 cfs for each of three cross sections. Bedload transport rates were measured in March 2000 at Riffle 4B at flows of 4,020 cfs, 4,960 cfs, 5,980 cfs, and 6,700 cfs. Data points from the two lower discharges (4,020 and 4,960 cfs) were nearly identical (i.e., there was no increase in transport between those two discharges). An empirically derived bedload transport rating curve was developed from these monitoring data. With the few data points available, however, this rating curve is considered preliminary.

Applying the rating curve to the regulated flow record at La Grange (USGS 11289650) for the post-New Don Pedro period (WY 1972–2001) resulted in an average annual sediment transport rate (for sediment > 8 mm) of 8,600 tons/yr (5,400 cu yds/yr), with rates as high as 200,000 tons/yr (126,000 cu yds/yr) in WY 1997. Excluding the 1997 water year, the average annual bedload transport rate (for sediment > 8 mm) was 1,930 tons/yr (1,211 cu yds/yr). During this same period, if flood release recommendations from the Habitat Restoration Plan are applied to the hydrograph, average annual bedload transport rates would have been from 1,930 to 2,240 tons/yr (1,200 to 1,400 cu yds/yr) (for sediment > 8 mm), or 15% greater than under actual conditions.

The EASI model (Enhanced Acronym Series 1 & 2 with Interface) was used to predict contemporary bedload transport rates in the primary spawning reach and to evaluate the benefits and/or potential impacts of alternative sediment augmentation approaches. The model focused on the 2,000 ft reach from Riffle 5A to Riffle 4A and included the bedload transport measurement site at Riffle 4B. The model integrated survey data from eight cross sections in this reach and the bedload transport data collected at Riffle 4B. The model predicted that long-term average bedload sediment transport rates (for sediment >8 mm) in the modeling reach is 1,670 ton/yr. This estimate is similar to the estimate derived from bedload measurements at R4B (1,930 tons/yr) based on the post-NDPP flow records. Part of the strategy for coarse sediment management is to progressively reduce the overall particle size distribution so that bed sediments are mobilized more frequently by the contemporary regulated flow regime. The EASI model was used to evaluate the effect of varying the surface grain size on particle size distribution by using the finest and coarsest of available pebble counts as model input, which resulted in a predicted long-term coarse sediment transport rate of 4,010 tons/year for the finest bed texture and 490 tons/year for the coarsest bed texture.

3.4.1.3 Fine sediment studies

Fine sediment sources

High fine sediment loading occurred in the lower Tuolumne River in January 1997 when several hundred thousand cubic meters of sediment were eroded from the New Don Pedro Dam spillway and supplied to La Grange Reservoir and the lower Tuolumne River. While the coarse sediment from the event deposited in La Grange Reservoir, much of the sand passed over La Grange Dam and was deposited in the Tuolumne River (McBain and Trush 2004b). This event dramatically increased the volume of sand stored in the lower Tuolumne River, particularly on floodplains. To develop restoration strategies for the Tuolumne River, McBain and Trush (2000) conducted field reconnaissance of fine sediment sources between La Grange Dam (RM 52) and Waterford (RM 31.5). Gasburg Creek was identified as one of three potential significant fine sediment sources in the study reach. From 1993 aerial photographs, McBain and Trush identified a delta at the confluence of Gasburg Creek with the mainstem Tuolumne River that they estimated to contain 291 m^3 of sediment. Sheet runoff from a sand extraction mine just north of the Old La Grange Bridge was a significant source of sand from Gasburg Creek. The contribution from the sand mine appears to have been reduced since its peak production, but some sediment from fill associated with the sand mine is still being supplied to Gasburg Creek.

Lower Dominici Creek (RM 47.8) was assessed as having “moderate” input potential, while the two other tributaries, Gasburg Creek (RM 50.3) and Peaslee Creek (RM 45.2) were assessed as having “large” input potential. These assessments were made in part by volume estimates of the sand in deltas observed at each of the tributaries believed to have been deposited on the receding limb of a major flood event in January 1997. As part of the Fine Sediment Management program, bedload sampling was conducted on lower Dominici Creek during storm events occurring in 2002–2003.

Spawning reach fine sediment storage inventory

In June 2001, Stillwater Sciences conducted a reconnaissance-level snorkel survey of fine sediment deposits (sand and silt) in the lower Tuolumne River from the USGS gauging station below La Grange Dam (RM 52.0) to Robert’s Ferry Bridge (RM 39.6) (Stillwater Sciences 2002 In McBain and Trush 2004b, Appendix E). This study estimated fine sediment storage in pools and lateral channel deposits (including sediment deposited in mining pits) and estimated the relative contribution of in-channel fine sediment sources relative to tributaries. Aerial photos were used in the field to delineate planform boundaries of sand deposits in pools, gravel and sand bars, and on floodplain surfaces. An approximate depth of sand was then assigned to each deposit to estimate the volume.

In general, the survey noted that all streambed surface and subsurface substrates contained a large volume of sand stored in the channel. Only limited sand deposits were observed in pools in the reach upstream of Basso Bridge (RM 47.5), and moderate amounts of sand storage were observed from Basso Bridge to Peasley Creek (RM 45.3). The highest volumes of sand were observed in the Dredger Reach from Peasley Creek to Roberts Ferry Bridge (RM 39.5). The survey estimated approximately 102,000 cu yds of sand within the bankfull channel in the reach upstream of Roberts Ferry Bridge, with about 77% of this material deposited in pools within the low flow channel. Gasburg Creek and Peasley Creek appeared to be the largest contributors of fine sediment in the survey reach.

Gasburg Creek sediment source analysis
In 2003, a sediment source analysis for Gasburg Creek was conducted to provide recommendations for sizing a sedimentation basin to be constructed near the confluence with the lower Tuolumne River. With a basin area of some 2.4 square miles, Gasburg Creek enters the Tuolumne River floodplain through a culvert under the MID Main Canal. Based on this sediment source analysis, it was estimated that about 920 m^3/yr of fine sediment is annually supplied to the Tuolumne River from Gasburg Creek. Surveys by Stillwater Sciences in June 2001 estimated that at least 7,100 m^3 of fine sediment are stored in pools and overbank deposits in the lower Tuolumne River between Gasburg and Lower Dominici creeks over a distance of 4 km. In the same survey, we found that at least 65,000 m^3 of fine sediment are stored between La Grange Dam and Robert's Ferry Bridge, a distance of 19.3 km. It should be noted that the stored fine sediment volume does not account for fine sediment stored in the channel bed. Using initial calculations, the volume of sand stored in the bed between Gasburg and Lower Dominici creeks ranges from 8,000–24,000 m^3, or 1.1–3 times the amount of sediment stored in pools and overbank deposits.

Impacts on Downstream Restoration Projects
Although Gasburg Creek represents a relatively small portion of the total stored fine sediment in the lower Tuolumne River, the creek's fine sediment discharge may have significant adverse impacts to the primary spawning reach in the lower Tuolumne River, located immediately downstream of their confluence. Any habitat enhancement projects that reduce the amount of sand in the bed of the Tuolumne River (e.g., gravel cleansing or gravel augmentation) could be adversely affected by continued fine sediment input from Gasburg Creek.

Effectiveness of gravel cleaning studies on the lower Tuolumne River, 1992-1993
The Districts previously tested several methods for gravel cleaning including (a) a bulldozer with its blade angled to plow furrows through the riffle bed, (b) an excavator that lifted up buckets full of gravel and sifted them back into place allowing fines to be winnowed out and transported away as the gravels fell through the water column, and (c) hydraulic back flushing using a small pump and single nozzle. A small suction pump and nozzle were also tested in conjunction with the back flushing. Gravel samples taken before and after the tests indicated that the back flushing method offered the most uniform cleaning of fines from the gravels. Results of further studies with a gravel cleaning device conducted in 1992–1993 were not available for inclusion in the prior 1991–1993 gravel cleaning report (TID/MID 1996). A complete write-up is provided as a technical appendix to the Coarse Sediment Management Plan (McBain & Trush 2004b).

Results and Discussion

Several indices were used to evaluate the effect of the cleaning method. Tappel and Bjornn (1983) suggested that ideal quality spawning gravel size composition for Chinook salmon and *O. mykiss* is adequately characterized by the percentage by weight of 0.85 mm diameter substrate, in combination with the percentage by weight of 9.5 mm diameter substrate. In addition to the Tappel and Bjornn index, other gravel quality indices used were Fraction Fines, Geometric Mean Diameter, and Fredle Index. The values of the gravel quality indices were calculated using the combined (surface and sub-surface) samples to account for mixing of the surface and subsurface layer during cleaning. For the cleaning test samples, with the exception of the Tappel-Bjornn Index, all gravel quality indices improved as a result of cleaning.

Although the prior Tuolumne River studies indicated that survival-to-emergence was low, the 1993 gravel-cleaning results showed much higher Tappel & Bjornn indices in both treatment and control gravels. Some of the results were low, but the mean survival-to-emergence for treatment and controls was near 90%. Recent permeability studies in the spawning reach predicted survival-to emergence ranged from 34 percent (95% Confidence Interval (CI): 31−37 percent) at Riffle 7 to 51 percent (95% CI: 35−67 percent) at Riffle 2 (TID/MID 2000). This discrepancy may either be due to differing methodologies in that the recent studies developed Tappel & Bjornn indices from permeability measurements. These differences may also be due to the 1993 test within riffles area with particularly clean substrate, followed by large volumes of fine sediment deposited in from the 1997 flood, and possibly some sampling artifact that under-represented the fines present in the bulk samples. In any case, the analysis of the 1993 gravel cleaning data do show a significant difference between pre- and post-cleaning and controls. Recommendations for up-coming gravel cleaning projects will consider various cleaning methods.

3.4.1.4 Habitat mapping

Reach-wide spawning habitat availability

Within the approximately 23-mile-long gravel-bedded reach, Chinook salmon spawning habitat was assessed in 1988 (TID/MID 1992) and 1999–2001. The 1988 assessment, which estimated spawning habitat area by digitizing riffle area from aerial photos taken during flows of 100 cfs and 230 cfs, assumed that the entire riffle area provided suitable spawning habitat. Between September 1999 and February 2001, spawning habitat in the 16-mile reach from La Grange Dam (RM 52.0) to the Santa Fe Aggregates haul road bridge (RM 36.3) was resurveyed to document changes in riffle area since 1988 (including the effects of the 1997 flood) and to provide a more detailed assessment of spawning habitat extent that reflects the effects of substrate texture and local hydraulics during spawning flows. Table 3.4.1.4-1 shows riffle areas developed from these surveys as well as 1988 estimates for comparison.

Table 3.4.1.4-1. Estimates of riffle areas for different reaches for surveys conducted in 1988 and surveys conducted in 1999–2001.

Named Riffle	Estimated riffle area in 1988 (ft²) at 100 cfs	Estimated riffle area in 1988 (ft²) at 230 cfs	Estimated riffle area in 2000 (ft²) at 250-350 cfs	Change in riffle area between 1988 and 2000 (ft²)
Section "A"				
RA1/A2	10,568	10,568	3,989	-6,579
RA3(A,B), RA4	22,233	22,475	11,762	-10,713
RA5A	14,863	16,277	0	-16,277
RA5B	8,336	8,336	0	-8,336
RA6	6,232	10,147	0	-10,147
Total:	**62,232**	**67,803**	**15,751**	**-52,052**
Section "1A"				
RA7A	7,596	7,596	33,099	25,503
R1A	92,257	92,257	23,559	-68,698
R1B	27,269	27,269	19,735	-7,534
R2	78,890	86,867	103,766	16,899
R3A	27,366	38,268	15,622	-22,646
R3B	44,135	44,135	77,606	33,471
R4A	125,523	125,523	94,827	-30,696
R4B	165,439	178,077	171,421	-6,656
R5A	41,256	64,395	31,773	-32,622
R5B	7,887	9,167	19,407	10,240
Total:	**617,618**	**673,554**	**590,815**	**-82,739**
Section "1B"				
R6	24,458	26,050	0	-26,050
R7	57,853	67,747	76,643	8,896
R8	22,023	22,023	8,536	-13,487
R9	34,862	34,862	0	-34,862
R10	4,510	7,458	0	-7,458
R11	13,627	23,206	0	-23,206
R12	5,959	5,959	52,321	46,362
R13A	9,579	10,551	10,116	-435
R13B	10,151	10,151	6,494	-3,657
R13C	8,514	12,283	6,335	-5,948
R14	9,478	9,478	7,847	-1,631
R15/16	24,792	26,598	24,167	-2,431
R17A	4,431	4,431	14,099	9,668
R17B	11,272	11,272	0	-11,272
R17C	18,315	18,315	0	-18,315
R17D	2,071	2,072	0	-2,072
R18	17,421	17,421	12,129	-5,292
R19	9,736	9,736	0	-9,736
R20	19,203	19,203	26,321	7,118
R21	5,974	5,974	18,900	12,926
R22	4,037	4,037	17,978	13,941

Named Riffle	Estimated riffle area in 1988 (ft²) at 100 cfs	Estimated riffle area in 1988 (ft²) at 230 cfs	Estimated riffle area in 2000 (ft²) at 250-350 cfs	Change in riffle area between 1988 and 2000 (ft²)
R23A	6,933	6,933	12,110	5,177
R23B	9,091	9,091	4,693	-4,398
R23C	11,786	14,088	18,062	3,974
R23D	20,901	22,698	36,229	13,531
R24	18,175	18,175	20,935	2,760
Total:	**385,152**	**419,812**	**373,915**	**-45,897**
Section "2"				
R25	16,296	18,785	19,104	319
R26A	14,432	21,214	26,726	5,512
R27	4,003	4,003	6,747	2,744
R28A	29,887	29,887	15,126	-14,761
R28B	10,381	10,381	11,795	1,414
R29	30,036	43,994	9,421	-34,573
R30A	11,268	11,268	8,772	-2,496
R30B	13,496	13,496	8,311	-5,185
R30C	21,326	21,326	0	-21,326
R31	24,284	25,033	32,902	7,869
R32	3,628	3,628	6,605	2,977
R33A	28,335	29,472	13,934	-15,538
R34	15,208	16,677	8,704	-7,973
R34A	5,337	8,005	0	-8,005
R35A/B	61,217	66,792	94,316	27,524
R36A	34,954	34,954	44,690	9,736
R36B	53,974	53,974	17,312	-36,662
R37	25,207	25,207		
R38	23,981	26,316		
R39	10,522	12,972		
R40	22,801	22,801		
R41	48,996	62,483		
R41A	3,739	3,739		
R42	55,941	55,941		
R43	7,758	7,758		
R44	27,866	32,321		
R45	13,322	13,322		
R46	10,769	23,414		
Total:	**628,964**	**699,163**		
Section "3"				
R47	19,620	20,095		
R48A	6,968	6,968		
R48B	16,255	22,020		
R49	16,672	16,672		
R50	16,097	20,118		
R51	17,370	31,594		
R52AB	33,033	53,659		

Named Riffle	Estimated riffle area in 1988 (ft²) at 100 cfs	Estimated riffle area in 1988 (ft²) at 230 cfs	Estimated riffle area in 2000 (ft²) at 250-350 cfs	Change in riffle area between 1988 and 2000 (ft²)
R53	4,523	13,488		
R54	14,611	14,611		
R55	9,917	23,392		
R56	37,335	84,769		
R57	28,709	30,427		
R58	16,784	22,193		
R59	5,201	5,201		
R60	29,028	29,661		
R60A	9,990	16,929		
R61	37,389	37,389		
R62	41,530	41,808		
R63	41,179	41,179		
R64	46,584	62,384		
R65	65,020	95,072		
R66	28,179	40,814		
R67	-	-		
R68	88,000	90,824		
Total:	**629,994**	**821,267**		
Section "4"				
R69	51,198	51,198		
R70	12,862	12,862		
R71	22,457	22,457		
R72	60,905	60,905		
R73	18,503	18,503		
R74	14,567	14,567		
R75	9,265	9,265		
R76	13,053	13,053		
R77	16,493	16,493		
R78	16,307	16,307		
Total:	**235,609**	**235,609**		

Although it appears that the 1997 flood scoured away several riffles in the primary spawning reach below La Grange Dam, the post-flood habitat maps differ little from the pre-flood habitat maps, with only minor changes in riffle area and locations, and somewhat more significant changes in riffle shapes. Some riffles were also affected prior to the 1997 flood. The greatest changes occurred between Old La Grange Bridge and Basso Bridge. In the lower reach, from New Basso Bridge to Roberts Ferry Bridge, most of the riffle locations and sizes have remained unchanged since 1997, except for the few that have been broken down to a series of short pool-riffle short or have actually increased in length. A number of submerged riffles, generally less than one channel width long, but at least 1-meter below the water surface, were identified in the middle of long, deep pool runs. Lastly, because the actual area of suitable habitat is influenced by substrate texture, site-specific hydraulic characteristics, and other factors, this estimate likely over-represents available Chinook salmon spawning habitat (Report 90, TID/MID 1992, Appendix 6).

Chinook salmon spawning habitat increases due to recently implemented restoration projects

Coarse Sediment Management Phases I and II (CDFG/DWR gravel addition)
Significant potential spawning habitat increases resulted from gravel additions by CDFG carried out between riffles A7, above Old La Grange Bridge, downstream to riffle 1B. The CDFG placed about 27,000 cubic yards of gravel, which corresponded to approximately 178,000 ft^2 of additional riffle spawning habitat (Table 3.4.1.4-2).

Table 3.4.1.4-2. Estimated riffle area increases (ft^2) by reach in the lower Tuolumne River from constructed or planned restoration Projects

Actual or Planned Completion:		2002	2003	2006	TBD	TBD	TBD	TBD
River Mile	Reach	CSMP Phase 1 (CDFG 2002), Mining Reach Phase 1 (7/11 2002)	CSMP Phase 2 (CDFG 2003)	Mining Reach Phases 2 & 3 (Ruddy, Deardorff Project)	CSMP Phase 3	CSMP Phase 4	CSMP Phase 5	CSMP Phase 6
51.3	A	120,436	57,252		195,394	-	-	-
49.2	1A				250,353	237,478	249,822	57,871
44.6	1B				864,004	517,547	611,478	213,580
38.1	2	25,899		135,000	-	417,600	-	2,316
30.7	3				-	-	-	-
23.5	4				-	-	-	-

Table 3.4.1.4-2 also shows the 7/11 project (Gravel Mining Reach Phase I) was successful in increasing Chinook salmon spawning habitat area in Reach 2. In 1999, spawning habitat area (mapped at a flow of 254-265 cfs) was 12,814 ft^2 for the whole project reach and 5,318 ft^2 for

the channel reconstruction reach. Subsequent post-project habitat mapping (conducted at a flow of 185 cfs) identified a 6,142-ft^2 (82%) increase in Chinook salmon spawning habitat compared to 1999 conditions. Increased spawning habitat in the downstream reach could be due to increased channel confinement or the difference in flows during which habitat was mapped for pre- and post-project conditions. The effects of the difference in flow on spawning habitat in the reconstructed reach cannot be determined, but based on comparison to the downstream reach these effects are outweighed by the effects of riffle construction and modification.

Assuming a defended redd size of 200 ft^2/redd for Chinook salmon, pre-project spawning habitat area could support 64 redds in the project reach (Roberts Ferry Bridge to the 7/11 haul road bridge) and 27 redds in the channel reconstruction reach (Roberts Ferry Bridge to Riffle 30B). Post-project Chinook salmon spawning habitat area could support 174 redds in the project reach and 106 redds in the channel reconstruction reach. Currently available spawning data are not sufficient to assess project effects on Chinook salmon spawning use at the project riffles.

Chinook salmon juvenile rearing habitat increases due to recently implemented restoration projects

Chinook salmon Rearing Habitat in the Gravel Mining Reach Phase I - 7/11 Project

Project effects on Chinook salmon rearing habitat for the 7/11 Project were assessed using pre- and post-project habitat mapping. Rearing habitat was mapped based on flow depth, flow velocity, and cover. Mapping identified areas within the wetted channel as suitable or not suitable and did not attempt to describe or quantify habitat quality. Pre-project Chinook salmon rearing habitat was mapped during flows of about 260 cfs at La Grange in 1999. Post-project habitat was mapped at flows of 185 cfs in 2002.

The primary goals of the project included converting long dredger pools and mined out channel reaches to a geomorphically functional alternate bar (i.e., pool-riffle) channel morphology and reducing confinement of the high flow channel by setting back mining berms and constructing functional floodplains. Since the project increased low-flow channel confinement (to improve geomorphic processes that will create and sustain spawning and rearing habitats in the long-term), it reduced the area of the wetted channel during low flows. The pre- and post-project habitat mapping thus indicate a reduction in fry and juvenile rearing habitat area during the low flows of 150,700 ft^2 (64%) for fry and 494,500 ft^2 (47%) for juveniles because the area of the wetted channel was reduced. For both pre- and post-project conditions, however, fry habitat extends along the channel margins from the upstream to the downstream ends of the project, and juvenile habitat is almost ubiquitous throughout the low flow channel for the flows during which mapping was conducted.

The habitat mapping methods used did not attempt to assess changes in habitat quality. While the project reduced suitable fry and juvenile rearing area during low flows, it likely increased rearing habitat quality by increasing food production area (i.e., riffles) and increasing the area of pool heads suitable for drift foraging. Moreover, the project is expected to greatly increase fry and juvenile rearing habitat area and quality during high flows. Prior to project construction, mine dikes confined the high flow channel, so that as flows increased available low velocity rearing areas were extremely limited. By setting back the dikes, constructing gently sloping gravel bars, and constructing floodplains that are inundated at flows exceeding 5,000 cfs, the project is expected to increase high flow rearing habitat by approximately 1.4 million ft^2. Because high flows did not occur during the monitoring period, habitat mapping was not conducted during high flow conditions. Pre- and post-project juvenile habitat during high flow conditions, therefore, cannot be quantified based on available data. Habitat modeling, which can provide quantitative predictions of habitat area for a range of flows, could be used to fill this data gap.

Chinook salmon Rearing Habitat in the SRP 9 Project
A two dimensional hydraulic model (River 2D) was also used to compare Chinook salmon fry and juvenile habitat for pre- and post-project conditions over a range of flows. The restoration project increased Chinook salmon fry and juvenile habitat for all flows modeled, except fry habitat at 75 cfs. The increase in fry habitat was small for flows less than <1,000 cfs, but was 33,000 ft^2 to 124,000 ft^2 (185% to 636%) for flows from 1,000 to 3,000 cfs. The project also substantially increased juvenile Chinook salmon habitat, with increases for flows < 1,000 cfs ranging from 18,600 ft^2 to 27,300 ft^2 (46% to 121%) and for flows > 1,000 cfs ranging from 124,300 ft^2 to 164,000 ft^2 (280% to 385%).

The greatest benefits of the project for rearing salmon occur during flows > 1,500 cfs, when rearing habitat becomes available on the floodplains and in the high flow channels. During the period for which the 1995 FSA flow schedule has been in place during the Chinook salmon rearing period (1997–2004), flows sufficient to inundate the SRP 9 constructed floodplain and provide rearing habitat occurred in all years from 1997 through 2000 but were rare during the drier period from 2001 through 2004. From 1997 through 2000, flows were sufficient to inundate the floodplain and provide high quality rearing habitat an average of 166 days annually during the fry and juvenile rearing period (January 1 through June 15). During the drier years of 2001 through 2004, rearing season flows were sufficient to inundate the floodplain for only a few days each year, except in 2002 when flows never exceeded 1,500 cfs. These results suggest that the site could provide valuable fry and juvenile rearing during wetter years.

3.4.2 Biological assessments

3.4.2.1 Spawning utilization

The 7/11 project reach (including the Stanislaus County project of building a new Roberts Ferry Bridge) altered Riffles 29 and 30B and added Riffles 28C, 29B, and 30A), and monitoring demonstrated that the project was successful in increasing Chinook salmon spawning. Pre- and post-project redd counts for the modified riffles as well as unmodified riffles in the project reach (Riffles 31, 32 and 33) and nearby control riffles are shown in Table 3.4.2.1-1.

Table 3.4.2.1-1. Maximum weekly redd counts at project and control riffles within 7/11 Project Reach.

Riffle No.[1]	Max. Redd Count							Mean	
	1997	1998	1999	2000	2001	2002	2003	A 1997–2001	B 2002–2003
25 [K2]	13	15	6	27	21	13	11	16	12
26 [L1]	11	12	6	30	19	9	6	16	8
27 [L2]	9	9	2	28	20	12	6	14	9
28A,B [L3]	0	4	1	20	7	0	4	6	2
28C[2] [M1]						1	1	0	1
29[2] [M2]	6	7	3	11	14	4	2	8	3
29B[2] [N1]							3	0	3
30A, B[2] [N/A, N2]	6	5	0	5	0	10	5	3	8
31, 31A, 31B [N/A, N3, N4]]	11	10	9	19	47	17	7	19	12
32 [O1]	6	2	1	7	10	0	5	5	2.5
33 [O2]	12	5	2	16	24	2	6	12	4
Project:Control Ratio[3]	0.36	0.30	0.20	0.15	0.21	0.44	0.41	0.22	0.48

Notes: 1. Riffle numbers use the "traditional" numbering system used on the Tuolumne River. Revised riffle numbers used by CDFG in 2002 are shown in [brackets].
2. Riffle modified by the project.
3. Ratio of the annual maximum redd count at reconstructed riffles (Riffles 28C, 29, 29B, and 30) to upstream control riffles (Riffles 25, 26, 27, 28A, and 28B.)

Comparing pre-project to post-project spawning use at project and control riffles, the project appears to have nearly doubled Chinook salmon spawning use in the channel reconstruction reach (Table 3.4.2.1-1). In pre-project years, the ratio of the number of redds (using the annual maximum redd count) at reconstructed riffles to upstream control riffles averaged 0.24. After riffle reconstruction, this ratio increased to 0.48 for the two years of data available. These, results, however, should be interpreted with caution. The redd counts used in the analysis are from drift boat counts conducted by various CDFG staff over several years. While these redd counts provide important reach-scale data for assessing spawning distribution, differences in riffle naming systems and inaccuracy of the rapid counts make these data less usable at the individual riffle-scale.

A more complete before-after-control-impact (BACI) analysis of these data may better identify the effects the project of Chinook salmon spawning use in the reach. This analysis would need to include a detailed review of the data and riffle names used during each survey and should consider total escapement, river-wide spawning distribution, and redd density at project and control riffles. The analysis would also need to consider the variable accuracy of the counts between years. Recent calibration counts that compare detailed redd counts to the drift boat counts indicate that the boat counts can severely underestimate the number of redds present at a riffle and that underestimation is highly variable depending on redd density (Report 2004-1, TID/MID 2005). At low spawning densities, as occurred in the project reach, CDFG considers the drift counts to be fairly accurate (Report 2004-1, TID/MID 2005)

3.4.2.2 Largemouth and Smallmouth Bass Abundance and Distributions

Monitoring of largemouth and smallmouth bass abundance at the SRP 9/10 project and control sites from 1998 through 2003 documented a pattern of population depletion following the 1997 flood and subsequent recovery during recent low water years. This finding is consistent with reproductive requirements for these species and river flows and temperatures from 1999 through 2003. Since 1999, low spring and summer flows in the river have provided suitable spawning temperatures and flow velocities for these species. Both species have increased in abundance throughout the reach, though largemouth bass are more abundant than smallmouth bass. At least five cohorts for each species were present in the reach.

The project at SRP 9 was not successful in reducing largemouth bass linear density during the low flow years that have occurred since project construction. Comparing bass distribution between project and control sites, piscivore-sized largemouth bass densities were highest at SRPs 8 and 10, intermediate at SRPs 7 and 9, and lowest at Riffle 64 and Charles Road. This pattern did not change between pre- and post-project monitoring. Project effects on smallmouth bass are less clear. Monitoring did not identify any statistically significant trends in smallmouth bass linear density between the project and control sites. Despite these results, the project appears to have increased smallmouth bass abundance at the site relative to pre-project conditions and other SRP sites. The most important factor limiting the success of the SRP 9 project in reducing bass habitat and abundance seems to be channel slope. Channel gradient at the Riffle 64 and Charles Road control sites is an order of magnitude steeper than at SRP 9 and the low-flow channel is 24% narrower. The steeper slope combined with narrower channel width at the channel control sites increases flow velocity relative to conditions at SRP 9. The results of the habitat model indicate that velocity is a key variable limiting bass habitat at the channel sites.

Despite the continued high abundance of smallmouth and largemouth bass at the SRP 9, habitat suitability modeling conducted at SRP 9 for pre- and post-project conditions (using the the River 2D model) indicates that the project increases habitat segregation between bass and juvenile Chinook salmon and may provide a "safe-velocity corridor" for outmigrant salmon during relatively low flow conditions. By creating a smaller channel cross section, the SRP 9 project increased flow velocity through the site relative to pre-project conditions. Within this safe velocity corridor, higher flow velocities exclude largemouth and smallmouth bass from the center of the channel and segregate outmigrant salmon from these non-native predators, thus potentially reducing bass predation efficiency. Based on the River 2D model for SRP 9, this safe velocity corridor is expected to occur at flows of 300 cfs and higher for post-project conditions, compared to 2,000 cfs and higher for pre-project conditions. This hypotheses is based on model results and has not been tested in the field.

3.4.2.3 Riparian habitat

Special Run Pools 9 and 10 Projects

The monitoring plan for the SRPs 9 and 10 projects was developed to test the following specific hypotheses related to riparian vegetation:

- Planted riparian vegetation becomes established on the constructed floodplain.
- Natural recruitment of native riparian plant species occurs on the constructed floodplain.
- Riparian vegetation does not encroach into the constructed channel.

The monitoring plan for the SRP 9/10 project includes plot-based surveys of species composition, survival and growth in the active channel, floodplain, and terrace. The monitoring schedule includes surveys in Years 0, 2, 3, and 5 or following a high flow event exceeding 5,000 cfs. The SRP 10 site is still in the design phase.

Very little monitoring of riparian vegetation has occurred at SRP 9 to date (McBain and Trush and Stillwater Sciences 2004). At this site, planting was conducted from November 1 through December 31, 2001; irrigation and plant maintenance continued through September 2003. HDR Engineering has developed as-built maps showing the locations and species of planted vegetation. Post-project monitoring of planted vegetation has been limited to quantifying survival of planted vegetation and replacing plants as stipulated in the construction contract. Percent cover and growth of planted vegetation has not been monitored. Recruitment of native vegetation on constructed surfaces (H8) and encroachment of riparian vegetation into the active channel (H9) also have not been assessed.

In 2002, HDR Engineering conducted a brief survey of tree survival at the site. Survival of planted trees one year after planting was fairly high, exceeding 70% for most species (Table 29). Survival was higher on the north bank than the south bank due to human disturbance on the south bank. (The south bank is accessible via a trail from Fox Grove County Park.) Beaver damage to several trees was also noted. Survival has not been assessed since irrigation was ended. Post-irrigation success of the riparian plantings, therefore, can not be determined.

Table 3.4.2.3-1. Vegetation survival at SRP 9 in 2002.

Species	South Bank Floodplain			North Bank Floodplain		
	No. Planted (2001)	No. Live (2002)	% Survival	No. Planted (2001)	No. Live (2002)	% Survival
White alder *(Alnus rhombifolia)*	9	6	66	9	5	55.6
Oregon ash *(Fraxinus latifolia)*	78	70	89.7	51	49	96
Black willow *(Salix goodingii)*	49	31	63.3	55	42	76.4
Box Elder *(Acer negundo)*	86	73	84.9	59	44	74.6
Cottonwood *(Populus fremontii)*	106	98	92.5	126	123	97.6
Red Willow *(Salix laevigata)*	33	20	60.6	15	12	80
Valley Oak *(Quercus lobata)*	175	146	83.4	35	34	97.1
Yellow Willow *(Salix lutea)*	22	10	45.5	10	7	70

Source: HDR Engineering, unpublished data, as reported in McBain &Trush and Stillwater Sciences 2004.

Gravel Mining Reach Phase I (7/11 Project)
The monitoring plan for the 7/11 project was developed to test the following specific hypotheses related to riparian vegetation:

- Planted riparian vegetation becomes established on the constructed floodplain.
- Natural recruitment of native riparian plant species occurs on the constructed floodplain.
- Riparian vegetation does not encroach into the constructed channel.

The monitoring plan includes plot-based surveys of vegetation species composition, survival and growth in the active channel, floodplain, and terrace. The monitoring schedule includes surveys in Years 0, 2, 3, and 5 or following a high flow event exceeding 5,000 cfs. Very little monitoring of riparian vegetation has occurred at the 7/11 Reach to date (McBain and Trush and Stillwater Sciences 2004). At this site, planting was conducted from February through April 2003, with additional follow-up planting in January 2004. Irrigation and plant maintenance ended in September 30, 2004. HDR Engineering has developed as-built maps showing the locations and species of planted vegetation. Post-project monitoring of planted vegetation has been limited to quantifying survival of planted vegetation and replacement of plants as stipulated in the construction contract. Percent cover and growth of planted vegetation has not been monitored. Recruitment of native vegetation on constructed surfaces (H8) and encroachment of riparian vegetation into the active channel (H9) have not been assessed.

The portion of the 7/11 floodplain that was lowered to be inundated at 4,500 cfs could provide a good opportunity to observe floodplain evolution (deposition, inundation frequency and duration, and riparian revegetation response) to compare evolution between the reaches. No monitoring is currently funded to test the effects of this change in floodplain design on riparian vegetation recruitment and establishment.

3.5 Riverwide Monitoring

The 1995 FSA called for river-wide monitoring (FSA Section 13), including documenting changes in large-scale geomorphic processes, biological characteristics, and trends, providing information to evaluate the effectiveness of flow and non-flow measures and to implement the adaptive management strategy set forth in the 1995 FSA. Most monitoring under Section 13 focused on assessing salmon population dynamics, habitat utilization, and the success of the restoration program in maintaining the population at acceptable levels and increasing the population's resiliency on a river-wide basis.

The first part of FSA Section 13 concerned completion of certain elements of the 1986 Study Agreement. All of these items (fluctuation study, and 1995 juvenile salmon study, temperature monitoring, and smolt survival index study) were completed and reported in the Districts' 1996 report to FERC.

Section 13 also specified that up to $1.355 million would be spent over 10 years to conduct cooperative monitoring and studies on: salmon spawning escapement, quality and condition of spawning habitat, relative fry density/female spawners, fry distribution and survival, juvenile distribution and temperature relationship, smolt survival indices, and smolt production, each with initial frequency and costs identified in FSA Appendix A. The TRTAC was specifically authorized to modify the monitoring program, as long the total funding limit was not exceeded. There were several adjustments made during the 1996–2004 implementation of the monitoring program and these are described in the following sections. Table 3.5-1 depicts how the monitoring elements that were conducted compare to those initially identified in the 1995 FSA. The specified total funding amount was reached in 2004; however the Licensees are presently reviewing the Section 13 expenditures.

In addition to monitoring funded by the Section 13 program, the Districts have conducted other monitoring regarding aquatic invertebrates, and expanded monitoring specifically for rainbow trout. Table 3.5-2 lists the primary field activities done in each calendar year from 1996–2004; more information specific to rainbow trout is in Section 3.5.3.1.

Table 3.5-1. Comparative table of TRTAC implementation of FSA Monitoring Activities.

TRTAC IMPLEMENTATION		**FSA APPENDIX "A"**	
TRTAC CATEGORY	**YEARS (9 from 1996–2004)**	**INITIAL FSA APPENDIX "A" CATEGORY**	**YEARS**
Spawning survey	9	A. Spawning survey	10
Supplemental redd counts	2		
Spawning gravel and incubation studies	3	B. Spawning habitat quality	4
(addl. work done under project monitoring)		(La Grange to Waterford)	
Seine (mid JAN-mid MAR)	9	C. Relative fry density/female spawners	4
Upper screw traps	3	(seining 15JAN-15MAR)	
Seine (mid JAN-mid MAR)	9	D. Fry distrib. & survival (fluctuation)	4
Upper screw traps	3	(screw traps 15JAN-15MAR; mark/recapture)	
Stranding survey	5		
Thermographs	9	E. Juvenile distribution & temp.	10
Seine (mid MAR-MAY)	9	(seining 15MAR-15JUN; thermographs)	
Snorkel (summer)	8		
Upper screw trap	3		
Large paired CWT releases	7	F. Smolt survival	10
Mark/recapture & upper screw traps	3	(Large CWT, screw trap or trawl;	
Mossdale trawl	7	mark/recapture)	
Lower screw traps	7		
Lower screw traps	9	G. Smolt production	10
(data on fry and juvenile production in some years)		(screw trap)	(subject to other funding)
Items in underline overlap into other original FSA categories; water temperature relates to all life stages			

Table 3.5-2. Monitoring activities by year and month.

Year	**1996**												**1997**												**1998**											
Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Water temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Water quality survey																																				
Gravel quality study																																			X	
Spawning surveys										X	X	X										X	X	X										X	X	X
Seining surveys	X	X	X	X	X	X							X	X	X	X	X								X	X	X	X	X							
Snorkel surveys							X											X												X						
Rotary Screw Trap -- Upper																										X	X	X	X							
Rotary Screw Trap -- Lower				X	X											X	X									X	X	X	X	X						
Smolt survival CWT releases				X												X												X								
Stranding assessment		X											X				X																			
Invertebrate surveys								X											X																	

Year	**1999**												**2000**												**2001**											
Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Water temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Water quality survey																																				
Gravel quality study							X	X			X																									
Spawning surveys										X	X	X										X	X	X	X									X	X	X
Seining surveys	X	X	X	X	X								X	X	X	X	X								X	X	X	X	X							
Snorkel surveys						X												X												X			X			
Rotary Screw Trap -- Upper	X	X	X	X	X								X	X		X	X																			
Rotary Screw Trap -- Lower	*X*	*X*	*X*	*X*	*X*	*X*							X	X	X	X	X	X							X	X	X	X	X							
Smolt survival CWT releases				*X*												X												X								
Stranding assessment					*X*										X																					
Invertebrate surveys								X											X													X				

Year	**2002**												**2003**												**2004**											
Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Water temperature	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Water quality survey																														X						
Gravel quality study				X																																
Spawning surveys	X									X	X	X										X	X	X	X	X	X	X						X	X	X
Seining surveys	X	X	X	X	X								X	X	X	X	X								X	X	X	X	X							
Snorkel surveys						X			X									X			X									X		X	X			
Rotary Screw Trap -- Upper																																				
Rotary Screw Trap -- Lower	X	X	X	X	X	X										X	X	X										X	X	X						
Smolt survival CWT releases				X																																
Stranding assessment					X	X																														
Invertebrate surveys							X												X												X					

3.5.1 Physical conditions

3.5.1.1 Quality and condition of spawning habitat

Low survival-to-emergence has been considered a limiting factor for Chinook salmon recruitment in the Tuolumne River. Previous studies of lower Tuolumne River salmon habitat (TID/MID 1992, Appendix 1) have attributed low salmonid survival-to-emergence to poor spawning gravel quality, which has resulted from deposition of fine sediment.

Fine sediment in spawning gravel can regulate survival-to-emergence in two important ways. First, fine sediment can clog gravel interstices, impeding emergence and effectively entombing alevin within the gravel (Philips et al. 1975, Hausle and Coble 1976). Second, increased proportions of fine sediment reduce substrate permeability (Cooper 1965, Lotspeich and Everest 1981, McNeil 1964, Platts et al. 1979), impeding intra-gravel flow and thus hindering oxygen delivery and waste removal, which are crucial for survival of eggs and alevins (Coble 1961, Silver et al. 1963, McNeil 1964, Wickett 1958). Intra-gravel flow depends not only on permeability, but also on hydraulic conditions within the redd; low permeability and slow apparent velocity in a redd are both known to contribute to reduced embryo survival for Chinook salmon (Gangmark and Bakkala 1960). Preliminary data from recent work on the Tuolumne River suggest that poor hydraulic conditions may be an important regulator of survival-to-emergence rates in some redds. These data are discussed below, under the "Survival-to-emergence measurements" heading.

The distribution and composition (and thus quality) of channel bed sediment along the Tuolumne River has changed significantly over the years. Increased sediment loading from gold mining, beginning in 1848, was the first in a series of human impacts. Dam construction along the river has since isolated lower spawning reaches from upstream sources (both natural and anthropogenic) of coarse sediment. But uncontrollable, natural events have continued to alter the riverbed and are likely to affect the outcome of planned restoration projects; a prime example of such an event is the extensive fine sediment deposition that occurred during the January 1997 flood. As a means to consider how restoration projects might be affected by the 1997 flood, in particular, the changes in the quality of gravel after the event are considered below.

Historical gravel quality assessments prior to the 1997 Flood event

Few quantitative historical data on spawning gravel quality were available for the Tuolumne River until 1987-1988, when the Districts conducted three studies to assess the effects of fine sediment on survival-to-emergence of fall Chinook salmon. The goals of the studies were to:

- determine rates of fine sediment intrusion into redds, using sediment trapping experiments,
- predict survival-to-emergence from measurements of substrate size, using a model developed by Tappel and Bjornn (1983), and

- document actual survival-to-emergence by trapping alevins emerging from natural redds.

Sampling designs for each of these studies are detailed in Appendix 8 (Volume 4) of the TID/MID report (1992). Taken together, results from the 1987-1988 studies yielded an overall assessment of poor spawning gravel quality in the Tuolumne River. The cumulative percentage of sediment finer than 0.85 mm, a frequently used indicator of fine sediment impairment, averaged 17% (range = 11.1-28.6 %) in 1987 and 11% (range = 5.0% to 24.0%) in 1988 (TID/MID 1992). Mean survival, predicted from the Tappel-Bjornn survival-to-emergence model was 15.7 percent in 1987 and 34.1 percent in 1988. Observed survival-to-emergence from the alevin trapping experiments ranged from 0 to 68% among the redds, with an overall, grand average of 34% (TID/MID 1992). The survival-to-emergence observations, grouped by year, yielded averages of one percent in 1988 and 32 percent in 1989 (TID/MID 1992). The exceptionally low emergence from traps in 1988 was attributed to exposure of eggs to high water temperatures during incubation. In general, both the predicted and the observed estimates of survival-to-emergence for the Tuolumne River, as of 1988, were much lower than what might have been expected based on data from laboratory experiments, which often report greater than 90 percent survival in clean gravel substrates (e.g., Koski 1966, McCuddin 1977, Cederholm et al. 1981, Tappel and Bjornn 1983). This suggested that survival-to-emergence of fall Chinook salmon in the Tuolumne River was substantially reduced due to poor gravel quality.

TRTAC Gravel Quality Assessment s following the 1997 Flood

Loss in available spawning area due to the January 1997 flood stands out as one of the largest changes in habitat conditions for the Tuolumne River Chinook salmon run in recent years. The January 1997 flood spill eroded approximately 500,000 cu yds of mixed topsoil and crushed bedrock from the area between the Don Pedro Dam emergency spillway structure and the Tuolumne River. The eroded material was partly contained by La Grange Reservoir, but some of it spilled into the lower Tuolumne River (McBain and Trush 2000). Small tributaries downstream of La Grange Dam are not known to supply significant volumes of coarse sediment to the river.

In 1998, the Tuolumne River Technical Advisory Committee (TRTAC) began monitoring substrate permeability in riffles throughout the Tuolumne River spawning reach. The goals of the study included (1) developing an accurate, precise method for assessing salmon spawning gravel quality from permeability measurements (2) developing a sampling design for assessing effects of management actions on gravel permeability, and (3) conducting the first year of annual monitoring.

Permeability data

The mean permeability (per riffle) documented throughout the river ranged from 2,497 to 8,024 cm/hr. Permeability and survival-to-emergence did not exhibit a strong upstream-downstream trend, as had been observed in previous pilot studies of permeability. There was no detectable difference in permeability among the riffles sampled.

To establish a baseline for comparison with results from future monitoring efforts, existing gravel permeability and survival-to-emergence rates had to be determined for a representative series of spawning riffles along the lower Tuolumne River. Direct measurements of permeability and survival-to-emergence rates would have been ideal, but were not feasible due to high costs. The study instead relied on survival-to-emergence rates that were inferred from permeability measurements and a simple predictive model, based on existing data.

Model for predicting survival-to-emergence

Paired measurements of permeability and survival-to-emergence are rare. Tagart (1976) measured survival-to-emergence for Coho salmon by trapping 19 natural redds over two seasons in tributaries of the Clearwater River, Washington. McCuddin (1977) measured survival-to-emergence of Chinook salmon and steelhead in artificial redds constructed in experimental troughs. When data from these two studies are plotted together, they reveal a compelling correlation: survival-to-emergence increases systematically with measured permeability (Figure 3.5.1.1-1) in a roughly log-linear relationship that spans more than two orders of magnitude in permeability:

$$\text{Survival} = -0.82530 + 0.14882 * \mathit{ln}\ \text{Permeability} \quad (r^2 = 0.85,\ p<10^{-7})$$

This log-linear relationship can be used to predict survival-to-emergence with the following caveat: compatibility of the model's two data sets is potentially limited by differences in methodology and the fact that the two studies considered different species in their analyses.

.

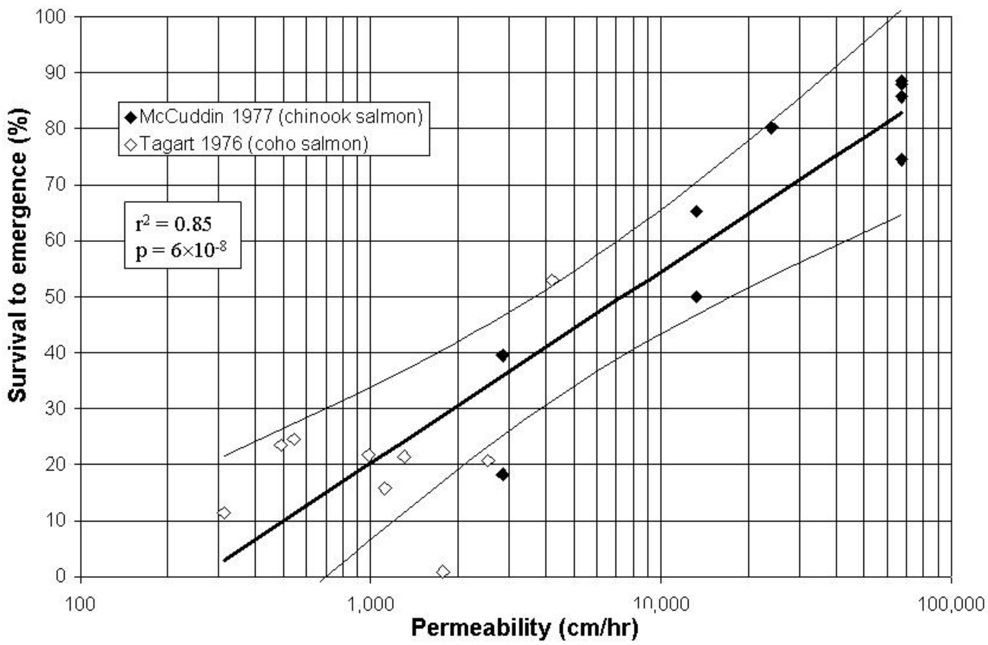


Figure 3.5.1.1-1. Salmonid survival-to-emergence vs. permeability, with 95% model confidence band.

Predicted survival-to-emergence, based on field measurements of substrate permeability, ranged from 34% (95% CI = 31–37%) to 51% (95% CI = 35–67%), generally decreasing with downstream distance in the Tuolumne River (Report 2000-7, TID/MID 2001). Survival-to-emergence exceeded 50 percent at Riffle 1A, just downstream from a 1999 CDFG spawning gravel augmentation site. The next highest permeability and predicted survival-to-emergence was 40 percent at Riffle 2.

Survival-to-emergence measurements

As part of the Tuolumne River Fine Sediment Management Project, the Districts' 1987–1988 trapping experiments (reviewed briefly above) were extended to explore how survival-to-emergence rates vary with gravel quality for a range of artificial sand/gravel compositions. This provided an opportunity to directly test the hypothesis that survival-to-emergence of Chinook salmon is correlated with permeability, such that incubation and emergence success can be predicted reliably from field-based measurements of permeability. Gravel quality varied widely in the 12 artificially constructed Chinook salmon redds considered in the study. Data collected for each redd included intra-gravel permeability, dissolved oxygen, temperature, egg survival, and fry emergence.

Permeability in the redds remained relatively constant over the course of the study. Dissolved oxygen measured in egg pockets remained suitably high (> 8 mg/l) (Phillips and Campbell 1961) at most redds. Alevin development did not appear to be affected by dissolved oxygen.

Intra-gravel temperatures fluctuated with flow and air temperature, but remained cool and well within the optimal range for salmonid egg incubation and alevin development (5–14.4 °C after Bell 1986).

Results indicate that gravel permeability and egg survival-to-emergence are strongly coupled, with fry emergence ranging from zero at low permeability to 37% in redds with high permeability. Re-excavation of several low permeability redds revealed that low emergence was probably due to egg mortality rather than fry entombment.

Two surprises emerged from the experiments. First, permeability observed in field measurements differed from what was predicted, based on mixture compositions. Second, fry emergence was substantially lower than what was predicted from the empirical, log-linear relationship described above, especially in redds with high permeability. Several factors may have contributed to the unexpectedly low survival rates. These include:

(1) mechanical shock during egg placement,
(2) temperature shock, during immersion of eggs in river water,
(3) escape from the traps,
(4) a natural limit on survival to emergence in the lower Tuolumne River of 30–40% (such that relationships between permeability and survival from previous studies do not apply in the Tuolumne River), and
(5) low interstitial velocities in the artificial redds (with insufficient flow, despite high permeability).

Possibilities (1) and (2) can be ruled out by considering the advanced stage of development and the resilience of the eggs used in the experiment, and also the careful handling of eggs during redd construction (which overall was probably much less shocking to the eggs than emplacement by spawning would have been). Possibility (3) is considered unlikely, based on experiments conducted during the 1987–1988 survival to emergence studies. Possibility (4) is difficult to rule out, in the absence of additional experimental data. However, results from other river systems indicate that emergence should have been much higher under the controlled conditions of this experiment. By process of elimination, possibility (5) (poor hydraulic conditions) seems to be the most likely cause of the low survival-to-emergence documented in this study.

Currently, the working hypothesis is that the lower-than-expected survival rates are caused by substandard hydraulic conditions within redds. Redd locations were selected to conform to ideal water depth, velocity, and substrate conditions, based on published data and observations from Tuolumne River spawning sites. Even so, the site selection at the study riffle may have been biased, because wild salmon had already spawned there, presumably selecting the best redds and possibly leaving only sites with suboptimal hydraulic conditions

Flow through a redd is a function of not only permeability but also hydraulic pressure gradient (hydraulic head) (Cooper 1965, Coble 1961). A common way of determining hydraulic pressure gradient is to measure the apparent velocity of water from the volume of water passing through the redd per unit time. Low permeability and slow apparent velocity in a redd can contribute to reduced embryo survival for Chinook salmon (Gangmark and Bakkala 1960). Hence, high gravel permeability by itself may not be sufficient to ensure survival; appropriate hydraulics conditions are required as well.

3.5.1.2 Water temperature monitoring

In accordance with Article 58 of the 1996 FERC Order, the Districts have monitored water temperatures within the lower Tuolumne River as a means of determining juvenile distribution and temperature relationships. Water temperature is the physical factor with perhaps the greatest influence on anadromous salmonids, short of complete absence of water. Not only does temperature directly influence chemical equilibria, but invertebrate and fish communities are also extremely sensitive to temperature (Spence et al. 1996). Temperature has direct but often subtle effects on life history timing, habitat suitability, growth rates, rates of infection, mortality from disease and toxic chemicals, and exposure to predators better adapted to warmer water temperatures. This section provides data on water and air temperatures collected by the Districts for water years 1996–2004. Some comparative data for water temperature and flow conditions pre- and post-1996 for the summer period is included in Section 3.5.3.1 in the discussion under rainbow trout.

Thermograph Deployment

The Districts began monitoring water temperatures at five locations in the Tuolumne River on a continuous basis in the spring of 1987, starting at Riffle 4B (RM 48.0) and ending at Shiloh Rd. (RM 3.4), and one location at Claus Rd. (RM 5.4) in Dry Creek. The 1995 FSA required at least five thermographs to be deployed in the river with air and water temperature data to be reported by the Districts. Additional locations were added to better document the Tuolumne River and one location downstream was established at Gardner Cove (RM 80.0) on the San Joaquin River. Some river locations have changed over time due to equipment damage, theft, or other site-specific issues. Additional sites were added in 2001 to better document temperatures in the primary reach utilized by juvenile and adult *O. mykiss*. The Districts water temperature stations are currently at nine locations on the Tuolumne and two on the San Joaquin River (Table 3.5.1.2-1).

Table 3.5.1.2-1. Location and period of record for thermographs in use during 1996–2004.

River	Location	River Mile	Start date	End date	Comments
Tuolumne	La Grange powerhouse	51.8	11/14/2001	9/30/2004	
Tuolumne	Riffle A7	50.8	11/14/2001	9/30/2004	Recorder was lost 6/02/03 and replaced 1/6/03
Tuolumne	Riffle 3B	49.0	1/18/1990	9/30/2004	Recorder malfunction 1/5/00 to 4/9/01
Tuolumne	Riffle 13B	45.5	11/14/2001	9/30/2004	
Tuolumne	Riffle 19	43.4	1/30/1996	9/30/2004	
Tuolumne	Roberts Ferry	40.4	8/11/1998	9/30/2004	Recorder malfunction 1/5/00 to 8/1/00
Tuolumne	Ruddy Gravel	36.7	4/1/1987	9/30/2004	Recorder malfunction 8/11/98 to 12/28/98
Tuolumne	Charles Road	24.9	6/22/1988	7/2/1996	relocated to Hughson sewer
Tuolumne	Hughson Sewer	23.6	3/20/1997	9/30/2004	Out of water 11/00 to 2/01 and 9/12/03 to 1/5/04
Tuolumne	Shiloh Road	3.4	4/2/1987	9/30/2004	Recorder was lost 4/11/01 and replaced 11/16/01
San Joaquin	Dos Rios	86.2	2/13/1996	9/30/2004	Recorder malfunction 7/14/03 to 1/18/04
San Joaquin	Gardner Cove	80.0	1/27/1988	9/30/2004	Out of water 9/26/03 to 2/19/04

Air Temperature Data

Meteorological data (i.e., air temperature, relative humidity, solar insolation, and wind speed) collected at Modesto between 1978 and 1988 was used in development of an implementation of the SNTEMP model for the Lower Tuolumne River (TID/MID 1992). Modesto air temperatures exhibit a regular annual cycle with only moderate differences between years (Figure 3.5.1.2-1).

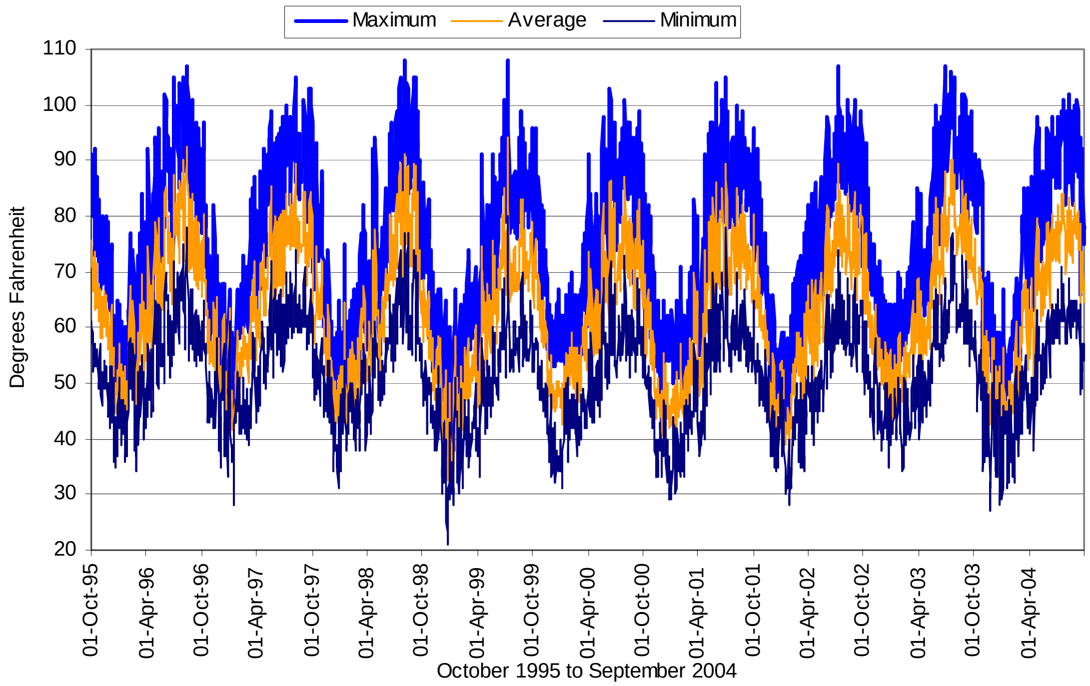


Figure 3.5.1.2-1. Modesto air temperature for water years 1996–2004.

Water Temperature Data

FERC Report 1997-5 summarized the 1987-1997 water temperature data from the Districts thermographs, including USGS data for stations at La Grange and Modesto. FERC Report 2002-7 summarized the 1998–2002 water and air temperature data collected by the Districts. The 2002 report also summarized available water temperature and conductivity data from USGS and CDWR stations at La Grange, Modesto, Patterson (SJR) and Vernalis (SJR). Subsequent annual reports have included updates of additional data.

Graphs of daily minimum, average, and maximum water temperatures for the October 1995 to September 2004 period show the annual range of water temperatures for several monitoring sites (Figures 3.5.1.2-2 to 3.5.1.2-7). In general, water temperatures increase with increasing distance downstream of the La Grange powerhouse, except during colder winter periods. Annual ranges and rate of increase are dependent on flow rate and ambient air temperatures. Daily average water temperatures at the USGS La Grange gage location generally range from about 10 to 13 °C throughout the years. Daily average water temperatures downstream to Riffle 19 (RM 43.4) have not exceeded 23 °C except for a brief period in the drought year summers of 2001 and 2002, whereas RM 23.6 and below has routinely exceeded 23 °C in daily average during summer. San Joaquin River temperature above and below the Tuolumne confluence is in Figures 3.5.1.2-8 and 3.5.1.2-9.

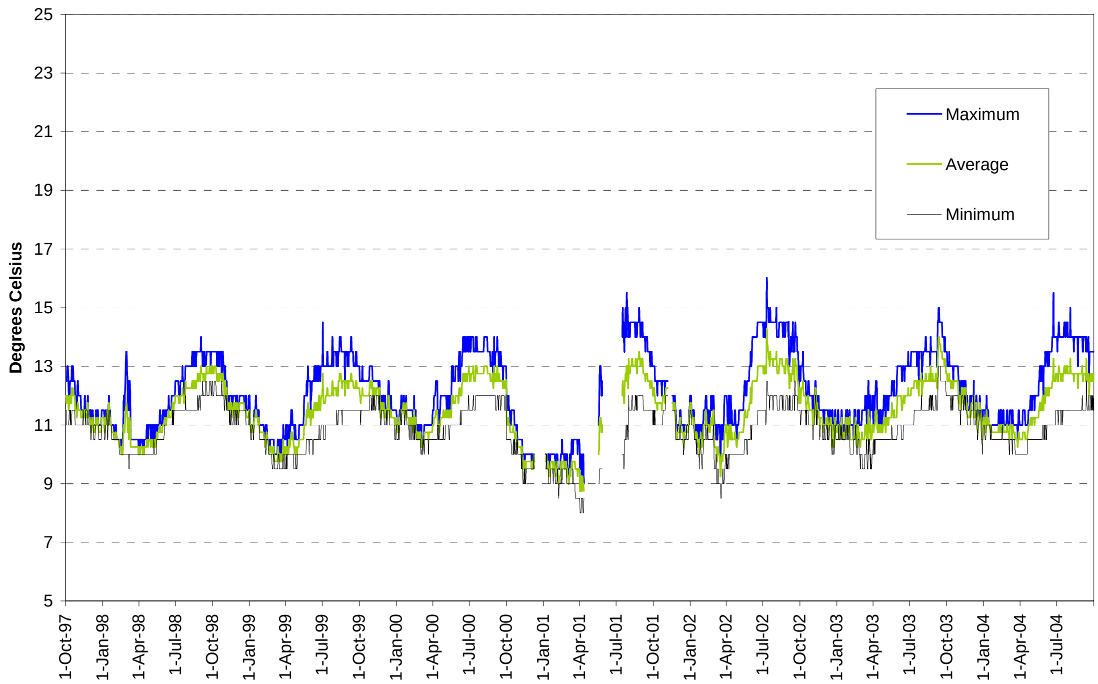


Figure 3.5.1.2-2. Water temperature (USGS data) at RM 51.8 for water years 1998–2004.

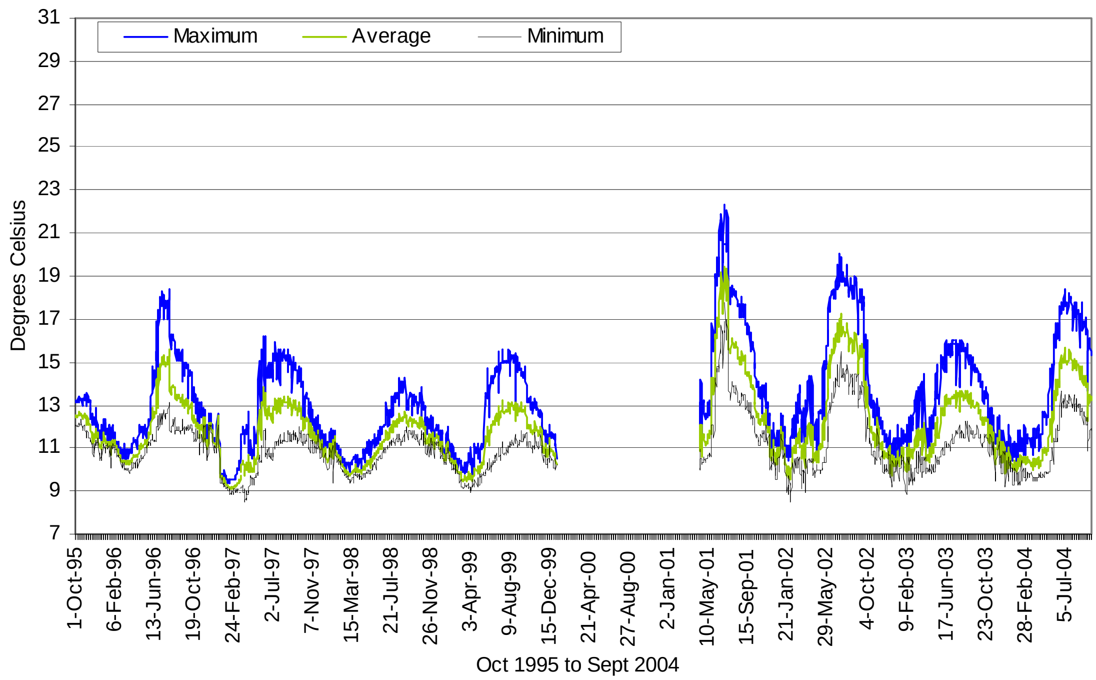


Figure 3.5.1.2-3. Water temperature at RM 49.0 for water years 1996–2004. Note: Recorder malfunction 1/5/00 to 4/9/01.

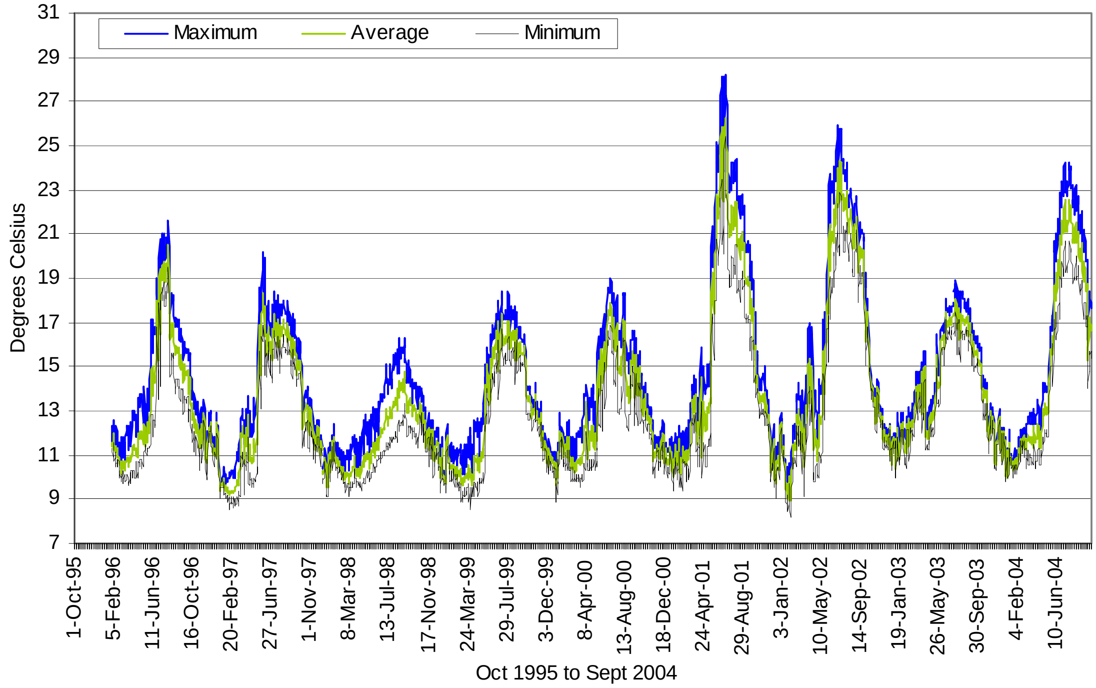


Figure 3.5.1.2-4. Water temperature at RM 43.4 for water years 1996–2004.

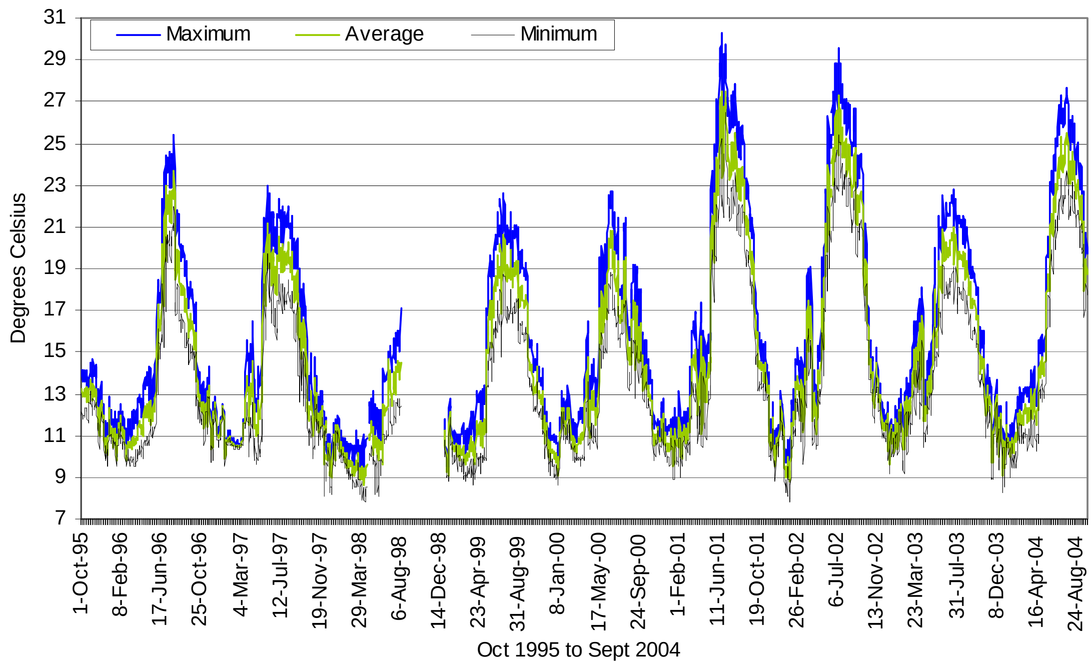


Figure 3.5.1.2-5. Water temperature at RM 36.7 for water years 1996–2004.

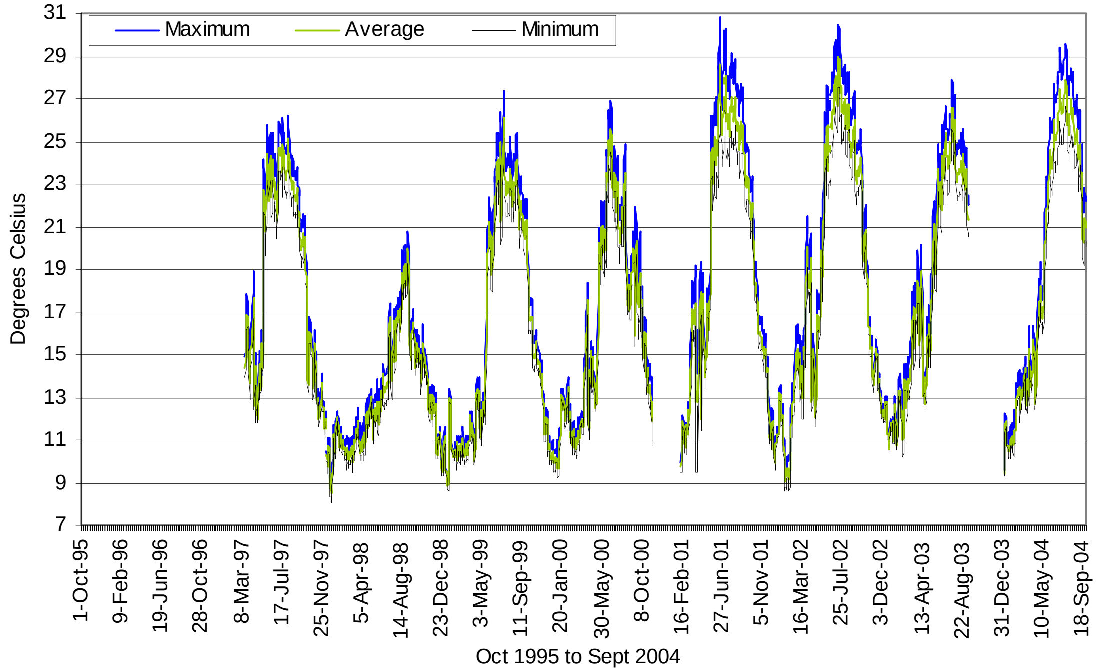


Figure 3.5.1.2-6. Water temperature at RM 23.6 for water years 1996–2004. Note: Recorder malfunction 7/14/03 to 1/18/04

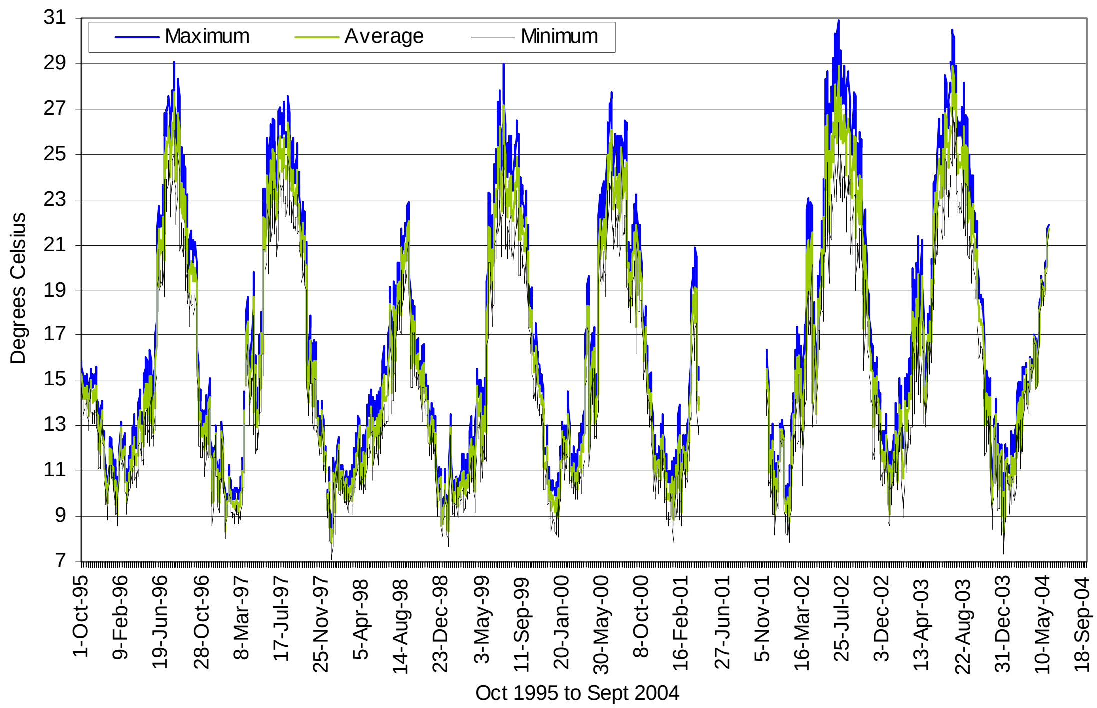


Figure 3.5.1.2-7. Water temperature at RM 3.4 for water years 1996–2004. Note: Recorder was lost 4/11/01 and replaced 11/16/01

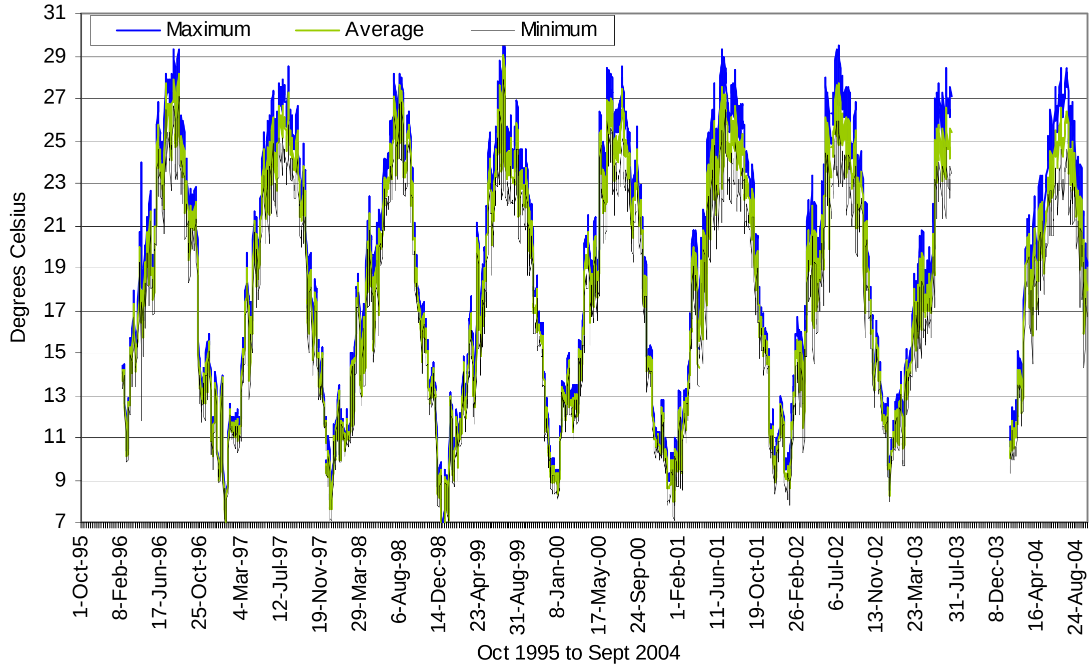


Figure 3.5.1.2-8. Water temperature at San Joaquin RM 86.2 for water years 1996–2004.

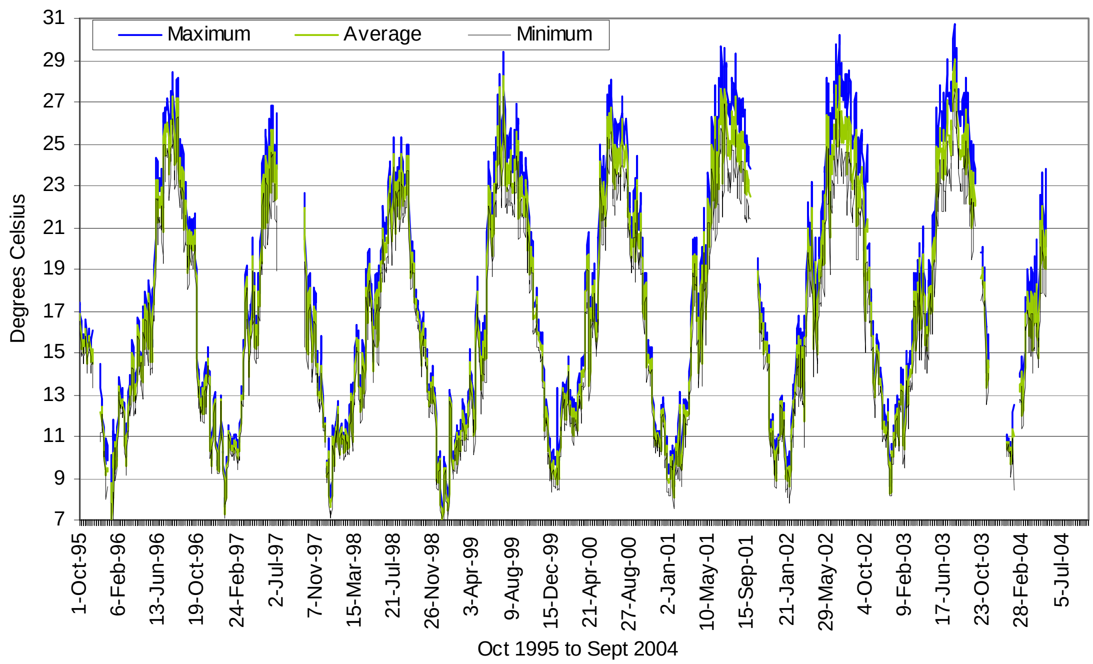


Figure 3.5.1.2-9. Water temperature at San Joaquin RM 80.0 for water years 1996–2004.

3.5.1.3 Water quality monitoring

The CVRWQCB Basin Plan generally provides standards through: 1) a designation of existing and potential beneficial uses; 2) water quality objectives to protect those beneficial uses; and 3) programs of implementation needed to achieve those objectives. Despite changes in land use, water use and water quality in the Tuolumne River, few studies have linked water quality to the health of aquatic resources (Dubrovsky et al. 1998). The CVRWQCB and USGS have conducted intermittent water quality monitoring in the Tuolumne River and Dry Creek – most monitoring in the basin has been focused on the San Joaquin River. The Districts' water quality monitoring has been mostly conducted during fishery monitoring activities (i.e. seine and snorkel surveys). Table 3.5.1.3-1 identifies the years in which data for the parameters were collected.

Table 3.5.1.3-1. Summary table of conductivity, turbidity, and dissolved oxygen sampling methods and year for water quality parameter hand-held sampling.

Parameter	1996	1997	1998	1999	2000	2001	2002	2003	2004
Conductivity	S1,S2	S1	S1	S1	S1,S2	S1,S2,I	S1,S2,I	S1,S2,I	S1,S2,I
Turbidity	S1	S1	S1	S1	S1	S1,S2	S1,S2	S1,S2	S1,S2
Dissolved Oxygen							I	I	S2(Sep.),I,DO

S1 = Annual seining studies conducted at 2-week intervals from January through May.
S2 = Snorkel surveys conducted in June (except 1998) and in Sept. (2001–2004)
I = Invertebrate sampling conducted in late July
DO = Dissolved oxygen monitoring study conducted in 2004

Electrical Conductivity

That salinity affects fish species is well-known; salinity is one of the strongest physical factors structuring biological communities (Loomis 1954). Salinity represents the accumulations of anions such as carbonates, chlorides, and sulfates, and cations such as potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na). Two general measures are used to assess salinity in water, electrical conductivity (EC) and total dissolved solids (TDS). EC measures the transmission of electricity between known electrode areas and path lengths (units µS/cm), whereas TDS is measured in mg/L by gravimetric analysis after drying with 0.65 used as a typical multiplier to convert from EC to TDS (APHA 1998).

EC has been measured in the lower Tuolumne River during seining surveys to ascertain any potential cues related to outmigration as well as identifying any potential problems due to high salinity inputs. In the lower Tuolumne River EC is generally low. Ranging from about 30 to 300 microSeimens per centimeter (µS/cm), EC depends largely on flow volume and distance downstream of the La Grange Dam. Table 3.5.1.3-2 shows that EC levels and variability increase with distance downstream as greater groundwater accretion accumulates within the river flow. Figure 3.5.1.3-1 demonstrates a general decrease in EC with increased flows as well as the aforementioned increase in EC with distance from Old La Grange Bridge. Notable increases in EC occur in the Tuolumne River below Dry Creek and below the confluence with the lower San Joaquin River. The San Joaquin River typically has much higher EC levels (200 to 2000 µS/cm) than within the Tuolumne River. Figure 3.5.1.3-2 shows that EC decreases approximately 300 µS/cm from locations above the Tuolumne/San Joaquin confluence (Laird Park) to below the confluence (Garner Cove/Old Fisherman's Club). That is, dilution by Tuolumne River flows generally decrease the salinity level of the San Joaquin River.

Table 3.5.1.3-2. Average EC (µS/cm) along the Tuolumne River and the San Joaquin River above and below the confluence with the Tuolumne River by month.

Site Description	RM	Electrical Conductivity (µS/cm)					
		Jan	Feb	Mar	Apr	May	Jun
Old La Grange Bridge	50.5	39	39	41	39	38	22
Riffle 4B/5B	48.0	41	41	43	39	38	25
Tuolumne River Resort	42.4	53	50	50	44	44	30
Hickman	31.6	67	59	60	54	54	33
Charles Rd.	24.9	97	87	83	74	81	
Legion Park	17.2	130	102	92	85	96	107
Riverdale Park/Venn	7.4	183	164	125	120	118	
Shiloh Rd.	3.4	163	127	112	111	129	144
Laird Park (San Joaquin River)	90.2	1192	1063	1110	1042	737	1320
Gardner Cove (Old Fisherman's Club on San Joaquin River)	79.4	1009	747	716	578	498	

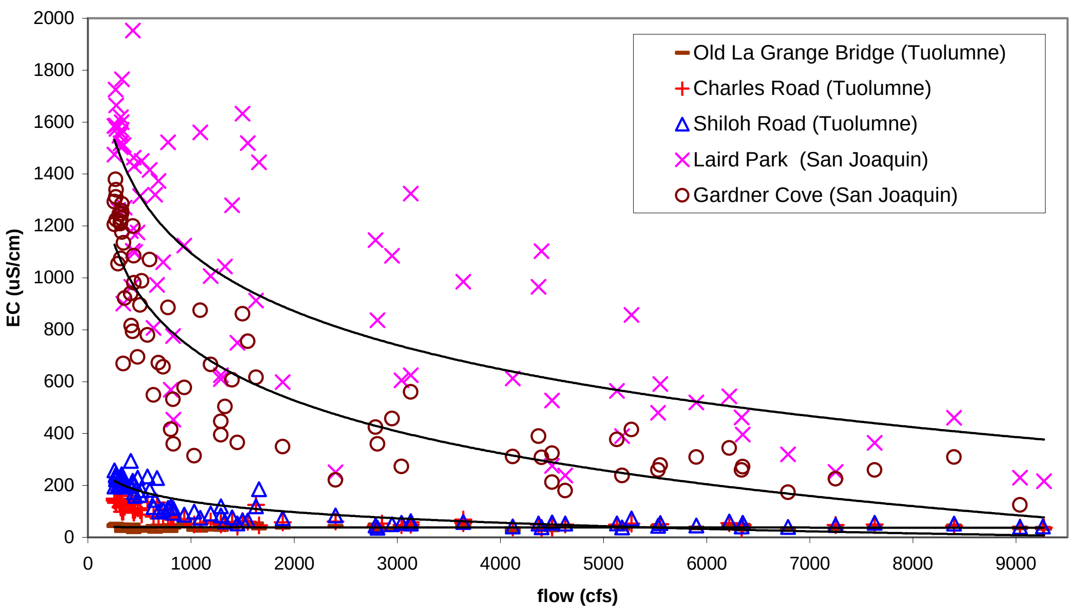


Figure 3.5.1.3-1. Electrical conductivity (EC) readings in the Tuolumne and San Joaquin rivers by flow, collected during seining for water years 1996–2004.

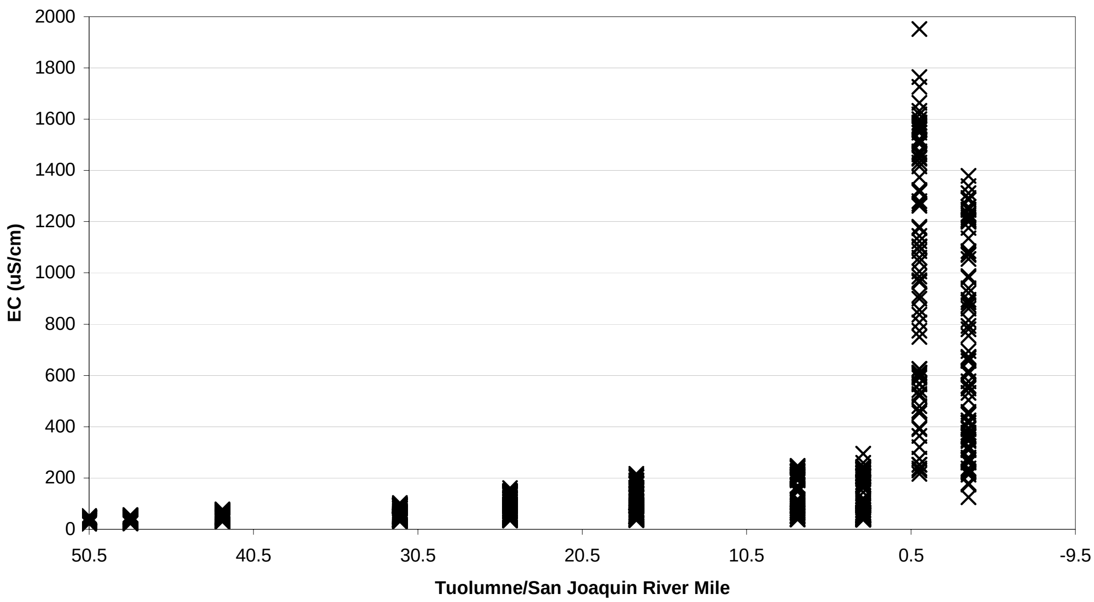


Figure 3.5.1.3-2. EC data at Tuolumne (RM 50.5 to 0.0) and San Joaquin River sites for water years 2001–2004. Note that Laird Park (above confluence) and Gardner Cove (below confluence) are located on the San Joaquin River and are represented as Tuolumne RM 0.0 and RM -3.0 for presentation.

Suspended Sediment and Turbidity

Turbidity is an optical property (light scattering) linked to sight-feeding abilities of juvenile Chinook salmon and potential predators. Very fine (colloidal) suspended matter such as clay, silt, organic matter, plankton and other microscopic organisms causes turbidity in water. Turbidity is closely related to total suspended solids (TSS) which is often estimated to have a 1:1 equivalence (Montgomery 1985), where 1 mg/L TSS is approximately one nephelometric turbidity unit (1 NTU).

In addition to its direct effects on primary production and rearing juvenile salmonids,high turbidity can cause decreases in the abundance of plants, zooplankton, and insect biomass, and reductions in herbivore, omnivore, and, consequently, predator classes of fish (Berkman and Rabeni, 1987 as cited in Henley et al. 2000). Extremely high turbidity can interfere with temperature, DO, and is also associated with total metals loadings and sorption of contaminants from the water column (e.g., polar organics and cationic metal forms).

Turbidity measured during the juvenile seining surveys in the Tuolumne is generally low, ranging from less than one to about 10 Nephelometric Units (NTU), except during periods with high storm runoff (Table 3.5.1.3-3). Below Old La Grange Bridge variability in turbidity is small and increases only slightly with distance downstream. Dry Creek, just downstream of RM 17, usually increases turbidity in the river from that point on (Figure 3.5.1.3-3) with San Joaquin River turbidity consistently higher than Tuolumne River sites. San Joaquin River turbidity generally decreases by approximately 10 NTU from above to below the confluence with the Tuolumne River (Table 3.5.1.3-3).

Table 3.5.1.3-3. Average Turbidity (NTU) along the Tuolumne River and the San Joaquin River above and below the confluence with the Tuolumne River by month.

Site Description	RM	Turbidity (NTU)				
		January	February	March	April	May
Old La Grange Bridge	50.5	1	2	1	1	1
Riffle 4B/5B	48.0	1	2	1	1	1
Tuolumne River Resort	42.4	1	2	2	2	1
Charles Rd.	24.9	2	2	3	2	2
Legion Park	17.2	2	3	5	3	4
Riverdale Park/Venn	7.4	7	6	12	6	5
Shiloh Rd.	3.4	5	8	14	7	6
Laird Park (on San Joaquin River above confluence)	SJR 90.2	24	38	38	29	32
Gardner Cove (Old Fisherman's Club on San Joaquin River below confluence)	SJR 79.4	16	22	31	18	23

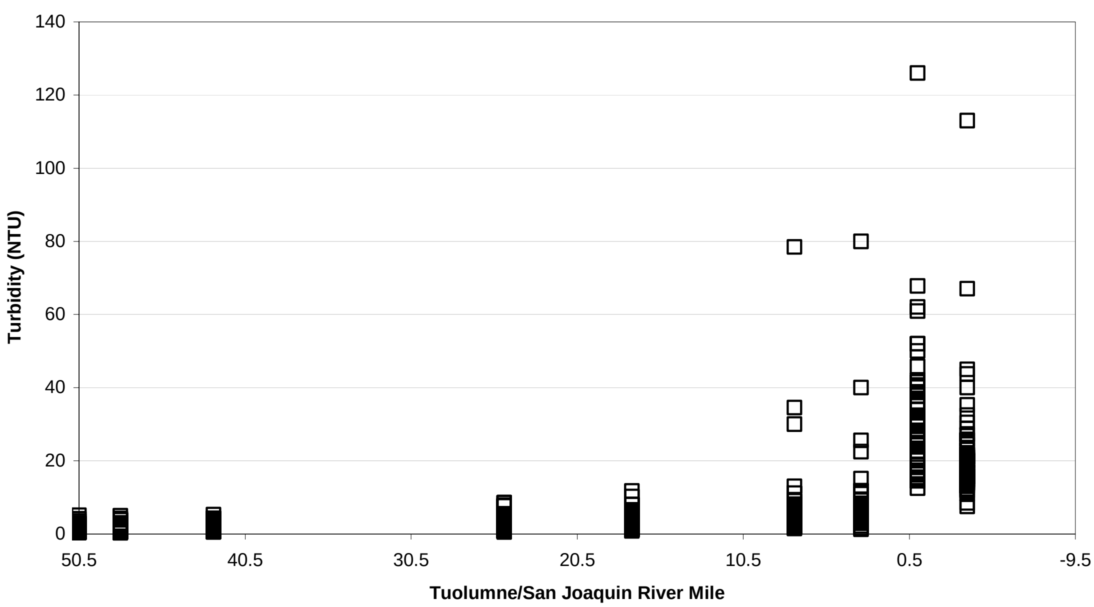


Figure 3.5.1.3-3. Turbidity readings at Tuolumne (RM 50.5 to 0.0) and San Joaquin River sites collected during seining for water years 1998–2004. Note that Laird Park (above confluence) and Gardner Cove (below confluence) are located on the San Joaquin River and are represented as Tuolumne RM 0 and -3 for presentation.

Dissolved Oxygen

Dissolved oxygen (DO) is a very important indicator of a water body's ability to support aquatic invertebrates and fish. Dissolved oxygen concentrations in water depend on several factors, including temperature (i.e., colder water absorbs more oxygen), and the volume and velocity of water flowing in the water body (re-aeration), salinity, and the number of organisms using oxygen for respiration. This last factor (respiratory consumption) is, in turn, strongly influenced by the amount of limiting nutrients (nitrogen and phosphorus) present, generally derived from anthropogenic sources such as fertilizer.

Following the establishment of the higher summer flow schedules under the 1995 FSA, some concern had been raised about potential DO and nutrient issues and potential impacts to salmonid rearing during lower summer flows in drier years, although there had been no specific evidence that a problem existed. NOAA Fisheries identified in a study request made in April 2004 their interest in having additional monitoring done on this subject. The Districts agreed that it would be useful to obtain some baseline information and therefore had a study conducted to evaluate dissolved oxygen and other water quality conditions in the upper part of the Tuolumne River during the transition period from the spring flow schedule to a lower summer flow period in early June 2004.

2004 Diel Water Quality Surveys

Two water quality meters were placed at River Mile 51 and 43 on the morning of May 28, 2004, and retrieved June 5 with flows at La Grange ranging from about 180 cfs on May 28 to 100 cfs on June 7. Continuous water quality data including water temperature, dissolved oxygen, conductivity, and pH were recorded over a seven-day period. These data were supplemented by spot checks of water quality parameters across the river cross-section and vertically at sites from RM 36.8-51.8. Water temperature exhibited a diel pattern of variation and ranged from 10.7-13.8 °C upstream and 13-20 °C at the downstream location. DO was at or near saturation throughout the sampling period at both locations ranging from 9.5-11 mg/L upstream and 9.2-11.3 mg/L at the downstream location. Conductivity increased with distance downstream, as did pH to a lesser degree.

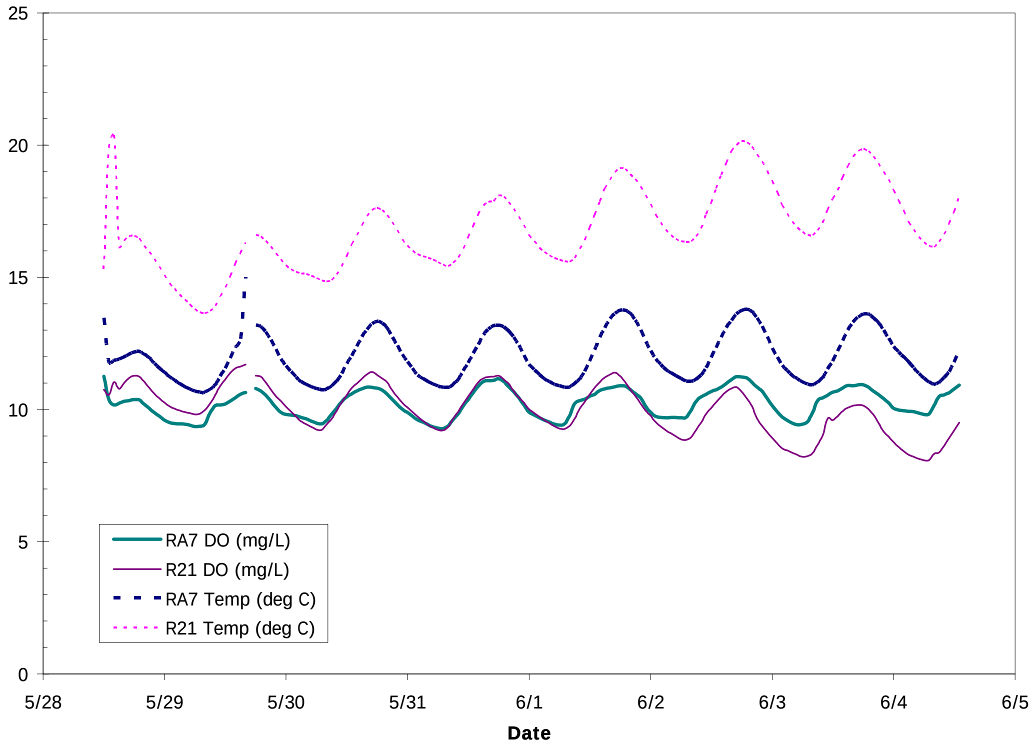


Figure 3.5.1.3-4. Diel dissolved oxygen, water and air temperature data collected from 5/28 to 6/7/2004 in the lower Tuolumne River

Water samples for nutrients, herbicides, pesticides and algae were collected near the two water quality monitoring locations on June 7. All parameters sampled were below the method reporting limits (MRLs), which are set by the laboratory to ensure a reporting accuracy with less than a 0.3% probability that replicate samples reported as non-detect (ND) would exceed the MRLs. The non-detect values for nutrients, pesticides, herbicides, and algae and relatively high DO levels suggest that water quality conditions were suitable for all aquatic beneficial uses (FERC Report 2004-10, TID/MID 2005).

3.5.2 Chinook salmon assessments

The 1995 FSA fishery monitoring program continued ongoing FERC-directed assessments on Chinook salmon begun in 1971. Adult population monitoring was done in the fall spawning surveys, primarily in October through December. Juvenile salmon monitoring during the January through May period was done through seining, screw trapping, and some stranding surveys. Smolt survival studies using tagged hatchery salmon were done in April and May. Snorkel surveys of juvenile salmon occurred in the period of June through September. Information on other fish species is in Section 3.5.3.

3.5.2.1 Spawning survey and population estimates

Fall-run Chinook spawning surveys have been conducted on the Tuolumne River by CDFG since 1971 as required under the fish study program for the Don Pedro Project. Up to 26 river miles below the La Grange Dam (downstream to Fox Grove at RM 26) were surveyed annually in weekly float surveys, typically in the OCT-DEC period (Figure 3.5.2.1-1). Surveys occasionally were done down to RM 24. Supplemental JAN-MAY float surveys were done in 2004, primarily for rainbow trout. Weekly live salmon and redd counts were recorded by riffles or riffle reaches and summarized by river reaches. Carcasses were collected by gaff for tagging and examination. Length and sex determination were recorded for all tagged carcasses and some scale and/or otolith samples have been collected since 1981. Fresh carcasses were checked for absence of the adipose fin indicated a fish of hatchery origin with a coded wire tag (CWT). Heads of CWT carcasses were collected for later dissection and recovery of the tag. In 1998 and 1999 tissue samples were collected and beginning in 2000, fin clips were taken for genetic analyses. The Districts prepared annual reports through 1997 and CDFG has provided subsequent annual spawning survey reports through the 2004 fall run. The Districts have provided spawning survey summary updates of the Tuolumne River surveys in their 1996–2004 annual reports to FERC.

Since 1971, spawning estimates have ranged widely from a low of 77 in 1991 to a high of 40,300 in 1985 (Table 3.5.2.1-1, Fig. 3.5.2.1-2). The estimates were based on mark-recapture methods of salmon carcasses. Total escapement was estimated using adjusted Peterson or modified Schaefer formulas; in some cases, Jolly-Seber formulas have been used by CDFG to make alternative estimates. Lower population levels tend to lag drier periods, with low estimates following the 1976-77 and 1987-92 drought years. The salmon estimate steadily increased after 1994 to about 17,900 fish in 2000. Since then, the estimates have been declining to about 1,900 in 2004, associated with the dry water years of 2001–2004. These general trends were also evident in the Stanislaus and Merced River populations, which are the neighboring major tributaries in the San Joaquin Basin upstream of the Delta (Table 3.5.2.1-1, Fig. 3.5.2.1-3). Table 3.5.2.1-2 is a summary of the annual Tuolumne River spawning survey data.

Salmon runs in the San Joaquin River upstream of the Merced River were eliminated by operation of the Friant Division of the Central Valley Project by the U.S. Bureau of Reclamation. Some estimates of "strays" running up the agricultural drainage flows above the Merced River were made by CDFG during 1988-91, prior to installation of a seasonal migration barrier on the San Joaquin River at the confluence of the Merced River.

The seasonal high number of redds counted for each riffle was summarized by section each year for the 1981–2003 period (Table 3.5.2.1-3). The redd counts show the spawning activity was usually concentrated in the upper 5 river miles, upstream of Basso Bridge (RM 47.5). In the most heavily used riffles, extensive redd superimposition results in some undercounting. CDFG conducted a redd count study in 1998 and 1999 to calibrate redd counts recorded during the regular spawning surveys. Calibration counts were conducted during 3 weeks of the spawning season in a stratified random sample of spawning riffles. Intensive redd counts were conducted by walking the areas and mapping the individual redd locations. In heavily used riffles, the calibration counts were often over 3 times higher than the regular counts taken from the weekly boat surveys.

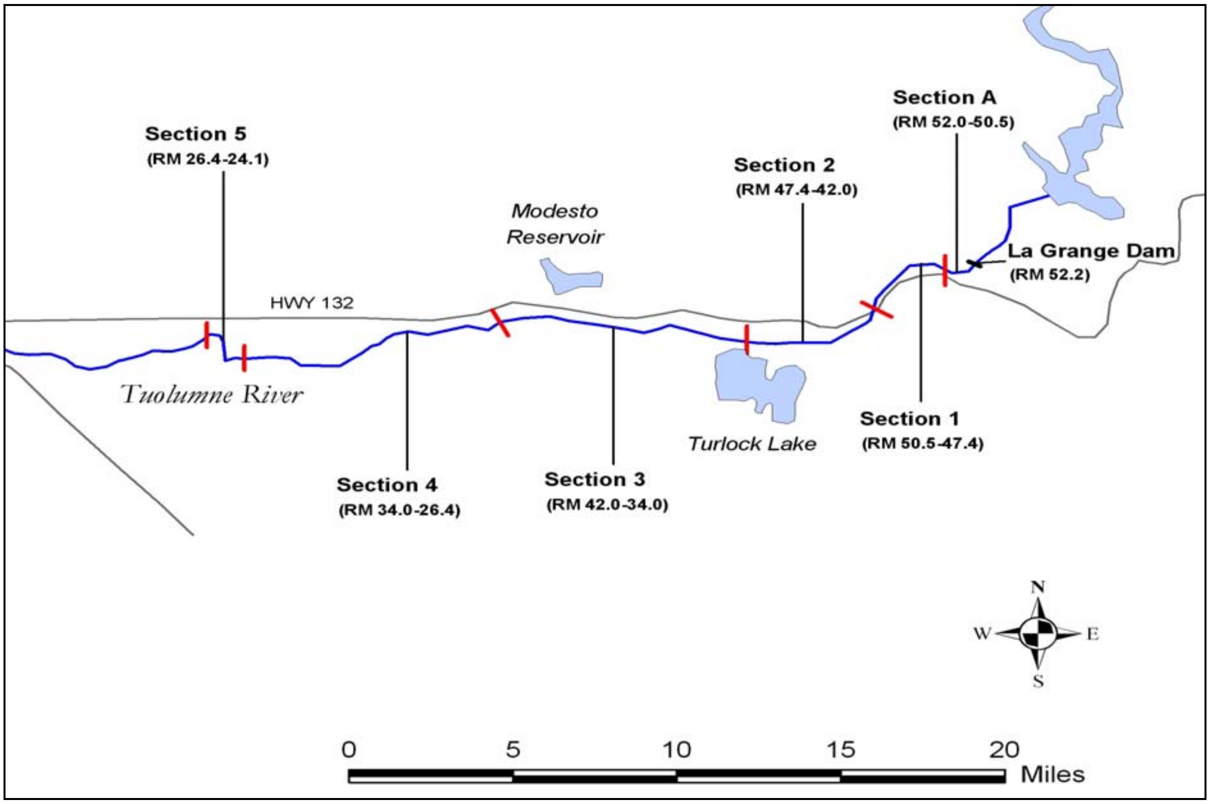


Figure 3.5.2.1-1 Map of spawning survey sections.

Table 3.5.2.1-1 San Joaquin basin Chinook salmon spawning run estimates.

Year	STANISLAUS	TUOLUMNE	MERCED (river)	MERCED (hatchery)	MERCED (total)	Trib. Total	SJ RIVER	Basin Total	Event
1971	13.6	21.9	3.5	0.1	3.6	39.1		39.1	New Don Pedro Dam on Tuolumne
1972	4.3	5.1	2.5	0.1	2.6	12.0		12.0	
1973	1.2	2.0	0.8	0.2	1.0	4.2		4.2	
1974	0.8	1.2	1.0	0.4	1.4	3.3		3.3	
1975	1.2	1.6	1.7	0.4	2.1	4.9		4.9	
1976	0.6	1.7	1.2	0.3	1.5	3.8		3.8	Drought
1977	0.0	0.5	0.4	0.2	0.6	1.0		1.0	Drought
1978	0.1	1.3	0.5	0.1	0.6	2.0		2.0	New Melones Dam on Stanislaus
1979	0.1	1.2	1.9	0.3	2.2	3.5		3.5	
1980	0.1	0.6	2.9	0.2	3.0	3.7		3.7	
1981	1.0	14.3	9.5	0.9	10.4	25.7		25.7	
1982		7.1	3.1	0.2	3.3	10.4		10.4	No Stanislaus estimate
1983	0.5	14.8	16.5	1.8	18.2	33.6		33.6	
1984	11.4	13.7	27.6	2.1	29.7	54.9		54.9	
1985	13.5	40.3	14.8	1.2	16.1	69.8		69.8	
1986	6.5	7.4	6.8	0.7	7.4	21.3		21.3	
1987	6.3	14.8	3.2	1.0	4.1	25.2		25.2	Drought
1988	10.2	6.3	4.1	0.5	4.6	21.2	2.3	23.5	Drought
1989	1.5	1.3	0.3	0.1	0.4	3.2	0.3	3.5	Drought
1990	0.5	0.1	0.0	0.0	0.1	0.7	0.3	0.9	Drought
1991	0.4	0.1	0.1	0.0	0.1	0.6	0.2	0.8	Drought
1992	0.3	0.1	0.6	0.4	1.0	1.4		1.4	Drought; Electric barrier on SJR
1993	0.7	0.4	1.3	0.4	1.7	2.8		2.8	Start of Annual Physical barrier on SJR
1994	1.0	0.5	2.6	0.9	3.6	5.1		5.1	
1995	0.6	0.9	2.0	0.6	2.5	4.1		4.1	
1996	0.2	4.4	3.8	1.0	4.8	9.3		9.3	
1997	5.6	7.2	2.7	0.9	3.7	16.4		16.4	
1998	3.1	8.9	3.3	0.8	4.1	16.1		16.1	
1999	4.0	7.7	3.0	0.8	3.8	15.5		15.5	
2000	11.0	17.9	11.0	2.0	13.0	41.9		41.9	
2001	6.0	9.3	9.2	1.3	10.5	25.8		25.8	Dry year
2002	6.9	7.1	7.9	1.8	9.7	23.7		23.7	Prelim. Estimates, Dry year
2003	4.5	2.9	2.9	0.5	3.4	10.8		10.8	Prelim. Estimates, Dry year
2004	4.4	1.9							Prelim. Estimates, Dry year

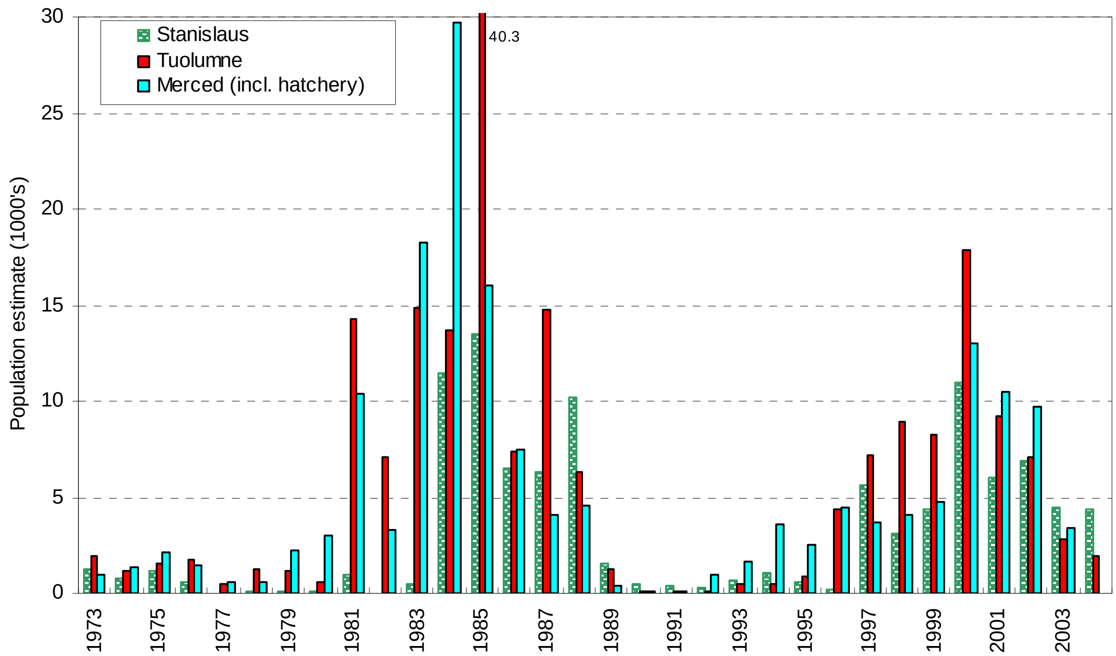


Figure 3.5.2.1-2 San Joaquin tributary Chinook salmon spawning run estimates.

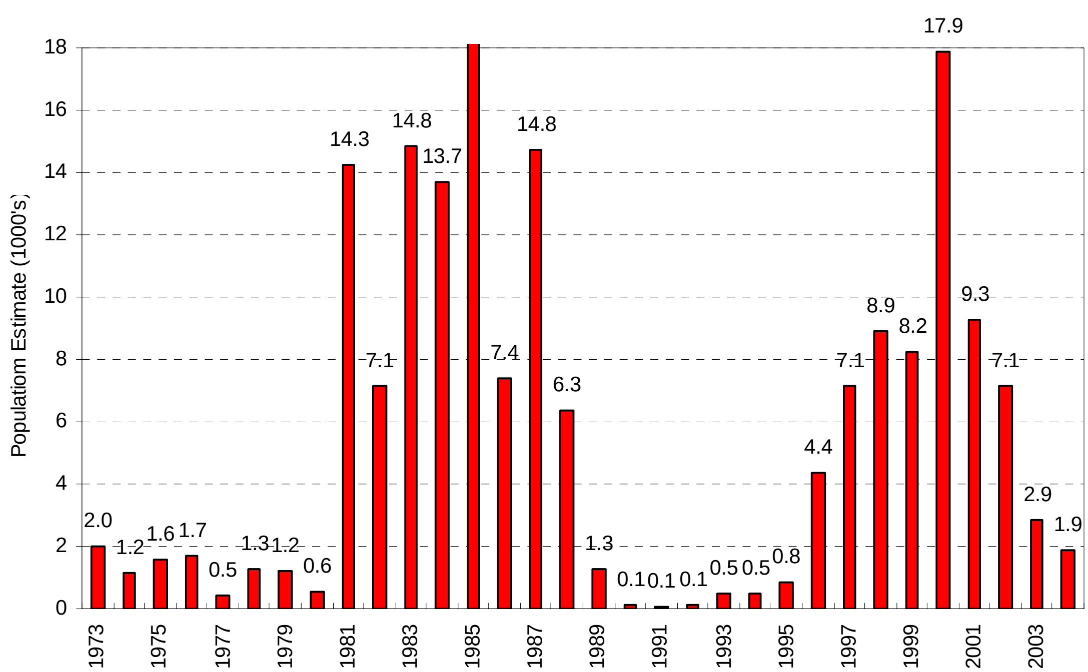


Figure 3.5.2.1-3 Tuolumne River Chinook salmon spawning run estimates.

Table 3.5.2.1-2 Tuolumne River spawning survey summary.

Year	Total Carcasses	% Female	Tagged Carcasses		% Recovered		(Weekly) Maximum Live Count	(Weekly) Maximum Redd Count (1)	Estimated Run
1971	2,283	58			10.4	e	2,128	1,598	21,885
1972	537	52			10.5	e	349	423	5,100
1973	351	59	270	35	13.0				1,989
1974	90	55	84	7	8.3				1,150
1975	130	60	125	8	6.4		154	212	1,600
1976	336	51	330	61	18.5		241	312	1,700
1977	45	62							450
1978	116	67	35	2	9.0	e	81	119	1,300
1979	305	51	75	22	29.3		153	204	1,184
1980	248	61	74	30	40.5		112	117	559
1981	5,819	44	664	334	50.3		1,646	1,650	14,253
1982	2,135	60	293	123	42.0		530	1,111	7,126
1983	1,280	25	270	25	9.3		263	465	14,836
1984	3,841	34	693	201	29.0		1,084	1,143	13,689
1985	11,651	56	895	273	30.5		2,986	3,034	40,322
1986	2,463	48	456	172	37.7		1,123	1,250	7,288
1987	5,280	31	1,069	461	43.1		2,155	850	14,751
1988	3,011	60	2,171	1,316	60.6		1,066	1,936	6,349
1989	625	52	491	318	64.8		291	461	1,274
1990	37	32	30	14	46.7		44	42	96
1991	30	45	12	7	58.3		24	51	77
1992	55	43	47	26	55.3		49	38	132
1993	187	61	169	96	56.8		94	215	431
1994	215	50	185	110	59.5		226	264	513
1995	461	54	415	175	42.2		270	174	928
1996	1,301	35	1,186	369	31.1		636	216	4,362
1997	1,520	59	1,056	253	24.0		1,258	716	7,548
1998	2,712	51	2,170	679	31.3		1,058	448	8,967
1999	3,980	46	2,375	1,398	58.9		1,403	404	7,730
2000	6,884	63	2,162	870	40.2		3,269	2,104	17,873
2001	5,400	54	1,170	717	61.3		1,865	1,251	9,222
2002	4,702	54	1,283	826	64.4		1,366	478	7,125
2003	1,489	60	585	328	56.1		463	349	2,961
2004	1,224		529	344	65.0		718	455	1,900

Notes: Redd counts were taken from TID/MID summary tables after 1980; redd counts for 1986 partially based on aerial photographs taken on 26 November 1986.
e - estimated

Table 3.5.2.1-3 Summary, by section and total, of maximum redd counts.

	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
SECTION A (La Grange Dam to OLGB)																								
Total:	128	106	2	55	185	116		102	141	48	0	6	12	45	45	39	57	108	68	60	187	261	38	44
Redd/Mile	98.5	81.5	1.5	42.3	142.3	89.2		78.5	108.5	36.9	0.0	4.6	9.2	34.6	34.6	30.0	43.8	83.1	52.3	46.2	143.8	200.8	29.2	33.8
Redd/1,000 ft2	1.70	1.41	0.03	0.73	2.45	1.54		1.35	1.87	0.64	0.00	0.08	0.16	0.60	0.60	0.52	0.76	1.43	0.90	0.80	2.48	3.46	0.50	0.58
Percent of Total	8	10	0	5	6	12	0	12	7	8	0	12	23	18	14	17	17	11	11	9	7	12	5	9
SECTION 1 (OLGB to Basso Bridge)	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Total:	510	467	110	358	1230	260	428	246	552	181	10	16	17	78	79	48	125	404	243	341	1503	1076	241	159
Redd/Mile	204	186.8	44	143.2	492	104	171.2	98.4	220.8	72.4	4	6.4	6.8	31.2	31.6	19.2	50	161.6	97.2	136.4	601.2	430.4	96.4	63.6
Redd/1,000 ft2	0.77	0.70	0.17	0.54	1.85	0.39	0.64	0.37	0.83	0.27	0.02	0.02	0.03	0.12	0.12	0.07	0.19	0.61	0.36	0.51	2.26	1.62	0.36	0.24
Percent of Total	30	42	24	31	41	27	38	29	29	31	17	31	32	31	25	21	36	41	38	50	53	50	32	34
SECTION 2 (Basso Bridge to TLSRA)	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Total:	461	308	180	428	874	233	271	216	402	130	21	9	7	61	95	61	84	272	180	183	710	333	155	102
Redd/Mile	92.2	61.6	36	85.6	174.8	46.6	54.2	43.2	80.4	26	4.2	1.8	1.4	12.2	19	12.2	16.8	54.4	36	36.6	142	66.6	31	20.4
Redd/1,000 ft2	1.15	0.77	0.45	1.07	2.18	0.58	0.67	0.54	1.00	0.32	0.05	0.02	0.02	0.15	0.24	0.15	0.21	0.68	0.45	0.46	1.77	0.83	0.39	0.25
Percent of Total	28	28	39	37	29	25	24	25	21	22	36	18	13	24	30	27	24	28	28	27	25	16	21	22
SECTION 3 (TLSRA TO Reed Gravel)	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Total:	440	218	155	265	605	342	365	209	431	149	21	13	7	49	82	56	58	171	125	69	345	361	210	122
Redd/Mile	57.1	28.3	20.1	34.4	78.6	44.4	47.4	27.1	56.0	19.4	2.7	1.7	0.9	6.4	10.6	7.3	7.5	22.2	16.2	9.0	44.8	46.9	27.3	15.8
Redd/1,000 ft2	0.61	0.30	0.22	0.37	0.84	0.48	0.51	0.29	0.60	0.21	0.03	0.02	0.01	0.07	0.11	0.08	0.08	0.24	0.17	0.10	0.48	0.50	0.29	0.17
Percent of Total	26	20	33	23	20	36	32	25	22	25	36	25	13	20	25	24	17	17	19	10	12	17	28	26
SECTION 4 (Reed Gravel to Fox Grove)	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Total:	137		18	37	~140		68	77	376	76	6	7	10	17	21	25	19	26	31	31	102	101	111	46
Redd/Mile	22.5		3.0	6.1	23.0		11.1	12.6	61.6	12.5	1.0	1.1	1.6	2.8	3.4	4.1	3.1	4.3	5.1	5.1	16.7	16.6	18.2	7.5
Redd/1,000 ft2	0.17		0.02	0.05	0.17		0.08	0.09	0.46	0.09	0.01	0.01	0.01	0.02	0.03	0.03	0.02	0.03	0.04	0.04	0.12	0.12	0.14	0.06
Percent of Total	8		4	3	5		6	9	20	13	10	14	19	7	7	11	6	3	5	5	4	5	15	10
SECTION 5 (Below Fox Grove)	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Total:									26	4														
Redd/Mile									9.6	1.5														
Redd/1,000 ft2									0.11	0.02														
Percent of Total									1	1														
ALL SECTIONS	1981	1982	1983a	1984	1985b	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995c	1996d	1997e	1998	1999	2000	2001	2002	2003
Grand Total	1676	1099	465	1143	3034	951	1132	850	1928	588	58	51	53	250	322	229	343	981	647	684	2847	2132	755	473
# of Females	6300	4200	3700	4700	22600		3498	4600	3809	663	31	35	55	264	255	502	1518	4423	4537	3548	11188	4980	3876	1703
Females/Redd	3.8	3.8	8.0	4.1	7.4		3.1	5.4	2.0	1.1	0.5	0.7	1.0	1.1	0.8	2.2	4.4	4.5	7.0	5.2	3.9	2.3	5.1	3.6
Flow (cfs)	230	420	620	500	350	230	230	210	100	220	130	130	160	270	175	300	400	350	320	390	370	180	193	252

Section A and 5 were not surveyed on a regular basis, Section riffle areas are estimated at 230 cfs.
^ = Included in preceding number
a = 1983 Redd counts were supplemented by aerial survey counts for sections 3 and 4.
In 1983, 261 stranded redds were also counted and are included in the totals for the sections.
b = 1985 Total redd count for section 4 was based on extrapolation of 1981 redd counts for the same riffles
c = 1995 Redd counts were unusually low considering the number of females.
d = 1996 surveys were terminated after first the week of December due to increase of flow to 5,000 cfs..
e = (?) Questionable counts that were omitted.
Poor visibility after Riffle 13C prevented a complete count after week 9.
Ariel surveys were performed in 1986

The percent of females in the 1971–2003 runs has ranged from a low of 25% in 1983 to a high of 67% in 1978. The years with less than 40% females had runs containing a large percentage of 2-year–old fish that have a majority of males (Fig. 3.5.2.1-4).

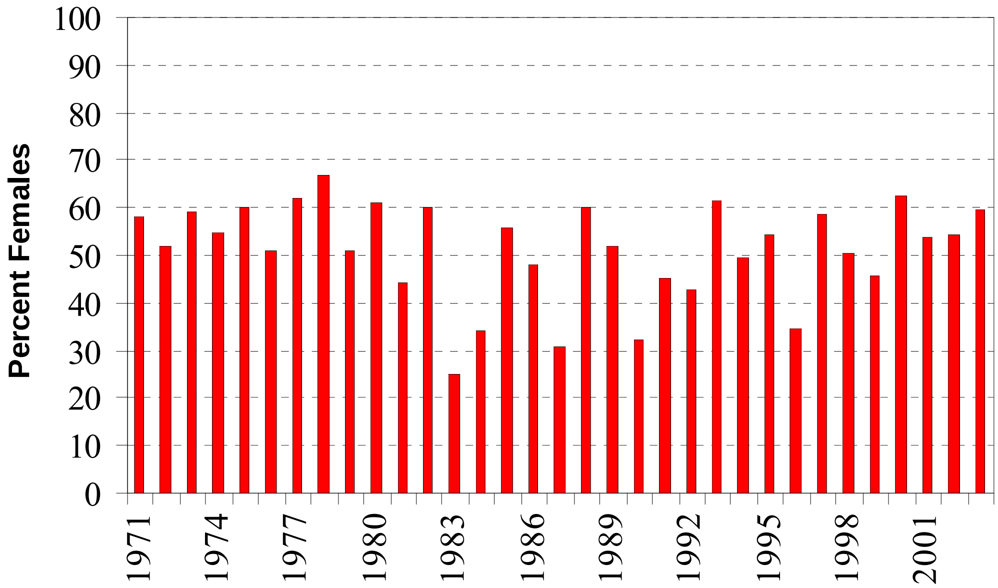


Figure 3.5.2.1-4 Percent of females in Tuolumne salmon run.

Fork length measurements have been recorded for carcasses since 1981. The size distribution for males and females is different with males typically being longer than females of the same age. Generally, the average length of all males is longer than of all females with the exception of years that have a high proportion of 2-year-olds, which are mostly males. Estimation of age-class composition based on visual examination of the length frequency distribution of fresh measured carcasses was made for the 1981–2003 surveys. The greater overlap in size range among older age classes (three to five-year-old salmon) results in more uncertainty. These initial estimates can be modified when age analysis of scale and otolith samples collected by CDFG and lengths of known age hatchery fish are available. The estimated female maximum fork lengths used for ages two, three, and four were typically about 65, 85, and 95 cm respectively. Male fork length maximums used for ages two, three, and four were 70, 90-95, and 105 cm, respectively. The most notable exceptions to the age/length estimates occurred in 1983-1984 and 1997–2000 when ocean growth of salmon may have been reduced due to warm water conditions that limited food resources. Ocean harvest rates affect the age and size distributions. The reduced rates in recent years allow a higher percentage of older fish to return as they experience reduced harvest over their life span.

Using these estimated age/length ranges, two-year-olds dominated the 1981, 1983, 1984, 1987, 1992, and 1996 runs. The 1982, 1985, 1986, 1988-1991, 1993-1995, 1997, 2000, 2002 and 2003 runs were mostly three-year-olds (Fig. 3.5.2.1-5). The 1998 and 1999 runs were estimated to have nearly equal numbers of two and three-year-old salmon. Four-year-olds had not been the most abundant age class in any year until 2001, but were estimated to be more than 10% of the 1986, 1989, 1990, and 1997–2003 runs. Five-year-olds are estimated to have comprised from 0-5% of the runs.

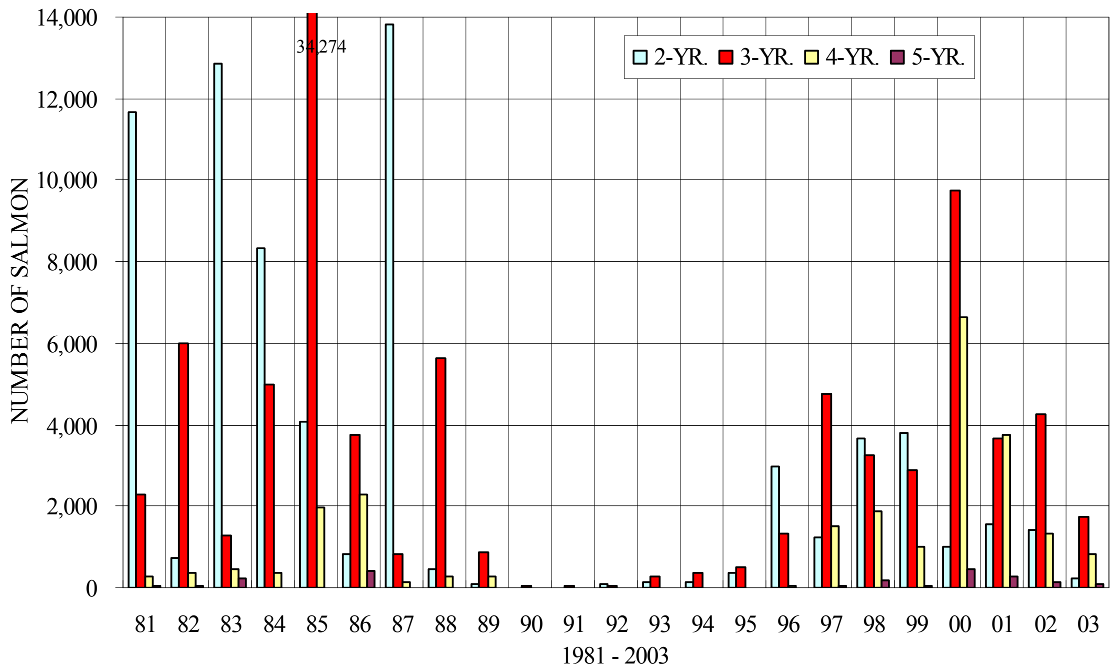


Figure 3.5.2.1-5 Estimated salmon numbers in Tuolumne runs by age class.

A linear regression analysis of the logarithmic values for estimated 2-year old salmon and the following year estimated 3-year olds resulted in an r^2=. 88 for the 1981–2002 period, excluding the 1984 outlier (Fig. 3.5.2.1-6). A similar analysis for estimated 2-year old female salmon only and the following year estimated 3-year old females resulted in an r^2= 0.84 (Fig. 3.5.2.1-7). These analyses indicate a high degree of correlation for both 2-year old salmon (both sexes) and 2-year old females returning the following year as 3-year olds of that brood year. The data for analysis that would include 3-year old salmon in 2004 is unavailable at this time.

Large numbers of CWT hatchery salmon have been released into the Tuolumne River or nearby San Joaquin River since 1986 as part of the Tuolumne River smolt survival evaluations (see Figure 3.5.2.1-8). In addition, smaller numbers of mostly untagged color (Panjet) marked salmon have been released since 1995 as part of the rotary screw trap evaluations (and other survival evaluations in 1998–2000). Other large releases of CWT salmon were made by CDFG in the Merced, Stanislaus, and San Joaquin Rivers. In addition, CDFG releases large numbers of unmarked hatchery salmon in some years in the Merced River. As a result of these releases, the number of CWT salmon comprising the Tuolumne River run has generally ranged from 10-25% since 1989, with the exception of a higher percentage in 1990, 1991, and 2002 and a smaller percentage in the 2000 run (Fig. 3.5.2.1-9).

For the 1981–2003 period, the estimated number of CWT salmon ranged from a low of 0 in 1981-82 to a high of about 2,175 in 2002 (Fig. 3.5.2.1-8). Most of the Tuolumne River CWTs are of Merced River Hatchery origin, especially the Tuolumne River and south delta smolt study releases (Fig. 3.5.2.1-10).

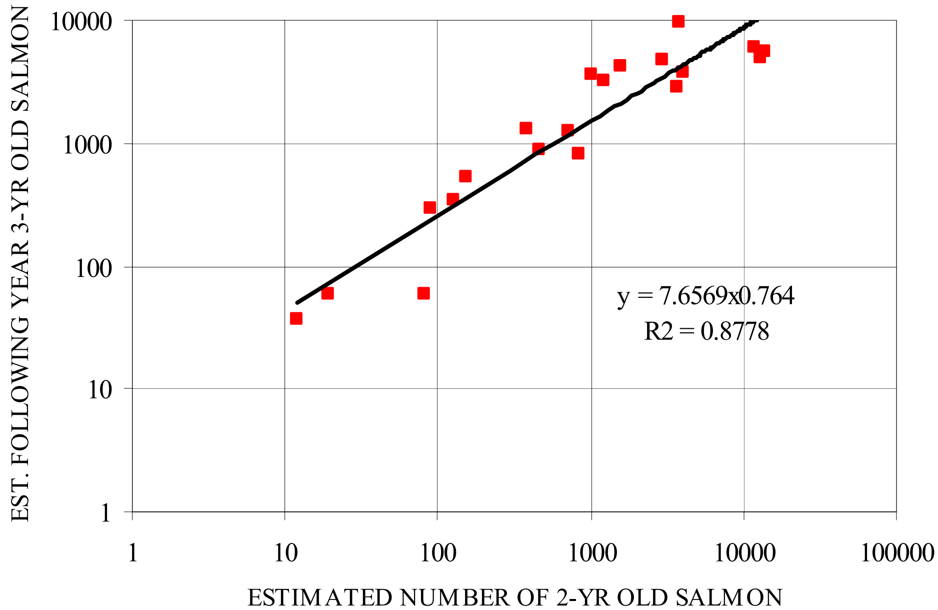


Figure 3.5.2.1-6 Estimated 2-year old salmon v. following year 3-yr old salmon.

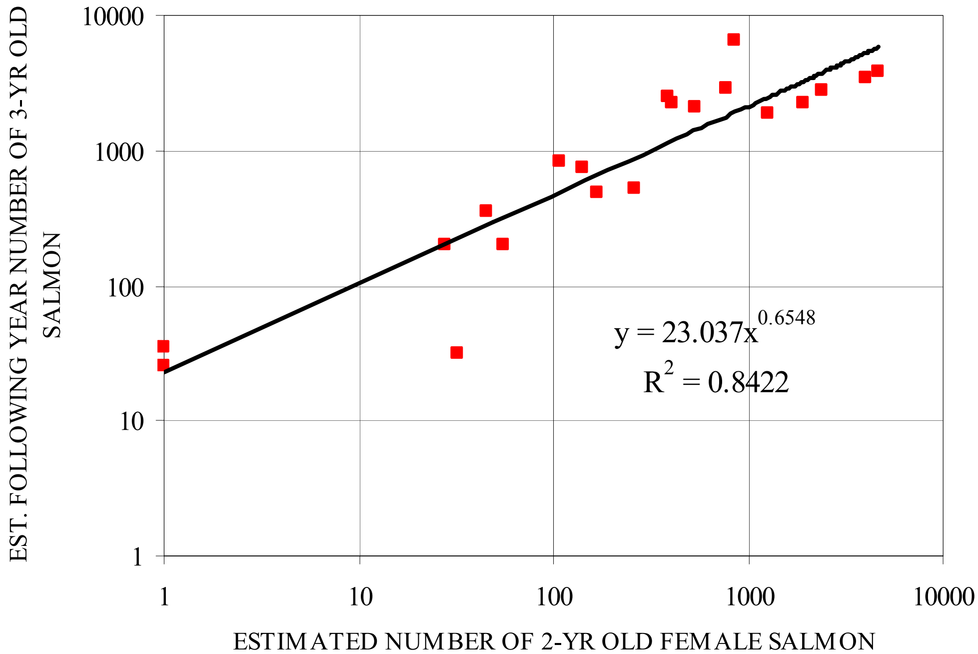


Figure 3.5.2.1-7 Estimated 2-year old female salmon v. following year 3-yr old female salmon.

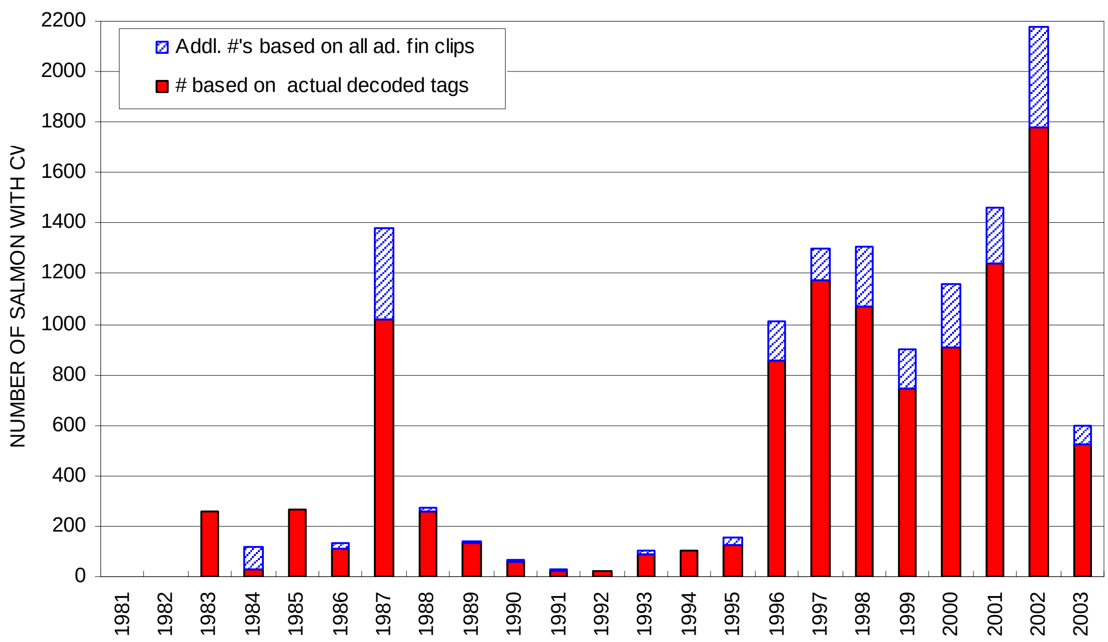


Figure 3.5.2.1-8 Estimated number of CWT salmon in Tuolumne runs.

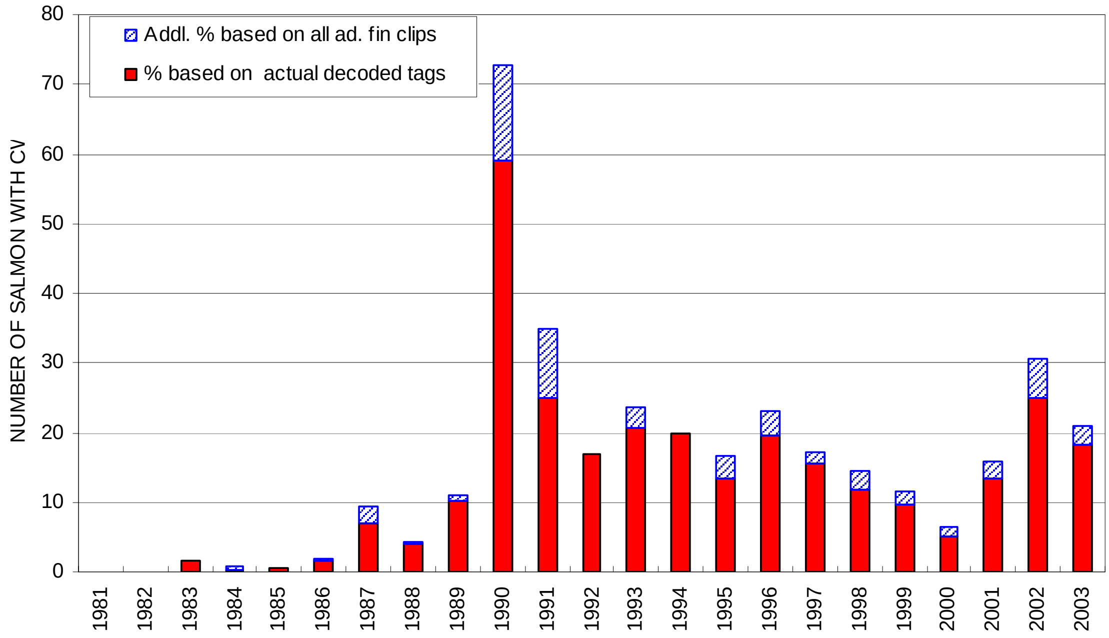


Figure 3.5.2.1-9. Estimated percentage of CWT salmon in Tuolumne runs.

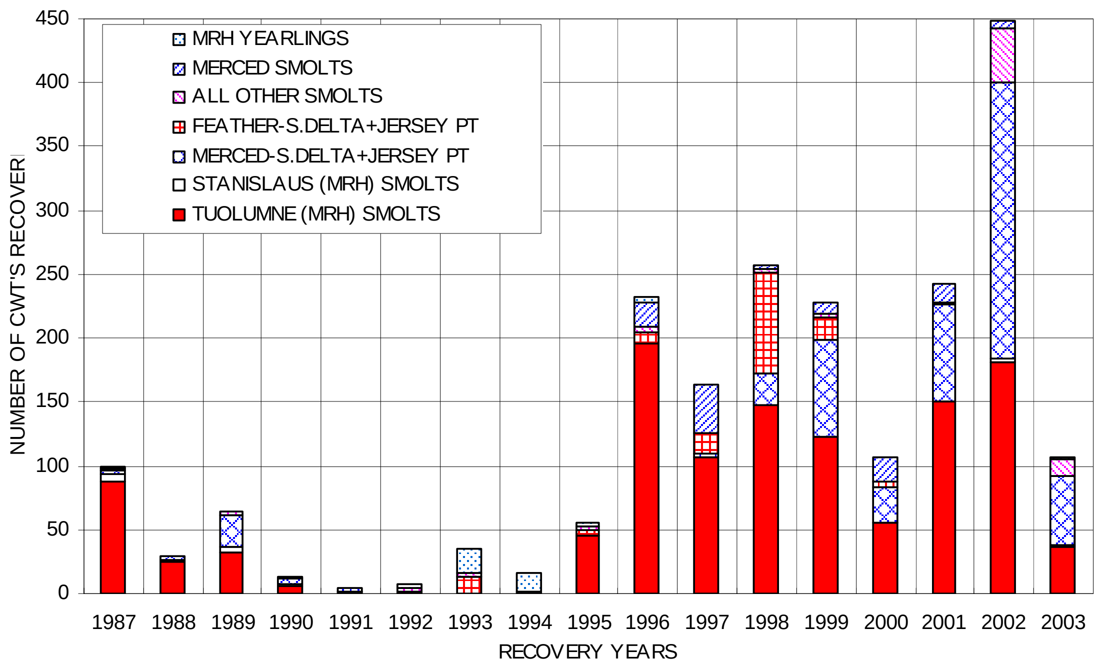


Figure 3.5.2.1-10 Number of CWT salmon carcasses recovered in the Tuolumne River shown by the origin and release location.

3.5.2.2 Seine surveys

The 1995 FSA identified two periods and areas of seine monitoring – 15JAN to 15MAR for 4 years from La Grange to Waterford (Sec. 13c) and 15MAR to 15JUN for 10 years for the entire river (FSA Sec. 13e). The TRTAC decided to continue existing riverwide seine surveys, which the Districts had done since 1986, from JAN-MAY each year, including some San Joaquin River sites, to provide a consistent and comparable ongoing program. A specific element of FSA Sec. 13c was to compare the salmon fry density obtained by seining to the estimated number of female salmon spawning during the prior fall. As detailed in FERC Report 1996-2, it was concluded that the seining survey was not designed to provide information on survival to emergence success in specific reaches or riffles. However, analysis of riverwide average and peak fry densities and estimated female spawners was presented and has been updated annually. FSA Sec. 13d also had fry distribution monitoring. The seine surveys documented fry distribution and supplemented other seasonal sampling, such as the rotary screw trapping reported in Sec. 3.5.2.4 of this report.

The Districts have provided annual reports of seining surveys, including summary updates that review several recent years. Annual seine reports contain (1) salmon density by location, by river section, and for the total river, (2) comparisons of riverwide and section density, (3) fry density to female salmon, and (4) capture data for all fish species. Data for the 1996–2004 period are primarily addressed in this report, although more years are included on some aspects. Water temperature data collection was also required in FSA Sec. 13e and thermograph and air temperature data are covered in Sec. 3.5.1.2 of this report. Data for other fish species is covered in Sec. 3.5.3.1 of this report.

The seining survey reach for 1996–2004 was the Tuolumne River from La Grange Dam (RM 52.0) to its confluence with the San Joaquin River (RM 83.8) and the San Joaquin River from Laird Park (RM 90.2) to Gardner Cove (RM 77.8). Since 1996, 6 to 8 locations have been sampled on the Tuolumne and 2 in the San Joaquin (Table 3.5.2.2-1). Each location was sampled between 8 and 11 times per year, usually from January through May (Table 3.5.2.2-2). Flow conditions for the 1996–2004 period varied widely, with 1996-1998 having the highest flows, 1999 and 2000 with moderate flows, and 2001–2004 with the lowest flows.

Table 3.5.2.2-1. Seining sites for Tuolumne and San Joaquin Rivers from 1986–2004.

TUOLUMNE RIVER																					
Site	**Location**	**River Mile**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
1	Old La Grange Bridge	50.5	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X
2	Riffle 4B	48.4	X	X	X	X	X	X				X	X	X	X						
3	Riffle 5	47.9		X	X	X	X	X	X	X	X					X	X	X	X	X	X
4	Tuolumne River Resort	42.4			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Turlock Lake State Rec. Area	42.0	X	X																	
6	Reed Gravel	34.0	X	X	X	X	X	X													
7	Hickman Bridge	31.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	Charles Road	24.9		X	X	X	X	X	X	X				X	X	X	X	X	X	X	X
9	Legion Park	17.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Riverdale Park / Venn	12.3 / 7.4		X	X	X	X	X								X	X	X	X	X	X
11	McCleskey Ranch	6.0	X	X	X	X	X	X	X	X	X										
12	Shiloh Bridge	3.4	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X
SAN JOAQUIN RIVER																					
Site	**Location**	**River Mile**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
13	Laird Park	90.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	Gardner Cove	77.8		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
15	Maze Road	76.6	X	X	X																
16	Sturgeon Bend	74.3		X	X																
17	Durham Ferry Park	71.3	X	X	X	X	X	X	X	X											
18	Old River	53.7		X																	

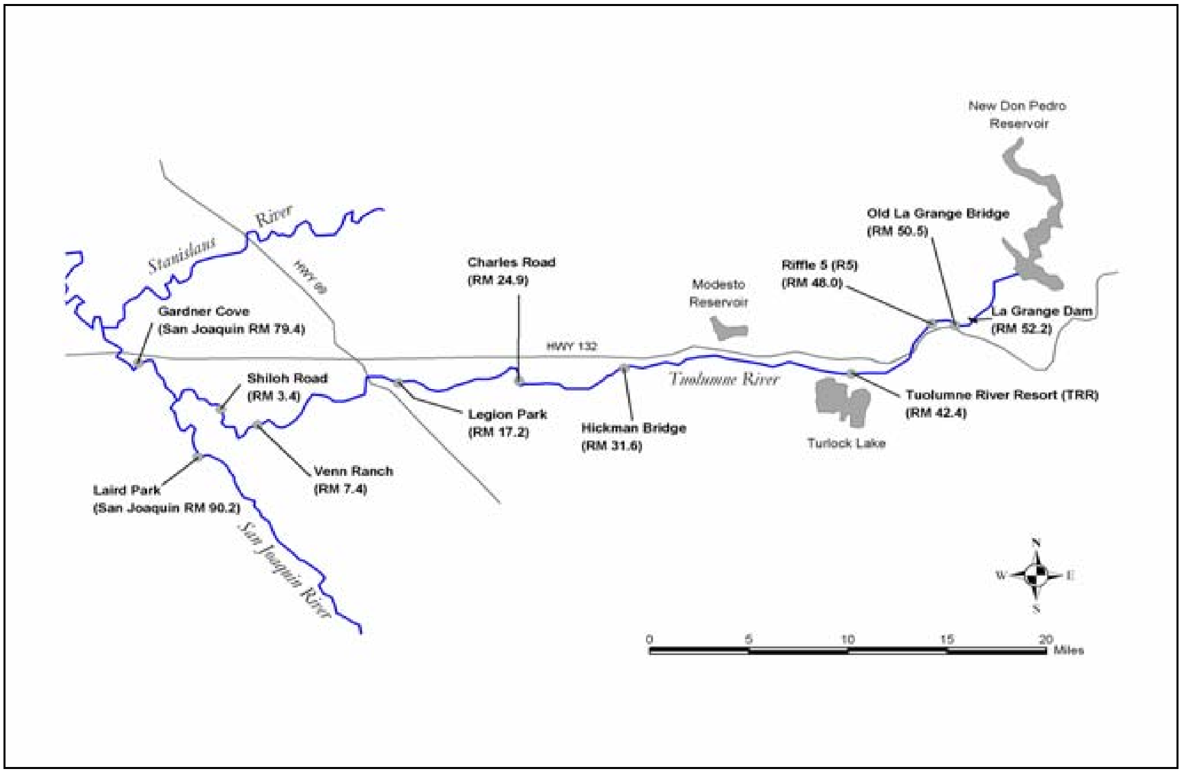


Figure 3.5.2.2-1 Map of 2004 seining locations.

Table 3.5.2.2-2 Seining survey summary for 1986–2004 (Tuolumne and San Joaquin Rivers).

	TUOLUMNE RIVER					SAN JOAQUIN		
Sampling Year	**Sampling Periods**	**Salmon Captured**	**Sites Sampled**	**Average Density**	**Growth Index (est. mm/day)**	**Salmon Captured**	**Sites Sampled**	**Average Density**
1986	18	5514	8	20.7	0.45	854	3	14.2
1987	21	14825	11	22.4	0.45	734	6	1.9
1988	14	6134	11	14.3	0.58	295	4	2.1
1989	13	10043	11	27.0	0.64	83	3	0.6
1990	14	2286	11	6.0	0.57	48	3	0.5
1991	8	120	11	0.5	No estimate	0	3	0.0
1992	5	144	7	1.2	No estimate	0	3	0.0
1993	7	124	8	0.8	0.68	0	3	0.0
1994	7	2068	5	21.6	0.65	2	2	0.0
1995	8	512	5	6.1	0.79	43	2	1.1
1996	8	785	6	7.6	0.66	7	2*	0.2
1997	10	379	7	2.7	0.48	11	2*	0.4
1998	10	1950	7	14.4	0.46	99	2	2.5
1999	10	3443	8	24.6	0.54	560	2	13.6
2000	10	3213	8	27.0	0.46	19	2	0.6
2001	11	5567	8	41.3	0.67	83	2	2.6
2002	10	3486	8	25.6	0.64	0	2	0.0
2003	10	5983	8	39.3	0.68	1	2	0.0
2004	11	3280	8	19.3	0.55	0	2	0.0

--- Not Sampled
*All San Joaquin River locations were not always sampled

Seining was done using 6-ft high, 1/8-inch mesh nylon seine nets in lengths of 20 or 30 feet. The same general areas were sampled each time to permit comparisons through the sampling period, but sample areas varied somewhat as a result of changes in flow. Seine hauls were made with the current and parallel to shore. The salmon caught were anesthetized with MS-222, measured (FL in mm) and then revived before being released. Other measurements made were area sampled, (determined from estimating average length and width of a seine haul) water temperature, visibility, EC, and maximum depth of the area sampled. Other observations include time of day, weather conditions, habitat type, and substrate type. Other fish species were recorded separately. Any salmon undergoing outward signs of smoltification, such as losing scales during handling, were also noted.

The increase in average fork length (FL) during the January to April period was similar in timing and magnitude for 1998–2004 (Fig. 3.5.2.2-2). The two prior years exhibited similar magnitude to the pattern but were about 2-3 weeks earlier in their timing, indicating earlier emergence. By mid-April, average FL varies greatly, probably reflecting some smolt-sized fish (>70 mm) leaving the river. Minimum FL usually remained low into May and was similar for most years (Fig. 3.5.2.2-3). Maximum FL generally increases from mid-January to mid-April and exhibits the largest range in variability between years (Fig. 3.5.2.2-4). An indirect method to estimate growth rate was used by dividing the amount of increase in maximum FL, over an extended period of time, by the number of days during the period. Estimated growth rate using this method ranged from .46 mm/day to .68 mm/day for the 1996–2004 period of years, averaging .57 mm/day (Table 3.5.2.2-2).

Fry densities rapidly increase from mid January, reach their peak, and decline by mid-March (Figure 3.5.2.2-5). Densities of juvenile salmon (>50mm FL) are much lower in magnitude than fry densities and generally peak between late February to early April and decline through May (Figure 3.5.2.2-6) .

Analysis of peak and average fry density vs. female spawners for the 15JAN-15MAR period for the years 1986 to 2003 indicates a positive correlation between the two factors (Figures 3.5.2.2-7 -8). The relatively low number of fry captured in 1997 is likely due to the scouring effects of flood releases in early January 1997 on incubating eggs/alevins in the gravel combined with massive movement of fry downstream of the Tuolumne River.

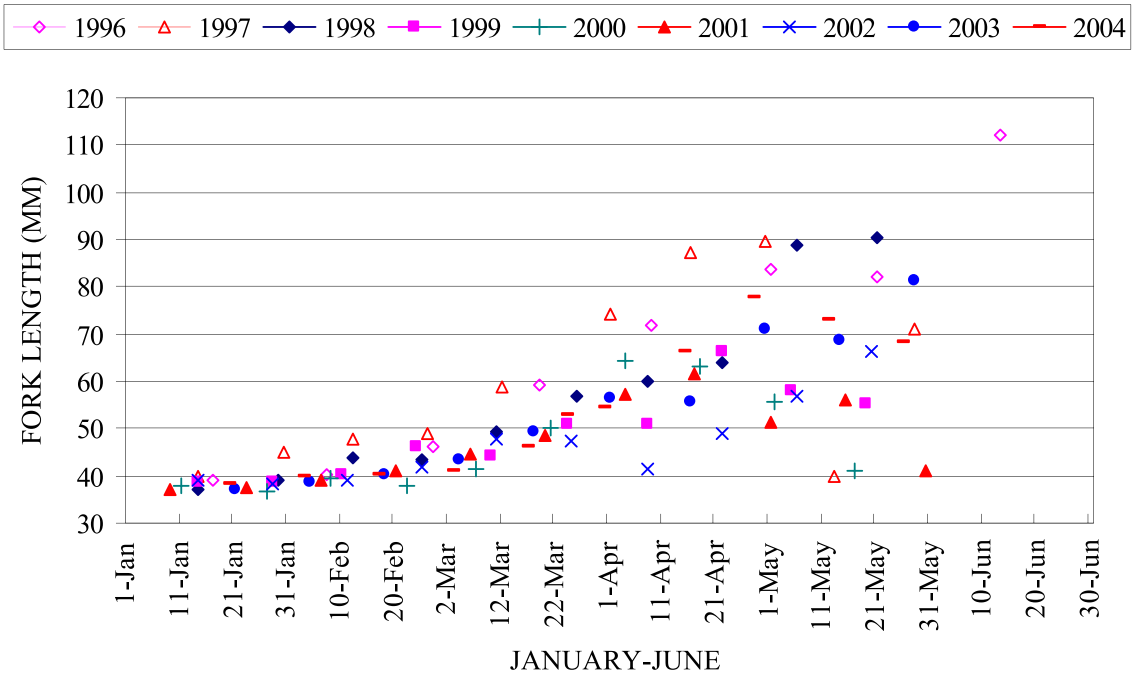


Figure 3.5.2.2-2 Average fork length for salmon from seining in 1996–2004.

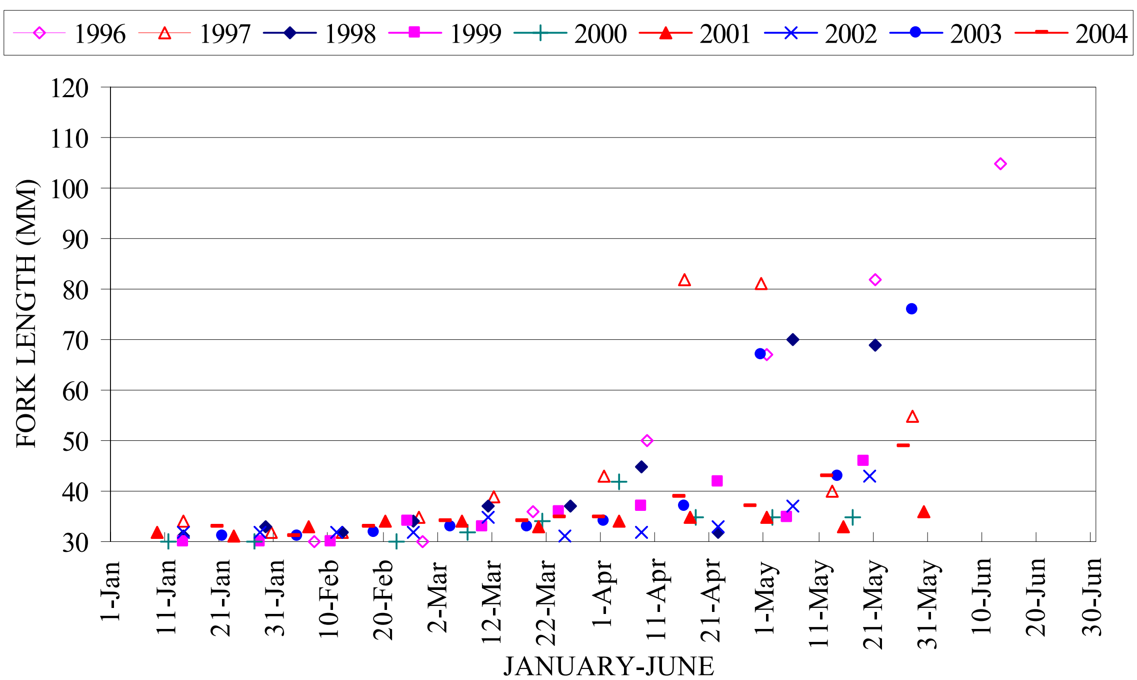


Figure 3.5.2.2-7 Peak salmon from seining in 1996–2004.

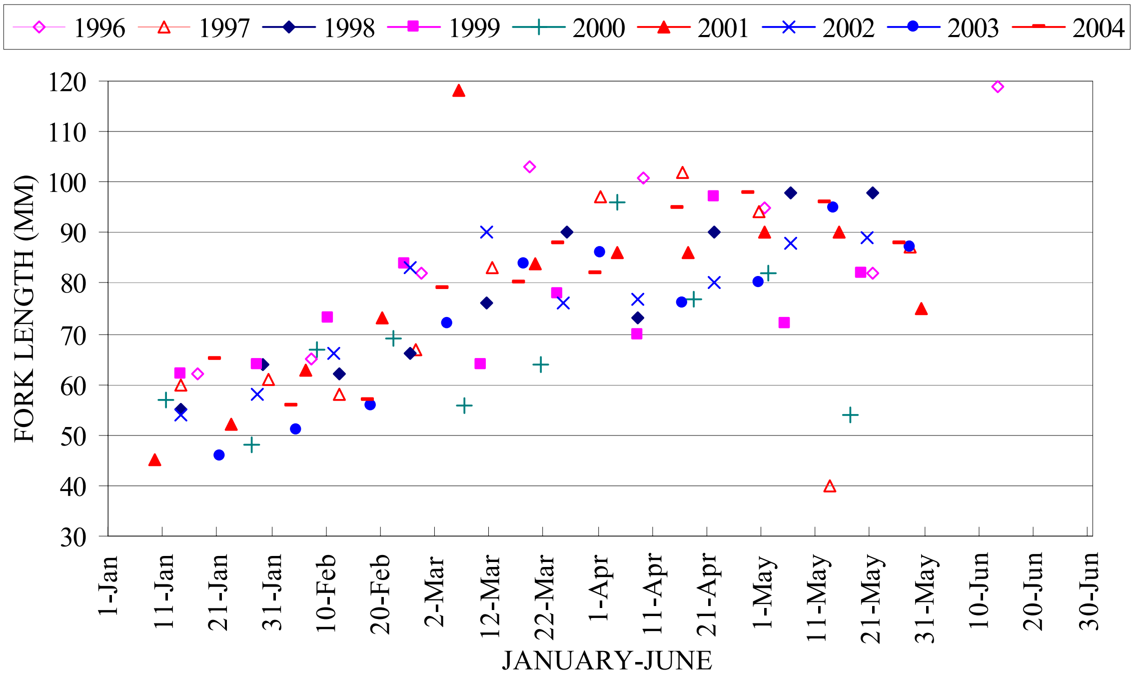


Figure 3.5.2.2-4 Maximum fork length for salmon from seining in 1996–2004.

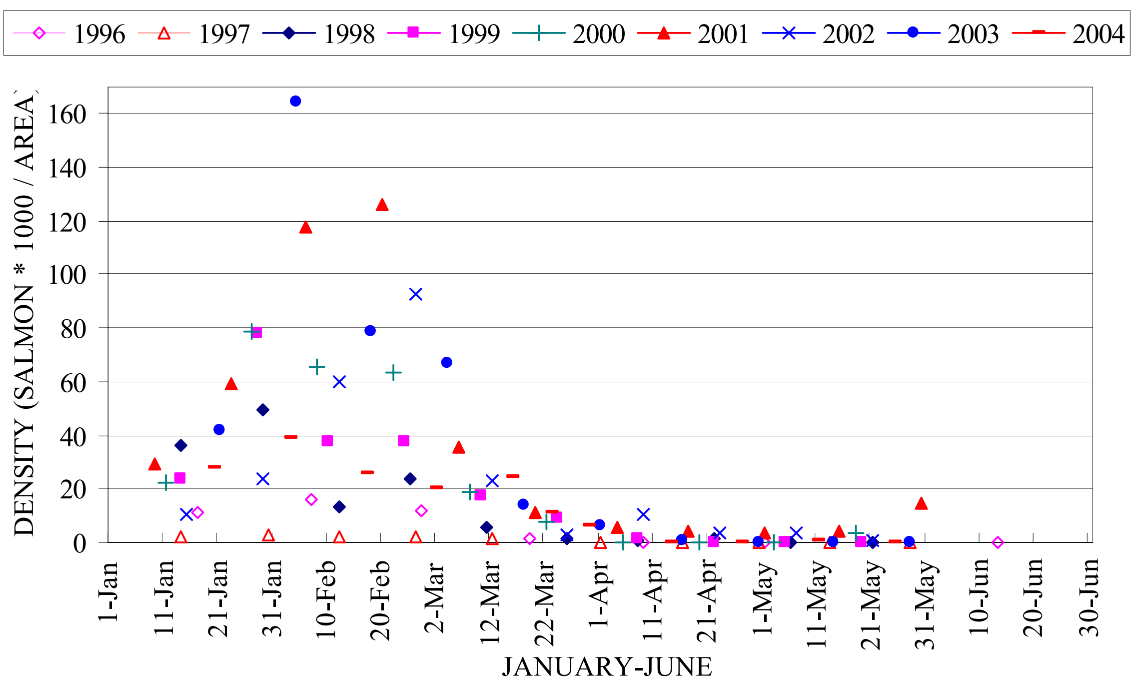


Figure 3.5.2.2-5. Density for fry salmon (< 50mm FL) from seining in 1996–2004.

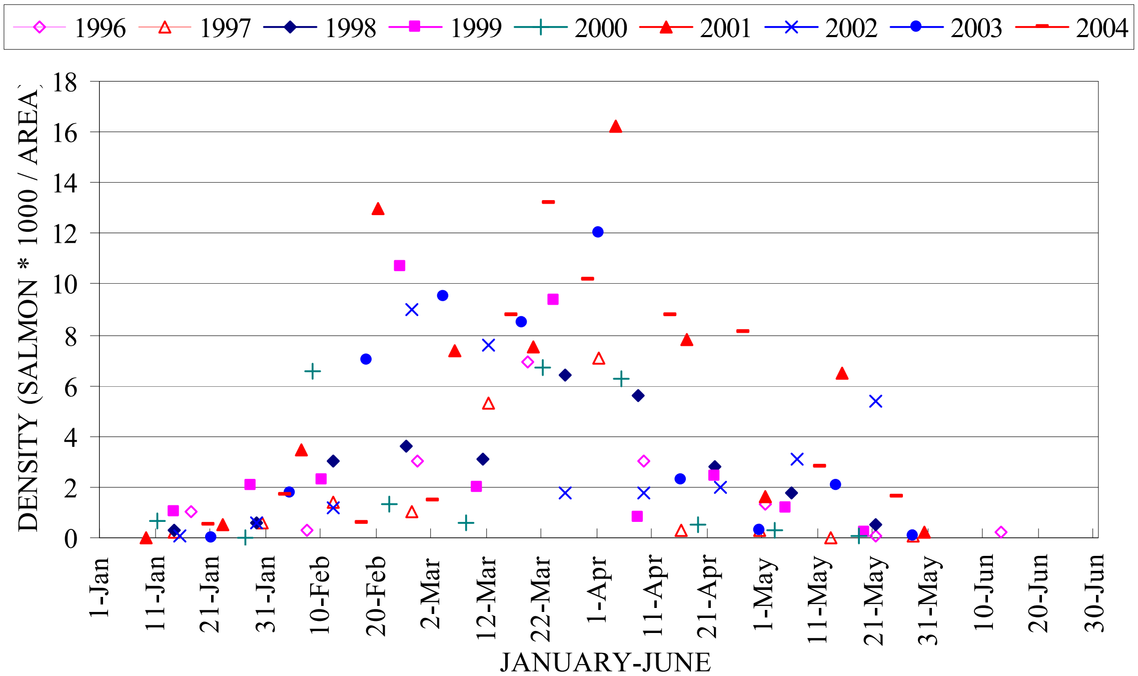


Figure 3.5.2.2-6. Density for juvenile salmon (>50mm FL) from seining in 1996–2004.

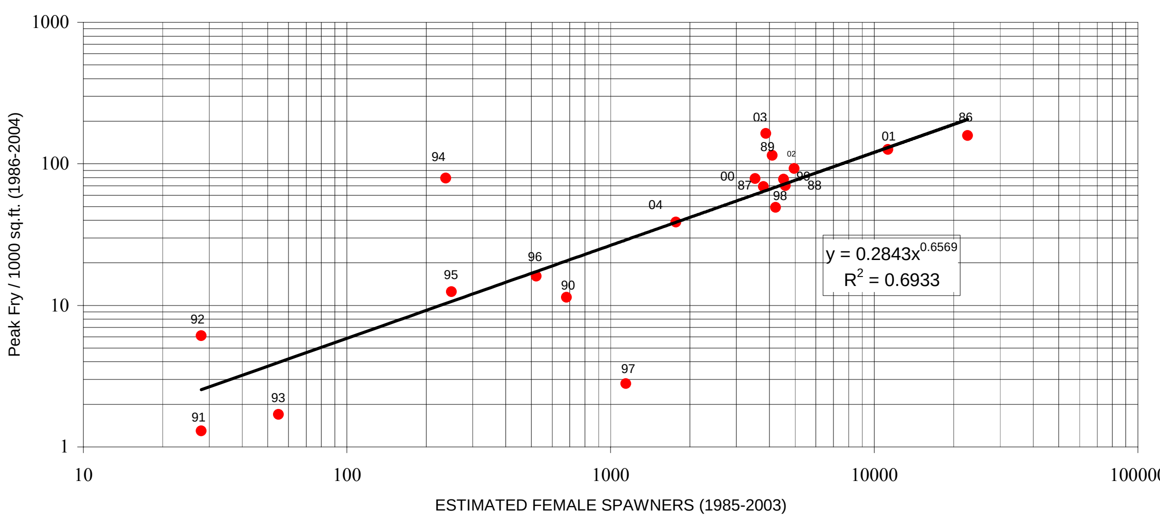


Figure 3.5.2.2-7 Peak salmon fry density from seining vs. estimated female spawners (1985–2003).

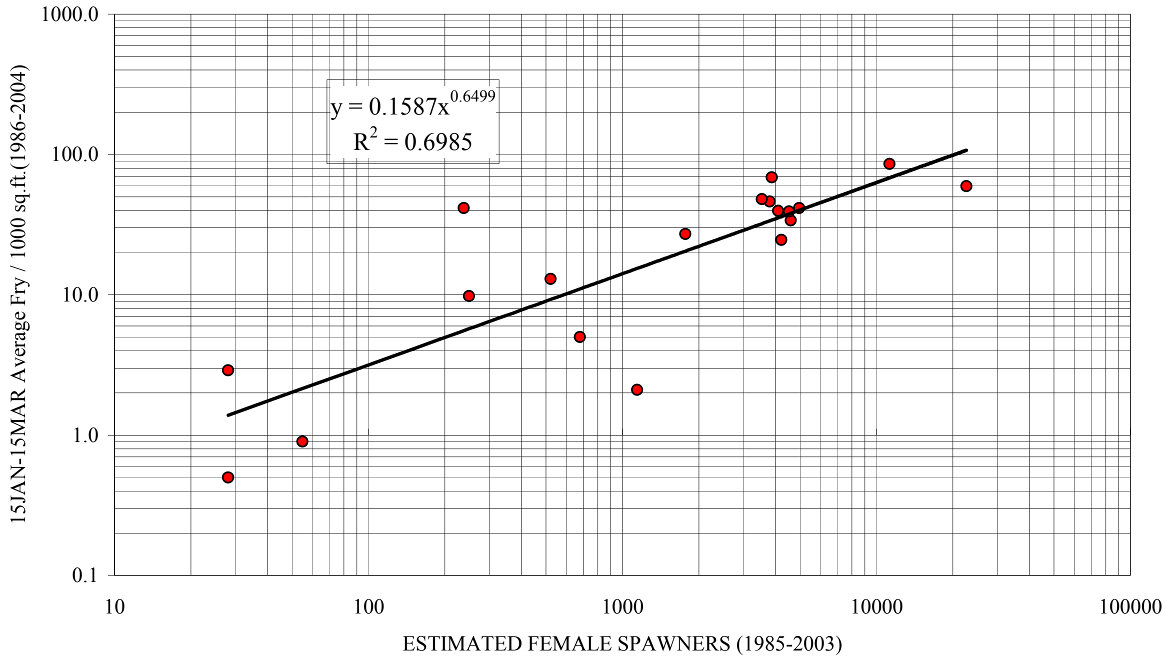


Figure 3.5.2.2-8 Average salmon fry density from seining vs. estimated female spawners (1985–2003).

3.5.2.3 Snorkel surveys

Annual snorkel surveys in early summer were done in most years since 1996 as part of the riverwide FSA monitoring, although surveys were not done in high flow years such as 1998. The precursor to these surveys was the Districts' 1988-1994 summer flow studies that included snorkel surveys. Snorkel surveys were initially done in the reach from La Grange to Waterford (RM 51-31) at 9 sites. The number, location, and area sampled by site have varied over the years (Table 3.5.2.3-1). In 1996, the upper section of riffles upstream of Basso Bridge was surveyed by CDFG utilizing different methodology that was not comparable. The 1995 FSA June snorkeling was expanded to 12 sites in 2001, following a pilot effort at 19 sites in JUN2000. The Districts added an annual 12-site snorkel survey in SEP in 2001 and conducted a supplemental August survey in 2004. Sites used in June and September of 2004 are in Fig. 3.5.2.3-1.

Observations were conducted using an underwater "sightings" per unit effort method where a person would snorkel a specified area for a given period of time and record the species, numbers, and sizes of fish observed. A combination of different habitat types were observed, including riffles, runs, and pools. The overall river section examined is limited to the reach with suitable underwater visibility, this generally being the 20-mile section below La Grange Dam downstream to Waterford. The snorkeling method employed provides an index of species abundance as the fish/unit of effort is recorded for time and area covered. Number and size of fish observed at each site are counted or estimated for each species.

Each habitat type sampled mostly involved one observer snorkeling a specified habitat area for a certain time period. Whenever feasible, the surveys were conducted moving upstream against the current - a side-to-side (zigzag) pattern was used if the width of the survey section allowed. Occasionally, two snorkelers moved upstream in tandem, with each person counting fish on their side of the center of the survey section. Whenever possible, the entire width of the habitat section selected was carefully surveyed. The only exceptions were the habitat areas that are too wide to effectively cover. If high water velocity precluded upstream movement, snorkelers may have floated downstream with the current, remaining as motionless as possible through the study area, although stream margins at those sites may have been viewed in an upstream direction.

Usually, when a snorkeler observed a fish, the total length of the fish was estimated using a ruler outlined on the diving slate to the nearest 10 mm. For some larger fish, the lengths may have been estimated by viewing the fish in reference to adjacent objects and then measuring that estimated length. In cases where larger numbers of fish are observed, the observer estimated the length range and number of fish in the group. Care was taken to observe and count fish just once as fish passed by. Other data that was recorded at each location included water temperature, electrical conductivity, turbidity, horizontal visibility, area sampled, average depth, sample time, general habitat type and substrate type. Discussion for other species is covered in Sec. 3.5.3.1 of this report.

The count and density indices of salmon observed during the 1996–2004 period of years are summarized in Tables 3.5.2.3-2 & 3. Surveys conducted since 2000 are the most comparable because the sites surveyed were most similar. In general, Chinook salmon counts are highest in the section of river upstream of Riffle 5B (RM 47.9) and during the early summer survey period. Salmon were observed at Riffle 57 (RM 31.5), near Waterford in July 1996 and June1999. The number and relative density observed during the early summer period were similar in most years since 2000. In all years except 2000, Chinook were observed at least to the Riffle 21/Riffle 23 locations about 10 miles downstream of the La Grange Dam. In June 2003 and June 2004 salmon were observed downstream to Riffle 35A (RM 37.0).

Late summer surveys began in 2001. The number of salmon observed and their distribution in the river was much smaller than seen in the early summer period. Salmon were not observed downstream of Riffle 7 (RM 46.9) except during the September 2003 survey when they were seen downstream to RM 35.5.

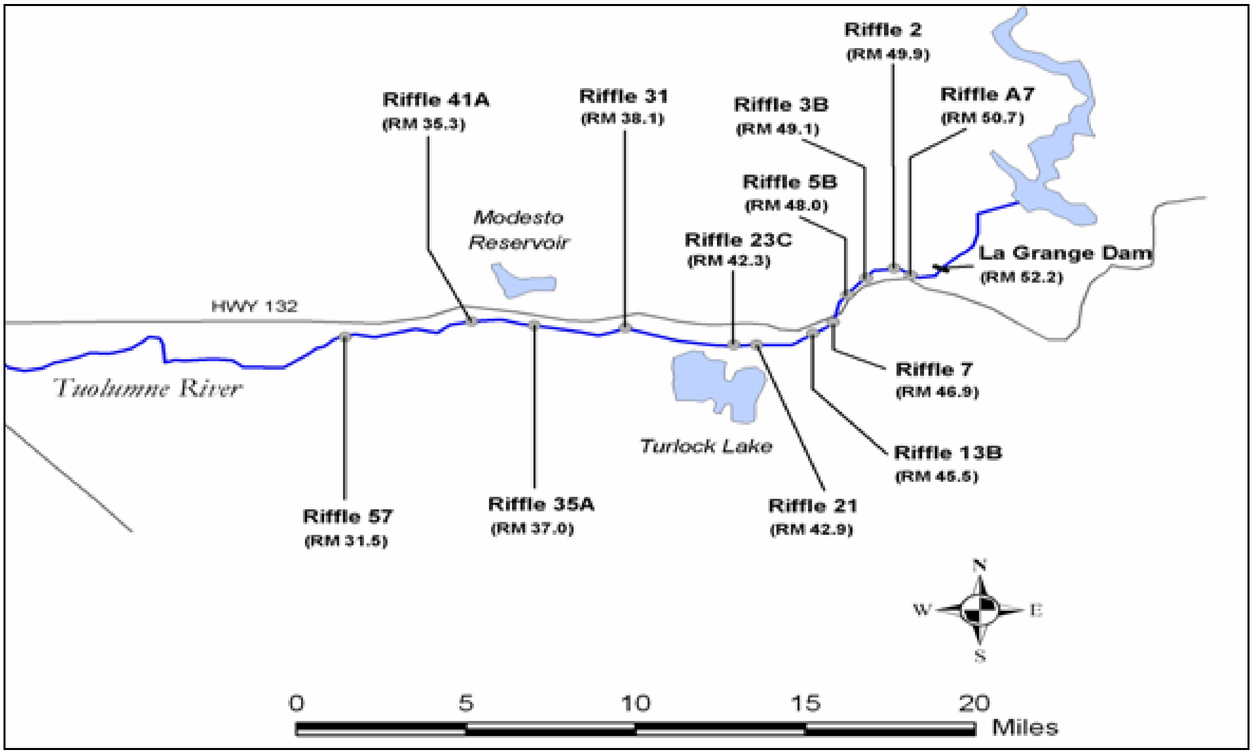


Figure 3.5.2.3-1 Snorkel survey sites in June and September, 2004

Table 3.5.2.3-1. Snorkel survey locations and month.

	RM	51.6	50.7	50.4	49.9	49.1	48.4	48.0	46.9	46.4	45.8	45.6	44.4	42.9	42.3	42.0	40.9	40.3	38.5	38.1	37.8	37.0	36.7	36.2	35.4	35.3	34.0	32.2	31.5	24.9
	Riffle	A3/A4	A7	1A	2	3B	4B	5B	7	9	12	13A-B	17A2	21	23B-C	24	26	27	30B	31	33	35A	36A	37	39-40	41A	46	52B	57-58	Charles
1982	AUG				X		X	X																						
1984	APR						X	X																					X	
	AUG	X	X		X			X																						
1985	MAR	X					X	X																					X	
1986	JUL						X									X											X			
	AUG	X	X		X		X	X																						
	JAN				X			X																			X			
1987	APR			X	X			X																X						
	OCT	X	X																											
1988[1]	MAY	X			X			X		X					X						X				X			X		X
	SEP	X			X			X		X					X						X				X			X		X
1989[1]	MAY	X	X		X			X		X					X						X				X				X	X
	SEP	X	X		X			X		X					X						X				X				X	X
1990[1]	JUN	X			X			X		X					X						X				X				X	X
	SEP	X			X			X		X					X						X				X				X	X
1991	JUN	X			X			X		X					X										X				X	X
	SEP	X			X			X		X					X										X				X	X
1992	JUN	X			X			X		X					X										X				X	X
	SEP	X			X			X		X					X										X				X	X
	MAY	X	X	X	X		X	X		X		X				X							X						X	
1993	JUN	X	X	X	X					X															X				X	X
	JUL	X	X					X							X								X							
	OCT	X	X	X	X					X															X				X	X
1994	MAY		X					X							X								X						X	
	JUL	X			X			X		X															X				X	
	OCT	X			X			X		X															X				X	X
1995	NOV	X	X					X								X														
1996	JUL		X	X	X	X	X	X	X					X								X	X						X	
1997	JUN	X	X		X	X		X	X						X								X						X	
1999	JUN		X		X	X		X	X						X				X				X						X	
2000	JUN		X	X		X		X	X		X	X	X	X	X		X	X		X		X		X		X	X	X	X	
2001	JUL		X		X	X		X	X			X		X	X					X				X		X			X	

	RM	51.6	50.7	50.4	49.9	49.1	48.4	48.0	46.9	46.4	45.8	45.6	44.4	42.9	42.3	42.0	40.9	40.3	38.5	38.1	37.8	37.0	36.7	36.2	35.4	35.3	34.0	32.2	31.5	24.9
	Riffle	A3/A4	A7	1A	2	3B	4B	5B	7	9	12	13A-B	17A2	21	23B-C	24	26	27	30B	31	33	35A	36A	37	39-40	41A	46	52B	57-58	Charles
	SEP		X		X	X		X	X			X		X	X					X				X		X			X	
2002	JUN		X		X	X		X	X			X		X	X				X			X				X			X	
	SEP		X		X	X		X	X			X		X	X				X			X				X			X	
2003	JUN		X		X	X		X	X			X		X	X					X		X				X			X	
	SEP		X		X	X		X	X			X		X	X					X		X				X			X	
2004	JUN		X		X	X		X	X			X		X	X					X		X				X			X	
	AUG	X	X	X	X	X	X	X	X	X		X		X	X					X		X				X			X	
	SEP		X		X	X		X	X			X		X	X					X		X				X			X	

(1) Some limited additional snorkeling was conducted during the summer flow study period in these years

CDFG surveyed from RA7 to R5B using incomparable methodology

Table 3.5.2.3-2 Yearly comparison of salmon observed during the 1996–2004 snorkel surveys.

DATES	1996	1997	1999	2000	2001	2001	2002	2002	2003	2003	2004	2004	2004
LOCATIONS	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	Sept. 18-20	June 11-13	Sept. 24-26	June 18-20	Sept. 17-19	June 16-18	Aug. 3-6	Sept. 15-17
Riffle A7 (RM 50.7)	20	0	23	211	277	21	429	2	426	2	390	77	0
Riffle 1A (RM 50.4)	29	-	-	47								0	
Riffle 2 (RM 49.9)	16	0	3	-	4	0	10	0	72	1	16	0	0
Riffle 3B (RM 49.1)	4	0	108	34	52	0	83	0	16	3	59	3	0
Riffle 5B (RM 47.9)	56	0	20	35	47	0	17	0	4	4	4	0	0
Sec. Total	**125**	**0**	**154**	**327**	**380**	**21**	**539**	**2**	**518**	**10**	**469**	**80**	**0**
Riffle 7 (RM 46.9)	20	1	57	0	17	0	15	1	0	0	4	0	0
Riffle 12 (RM 45.8)	-	-	-	6									
Riffle 13A-B (RM 45.6)	-	-	-	5	6	0	10	0	9	0	3	0	0
Riffle 17A2 (RM 44.4)	-	-	-	0									
Riffle 21 (RM 42.9)	2	-	-	0	0	0	1	0	0	1	7	0	0
Riffle 23B-C (RM 42.3)	-	2	1	0	1	0	2	0	8	0	1	0	0
Sec. Total	**22**	**3**	**58**	**11**	**24**	**0**	**28**	**1**	**17**	**1**	**15**	**0**	**0**
Riffle 26 (RM 40.9)	-	-	-	0									
Riffle 27 (RM 40.3)	-	-	-	0									
Riffle 30B (RM 38.5)	-	-	0	-				0	0				
Riffle 31 (RM 38.1)	-	-	-	0	0	0				0	0	0	0
Riffle 35A (RM 37.0)	0	-	-	0			0	0	2	1	7	0	0
Riffle 36A (RM 36.7)	0	0	0	-									
Riffle 37 (RM 36.2)	-	-	-	0	0	0							
Sec. Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**7**	**0**	**0**
Riffle 41A (RM 35.3)	-	-	-	0	0	0	0	0	0	1	0	0	0
Riffle 46 (RM 34.0)	-	-	-	0									
Riffle 52B (RM 32.2)	-	-	-	0									
Riffle 57 (RM 31.5)	1	0	1	0	0	0	0	0	0	0	0	0	0
Sec. Total	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Grand Total	**148**	**3**	**213**	**338**	**404**	**21**	**567**	**3**	**537**	**13**	**491**	**80**	**0**

CDFG did not provide area measurements needed to calculate density indices

Table 3.5.2.3-3 Yearly comparison of density indices for salmon observed during the 1996–2004 snorkel surveys.

YEAR	1996	1997	1999	2000	2001	2001	2002	2002	2003	2003	2004	2004	2004
LOCATIONS	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	Sept. 18-20	June 11-13	Sept. 24-26	June 18-20	Sept. 17-19	June 16-18	Aug. 3-6	Sept. 15-17
Riffle A7 (RM 50.7)		0.00	5.44	37.02	44.68	2.97	45.20	0.14	40.09	0.21	36.62	6.58	0.00
Riffle 1A (RM 50.4)		-	-	9.40								0.00	
Riffle 2 (RM 49.9)		0.00	0.43	-	0.38	0.00	0.60	0.00	5.96	0.09	1.07	0.00	0.00
Riffle 3B (RM 49.1)		0.00	24.55	7.08	4.77	0.00	9.40	0.00	1.56	0.33	6.63	0.19	0.00
Riffle 5B (RM 47.9)		0.00	3.09	5.67	4.53	0.00	0.80	0.00	0.27	0.32	0.42	0.00	0.00
Sec. Total		**0.00**	**6.95**	**15.09**	**10.02**	**0.45**	**9.76**	**0.03**	**10.83**	**0.24**	**10.65**	**0.59**	**0.00**
Riffle 7 (RM 46.9)	13.33	0.21	21.92	0.00	2.36	0.00	2.40	0.19	0.00	0.00	0.42	0.00	0.00
Riffle 12 (RM 45.8)	-	-	-	1.13									
Riffle 13A-B (RM 45.6)	-	-	-	2.94	1.64	0.00	1.50	0.00	1.18	0.00	0.33	0.00	0.00
Riffle 17A2 (RM 44.4)	-	-	-	0.00									
Riffle 21 (RM 42.9)	1.14	-	-	0.00	0.00	0.00	0.20	0.00	0.00	0.17	0.89	0.00	0.00
Riffle 23B-C (RM 42.3)	-	0.53	0.70	0.00	0.21	0.00	0.50	0.00	1.68	0.00	0.16	0.00	0.00
Sec. Total	**6.77**	**0.35**	**14.41**	**0.53**	**1.27**	**0.00**	**1.29**	**0.04**	**0.67**	**0.04**	**0.46**	**0.00**	**0.00**
Riffle 26 (RM 40.9)	-	-	-	0.00									
Riffle 27 (RM 40.3)	-	-	-	0.00									
Riffle 30B (RM 38.5)	-	-	0.00	-				0.00	0.00				
Riffle 31 (RM 38.1)	-	-	-	0.00	0.00	0.00				0.00	0.00	0.00	0.00
Riffle 35A (RM 37.0)	0.00	-	-	0.00			0.00	0.00	0.26	0.14	0.72	0.00	0.00
Riffle 36A (RM 36.7)	0.00	0.00	0.00	-									
Riffle 37 (RM 36.2)	-	-	-	0.00	0.00	0.00							
Sec. Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.12**	**0.07**	**0.32**	**0.00**	**0.00**
Riffle 41A (RM 35.3)	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00
Riffle 46 (RM 34.0)	-	-	-	0.00									
Riffle 52B (RM 32.2)	-	-	-	0.00									
Riffle 57 (RM 31.5)	1.25	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sec. Total	**1.25**	**0.00**	**0.74**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**0.00**	**0.00**

CDFG did not provide area measurements needed to calculate density indices

3.5.2.4 Screw trap monitoring and juvenile salmon production

The 1995 FSA Section 13 identified four monitoring items associated with rotary screw traps (RST) – (1) 15JAN to 15MAR for 4 years with regulated flow fluctuations (FSA Sec. 13d), (2) annual smolt survival indices (FSA Sec. 13f), (3) restoration measure evaluation (FSA Sec. 13f), and (4) annual smolt production (FSA Sec. 13g). The smolt survival indices using coded wire tagged hatchery salmon and restoration measure evaluation using marked hatchery salmon are addressed in Section 3.5.2.5 of this report. This section reviews results for naturally produced salmon and provides a comparison with the capture of hatchery salmon; information on other species caught is presented in Section 3.5.3.1 of this report.

Two 8-foot diameter rotary-screw traps were operated in the lower Tuolumne River at the Grayson (RM 5)/Shiloh Bridge (RM 3.5) locations to monitor the number, size, timing and rate of fry and/or juvenile Chinook salmon and other fishes emigrating from the Tuolumne River (only one trap was used in 1998). The trapping operation was funded under the CVPIA Comprehensive Assessment and Monitoring Program (CAMP) from 1995 to 2002. RST operation in 2003–2004 was done solely under the 1995 FSA. Screw traps were also used at upstream sites in 1998–2000 as part of items 1, 2, and 3 above (Table 3.5.2.4-1). The RST sampling is similar to the previous fyke net monitoring done during 1973-86 (summarized in 1992 FERC Report, Appendix 13) in that the sampling gear is stationary in the river current and operates in the upper part of the water column.

Table 3.5.2.4-1 Rotary screw trap locations, sampling period, and flow range.

Lower RST sites and period of monitoring					Upper RST sites and period of monitoring				
Year	Location	River mile	Period	La Grange Flow Range	Year	Location	River mile	Period	La Grange Flow Range
1995	Shiloh Rd.	3.4	April 25-June 01	4,750-8,710	1998	TLSRA	42.0	February 10-April 13	3,191-7,941
1996	Shiloh Rd.	3.4	April 18-May 29	1,970-6,790		7/11	38.5	April 15-May 31	2,086-6,641
1997	Shiloh Rd.	3.4	April 18-May 24	219-2,860		Charles Rd.	25.0	March 27-May 5	2,086-6,641
1998	Shiloh Rd. (1 trap)	3.4	February 15-July 01	2,040-8,010		Charles Rd.	24.7	May 5-June 1	2,202-4,981
1999	Grayson Ranch	5.2	January 12-June 06	265-7,580	1999	7/11	38.5	January 19-May 16	362-7,582
2000	Grayson Ranch	5.2	January 09-June 12	274-6,610		Hughson	23.7	April 8-May 21	433-3,535
2001	Grayson Ranch	5.2	January 03-May 29	138-3,400	2000	7/11	38.6	January 10-February 27	310-3,663
2002	Grayson Ranch	5.2	January 15-June 06	115-1,310		Deardorff	35.5	April 8-May 24	321-3,843
2003	Grayson Ranch	5.2	April 01-June 06	180-1,340		Hughson	23.7	April 8-May 24	321-3,843
2004	Grayson Ranch	5.2	April 02-June 09	132-1,440					

Lower Tuolumne screw trap sampling

Sampling at the lower RST sites in 1995-97 began in mid to late April in conjunction with smolt survival study fish releases. These later samplings missed the early part of the natural smolt outmigration period. The 2003–2004 sampling began near 01APR. Sampling in 1998–2002 was extended to include much of the winter fry migration period that begins in January, although 1998 sampling did not begin until 15FEB. An example of the deployed traps is in Fig. 3.5.2.4-1.

Figure 3.5.2.4-1 Rotary screw traps at Grayson (RM 5).

In the earlier months sampled in 1998–2002, peaks in fry catch typically occurred in January and February. Changes in flow, particularly flow increases, were associated with higher catches. In 1998, a single RST began operating on February 15 when large numbers of fry were already present and flows were over 5,500 cfs. River flows in 1998 reached nearly 7,000 cfs in late February and early March and fry migration occurred through March (Blakeman, 2004). In 1999 large numbers of fry were captured from late January through early February when Modesto flows increased to over 3,000 cfs and in 2000 much smaller numbers of fry were captured from mid-February to early March when Modesto flows were increased to over 4,000 cfs (Report 2001-1 TID/MID 2002) In 2001 the timing of fry migration was similar to that of 2000 (Report 2002-1 TID/MID 2003) The peak fry migration period occurred from mid-February to mid-March when flows increased between 1,000-3,500 cfs. In 2002 Tuolumne River flows remained constant at about 300 cfs from mid-January to mid-April and fry migration essentially did not occur in 2002 (Blakeman, 2004).

For the later smolt period, peaks in catch were generally related to changes in stream flow, though this may not be as key an element as with fry. Results suggested that other variables than flow (moon phase, turbidity, time of day and weather, physical size) may be involved. In the shorter sample periods of 1995-97, there were 141, 630, and 57 natural smolts captured, respectively (Heyne and Loudermilk 1997, 1998). The numbers of natural smolts captured for the 1998–2002 period of years was not identified in annual CDFG reports. The total catch of natural juvenile salmon in 1998–2002 was 2,521 fish, 19,327 fish, 2,250 fish, 6,478 fish, and 438 fish, respectively (Reports 2001-1 and 2002-1, TID/MID 2002 and 2003; Blakeman 2004a). The total catch in the mostly APR-MAY sampling of 2003–2004 was 359 (Blakeman 2004b) and 509 (Report 2004-5, TID/MID 2005). Figure 3.5.2.4-2 has the daily catch numbers for 1995–2004.

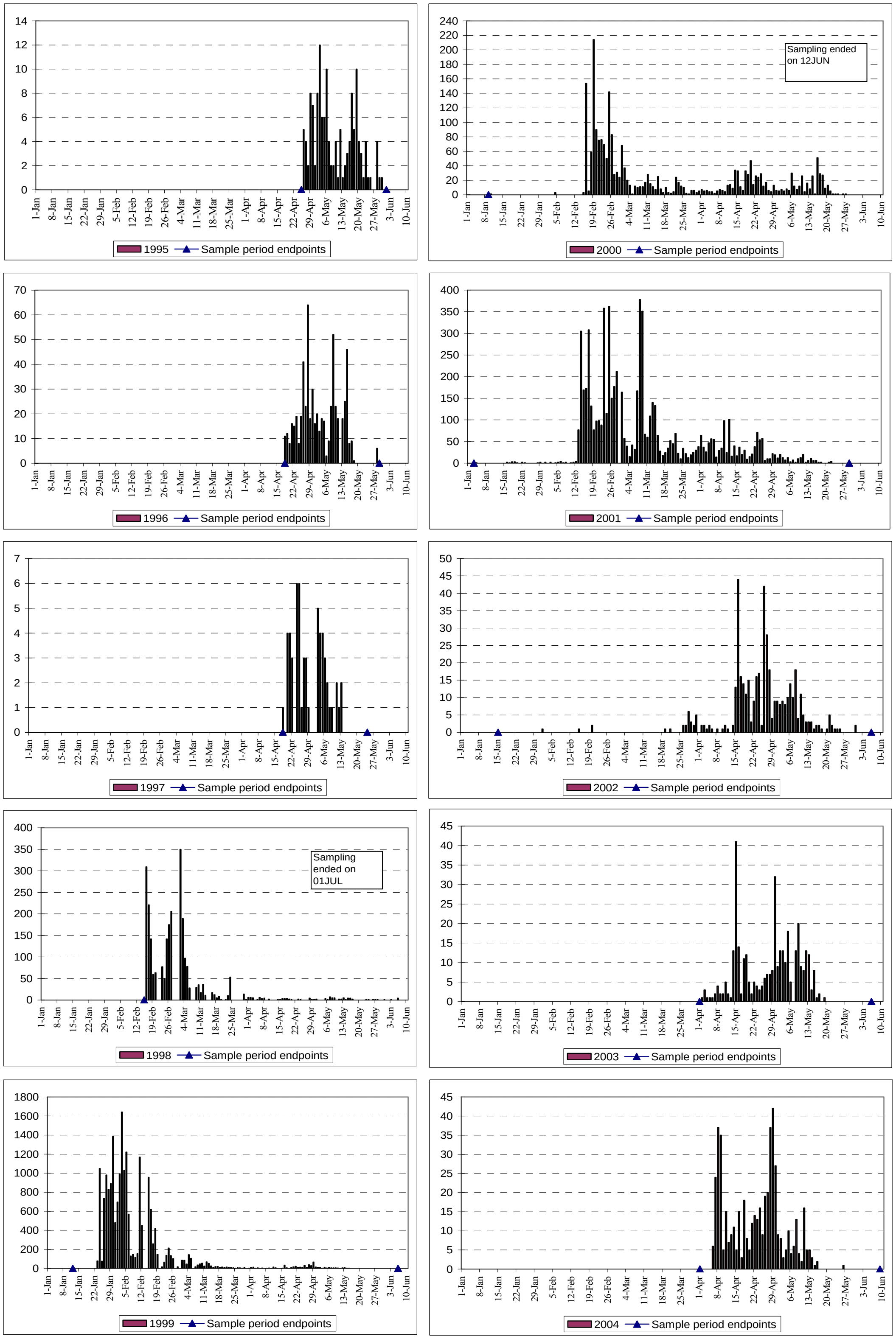


Figure 3.5.2.4-2 Daily salmon catch at lower screw traps 1995–2004.

Upper Tuolumne screw trap sampling

Rotary screw traps were deployed at upstream sites in 1998–2000 (Table 3.5.2.4-1). Results from the 1998 Tuolumne River outmigrant trapping (FERC Report 97-4, TID/MID 1998) indicate that peak fry catch occurred during high flow conditions in February and March, but patterns in daily catch of fry did not mimic patterns in flow magnitude. Daily catch of fry was correlated with increased turbidity. Juvenile salmon ≥50 mm FL were captured in pulses during April-May at both of the upper trap locations. Results from the 1999 Tuolumne River monitoring (Report 99-5, TID/MID 2000) concluded there was no apparent relationship between flow and fry catch at the upper trap, although a significant portion of fry may have left the reach prior to the onset of sampling. Peak fry outmigration from the primary spawning reach was during January and February. Juvenile outmigration mostly occurred during the April-May period. Catch patterns in 2000 were similar to those in 1999, with the majority occurring as fry during January and February. Juvenile outmigration during the April-May period appeared to correspond to flow decreases following extended periods of high flow. As in 1999, peaks in juvenile migration also corresponded with the release of a large number of CWT hatchery fish for smolt survival studies at Old La Grange Bridge.

In 1998 at the uppermost trap, which operated from February 10 through May 30, 53% of the salmon measured were <50 mm FL. All of the measured salmon at the Charles Road trap were ≥50 mm FL. In 1999 at the upper trap, which operated from January 19 to May 16, 95% of the salmon measured were <50 mm FL while 98% of the measured salmon at the Hughson trap were ≥50 mm FL. In 2000 at the upper trap, which operated from January 10 to February 27, 97% of the measured wild salmon were <50 mm FL. At the Deardorff and Hughson traps that operated from April 8 to May 24, nearly 100% were ≥50 mm FL.

Juvenile Salmon Production

The RST monitoring at upper and lower sites provided data to base an estimate of fish passage by extrapolating the daily catch data. Comparisons of wild salmon catch to CWT salmon catch can also be made when present. Both fry and smolt estimates were developed in some cases; no fingerling (or juvenile) distinction was used. Estimated passage from catches at the lower RST sites (Shiloh or Grayson) can be considered production estimates for salmon moving out of the Tuolumne River during the sampling period due the trap location's proximity to the San Joaquin River. Note that not all dates within the overall sampling period each year were sampled and occasional trap slowdowns or stoppages occurred so other data gaps are present. Potential issues such trap live box retention or predation within the live box are not considered here.

Juvenile salmon production indices for the lower Tuolumne trap locations

The passage estimates for the lower RST sites have been reported in various ways by CDFG through the years. This is a provisional summary due to the variable pattern of reporting and the absence of required files from CDFG. The years from 1995-97 and 2003-04 have "smolt" (either all salmon caught in the APR-JUN period or all fish > or = 65 mm FL) production estimates only, due to the sampling being limited to the spring period. Separate "fry" (< 65 mm FL) and smolt estimates were calculated by CDFG in 1999 and 2000 only. This CDFG classification of fry differs from that used in the seining and other Tuolumne studies that employ a 50 mm FL threshold. The years of 1998 and 2001-02 had only a combined total production estimate reported for all life stages over the entire winter/spring sampling season (Table 3.5.2.4-2).

Vulnerability (efficiency) indices were used in some cases by CDFG to estimate juvenile production (Report 2001-2, TID/MID 2002). These indices were developed by releasing marked groups of hatchery fish (typically 2,000 each) within a mile upstream. Estimates based on flow and the percent of flow sampled by the traps were provided in some cases – only one estimate is used here for each year as there was little difference in the estimates. A high degree of variability exists in the vulnerability capture data, even after pooling the data over several years. Low trap efficiency (<10%) also decreases the confidence in the population estimates. Consequently, estimates of juvenile production should be treated cautiously until further review is available.

Estimated production for 1995, 1996 and 1997 was 21,933, 56,538, and 3,990, respectively – those values are expansions of 40% over the initial estimates derived in the short sampling period of those years. The somewhat longer sampling seasons (included all of APR-MAY) of 2003-04 had estimates of 7,261 and 13,164. The smolt estimates for long seasons of 1999 and 2000 were 30,864 and 47,703 respectively. The fry estimates for those years were 1,042,805 and 84,314, or about 34 times and 2 times the smolt estimates. The long sampling seasons of 1998, 2001, and 2002 had CDFG estimates that were not partitioned into fry and smolts, but relatively few fry were captured in 2002. That is likely due to low winter flows that year that did not move salmon downstream, unlike the pattern observed in 1998–2001.

Table 3.5.2.4-2 Salmon production estimates for the lower screw trap sites.

							Expanded	Total
		Sampling Period		Actual	"Fry"	"Smolt"	smolt est.	production
Year	Location	Start Date	End Date	Catch	estimate	estimate	(seasonal adj)	estimate
1995	Shiloh	25-Apr	1-Jun	141	na	15,667	21,933	
1996	Shiloh	18-Apr	29-May	610	na	40,385	56,538	
1997	Shiloh	18-Apr	24-May	57	na	2,850	3,990	
1998	Shiloh (1 RST)	15-Feb	1-Jul	2,546				1,615,673
1999	Grayson	12-Jan	6-Jun	19,311	1,042,805	30,864		1,073,669
2000	Grayson	9-Jan	12-Jun	2,250	84,314	47,703		132,017
2001	Grayson	3-Jan	29-May	6,478				111,644
2002	Grayson	15-Jan	6-Jun	438				14,540
2003	Grayson	1-Apr	6-Jun	359	na	7,261		
2004	Grayson	2-Apr	9-Jun	509	na	13,134		

na: not available - no sampling during fry season

Juvenile salmon production indices for the upper Tuolumne trap locations (1998–2000)
The upstream trap sampling allowed estimated ranges of both fry and juvenile/smolts depending on the period of operation of the various trap locations. Abundance estimates for the three years are in Table 3.5.2.4-3, including comparisons at different sites over the same time period. The estimates were based on two methods: (1) expanded daily catch based on mean trap efficiencies in all years and (2) the expanded daily catch estimate based on percent of flow sampled in two years. Estimates based on % of flow were consistently lower. Large fry (<50 mm FL) catches were made at the uppermost site in 1999 and 2000, when sampling was started in mid-January. Abundance estimates from mostly the April-May period were roughly comparable between the upper and middle trap sites, with the exception the 2000 estimate based on % of flow, which was much smaller at the middle site.

Table 3.5.2.4-3 Salmon abundance estimates for the upper screw trap sites.

Year	Location	Sampling Period Start Date	Sampling Period End Date	Actual Catch	Effic. based abundance estimate	% of flow based abundance estimate
1998	RM38.5-42	10-Feb	30-May	9,537	259,581	
(1 trap)		*27Mar-30May only*			*66,331*	
	RM 24.7-25	27-Mar	31-May	981	66,848	
1999	RM38.5	19-Jan	16-May	80,792	7,297,177	1,737,052
		05Apr-16May only			*13,407*	*7,768*
	RM 23.7	8-Apr	21-May	449	10,466	7,175
		05Apr-16May only			*9,324*	*6,971*
2000	RM 38.6	10-Jan	27-Feb	61,199	3,481,884	298,755
	RM 35.5	8-Apr	24-May	634	19,938	13,582
	RM 23.7	8-Apr	24-May	264	19,010	2,942

3.5.2.5 Smolt survival indices

FSA Section 13 (f) identified annual study of coded-wire tag (CWT) monitoring of Chinook salmon smolt survival, using paired releases of hatchery salmon. In addition to CWT releases conducted prior to the 1995 FSA under the 1986 Study Plan (1986, 1987, 1990, 1994–95), CWT releases were conducted in April of each year from 1996–2002 (Table 3.5.2.5-1). The releases have been made at flows below La Grange Dam ranging from about 550-7,700 cfs. The upper and lower release group numbers have ranged from about 50,000-100,000 (in tag code groups of about 25,000 each) and all releases were made between mid-April to early May. FSA Section 13f also specified an annual marked smolt study to monitor the relative effectiveness of restoration measures in meeting FSA goals. These additional multiple-mark-recapture (MMR) releases were conducted during 1998–2000. Following is a summary and evaluation of smolt survival studies conducted from 1986–2002 on the lower Tuolumne River.

Background

Since 1986, the TRTAC has conducted a series of experiments to quantify the relationship between Chinook salmon smolt survival and flow in the Tuolumne River. Since 1986, about 1.7 million CWT smolts derived from Merced River stock have been reared in the Merced River Hatchery and released in the Tuolumne River CWT studies (Figure 3.5.2.5-1). Concerns over the continued use of large numbers of Merced River origin fish, including their impacts and the utility of the information derived from the tests, was the subject of a Peer Review process in 1998 (Report 97-4, TID/MID 1998). Additional hatchery smolt studies and methods were used in 1998–2000 and are addressed in the Section 3.4.7.2 of this report. A smolt survival agreement was reached by TRTAC representatives at a meeting on 16

December 1999, which included termination of the CWT study releases that did end in 2002. In addition, the TRTAC Monitoring Subcommittee was assigned the task of reviewing and evaluating the smolt survival studies, and specifically Mossdale recovery data, from 1987–2002.

Table 3.5.2.5-1. Release and recovery data for Tuolumne River CWT smolt survival releases.

Release Year	CWT Tag. No.	Effective Release No.	Avg. Fork Length (mm)	Water Temp (deg F)	Release Site	DATE	PUSHNET RST	Mossdale Trawl	SWP Pumps	SWP (expanded)	CVP Pumps	CVP (expanded)	Jersey Pt. (Antioch)	Jersey Pt. (survival)	Chipps Island	Chipps Island (survival)	Ocean Catch	Ocean Catch (expanded)	Spawners
1986	06-46-54	49,630			OLGB	14APR86	-	-	131		183		-	-	16		226	976	60
LG FLOW:	06-46-55	49,518			OLGB	14APR86	-	-	135		205		-	-	18		210	929	58
6600 cfs	06-46-56	51,300			MAPES	14APR86	-	-	159		255		-	-	10		219	969	54
w/o HORB	06-46-57	52,174			MAPES	14APR86	-	-	155		238		-	-	10		231	1037	50
TOTAL	UPPER	99,148	81	51	OLGB	RM diff.	-	-	266	6573	388	3312	-	-	34	0.40	436	1905	118
TOTAL	LOWER	103,474	80	51	MAPES	= 50	-	-	314	7351	493	3465	-	-	20	0.27	450	2006	104
1987	06-46-60	29,953			OLGB	16APR87	97	47	20		44		-	-	2		10	32	2
	06-46-61	30,609			OLGB	16APR87	137	47	23		48		-	-	0		6	37	1
LG FLOW:	06-46-62	29,037			OLGB	16APR87	120	34	22		46		-	-	3		7	31	5
560 cfs	06-46-63	30,703			RDP	16APR87	374	109	184		71		-	-	4		25	142	12
w/o HORB	06-45-01	31,869			RDP	16APR87	339	91	213		62		-	-	5		25	141	8
	06-45-02	30,937			RDP	16APR87	353	117	204		79		-	-	8		23	82	9
TOTAL	UPPER	89,599	85	55	OLGB	RM diff.	354	128	65	593	138	1648	-	-	5	0.05	23	100	8
TOTAL	LOWER	93,509	82	64	RDP	= 38	1066	317	601	5685	212	2569	-	-	17	0.18	73	365	29
1990	H601110201	23,494			OLGB	30APR90	-	19	40		23		-	-	1		0	0	1
	H601110202	21,766			OLGB	30APR90	-	12	27		11		-	-	1		0	0	0
LG FLOW:	H601110114	24,134			OLGB	30APR90	-	21	45		25		-	-	1		2	12	0
600 cfs	H601110115	24,259			OLGB	30APR90	-	11	34		18		-	-	1		1	5	0
w/o HORB	H601110203	27,263			MAPES	01MAY90	-	47	29		26		-	-	1		1	1	0
	H601110204	26,067			MAPES	01MAY90	-	47	21		21		-	-	0		1	17	0
	H601110205	24,905			MAPES	01MAY90	-	75	2		27		-	-	0		0	0	0
TOTAL	UPPER	93,653	83	52	OLGB	RM diff.	-	63	146	878	77	440	-	-	4	0.04	3	17	1
TOTAL	LOWER	78,235	72	66	MAPES	= 50	-	169	52	463	74	316	-	-	1	0.01	2	18	0
1994	0601110302	27,803			OLGB	23APR94	-	85	2	7	1	12	-	-	2		24	86	39
LG FLOW:	0601110303	27,803			OLGB	23APR94	-	62	2	40	1	12	-	-	1		23	86	44
1200 cfs	0601110304	27,802			OLGB	23APR94	-	60	2	4	0	0	-	-	0		24	81	31
w/ HORB	0601110305	25,029			MAPES	24APR94	-	47	0	0	3	48	-	-	1		28	110	46
	0601110306	25,029			MAPES	24APR94	-	25	2	14	2	24	-	-	1		15	43	27
TOTAL	UPPER	83,408	85	51	OLGB	RM diff.	-	207	6	51	2	24	-	-	3	0.03	71	253	114
TOTAL	LOWER	50,058	82	62	MAPES	= 50	-	72	2	14	5	72	-	-	2	0.04	43	153	73
1995	H61110311	29,989			OLGB	04MAY95		22	28	474	48	510	-	-	8		87	290	50
LG FLOW:	H61110312	28,988			OLGB	04MAY95		16	13	177	43	461	-	-	5		96	337	59

Release Year	CWT Tag. No.	Effective Release No.	Avg. Fork Length (mm)	Water Temp (deg F)	Release Site	DATE	PUSHNET RST	Mossdale Trawl	SWP Pumps	SWP (expanded)	CVP Pumps	CVP (expanded)	Jersey Pt. (Antioch)	Jersey Pt. (survival)	Chipps Island	Chipps Island (survival)	Ocean Catch	Ocean Catch (expanded)	Spawners
7700 cfs	H61110313	30,287			OLGB	04MAY95		20	17	277	55	572	-	-	8		108	373	54
w/o HORB	H61110314	27,770			SERVICE	05MAY95		23	19	236	57	607	-	-	5		91	315	67
	H61110315	29,139			SERVICE	05MAY95		23	19	203	67	707	-	-	7		96	310	82
TOTAL	UPPER	83,549	86	48	OLGB	RM diff.	11	58	58	928	146	1543	-	-	21	0.25	291	1000	163
TOTAL	LOWER	53,298	89	51	SERV.RD	= 41.5	11	46	38	439	124	1314	-	-	12	0.22	187	625	149
1996	H61110506	21,501			OLGB	26APR96		25	2	18	14	192	-	-	0		1	3	2
LG FLOW:	H61110507	22,761			OLGB	26APR96		16	2	8	7	84	-	-	2		2	9	2
2600 cfs	H61110508	22,893			OLGB	26APR96		23	4	24	11	132	-	-	1		3	8	5
w/o HORB	H61110509	22,715			SERVICE	27APR96		67	2	24	13	180	-	-	1		3	10	4
	H61110510	27,745			SERVICE	27APR96		89	2	0	17	240	-	-	3		4	13	5
TOTAL	UPPER	67,155	88	49	OLGB	RM diff.	222	64	8	50	32	408	-	-	3	0.04	6	20	9
TOTAL	LOWER	50,460	90	57	SERVICE	= 41.5	133	156	4	24	30	420	-	-	4	0.07	7	23	9
1997	H61110607	35,004			OLGB	22APR97	4	8	1	12	7	84	1		1		3	6	18
	H61110608	33,695			OLGB	22APR97	5	12	3	16	16	204	2		0		7	29	11
LG FLOW:	H61110609	27,622			OLGB	22APR97	4	10	1	8	8	96	3		1		8	30	7
2800 cfs	H61110610	8,882			OLGB	22APR97	0	2	0	0	1	12	0		1		1	3	2
w/ HORB	H61110604	31,739			SERVICE	23APR97	52	14	4	28	4	48	19		6		25	83	55
	H61110605	32,297			SERVICE	23APR97	66	22	3	14	6	72	13		2		21	84	46
	H61110606	27,075			SERVICE	23APR97	43	20	2	6	7	84	7		4		11	46	26
TOTAL	UPPER	93,501	71	48	OLGB	RM diff.	13	32	5	36	32	396	6	0.01	3	0.04	19	68	38
TOTAL	LOWER	72,464	75	56	SERVICE	= 41.5	161	56	9	48	17	204	39	0.11	12	0.17	57	213	127
1998	61110703	32787			OLGB	15APR98		51	1	6	26	284	26	0.14	25	0.42	31	94	22
	61110704	26633			OLGB	15APR98		40	0	0	22	280	4	0.03	5	0.09	24	75	21
LG FLOW:	61110705	27404			OLGB	15APR98		30	1	6	25	312	8	0.05	19	0.36	32	104	27
6400 cfs	61110706	7234			OLGB	15APR98		9	2	22	7	84	0	0.00	2	0.13	14	45	8
w/o HORB	61110707	25754			OFC(SJR)	16APR98		34	0	0	17	212	13	0.09	17	0.35	12	44	10
	61110708	22006			OFC(SJR)	17APR98		30	0	0	18	220	5	0.05	19	0.45	11	41	14
TOTAL	UPPER	94058	83	51	OLGB	RM diff.	46	130	4	34	80	960	38	0.05	51	0.25	101	318	78
TOTAL	LOWER	47760	86	59	OFC(SJR)	= 53.5	------	64	0	0	35	432	18	0.07	36	0.40	23	85	24
1999	06-46-01	25534			OLGB	17APR99		10	56	355	41	339	6	0.05	3	0.07	23	85	26
	06-46-02	25679			OLGB	18APR99		17	67	475	58	542	6	0.05	2	0.05	28	91	36
LG FLOW:	06-46-03	25008			OLGB	19APR99		18	61	390	62	538	3	0.03	2	0.05	28	86	35
2000 cfs	06-46-04	25121			OFC(SJR)	18APR99		49	78	426	83	883	11	0.10	11	0.27	30	92	49
w/o HORB	06-46-05	25836			OFC(SJR)	19APR99		115	94	559	52	466	15	0.12	9	0.21	32	93	43

Release Year	CWT Tag. No.	Effective Release No.	Avg. Fork Length (mm)	Water Temp (deg F)	Release Site	DATE	PUSHNET RST	Mossdale Trawl	SWP Pumps	SWP (expanded)	CVP Pumps	CVP (expanded)	Jersey Pt. (Antioch)	Jersey Pt. (survival)	Chipps Island	Chipps Island (survival)	Ocean Catch	Ocean Catch (expanded)	Spawners
TOTAL	UPPER	76221	86		OLGB	RM diff.	184	45	184	1220	161	1419	15	0.04	7	0.06	79	262	97
TOTAL	LOWER	50957	85		OFC(SJR)	= 53.5	------	164	172	985	135	1349	26	0.11	20	0.24	62	185	92
2000	06-45-56	23603			OLGB	13APR00		17	13	59	1	12	5	0.05	6	0.13	23	72	38
	06-45-57	22096			OLGB	15APR00		15	4	22	2	24	2	0.02	1	0.02	24	81	28
LG FLOW:	06-45-58	26975			OLGB	15APR00		8	10	59	0	0	3	0.03	5	0.11	22	68	31
3800 cfs	06-45-59	23071			OFC(SJR)	16APR00		33	27	116	1	12	12	0.12	4	0.09	44	141	53
w/ HORB	06-45-60	21698			OFC(SJR)	14APR00		49	20	95	1	12	10	0.10	5	0.12	34	104	60
TOTAL	UPPER	72674	74		OLGB	RM diff.	241	40	27	140	3	36	10	0.03	12	0.09	69	221	97
TOTAL	LOWER	44769	74		OFC(SJR)	= 53.5	------	82	47	211	2	24	22	0.11	9	0.10	78	245	113
2001	06-44-12	24600			OLGB	22APR01		38	0	0	0	0	2	0.02	2	0.04	2	7	7
	06-44-13	22758			OLGB	22APR01		40	0	0	1	12	6	0.05	2	0.04	4	23	2
LG FLOW:	06-44-14	21527			OLGB	22APR01		32	0	0	0	0	10	0.09	4	0.09	5	15	4
620 cfs	06-44-43	22051			OFC(SJR)	28APR01		165	0	0	0	0	35	0.30	13	0.28	12	40	27
w/ HORB	06-44-44	24393			OFC(SJR)	26APR01		262	2	12	1	12	25	0.19	12	0.23	16	56	27
TOTAL	UPPER	68885	82	52	OLGB	RM diff.	109	110	0	0	1	12	18	0.05	8	0.06	11	45	13
TOTAL	LOWER	46444	84	68	OFC(SJR)	= 53.5	------	427	2	12	1	12	60	0.25	25	0.26	28	96	54
2002	06-44-06	24976			OLGB	24APR02		65	2	12	1	12	3	0.020	1	0.020			1
	06-44-67	24813			OLGB	24APR02		63	2	12	0	0	5	0.037	7	0.141			0
LG FLOW:	06-44-68	25220			OLGB	24APR02		51	2	18	1	12	3	0.023	0	--			0
1300 cfs	06-44-61	25701			OFC(SJR)	26APR02		116	1	6	0	0	1	0.007	6	0.111			1
w/ HORB	06-44-69	23870			OFC(SJR)	29APR02		25	2	15	1	12	2	0.015	3	0.063			3
TOTAL	UPPER	75009	86	54	OLGB	RM diff.	1008	179	6	42	2	24	11	0.026	8	0.053			1
TOTAL	LOWER	49571	86	62	OFC(SJR)	= 53.5	------	141	3	21	1	12	3	0.011	9	0.087			4

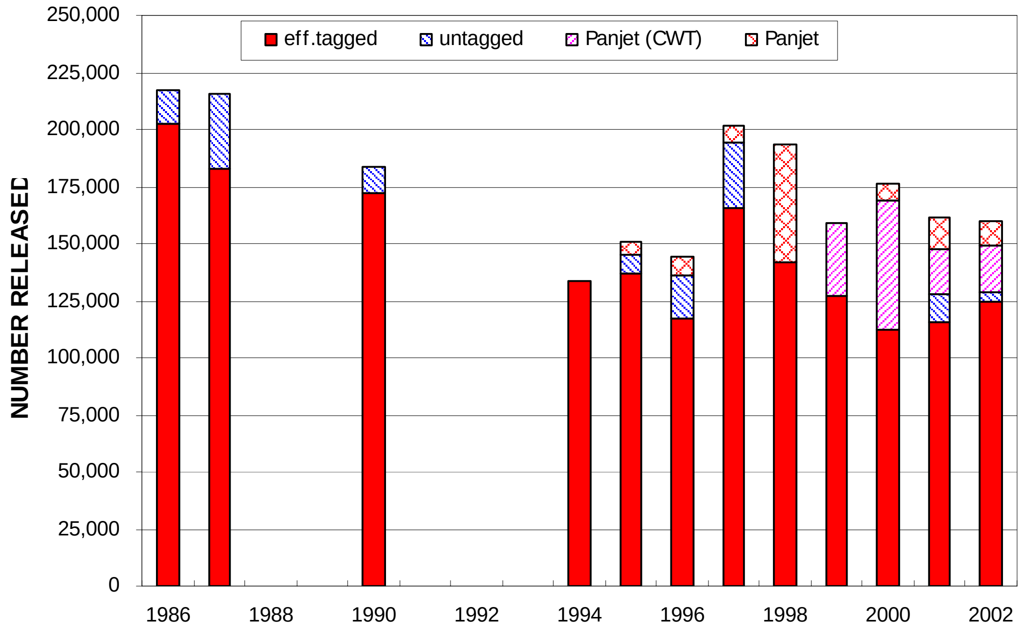


Figure 3.5.2.5-1 Tuolumne River salmon smolt release numbers 1986 to 2002.

Riverwide Indices

The CWT experiments use a paired release-recapture design (Burnham et. al. 1987). In these experiments, "treatment" fish are released at Old La Grange Bridge in the Tuolumne River and a "control" group is released at one of several downstream locations, which varied depending on the year of study. The control group releases are made a day or two after the upstream releases in an attempt to ensure the two groups migrated together. The in-river survival is estimated by comparing the rates at which the two groups are recovered at one or more locations (Figure 3.5.2.5-2) further downstream (*e.g.*, Mossdale, CVP and SWP Fish Protection Facilities, Chipps Island Trawl, etc.).

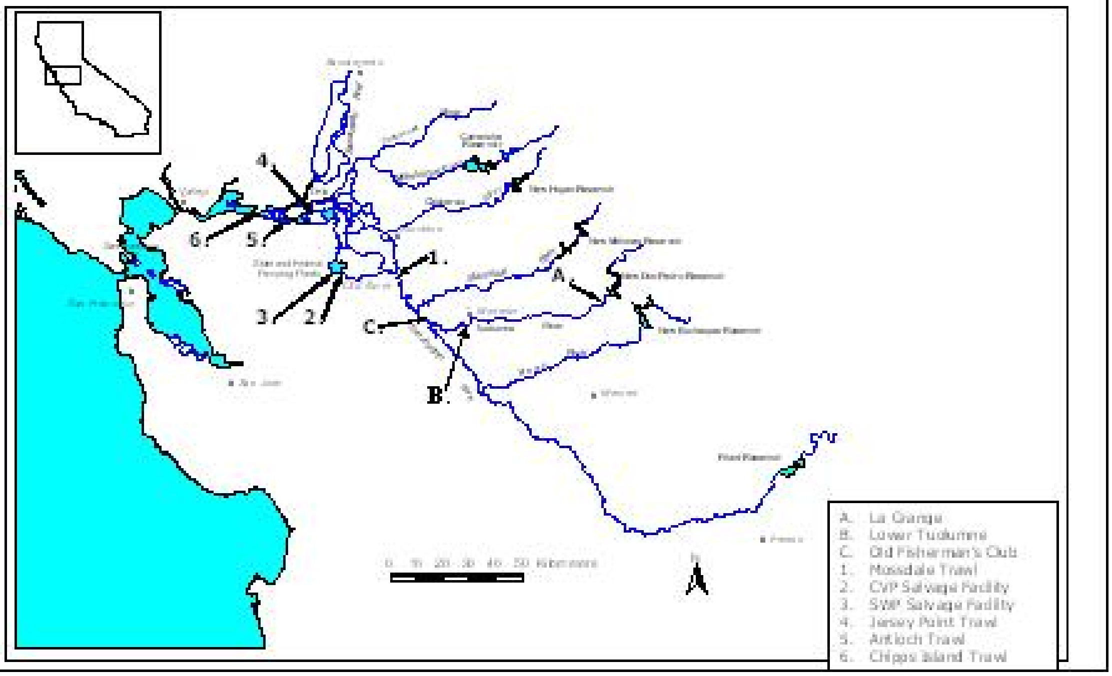


Figure 3.5.2.5-2 Tuolumne River CWT smolt release and inland juvenile recovery sites.

Relative riverwide survival indices are calculated by dividing the number of recoveries from the upper release group by the lower release group, adjusting to account for different numbers in the release groups. Given the known release numbers n_c and n_t for the control and treatment groups, respectively, and corresponding recovery numbers m_c and m_t at some downstream location, the usual estimate of in-river survival is:

$$\hat{S} = \frac{m_t / n_t}{m_c / n_c}, \qquad \widehat{\text{var}}\left(\hat{S}\right) = \hat{S}^2 \left(\hat{\sigma}_t^2 / m_t^2 + \hat{\sigma}_c^2 / m_c^2\right)$$

Where $\hat{\sigma}_t^2$ and $\hat{\sigma}_c^2$ are the estimates of the variances of m_c and m_t, respectively. Annual CWT summary reports have analyzed smolt survival indices derived from juvenile recovery locations, adult ocean catch, and inland spawner recoveries. Some recovery data are expanded ("expd." in some tables and figures here) to account for partial sampling or sampling effort (e.g. delta pump salvage, ocean catch). Additional smolt survival analysis examining whether certain key study assumptions were met based on recoveries at Mossdale and other factors are addressed in FERC Reports 2001-5, 2002-4, and 2004-7.

Riverwide Survival Estimates Based Upon Multiple Recovery Locations
Annual CWT summary reports have analyzed smolt survival indices derived from juvenile recovery locations, adult ocean catch, and inland spawner recoveries (Table 3.5.2.5-3). Because of the extended recapture periods in most years (i.e., up to 30 days), the target release flow at La Grange often did not represent conditions fully experienced by the study fish in the

river. At the December 6, 2002 Monitoring Subcommittee meeting, it was decided that the flow basis of the survival estimates used in the prior evaluation report (TID/MID 2002) would be changed. Instead of representing flow experienced by the study fish by mean flow at Modesto over the time period from release to 70% recapture, it was agreed to also use an average flow at La Grange that was weighted by the daily recaptures at the Mossdale trawl.

Table 3.5.2.5-2. Smolt survival indices from all locations with initial and adjusted La Grange flow data.

RELEASE YEAR	La Grange Flow (cfs)	La Grange Flow (adj.) (cfs)	Trawl Moss-dale	(adj.) Moss-dale	"pump" SWP Expd.	"pump" CVP Expd.	Trawl Jersey Pt Antioch	Trawl Chipps	"adult" Ocean Catch	"adult" Spawn	Trawl average	Adjusted Trawl average	Pump average	Adult average
1986	6,600	6,600			0.93	1.00		1.48	0.99	1.18	1.48	1.48	0.97	6,600
1987	560	563	0.42	0.35	0.11	0.67		0.28	0.29	0.29	0.35	0.32	0.39	560
1995	7,700	8,217	0.80	0.82	1.35	0.75		1.14	1.02	0.70	0.97	0.98	1.05	7,700
1996	2,600	2,816	0.31	0.35	1.57	0.73		0.57	0.65	0.75	0.44	0.46	1.15	2,600
1998	6,400	4,050	1.03	1.17		1.13	0.71	0.63	1.90	1.65	0.79	0.84	1.13	6,400
1999	2,000	1,960	0.18	0.34	0.83	0.70	0.39	0.24	0.95	0.70	0.27	0.32	0.77	2,000
2000	3,800	2,982	0.30	0.50	0.41		0.28	0.84	0.55	0.53	0.47	0.54	0.41	3,800
2001	640	634	0.17	0.27			0.20	0.21	0.24	0.22	0.19	0.23		640
2002	1,300	1,300	0.53	0.53	1.32		2.36	0.61	1.67		1.17	1.17	1.32	1,300

Notes: 1. Tuolumne Smolt Survival Index -- min. of 4 recoveries in one release group and excluding 1990, 1994, and 1997
2. La Grange flow adjusted in 1987–2001 only; 2002 Mossdale using 1st lower group only

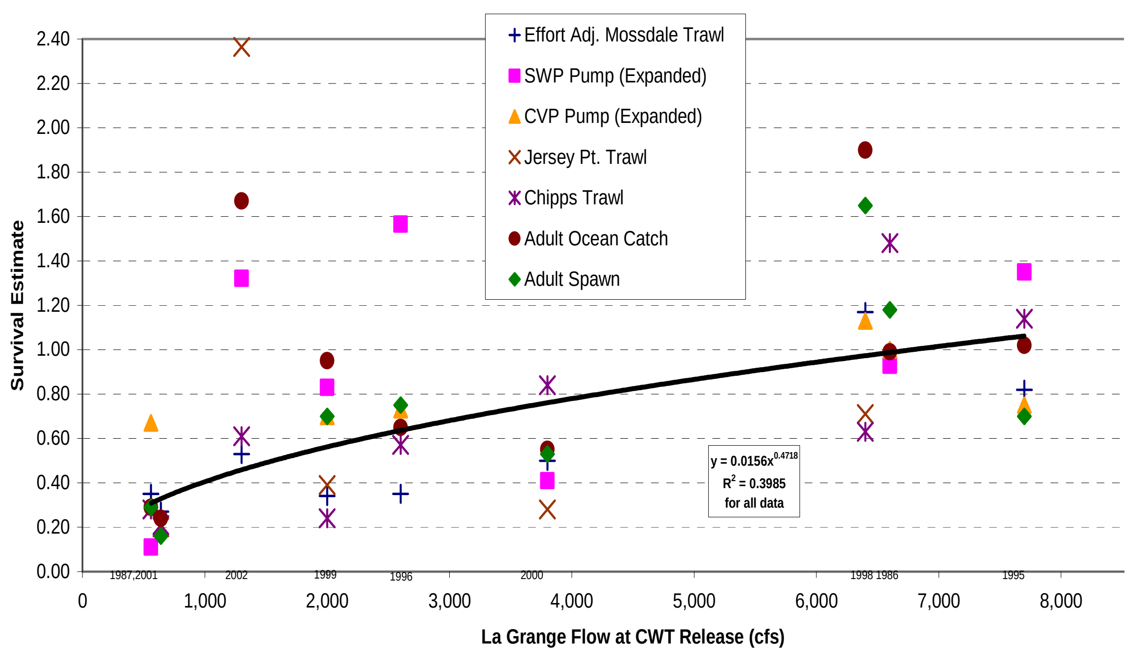


Figure 3.5.2.5-3. Survival indices (min. 4 recoveries from either release group; using adjusted Mossdale values) of validated data (excluding 1990, 1994, 1997) plotted against flow at release.

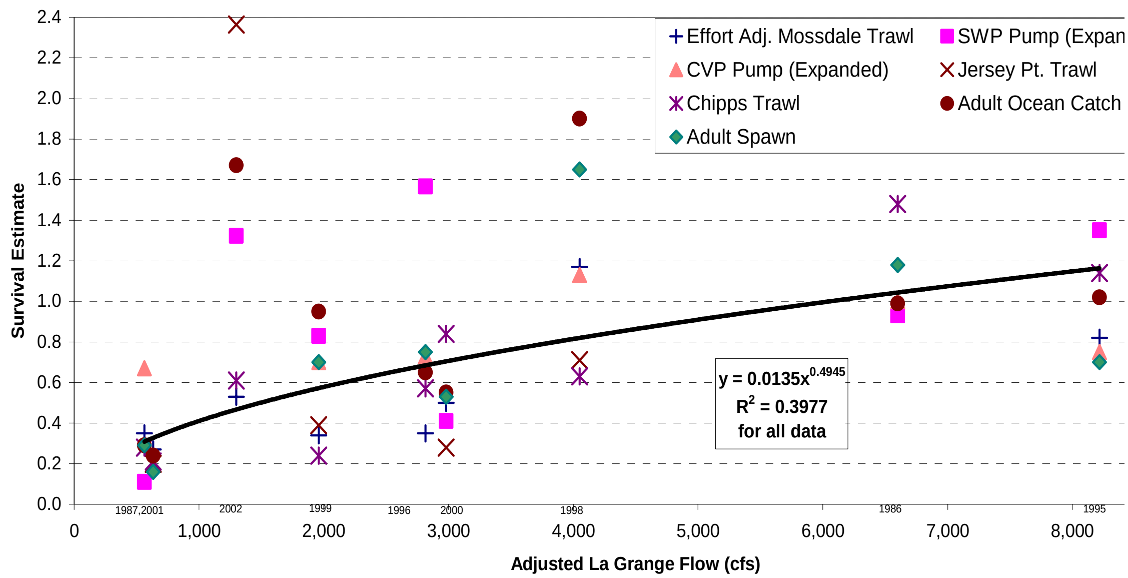


Figure 3.5.2.5-4. Survival indices (min. 4 recoveries from either release group; using adjusted Mossdale values) of validated data (excluding 1990, 1994, 1997) plotted against adjusted La Grange flow.

In general, the survival indices, when examined for all recovery locations, are variable, but trend from relatively low survival (all <0.7) with low flows (<700 cfs) to relatively high survival (all>0.6) with flood flows (>4,000 cfs); results with medium flows (1,300-3,000 cfs) ranged from low to high, but with a majority of indices in an intermediate range of 0.35-0.75 (Figures 3.5.2.5-3 to 4). In some cases the indices exceed 1.0 and/or are based on few recoveries. Survival results grouped by general flow categories (using adjusted Mossdale indices and adjusted La Grange flows) are:

1. *Low Flows.* There are two valid years in this category (1990 was excluded). Survival indices for 1987 and 2001 at 560-640 cfs show relatively low, but still variable, survival results. The 1987 juvenile survival indices ranged from .11 to .67 and both adult indices were 0.29. The 2001 juvenile survival indices ranged from 0.17 to 0.27 and the incomplete adult survival indices are 0.16-0.24.

2. *Medium Flows.* There are four valid years in this category (1994 and 1997 were excluded). Survival indices for 1996, 1999, 2000, and 2002 with adjusted medium flows (1,300-3,000 cfs) show highly variable results, ranging from 0.18-1.67. The adult survival indices were relatively high, ranging from 0.53-1.67, while some of the juvenile-based indices were lower.

3. *High Flows.* There are three years in this category; there was no Mossdale trawling in 1986. Survival indices for 1986, 1995, and 1998 with high adjusted flow conditions

(4,000-8,200 cfs) ranged from 0.63 to 1.89. These indices indicate relatively high survival with flood flows, but with variable results.

Mossdale Smolt Survival Review

At the request of the TRTAC, the Monitoring Subcommittee has conducted a multi-year review of the CWT experiments. Its purpose was to provide a critical review of the underlying data quality of each year's smolt survival index so that these indices might be used in the development of a smolt survival relationship with flow. A key, but uncertain assumption is that flow is considered in these studies as a surrogate for all other factors that may affect relative CWT smolt survival, such as predator populations, predation rates, food availability, smolt condition and behavior, temperature, turbidity, agricultural pumping or diversions, pollution, etc. These factors, which obviously vary from year to year and independently from flow, are generally unknown (other than temperature), further complicating the assessment of study results in regards to the relative survival of CWT hatchery salmon related to flow. For example, the release locations have varied somewhat over time, resulting in variable distances from about 38–53.5 river miles and thus variable exposure to mortality for the upper and lower release groups.

The Monitoring Subcommittee initially defined several data analysis tasks that were completed by Stillwater Sciences on a sub-set of the data set between the years 1987, 1990, 1994–2002 (TID/MID 2002, 2003, and 2004). Mossdale recovery data was analyzed because those indices had lacked adjustments for capture effort and, due to proximity to the Tuolumne River and the number of recaptures, was best situated to evaluate whether in a given year that key assumptions of the study were adequately met. Table 3.5.2.5-3 shows adjusted survival indices at Mossdale based upon the number of tows and times that the Mossdale trawl was in operation during each of the years under evaluation.

Table 3.5.2.5-3 Comparison of Tuolumne River smolt survival between 1987 and 2002 using actual and capture-effort-expanded CWT smolt recoveries.

Year and CWT Release Group Number	Flow (cfs) at Release Measured at La Grange (Modesto)	Mean Flow (cfs) at La Grange weighted by daily recaptures at Mossdale	Mean Water Temperature (°C) at Modesto weighted by daily recaptures at Mossdale	Actual Recaptures	Apparent Survival (%)	Capture Effort Expanded Recaptures	Expanded Survival (%)
1987 Upper 89,599	563	563	17.6	128	42 ± 9	2,494	35 ± 8
1987 Lower 93,509	(741)			317		7,174	
1990 Upper 93,653	599	241	19.4	63	30 ± 9	698	30 ± 9
1990 Lower 77,425	(556)			173		2,357	
1994 Upper 83,408	1,160	889	15.8	207	173 ± 46	NA	NA
1994 Lower 50,058	(862)			72		NA	
1995 Upper 83,549	7,730	8,217	11.3	58	79 ± 30	827	82 ± 16
1995 Lower 53,298	(7,740)			47		655	
1996 Upper 67,155	2,580	2,664	13.4	66	32 ± 9	525	35 ± 5.3
1996 Lower 50,460	(2,810)			156		1143	
1997 Upper 93,501	2,860	1,436	14.7	32	44 ± 19	273	33 ± 7.4
1997 Lower 72,464	(2,970)			56		663	
1998 Upper 94,058	6,400	4,050	12.1	130	103 ± 31	816	117 ± 18
1998 Lower 47,760	(7,100)			64		361	
1999 Upper 76,221	1,953	1,960	14.2	45	19 ± 6	248	34 ± 12
1999 Lower 50,957	(1,965)			158		728	
2000 Upper 72,674	3,793	2,982	13.1	37	28 ± 11	210	50 ± 20
2000 Lower 44,769	(3,750)			81		422	
2001 Upper 68,885	623	635	17.3	107	18 ± 4	390	27 ± 6
2001 Lower 46,443	(651)			399		1,439	
2002 Upper 74,924	1,310	1,274	15.9	179	53 ± 12	859	53 ± 12
2002 Lower 23,871	1,265			116		556	

A number of other factors that could not be adjusted were identified by the Monitoring Subcommittee that may have affected the paired release assumptions regarding equal probability of survival and capture of the treatment and control groups, including:

(1) differences in fish size (fork length), origin, condition, or handling;
(2) whether the treatment and control groups migrate together below the control group's release site;
(3) differences in environmental conditions experienced by each group traveling downstream in the Tuolumne River and San Joaquin River reaches; and lastly
(4) differences in capture effort as each group arrives at Mossdale.

Based upon the analyses to date, the CWT smolt survival experiments meet the majority of paired release study assumptions set forth by the TRTAC Monitoring Subcommittee. Three years of data were excluded (1990, 1994 and 1997) based upon violations of paired release study assumptions (TID/MID 2004). The 1990 and 1994 tests had known problems with the lower release groups not matching the timing of pulse flows. The 1997 release fish were of different sizes and were exposed to differing temperatures during transport and release. The 2002 results exclude the recovery data at Mossdale for the second of the lower release groups as that catch data was greatly reduced due to unequal effort.

Release Flow versus Mossdale Survival relationships

As part of the CWT evaluation described above, validated survival indices were paired with various estimates of the flows best representing test conditions. Recovery weighted flow averages during the experiments at La Grange were calculated by multiplying daily average flow by the daily smolt recovery at Mossdale, making a summation of these products for all days between first and last recapture, and then dividing by the total smolt recovery. Adjustment for water travel time from La Grange to Mossdale was also included by "lagging" the flow at La Grange by three days preceding the recapture dates. Figure 3.5.2.5-5 shows a linear model between recovery weighted mean flow at La Grange and capture effort adjusted survival with only validated survival estimates (i.e., excluding 1990, 1994 and 1997) from the most recent CWT evaluation report (TID/MID 2004).

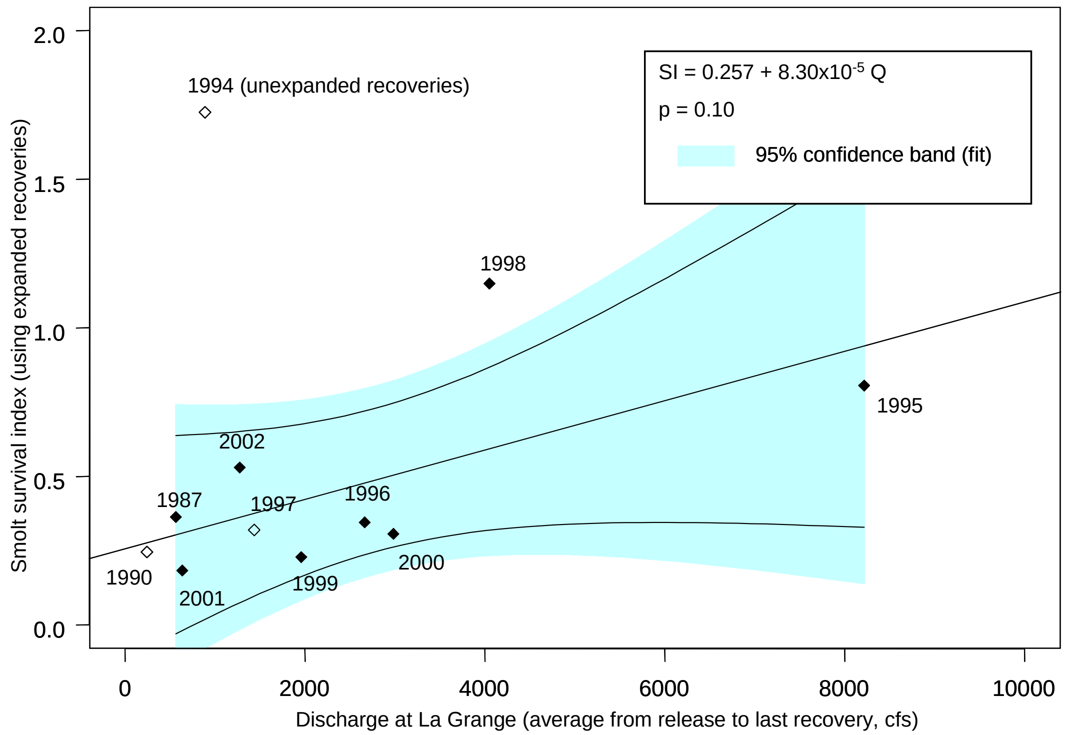


Figure 3.5.2.5-5. Linear regression of validated smolt survival indices by the recovery-weighted flow (cfs) at La Grange from release to last recapture at Mossdale Trawl.

Figure 3.5.2.5-6 shows a logistic model between survival and the recapture-weighted flow at LaGrange which assumes all fish from the upper release group of a given experiment have the same probability of surviving to the downstream release location, survival is constrained between 0–100%, and expanded recoveries at the downstream location (Mossdale) may be treated as samples from a gamma distribution (interpreted as an overdispersed Poisson distribution).

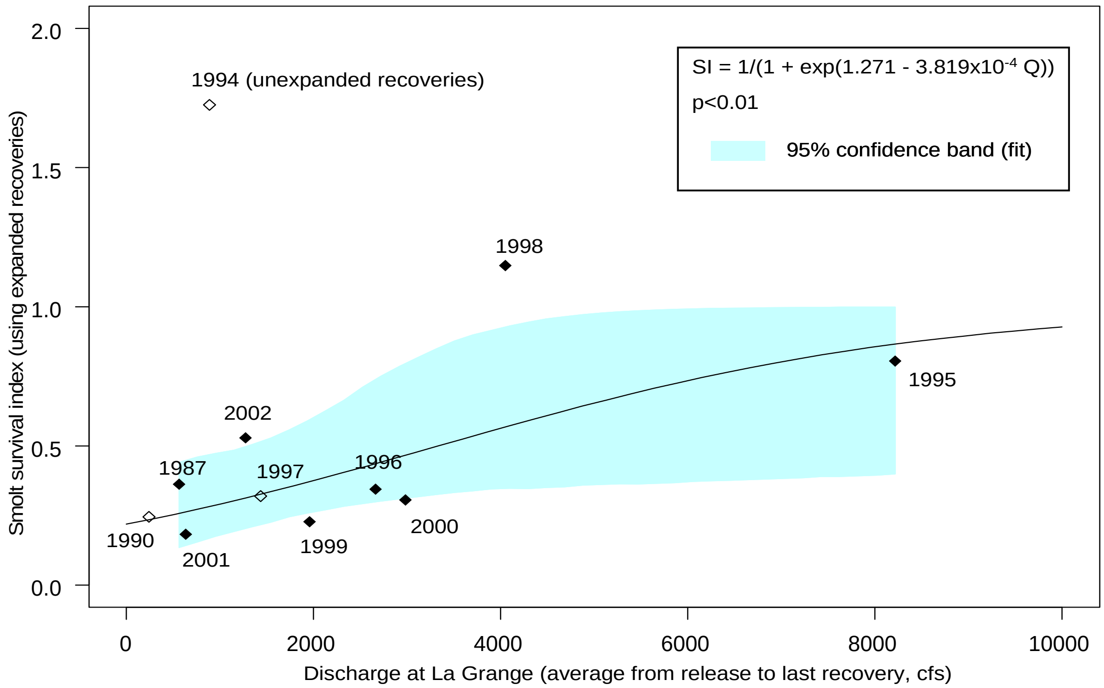


Figure 3.5.2.5-6. Logistic regression of validated smolt survival indices by the recovery-weighted flow (cfs) at La Grange from release to last recapture at Mossdale Trawl.

The resulting linear (Figure 3.5.2.5-5) and logistic (Figure 3.5.2.5-6) relationships between chinook salmon smolt survival and flow in the Tuolumne River is only sufficient to provide a broad estimate of survival at specific flows. Analysis of smolt survival estimates from other recovery locations or more experiments would be needed to narrow the confidence intervals shown to date. The breadth of the confidence interval suggests that an attempt to reduce the existing confidence interval by one half would require four times the current number of smolt survival estimates used (i.e., 4 x 7 or 28 additional survival/flow estimates).

Reach Specific Survival Indices

The river-wide CWT survival tests did not provide specific information on survival for segments within the lower river, such as gravel v. sand-bedded, or for specific sites where predation on smolts was considered to be more prevalent. To address survival within discrete reaches and provide more information on evaluating success of individual or collective restoration measures required additional monitoring sites. Because of concerns regarding the potential effect of the introducing large numbers of out-of-basin hatchery fish on the Tuolumne River wild Chinook salmon population, the TRTAC developed the multiple mark-recapture (MMR) smolt survival monitoring program described in Burnham et al. (1987) as a means of estimating reach-specific survival across the predator isolation (SRPs 9 and 10) and

Gravel Mining Reach restoration projects (Report 2000-7; TID/MID 2001). Releases of smaller groups of about 1,000-7,500 dye-marked salmon were used to augment information obtained from the single large CWT release at La Grange.

Specific evaluations were conducted in 1998–2000 using upstream RST sites to monitor natural smolts and conduct multiple mark-recapture (MMR) smolt survival tests. It had been initially assumed that the paired release method using marked smolts could be used to study survival in short SRP reaches. Initial tests of survival through SRPs 9 and 10 were not very successful and it was concluded that the river section tested had to be longer (> 1.5 miles) to allow for better dispersal of CWT smolts through SRP sites. Three reaches, classified as primary spawning, mining, and sand-bedded, were used to describe the Tuolumne River below the La Grange Dam. Upstream RSTs were deployed at RM 42/38.5 (below primary spawning reach) and near RM 24-25 (below mining reach). The lower screw traps near RM 4-5 were below most of the sand-bedded reach. Survival tests were done at La Grange flows of about 1,300-4,800 cfs over the 3-year period and some estimates over 45.5 miles of river were also feasible. The survival results are best considered as indices as large confidence intervals, poor goodness of fit, or other model issues were often present, resulting in some cases from the relatively low number of recoveries of marked salmon (Table 3.5.2.5-4). Other problems, such as no fish being recaptured or trap operation problems (debris, etc.) precluded determining some estimates.

Table 3.5.2.5-4 Multiple-mark-recapture survival estimates for the study reaches in the lower Tuolumne River.

		Reaches:	Spawning	Mining	Sand-bedded	Overall
Year	Dates	LG flow	12 miles	13.5 miles	21.5 miles	47 miles
1998	27-28APR	4,050		33%		
	6-7MAY	2,300	100%	25%		
	12-13MAY	3,240		13%		
	20-21MAY	4,770		na		
			12 miles	15 miles	18.5 miles	45.5 miles
1999	17-20APR all	2,000	100%	19%	45%	9%
	CWT		100%	17%	63%	11%
	MMR			6.6%	5.8%	
	28APR-1MAY all	3,200	100%	53%	24%	
			12 miles	15 miles	18.5 miles	45.5 miles
2000	13-15APR MMR	3,700	100%	56%	35%	19%
	27-28APR MMR	1,300	100%	100%	9%	9%
	4-5MAY MMR	2,350	100%	40%	18%	7%

CWT: large release groups at La Grange (about 75,000)
MMR: small release groups (about 1,000-7,500 each)
All: all release groups

Estimated reach-specific-survival was consistently found to be near 100% in the primary spawning reach, in the mining reach ranged from 7-100%, in the sand-bedded reach ranged from 6-63%, and overall river survival ranged from 7-19%.

Other San Joaquin Basin CWT Studies

Many other CWT survival tests have been done in the San Joaquin River system and the delta using Merced River hatchery smolts to obtain survival information on migration route reaches from upstream release sites in the tributaries down through the delta to Jersey Point near the confluence with the Sacramento River. Through 2003, there had been 18 paired study releases in the Merced River (1994–2003), 8 paired study releases in the Stanislaus River (1986–2003), and 22 paired study releases (within 15 test periods) in the delta (1996–2003) – the results were summarized in Report 2003-3. Many of these test release groups also would allow survival estimates to be obtained for reaches of the San Joaquin River from the Merced River to the delta, although that analysis has not been made to date. The tributary results thus far suggest this method has shown a general trend of increasing relative survival associated with increasing tributary flow when examined over a span that includes higher flows, as has been done for the Tuolumne and Merced Rivers. This is not an unexpected outcome and may be the primary conclusion derived from all the expense, effort, stock mixing, and population effects to date. The results of the other tributary releases are still in need of further evaluation, as was done for the Tuolumne releases based on Mossdale recoveries.

Unlike other "monitoring" efforts, the CWT studies have inherent population and genetic impacts on the salmon population. The results are quite variable and the method may inherently not be suited to detect major differences over the smaller flow range of "non-flood" releases for the reasons stated above, at least for tributary evaluations. Continuing tributary CWT survival tests is questionable unless further insights are developed and until a more complete assessment is made of existing data for all tributaries.

3.5.2.6 Flow fluctuation assessments

FSA Section 13d identified monitoring to document the distribution and movement of salmon fry in the Tuolumne River associated with large flow fluctuations from mid-January to mid-March. Initially identified was multiple rotary screw trap monitoring and use of a mark/recapture method in four years during periods of large flow fluctuations within the spawning reach. If regulated flow fluctuations were found to move fry out of the river, a second phase was identified that would examine survival of marked or tagged fry. FSA Section 16 had flow-specific hourly ramping rates ranging from 500-900 cfs per hour for flow decreases below 4,500 cfs during the period of October 16-March 15. The 1996 FERC Ordering Paragraph (G) states "all results and a discussion of the results of all monitoring studies related to the effects of flow release fluctuations on the salmon resources in the lower Tuolumne River" are to be included in the April 1, 2005 filing. Fluctuation assessments prior to the 1996 FERC Order had primarily involved stranding surveys under the 1986 study plan. The results of the 1986-89 surveys were included in 1992 FERC Report Appendix 14 and the 1990-96 surveys were included in FERC Report 1996-2.

Regulated flow reductions can cause stranding and entrapment of fry and juvenile salmon on gravel bars and floodplains and in off-channel habitats that may become cut off from the channel when flows are reduced. Mortality by asphyxiation, desiccation, temperature or low oxygen stress, or predation by birds and mammals often results. Stranding is also a natural and complex occurrence on unregulated streams in association with flow changes resulting from runoff events. Natural runoff flow reductions, which can be large and rapid, often occur in the JAN-MAR period in this region. The regulated flows from La Grange can dampen much of that flow change, but flows in the winter period still must often vary in some years, depending on flood flow management needs, and some stranding is unavoidable in all cases. Since the fry life stage is one of inherent high mortality rate, stranding losses should be considered in the context of the overall population and consider offsetting benefits to surviving fry moved downstream by higher flows in compensation for any stranding losses as flows are reduced, as is the case for unregulated streams as well.

The Licensees have not released large hydropower flow fluctuations to the river with repeated daily patterns since well before the 1995 FSA - the flow changes that did occur in the winter period were flood management flows. Fluctuating river flows at La Grange have been non-hydropower peaking flows and typically have had extended flow reduction periods when feasible to minimize potential stranding. Occasional use of downstream spills from the TID canal system to the river at RM 32.8 (Hickman Spill) and RM 20.3 (Faith Home Spill) and from the MID canal system to Dry Creek has been made to help keep releases at La Grange less variable during Don Pedro hydropower peaking operations and flow changes associated with flood management operations. Flow changes that took place after the mid-March specified fry period were associated with spring pulse flow or minimum flow schedules, in addition to flood management flows.

Table 3.5.2.6-1 lists the stranding surveys completed from 1986–2002 with more complete data included in Appendix D. Table 3.5.2.6-2 provides details on surveys completed since the 1995 FSA (1996–2002). Since the flows released by the Districts have not been the daily peaking pattern envisioned by the 1995 FSA and the 1995 FSA did not mandate a specific stranding assessment, the fluctuation and fry distribution monitoring plan employed by the TRTAC was a modified approach that entailed review of all previous stranding surveys since 1986, documenting the physical conditions under which stranding may occur, and used seining and multiple screw trapping to assess fry distribution. The stranding assessment work was mainly completed from 1998 to 2000 and a comprehensive report (Report 2000-6, TID/MID 2001) filed in 2001 reviewed the results of the 1986–2000 stranding assessments, evaluated the effectiveness of the 1995 FSA ramping rates, documented conditions under which stranding may occur, and identified potential areas for floodplain improvements. Some opportunistic surveys following FERC Report 2000-6 were completed in 2002 after the specified fry period that year during reductions in pulse flows and minimum flow schedules. Other fry distribution information from monitoring with seines and multiple screw traps is reviewed in Sections 3.5.2.2 and 3.5.2.4 of this report.

Table 3.5.2.6-1. Summary of 1986–1992 and 1994–2002 Juvenile Stranding Surveys.

Year	Month	Beginning Flow (cfs)	Ending Flow (cfs)	Change in Flow (cfs)	No. of sites surveyed	No. of stranded salmon
1986	Dec	4,700	500	4,200	3	16
1986	Dec	4,000	200	3,800	6	16
1987	Jan	2,600	200	2,400	7	25
1987	Jan	1,200	500	700	5	20
1987	May	550	200	350	1	52
1987	Jun	200	3	197	6	403
1988	Jan	550	125	425	3	9
1988	Feb	300	120	180	7	18
1988	Apr	550	115	435	11	17
1988	Apr	550	100	450	9	5
1988	May	67	10	57	4	53
1989	Apr	730	120	610	7	0
1989	Apr	1,050	400	650	7	52
1990	Mar	167*			5	12
1990	Mar	162*			6	34
1990	Mar	174*			3	17
1990	Mar	180*			8	30
1990	Mar	220	120	100	6	11
1990	May	560	280	280	7	5
1991	May	1,120	667	453	7	0
1991	May	667	284	383	3	0
1992	May	1,000	550	450	6	0
1992	May	160	50	110	10	0
1994	Apr	1,100	550	550	5	0
1995	Mar	2,900	1,200	1,700	4	98
1995	Mar	7,700	4,700	3,000	5	2
1995	Mar	4,700	1,900	2,800	4	2
1995	Jun	8,600	1,000	7,600	2	0
1996	Feb	5,000	3,000	2,000	6	54
1997	Jan	9,700	5,700	4,000	3	1
1997	May	1,900	800	1,100	4	0
1999	May	3,500	500	3,000	25	21
2000	Mar	7,000	5,400	1,600	17	16
2000	Mar	7,000	4,000	3,000	31	81
2002	May	1,300	900	400	6	0
2002	May	900	600	300	5	0
2002	May	243	193	50	3	1
2002	June	226	99	127	4	0

*These figures are mean daily flows reported by the USGS for the Tuolumne River below La Grange Dam, near La Grange (Gauge No. 11289650). Instantaneous flows and flow fluctuations were not reported in the FERC documents for these surveys.

Table 3.5.2.6-2 Stranding surveys completed from 1996–2002.

Year	Date	Location	River mile	Flow reduction
1996	February 22	OLGB to TLSRA	(50.5-42.0)	5,000 to 3,000
	June 4	A3/A4 to TLSRA	(51.6-42.0)	2,100 to 1,200
1997	January 21	R1B- R5	(50.1-47.9)	9,700 to 5,700
	May 15	RA7-R5	(50.7-47.9)	1,900 to 800e
1999	May 16-17	OLGB to R5	(50.5-47.9)	3,500 to 500
2000	March 18-20	R1B-R17B	(50.1-44.2)	7,000 to 4,000
2002	May 2	RA7-R5	(50.7-47.9)	1,300 to 900
	May 3	RA7-R5	(50.7-47.9)	900 to 600
	May 17	RA7-R5	(50.7-47.9)	540 to 193 (4 days)
	June 3	A3/A4 to R5	(51.6-47.9)	226 to 99 (4 days)

Review of Stranding Studies through 1997

The FERC Report 2000-6 reviewed all the data gathered in various stranding surveys from 22 sites in the 1986–1996 period with flows observed ranging from 57 to 7,600 cfs in those years. Additional surveys in 1997 (Report 1997-2, TID/MID 1998) were done, including a flow change from 9,500 to 5,700 cfs. In WY 1987 under a "normal flow schedule", hydropower peaking flow fluctuations occurred from December into February followed by only minimum flow or pulse flow changes into June. WY 1988 and 1989 were dry years and flow changes were relatively minor, primarily associated with spring pulse flows. Due to continued dry conditions and low reservoir storage, flow changes in 1990-1994 were also mainly limited to spring pulses or minimum flow schedules. Wetter conditions resulted in flood releases in 1995-1997.

The review indicated the highest potential for stranding occurred between 1,100–3,100 cfs, which corresponds to a broad floodplain inundation zone in several areas of the spawning reach. The greatest numbers of stranded juvenile salmon were documented after flows were reduced from 5,000 to 3,000 cfs (February 1996), from 2,900 to 1,200 cfs (March 1995), from 1,050 to 400 cfs (April 1989), from 550 to 200 cfs (May 1987), and from 230 to 10 cfs (June 1987). In years of high juvenile salmon density, stranded salmon were generally found on gently sloping stream banks and gravel bars on a wide range of substrates in the upper five miles. For instance, in May and June 1987, the density of salmon was relatively high (5 – 15 fish/1,000 ft^2); flow reduction was in the range at which many bank areas and side channels became exposed; flow reduction was rapid; and a long period of stable, higher flows preceded the flow reduction, which may have increased use of marginal areas by juvenile salmon prior to flow reduction. These conditions likely contributed to the high rates of stranding that were observed in 1987.

No stranded salmon were found when densities were low, as in 1991, 1992, and 1994. However, other species, including riffle sculpin (*Cottus gulosus*), Sacramento pikeminnow (*Ptychocheilus grandis*), Pacific lamprey (*Lampetra tridentata*), Sacramento sucker

(*Catostomus occidentalis*), mosquitofish (*Gambusia affinis*), and several centrarchid species, were found stranded.

Review of stranding surveys conducted since 1997

Stranding surveys were conducted in three more years under the TRTAC program to supplement the stranding surveys reviewed through 1997; only the March 2000 surveys were during the fry period. GIS floodplain maps were developed from aerial photography taken at several flow levels to document floodplain exposure throughout the lower Tuolumne River corridor from La Grange Dam (RM 52) to Empire (RM 22). Inundation areas were delineated for 620 cfs, 1,100 cfs, 3,100 cfs, 5,300 cfs, and 8,400 cfs flow levels and high priority areas were identified. Geomorphic observations of surface slope and substrate size were made between November 1998 and March 2000 to identify relationships with stranding locations and stranding densities for flows of 300-5,300 cfs. The geomorphic surveys were conducted from La Grange Dam (RM 52) to Basso Bridge (RM 47.3).

The 1999–2000 surveys observed few stranded salmon and the stranding locations (Riffles 1A, 1B and 4B) were consistent with prior observations of stranding in the upper reach (RM 50.5 to RM 42.3). There was limited entrapment in floodplain potholes/dredger ponds and some live salmon were found in seining of backwater and side channels. Those fish may have returned to the main channel or some may have become stranded upon further flow reduction. The 2002 surveys also found few stranded salmon. The surveys recorded that salmon were present in the river at a number of locations where no stranding occurred, despite high in-river density based on concurrent river seining. That may be attributed to more favorable flow levels and ramping rates. The 1999–2002 surveys confirmed higher stranding risk on low gradient sand and gravel substrates in the primary spawning reach down to RM 47.8 of the Tuolumne River. Other species found were riffle sculpin, Pacific lamprey, Sacramento sucker, and mosquitofish.

The review of the survey data indicated several factors may contribute to the magnitude of juvenile stranding, including: (1) salmon density, (2) flow reduction and the minimum flow in the fluctuation cycle (which determines the amount of potential stranding area exposed) as well as ramping rate, (3) particular locations with higher stranding potential, and (4) physical characteristics of these sites in terms of slope and substrate categories.

Overall, little salmon stranding has been documented in the post-FSA period. The Districts have not had daily hydropower peaking releases to the river, as was the case in WY 1987, and flood management flow reduction rates are at or below the 1995 FSA ramping rate limits, further reducing the magnitude of stranding events. The operation of flood management flows and extending spring pulse rampdowns and reductions in minimum flow schedules reduces stranding below pre-FSA levels. Floodplain restoration could further reduce stranding potential and the floodplain restoration projects in the spawning reach all have “anti-stranding” channel features incorporated into their project designs.

3.5.3 Biotic community assessments

The broader biotic community of the river has been documented in the 1995 FSA monitoring program by the fish species data that is summarized in Section 3.5.3.1. Included in that section is a more detailed review of specific information obtained on rainbow trout. The Districts on their own have conducted additional monitoring of aquatic invertebrates throughout the 1995 FSA monitoring period – which information is summarized in Section 3.5.3.2.

3.5.3.1 Fish species, including rainbow trout (*Oncorhynchus mykiss*)

The various monitoring surveys gathered data on many other fish species besides Chinook salmon - this was especially the case during seine, screw trap, and snorkel sampling. A list of all Tuolumne river species encountered since 1981 is in Table 3.5.3.1-1. Table 3.5.3.1-2 has the fish species observed in the Tuolumne and San Joaquin Rivers, by sampling method, for the 1996–2004 period (upper RST sampling was only done in 1998–2000). Monitoring in the 1996–2004 period resulted in capture of 37 species in the Tuolumne and San Joaquin Rivers.

The three sampling methods of seine, snorkel, and screw trap varied in species observed and habitats sampled. The screw traps caught more species than seining, as would be expected from that continuous monitoring and more intensive effort. Snorkeling was limited to the upper 20 miles of the Tuolumne River where fewer species are present. Smaller fish tend to be caught with the screw traps and seines and that sampling was done in the winter/spring, so larger individuals and seasonal migratory fishes, such as non-native American shad and striped bass, were likely underrepresented. Other sampling methods, such as angling, would provide more information on those species. Additional data on fish species was obtained from electrofishing done for the project monitoring (see Section 3.4.2).

Fish species distribution and abundance data for the Tuolumne River from five sample methods (seine, screw trap, fyke net, electrofishing, snorkel) were reviewed in Ford and Brown, 2001 (Report 2001-8, TID/MID 2002) and Brown and Ford, 2001 (FERC Report 2002-9, TID/MID 2003). The data analyzed were primarily from 1986-1997, but fyke netting during 1973-86 was included in Ford and Brown, 2001. Those analyses showed native species were dominant upstream of RM 50 and introduced species were dominant downstream of RM 31. The river upstream of RM 50 had cooler summer water temperatures and gravel riffles while the area downstream of RM 31 had warm summer conditions and was largely modified by inchannel gravel mining down to RM25 and mostly sand-bedded below there. The resident fish community appeared to vary in response to annual differences in flow conditions with some native species such as Sacramento sucker, Sacramento pikeminnow, and riffle sculpin, which are riffle spawners, becoming more abundant in the year following a high flow year. There was no discernible seasonal change in fish communities when early summer and late summer samples from the same sites were compared.

The overall distribution of fish species in the Tuolumne continues to be related to longitudinal habitat and temperature trends. A comparable statistical analysis for all 1998–2004 data has not been done, but higher summer flows under the 1996 FERC Order have extended the coolwater reach several miles downstream of RM 50 as described later in this section. The lower gradient and seasonally warmer downstream half of the river had many of the same species that were abundant in the San Joaquin River (e.g. inland silverside, red shiner). Species that were not recorded in Tuolumne sampling prior to 1998 include river lamprey (this species was likely recorded as the more abundant Pacific lamprey previously), and the non-native wakasagi and American shad. Spotted bass and redeye bass are two introduced centrarchid species that may be present, but are unconfirmed.

Table 3.5.3.1-1 Fishes of the lower Tuolumne River observed since 1981 in fishery studies

Family	Genus/Species	Native
Petromyzontiformes	Petromyzontidae - lampreys	
	Pacific lamprey, Lampetra tridentata (Gairdner, 1836)	N
	river lamprey, Lampetra ayresii (Gunther, 1870)	N
Acipenseriformes	Acipenseridae - sturgeons	
	white sturgeon, Acipenser transmontanus Richardson, 1836	N
Clupeiformes	Clupeidae - herrings	
	American shad, Alosa sapidissima (Wilson, 1811)	
	threadfin shad, Dorosoma petenense (Gunther, 1867)	
Cypriniformes	Cyprinidae - carps and minnows	
	common carp, Cyprinus carpio Linnaeus, 1758	
	goldfish, Carassius auratus (Linnaeus, 1758)	
	golden shiner, Notemigonus crysoleucas (Mitchell, 1814)	
	hitch, Lavinia exilicauda Baird & Girard, 1854	N
	Sacramento blackfish, Orthodon microlepidotus (Ayres, 1854)	N
	splittail, Pogonichthys macrolepidotus (Ayres, 1854)	N
	hardhead, Mylopharodon conocephalus (Baird & Girard, 1854)	N
	Sacramento pikeminnow, Ptychocheilus grandis (Ayres, 1854)	N
	red shiner, Cyprinella lutrensis (Baird & Girard, 1853)	
	fathead minnow, Pimephales promelas Rafinesque, 1820	
	Catostomidae - suckers	
	Sacramento sucker, Catostomus occidentalis Ayres, 1854	N
Siluriformes	Ictaluridae – North American catfishes	
	white catfish, Ameiurus catus (Linnaeus, 1758)	
	brown bullhead, Ameiurus nebulosus (Lesueur, 1819)	
	black bullhead, Ameiurus melas (Rafinesque, 1820)	
	channel catfish, Ictalurus punctatus (Rafinesque, 1818)	
Salmoniformes	Osmeridae – smelts	
	wakasagi, Hypomesus nipponensis McAllister, 1963	
	Salmonidae – trouts and salmons	
	Chinook salmon, Oncorhynchus tshawytscha (Walbaum, 1792)	N

Family	Genus/Species	Native
	rainbow trout, Oncorhynchus mykiss (Walbaum, 1792)	N
Atheriniformes	Atherinopsidae – New World silversides	
	inland silverside, Menidia beryllina (Cope, 1867)	
Cyprinodontiformes	Poeciliidae - livebearers	
	western mosquitofish, Gambusia affinis (Baird & Girard, 1853)	
Scorpaeniformes	Cottidae - sculpins	
	prickly sculpin, Cottus asper Richardson, 1836	N
	riffle sculpin, Cottus gulosus (Girard, 1854)	N
Perciformes	Moronidae - temperate basses	
	striped bass, Morone saxatilis (Walbaum, 1792)	
	Centrarchidae - sunfishes	
	black crappie, Pomoxis nigromaculatus (Lesueur, 1829)	
	white crappie, Pomoxis annularis Rafinesque, 1818	
	warmouth, Lepomis gulosus (Cuvier, 1829)	
	green sunfish, Lepomis cyanellus Rafinesque, 1819	
	bluegill, Lepomis macrochirus Rafinesque, 1819	
	redear sunfish, Lepomis microlophus (Gunther, 1859)	
	largemouth bass, Micropterus salmoides (Lacepede, 1802)	
	smallmouth bass, Micropterus dolomieu Lacepede, 1802	
	Percidae - perches	
	bigscale logperch, Percina macrolepida Stevenson, 1971	
	Embiotocidae - surfperches	
	tule perch, Hysterocarpus traskii Gibbons, 1854	N

Total: 38 species in 15 families, including 14 native (N) species in 7 families

Table 3.5.3.1-2 Fish species observed in 1996–2004 monitoring.

Common Name	Abbrev.	Native Species	Tuolumne River				SJR
			Snorkel	Upper RST	Lower RST	Seine	Seine
Pacific lamprey	LP	**N**	**X**	**X**	**X**	**X**	
river lamprey	RL	**N**		**X**			
American shad	AS			X	X		
threadfin shad	TFS			X	X	X	X
common carp	CP		X	X	X		X
goldfish	GF			X	X		X
golden shiner	GSH			X	X	X	X
hitch	HCH	**N**		**X**	**X**		**X**
Sacramento blackfish	SBF	**N**			**X**		**X**
splittail	ST	**N**			**X**		**X**
hardhead	HH	**N**	**X**	**X**	**X**	**X**	
Sac. pikeminnow	PM	**N**	**X**	**X**	**X**	**X**	**X**
red shiner	PRS			X	X	X	X
fathead minnow	FHM					X	X
Sacramento sucker	SKR	**N**	**X**	**X**	**X**	**X**	**X**
white catfish	WCF		X			X	X
brown bullhead	BBH			X	X		X
black bullhead	BLBH			X	X		
channel catfish	CCF			X	X	X	X
wakasagi	WAG				X		
Chinook salmon	CS	**N**	**X**	**X**	**X**	**X**	**X**
rainbow trout	RT	**N**	**X**	**X**	**X**	**X**	
inland silverside	ISS				X	X	X
western mosquitofish	GAM		X	X	X	X	X
prickly sculpin	PSCP	**N**		**X**	**X**	**X**	**X**
riffle sculpin	RSCP	**N**	**X**	**X**	**X**	**X**	
striped bass	SB			X	X	X	X
black crappie	BCR			X	X		X
white crappie	WCR			X	X		X
warmouth	WM			X	X		
green sunfish	GSF			X	X	X	X
bluegill	BG		X	X	X	X	X
redear sunfish	RSF		X	X	X	X	X
largemouth bass	LMB		X	X	X	X	X
smallmouth bass	SMB		X	X	X	X	X
bigscale logperch	BLP			X	X	X	X
tule perch	TP	**N**					**X**
		TOTAL:	**14**	**30**	**33**	**23**	**28**

Rainbow Trout (*Oncorhynchus mykiss*)

The status of rainbow trout in the lower Tuolumne River became a subject of heightened interest following the ESA listing by NOAA Fisheries in 1998 of Central Valley steelhead as threatened. The FERC began informal consultation with NOAA Fisheries and the Districts in 2003 regarding steelhead issues. The FERC staff requested on August 28, 2003 that the Districts provide their available information on *Oncorhynchus mykiss* and the Districts filed their detailed response on October 9 and December 1, 2003. That information, including CDFG data, was the first compilation of data specific to lower Tuolumne River rainbow trout from disparate sources. FERC Report 2004-11 has additional detail updating that summary. Table 3.5.3.1-3 is an update of the Districts data though 2004. The Districts filed more information with FERC on May 20, 2004, that included (a) results of the Districts' March 2004 documentation of rainbow trout in the upper canals near La Grange Dam, (b) results of a Central Valley rainbow trout genetic study funded by CDFG, (c) the 1995 USFWS IFIM report that addressed rainbow trout habitat in the lower Tuolumne River under the 1986 study plan, and (d) the April 2004 decision of the Eastern District of California ruling that the Central Valley steelhead ESA listing was legally flawed. NOAA Fisheries again proposed listing the Central Valley steelhead as threatened in June 2004.

Additional field monitoring by the Districts to augment the 1995 FSA program and better assess the status of rainbow trout/steelhead (*Oncorhynchus mykiss*) and their habitat began in 2000. The added fishery monitoring included more snorkel surveys starting in 2000 and an extended spawning survey with CDFG from FEB-MAY of 2004 (2 redds were observed). Other related monitoring starting in 2001 involved adding more thermographs and additional invertebrate sampling. A water quality survey was performed in June of 2004. The temperature, invertebrate, and water quality information is reviewed in other sections of this report.

Other trout sampling by CDFG had included electrofishing in 2001 to obtain samples for genetic and otolith studies. The CDFG otolith study is scheduled to be completed by the end of 2005, but CDFG has informally reported that early specimens (about 20) had no signs of anadromy. The Districts had proposed an angling survey for rainbow trout in 2000 and requested permit approval from both CDFG and NOAA Fisheries. CDFG declined to approve that sampling under their scientific collecting permit program and NOAA fisheries has taken no action on the Districts 2000 application for a take permit for monitoring activities. The CDFG conducted an angling survey in winter/spring of 2004 and that information is included in Table 3.5.3.1-4 -- no other data to update the table has been provided. The CRRF provided to the TRTAC in March 2004 a report with mapping of general rainbow trout areas, overlain on river mesohabitat maps prepared by McBain & Trush, based on angling experience and habitat features.

The number of rainbow trout observed in June-September snorkel surveys and in seine surveys from 1982–2004 is shown in Tables 3.5.3.1-5 & 6. Distribution of rainbow trout from snorkel and seine surveys for those years is shown in Figures 3.5.3.1-1 & 2. The 1996 FERC Order summer flow schedule has consistently extended the available trout habitat downstream to at least Riffle 23C (RM 42.3), several miles further than under the prior summer flow schedule. The primary physical difference accounting for the extended distribution of rainbow trout in the post-FSA period is the higher summer flow regime that extends cool water habitat in the summer over several more miles of river. Water temperatures recorded at RM 49.0 in Figure 3.5.3.1-3 illustrate this change. Figure 3.5.3.1-4 shows the lower summer flows prior to the 1995 FSA often were less than 30 cfs, resulting in daily average water temperature at RM 49 often exceeding 23 degrees C.

The nature and origin of the rainbow trout present in the river below La Grange Dam is unknown as the results of the genetic study for the lower Tuolumne River were inconclusive. The finding of numbers of large trout in the upper canal system near LaGrange Reservoir strongly suggests some trout in the river are from that source. Rainbow trout, including hatchery trout, may also come into La Grange Reservoir from Don Pedro Reservoir. CDFG operates a rainbow trout hatchery on Moccasin Creek, tributary to the Tuolumne River at upper Don Pedro Reservoir. Additionally, there are hatchery trout planted in Turlock Reservoir and there is potential for hatchery trout to enter the lower river through intermittent spill operation below Turlock Reservoir.

Table 3.5.3.1-3 The Districts rainbow trout records in the Tuolumne River for 1982–2004.

Method	River	Location	River Mile	Date	#	Fork length (mm) [1]
Snorkel	Tuol	R5	48.0	08/01/82	2	350
Seine (DFG)	Tuol	OLGB	50.5	04/15/83	1	39
Seine (DFG)	Tuol	OLGB	50.5	05/06/83	1	60
Seine (DFG)	Tuol	OLGB	50.5	06/09/83	1	41
Seine (DFG)	Tuol	OLGB	50.5	02/16/84	4	?
Seine (DFG)	Tuol	OLGB	50.5	03/01/84	2	?
Stranding	Tuol	R4B	48.4	03/16/84	4	25-30
Snorkel (spring)	Tuol	R4B-5	48.0-48.4	04/11/84	12	150-300
Snorkel	Tuol	RA3	51.6	08/10/84	27	100-200
Snorkel	Tuol	RA7	50.7	08/10/84	26	?
Snorkel (spring)	Tuol	RA3	51.6	03/21/85	2	300,350
Seine	Tuol	R4B	48.4	04/23/86	1	37
Seine	Tuol	OLGB	50.5	05/12/86	1	29
Seine	Tuol	OLGB	50.5	05/19/86	1	26
Seine	Tuol	OLGB	50.5	05/30/86	1	29
Seine	Tuol	R4B	48.4	05/30/86	1	30
Seine	Tuol	OLGB	50.5	06/11/86	2	36,54
Seine	Tuol	R4B	48.4	06/11/86	2	74,67
Seine	Tuol	R4B	48.4	06/19/86	1	80
Seine	Tuol	OLGB	50.5	06/26/86	5	46,66,79,58,67
Snorkel	Tuol	R4B	48.4	07/01/86	5	40-80
Snorkel	Tuol	RA3	51.6	08/14/86	6	5(100-160), (350)
Snorkel	Tuol	RA7	50.7	08/14/86	13	70-150
Snorkel	Tuol	R2	49.9	08/14/86	25	<175
Snorkel	Tuol	R4B	48.4	08/14/86	10	<175
Snorkel	Tuol	R5	48.0	08/14/86	10	<175
Seine	Tuol	R4B	48.4	02/26/87	1	28
Seine	Tuol	R4B	48.4	03/04/87	1	33
Seine	Tuol	OLGB	50.5	03/26/87	1	26
Mark-Recap.	Tuol	R4A	48.8	05/14/87	1	88
Seine	Tuol	R5	48.0	05/20/87	2	59,32
Seine	Tuol	OLGB	50.5	05/20/87	3	31,30,29
Stranding	Tuol	RA4	51.6	06/01/87	7	29-35
Stranding	Tuol	R5	48.0	06/02/87	5	62-92
Seine	Tuol	OLGB	50.5	06/03/87	2	33,37
Seine	Tuol	OLGB	50.5	05/16/88	1	34
Electro	Tuol	R2	49.9	05/30/90	1	73
Snorkel	Tuol	RA3	51.6	06/09/92	1	150
Snorkel (late fall)	Tuol	RA7	50.7	11/30/95	1	250
Snorkel (late fall)	Tuol	R5	48.0	11/30/95	2	220,250
Snorkel	Tuol	R7	46.9	07/03/96	4	90-110
Seine	Tuol	TRR	42.2	03/12/97	1	35
Snorkel	Tuol	RA3	51.6	06/25/97	4	200,250,250,300
Snorkel	Tuol	RA7	50.7	06/25/97	2	250,400
Snorkel	Tuol	R2	49.9	06/25/97	2	250
Seine	Tuol	R4B	48.4	04/22/98	1	28
RST 7/11	Tuol	7/11	38.5	01/21/99	1	198
Seine	Tuol	TRR	42.2	02/24/99	1	25
RST 7/11	Tuol	7/11	38.5	04/01/99	1	45
Seine	Tuol	R5	48.0	04/08/99	1	27
Seine	Tuol	OLGB	50.5	05/19/99	3	32,43,46
Snorkel	Tuol	RA7	50.7	06/15/99	14	70-110
Snorkel	Tuol	R3B	49.1	06/15/99	31	70-100
Snorkel	Tuol	R5	48.0	06/15/99	10	4(75-100), 6(220-300)
Snorkel	Tuol	R7	46.9	06/16/99	15	75-130
Snorkel	Tuol	R23B-C	42.3-42.4	06/16/99	9	80-130
Seine	Tuol	TRR	42.2	03/21/00	1	26
Angling	Tuol	R3B, R13B	49.1, 45.5	04/12/00	2	385,355
Seine	Tuol	R5	48.0	05/17/00	3	48,56,63
Snorkel	Tuol	RA7	50.7	06/05/00	14	50-120
Snorkel	Tuol	R1A	50.4	06/05/00	3	60,70,80
Snorkel	Tuol	R3B	49.1	06/05/00	14	11(70-110), 200,225,250
Snorkel	Tuol	R5	48.0	06/05/00	19	14(50-110), 5(200-350)
Snorkel	Tuol	R7	46.9	06/21/00	52	47(45-100), 5(225-350)
Snorkel	Tuol	R12	45.8	06/06/00	5	250-350
Snorkel	Tuol	R13A	45.6	06/06/00	20	19(60-110), 200
Snorkel	Tuol	R17A2	44.4	06/06/00	14	75-120
Snorkel	Tuol	R21	42.9	06/06/00	27	25(70-110), 225,250
Snorkel	Tuol	R23C	42.3	06/06/00	4	70,80,90,225
Snorkel	Tuol	R26	40.9	06/07/00	4	150-225
Snorkel	Tuol	R27	40.3	06/07/00	2	275,325
Snorkel	Tuol	R31	38.1	06/07/00	2	200,325
[1] estimated total length for snorkel data						

Table 3.5.3.1-3 (Continued)

Method	River	Location	River Mile	Date	#	Fork length (mm) [1]
Seine	Tuol	OLGB	50.5	03/20/01	1	26
Seine	Tuol	R5	48.0	03/20/01	1	32
Seine	Tuol	TRR	42.2	03/20/01	2	48,51
Seine	Tuol	R5	48.0	05/15/01	41	(36-77)
Snorkel	Tuol	RA7	50.7	06/18/01	7	70-95
Snorkel	Tuol	R2	49.9	06/18/01	3	75,80,90
Snorkel	Tuol	R3B	49.1	06/18/01	8	4(120-160), 4(180-200)
Snorkel	Tuol	R5	48.0	06/18/01	4	80,140,160,280
Snorkel	Tuol	R7	46.9	06/19/01	4	90,90,100,150
Snorkel	Tuol	R13B	45.5	06/19/01	3	90,130,160
Snorkel	Tuol	R21	42.9	06/19/01	2	120,150
Snorkel	Tuol	RA7	50.7	09/18/01	3	160,270,300
Snorkel	Tuol	R2	49.9	09/18/01	3	225,280,330
Snorkel	Tuol	R3B	49.1	09/18/01	1	280
Snorkel	Tuol	R5	48.0	09/18/01	2	275,300
Snorkel	Tuol	R21	42.9	09/19/01	3	190,225,275
Seine	Tuol	OLGB	50.5	04/23/02	2	32,32
Seine	Tuol	R5	48.0	05/07/02	1	28
Snorkel	Tuol	RA7	50.7	06/11/02	5	70-80
Snorkel	Tuol	R2	49.9	06/11/02	1	225
Snorkel	Tuol	R3B	49.1	06/11/02	11	60-120
Snorkel	Tuol	R5	48.0	06/12/02	3	160,300,380
Snorkel	Tuol	R7	46.9	06/12/02	5	100, 4(140-160)
Snorkel	Tuol	R13B	45.5	06/12/02	2	120,140
Snorkel	Tuol	R21	42.9	06/12/02	1	125
Snorkel	Tuol	RA7	50.7	09/24/02	1	400
Snorkel	Tuol	R2	49.9	09/24/02	4	300,330,420,480
Snorkel	Tuol	R3B	49.1	09/24/02	1	200
Snorkel	Tuol	R7	46.9	09/25/02	2	150,225
Snorkel	Tuol	R13B	45.5	09/25/02	4	110,160,200,220
Seine	Tuol	TRR	42.3	04/01/03	1	29
Snorkel	Tuol	RA7	50.7	06/18/03	66	65(45-140), (350)
Snorkel	Tuol	R2	49.9	06/18/03	8	5(120-130), 300,325,420
Snorkel	Tuol	R3B	49.1	06/18/03	5	110-150
Snorkel	Tuol	R5	48.0	06/18/03	6	5(90-120), 370
Snorkel	Tuol	R7	46.9	06/19/03	14	13(80-125), 375
Snorkel	Tuol	R13B	45.5	06/19/03	1	390
Snorkel	Tuol	R23C	42.3	06/19/03	1	90
Snorkel	Tuol	RA7	50.7	09/17/03	16	15(45-60), 210
Snorkel	Tuol	R2	49.9	09/17/03	2	200,350
Snorkel	Tuol	R3B	49.1	09/17/03	21	16(60-80), 180,200,220,325,475
Snorkel	Tuol	R5	48.0	09/17/03	10	9(60-70), 325
Snorkel	Tuol	R7	46.9	09/18/03	9	125-225
Snorkel	Tuol	R13B	45.5	09/18/03	6	60, 190,210,225,300,330
Snorkel	Tuol	R21	42.9	09/18/03	6	5(190-225), 320
Snorkel	Tuol	R23C	42.3	09/18/03	1	210
Seine	Tuol	OLGB	50.5	03/16/04	1	29
Seine	Tuol	TRR	42.3	03/16/04	1	29
Seine	Tuol	TRR	42.3	03/30/04	2	31,32
Seine	Tuol	R5	48.0	04/14/04	2	31,38
Seine	Tuol	R5	48.0	05/25/04	1	64
Snorkel	Tuol	RA7	50.7	06/16/04	12	11(50-80), 420
Snorkel	Tuol	R2	49.9	06/16/04	23	20(80-130), 180,320,400
Snorkel	Tuol	R3B	49.1	06/16/04	22	21(80-130), 480
Snorkel	Tuol	R5	48.0	06/16/04	11	9(90-130), 300,370
Snorkel	Tuol	R7	46.9	06/17/04	13	110-140
Snorkel	Tuol	R13B	45.5	06/17/04	5	110-125
Snorkel	Tuol	R21	42.9	06/17/04	5	110-130
Snorkel	Tuol	RA3/A4	51.6	08/03/04	5	170-275
Snorkel	Tuol	RA7	50.7	08/03/04	6	120-200
Snorkel	Tuol	R1A	50.5	08/03/04	4	300-425
Snorkel	Tuol	R2	49.9	08/03/04	2	290,320
Snorkel	Tuol	R3B	49.1	08/04/04	5	140,150,160,350,525
Snorkel	Tuol	R4B	48.4	08/04/04	8	7(90-200),350
Snorkel	Tuol	R5	48.0	08/04/04	15	60, 14(150-225)
Snorkel	Tuol	R7	46.9	08/04/04	5	140-160
Snorkel	Tuol	R10	46.2	08/05/04	3	340,400,450
Snorkel	Tuol	R13B	45.5	08/05/04	13	100-210
Snorkel	Tuol	R21	42.9	08/05/04	9	100-170
Snorkel	Tuol	R23C	42.3	08/05/04	1	200
Snorkel	Tuol	RA7	50.7	09/15/04	11	40-110
Snorkel	Tuol	R2	49.9	09/15/04	7	100, 6(200-380)
Snorkel	Tuol	R3B	49.1	09/15/04	7	4(60-110), 360,400,425
Snorkel	Tuol	R5	48.0	09/15/04	6	45, 5(140-360)
Snorkel	Tuol	R7	46.9	09/16/04	2	180,300
Snorkel	Tuol	R21	42.9	09/16/04	7	4(160-180), 3(280-310)
[1] estimated total length for snorkel data						

Table 3.5.3.1-4 CDFG rainbow trout records in the Tuolumne River (compiled by Districts from available data).

Date	Location	River Mile	Method	# observed	Forklength (mm)	Life Stage	Sex	Adipose Clip	Scales	# of otoliths	DNA
30-Nov-1983			Sp. Survey(?)		440		M	N	Y		N
9-Jul-1996	R1A	50.5	Snorkel	2							
9-Jul-1996	R1B	50.2	Snorkel	1							
9-Jul-1996	R1C	50.0	Snorkel	48							
9-Jul-1996	R2	49.9	Snorkel	91							
9-Jul-1996	R3A	49.4	Snorkel	11							
9-Jul-1996	R3B	49.1	Snorkel	127							
9-Jul-1996	R4A	48.8	Snorkel	25							
9-Jul-1996	R4B	48.4	Snorkel	30							
9-Jul-1996	R5A	48.0	Snorkel	20							
9-Jul-1996	R5B	47.9	Snorkel	25							
21-Nov-1997	1A	50.5	Sp. Survey(?)		410			N	Y		N
24-Nov-1997	1A	50.5	Sp. Survey(?)		410			N	Y		N
24-Nov-1997			Sp. Survey(?)		410		F			1	
1-Dec-1997			Sp. Survey(?)		480		F		Y	1	
1-Dec-1997			Sp. Survey(?)		480		F	N	Y		N
12-Nov-1998	R12	45.8	Sp. Survey(?)		420			N	Y		N
25-Nov-1998			Sp. Survey(?)		360		M			2	
2-Dec-1998	R1A	50.5	Sp. Survey(?)		320			N	Y		N
2-Dec-1998			Sp. Survey(?)		340			N	Y		N
2-Dec-1998			Sp. Survey(?)		340				Y	1	
31-Aug-1999	RA5	51.3			340			N	Y		N
31-Aug-1999	RA3	51.6			360			N	Y		N
3-Dec-1999	37	36.2	Sp. Survey(?)		320				Y	2	
3-Dec-1999	22	42.8	Sp. Survey(?)		320				Y	2	
3-Dec-1999			Sp. Survey(?)		320				Y	1	
7-Dec-1999	36	36.7	Sp. Survey(?)		320				Y	2	
8-Dec-1999	Basso	47.5	Sp. Survey(?)		280			N	Y		N
8-Dec-1999	Basso	47.5	Sp. Survey(?)		430				Y	2	
20-Dec-1999	37	36.2	Sp. Survey(?)		460				Y	2	
28-Dec-1999			Sp. Survey(?)		440				Y	1	
21-Feb-2000	Grayson	5.2	Screw trap		230						
13-Nov-2000	1A	50.5	Sp. Survey(?)		349	6	F	0	Y	2	Y
15-Nov-2000	17B	44.3	Sp. Survey(?)		405	6	F	0	Y	2	Y
15-Nov-2000	12	45.9	Sp. Survey(?)		424	6	F	0	Y	2	Y
21-Nov-2000	3C	49.0	Sp. Survey(?)		410	7	F	0	Y		Y
22-Nov-2000	4B	48.4	Sp. Survey(?)		440	7	M	0	Y	1	Y
22-Nov-2000	5B	48.0	Sp. Survey(?)		446	6	M	0	Y	2	Y
28-Nov-2000	2	49.9	Sp. Survey(?)		443	7	M	1(?)	Y	1	Y
29-Nov-2000	13C	45.6	Sp. Survey(?)		430	7		0	Y	2	Y
11-Dec-2000	5A	48.0	Sp. Survey(?)		455	6	F	0	Y	2	Y
11-Dec-2000	1A	50.5	Sp. Survey(?)		473	6	M	0	Y	2	Y
13-Dec-2000	8B	46.7	Sp. Survey(?)		400	7	F	0	Y		Y
18-Dec-2000	1B	50.1	Sp. Survey(?)		355	7		0	Y	1	Y
27-Dec-2000	4B	48.4	Sp. Survey(?)		455	6	F	0	Y	1	Y
27-Dec-2000	4B	48.4	Sp. Survey(?)		501	6	F	0	Y	2	Y
28-Dec-2000	8B	46.7	Sp. Survey(?)		446	6	F	0	Y	2	Y
11-Jan-2001	5B	48.0	Angling		740	6	M	N	N		Y
15-Jan-2001	A2	51.7	Angling		280	5			N		N
17-Jan-2001					540				Y		
29-Mar-2001	Gasburg	50.2			360			N	Y		N
29-Mar-2001	Gasburg	50.2			440				Y		N
5-Apr-2001	Gasburg	50.2			430			N	Y		Y
5-Apr-2001	Gasburg	50.2			290				Y		N
11-Apr-2001	RA7	50.7			360			N	Y		N
14-Apr-2001	R1A	50.5			320			N	Y		N
14-Apr-2001	R1A	50.5			350			N	Y		N
14-Apr-2001	RA1(1A?)	50.5			380			N	Y		N
17-Apr-2001	R1A	50.5			310			N	Y		N
17-Apr-2001	R1A	50.5			370			N	Y		N

Life stage Codes	
1	Yolk Fry
2	Fry
3	Parr
4	Silvery Parr
5	Smolt
6	Adult
7	Unknown

Table 3.5.3.1-4 (*Continued*)

Date	Location	River Mile	Method	# observed	Forklength (mm)	Life Stage	Sex	Adipose Clip	Scales	# of otoliths	DNA
19-May-2001			E-fishing		29	2		0			
19-May-2001			E-fishing		42	3		0			
19-May-2001			E-fishing		42	3		0			
19-May-2001			E-fishing		43	3		0			
19-May-2001			E-fishing		44	3		0			
19-May-2001			E-fishing		44	3		0			
19-May-2001			E-fishing		45	3		0			
19-May-2001			E-fishing		46	3		0			
19-May-2001			E-fishing		49	3		0			
19-May-2001			E-fishing		49	3		0			
19-May-2001			E-fishing		54	3		0			
19-May-2001			E-fishing		54	3		0			
19-May-2001			E-fishing		55	3		0			
19-May-2001			E-fishing		56	3		0			
19-May-2001			E-fishing		56	3		0			
19-May-2001			E-fishing		57	3		0			
19-May-2001			E-fishing		57	3		0			
19-May-2001			E-fishing		58	3		0			
19-May-2001			E-fishing		59	3		0			
19-May-2001			E-fishing		60	3		0			
19-May-2001			E-fishing		60	3		0			
19-May-2001			E-fishing		60	3		0			
19-May-2001			E-fishing		62	3		0			
19-May-2001			E-fishing		62	3		0			
19-May-2001			E-fishing		63	3		0			
19-May-2001			E-fishing		65	3		0			
19-May-2001			E-fishing		66	3		0			
19-May-2001			E-fishing		66	3		0			
19-May-2001			E-fishing		66	3		0			
19-May-2001			E-fishing		67	3		0			
19-May-2001			E-fishing		67	3		0			
19-May-2001			E-fishing		68	3		0			
19-May-2001			E-fishing		71	3		0			
19-May-2001			E-fishing		71	3		0			
19-May-2001			E-fishing		72	3		0			
19-May-2001			E-fishing		72	3		0			
19-May-2001			E-fishing		73	3		0			
19-May-2001			E-fishing		73	3		0			
19-May-2001			E-fishing		74	3		0			
19-May-2001			E-fishing		80	3		0			
19-May-2001			E-fishing		83	3		0			
19-May-2001			E-fishing		86	3		0			
19-May-2001			E-fishing		87	3		0			
19-May-2001			E-fishing		91	3		0			
19-May-2001			E-fishing		92	3		0			
22-May-2001			E-fishing		42	3		0			
22-May-2001			E-fishing		46	3		0			
22-May-2001			E-fishing		47	3		0			
22-May-2001			E-fishing		48	3		0			
22-May-2001			E-fishing		49	3		0			
22-May-2001			E-fishing		55	3		0			
22-May-2001			E-fishing		59	3		0			
22-May-2001			E-fishing		63	3		0			
22-May-2001			E-fishing		68	3		0			
22-May-2001			E-fishing		72	3		0			
22-May-2001			E-fishing		86	3		0			

Life stage Codes

1	Yolk Fry
2	Fry
3	Parr
4	Silvery Parr
5	Smolt
6	Adult
7	Unknown

Table 3.5.3.1-4 (*Continued*)

Date	Location	River Mile	Method	# observed	Forklength (mm)	Life Stage	Sex	Adipose Clip	Scales	# of otoliths	DNA
14-Jun-2001					458	6		0	Y	Y	Y
30-Sep-2001					108	3		0			
30-Sep-2001					163	3		0			
30-Sep-2001					206	3		0			
30-Sep-2001					213	3		0			
30-Sep-2001					216	3		0			
30-Sep-2001					222	3		0			
30-Sep-2001					272	3		0			
30-Sep-2001					286	3		0			
30-Sep-2001					297	3		0			
30-Sep-2001					301	3		0			
30-Sep-2001					310	3		0			
30-Sep-2001					317	3		0			
30-Sep-2001					365	3		0			
16-Oct-2001			Sp. Survey(?)		460				Y		
11-Nov-2001			Sp. Survey(?)		711	6		0			
12-Nov-2001	(12DEC?)		Sp. Survey(?)		335	7		0	Y		Y
12-Nov-2001	(12DEC?)		Sp. Survey(?)		370	7		0	Y		
18-Dec-2001			Sp. Survey(?)		420				Y	Y	Y
17-Jan-2002					430				Y		
25-Jan-2002					470				Y		Y
17-Jun-2002	A7	50.7	Snorkel	8	300-400						
3-Jul-2002	A7	50.7	Snorkel	1							
3-Jul-2002	1A	50.5	Snorkel	2							
3-Jul-2002	1B	50.1	Snorkel	1							
12-Mar-2004	5B	48.0	Angling		295		unk		Y		Y
12-Mar-2004	2	49.9	Angling		351		unk		Y		Y
23-Mar-2004	2	49.9	Angling		355		unk		Y		Y
7-Apr-2004	1B	50.1	Angling		525		M		Y	2	Y
7-Apr-2004	1B	50.1	Angling		380		M		Y		Y
7-Apr-2004	1B	50.1	Angling		375		F		Y		Y
7-Apr-2004	2	49.9	Angling		395		F		Y		Y
7-Apr-2004	2	49.9	Angling		305		unk		Y		Y
7-Apr-2004	2	49.9	Angling		460		F		Y	2	Y
7-Apr-2004	3C	49.0	Angling		480		F		Y	2	Y
7-Apr-2004	3C	49.0	Angling		305		M		Y		Y
7-Apr-2004	3C	49.0	Angling		395		F		Y		Y
8-Apr-2004	7	46.9	Angling		480		F		Y	2	Y
8-Apr-2004	7	46.9	Angling		350		F		Y		Y
8-Apr-2004	7	46.9	Angling		350		unk		Y		Y
8-Apr-2004	8A	46.7	Angling		335		unk		Y		Y
8-Apr-2004	7	46.9	Angling		385		unk		Y		Y
8-Apr-2004	8A	46.7	Angling		415		F		Y		Y
8-Apr-2004	8B	46.7	Angling		260		M		Y	2	Y
27-Apr-2004	1B	50.1	Angling		390		F		Y		Y
27-Apr-2004	2	49.9	Angling		265		unk		Y		Y
27-Apr-2004	3C	49.0	Angling		580		F		Y	2	Y
27-Apr-2004	4C	48.2	Angling		335		unk		Y		Y
28-Apr-2004	14	45.0	Angling		445		unk		Y		Y
28-Apr-2004	15	44.8	Angling		356		unk		Y		Y
13-May-2004	31B	38.0	Angling		406		unk		Y		Y
13-May-2004	31B	38.0	Angling		406		unk		Y		Y
12-Jul-2004	28A	40.2	Mort		330		unk		Y	2	Y

Life stage Codes

1	Yolk Fry
2	Fry
3	Parr
4	Silvery Parr
5	Smolt
6	Adult
7	Unknown

The primary physical difference accounting for the extended distribution of rainbow trout in the post-FSA period (Figures 3.5.3.1-1 and -2) is the higher summer flow regime that extends cool water habitat in the summer over more miles of river. Water temperatures recorded at RM 49.0 in Figure 3.5.3.1-3 illustrate this change. Figure 3.5.3.1-4 shows the lower summer flows prior to the 1995 FSA often were less than 30 cfs, resulting in daily average water temperature at RM 49 often exceeding 23 degrees C.

Figure 3.5.3.1-1 Location of rainbow trout recorded in June-September snorkel surveys from 1982–2004. Note: Open symbols indicate years in which surveys were conducted, but no rainbow trout were observed.

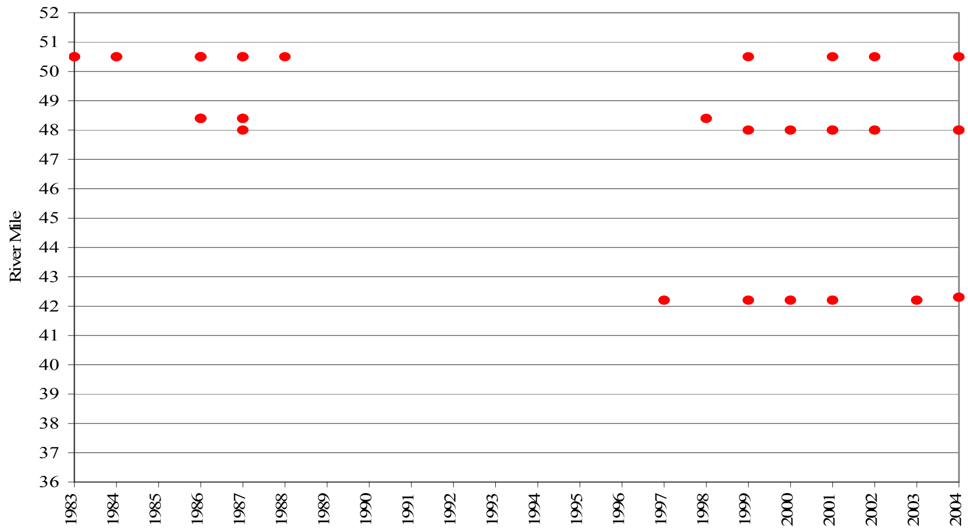


Figure 3.5.3.1-2 Location of rainbow trout recorded in seine surveys from 1982–2004.

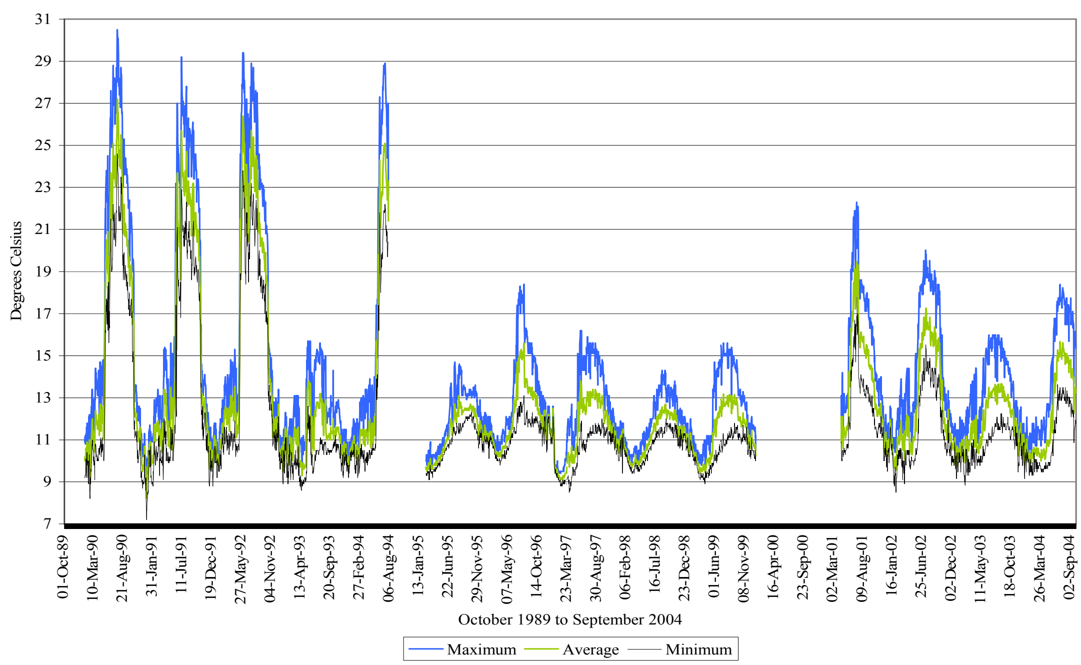


Figure 3.5.3.1-3 Water temperature at RM 49.0 for water years 1990–2004.

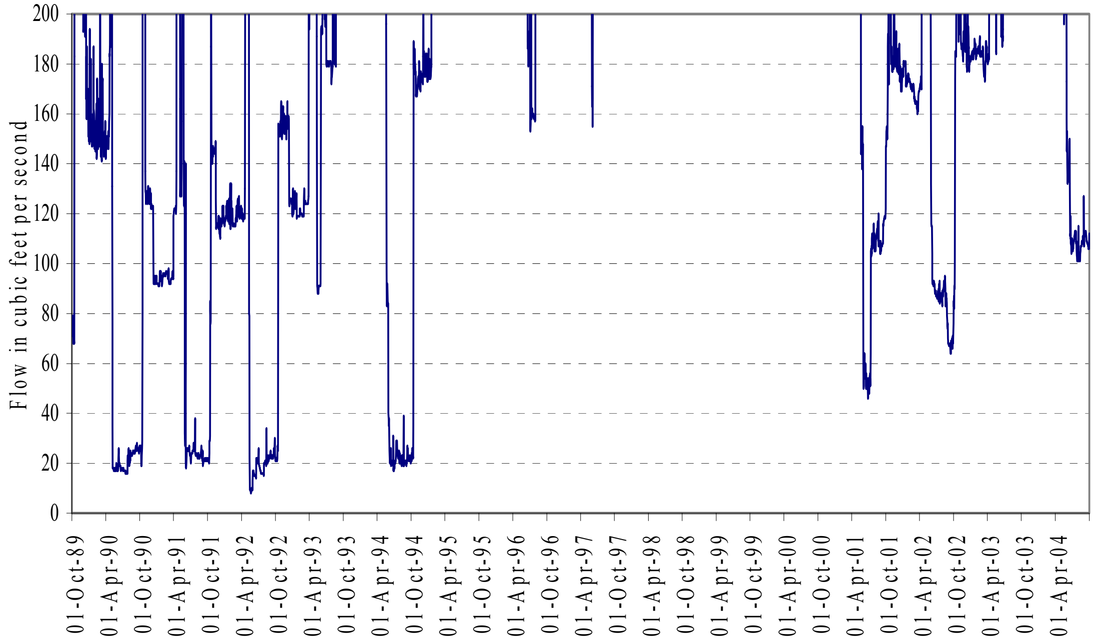


Figure 3.5.3.1-4 Flow at La Grange (RM 51.8) for water years 1990–2004 (y-axis limit set at 200 cfs).

3.5.3.2 Aquatic invertebrate monitoring

Aquatic invertebrate sampling conducted on the Tuolumne River by the Districts dates back to 1988 in conjunction with fishery studies and other programs relating to the Don Pedro Project. Summer Flow Invertebrate studies were designed to examine the effect of flow magnitude on wetted areas and the aquatic invertebrate community in the lower Tuolumne River. Information from the 1988 Annual Summer Flow Invertebrate Report is presented in the 1992 FERC Report (TID/MID 1992) The adequacy of the food supply for juvenile salmon was found to be more than adequate to support Tuolumne River salmonids based on gut samples, drift samples, and benthic samples (TID/MID 1992, Appendix 2). Additional Summer Flow Invertebrate data for the years 1989–1993 are presented in the 1996 FERC Report (Report 89-93, TID/MID 1997, Appendix 28).

In 1996, the FERC Order increased the summer flow schedule in the Tuolumne River and the Districts have continued to collect summer invertebrate samples in most years. Analyses of the post-FSA period are presented in Report 02-8 (TID/MID 2003) based on aquatic invertebrate samples collected in the years 1994, 1996, 1997, 2000–2004 by Stillwater Sciences staff on behalf of the Districts. Note that no invertebrate samples were collected in the high flow years of 1995 and 1998 and in 1999.

Comparison of Invertebrate Productivity under Pre- and Post-FSA Flow Regimes

Extensive invertebrate data that document invertebrate conditions prior to the onset of the 1995 FSA flows has been analyzed for summer conditions from 1988 to 1993 (Reports 90 and 89-93 TID/MID 1992, 1997). Although invertebrate abundance continues to be variable in the post-FSA period, recent samples show a slight decline (Figure 3.5.3.2-1) in the number of organisms represented (Report 2002-8, TID/MID 2003). It should be noted that the oldest of the most recent samples to be identified (1994) corresponded to an unusually low density estimate relative to other samples. Although the temperatures of the preceding month were the highest of all other samples, other years also had high densities at higher temperatures and this may be indicative of a sampling or preservation problem with the 1994 samples.

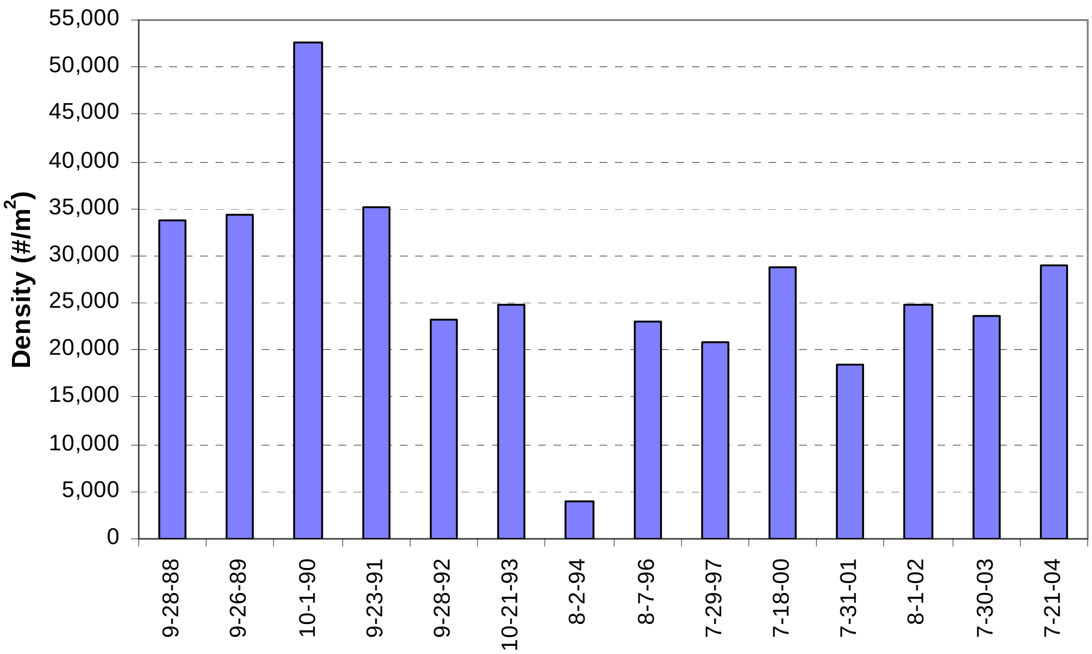


Figure 3.5.3.2-1. Invertebrate density from Hess samples at Riffle 4A in the lower Tuolumne River, 1988–2004.

Changes in Aquatic Invertebrate Community Structure under Post-FSA Flow Regime

The types of organisms represented by the Riffle 4A Hess sampling appear to have shifted following the establishment of the current summer flow schedules under the 1995 FSA (Report 2002-8, TID/MID 2003). Although moderate increases in summer flows were not expected to influence instream temperatures of the shallow gravel bedded portions of the river during summer and early autumn, it is surprising to note an increase in EPT taxa since the establishment of the 1995 FSA flow schedule (Figure 3.5.3.2-2). Although stoneflies (Plecoptera) continue to be rare in Tuolumne River Hess samples taken at Riffle 4A, stoneflies are present in the cooler water areas such as Riffle A4 (RM 51.6) in both 2001 and

2002. In addition to the increased occurrence in stoneflies relative to past studies (Reports 90 and 89-93, TID/MID 1992, 1997), Ephemeroptera species (e.g., Baetis, Trycorythodes) species increased in the Post-FSA sampling period.

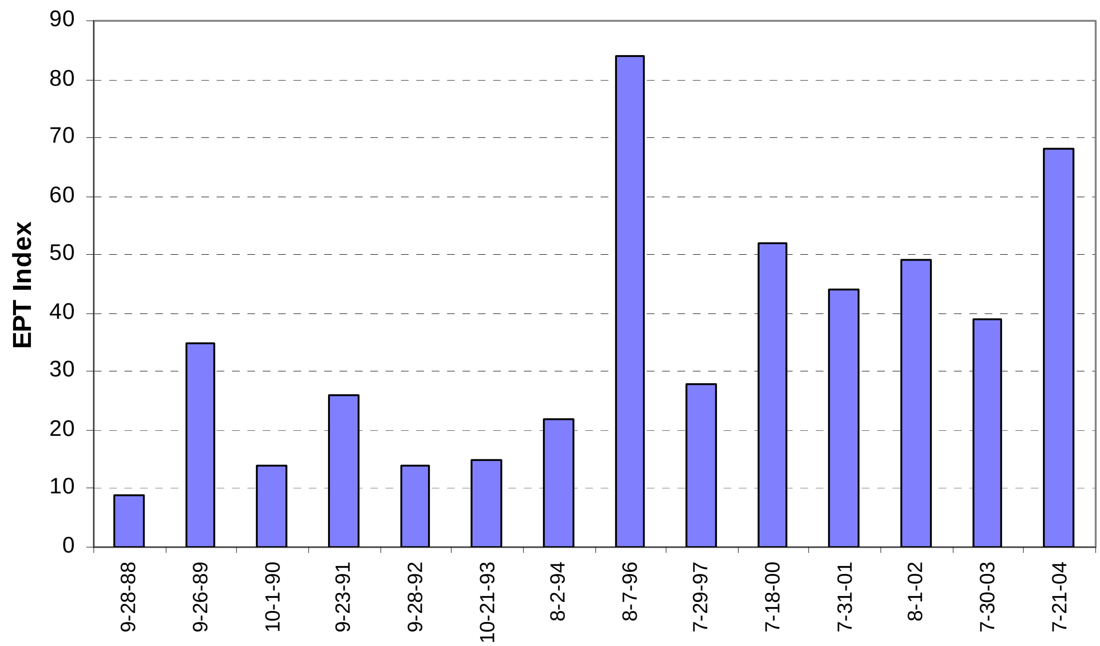


Figure 3.5.3.2-2. EPT Index from Hess samples at Riffle 4A in the lower Tuolumne River, 1988–2004.

With the exception of the first year, samples were collected following the 1997 floods, chironomids appear to have declined in the post-FSA period and EPT species increased. Whether increased summer flows are large enough to explain this variation, in other river systems high flows shifted the invertebrate community from armored, sessile invertebrates to invertebrates such as mayflies, which are more available as food for juvenile salmonids (Power 1990). The mechanism for this change in the invertebrate community has been hypothesized to include direct abrasion in the form of scour by sand transported over riffles, flow turbulence, and bed mobility (Chutter 1969, Hemphill and Cooper 1983).

The results to date support a hypothesis of a gradient of habitat quality from upstream (high) to downstream (low) due to increases in fine sediments and temperature. Lacking suitable reference sites from other low gradient Central Valley rivers, it is unclear whether this represents higher than expected upstream conditions or poorer than expected downstream conditions.

Changes in Food Supply for Rearing Salmonids under Post-FSA Flow Regime

Although overall invertebrate abundances in Hess samples have declined slightly in the post-FSA period, community composition has shifted away from pollution tolerant organisms and towards those with higher food value for fish. In addition to the increased occurrence in stoneflies relative to past studies, Ephemeroptera species and diversity increased in the post-FSA sampling period. This apparent trend is indicative of improved instream conditions for resident fish species in the lower Tuolumne River.

3.5.3.3 Riparian vegetation recruitment study

In 2001, the US Fish and Wildlife Service awarded a grant to Stillwater Sciences for development of a field-calibrated model of riparian tree recruitment in the San Joaquin Basin. The objective of the CBDA-funded project was to conduct research that would support the development of a conceptual model of seedling establishment for pioneer riparian tree species (e.g., native willows and cottonwoods) and to field-calibrate the model parameters for sites in San Joaquin Basin rivers. The information would be used to develop management recommendations and tools to guide the many riparian restoration and revegetation efforts planned for the Tuolumne, Merced, Stanislaus, and San Joaquin rivers. The ecological goal is to promote the sustainability of pioneer riparian communities, which are currently in decline, within the constraints of current resource demands in the Basin.

As part of the CBDA-funded project, Stillwater Sciences reviewed existing information; adapted an existing conceptual model to local conditions and species; developed a study plan; and conducted field-research to calibrate the conceptual model to conditions in the San Joaquin Basin. The CBDA-funded project focused the field research on the lower Tuolumne River. The field work and analyses consisted of the following subtasks:

- Documenting seed release phenology (i.e. life history timing) of ninety trees (thirty each of three species) at three sites along a 40 km reach of the Tuolumne River during the growing season (April through August) and testing the duration of seed viability of a subset of trees using laboratory germination assays. (Outside funding allowed expansion of the scope to incorporate three additional sites along the San Joaquin River in the southern portion of the San Joaquin Basin and to conduct the phenology study in 2003 at all six sites.)
- Conducting a controlled experiment in tanks to evaluate seedling mortality and growth response to artificially-manipulated water table decline rates, which spanned the range of variability documented on the Tuolumne River. (Outside funding allowed expansion of the scope to investigate plant physiological mechanisms associated with the different species' mortality rates. These analyses include leaf morphological adaptations to drought and long-term water use efficiency as indicated by carbon isotope ratios.)
- Selecting, instrumenting, and monitoring three sandbar sites on the lower Tuolumne for hydrologic conditions throughout the growing season. The collected data includes river stage, groundwater levels, air temperature and relative humidity.
- Installing permanent plots on those same sandbars to monitor survival and growth of naturally recruited seedlings. The plots were established as a replicated experiment to

test the effects of vegetation clearing, elevation above summer baseflow, and lateral bar position on seedling success.

- Conducting a larger-scaled survey of seedling establishment patterns along a twelve-mile reach of the Tuolumne River to evaluate the general applicability of the model calibration results to a larger geographic area (i.e. river corridor).

The original field calibration effort covered one year (2002) of data collection. In 2004, limited studies on seed release timing and seedling recruitment were conducted to further develop and test the field-calibrated model. Fieldwork and data collection for the project is now complete, and data analysis and completion of a final synthesis report are underway. Separate but related research and analyses have been conducted as part of academic research by John Stella, one of the key project team members, who is also a doctoral candidate at UC Berkeley in the Department of Environmental Science, Policy and Management. Research done under academic funding sources include much of the 2003 and 2004 data collection, and effectively extend the scope of the original research conducted for the CBDA 1999 contract. This complementary research presents a key opportunity to gain multi-year insight into the physical factors, biological responses, and management actions that determine the sustainability of riparian trees through out the CBDA program area. The additional data will allow integration of the results of all research efforts into a unified set of management tools that reflect the state of riparian research and management recommendations in the Central Valley.

This Page Intentionally Left Blank

4 ASSESSMENT OF THE SUCCESS OF THE 1996-2004 TUOLUMNE RIVER FISH MANAGEMENT PROGRAM

This chapter constitutes the Districts' assessment of the success of the recovery strategy at meeting Programmatic (FSA Section 8) and Comparative (FSA Section 9) goals before discussing the relevance of factors within and outside the control of the Districts (FSA Section 10). Section 10 of the 1995 FSA describes the assessment as follows:

> "Assessment of achievement of the above [Section 9] goals will require and evaluation of trends established over several years. The participants agree that, given a good faith effort to implement the [Section 8] strategy for recovery of Tuolumne River Chinook salmon, a fair assessment of the strategy will require analysis of conditions from implementations to the year 2005. If the above goals are not achieved because of factors within the control of the Districts, or there has not been a good faith effort to fulfill the terms of this settlement, any participant may, at its own discretion, notify all other participant, in writing, that it is withdrawing from the settlement. Examples of factors within the control of the Districts include: New Don Pedro Dam operations (including decisions on the delivery, distributions, and transfer of water within and outside of the Districts) and river flows at La Grange Dam except during flood control operations, and land use activities on District-owned lands within the Tuolumne River riparian corridor. Examples of factors outside the control of the Districts include: Delta export operations, commercial and sport salmon harvest, land use activities on non-District owned lands within the Tuolumne River riparian diversions below La Grange Dam.
>
> In the event the goals are not achieved because if factors within the control of the Districts, the Districts agree to implement additional non-flow measures. The Districts, CDFG, and FWS will determine appropriate measures after reviewing recommendations from the TAC. In the event that goals are not achieved because of factors outside the control of the Districts, no additional measures would be required.
>
> If a participant has a concern regarding fulfillment of the terms of this settlement, the participants agree to make a good faith effort to resolve any concerns. The participants agree to address the concerns at the TAC. If the concern is not resolved by the TAC, it will be addressed by the Management Committee in a timely manner."

To provide background for the assessment of the success of the 1996-2004 Tuolumne River fish management program, Chapter 3 of this report constitutes a synthesis of the project and riverwide monitoring from the 1995 FSA implementation (and before) to the year 2005. As early as 1971, the Districts, CDFG, USFWS, and other agencies have conducted targeted research to assess salmon population dynamics of the Tuolumne River and the San Joaquin Basin. Based on these studies and other investigations, several factors that potentially limit Chinook salmon escapement, production, and survival in the Tuolumne River have been identified. These factors include conditions within the Sacramento/San Joaquin River delta

(Delta), oceanic and estuarine conditions, harvest, and in-river conditions related to climate, and habitat conditions, including land use and riparian water diversions.

4.1 Programmatic (FSA Section 8) Goals

The 1995 FSA (Section 8) lists three programmatic goals that the strategy for the recovery of Tuolumne River Chinook salmon attempts to achieve:

1) increase naturally occurring salmon populations,
2) protect any remaining generic distinctions, and
3) increase salmon habitat in the Tuolumne River.

Both instream flow (changes to the FERC Flow schedule) and non-flow measures (habitat restoration projects) were to be employed and the participants to the settlement agreed to the following strategy for recovery of Tuolumne River Chinook salmon:

> "Implement measure generally agreed upon as necessary to improve Chinook salmon habitat and increase salmon populations. These measures include increased flows, habitat rehabilitation and improvement, and measures to improve smolt survival. When the Chinook salmon population increases to acceptable levels, implement additional measures of some risk that the Technical Advisory Committee (TAC) agrees may help improve the population
>
> The participants to the settlement agree to an adaptive management strategy that would initially employ measures considered feasible and have a high chance of success. The success of these initial measures would be evaluated and, based on the results of evaluation, the measures would either be fine-tuned to improve success or alternative measures would be taken.
>
> In support of this adaptive management strategy, a detailed review will be conducted annually to assess progress toward meeting the goals described in this settlement."

The adaptive management strategy for the Tuolumne River provides a framework for developing testable management actions that may be linked to physical as well as salmon population responses. The project and river-wide monitoring programs (Sections 3.4 and 3.5) include documenting changes in physical processes, biological characteristics, and trends, providing information necessary to evaluate the effectiveness of flow and non-flow measures and to implement the adaptive management strategy set forth in the FSA. Below is a discussion of the three programmatic goals set for the under FSA Section 8.

4.1.1 Increase naturally occurring Chinook salmon populations in the Tuolumne River

Although FSA Section 8 provides for the Programmatic Goal of "increase naturally occurring salmon populations" and Section 9 provides for the Comparative Goal of "increase in naturally reproducing Chinook salmon in this subbasin," the parties to the 1995 FSA specifically rejected in Section 9 the setting of numeric goals. During the negotiations, the parties did discuss various possible Chinook salmon adult escapement targets, including the Central Valley Project Improvement Act's doubling goal (Title 34, Section 3406(b)) and the goal of "significantly increasing the natural production of salmon and steelhead trout by the end of this century" goal under California Fish and Game Code Section 6902(a).

Even though the 1995 FSA specifically did not include numeric goals, Tuolumne River fall-run Chinook salmon escapement has ranged from about 100 to 40,300 fish following the completion of the Don Pedro Dam in 1971. Average estimated escapement for the years 1967–1991, which is the target number to be doubled by the USFWS Anadromous Fish Restoration Program (AFRP), was 8,900 (USFWS 1995). The recent high of 40,300 in 1985 was mostly associated with juvenile survival in 1983, a very wet year. Average escapement from 1996–2004 was 7,500 with a peak of 17,900 in 2000 (Section 3.5.2.1). Although this number is lower than the AFRP number, as discussed below a number of factors may confound simple comparison of mean escapement levels.

In terms of salmonid life history, a primary difficulty in determining whether there is a change in the long-term productivity of the Tuolumne River is to determine if a change is likely to be ongoing rather than temporary. To determine if fundamental changes have occurred, one tries to separate out, or control for, the effects of natural environmental variation on observed mean production levels. The fact that there are cycles to climate and ocean conditions, and subsequently, periods of "high" and "low" ocean survival rates, can confound simple comparisons of mean levels. For example, high ocean survival rates may coincide with one period and low rates may coincide with the other period. For these reasons, simple comparisons of observed escapements between two time periods before and after the 1995 FSA may not provide sufficient evidence for a fundamental change. To address these issues, two primary models were initially developed by the Districts to identify and assess the relative importance of factors influencing Tuolumne River Chinook salmon population abundance and to predict the effects of management actions on the population:

- The Stock-Recruit model (TID/MID 1992, Appendix 2; Report 96-5. TID/MID 1997)
- The EACH population model (TID/MID 1992, Appendix 1)

Use of these models to assess long-term changes in the abundance of Tuolumne River Chinook salmon is discussed in the following sections.

4.1.1.1 Population models for Tuolumne River Chinook salmon

Stock-Recruit relationships for the Tuolumne River

Based upon the long-term escapement data collected prior to the 1995 FSA, San Joaquin River Chinook salmon runs in some years contain a large proportion of 2-year-olds in the run and many of these are female (TID/MID 1992). By representing the proportions of 2, 3, and 4 year-old fish in the run, a smoothed Ricker-type relationship between spawners and subsequent recruits was derived with a peak recruitment occurring at approximately 15,000-20,000 spawners. With a stock recruitment relationship of this form, escapements progressively further from the optimum will give rise to progressively smaller recruitments, and consequently smaller subsequent escapement, regardless of the prevailing environmental conditions. The shape of the curve is determined by the nature and extent of density-dependent mortality and by the maximum intrinsic reproductive rate of the salmon, which determines the slope of the curve at the origin when density-dependent mortality is zero. Interestingly, redd superimposition and reduced survival for later eggs known to occur in the San Joaquin River system, leads quite naturally to density dependent mortality of the kind described by the Ricker curve.

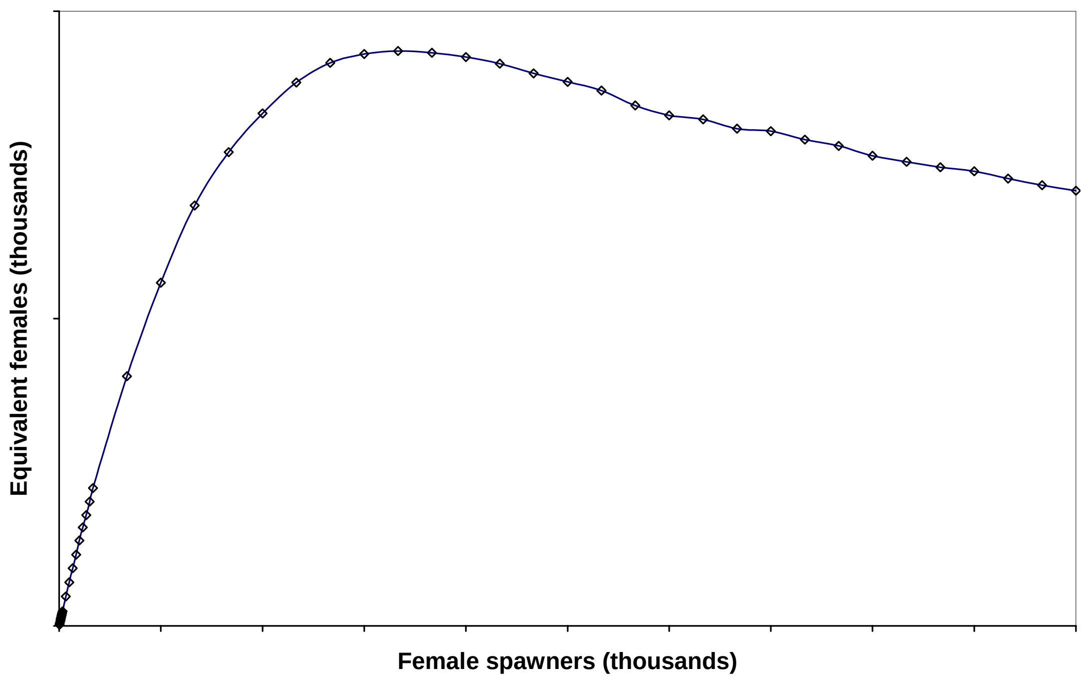


Figure 4.1.1.1-1 Idealized Ricker type curve representing subsequent recruits from a given parent stock size.

As suggested above, the form of the underlying stock-recruitment relationship for the Tuolumne River is determined by a number of density-dependent (e.g., food supply, juvenile habitat, spawning gravel availability) and density independent factors (e.g., spring-outflow, Delta export pumping, gravel quality, water quality, predation, harvest). With a constant harvest rate and constant environmental conditions, the shape of the curve determines the equilibrium population size. However, with highly variable environmental conditions related to flood and drought cycles in the San Joaquin River system, it is unreasonable to expect a convergence of the population size to an equilibrium level of a particular run size.

Stock Recruit Model

The Stock-Recruit model (TID/MID 1992) is a statistical analysis of the time-series of historical escapements to the San Joaquin basin. In an effort to understand management implications on the behavior of the fluctuating population of the San Joaquin River basin, the

Stock Recruitment Model uses statistical analysis of the time-series of historical escapements to the San Joaquin basin in relation to flow and Delta exports. More specifically, the model attempts to capture how density independent mortality, as influenced by spring flow, combines with density dependent mortality to affect the rate and magnitude of changes in population of the San Joaquin system's Chinook salmon. By modeling recruits, the model provides a more accurate measure of salmon production than escapement because escapement is composed of spawners of three different cohorts. The goal of the analysis was to identify the effects of environmental variability (represented by spring outflow) in the presence of the complex auto-correlation resulting from stock-production relationships. As shown in a recent model run (Figure 4.1.1.1-2), general escapement levels for the San Joaquin basin as a whole are predicted very well but the model tends to underestimate escapement in peak years.

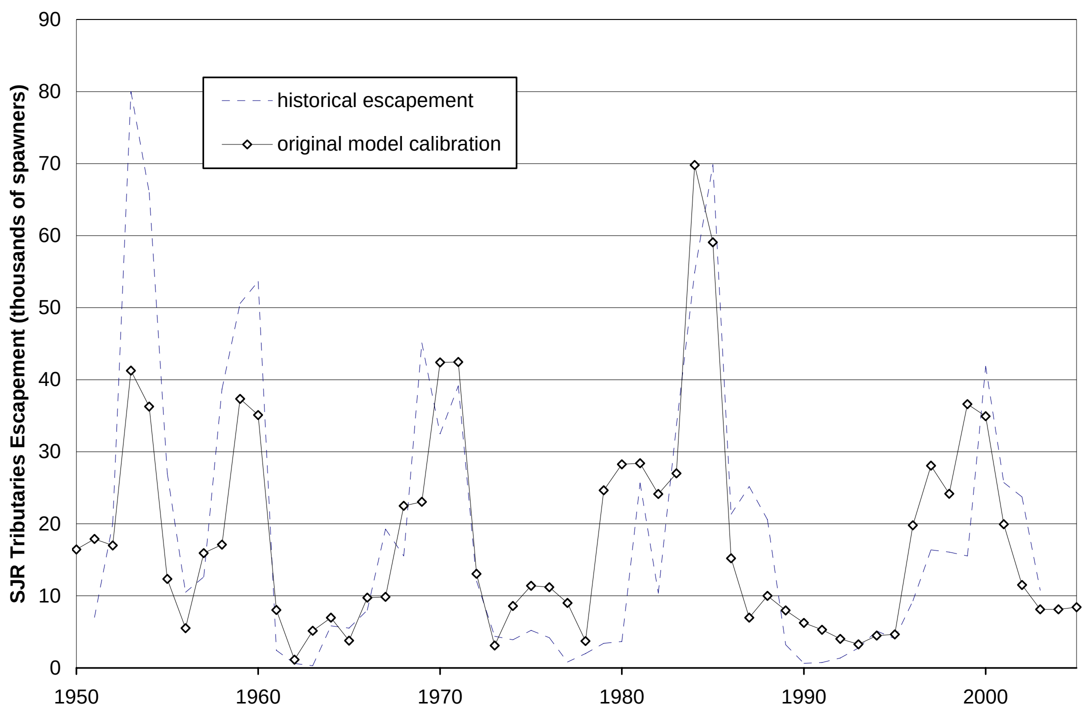


Figure 4.1.1.1-2 Observed and predicted escapement using fully deterministic version of Rein state-space model (Stock-Recruit Model) for 1950–2004. Note that in the deterministic form of the model, run estimates are based on initial population estimates and are determined based upon basin outflow thereafter with no corrections for actual escapements in each year.

EACH Model

The EACH model (Report 91, TID/MID 1992, Appendix 1) is a deterministic simulation that represents the dynamics of populations from each of the three salmon-bearing tributaries to the San Joaquin River. The Districts originally developed the EACH model in 1987–1991 to place knowledge specific to individual life-stages and geographical locations into a life-history context, and to provide a tool for studying the multigenerational dynamics of the populations in the presence of constantly changing environmental conditions. The model represents populations from each of the three salmon-bearing tributaries to the San Joaquin River and tracks each group of fish through their life cycle and migration. The model uses flow to represent environmental conditions, and mortality at each life stage is assumed to be either constant or linearly related to flow. The EACH model also tracks long term averages and trends in Tuolumne River population abundance very well.

4.1.1.2 Model comparisons of long term escapement levels under the Article 37 Flow regime of the 1996 FERC Order

As stated previously, year to year variations in the underlying life-history parameters affecting Tuolumne River salmonids may confound short-term comparisons of average escapement before and after the 1996 FERC Order. For example, long-term escapement since the completion of Don Pedro Dam has averaged near 6,700 spawners, whereas the periods of 1986–1995 and the post-1996 FERC Order period since (1996–2004) have averaged 3,200 and 7,500 spawners, respectively (See Table 3.5.2.1-1). In addition to long term oceanic cycles, there was the severe six-year California Drought from 1987–1992 and then the recent dry period from 2001–2004. Escapement peaked in 2000 at 17,900 spawners following a period of wet and above normal water years with some of the largest flood flow releases in the Don Pedro Project history. For this reason, singling out one or a few years may misrepresent fundamental changes to the Tuolumne River salmon population.

Model selection

The shape and overall scale of the stock-recruit relationship for the Tuolumne River (Figure 4.1.1.1-1) is important in determining the rate and direction of changes in the population size due to fundamental changes in the life history parameters of Tuolumne River Chinook salmon. Because the implementation of the planned habitat restoration projects for the Tuolumne River is relatively recent and only a few projects have been completed, the underlying stock-recruit relationship of the Tuolumne River would not be expected to change in the period immediately following the 1995 FSA. For this reason, the original model calibration parameters were retained and the models used to test only the effectiveness of the amended Article 37 flows under the 1996 FERC order.

Although the EACH model is perhaps better tailored to directly predict Tuolumne River Chinook salmon responses to various management actions, internal coding of the sub-models and input files currently prevents predictions beyond the year 2000. At the same time, the Stock Recruit model represents the fall run of the entire San Joaquin basin. However, the Stock Recruit model may be used to evaluate Tuolumne-specific measures by assuming that the Tuolumne River is a reasonable surrogate for the basin as a whole. That is, if we scale changes in flow contributions, habitat quality and availability for the entire basin, the basin-wide population should respond in the same way that the Tuolumne River population would respond to corresponding changes to the Tuolumne River alone. For the remainder of this discussion, the Stock Recruit model was used to evaluate changes under the revised Article 37 Flow schedule of the 1996 FERC Order.

Flow Regimes
To assess whether the 1996 FERC Order flow schedule has provided a fundamental increase in the abundance of Chinook salmon, two series of synthetic flows were calculated from the historical flow record below La Grange Dam (USGS 11289650) from the completion of Don Pedro Dam to the present (1971–2004):

- **1986 Study Plan synthetic flow.** The first data series was created by replacing the minimum flows under the 1996 FERC Order flow schedule by the flows provided by the original Article 37 Flows from the 1964 project license as amended by the 1986 study plan agreement between the Districts and CDFG. This flow schedule had two primary water year types, Schedule A (normal) and Schedule B (dry) with experimental changes to the Schedule A by reallocating spring outflow. The resulting flow time series is identical to actual flows up until the 1996 FERC Order (1971–1995), with a decrease in flows from 1996–2004.

- **1996 FERC Order synthetic flow**. The second data series was created by replacing the minimum flows under the original Article 37 Flows from the 1964 project license with those provided under the Article 37 amendment from the 1996 FERC Order. That is, in years when La Grange flows reached lows of the FERC minimums, the minimums were replaced by the current flow schedule. This flow schedule has ten water year types as described in Appendix A of this report. The resulting flow time series is identical to actual La Grange flows from 1996–2004 but higher than the actual flows for the prior period from 1971–1995.

Although these flow series may not be an entirely accurate depiction of potential conditions over the years preceding or following when the pertinent flow schedules were in place due to reservoir storage and year-to-year flood control releases, the following simulations were conducted to illustrate the long term benefits of the 1996 FERC Order.

Model Simulations
Using the Stock Recruit model, simulations for changing the long-term spring outflow totals were performed by scaling the San Joaquin run model by the proportion of flow contributed by the Tuolumne River. That is, because the Tuolumne population makes up a significant proportion of the San Joaquin basin run, by scaling the Tuolumne Flow changes to the entire basin, the basin-wide population should respond in the same way that the Tuolumne River population would respond to corresponding changes to the Tuolumne River alone. Figure 4.1.1.2-1 shows the long-term time series of predicted escapements for the San Joaquin Basin as a whole using synthesized flows from the 1985 Study Plan and 1996 FERC Order.

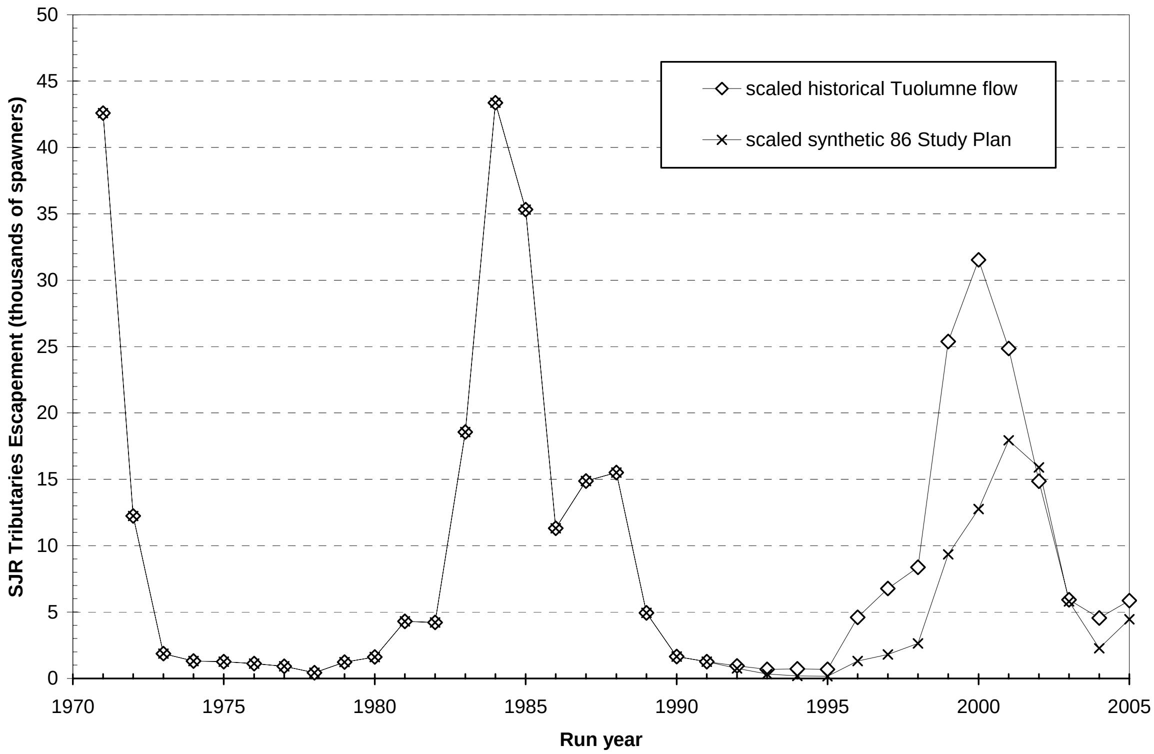


Figure 4.1.1.2-1 Predicted San Joaquin Basin escapement under two synthesized flow regimes for the Tuolumne River from 1971–2005.

The model runs show that over a simulation period of 1971–2005, the scaled 1996 FERC Order synthetic flows would have provided substantially higher escapement than provided under the prior flow schedule. Note that predicted escapement under the scaled historical flows are identical to the scaled 1986 Study Plan flows up until 1992, whereas two data series are seen thereafter. Although the spring outflows in the post 1996 FERC Order period are identical for the scaled historical flow and scaled synthetic 1996 FERC Order flow, the predicted escapement under the scaled 1986 study plan flows diverge below those provided under the 1996 FERC Order.

When the model results shown in Figure 4.1.1.2-1 are adjusted to actual Tuolumne River escapement levels averaged over the modeling period (i.e., approximately 6,700 spawners from 1971–2004), the prior flow schedule would have produced escapement levels 16% lower, whereas the flows provided under the 1995 FSA would have increased long-term escapement by 37% or a long term average of 9,100 spawners. As expected and intended by the amended Article 37 flow schedule, increasing the minimum flows would have increased the population minimums during the two population crises during the late 1970s and early 1990s. The overall model result is that the current flow regime supports an increase in the abundance of Tuolumne River salmon. However, these population assessments must be considered provisional, because the planned habitat restoration projects discussed under

Section 4.1.3 are not 100% complete and most of the projects that have been implemented are too recent to have had demonstrable effects on the underlying stock-recruitment relationship of the Tuolumne River.

4.1.2 Protect any remaining genetic characteristics unique to the Tuolumne River Chinook salmon population

Preliminary information from genetic studies on Central Valley chinook salmon indicate differences between seasonal runs but little divergence among fall-run stocks (Bartley et al. 1990; Nielsen et al. 1994; Banks et al. 1996, 2000). A three-year evaluation was undertaken in 1999 by CDFG to characterize and discriminate to the extent feasible the genetic makeup of fall-run Chinook salmon in the tributaries of the San Joaquin River relative to those in the Sacramento River basin. Although future studies may reveal possible genetic differences in fall-run Chinook salmon from the Tuolumne River and other Central Valley streams, the results to date suggest that hatchery planting programs conducted over the past decades may have caused a high degree of gene flow between any potential sub-populations.

The use of non-Tuolumne origin study fish (and hatchery fish in general) and their effects upon the genetic distinction have been the subject of much debate by the TRTAC members regarding the impacts on any remaining genetic distinctions. For example, runs over the last 12 years have had about 7%-30% of salmon with an adipose fin clip, indicating hatchery salmon with a coded-wire tag (CWT), many of these being Merced River hatchery fish used in the Tuolumne smolt survival evaluations (see Fig. 3.5.2.1-10). This is in contrast to less than 3% CWT salmon found during 1981-86, prior to the first spawners returning from Tuolumne smolt survival releases. Furthermore, on average, 57% of the smolts captured in the lower screw traps during mid-April through May from 1996-2002 were of known hatchery origin, either from upstream survival releases or trap efficiency evaluations (Fig. 4.1.2-1).

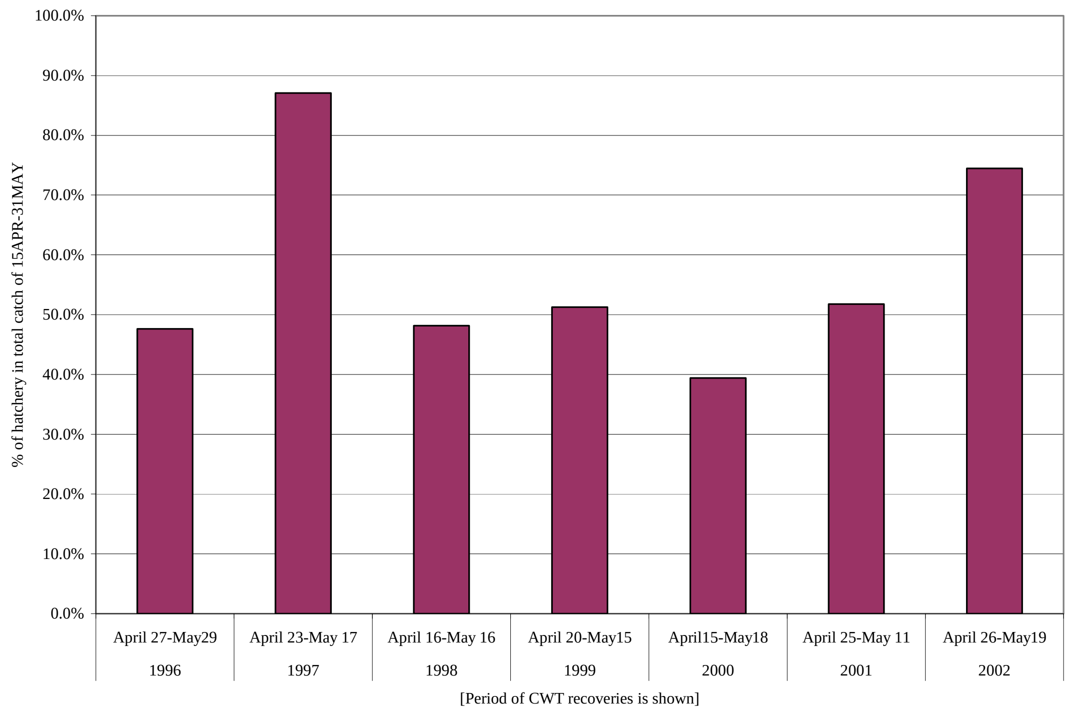


Figure 4.1.2-1 Percentage of hatchery salmon caught in the lower screw traps during April 15 to May 31 of 1996-2002.

It is expected that the proportion of known hatchery salmon will decline after the last return of the Tuolumne 2002 CWT survival study fish in 2005–2006. However, there is an unknown amount of untagged hatchery fish in the runs from other local sources: (1) CDFG has in some years released up to 500,000 unmarked smolts in the Merced River and (2) efficiency release fish (approx 10,000-20,000 annually) for RST calibration in the Tuolumne and other tributaries. These untagged adult salmon, if such releases are continued, along with spawners that are from other Merced hatchery origin releases, will continue to affect the genetic composition of the Tuolumne population. The Districts have suggested in the past that tagged salmon in the Tuolumne could be intercepted at a weir and used for additional egg take for the Merced Hatchery (for fish confirmed to be of Merced origin), although ending the large Tuolumne CWT releases has reduced the potential need for that effort.

4.1.3 Increase salmon habitat in the lower Tuolumne River

As discussed in Section 3.3, since the completion of the FSA, the Districts have worked with the TRTAC to develop and implement non-flow measures as required by Section 12 of the 1995 FSA as part of the overall recovery strategy outlined under Section 8 to achieve the programmatic goal to increase salmon habitat, including monitoring of specific aspects of salmon biology and habitat required by the FSA. Through the development of a geomorphic processed-based restoration plan for the 52 miles of the river downstream of La Grange Dam

(McBain & Trush 2000), several large-scale channel reconstruction projects were identified. Nine of the ten top-priority habitat restoration projects have been funded to date, including $33 million dollars above the initial $1 million required under the FSA (Section 12). Two projects have been completed and the initial phases of seven additional projects have been implemented.

4.1.3.1 Spawning habitat losses and changes in spawning utilization following the 1997 flood

One of the largest changes in the habitat conditions for the Tuolumne River Chinook salmon run in recent years corresponds with the losses in spawning area due flooding in the winter of 1997, which scoured away many riffles in the primary spawning reach below La Grange Dam. Changes in spawning habitat were recently assessed in a baseline survey conducted in December 2000 to compare with the next most recent surveys conducted in 1988. The 1988 habitat mapping surveys divided the lower Tuolumne River into six reaches using GIS analysis of aerial photographs at 230 cfs (TID/MID 1992, Appendix 8). Using the most recent spawning habitat assessment (McBain & Trush 2004b), Table 4.1.3.1-1 suggests that long term gravel attrition and the 1997 flood event may have decreased spawnable habitat in the lower Tuolumne River below 80% of the spawnable areas mapped in 1988. The greatest observable changes are in the riffles upstream of New La Grange Bridge (NLGB), compared to riffles between NLGB and Basso Bridge (McBain & Trush 2004b).

Table 4.1.3.1-1. Comparison of riffle area changes before and after the 1997 flood.

River Mile	Reach	Named Riffles	Estimated riffle area in 1988 (ft^2)	Estimated riffle area in 2001 (ft^2)	Percent Reduction in riffle area
51.3	A	A1–A6	67,803	15,751	76.8%
49.2	1A	A7A–5B	673,554	590,815	12.3%
44.6	1B	6–24	419,811	373,915	10.9%
38.1	2	25–46	699,163	549,542[a]	21.4%
30.7	3	47–68	821,267	645,516[a]	21.4%
23.5	4	69–78	235,609	185,189[a]	21.4%

a. Assumed areas for lower reaches estimated as 78.6% of the 1988 areas based upon totals for upper three reaches.

Using the reported areas common to both surveys in 1988 and 2000, the areas in Table 4.1.3.1-1 corresponds to reductions of 76.8%, 12.3%, and 10.9% of the riffle area in the upper three reaches, or over 180,000 ft^2 combined. Downstream in the Gravel Mining Reach, conditions appeared to have degraded but these areas were not mapped. Assuming these areas lost gravels at a similar rate as the upper reaches combined (21.4% reduction), this would correspond to a loss of over 375,000 ft^2 in the lower three reaches, or a loss of 556,000 ft^2, or 19%, on a riverwide basis.

4.1.3.2 Changes in rearing habitat at completed restoration projects sites

Although no seining surveys have been completed to document use by fry/juveniles rearing at the 7/11 project site (Section 3.3.1.1), hydraulic model simulations and on-the-ground mapping of suitable rearing habitat was conducted as part of project monitoring (McBain & Trush and Stillwater Sciences 2004). Preliminary results indicate reduced Chinook salmon fry and juvenile rearing habitat area during low flows, but increased rearing area is expected during high flows and increased habitat quality during both low and high flows.

4.1.3.3 Assessment of spawning habitat increases by gravel augmentation projects

As part of the TRTAC's overall sediment management and implementation plan, the AFRP-funded Coarse Sediment Management Program (CSMP) (McBain & Trush 2004) included a modeling task to assess the impacts of these gravel losses as well as potential benefits of planned gravel "transfusions" that have been considered along with controls on fine sediment accumulation. Objectives of the coarse sediment augmentation include:

- Increase spawning and rearing habitat availability for Chinook salmon by introducing appropriately sized coarse sediment (1/4" to 6") in the most heavily used spawning reaches between La Grange Dam (RM 52) and Basso Bridge (RM 47).
- Improve spawning and rearing habitat quality by introducing coarse sediment that can be transported and redeposited more frequently by the contemporary (and future) flow regime.
- Reverse historic trends in coarse sediment depletion by introducing sediment as natural morphologic features and in-river storage sites (short-term sediment augmentation)
- Maintain sediment storage by introducing coarse sediment (gravel and cobble) at a rate greater than downstream transport during high flows (long-term sediment supply maintenance).
- Rehabilitate fundamental fluvial processes by improving the river's ability to transport coarse sediment, create and maintain dynamic channel morphology and associated habitat complexity.
- Indicators of this improvement include increased number of exposed gravel bars, a more variable channel width, active floodplain formation, increased channel migration, and bedload routing throughout the reach.

Table 4.3.1.3-1 shows that long-term gravel attrition and the 1997 flood event decreased spawning habitat in the lower Tuolumne River areas mapped in 1988. Off-setting these losses, Section 3.3 describes several channel restoration and gravel augmentation projects have been completed under the Gravel Mining Reach Phase I, SRP 9 Predator Isolation Project, the CSMP Phases I and II (CDFG gravel additions). In addition to these completed projects, Table 4.1.3.3-1 shows the projected riffle area changes of all planned gravel augmentation projects by spawning reach (Section 3.4.1.2); implementation of those projects are subject to outside funding and permit approvals.

Table 4.1.3.3-1: Riffle area changes corresponding to planned gravel introductions.

Reach	1988 Riffle Areas	2001 Areas mapped after 1997 flood (% of 1988 Area)	2004 Areas including as-built mapping of completed restoration projects (% of 1988 Area)	Projected Future Riffle Area (% of 1988 Area)
A	67,803	15,751 (23.2%)	193,439 (285%)	388,833 (573%)
1A	673,554	590,815 (87.7%)	590,815 (87.7%)	1,386,338 (206%)
1B	419,811	373,915 (89.1%)	373,915 (89.1%)	2,580,523 (615%)
2	699,163	549,542 (78.6%)	575,441 (82.3%)	1,180,357 (169%)
3	821,267	645,516 (78.6%)	645,516 (78.6%)	645,516 (78.6%)
4	235,609	185,189 (78.6%)	185,189 (78.6%)	185,189 (78.6%)
Totals:	2,917,207	2,360,728 **(80.9%)**	2,564,315 (**87.9%**)	6,366,756 (**218%**)

In summary, apparent losses in spawning gravel following the 1997 flood event appear to have been partially restored by the planned restoration projects. If all of the planned projects can be completed, then the spawning habitat within the Tuolumne River that existed prior to the 1995 FSA could be effectively doubled.

4.1.3.4 Changes in spawning utilization following the 1995 FSA

On the basis of CDFG spawner surveys, spawning use within individual reaches were assigned as a fixed fraction of the total run (Table 4.1.3.4-1). Reach 1A currently accounts for over half of the spawning activity in the lower Tuolumne River over the most recent period since the 1997 Flood.

Table 4.1.3.4-1. Long-term spawning utilization estimated by maximum redd counts and weighted by annual run size before and after the 1997 flood event.

River Mile	Reach	Named Riffles	Spawning Preferences from 1986–1996 spawner surveys	Spawning Preferences from 1997–2004 spawner surveys
51.3	A	A1–A6	2%	4%
49.2	1A	A7A–5B	37%	56%
44.6	1B	6–24	28%	22%
38.1	2	25–46	28%	13%
30.7	3	47–68	5%	5%
23.5	4	69–78	< 1%	< 1%

Data Source: CDFG, La Grange CA.

In earlier studies (TID/MID 1992, Appendix 6), spawner use showed a nearly linear trend of preferences decreasing from upstream to downstream. By comparing the ratios of the total females that used a given spawning section to the percent of total available gravels in that section, the relative propensities to spawn within a given section can be calculated. Interestingly, when annual CDFG spawner surveys were extended further upstream in the late 1990s, relative spawner preferences at the uppermost sections were seen to be disproportionately higher than downstream areas. For this reason, prior concerns over redd superimposition within the uppermost spawning riffles (TID/MID 1992 Appendices 6 and 7) in high escapement years may still be valid (Section 3.5.2.1).

Changes in spawning utilization of completed restoration projects
As discussed in Section 3.4.2.1-1, at the 7/11 Project site and surrounding project reach comparisons of pre-project to post-project spawning use at project and control riffles suggest that the project appears to have nearly doubled Chinook salmon spawning use in the channel reconstruction reach.

4.1.3.5 Model simulations to evaluate recent and planned increases in spawning gravel additions

Using similar assumptions as those discussed in Section 4.1.1, the Stock Recruitment model was used to translate changes to spawning habitat availability (Table 4.3.1.3-1) into expected changes to overall population levels, taking population dynamics and varying environmental conditions into account. By rescaling the adjustable parameters in the model, three scenarios were evaluated on the basis of long-term escapement estimates corresponding to the following conditions:

1. Escapement for Year 2001 riffle areas following the 1997 flood event.
2. Escapement for riffle area increases from recently completed (2001, 2002) gravel augmentation projects.
3. Escapement for long-term maximum potential riffle area increases corresponding to implementation of all planned gravel augmentation projects.

Results indicate that the loss of usable spawning gravel suggested by the changes between the 1988 and 2001 gravel surveys should reduce general escapement to 84% of 1988 (pre-FSA) conditions. The remaining scenario results using the Table 4.1.3.3-1 area changes as well as historical spawner preferences from Table 4.1.3.4-1 are as follows:

- Gravel augmentation completed through 2004 should restore general escapement levels to 93% of 1988 levels.
- Long-term maximum escapement levels corresponding to completion of all gravel augmentation projects should increase general escapement levels to 270% of 1988 (pre-FSA) levels.

In summary, the population model results suggest that significant production benefits may be realized from planned gravel addition actions to the upper three spawning reaches (1A, 1B, 2, and 3) in the Tuolumne River. Chapter 5 contains additional recommendations regarding continuation of planned restoration projects.

4.2 Comparative (FSA Section 9) Goals

Section 9 describes the following comparative goals for demonstrating success of the recovery strategy as well as a timetable for achieving those goals:

> "Many of the factors that will affect the Chinook salmon population are beyond the control of the participants to the settlement. Rather than setting numeric goals in this settlement, comparative goals are identified whose attainment may be readily determined. These comparative goals are:
>
> 1. Improvements in smolt survival and successful escapement in the Tuolumne River.
> 2. Increase in natural reproducing Chinook salmon in this subbasin.
> 3. Barring events outside the control of the participants to the settlement, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested, on an experimental basis."

The project monitoring (Section 3.4) and river-wide monitoring programs (Section 3.5) includes documenting changes in physical processes, biological characteristics, and trends, providing information necessary to evaluate the effectiveness of flow and non-flow measures and to implement the adaptive management strategy set forth in the FSA. Below we discuss each of the three comparative goals under FSA Section 9.

4.2.1 Improve smolt survival and escapement in the Tuolumne River

4.2.1.1 Smolt survival studies

As provided under FSA Section 13 (f), funding for paired CWT releases was provided to CDFG and conducted in April of each year from 1996–2002 (Section 3.5.2.5). Although no numeric targets have been provided for Chinook salmon survival on the Tuolumne River, efforts at designing a robust survival monitoring program to date have met with limited success and the resulting survival indices continue to be variable (0.1 to > 1.0) with only weak relationships with flow or other factors such as changes due to the completed and upcoming predator isolation projects. For example, initial tests of survival through SRPs 9 and 10 were not very successful and it was concluded that the length of river under evaluation had to be increased to provide better dispersal of CWT smolts through SRP sites and to improve RST capture probability.

Because of the difficulties in measuring smolt survival using paired coded-wire tagged (CWT) or multiple mark recapture (MMR) releases and genetic issues regarding the use of large hatchery releases, the TRTAC has considered alternative approaches to direct smolt survival experiments. For example, it has been suggested that the role of predation can be further studied through predation rate measurements and predator abundance estimates. These and other recommendations are discussed in Chapter 5.

4.2.1.2 Predator reduction measures under the 1995 FSA

As required under FSA Section 12(b), several predator isolation projects were developed under the Restoration Plan. Monitoring of the initial predator isolation project at SRP 9 to date appears inconclusive and suggests the project may not have been as successful in reducing largemouth bass linear density during the low flow years that have occurred since project construction in 1999 (Section 3.4.2.2). Monitoring of largemouth and smallmouth bass abundance at the SRP 9/10 project and control sites from 1998 through 2003 documented a pattern of population depletion following the 1997 flood and subsequent recovery during recent low water years. This finding is consistent with reproductive requirements for these species and river flows and temperatures from 1999 through 2003. Since 1999, low spring and summer flows in the river have provided suitable spawning temperatures and flow velocities for these species. Both species have increased in abundance throughout the reach, through largemouth bass are more abundant than smallmouth bass. At least five cohorts for each species were present in the reach. Chapter 5 contains several recommendations as to continuing efforts to reduce predator impacts on Tuolumne River salmon populations.

4.2.1.3 Improvements of conditions for rearing juveniles in the lower Tuolumne River

Smolt production estimates using RST for part of the seasons in 1995, 1996 and 1997 was 21,933, 56,538, and 3,990, respectively (Section 3.5.2.4). The smolt estimates for longer sampling seasons of 1999, 2000, 2003 and 2004 were 30,864, 47,703 7,261, 13,164, respectively. For years in which CDFG sampling was partitioned into fry and smolts (1999 and 2000), estimated total expanded fry production was 1,042,805 and 84,314, or about 34 times and 2 times the smolt production estimates for these two years. As required under FSA Section 13(c), the Districts have provided annual reports of seining surveys, including summary updates that review several recent years (Section 3.5.2.2). Although annual seining surveys are generally considered unsuitable for assessing absolute juvenile production, long term variations in average density appear to increase corresponding to the high escapement years following the 1995 FSA.

Several studies conducted in the late 1980s and early 1990s demonstrated the adequacy of the food supply for juvenile salmon in the Tuolumne River based on gut samples, drift samples, and benthic samples (TID/MID 1992, Appendix 16). As discussed in Section 3.5.3.2, although overall invertebrate abundances in Hess samples collected at a long-term monitoring site (Riffle 4A) have declined slightly in the post-FSA period, community composition has shifted away from pollution tolerant organisms and towards those with higher food value for fish. In addition to the increased occurrence in stoneflies relative to past studies, Ephemeroptera species and diversity increased in the post-FSA sampling period. This apparent trend is indicative of improved instream conditions for resident fish species in the lower Tuolumne River.

4.2.1.4 Improvements in escapement levels

As discussed in Section 4.1.1 above, long-term escapement since the completion of Don Pedro Dam has averaged near 6,700 spawners, whereas the periods of 1986–1995 and the post-FSA period since (1996–2004) have averaged 3,200 and 7,500 spawners, respectively. As discussed in Section 4.1.1.2, long-term escapement levels since the completion of the New Don Pedro Dam (1971–2004) would have produced escapement levels 16% lower, whereas the flows provided under the 1995 FSA would have increased long-term escapement by 37% relative to the original Article 37 flows in place prior to the 1996 FERC Order.

4.2.2 Increase in naturally reproducing Chinook salmon in the Tuolumne River subbasin

As stated in Section 3.5.2.1, the numbers of adult salmon returning from the ocean to spawn in the Tuolumne River and in the San Joaquin system as a whole have fluctuated widely throughout the period of record, generally alternating between a periods with high escapements and periods with low escapements. Large numbers of CWT hatchery salmon have been released into the Tuolumne River or nearby San Joaquin River since 1986 as part of the Tuolumne River smolt survival evaluations Sections (3.5.2.1 and 3.5.2.5). Spawning runs over the last 12 years have had about 7%-30% of salmon with an adipose fin clip, indicating Merced River hatchery origin fish. This is in contrast to less than 3% prior to the smolt survival studies. Although it is expected that the proportion of known hatchery fish will decline after the last of the 2002 Tuolumne release fish return in 2005–2006, other large releases of hatchery reared salmon in the basin and south Delta continue to affect the naturally reproducing salmon populations in the lower Tuolumne River.

4.2.3 Population Resiliency

Participants to the 1995 FSA agreed that barring events outside the control of the Districts, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested. One of the primary concerns that led to the establishment of the 1995 FSA Flow schedules related to improving smolt production and outmigration survival in the drier year types. Thus, a population resiliency goal was included in FSA Section 9 to ensure adequate population levels were maintained by the 1995 FSA Fishery Flow measures (FSA Section 11) prior to testing some of the more experimental measures outlined under FSA Section 12e or developed as part of the Restoration Plan.

The resiliency of the Tuolumne River Chinook salmon population is not numerically defined in the FSA, but can relate to both the lowest levels reached and the rate at which the population recovers from population declines. Examining the periods of population crises that have occurred in the past (e.g. early 1960s, 1970s and early 1990s), it appears that the Tuolumne River Chinook salmon population has the ability to recover from levels in the hundreds of fish to tens of thousands of fish within a single generation (i.e., 3–4 years). As discussed in Sections 4.3 and 4.4, a number of factors (e.g., annual rainfall, delta exports, etc.) can affect the apparent rate of recovery from the effects of various stressors on the population. For this reason, the Districts have interpreted the population resiliency goal to mean an increase in the minimum levels of returning salmon within the long-term population cycles of the San Joaquin basin so that a larger parent stock is present from the beginning of the next upward cycle following a decline. CDFG has considered whether the Tuolumne River salmon population had sufficiently recovered to allow resumption of in-river salmon sport fishing and, beginning in 2000, through the California Fish and Game Commission authorized a 1 salmon per day sport catch limit in season within a portion of the Tuolumne River and the San Joaquin River upstream of the Delta.

Extending the modeling results discussed in Section 4.1.1.2 to consider only escapement levels in drier year types, the minimum 1995 FSA flow schedules in the absence of flood management releases can be shown to be sufficient to maintain a self-sustaining population of several thousand returning spawners. Although these results contain a number of assumptions whose accuracy is difficult to assess, increasing the minimum flows in the post 1995 FSA period appears to have increased the population minimums during the two population crises during the late 1970s and early 1990s, there is some evidence that the overall San Joaquin system may be less productive for salmon in recent times. However, this is likely due to issues of survival through the Delta due to export, salvage, predation and other factors (Section 4.4).

4.3 Factors within the Control of the Districts

Of the factors listed in Chapter 2 affecting salmon runs in the Tuolumne River, only two factors are considered within the control of the Districts:

1. Instream flow management
2. Habitat modifications within District and other lands along the Tuolumne River

4.3.1 Instream flow management

As described in annual reports submitted to FERC from 1996 to the present, Don Pedro Project operations and river flows at La Grange Dam have complied with the requirements of the FSA and the 1996 FERC Order on a real-time basis. Infrequent instances of the USGS retroactively re-rating the La Grange gage is discussed in Section 3.2.1.3. As required under Article 37, the annual FERC fish flow schedule, including spring and fall pulse flows, are discussed and coordinated with CDFG and USFWS. USFWS has in turn consulted with NOAA Fisheries. Section 3.2 describes instream flow management of the lower Tuolumne River, including the establishment of FERC fish flows under the 1996 Order. Appendix A of this Report describes in detail the annual FERC fish flow schedule procedure.

Other instream flow management measures relate to the San Joaquin River Agreement and VAMP studies coordinated by the San Joaquin River Group Authority pursuant to SWRCB Decision 1641. As stated in Section 3.2.2, CDFG and USFWS as well as the Districts are active participants in the VAMP process, which facilitates the flow allocation approval process under Article 37 and the integration of the Article 37 spring outmigration pulse flow block of water with the supplemental water provided by the SJRGA agencies, including the Districts, for the VAMP studies. Article 37 provides flexibility to shape, integrate, and adjust the Don Pedro Project's flows to meet the needs of VAMP.

In January 1997, a major regional flood event occurred at flows unprecedented since the 1971 completion of the new Don Pedro Dam. Although the Districts were in compliance with rules established under the USACE (1972) flood control manual, combinations of rain on snow produced computed natural flows for the Tuolumne River averaging near 120,000 cfs and the

Districts operated the radial gate and Ogee crest spillway for the first time since construction. Three subtropical storms hit Central California between Sunday, December 29, 1996 and Thursday, January 2, 1997, causing the flow into Don Pedro Reservoir to reach a peak hourly inflow of at 121,000 cubic feet per second (cfs) or a peak daily inflow of 89,200 cfs on January 2. The peak hourly outflow was 59,000 cfs, with a peak daily outflow of 50,100 cfs occurring on January 3. These subtropical storms caused the 340,000 acre-feet of flood control space to fill rapidly and water flowed over the Don Pedro Dam spillway, for the first, and only, time in the history of the Project. Although the flood peak was reduced by half, as it flowed through Don Pedro Reservoir, the releases and spills from the reservoir exceeded designated downstream channel capacity.

4.3.2 Habitat modifications

As stated in Chapter 2, the Tuolumne River and other San Joaquin basin rivers have been subject to significant habitat alteration including historic gold dredging operations within the primary spawning reaches, large scale aggregate mining, clearing of riparian forests and the installation of riprap by agencies or landowners to stabilize banks, further reducing favorable salmon habitat. The Habitat Restoration Plan (McBain &Trush 2000) built upon the FSA Section 8 goals to provide a set of specific goals to restore these habitats as well as wider ecosystem values within contemporary constraints of flow and sediment regulation, and regional anthropogenic disturbances.

Section 12 of the 1995 FSA directed the TRTAC to identify ten top-priority habitat restoration projects including a minimum of two salmon predator pond isolation projects, with the objective of implementing the priority projects by the year 2005 and the provision that other parties would help seek additional funding. From the list of projects identified under the Restoration Plan (McBain &Trush 2000), the ten priority projects selected by the TRTAC went far beyond the funding specified by the FSA, requiring much more funding if they were to be implemented. The restoration program has been highly successful in obtaining major funding from other sources, resulting to date in over $33 million dollars to complement the initial $1 million of the FSA Section 12 (Section 3.3).

With the exception of permitted habitat modifications conducted on lands acquired by the Districts for the priority restoration projects (Section 3.3) and other permitted habitat modifications conducted by others, no land use activities have occurred on District-owned lands within the Tuolumne River riparian corridor that adversely impacted Tuolumne River fishery resources. As stated in Section 3.3, two of the ten priority projects have been implemented, including revegetation and maintenance for two years after planting. These projects are SRP 9 and the 7/11 Segment of the Mining Reach Projects. Of the remaining eight projects, seven are either fully or partially funded and work is proceeding on all that have funding.

4.4 Factors outside the Control of the Licenses

As stated in Section 2, conditions affecting salmon runs in the Tuolumne River include many factors which are outside of the Districts control such as Delta export flows and other issues related to direct mortality of juvenile salmonids, ocean harvest, water quality, agricultural and other land uses, riparian diversions, and the impacts of the 1997 flood. As discussed in this section, direct and indirect losses (reduced juvenile survival) associated with the State and Federal Delta water export facilities is considered to be especially significant for SJR salmon as compared to Sacramento basin salmon. Actions taken elsewhere in the San Joaquin River system to improve survival can be negated by operations of these facilities. As a result, the productivity of SJR salmon populations is adversely affected in most, if not all, years.

During the period of additional salmon protective measures (basin spring pulse flows, reduced delta export, and installation of HORB) for part of the smolt outmigration in April-May, the smolt survival indices through the Delta have ranged from only about 2-19% for 2000-2004. Since there are no Delta protective measures prior to mid-April, San Joaquin River juveniles (including fry and smolts), rearing or migrating prior to that time are subjected to nearly continuous high export rates and even reverse flow conditions in outmigration routes. Thus when otherwise beneficial winter or early spring hydrologic conditions in wetter years and the associated large early outmigration of juveniles from the tributaries occur, impacts to the part of the population that enters the Delta are likely to be extreme. As a result, it now takes ever larger flood management flows to overcome export-related impacts prior to mid-April.

In the near future, it is anticipated that several actions and projects will be taken by California and Federal agencies that may help mitigate some of the described non-District impacts on the fish resources of the San Joaquin Basin and particularly salmon resources of the Tuolumne River. However, there is also the potential for conditions to worsen if several proposed actions are taken (e.g. the SWP export rate is allowed to increase to 8,500 cfs, the City of Stockton Delta Water Intake is built, and the Stockton Deepwater Ship Channel is enlarged) without adequate safeguards and implemented mitigation measures.

4.4.1 Delta issues

Historically, the Sacramento-San Joaquin Delta (Fig. 4.4.1-1) provided high quality rearing habitat for juvenile Chinook salmon. Human modification of the Delta, however, has greatly degraded this once favorable environment. Today, ‘direct effects’ or entrainment mortality of juvenile salmonids at or near the federal and state export facilities and predation in the Clifton Court Forebay to the state’s export pumps and a number of ‘indirect effects’ combine to reduce the survival of Chinook salmon rearing in and migrating through the Delta. Indirect effects include decreased water quality, habitat abundance and quality, food choice and abundance, and increased vulnerability to predation in Delta channels. This section summarizes a number of these direct and indirect effects on juvenile and upmigrant salmonids.

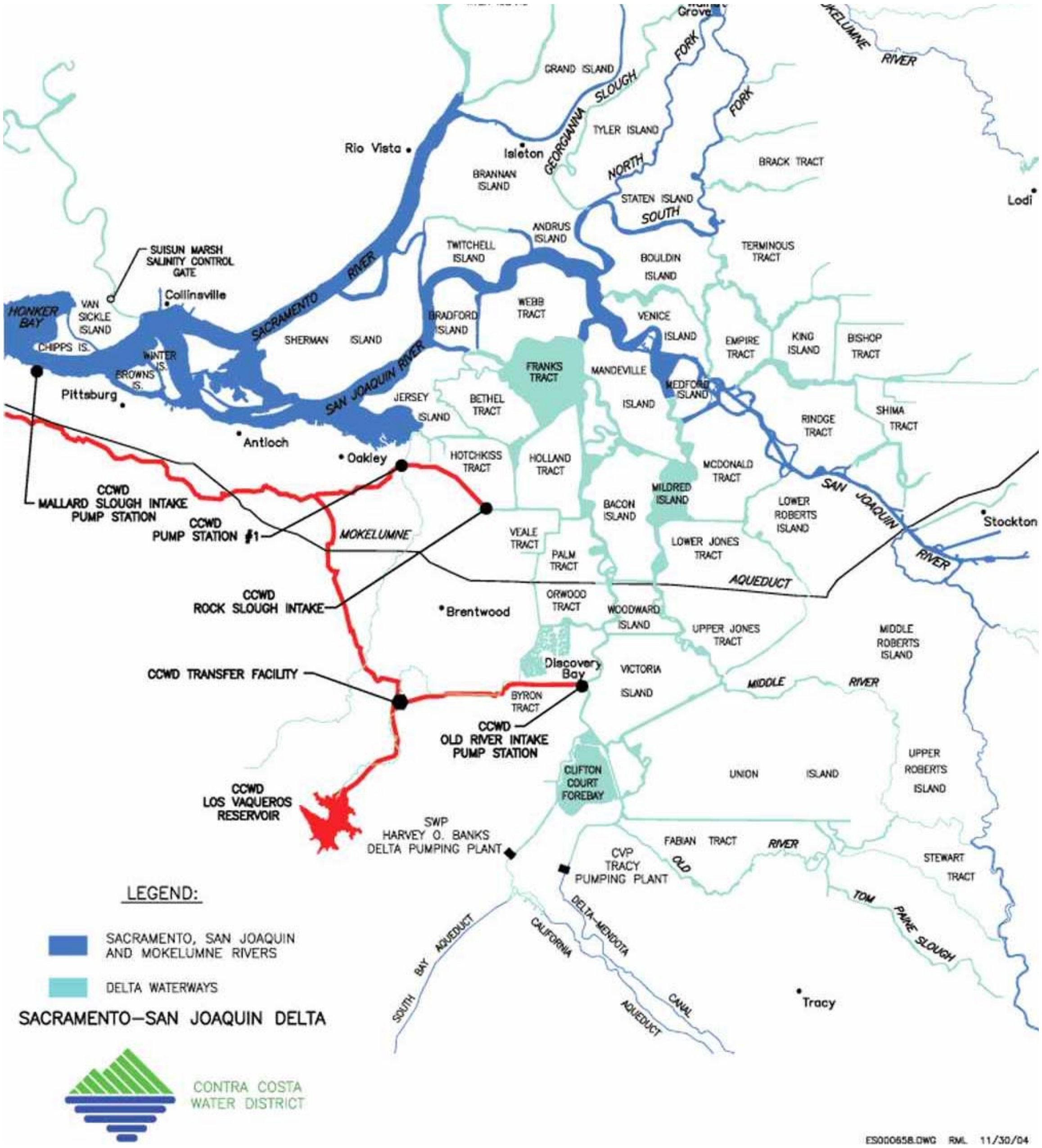


Figure 4.4.1-1 Overall map of the Sacramento River-San Joaquin River Delta region. (from Contra Costa Water District website).

4.4.1.1 Delta export and barrier operations

The federal Central Valley Project Tracy Pumping Station (completed in 1951) and the California State Water Project Harvey O. Banks Pumping Plant (completed in 1968) withdraw large volumes of water from the Old River channel of the San Joaquin River in the south Delta. The CVP pumping plant at Tracy has a maximum capacity of 4,600 cfs, although the Delta-Mendota Canal leading from the pumps is often limited to 4,200 cfs. The SWP pumping plant has a capacity of 10,300 cfs, but under present operational constraints is generally limited to 6,680 cfs.

Delta water export greatly increased after the SWP was completed (Fig. 4.4.1.1-1). Combined export rates are now usually over 6,000 cfs almost year-round and often exceed 10,000 cfs (Fig. 4.4.1.1-2). Since 2000, export reductions below 4,000 cfs have been limited to the spring VAMP and post-VAMP period in April-May. The export rates routinely far exceed the flow of the San Joaquin River at Vernalis except during the limited April-May period and in very wet seasons, such as in 1998 (Figure 4.4.1.1-3)

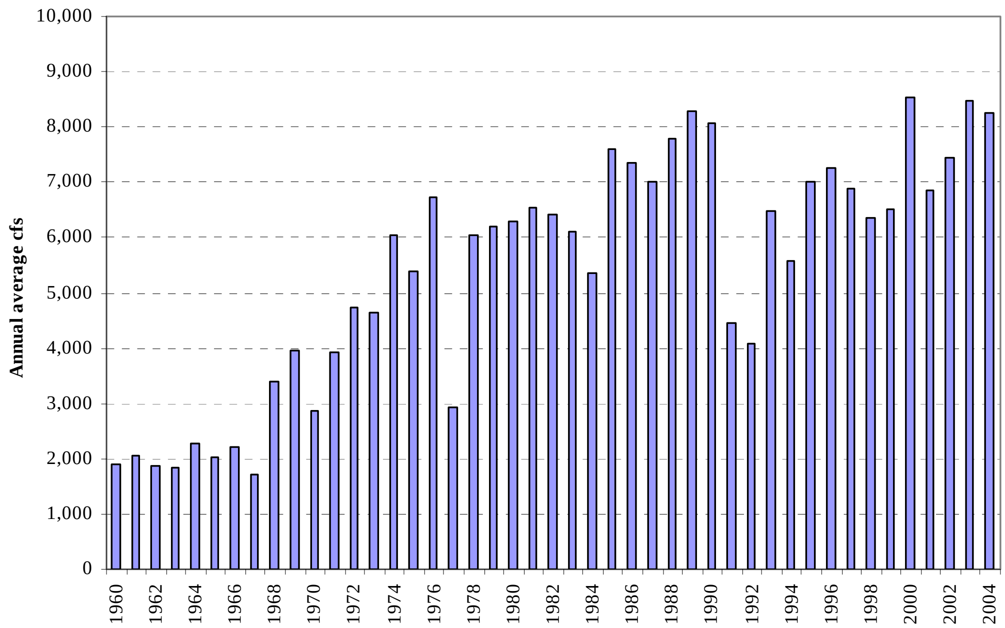


Figure 4.4.1.1-1. Average annual SWP and CVP export rate for water years 1960-2004

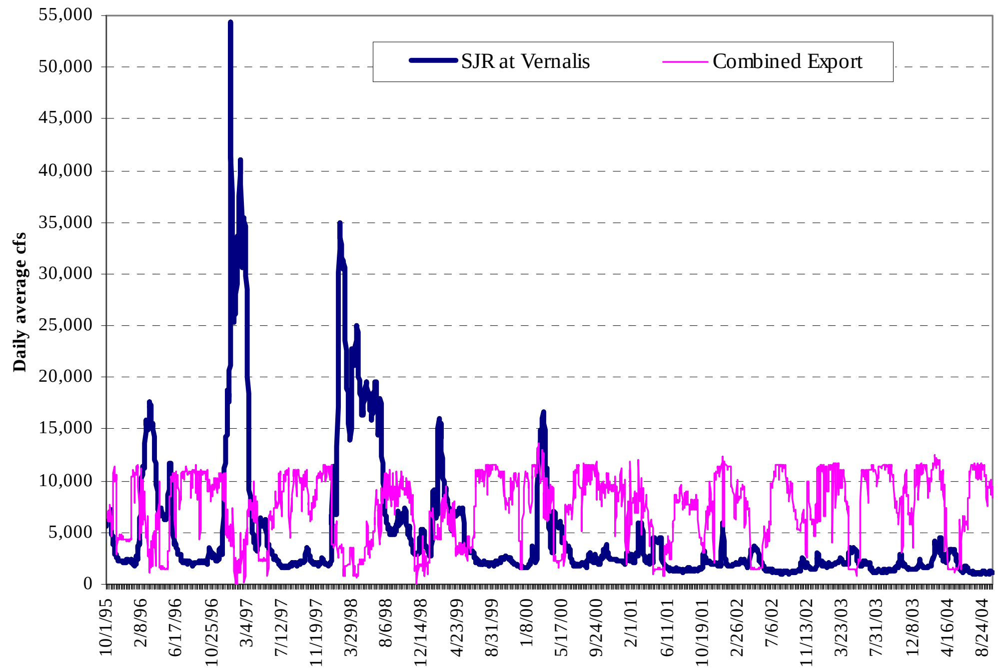


Figure 4.4.1.1-2. Daily average flow in the San Joaquin River at Vernalis and combined CVP and SWP export for WY 1996-2004.

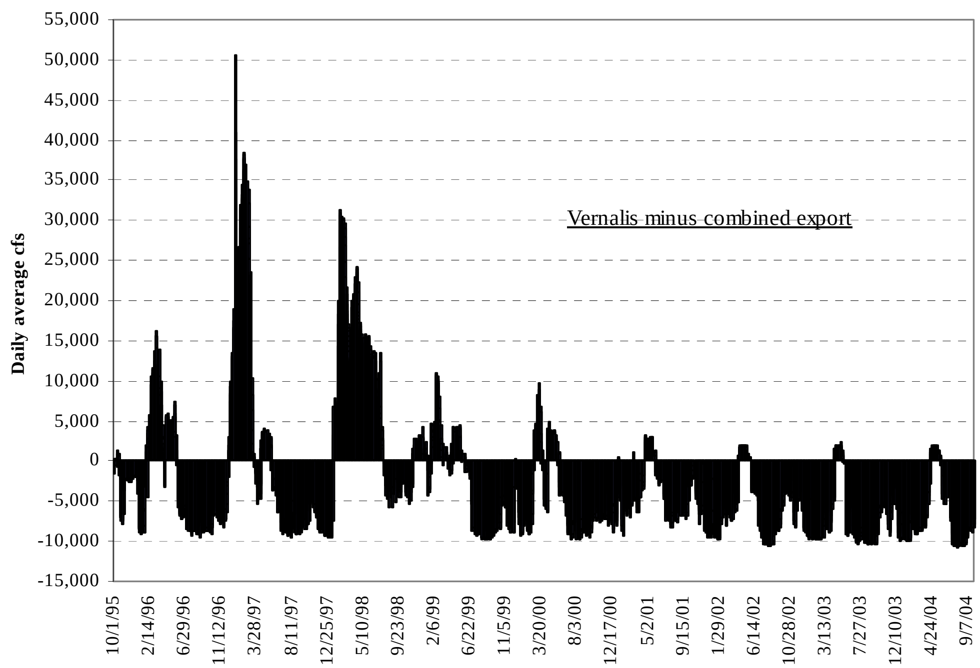


Figure 4.4.1.1-3. Daily average flow in the San Joaquin River at Vernalis minus combined CVP and SWP export for WY 1996-2004.

Barrier Operations

Physical and mechanical barriers are operated within the Delta to control the path of flow towards the pumps, improve water quality, and minimize impacts to fish. In low freshwater outflow years (and particularly when export pumping is high), Sacramento River water mixes with saline ocean water, and then is drawn upstream into the San Joaquin River by the CVP and SWP operations, creating "reverse flow" conditions. A prolonged period of reverse flow can deteriorate water quality and harm fisheries in the lower San Joaquin River (DWR Bulletin 160-93) by hindering salmonid juvenile outmigration, subjecting them to increased predation, and moving them towards the SWP/CVP export pumps.

Within the central and southern Delta, the diversion facilities have a large effect on channel net flow direction and magnitude, including Old and Middle rivers, the Grant Line Canal, and the San Joaquin River. Data collected by USGS and CDWR document that when a net positive flow exists at the San Joaquin River at Stockton, approximately 33 percent of the water exported by the projects is drawn down Old River, 45 percent through Middle River, and 22 percent through upper Old River and Grant Line Canal. Net reverse flows can occur in the San Joaquin River at Stockton when the quantity of water drawn to the pumps through upper Old River and Grant Line Canal exceeds San Joaquin River flow entering the Delta upstream (Oltman 1996).

In years when spring flow in the San Joaquin is less than 7,000 cfs, a temporary barrier is placed at the head of Old River (Head of Old River Barrier [HORB]) to prevent drawing outmigrating salmon out of the San Joaquin River toward the pumps near Tracy. The barrier is constructed with unscreened culverts that can transport water to agricultural diversions downstream in Old River, while allowing fish to migrate down the San Joaquin River. Without the barrier in place, approximately 60 percent of the water flows down Old River, and 40 percent flows down the San Joaquin River. During low outflow years and summer months, it is possible for flow down Old River to exceed 100 percent of San Joaquin River inflow to the Delta, with the remaining water provided by reversed flow in the lower San Joaquin River (CDWR 1986).

Additional temporary rock barriers (constructed by DWR in late fall) are in place along the Grant Line Canal, and on the Old and Middle rivers near Tracy to improve water levels and water quality for Delta agriculture.

The South Delta Improvement Program

As shown in Figures 4.4.1.1-1 through 3, demands for water supplies from the Delta for municipal, agricultural, and environmental purposes have increased in recent years, creating conflicts between water users and efforts to sustain the Delta's aquatic ecosystem and recover threatened and endangered fish. The joint state-federal CBDA Program was formed to develop and implement a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta system. The CBDA Programmatic EIS/EIR (PEIS/EIR) and Programmatic Record of Decision (ROD) were issued in July and August 2000, respectively. The CALFED ROD identifies the South Delta

Improvements Program (SDIP) as an action included in its Programmatic EIR/EIS to optimize the use of the Delta as the means for conveyance of State and Federal project export water. Through its PEIS/EIR, CALFED determined that its overall program objectives could not be met without some south Delta conveyance improvements. Since that time, the state DWR and the USBR have jointly proposed the construction of the SDIP.

The project goal of the SDIP is to increase the maximum allowable diversion capacity at the State Water Project's (SWP's) Clifton Court Forebay, to provide an adequate water supply for South Delta Water Agency (SDWA) and to improve conditions for San Joaquin River salmon in the southern portion of the Delta. It is claimed that the SDIP would result in the following benefits:

- increased water supply reliability for SWP, CVP, and EWA;
- increased water surface levels for SDWA agricultural water diverters;
- improved water quality for SDWA agricultural water diverters;
- improvement of conveyance capacity in portions of the South Delta; and
- improved conditions for San Joaquin River Salmon.

The proposed SDIP project and alternatives would consist of the following project elements.

- increasing the maximum allowable diversion capacity of the SWP export pumps from Clifton Court Forebay to 8,500 cubic feet per second (cfs);
- dredging portions of Old River and West Canal to improve conveyance capability during periods of high SWP and CVP Delta exports;
- constructing permanent operable barriers to improve water supply reliability and water quality in the south Delta;
- dredging local channels to reduce the frequency of barriers operations and to accommodate improvements to existing agricultural diversions both upstream and downstream of the proposed barriers; and
- constructing a permanent operable fish control structure at the head of Old River to reduce fish losses at the CVP and SWP export facilities.

The schedule for implementing the SDIP is as follows.

- Draft EIR/EIS will be complete by Mid-2005.The Draft EIR/EIS should contain an analysis of the physical and biological impacts arising from the proposed project and alternatives to the project. In addition, it should address the cumulative impacts of implementation of alternatives in conjunction with other past, present, and reasonably foreseeable actions. Transitional implementation of 8500 cfs, dredging/diversion improvements 2005-2007
- Construct permanent operable barriers by December 2007
- Fully operate under 8,500 cfs by January 1, 2008

Once the permanent operable fish control structure at the head of Old River is complete and operating, the Districts hope that it will offer increased protection to Tuolumne River and other San Joaquin Basin salmon fry, juvenile, and smolts from direct and indirect mortality impacts from CVP/SWP export operations and will more than offset any increased adverse impacts from any authorized increase in export pumping rates.

4.4.1.2 Salmon salvage and mortality associated with export pumps

Migrating juveniles from the San Joaquin River system go directly to the pumping facilities by entering Old River below Mossdale. Others may still reach the export facilities by going southward down channels west of Stockton (e.g. Turner Cut, Columbia Cut, Middle River). The percentage of salmon reaching the export facilities is a function of the percentage of the water in the San Joaquin passing through Old River, which is in turn, is affected by the volume of export water pumped relative to the volume of flow in the San Joaquin River. As stated above, approximately 60% of the San Joaquin River flow would flow down Old River without any Delta export operations.

Combined export rates usually exceed the entire San Joaquin River flow (as measured at Vernalis) and extensive net reverse flows occur in many channels leading to the export facilities, where the salmon are subject to entrainment into the pumping facilities. Although both projects are equipped with fish screens and salvage facilities, direct mortalities to fry and juvenile salmon are quite high. That mortality occurs from predation, particularly in Clifton Court Forebay of the State Water Project, entrainment, by physical damage and stress during salvage operations, and by predation at release points for salvaged fish near the western (downstream) edge of the Delta. Indirect mortality due to the pumping operation (e.g. increased travel time and predation exposure) is also a factor affecting survival.

Operation of the Delta pumps has been considered to be one of two primary sources of mortality of smolts outmigrating from the Tuolumne River, resulting in an estimated loss of 35–44% of juveniles migrating through the San Joaquin River in water years 1973–1988 (TID/MID 1992, Appendix 26). It is generally considered that the worst condition for survival of Sacramento River salmon is to have them directly enter into the Central Delta, either through the Delta Cross Channel or through Georgiana Slough, both leading to the Mokelumne River where there is a greater likelihood of being drawn further southward to the export facilities. This is in direct contrast to the situation for the San Joaquin River salmon, where it is generally considered best for their survival if they can at least reach the Central Delta using the lower San Joaquin River through Stockton rather than entering the Head of Old River that leads directly to the export and salvage facilities. Thus the San Joaquin River salmon are routinely subject to higher mortality due to the export operations than are Sacramento River salmon, even with some protective measures during a 4-6 week period in April and May.

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release them downstream at two sites in the western Sacramento-San Joaquin Delta (captured tagged salmon are sacrificed to read the tag). The untagged salmon are either naturally produced or are untagged hatchery salmon, potentially from any source in the Central Valley. It is not certain which unmarked salmon are of San Joaquin basin origin, although the timing of salvage and fish size can be compared with

Mossdale trawl data and facility recovery data for Merced River Fish Facility CWT smolts to provide general indications. San Joaquin salmon captured at the Chipps Island trawl below the confluence of the Sacramento and San Joaquin Rivers may have traveled through the Central Delta or been transported and released through the salvage process.

The number and density of juvenile salmon that migrated through the system, the placement of the HORB, and the amount of water pumped by each facility are some of the factors that influence the number of juvenile salmon salvaged and lost. Density is an indicator of when concentrations of juvenile salmon may be more susceptible to the export facilities and salvage system. The salvage estimates at the facilities are based on expansions from sub-samples taken throughout the day. Four to five salmon are estimated to be lost per salvaged salmon in the SWP facility based on high predation rates in Clifton Court Forebay. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50 to 80% of the number salvaged, or about six to eight times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, additional mortality associated with trucking and handling, or post-release predation. Density (relative abundance) of salmon is based on the number of salvaged salmon per acre-foot of water pumped. The CDFG and DWR maintain a database of daily, weekly, and monthly salvage data. Fry salmon (<50mm) may not be as effectively screened, leading to higher losses. It is assumed that nearly all the salvage data pertinent to San Joaquin River salmon would be during the January through June period. Since the CVP diversion is first encountered going down Old River, it may be that San Joaquin River salmon are preferentially drawn into that facility without the HORB in place. The HORB was installed during part of the April 15- May 30 period of 1994, 1996, 1997, and 2000-2004 (high San Joaquin River flows prevented installation in 1993, 1995, 1998 and landowner access problems prevented installation in 1999).

Data for unmarked salmon in the January to June period of 1993-2004 are presented here (salvage data for 1993-99 were previously reported in FERC Report 1999-6 and in subsequent annual reports). A more detailed comparative review of the number, size, and timing of all outmigration data during these years from the tributary sampling (screw trap and seine), San Joaquin River sampling (trawl and seine), and salvage facilities has not been done, but is feasible after certain data becomes available from CDFG.

Combined salvage or loss numbers were highest in 1998-2001 (Fig. 4.4.1.2-1). CVP salvage numbers are usually higher than at SWP, which has corresponding higher losses associated with the Clifton Court Forebay (Figures 4.4.1.2-2 and 3).

Figures 4.4.1.2-4 through 6 show monthly salvage, loss, and density of unmarked salmon at CVP and SWP facilities from January-June for 1993-2004. The relative monthly values vary among years, by facility, and by the number of salmon in the area. The higher salvage and loss at CVP were in January, February, and April of 1998, in February, April, and May of 1999, and in February and April of 2000. The higher salvage and loss at SWP were in April and May of 1999, April of 2000, and April of 2001 (Figs. 4.4.1.2-4 and 5). The highest monthly salvage and loss in 2004 was in March at both CVP and SWP. Densities tend to have the same general pattern (Fig. 4.4.1.2-6).

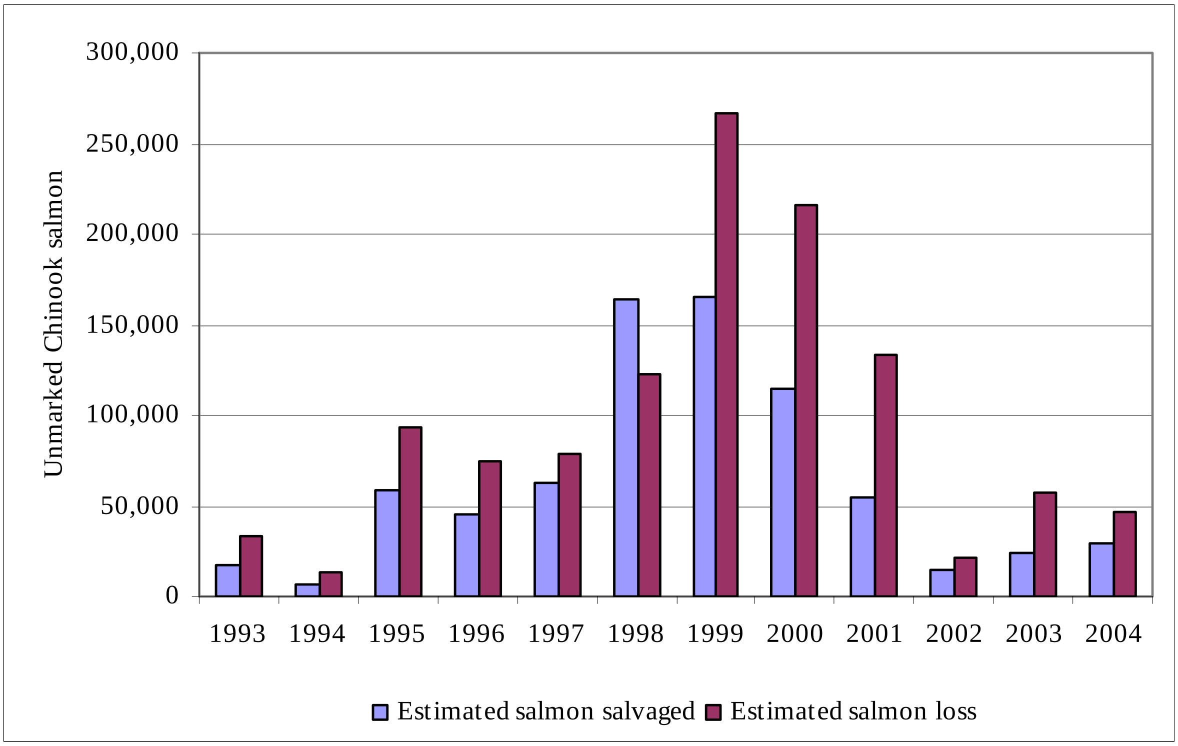


Figure 4.4.1.2-1. Combined SWP & CVP unmarked salmon salvage and loss from January-June for 1993-2004

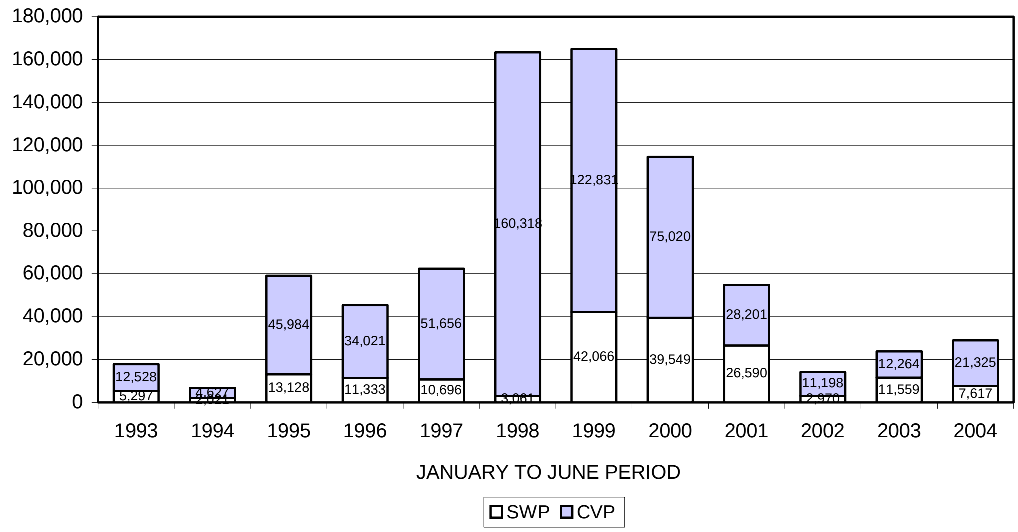


Figure 4.4.1.2-2. Estimated salvage of unmarked salmon from January-June for 1993-2004

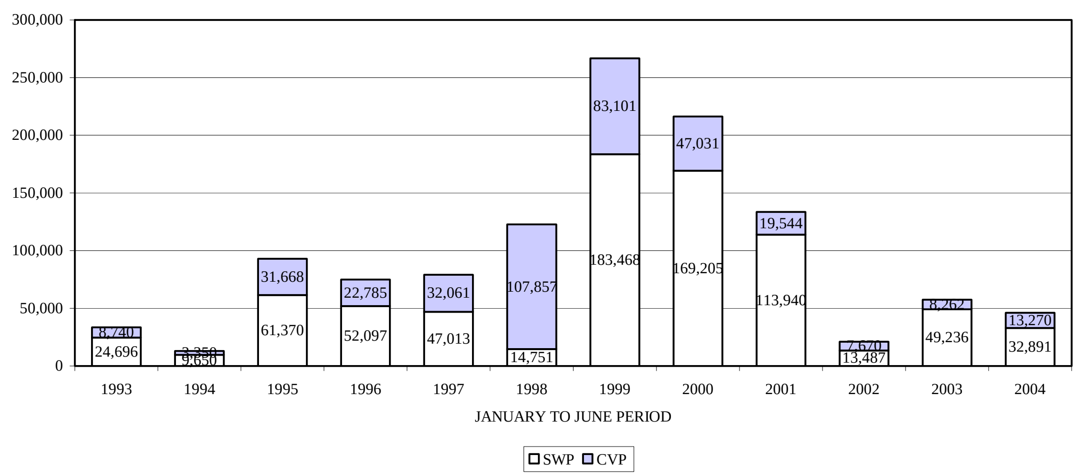
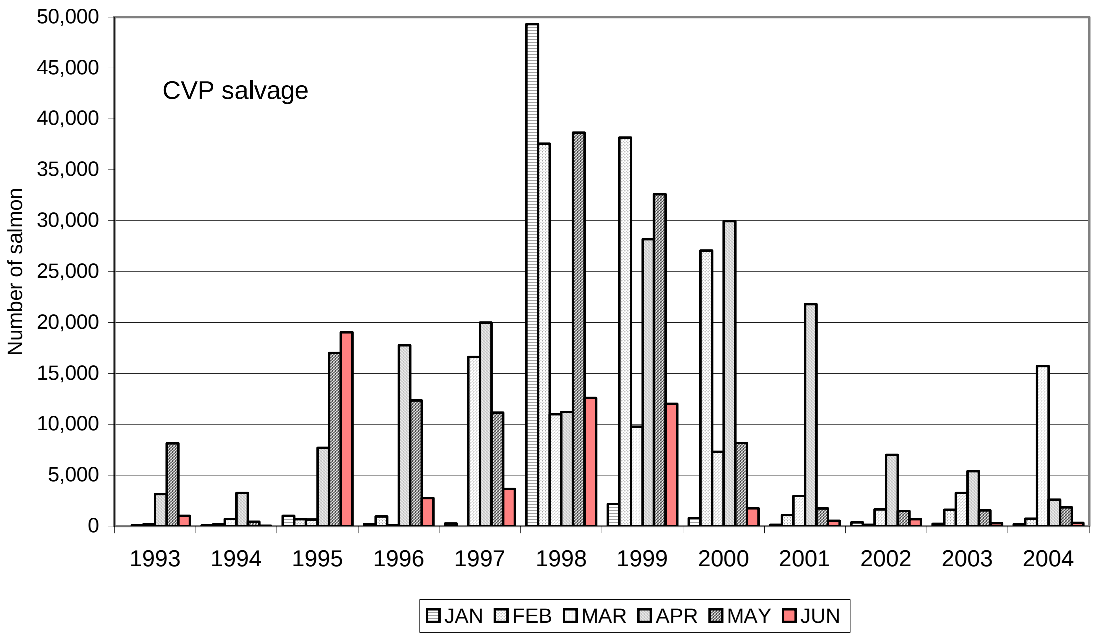


Figure 4.4.1.2-3. Estimated loss of unmarked salmon from January-June for 1993-2004



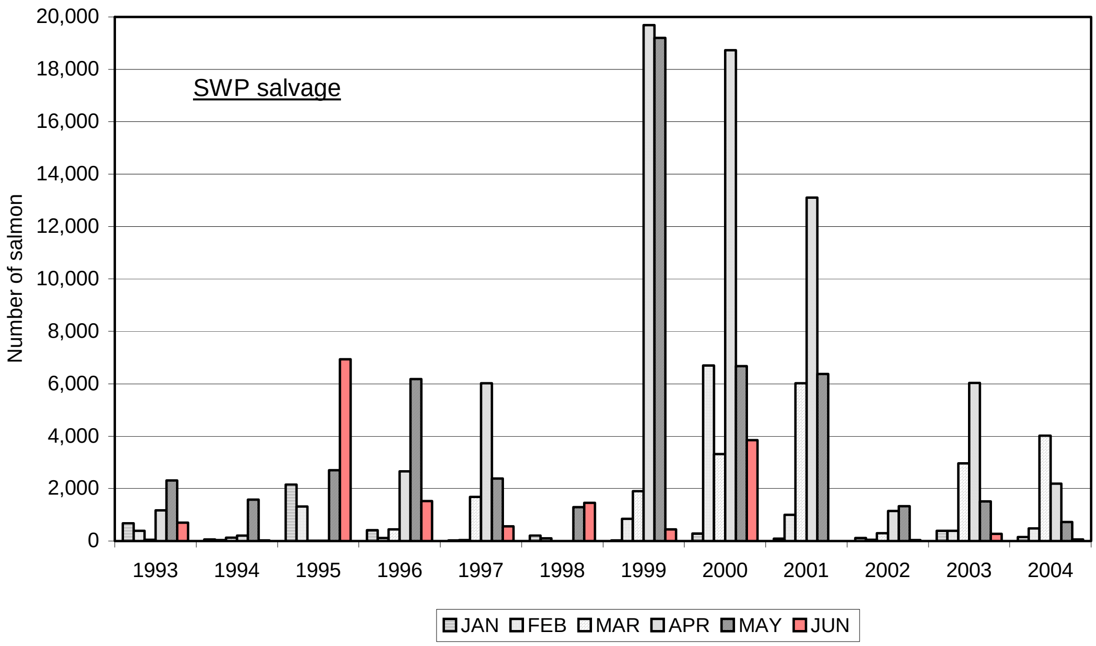
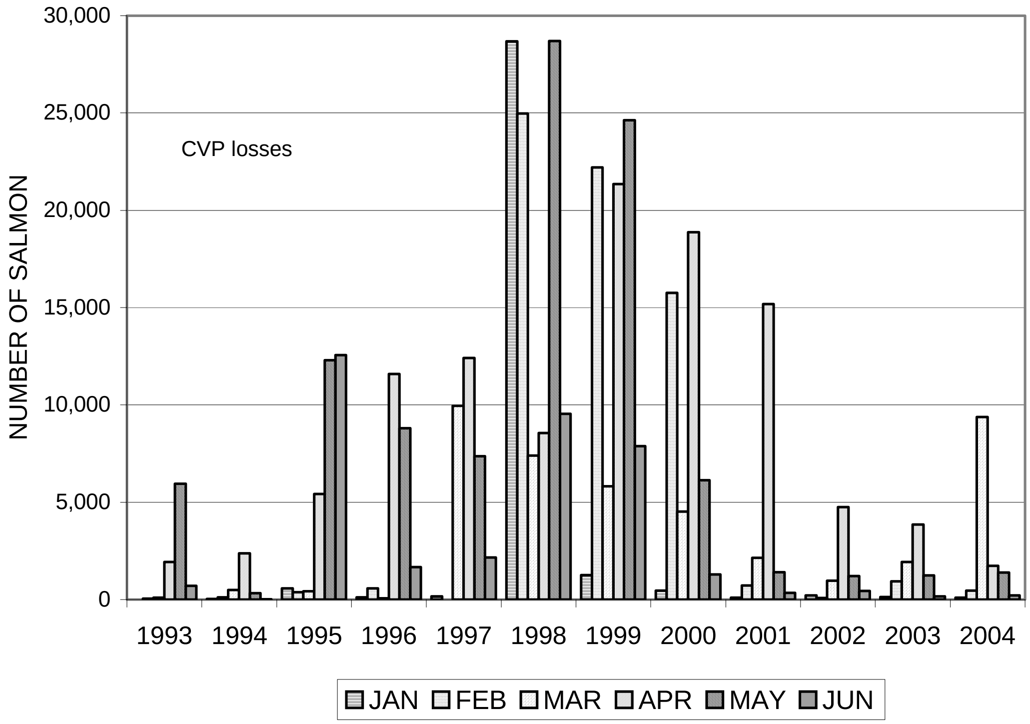


Figure 4.4.1.2-4. Salvage, by month, of unmarked salmon at CVP and SWP facilities from January-June for 1993-2004



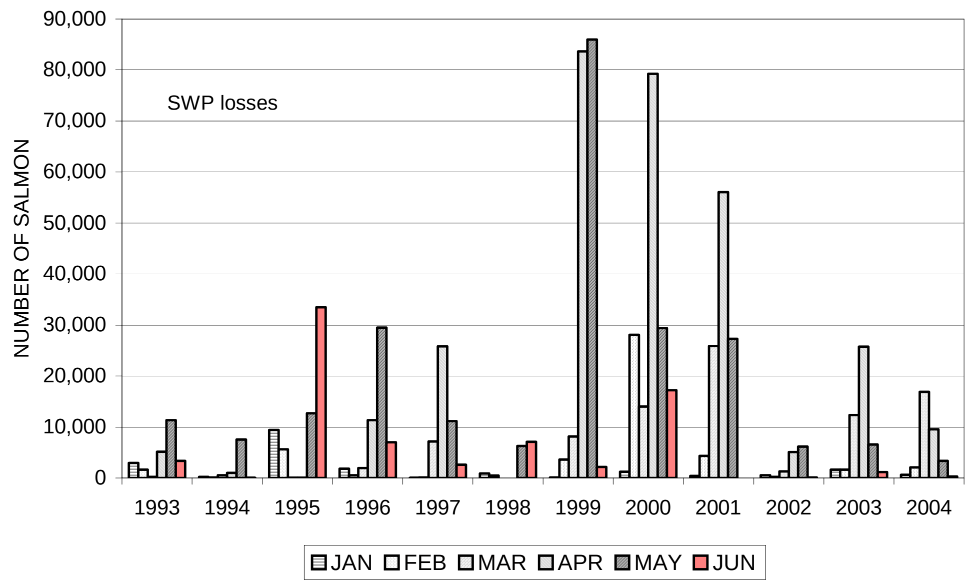
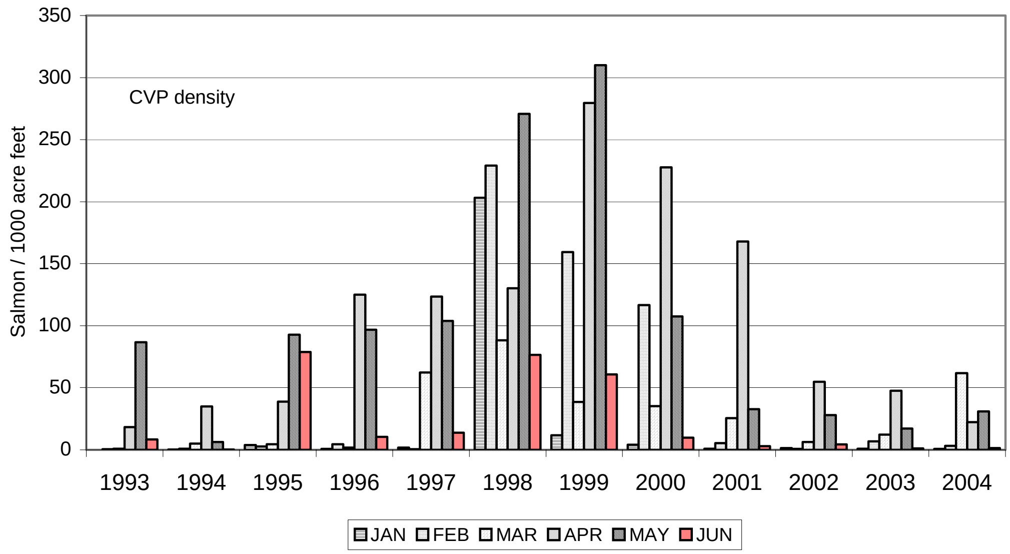


Figure 4.4.1.2-5. Losses, by month, of unmarked salmon at CVP and SWP facilities from January-June for 1993-2004



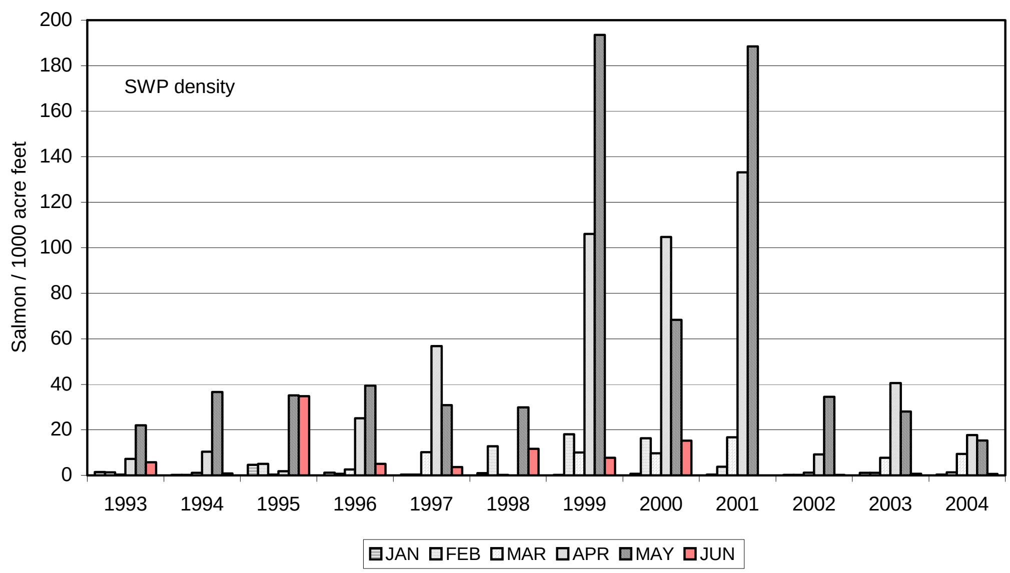


Figure 4.4.1.2-6. Average density (number salvaged per 1000 AF export), by month, of unmarked salmon at CVP and SWP facilities from January-June for 1993-2004

Figure 4.4.1.2-7 shows the size and timing of unmarked salmon salvaged at CVP and SWP facilities from August-July of 1999-2000 and 2003-2004. Both 2000 and 2004 had fry and juvenile migration into the San Joaquin River prior to mid-March. For comparison, Figure 4.4.1.2-8 has Mossdale Kodiak trawl individual daily fork lengths of all unmarked juvenile Chinook salmon from March 15 through June 30, 2004. The size and timing of the juvenile salmon at Mossdale in spring 2004 corresponds to the catch at the export facilities.

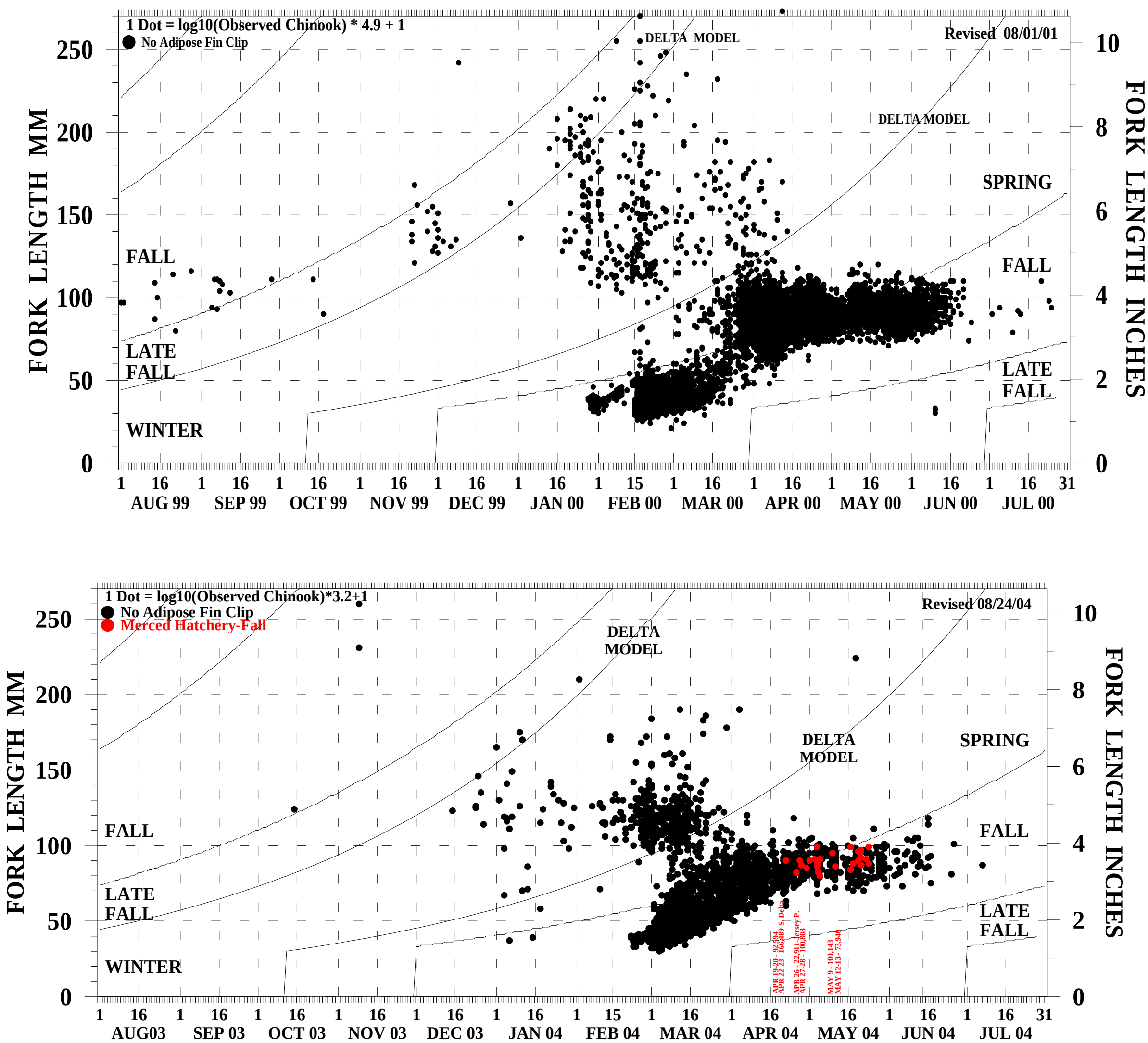


Figure 4.4.1.2-7. Size and timing of unmarked salmon salvaged at CVP and SWP facilities from August-July of 1999-2000 and 2003-2004. San Joaquin River salmon are mainly <120 mm within January-June "spring" and "fall" designations shown. Merced Hatchery CWT smolts are shown in red on the lower 2003-2004 chart (Source: E. Chappell, DWR).

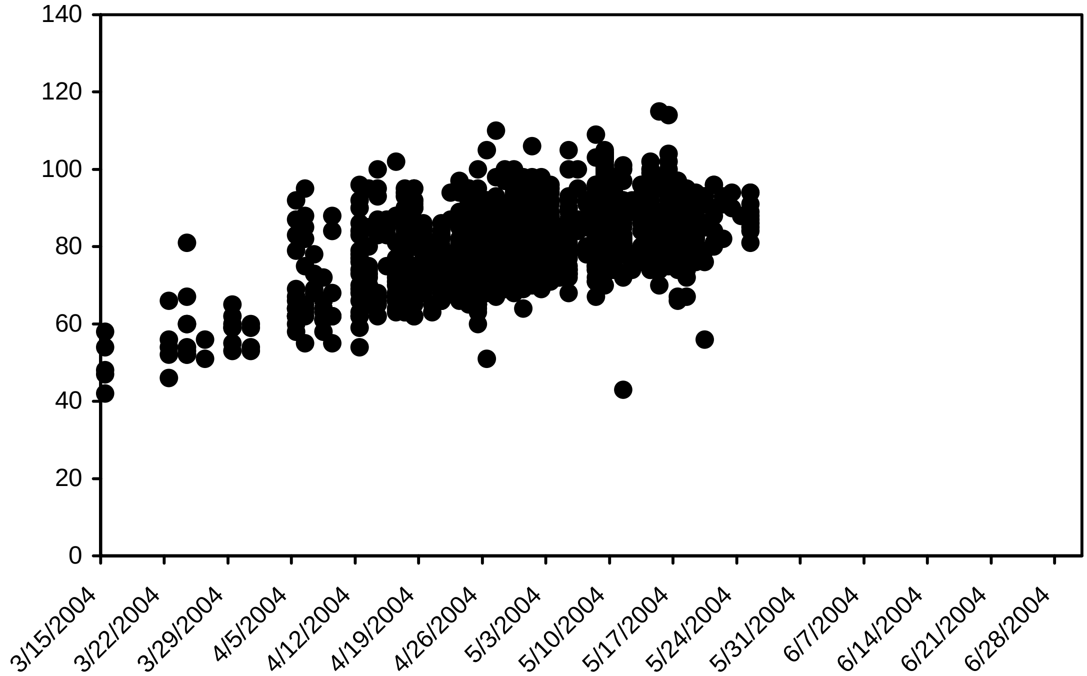


Figure 4.4.1.2-8. Mossdale Kodiak trawl individual daily fork lengths of all unmarked juvenile Chinook salmon, March 15, 2004 through June 30, 2004 (from SJRGA 2005).

4.4.1.3 Delta predation mortality

Results of coded-wire tag mark-recapture studies with releases occurring in San Joaquin River tributaries have consistently shown a pattern of substantial mortality of juvenile fall-run Chinook salmon during outmigration (Hanson 2000)). Although not directly quantified, the high mortality rates observed in many of these studies are consistent with predation-related mortality (Hanson 2000). Despite this evidence, limited information is available to characterize patterns and magnitude of predation on juvenile salmonids in Central Valley rivers and the Delta. Studies conducted within San Joaquin River tributaries (TID/MID 1992, Demko et al. 1998) have shown that predation by species such as striped bass, smallmouth bass, and largemouth bass is a significant factor affecting Chinook salmon smolt survival. Delta predation studies indicate that the effects of predation on salmon smolt survival in the Delta appear to vary considerably in response to the abundance of other prey and the clumped distribution of salmon (and other prey) that often occurs at man-made structures and water facilities.

Striped bass are a top predator in the Delta with average populations of 1.7 million adults during the late 1960s to early 1970s and 1.25 million adults during 1967–1991 (USFWS 1995.) Striped bass likely exerted considerable predation pressure on outmigrating juvenile salmon and are considered to be a primary cause of juvenile salmon mortality the state water-export facility in the south delta (USFWS 1995, as cited by Yoshiyama et al. 1998), where juvenile salmon density is high due to entrainment and salvage operations. Although studies have been conducted in Clifton Court Forebay to evaluate predation on juvenile Chinook salmon, Gingras and McGee (1997, p. 13) stated that "… predation at Clifton Court Forebay has not been thoroughly modeled…" Mortality rates for salmon smolts in the Forebay, as estimated by mark/recapture experiments conducted at intervals from 1976 through 1993, were observed to range from 63% to 99%, with most mortality widely assumed to be due to predation by striped bass (Gingras 1997). Yoshiyama et al. (1998) noted that "[S]uch heavy predation, if it extends over large portions of the Delta and lower rivers, may call into question current plans to restore striped bass to the high population levels of previous decades, particularly if the numerical restoration goal for striped bass (2.5 to 3 million adults; USFWS 1995; CALFED 1997) is more than double the number of all naturally produced Central Valley Chinook salmon (990,000 adults, all runs combined; USFWS 1995)."

Although studies from the 1960s indicated that juvenile Chinook salmon were once an important prey of striped bass in the Delta (Stevens 1966, Thomas 1967), recent studies of Delta predation indicate that predator diets have changed in recent decades. From September 1963 and August 1964, Stevens (1966) conducted an analysis of 8,628 striped bass stomachs collected in eight types of Delta environments. Subadult striped bass consumed Chinook salmon in the spring, with salmon occurring at 4% frequency and 10% volume; adult striped bass also consumed Chinook salmon during spring, but at a lower frequency and volume (Stevens 1966). More recently, Nobriga et al. (2003) report that changes in Delta ecology—most significantly the increased abundance of non-native prey fishes—has reduced the magnitude of predation on Chinook salmon migrating through the Delta. Preliminary findings indicate that juvenile Chinook salmon may not currently be as an important diet component of striped bass or largemouth bass in shallow water Delta habitats. Chinook salmon occurred in only 0.3% of striped bass stomachs and 0.6% of largemouth bass stomachs during sampling in 2000–2001 (Nobriga et al. 2003).

The large number of native and introduced fish species now present in the Sacramento-San Joaquin systems makes it difficult to predict the potential effects of ongoing Delta management measures to reduce predation. In addition, habitat restoration measures currently underway to increase shallow-water habitats in the Delta may affect predation on outmigrating juvenile salmonids by increasing or decreasing available habitat for native and non-native predator species and/or their prey.

4.4.1.4 VAMP studies to determine relationships between Delta smolt mortality and San Joaquin flow

The VAMP was officially initiated in 2000 and built upon previous South Delta evaluations that included with and without HORB conditions and associated CWT hatchery smolt survival releases. The temporary spring HORB has been installed with several culverts in some years and with various timing and amounts of water delivered through them into Old River. A separate evaluation of fish entrainment through the culverts in the HORB into Old River is reviewed in the annual VAMP reports. Loss indices of VAMP CWT salmon through the HORB for 2001-2004 have ranged from 0.4% to 1.4 %, indicating that entrainment has been very minor.

VAMP is established for a 31-day period, but export curtailment and/or HORB placement is extended later in May in most years and affords additional conditions considered to be beneficial for later migrants. However, since the temporary HORB cannot be installed with Vernalis flows over 5,000 cfs, upstream flows on the Tuolumne and Stanislaus Rivers were actually reduced in early April 2000 so that the HORB could be built –this occurred while exports remained much higher than during VAMP. Also, in 2001 the barrier completion was delayed until after the flow period began.

The upper (test) CWT releases are made at Durham Ferry (RM 71.2, one mile downstream of Vernalis) and at Mossdale 15 miles downstream (RM 56, about 2 miles upstream of the Head of Old River). The lower (control) CWT releases are made at Jersey Point (RM 12). Based on data gathered during the experimental mark-recapture studies that occurred during a 31-day period in April and May of each year, a set of conclusions and recommendations has been developed. Some key conclusions and recommendations derived from VAMP for 2000 through 2004 and contained in the 2004 Annual Technical Report (SJRGA 2005) are:

- Differential recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point group using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p<0.05$) difference in survival between the Durham Ferry and Mossdale releases conducted in 2004.

- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) showed that the relative proportions during 2004 were similar to 2003 but significantly lower than survival results from the 2002 VAMP, although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in all three years) were comparable. The factors contributing to the significantly lower survival in 2003 and 2004 are unknown.

- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports were not statistically significant based on results of VAMP tests over the past five years and similar pre-VAMP data gathered in 1994 and 1997.

- The index of salmon entrainment at the HORB from the single release in 2004 was substantially lower in comparison to the first releases made in 2002 and 2003 but similar to the 2001 loss. The comparisons may be limited due to the single release of test fish in 2004 and the varying culvert operations.

- The variability inherent in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, high target flow and low export conditions be tested improve the ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 72 percent of the unmarked salmon smolts migrating past Mossdale in 2004 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.

- The relationships between salmon survival rates and Vernalis flow and SWP/CVP export conditions tested in the first five years have not been found to be statistically significant. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports), or equivalent, are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

- It is recommended that further effort be given to identifying and evaluating opportunities to adaptively refine and modify the VAMP experimental design to improve the level of protection provided to juvenile Chinook salmon migrating downstream in the San Joaquin River, improve the ability to detect statistically significant relationships between flow and export rates and juvenile salmon survival if they exist, reduce potential adverse impacts to aquatic resources and their habitat within the upstream tributaries, and maximize the efficient use of available water resources within the San Joaquin River watershed during VAMP implementation.

The results of the VAMP study smolt releases are analyzed in several ways. The differences in survival indices were evaluated using absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where: SI_u is the survival index of the upstream group (Durham Ferry or Mossdale), SI_d is the survival index of the downstream group (Jersey Point) and i is either Antioch or Chipps Island.

Although referred to here as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

where: R_{C+A} is the combined recoveries at Antioch and Chipps Island of a CWT group, and ER is the effective release number.

The combined differential recovery rate is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where: CRR_u is the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and CRR_d is the combined recovery rate for the downstream group (Jersey Point).

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location – either Chipps Island or the ocean fishery. Survival results from VAMP and two earlier years with HORB in place). Yoshiyama et al. (1998) noted that "[S]uch heavy predation, if it extends over large portions of the Delta and lower rivers, may call into question current plans to restore striped bass to the high population levels of previous decades, particularly if the numerical restoration goal for striped bass1994, 1997) vs. river flow are in Table 4.4.1.4-1 and Fig. 4.4.1.4-1. Results for 2003 and 2004 were extremely low relative to other years. The salmon used in the 1994 and 1997 evaluations compared here were from Feather River Hatchery, whereas salmon were from Merced River Hatchery in the later years.

Table 4.4.1.4-1 Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point with HORB in place. (Source: SJRGA 2005)

Study Year	Combined Differential Recovery Rate	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019	0.005
2004	0.026	0.010

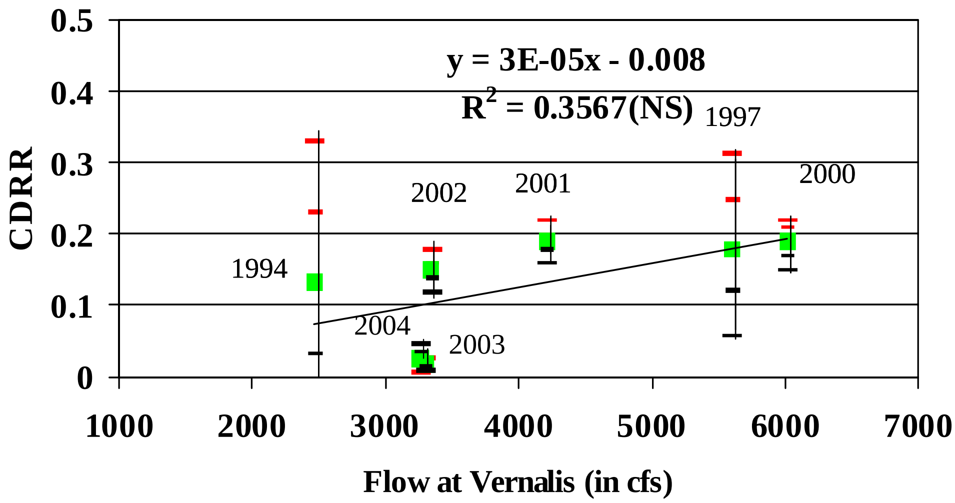


Figure 4.4.1.4-1 Combined Differential Recovery Rate (CDRR) and from Durham Ferry and Mossdale to Jersey Point (1994–2004). Note: Mean CDRR shown in green with ± 1 SE and ± 2 SE confidence intervals indicated. Head of Old River Barrier (HORB) in place versus San Joaquin River flow at Vernalis in cfs for 1994, 1997, 2000-2004. (Source: SJRGA 2005)

An overall result of the evaluations shown in Fig. 4.4.1.4-1 is that CDRR has been low (mean of 13-19%), or extremely low (mean of 2-3% in 2003-04), even with smolt protection measures in place. Assuming that: (1) the juvenile recovery data is indicative of the actual relative survival and that there is no major confounding factor, such as disease, affecting survival, and (2) the hatchery CWT salmon are reasonable surrogates for relative survival of natural smolts during the same period, then it could be expected that adult returns from natural outmigrant smolts for the 2002 and 2003 year classes that migrated during the 2003 and 2004 VAMP periods will be very low.

Additional comparative survival information is available from recovery of CWT salmon in the ocean harvest. A preliminary comparison was made of survival estimates based on ocean recovery data with the juvenile recovery data for Merced Hatchery CWT releases used in the south Delta. There is a lag time of several years for ocean data to become available - it is currently complete through age 4+ fish only for releases prior to 2001. The data compared included the same 2000-2002 release groups in the VAMP "with HORB" evaluations and other south Delta study releases from 1996-1999. The results to date of the ocean data compared with Chipps Island trawl data have a linear correlation R squared value of 0.63 (Fig. 4.4.1.4-2).

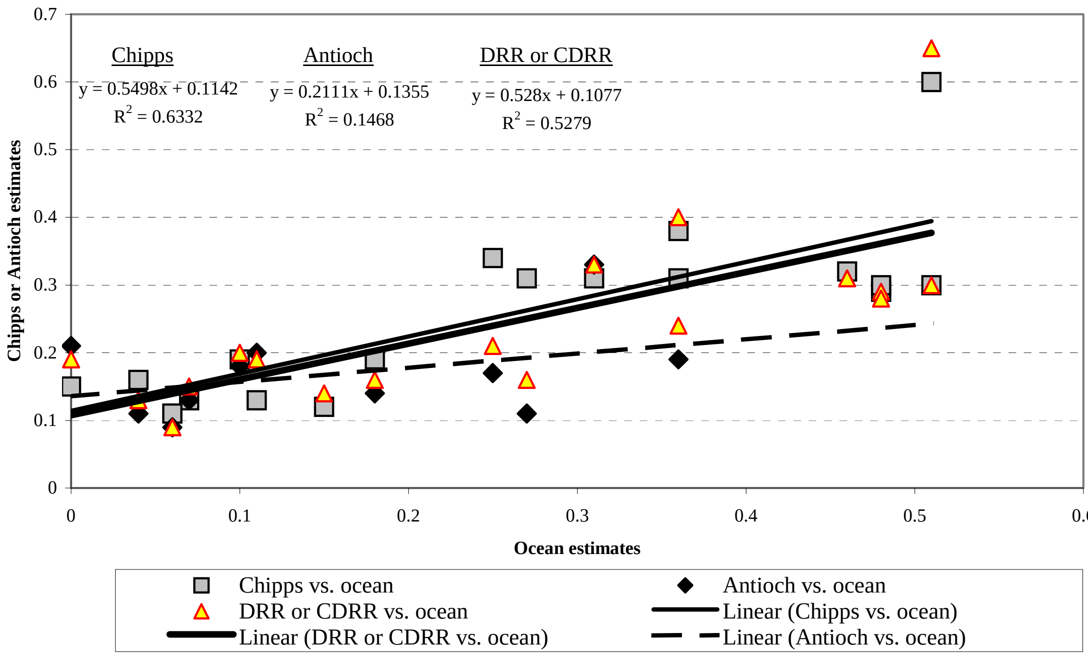


Figure 4.4.1.4-2. Comparison of Antioch and Chipps Island survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates for 1996-2002.

The proportion of San Joaquin River salmon migrating from 15March into June that may benefit from the protective measures during the VAMP period has been reported in the annual VAMP reports. Daily catch data (number per minute index) for unmarked salmon from the Mossdale trawl was used. The catch data is corrected for days not sampled at Mossdale. The VAMP period has spanned from 31% to 76% of the Mossdale catch during the 15March-June period and an additional 8% to 27% have been during the following export reduction shoulder period (Fig. 4.4.1.4-3). One complicating factor is data in some years includes hatchery releases of unmarked smolts from Merced Hatchery, as they cannot be distinguished from natural smolts in the trawl catch. Thus, natural smolts may have constituted a smaller percentage in those years. Also, the analysis did not include Mossdale data prior to mid-March.

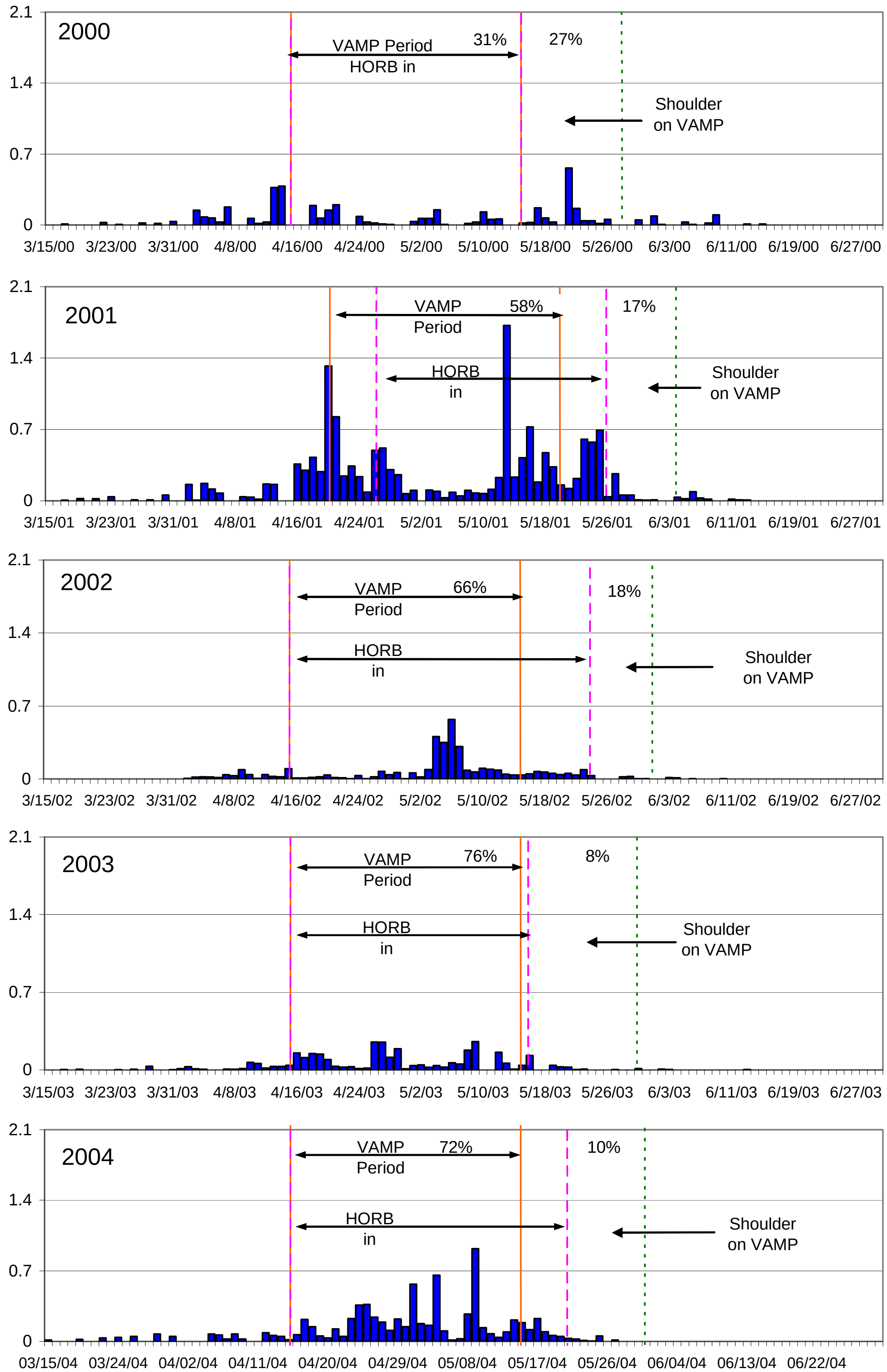


Figure 4.4.1.4-3. Catch per minute of all unmarked juvenile Chinook caught in the Mossdale Kodiak trawl between March 15 and June 30 of 2000 through 2004 (Source: SJRGA 2005)

4.4.2 Water quality issues

The SWRCB and the RWQCB are responsible for ensuring implementation and compliance with the provisions of the federal 1972 Clean Water Act (CWA) and California's Porter-Cologne Water Quality Control Act. Water quality impairments (Table 4.4.2-1) arise from many sources ranging from instream flows to land use to direct contaminant discharge.

Table 4.4.2-1. RWQCB Section 303(d) water quality limited water bodies downstream of La Grange Dam

Water Body	**Pollutant**	**Source**
San Joaquin River (Merced River to South Delta Boundary	Boron	Agriculture
	Chlorpyrifos	Agriculture
	DDT	Agriculture
	Diazinon	Agriculture
	EC	Agriculture
	Group A Pesticides	Agriculture
	Mercury	Resource Extraction
	Unknown Toxicity	Source Unknown
Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River)	Diazinon	Agriculture
	Group A Pesticides	Agriculture
	Unknown Toxicity	Source Unknown
Delta waterways (Western, Eastern and Stockton Ship Channel)	Organic enrichment/Low DO (Stockton Ship Channel only)	Municipal Point Sources; Urban runoff/Storm sewers
	DDT	Agriculture
	Diazinon	Agriculture; Urban runoff/Storm sewers
	EC (Western Delta only)	Agriculture
	Group A Pesticides	Agriculture
	Mercury	Resource Extraction
	Unknown Toxicity	Source Unknown

Source: Central Valley Regional Water Quality Control Board. 2002. Clean Water Act Section 303(d) list of water quality limited segments. Approved by U.S. Environmental Protection Agency in July 2003. http://www.waterboards.ca.gov/tmdl/docs/2002reg5303dlist.pdf

Parameters: EC = electrical conductivity; DDT = dichlorodiphenyltrichloroethane; DO = dissolved oxygen

Group A pesticides = One or more of the Group A pesticides, including: aldrin, dieldrin, chlordane, endrin, heptachlor, epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene.

Water quality in the San Joaquin River and Delta varies greatly in sources of inputs (both natural and anthropogenic) and spatial and temporal patterns (Spies et al. 2000, Davis et al. 2000, Werner et al. 2000). Temporal and spatial distributions of these many water quality components vary greatly intra- and inter-annually, and in many cases the mechanisms that determine these patterns are poorly understood. Nevertheless, there are several important water quality issues that may affect the survival and growth of juvenile salmon in the San Joaquin system and the spawning runs returning to the San Joaquin system. Invertebrate and fish communities are responsive to water quality conditions and the effects are most critically related to physical parameters such as DO, temperature and salinity. A number of studies have demonstrated that fish and invertebrate assemblages structure themselves along water quality gradients (Brown 2000; Hughes and Gammon 1987; Saiki 1984), with subtler effects of pesticide gradients at low levels such as disruption of olfactory cues and hormonal effects on salmonids (Moore and Waring 1996).

4.4.2.1 Nutrients and Dissolved Oxygen

High nutrient loads from agricultural fertilizers in the past decades are associated with eutrophication of the lower San Joaquin River and Delta (Kratzer and Shelton 1998 as cited in Dubrovsky et al. 1998). Nutrient enrichment of the lower San Joaquin River has significantly affected aquatic resources. Diurnal fluctuations in pH and DO concentrations can occur in waters with enhanced plant growth caused by eutrophication. Problems occur in the early morning when algal and plant respiration causes low oxygen levels in the water column, causing mortality of invertebrates and fish, or causing long-term shifts in community structure. Below, we discuss implications for dissolved oxygen and subsequent impacts on salmonids.

Delta export operations are believed to contribute to depleted dissolved oxygen (DO) levels in the San Joaquin River near Stockton in most years. Because of its size and its importance for migratory fish (particularly San Joaquin Basin salmonids), the Stockton Deep Water Ship Channel (DWSC) has been the focus of most DO research in the Delta (Hallock et al. 1970). Since 1968, the California Department of Water Resources has measured low DO levels (< 5mg/L) in the Stockton DWSC during the late summer and early fall, when the San Joaquin River inflows are low. Depressed DO may block upstream migration of salmon (Alabaster 1989, Kjelson et. al. 1981) and cause physiological stress and reduced growth rates of juvenile fish (USeptemberA 1997). As a result of the DO blockage, adult salmon may either stray at a higher rate away from the San Joaquin River tributaries, have higher pre-spawn mortality, or have reduced egg viability.

There are two parts to the Basin Plan DO water quality objectives that apply to the lower San Joaquin River (SJR) for the purpose of protecting fisheries-related beneficial uses:

- 5.0 mg/L at all times on the SJR within the Delta - This objective first appeared for all waters of the Delta in the Interim Water Quality Control Plans for the Sacramento-San Joaquin Delta adopted in 1967 (CVRWQCB, 1967).

- 6.0 mg/L between Turner Cut and Stockton from September 1 through November 30 - This objective was first adopted by the SWRCB in the 1991 Water Quality Control Plan for Salinity, San Francisco Bay / Sacramento-San Joaquin Delta Estuary. The 5.0 mg/L objective applies at all other times and locations not covered by the 6.0 mg/L objective.

The 1967 Interim Basin Plan stated, “migratory salmonids require at least 5.0 mg/L dissolved oxygen, as do the resident game fishes. Striped bass and other fishes also require at least 5.0

mg/L dissolved oxygen to successfully propagate" (CVRWQCB, 1967). This criterion was typically interpreted as being applicable at all times and places except for low flow conditions worse than the lowest seven-day flow with a ten-year return frequency (7Q10). Likewise, a study in the San Joaquin River found that the adult salmon migration run upstream past Stockton did not become steady until DO concentrations were above 5 ppm (mg/L) (Hallock, et al., 1970).

The problem area is within the fourteen river miles of the DWSC from the Port of Stockton to Disappointment Slough, and the critical reach most affected is from the Port of Stockton to Turner Cut (Fig. 4.4.2.1-1). As stated in Section 4.4.1.1, a temporary rock barrier at the head of Old River to increase San Joaquin River flows past Stockton, thus improving DO levels, has been installed during the fall of almost all years since 1969 to facilitate adult migration of San Joaquin system salmon. Although this has been marginally effective in some years, an example of DO levels in September-October of 2003 (Figure 4.4.2.1-2) shows minimum levels below 6 mg/L until mid-September with potential effects on upmigrant salmon.

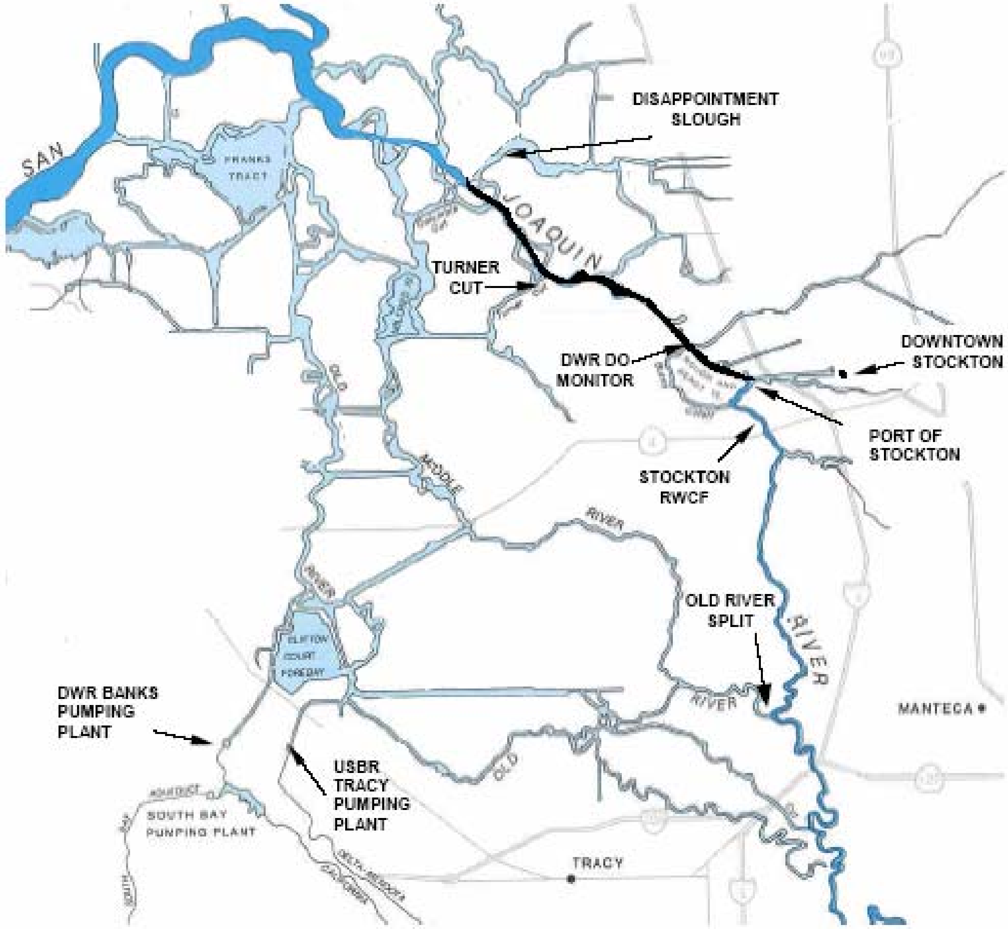


Figure 4.4.2.1-1. Map of the Delta Showing the Critical Reach (14 miles from Port of Stockton to Disappointment Slough) of the Deep Water Ship Channel (from Gowdy and Grober 2003)

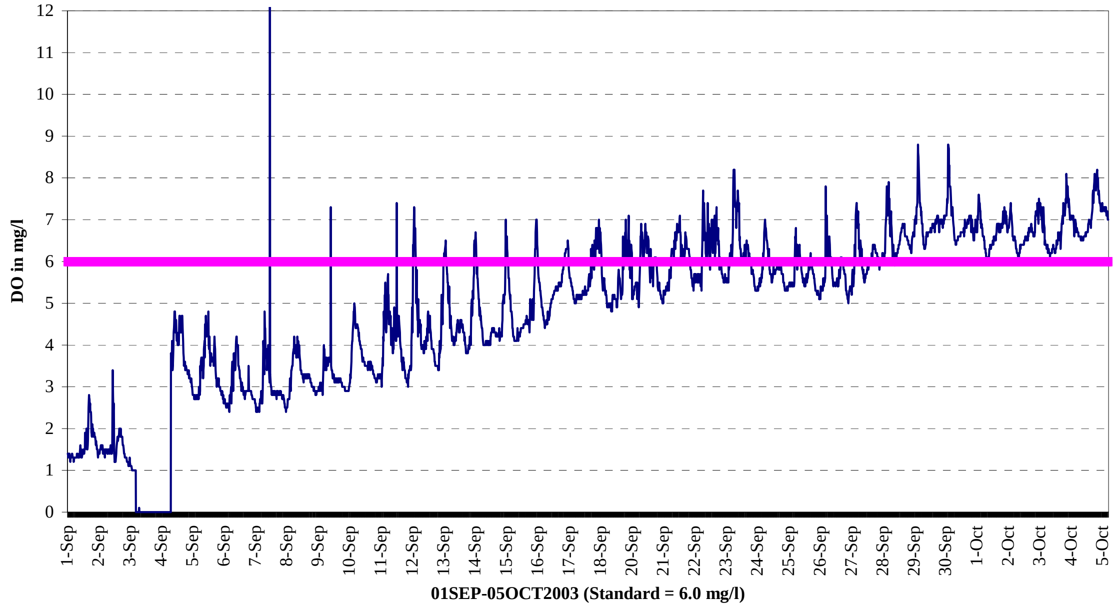


Figure 4.4.2.1-2. Fall 2004 dissolved Oxygen at Rough and Ready Island, Stockton

4.4.2.2 San Joaquin Basin DO TMDL

Recognizing that additional dilution flows are an unacceptable means of water quality protection (CVRWQCB 1995), the State Water Resources Control Board (SWRCB) first adopted a Clean Water Act (CWA) Section 303(d) list in January 1998 that identified this impairment and ranked it as a high priority for correction. Inclusion on this list (See Table 4.4.2-1) initiated the need under the CWA for the CVRWQCB to develop a Total Maximum Daily Load (TMDL) that identifies the factors contributing to the DO impairment and apportions responsibility for correcting the problem. It also initiated the need under the Porter- Cologne Water Quality Control Act to develop a program of implementation for the TMDL consisting of actions that the CVRWQCB will take to implement this TMDL and to bring the impaired reach of the DWSC into compliance with the Basin Plan DO objectives.

In a 2002 Synthesis Report (Lee and Jones-Lee, 2000), the three main contributing factors to the DO impairment identified in these studies are as follows:

1. Loads of oxygen demanding substances from upstream enters the DWSC where they oxidize and exert an oxygen demand.
2. The DWSC geometry reduces the capacity of the DWSC to assimilate loads of oxygen demanding substances by (i) reducing the efficiency of natural re-aeration mechanisms and (ii) magnifying the effect of oxygen demanding reactions.
3. Reduced flow through the DWSC reduces the assimilative capacity by reducing upstream inputs of oxygen to the DWSC and increasing the residence time for oxygen demanding reactions that further impact DO concentrations.

SWRCB Water Right Decision 1641 instructed the CVRWQCB to develop a TMDL for this impairment before they would take further water rights actions to implement the DO water quality objectives. In a January 2005 SWRCB D 1641 workshop on the impact of the CVP and SWP on water quality in the Delta, Dr. Lee concluded that based upon long-term data review, the key issue related to WQO objectives for DO is related to the large amounts of water withdrawn from the Federal CVP and SWP South Delta Pumps through the Head of Old River, thereby limiting fresh water exchanges at the Stockton DWSC.

In addition to the planned permanent barrier at Head of Old River, other TMDL actions are planned to improve dissolved oxygen conditions to meet the Basin Plan Objectives and protect the beneficial use of the water for fish migration. The TMDL is anticipated to be completed according to the following timeframe:

- Complete the RWQCB Phased TMDL and Basin Plan Amendment by February 2005
- Design, construct, and operate a demonstration aeration system, May 2005-December 2006
- Complete monitoring and modeling studies by June 2007
- Evaluate other control projects and mitigation strategies, 2005-2008
- Complete Final TMDL/Basin Plan Amendment for long-term control by 2009

The Districts continue to be active participants in the development and implementation of the San Joaquin River Dissolved Oxygen Program.

4.4.2.3 Pesticides and Herbicides

The CVRWQCB and USGS have conducted intermittent water quality monitoring in the Tuolumne River and Dry Creek – most monitoring in the basin has been focused on the San Joaquin River. Generally, pesticide and herbicide toxicity within the larger area of the San Joaquin River has been attributed to pesticides from agricultural nonpoint sources as summarized by Dubrovsky et al (1998). In the NAWQA studies, available drinking water standards were not exceeded, but the concentrations of several pesticides exceeded the criteria for the protection of aquatic life. Concentrations of organophosphate (OP) pesticides (i.e., Diazinon and Chlorpyrifos) in runoff are high, and highly variable, during winter storms. In late March and April, pesticides applied to alfalfa fields in the San Joaquin Basin and Delta islands enter the water column with spring rains (Kuilvila 2000).

Because of concerns over agricultural land use practices within the Tuolumne River corridor, the Districts included a suite of OP pesticides and chlorinated herbicides in the 2004 spring-time water quality assessment (Report 2004-10, TID/MID 2005). Although the results did not detect any herbicide or pesticide at ug/L levels within waters of the primary spawning reach of Tuolumne River Chinook salmon, a number of concerns regarding downstream conditions outside of the Districts control remain. Although exposure to toxic contaminants in the Delta and estuary (through direct contact and biomagnification of fat soluble compounds) probably does not often result in direct mortality to juvenile salmon, smoltification may render juvenile chinook salmon sensitive to stressors such as high temperature and poor water quality. Findings from the NOAA Fisheries Northwest Science Center strongly indicate that the biological effects of chemical contaminants on outmigrating juvenile fall-run Chinook salmon during their residency in certain urban estuaries can potentially lead to reduced survival (Casillas et al. 1997). Moore and Waring (1996) showed that the OP pesticide diazinon had sublethal effects on the olfactory system of mature male Atlantic salmon parr. Reductions in the ability of mature salmon to detect and respond to odorants and pheromones involved in reproduction may have long-term implications for populations. Chemical stimuli from nesting female salmonids are believed critical for synchronizing the spawning readiness of the male with that of the female (Sorensen 1992, as cited in Moore and Waring 1996). It is possible that OP pesticides may also affect olfactory imprinting during the smolt stage, resulting in increased straying of adult fish to other spawning streams (Moore and Waring 1996).

The Districts support continued efforts to reduce and minimize the effects due to pesticides within the larger San Joaquin River area. A 2002 draft workplan was published to develop a Diazinon and Chlorpyrifos TMDL for the Lower Sacramento River, Lower Feather River, Lower San Joaquin River (includes the San Joaquin River downstream of Mendota Dam to the Airport Way Bridge near Vernalis), and the main channels of the Sacramento – San Joaquin River Delta. On December 31, 2004 manufacturing of products for pre-construction termiticide treatments ended; however, previously manufactured containers of products can be used until the end of 2005. U.S. EPA is currently reviewing whether to allow this use to continue (and new products to be manufactured for this use) beyond 2005. Sales of urban-use products containing diazinon were also ended on December 31, 2004, and U.S. EPA sent out a press release on the issue.

4.4.2.4 Review of the 1995 water quality control plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

The California State Water Resources Control Board (SWRCB) is conducting a periodic review to evaluate new information for consideration of new water quality objectives or changes to the objectives specified in the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. There are a number of major issues that are being addressed that could impact the San Joaquin Basin and the Tuolumne River. The topics being addressed by the SWRCB are:

- Changes in the water quality compliance and baseline monitoring program
- Delta cross channel gates closure
- Salmon protection
- Chloride Objectives, Compliance Location at Contra Costa Canal at Pumping Plant #1, and Potential New Objectives
- Delta Outflow
- Export Limits
- River Flows: Sacramento River at Rio Vista
- River Flows: San Joaquin River at Airport Way Bridge, Vernalis: February–April 14, and May 16–June
- San Joaquin River at Airport Way Bridge, Vernalis:

31-day Pulse Flow April 15–May 15

- Southern Delta Electrical Conductivity
- Other changes to the Program of Implementation

The SWRCB conducted a multi-day public workshop during October and November 2004, and January through March 2005, to address the above listed topics. Extensive comments were presented on each topic. The SWRCB staff is now in the process of preparing plan amendments or a revised plan, including appropriate environmental documentation. The staff will then provide notice of a public hearing on the staff proposed amendments or revised plan. After the hearing the staff will prepare responses to comments on significant environmental points and will then schedule a Board meeting to vote on a resolution recommending adoption of the final plan amendments or revised plan.

4.4.3 Ocean and Inland harvest

Harvest of salmon directly reduces the potential spawning population. The inland commercial Delta gillnet fishery was ended in 1957 as it was considered too efficient. Thereafter the Central California commercial salmon fishery was limited to the ocean troll fishery. That fishery takes mixed stocks so there is no opportunity to target specific fall-run populations as would be with a terminal fishery. The sport fishery for San Joaquin salmon is also largely conducted in the ocean, but some occurs within the Bay-Delta region. The CDFG has considered whether the Tuolumne River salmon population had sufficiently recovered to allow resumption of in-river salmon sport fishing, and, beginning in 2000, through the California Fish and Game Commission, authorized a 1 salmon per day sport catch limit in season within a portion of the Tuolumne River and the San Joaquin River upstream of the Delta. No estimates are available that we are aware of for the inland sport harvest of San Joaquin salmon.

The Pacific Fishery Management Council (PFMC) sets escapement goals only for the Sacramento River fall Chinook salmon, so Central Valley ocean commercial and sport harvest is not managed with regard to the status of San Joaquin system salmon. The initial San Joaquin escapement goal set by the PFMC in 1977 was removed in 1984 specifically because of ongoing impacts to the San Joaquin salmon populations by the CVP and SWP Delta water export operations (Boydstun, 2001).

Ocean harvest and Central Valley escapement (spawning run) data are reported annually by the PFMC (PFMC 2005a,b), based mostly on data provided by CDFG. Estimated commercial and sport landings south of Point Arena on the California coast are considered the ocean harvest most associated with Central Valley salmon for management purposes. The annual fraction that is harvested of the combined total of harvest and "adult" escapement (including both naturally and hatchery spawned) is termed the harvest rate index (HRI). The adult escapement calculated by PFMC includes fall runs (about 90% of all Central Valley salmon) and spring runs of the current calendar year plus late-fall and winter runs of the following calendar year and does not include "jack" numbers. Adult and jack numbers are generally based on 24-inch fork length criteria, which at least in the San Joaquin basin, have been found to often not properly separate the 2-year age class. The Central Valley HRI does not distinguish between races or cohorts and does not include freshwater catch, ocean catch landed north of Point Arena, California, or non-retention mortality (e.g. hook and release mortality of undersized fish); thus harvest-related mortality is greater than reported rates indicate.

The PFMC reports Central Valley ocean catch (combined commercial and sport harvest) has varied from 232,000 to 691,000 Chinook salmon from 1996-2004 (Fig. 4.4.3-1), within the range observed in the preceding 1970-95 period. The estimated Central Valley adult escapement total for 1996-2004 has ranged from 310,000 to 845,000 (including the number spawned in hatcheries), often much higher than in the 1970-95 period (Figure 4.4.3-2).

The Central Valley HRI has been much lower in the last eight years (range of 26-62%) than in the nine-year period from 1987-95 (range of 71-79% (Figure 4.4.3-3). Basin-specific ocean harvest data are not available for this mixed-stock fishery, but the numbers are greatly dominated by the Sacramento system. Very large runs in the Sacramento system, combined with low to moderate harvests, largely contributed to the lower HRI in 2001-2003. San Joaquin basin adult fall runs (including Mokelumne River) are much smaller (averaging 7% of the Central Valley adult fall-run total from 1970-2007) (Figure 4.4.3-4) and have little correlation with Sacramento basin run estimates (Figure 4.4.3-5).

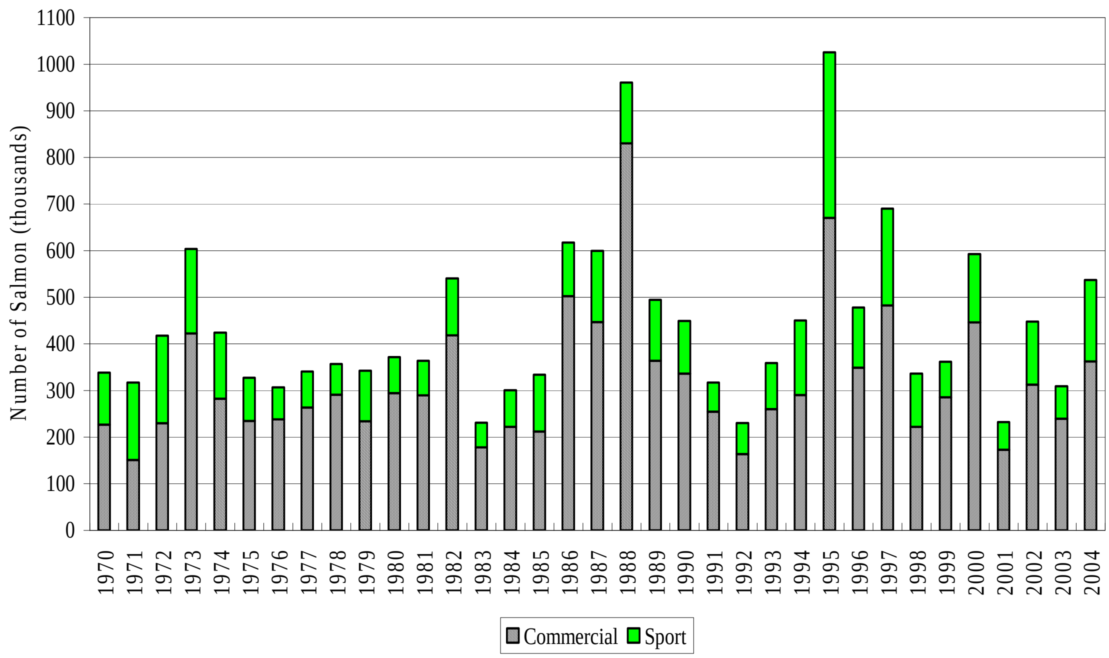


Figure 4.4.3-1 Ocean commercial and sport harvest estimates for Central Valley Chinook salmon

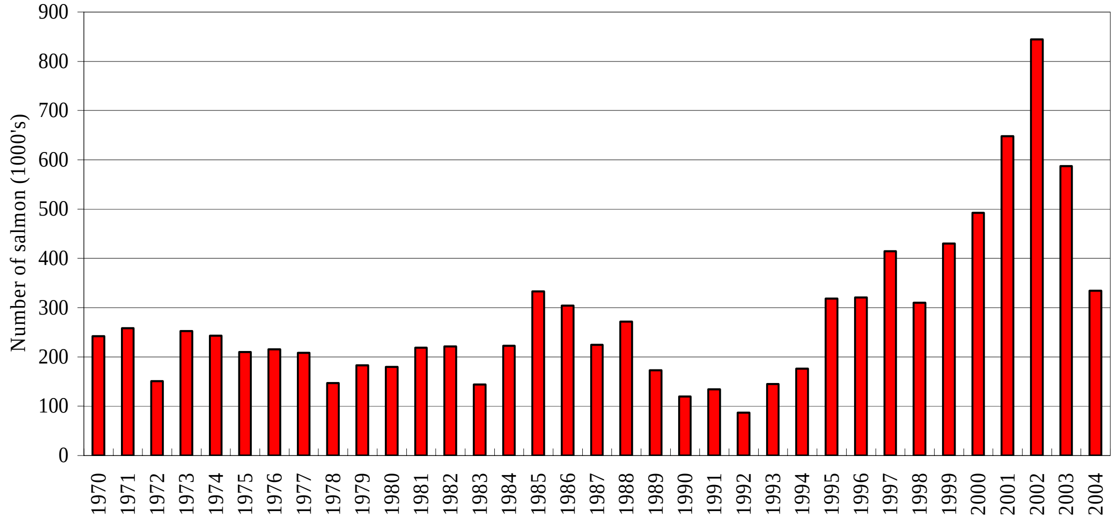


Figure 4.4.3-2 Escapement estimates for Central Valley Chinook salmon (1970–2004)

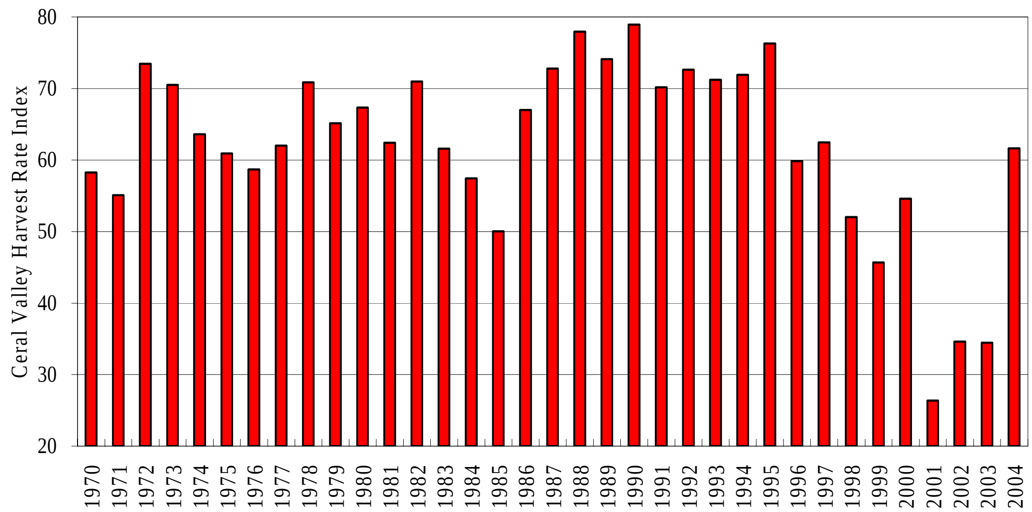


Figure 4.4.3-3 Harvest rate indices for Central Valley Chinook salmon from (1973–2004)

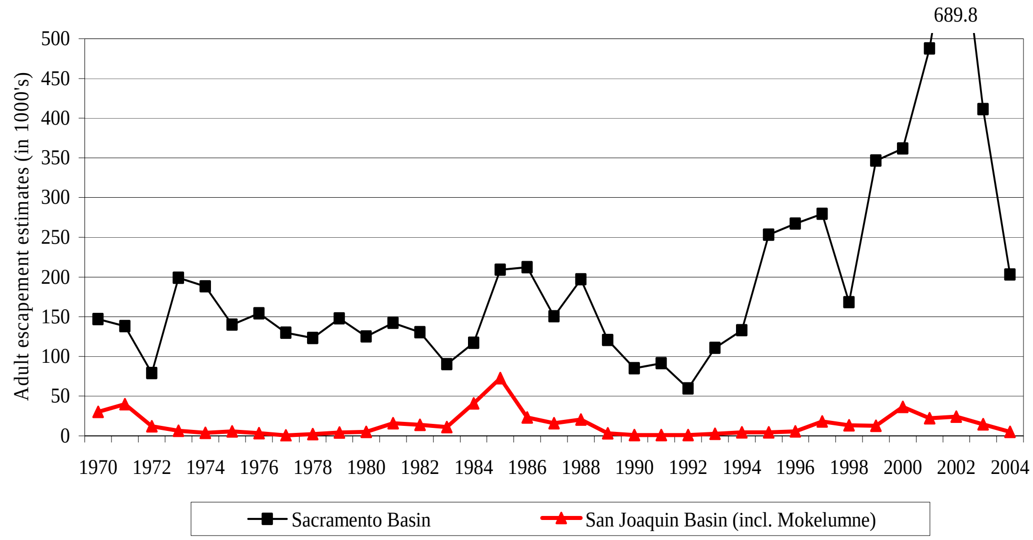


Figure 4.4.3-4 Escapement estimates for Sacramento and San Joaquin basins from (1970–2004)

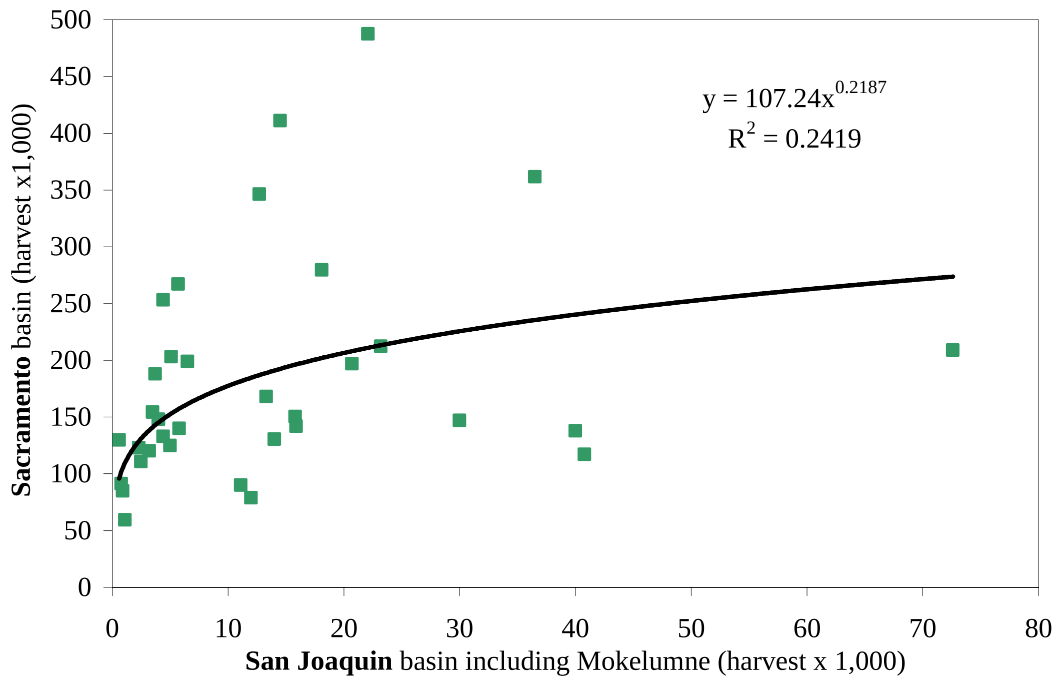


Figure 4.4.3-5 Comparison of escapement in Sacramento and San Joaquin basins (1970–2003)

A long-term negative result of ocean harvest has been to reduce the average size and age of salmon in Central Valley runs. A result of younger and smaller females has been to reduce the potential number of eggs deposited (since fecundity is related to size) and reduce overall population productivity. More immediate effects are when excessive harvest acts to further reduce the spawning population. Sensitivity to harvest rates varies among stocks, as natural spawning populations (rather than hatchery supported) and those incurring higher juvenile losses (such as Tuolumne River and other San Joaquin basin stocks affected by Delta water export-related mortality) cannot sustain high harvest rates.

4.4.4 Land use activities

As stated in Chapter 2, all major San Joaquin Rivers have been subject to significant habitat alteration. Land clearing for gold dredging, aggregate mining, and agricultural and urban development has resulted in the loss of 85% of the Tuolumne River's historical riparian forest. Vegetation that once extended from bluff to bluff prior to the gold rush era is now confined to a narrow band along the active channel margins in many areas, or is nonexistent. Between 1937 and 1993, nearly all of the areas in the gravel-bedded zone that historically supported riparian forests have been mined, grazed, or farmed.

Gold Dredging

During the early twentieth century, the Tuolumne River channel and floodplain were dredged for gold. The gold dredges excavated channel and floodplain deposits to the depth of bedrock (approximately 25 feet) and often realigned the river channel. After recovering the gold, the dredges deposited the remaining tailings back onto the floodplain, creating large, cobble-armored windrows that replaced the deep, rich soils of the valley floor deposits (McBain & Trush 2000)). By the end of the gold mining era, the floodplain adjacent to 12.5 miles of the river (RM 50.5–38) had been converted to tailings deposits. Although many tailings were excavated and removed from the floodplain to provide construction material for New Don Pedro Dam or as part of recent aggregate mining operations, tailings remain in the reach from RM 45.4 to RM 40.3.

Aggregate Mining

Downstream of the La Grange Dam, the Tuolumne River has also been extensively mined for aggregate. Large-scale aggregate mining began in the 1940s and continues today. Historically, aggregate mines extracted sand and gravel directly from the active river channel, creating large, in-channel pits ("Special" Run/Pools or SRPs). The SRPs are as much as 400 feet wide and 35 feet deep and occupy 32% of the length of the channel in the gravel-bedded reach. More recent mining operations have excavated sand and gravel from floodplains and terraces immediately adjacent to the river channel. These floodplain and terrace mine pits are typically separated from the river by narrow berms, which consist of alluvium that is left in place during the pit excavation (see Restoration Plan figure 2-21, p. 41). These unengineered berms have failed even during moderate flows, resulting in direct connection of the pits to the river channel. The January 1997 flood, which peaked at nearly 60,000 cfs, caused extensive damage in the mining reach, breaching nearly every pit berm.

Clearing of Riparian Forest for Agriculture

In the gravel-bedded reach, the historical riparian forest was relatively patchy, generally persisting only in areas with heavy (silty) soils, adequate soil moisture and protection from harsh flooding conditions. Floodplain vegetation between these patches of riparian forest was largely grassland, with occasional valley oaks. Riparian vegetation in the sand-bedded reach historically consisted of a lush, multi layered "gallery forest" of Fremont cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), Oregon ash (*Fraxinus latifolia*), and western sycamore (*Platanus racemosa*) (McBain & Trush 2000). In mature gallery forest stands, many vines (California grape [*Vitus californica*] and poison oak [*Toxicodendron diversiloba*]) connected the canopy tree layer with a dense underbrush of shrubs, grasses and forbs. Prior to 1900, extensive gallery forests probably extended for a half mile or more on either side of the river from RM 10 to the confluence with the San Joaquin River.

Bank Protection

Many miles of river edge have been lined with riprap by agencies or landowners to stabilize banks, further reducing favorable salmon habitat. Field and project levees for flood protection have reduced flood inundation areas that are generally associated with increased productivity. The degree of levees and riprap increases from the tributaries down the San Joaquin River leading into the Delta. Further impacts systemwide are associated with reduction and clearing of floodplain riparian vegetation and conversion to agricultural and urban uses.

Other Land Uses

Urban and agricultural growth continues to push into the riparian corridor along the river. After the 1997 flood, new subdivisions flooded in the Modesto area were found to have been constructed within the FEMA floodplain area designated before the 1997 flood. Other locations have various encroachments into the floodway. Such activities identify a need for better understanding and oversight within the floodway boundaries from FEMA, State Reclamation Board, State Lands Commission, Army Corps of Engineers, and by local planning agencies to reduce impacts of allowing development to occur in the floodway.

4.4.5 Agricultural and riparian diversions

CDFG has developed an inventory of riparian pumps along the Tuolumne River. These pumps are used for irrigation and some may also be used for frost protection for tree crops. In surveys conducted prior to the 1995 FSA, some thirty-six small riparian diversions were located on the lower Tuolumne River (Reynolds et al. 1993). Rearing or migrating salmon may be entrained into unscreened pumps. Although a small diversion fish screen program is under development for the Sacramento River basin, no such program has been implemented within the San Joaquin basin and no direct study of smolt mortality from irrigation entrainment has been implemented on the Tuolumne River.

Many unscreened riparian pumps are along the San Joaquin River and Delta channels and their impacts to juveniles have not been well documented. The CDFG stipulates screening requirements for three classes of diversions (over 250 cfs, under 250 cfs, and those installed after 1971), but CDFG data indicates that perhaps only a tenth of the 2,500 floodgates, siphons and pumps are screened (CDFG database, 2000). There are four large diversions directly from the San Joaquin River between the Merced River and the Delta. The lowermost (Banta-Carbona diversion) has a recently installed $9.8 million screening facility and bypass, but others don’t have operating screening systems. Because the elevation of island land surfaces is below the channel surface elevation, approximately half of the diversions are siphons (with the remainder divided evenly between pumps and floodgates) and most of the return drains require pumping over levees into channels (CDWR 2000) with subsequent direct mortality impacts on entrained juveniles.

4.4.6 Impacts of the 1997 flood

As stated previously, an extraordinary event took place on the Tuolumne River during the 1996-97 water year. During the middle of December 1996, a cold storm dumped heavy snow to relatively low elevations in the Tuolumne River watershed. Three subtropical storms hit Central California between Sunday, December 29, 1996 and Thursday, January 2, 1997, causing the flow into Don Pedro Reservoir to reach a peak hourly inflow of at 121,000 cubic feet per second (cfs) or a peak daily inflow of 89,200 cfs on January 2. The peak flow at Modesto was 55,800 cfs on January 4, through a river channel with an USACE-designated maximum flow of 9,000 cfs. This was over 16 feet above flood stage at Modesto. The outflow from Don Pedro and other San Joaquin Basin flood control projects caused record flood stages on both the Tuolumne River and the San Joaquin River during the first half of January 1997.

This flood event caused substantial damage to the salmon spawning habitat on the Tuolumne River by washing desirable gravel away from several spawning riffles and by depositing unwanted sediment in other riffles. Although prior concerns regarding redd scour on subsequent returns from the 1996 run appear to have been ameliorated (i.e., escapements of 9,000 and 16,420 in 1999 and 2000, respectively), the Districts' consultants have estimated that the 1997 flood may have decreased spawnable habitat in the lower Tuolumne River to approximately 80% of the spawnable areas mapped in 1988.

4.5 Achievement of the 1995 FSA Goals

As stated in Ordering paragraph (G) of the 1996 FERC Order, achievement of the 1995 FSA goals requires the evaluation of trends established over several years. The Districts have achieved some success in meeting both the programmatic and comparative goals of the 1995 FSA with only limited time to assess long-term trends resulting from actions taken since the 1996 FERC Order. Although monitoring and studies conducted to date suggests improved conditions for Tuolumne River Chinook salmon, participants in the development of the FSA recognized that the Tuolumne River salmon population responded not only to activities within the basin, but also to factors downstream in the San Joaquin River, Delta, and ocean.

Delta export remains the single largest stressor on Tuolumne River Chinook salmon outside of the Districts control, with both direct effects due to entrainment in the State and Federal pumps and predation in the State's Clifton Court Forebay, and indirect effects related to poor water quality (i.e., DO impairment) for migrating salmon. Delta export rates have grown in recent decades and are usually over 6,000 cfs almost year-round, often exceeding 10,000 cfs and only occasionally falling below the combined outflow of the entire San Joaquin basin tributaries. Smolt survival estimates through the Delta ranged from about 2% to 19% from 2000 to 2004 during the April-May period of additional salmon protective measures such as increased tributary outflows (i.e., Pulse flows, VAMP) and the temporary Head of Old River Barrier intended to reduce entrainment. A permanent operable fish control structure at the head of Old River, once complete and operating, may offer substantial protection to Tuolumne River Salmon fry, juvenile, and smolts from direct entrainment at Delta export facilities.

The Tuolumne River fish management program has implemented the flow and non-flow measures identified in the 1995 FSA with corresponding improvements in physical and biological community indicators. As provided under the adaptive management strategy for the recovery of the Tuolumne River Chinook salmon population under Section 8 of the 1995 FSA, if the initial measures implemented have led to acceptable population increases, then additional measures of "some risk" could be implemented to improve success of the program. Given that most of the stressors on the Tuolumne River Chinook salmon population are the results of factors outside of the Districts' control, Chapter 5 provides recommendations for consideration of additional non-flow measures and continuation of the Tuolumne River Fish Management program through relicensing.

5 CONTINUATION OF THE TUOLUMNE RIVER FISH MANAGEMENT PROGRAM THROUGH RELICENSING

5.1 Continue Monitoring

The Districts propose that fall spawning surveys (in cooperation with CDFG) and water temperature monitoring continue on an ongoing basis through FERC relicensing of the Don Pedro Project. In addition, the Districts support continuation of several other riverwide-monitoring elements (seine surveys, snorkel surveys, spring RST sampling, invertebrate sampling) if adequate funding sources are available.

The CBDA had provided grant funding to the Tri-Dam Project (FERC Project No. 2005 and 2067) for a water temperature model of the lower Stanislaus River and a short reach of the San Joaquin River down to Vernalis. CBDA has recently provided additional grant funding to the Tri-Dam Project to expand the model, including data collection, to include the lower Tuolumne and Merced Rivers and the San Joaquin River up to Stevinson (above the Merced River); work under this new grant will begin in 2005. The Districts will review the extent of continued thermograph monitoring as a result of this water temperature model expansion to the lower Tuolumne.

TID, with input from TRTAC participants, submitted a proposal to the CBDA Ecosystem Restoration Program in November 2004 to fund three years of several long-term river-wide monitoring elements. These included fall spawning surveys, biweekly seine sampling from January through May, spring RST operations, temperature monitoring, June snorkel surveys, and summer invertebrate sampling. All but the last item have been part of the FSA program.

The Districts do not support any future large CWT smolt survival evaluations in the Tuolumne River. The TRTAC has conducted a peer review and reached agreement in 1999 to terminate this controversial program by 2001 - an additional study year was added in 2002 due to the determination that the 1997 study was invalid. An extensive data review has now been completed. This "monitoring", unlike other monitoring elements, has several concerns that were identified in Sections 3.5.2.1, 3.5.2.5, and 4.1.2, including:

1. substantial population level effects that have not been minimized,
2. reduced ability to track natural production,
3. reduced genetic distinction of the Tuolumne population, inconsistent with the second programmatic goal under FSA Section 8,
4. genetic impacts and potential natural productivity effects, and
5. questionable assumptions that affect the utility and value of the results.

Existing large CWT releases in the Merced River and the Delta continue to result in substantial returns of Merced Hatchery fish to the Tuolumne River; additional Tuolumne CWT evaluations would further exacerbate that situation.

5.2 Continue TRTAC and Reporting

The Districts propose continuation of the current TRTAC process through relicensing to facilitate ongoing analysis, review, and dissemination of monitoring, projects, and flow operations. The Districts also support retaining the practice of providing annual reports to FERC. The reports may include river-wide, project-specific, and other monitoring, such as any supplemental efforts related to trout, aquatic invertebrates, or other investigations, results of complementary studies in the basin and delta, and continued review of other factors, such as harvest, that affect the status of the salmon population.

5.3 Continue existing instream flow schedules

Overall, the Article 37 flow regime established with the 1995 FSA and the 1996 FERC Order has provided improved habitat conditions for both Chinook salmon and rainbow trout. It has also been demonstrated that conditions are improved for aquatic insects, important food resources for both species. For salmon, it appears that the most imperative issue is that of Delta impacts to survival, but that must be solved by entities other than the Districts or FERC.

The 1995 FSA flow regime has resulted in significantly higher annual volumes under various hydrologic conditions than with the initial 1964 license requirements. Even the recent dry years of 2001–2004 have had required annual FERC flows of about 129,000 AF to 196,000 AF (exclusive of the any additional VAMP spring pulse flows). This is in contrast to the previous maximum annual FERC volume of 123,000 AF, whereas the current maximum annual FERC volume is 301,000 AF.

It is the Districts' recommendation that the current FERC Article 37 flow requirements be maintained. It is also recommended that flexibility in setting and adjusting flow schedules with CDFG and USFWS be maintained. This is particularly important when (1) basin-wide coordination is being done to implement spring pulse flows and schedules must be tailored to meet updates in forecasts and actual flows at Vernalis and (2) in drier years when overall fish flow volume adjustments, and corresponding flow schedule changes, must be made to reflect changing hydrologic conditions. The experiences gathered in recent years in both cases demonstrate the value of the current Article 37 provisions.

5.4 Continue control of river fluctuations

River flow changes under natural conditions are very dynamic and fish losses associated with those flow declines can be significant at times. The managed flows released by the Districts tend to not have the same widely ranging characteristics, so that potential fish losses, especially in the winter, are much reduced. There has been no major problem identified with fish losses resulting from the Districts operations in the post-FSA period. The primary flow changes are associated with flood management flow releases due to ACOE flood storage criteria, scheduled pulse flows, and changes in flows under the then applicable fish flow schedule. When feasible, these flow changes are phased over two or more days, thereby limiting the potential fish losses. The minimal documented losses since the 1995 FSA have been incidental in nature as losses can never be entirely avoided given that flows must be reduced at times. Therefore, the existing ramp-down requirements have provided adequate protections and should be maintained.

5.5 Continue implementation of habitat restoration projects

Two of the 10 habitat restoration projects selected by the TRTAC have been constructed, including revegetation and maintenance for two years after planting. These major projects are SRP 9 and the 7/11 Segment of the Mining Reach. Of the other eight projects, seven are either fully or partially funded and work is proceeding on all of those. The majority of the large-scale restoration construction and gravel addition work is anticipated to be completed during the next several years as necessary approvals are obtained and other preliminary work is completed and so long as outside funding continues to be available.

TID, with input from TRTAC participants, submitted a proposal to the CBDA ERP in November 2004 to continue and expand monitoring for several restoration projects (including SRP 9 and the 7/11 Reach), as well as long-term river-wide monitoring. The proposal seeks to support adaptive management of the lower Tuolumne River Restoration Program and of these restoration projects by: (1) extending existing site-specific project monitoring for constructed projects and projects near construction; (2) augmenting existing monitoring to include additional metrics; and (3) continuing funding for long-term river-wide monitoring that previously was supported by other sources.

As part of the implementation of the 2001 Fine Sediment Management Plan as one of the ten TRTAC priority, several activities are planned to improve the overall quality of spawning gravels for Tuolumne River salmonids. These include a sedimentation pond on Gasburg Creek, addition of clean gravels, and gravel cleaning. Prior spawning gravel quality analyses on the Tuolumne River predicted survival to emergence on the order of 30 percent (TID/MID 1992, Appendix 14) using the Tappel-Bjornn Index (Tappel and Bjornn 1983) On the basis of data collected in the 1993 Tuolumne River gravel cleaning experiments, analyses conducted under the Coarse Sediment Management Plan (McBain & Trush 2004) estimated it is possible to increase the life stage specific survival for egg and alevins within the population models by an estimated 12% through gravel cleaning. Extending population model results performed to evaluate population benefits of completing planned gravel augmentation projects (Section 4.1.3.5), a comprehensive gravel cleaning program could potentially produce escapement level increases of 30–40% over that obtained by gravel augmentation alone.

The feasibility of gravel cleaning as a long-term management tool for enhanced salmonid production relates to costs, available funding, limitations on streambed disturbance, and the rate of re-introduction of new fines from upstream and the mobilization of relict floodplain deposits. Questions that remain about gravel cleaning as an effective tool to manage fine sediment accumulation in the Tuolumne River include methods to be employed on a large scale in the spawning reach and how long the benefits of cleaned gravel will last. The Fine Sediment Management Plan will address both those questions, and implementation and monitoring of gravel cleaning work in summer 2005 is anticipated. Following an initial gravel cleaning program, a fine sediment source control program coupled with coarse sediment augmentation may be the most cost effective sediment management tool for development and maintenance of high spawning gravel quality in the Tuolumne River.

5.6 Additional measures to be implemented under FSA Sections 8 and 9

As provided under the adaptive management strategy for the recovery of the Tuolumne River Chinook salmon population under FSA Section 8, if the initial measures implemented have led to acceptable population increases, then additional measures of "some risk" could be implemented to improve the success of the program. The third Section 9 Comparative Goal states that, "[b]arring events outside the control of the participants to the settlement, by 2005 the salmon population should be at levels where there is some resiliency so that some of the management measures described herein may be tested, on an experimental basis." As discussed in Chapter 4 of this report, the Districts believe that escapement levels are within an acceptable range and resiliency of the Tuolumne River Chinook salmon population has been shown; therefore, consideration should now be given to implementing certain measures discussed during the negotiation of the 1995 FSA, including the use of temporary spawning barriers and enhancing turbidity during smolt outmigration (Section 12e pf the 1995 FSA).

5.6.1 Increase salmon spawning habitat utilization through temporary spawning barriers

Analysis of the number and distribution of spawners returning each year to the Tuolumne River and the environmental conditions occurring during spawning, rearing, and emigration of the juveniles indicates that an overabundance of spawners actually decreases the numbers of recruits produced (TID/MID 1992, Appendix 2). Redd superimposition is one factor that can cause a decline in recruitment with increased numbers of spawners. The Districts conducted a study of redd superimposition and its effects on the salmon population in the Tuolumne River in 1992 (TID/MID 1992 Appendix. 6). The study suggested that redd superimposition had the potential to increase egg mortality if later-constructed redds excavated the eggs pockets of previously constructed redds. Redd superimposition may also result in a net reduction of successfully emigrating smolts, because the new eggs hatch later and the smolts may migrate later in the spring when outmigration conditions have deteriorated. The potential for redd superimposition and associated egg mortality is most acute during years of high escapements when there is increased competition for spawning habitat.

The loss of spawning gravels caused by the 1997 flood has increased the potential for redd superimposition and associated egg mortality by increasing competition for decreased spawning areas. Based upon analysis of historical spawner survey data (Section 3.5.2.1), Figure 5.6-1 shows that adult Chinook salmon spawn preferentially in the most upstream spawning areas (Reaches A, 1A), often bypassing spawning areas with suitable spawning gravels, water temperatures, and water depths and velocities. Even during years of low escapements, adult salmon spawn in the lower sections of the spawning reach (reaches 2 and

3), though not in the densities that occur in the upstream spawning reaches. Annual spawning in these lower reaches reinforces the assessment that the spawning habitat is suitable. For these reasons the Districts continue to recommend an experiment using temporary barriers to distribute spawning more widely through the spawning reach, thereby aiming to reduce redd superimposition.

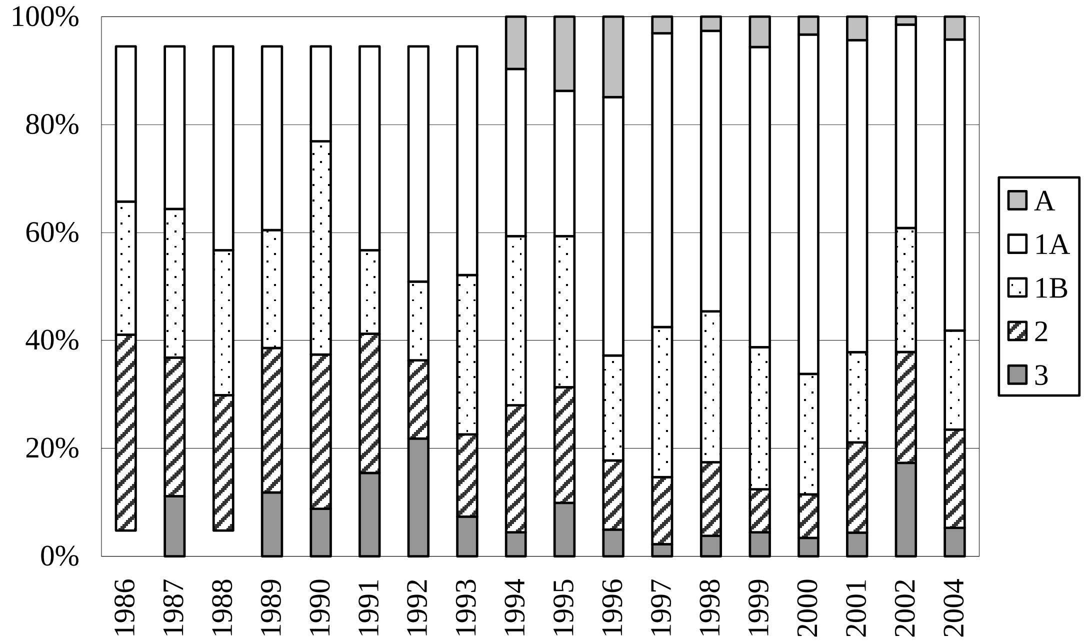


Figure 5.6.1-1. Redd distribution by spawning reach as a percentage of available riffle areas.

The Districts plan to implement several projects to increase spawning habitat in the Tuolumne River by adding spawning-sized gravels throughout the spawning reach and reconstructing channels in the Mining Reach. In order to maximize the benefits of these planned restoration measures, temporary spawning barriers (weirs or fences) would be installed in the river once upstream spawning areas near saturation, thereby inducing later-arriving adult migrants to spawn in downstream reaches with suitable habitat.

The temporary barriers would be installed when real-time monitoring of redd construction in spawning reaches A and 1A indicated that approximately 80% of the usable spawning area in this upstream reach had been utilized. The Districts funded the development of a redd superimposition model (TID/MID 1997, Report 96-6), which suggests that 80% utilization of spawning area in reaches and 1A would result in 31% egg loss due to superimposition in these reaches. Once the barriers were installed, fish behavior in response to the barrier would be monitored to determine the benefits of the barrier, including redd surveys downstream of the barrier to determine the success of the barrier in distributing spawning.

The spawning barrier evaluation would be conducted in years when escapements were high and the likelihood of redd superimposition would be increased in the upstream reaches as more adults compete for the available spawning habitat. It is worth noting that the use of spawning barriers could also provide benefits during periods of low escapements by reducing redd superimposition in upper spawning reaches, thereby optimizing the number of eggs produced per spawner, which may help the population to recover more quickly from low escapement periods.

5.6.2 Additional Measures to Reduce Predation of Smolts in Tuolumne River

Predation of juvenile salmon by introduced bass has been identified to be a primary factor limiting survival in the lower Tuolumne River (TID/MID 1992 Appendices 22 and 23). Predation on juvenile salmonids is particularly intense during their outmigration to the ocean as fry, juveniles, or smolts, due to their increased concentration/density (Foerster and Ricker 1941, Neave 1953, Hunter 1959, Rogers et al. 1972, Peterman 1976, Meacham and Clark 1979, Ruggerone and Rogers 1992).

Predation studies in the Tuolumne River identified 12 fish species that could potentially prey on fry and juvenile Chinook salmon, but largemouth and smallmouth bass were found to be the primary predators (TID/MID 1992, Appendices 22 and 23). Introduced predators are concentrated in the SRPs. Consequently, the Districts have completed the SRP 9 project, and are in the design phase of the SRP 10 project, to attempt to eliminate the lentic habitats that seem to confer a competitive advantage to non-native predators of juvenile salmon. The complexity and expense of the SRP projects, and the huge scope of this highly detrimental habitat resulting from aggregate mining operations, underscore the need to explore complementary alternatives to further reduce predation rates on juvenile salmon. It is also important to explore strategies that reduce predation in different types of habitats, not just the lentic habitats in the SRPs, because different non-native bass species (e.g., smallmouth bass) can thrive in lotic habitats more typical of restored river channels.

Potential measures identified to directly reduce bass abundance include electrofishing or angler harvest, possibly through bass tournaments, with captured fish relocated to nearby reservoirs. Measures to indirectly reduce predator abundance include filling in Special Run-Pools (SRPs) and connecting warm backwater habitats, thus reducing the extent of bass habitat and bass sources. Measures to reduce feeding rates include increasing turbidity during outmigration pulses to provide cover for juvenile salmonid emigrants.

5.6.2.1 Turbidity enhancement during outmigration pulse flows

Bass are visual predators and turbidity provides a form of cover for juvenile salmon migrating in the river (TID/MID 1992, Appendix 23). In 1992, the Districts conducted a laboratory study to test the effects of turbidity on bass predation efficiency (Ligon et. al, in preparation). The laboratory study indicated that increasing turbidity reduces the predation efficiency of non-native bass species found in the Tuolumne River—at 100 NTUs, predation efficiency was decreased by 95%. Historically, juvenile salmon would have been migrating though the Tuolumne River during periods of increased turbidity associated with higher winter and spring flows. Because the reservoir efficiently traps fine sediments, winter and spring flow releases usually lack fine sediment, such that turbidity has been greatly reduced. The lower Tuolumne has relatively few tributaries above Dry Creek and turbidity from these watersheds is dependent on intensity, duration, frequency, and magnitude of storm events.

The Districts support employing methods of increasing turbidity during winter and spring periods as a way of providing cover and migration stimuli for fry and juvenile salmon. Turbidity could be increased by cleaning upstream spawning riffles to expose subsurface fine sediments to fluvial transport (simultaneously improving spawning habitat quality) or by the controlled addition of suspended sediment to the river. Monitoring effects of increased turbidity could be considered.

5.6.2.2 Predator removal

The Districts continue to support evaluation of direct removal of introduced predatory species as a strategy for reducing predator abundance and reducing predation losses. Electrofishing done as part of project-related monitoring has been demonstrated as a successful method. Also, the use of bass tournaments or other angling on the Tuolumne River could be employed. The tournament approach could reward anglers who catch the most fish over a minimum size necessary for piscivory, rather than emphasizing the collection of the largest bass. The catch obtained through any of these methods could be released alive in Turlock, Modesto, Don Pedro Reservoirs, or other nearby impoundments to provide anglers with future recreational opportunities, depending on an approved program plan with CDFG.

5.6.2.3 Spatial Separation of Predators and Prey

Water temperatures and velocities can influence the behavior of non-native predator species such as largemouth bass and smallmouth bass. The Districts are implementing a pilot study, supported by additional funding by CBDA as part of the SRP 9 Project (Section 3.3.2.1) in the spring of 2005 to better examine if the colder water temperatures and higher velocities associated with spring pulse flows reduce predation rates on juvenile salmon, presumably by spatially separating predator species from the juvenile salmon. The hypothesis is that bass seek warmer water environments near channel margins during the spring pulse flows. Because salmon smolts generally use more central portions of the channel, the spring pulse flows may help to spatially separate predators and salmon smolts, thereby reducing juvenile salmon exposure to predation. Developing a better understanding of predator response to pulses in the spring may contribute to the timing and the design of pulse flows that are more effective in segregating predators from salmon smolts spatially. This pilot study will focus primarily on the reconstructed channel at the SRP 9 site, as well as the riffle controls sites and the SRP 10 control site.

5.7 Work Others Must Accomplish Outside the Control of the Districts

The Districts have implemented the fish management program and executed the requirements of the 1995 FSA and the 1996 FERC Order. It is clear there is considerable risk to Tuolumne River salmon once they move beyond the Tuolumne. The efforts described in this report show that major efforts are being made to improve conditions for San Joaquin Basin salmon, including those from the Tuolumne. Many of those actions are being taken to improve adverse conditions that are beyond the control of the Districts. Until the proposed actions are implemented, Tuolumne River salmon, as well as all San Joaquin Basin salmon, will be at risk when trying to get to and from the San Joaquin River tributaries, through the Sacramento-San Joaquin Delta Estuary.

6 REFERENCES

Alabaster, J. S. 1989. The dissolved oxygen and temperature requirements of king salmon Oncorhynchus tshawytscha in the San Joaquin Delta, California. Journal of Fish Biology 34: 331-332.

APHA, Ed. 1998. Standard Methods for the Examination of Water and Wastewater. 19th Edition. Washington, DC, American Public Health Association.

Baker, P. F., and J. E. Morhardt. 2001. Survival of Chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. Pages 163-182 in Contributions to the biology of Central Valley salmonids. Fish Bulletin 179: Volume 2, R. L. Brown, editor. California Department of Fish and Game, Sacramento.

Banks, M. A., B. A. Baldwin and D. Hedgcock. "Research on chinook salmon (*Oncorhyncus tshawytscha*) stock structure using microsatellite DNA. Bulletin of hte National Research Institute of Aquaculture, Supplement 2: 5-9.

Bell, M. C., editor. 1986. Fisheries handbook of engineering requirements and biological criteria. Report No. NTIS AD/A167-877. Fish Passage Development and Evaluation Program, U. S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Berkman, H. E., and C. F. Rabeni. 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18: 285-294.

Blakeman, D. 2004. 2003 Tuolomne River Chinook Salmon Spawning Escapement Survey preliminary data. Califorina Department of Fish and Game, Fresno, California.

Boydstun, L.B. 2001. Ocean salmon fishery management. Pages 183-196 in R.L. Brown, editor. Contributions to the Biology of Central Valley Salmonids: Fish Bulletin 179, Vol. 2. State of California, The Resources Agency, Department of Fish and Game, Sacramento, CA.

Brown, R. J. 1982. Screening agricultural diversions in the Sacramento-San Joaquin Delta. Unattributed report, printed by DWR. 42 pp.

Brown, L. R. 2000 Fish communities and their associations with environmental variables, lower San Joaquin River drainage, California. Environmental Biology of Fishes 57: 251-269.

CALFED. 1997. Ecosystem restoration program plan. Volumes I and II: Ecological zone visions. Review draft report. CALFED Bay-Delta Program, Sacramento, California.

CDFG (California Dept. of Fish and Game). 1987. Estimates of Fish Entrainment Losses Associated with the State Water Project and Federal Central Valley Project Facilities in the South Delta. The Resources Agency, Department of Fish and Game Bay-Delta Project. July 1987.

CDWR (California Department of Water Resources). 1986. Agreement between the Department of Water Resources and the Department of Fish and Game to offset direct fish losses in relation to the Harvey O. Banks Delta Pumping Plant. Report DWR-560. CDWR, Sacramento.

CDWR. 2000. Tuolumne River La Grange Gravel Addition Project: A summary of Monitoring Data (Preliminary Report). Prepared by the California Department of Water Resources, Fresno, CA.

Casillas, E., B. B. McCain, M. R. Arkoosh, J. E. Stein, U. Varanasi. 1997. Estuarine pollution and juvenile salmon health: Potential impact on survival. Pages 169-178 in Estuarine and Ocean Survival of Northeastern Pacific Salmon: Proceedings of the workshop, Newport, OR.

A. Emmett, R. L. , M. H. Schiewe. (Eds.). 1997. Estuarine and ocean survival of Northeastern Pacific salmon: Proceedings of the workshop. NOAA Technical Memorandum NMFS-NWFSC-29.

Cederholm, C. J., L. M. Reid, and E. O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. Pages 38-74 in Salmon-spawning gravel: A renewable resource in the Pacific Northwest? Report No. 39. State of Washington Water Research Center, Washington State University, Pullman, and the University of Washington, Seattle.

Chutter, F. M. 1969. The effects of silt and sand on the invertebrate fauna of streams and rivers. Hydrobiologia 34: 57-76.

Coble, D. W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of the American Fisheries Society 90:469-474.

Cook, L. and L. D. Buffaloe. 1998. Delta agricultural diversion evaluation summary Report, 1993-1995, Interagency Ecological Program for the San Francisco Bay/Delta Estuary Technical Report 61. 80 pp.

Cooper, A. C. 1965. The effect of transported stream sediments on the survival of sockeye and pink salmon eggs and alevin. Bulletin 18 of the International Pacific Salmon Fisheries Commission, New Westminster, British Columbia, Canada.

L. E. Davis, Congleton, J. L., W. J. LaVoie, and C. B. Schreck, 2000. Stress indices in migrating juvenile chinook salmon and steelhead of wild and hatchery origin before and after barge transportation. Transactions of the American Fisheries Society 129: 946-961.

Delta Fish Facilities Technical Coordinating Committee. 1980. Predation management for the Peripheral Canal Fish Facilities. Working Justification Paper 5. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary (California Department of Water

Resources, California Department of Fish and Game, U. S. Bureau of Reclamation, and U. S. Fish and Wildlife Service).

Demko, D. B., C. Gemperle, S. P. Cramer, and A. Phillips. 1998. Evaluation of juvenile chinook behavior, migration rate and location of mortality in the Stanislaus River through the use of radio tracking. Prepared by S. P. Cramer & Associates, Inc., Gresham, Oregon for Tri-Dam Project of the South San Joaquin and Oakdale Irrigation Districts.

DWR 1994. Bulletin 160-93, The California Water Plan Update, October 1994

Dubrovsky, N. M., C. R. Kratzer, L. R. Brown, J. M. Gronberg, and K. R. Burow. 1998. Water quality in the San Joaquin-Tulare basins, California, 1992-95. USGS Circular. 1159. U. S. Geological Survey, Denver, Colorado.

Foerster, R. E., and W. E. Ricker. 1941. The effect of reduction of predaceous fish on survival of young sockeye salmon at Cultus Lake. Journal of the Fisheries Research Board of Canada 5: 315-336.

Fuller 2005? - Fuller, I. C., A. R. G. Large, M. E. Charlton, G. L. Heritage, and D. J. Milan. 2003. *N/A Reach-scale sediment transfers: an evaluation of two morphological budgeting approaches. Earth Surface Processes and Landforms 28: 889-904.

Gangmark, H. A., and R. G. Bakkala. 1960. A comparative study of unstable and stable (artificial channel) spawning streams for incubating king salmon at Mill Creek. California Fish and Game 46:151-164.

Gingras, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate pre-screening loss to juvenile fishes: 1976-1993. Technical Report 55. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, California.

Gingras, M., and M. McGee. 1997. A telemetry study of striped bass emigration from Clifton Court Forebay: implications for predator enumeration and control. Technical Report 54. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, California.

Hallock, R. J., R. F. Elwell, and D. H. Fry, Jr. 1970. Migrations of adult king salmon, Oncorhynchus tshawytscha in the San Joaquin River delta as demonstrated by the use of sonic tags. Fish Bulletin. 151. California Department of Fish and Game.

Henley, W. F., M. A. Patterson, R. J. Neves, and A. D. Lemly. 2000. Effects of sedimentation and turbidity on lotic food webs: A concise review for natural resource managers. Reviews-in-Fisheries-Science 8:125-139.

Hanson, C. 2000. CALFED salmonid white paper. Preliminary Draft. Prepared for CALFED by Hanson Environmental, Inc., Walnut Creek, California.

Hausle, D. A., and D. W. Coble. 1976. Influence of sand in redds on survival and emergence of brook trout (Salvelinus fontinalis). Transactions of the American Fisheries Society 105: 57-63.

Hemphill, N., and S. D. Cooper. 1983. The effect of physical disturbance on the relative abundances of two filter-feeding insects in a small stream. Oecologia 58: 378-382.

Heyne, T., and W. Loudermilk. 1998. Rotary-screw trap capture of chinook salmon smolts with survival and production indices for the Tuolumne River in 1997. California Department of Fish and Game, Inland Fisheries Division, Region 4, Fresno.

Hughes, R. M., and J. R. Gammon. 1987. Longitudinal changes in fish assemblages and water quality in the Willamette River, Oregon. Transactions of the American Fisheries Society 116: 196-209.

Hunter, J. G. 1959. Survival and production of pink and chum salmon in a coastal stream. Journal of the Fisheries Research Board of Canada 16: 835-886.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. "Influences of freshwater inflow on chinook salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin Estuary." Proceedings of the nationalsymposium on freshwater inflow to estuaries. R. D. Cross and D. L. Williams, (eds.). FWS/OBS-81/04.U. S. Fish and Wildlife Service, Washington, D. C. 88-108 pp.

Koski, K. V. 1966. The survival of coho salmon (Oncorhynchus kisutch) from egg deposition to emergence in three Oregon coastal streams. Master's thesis. Department of Oregon State University, Corvallis.

Kratzer, C. R., and J. L. Shelton. 1998. Water quality assessment of the San Joaquin - Tulare basins, California: analysis of available data on nutrients and suspended sediment in surface water, 1972-1990. Professional Paper. 1587. U. S. Geological Survey, National Water-Quality Assessment Program, Sacramento, California.

Kuivila, K. M. 2000. Pesticides in the Sacramento-San Joaquin Delta: the State of Our Knowledge. CALFED BAY-Delta Science Conference, Sacramento Convention Center, Sacramento, California. October 3–5, 2000

Lee, G.F., and Jones-Lee, A. 2000. Issues in Developing the San Joaquin River Deep Water Ship Channel DO TMDL. Report to San Joaquin River Dissolved Oxygen Total Maximum Daily Load Steering Committee and the Central Valley Regional Water Quality Control Board, Sacramento, CA August 17, 2000.

Ligon, F. K., A. L. Percival, and T. P. Speed. In press. The effects of turbidity on largemouth bass feeding rate and implications for salmon management. Submitted to Ecological Applications

Loomis, W.F. 1954. Environmental factors controlling growth in hydra. J. Exp. Zool. 126:223-234.

Lotspeich F. B and Everest F. H., 1981. A New Method for Reporting and Interpreting Textural Compositionof Spawning Gravel United States Department of Agriculture Forest Service Pacific Northwest Forest and Range Experiment Station Research Note PNW-369

Mahoney, J.M. and Rood, S.B., 1998. Streamflow requirements for cottonwood seedling recruitment--an integrative model. Wetlands, 18(4): 634-645.

Mather, M. E. 1998. The role of context-specific predation in understanding patterns exhibited by anadromous salmon. Canadian Journal of Fisheries and Aquatic Sciences 55 (Supplement 1): 232-246.

McBain & Trush and Stillwater Sciences. 1999. Tuolumne River restoration project monitoring: Special Run Pools 9/10 and gravel mining reach 7/11 phase, Prepared for Tuolumne River Technical Advisory Committee, U. S. Fish and Wildlife Service Anadromous Fish Restoration Program, and CALFED Ecosystem Restoration Program, by McBain & Trush, Arcata and Stillwater Sciences, Berkeley, CA.

McBain & Trush, 2000. Habitat Restoration Plan for the lower Tuolumne River Corridor, Prepared for Tuolumne River Technical Advisory Committee (Don Pedro Project, FERC License No. 2299) by McBain and Trush, Arcata, CA.

McBain & Trush. 2004a. Tuolumne River Floodway Restoration Project Design Approach and Rationale for Gravel Mining Reach and Special Run Pools 9/10. Prepared for the Tuolumne River Technical Advisory Committee and the Anadromous Fisheries Restoration Program by McBain & Trush and Jennifer Vick. 26 February.

McBain and Trush, 2004b. Coarse sediment management plan for the lower Tuolumne River, Prepared for the Tuolumne River Technical Advisory Committee, with assistance from Stillwater Sciences, Berkeley, CA, and Trinity Associates, Arcata, CA.

McCuddin, M. E. 1977. Survival of salmon and trout embryos and fry in gravel-sand mixtures. Master's thesis. University of Idaho, Moscow.

McNeil, W. J. and Warren, H. A. 1964. Success of Pink Salmon Spawning Relative to sixe of Spawning Bed Materials. Contribution No. 157, College of Fisheries, University of Washington. United States Fish and Wildlife Service Special Scientific Report-Fisheries No. 469

Meacham, C. P., and J. H. Clark. 1979. Management to increase anadromous salmon production. Pages 377-386 in H. C. Clepper, editor. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D.C.

Mills, T. J., and F. Fisher. 1994. Central Valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. 8/94 draft. Inland Fisheries Technical Report. California Dept. of Fish and Game. 62 p.

Moore, A., and C. P. Waring. 1996. Sublethal effects of the pesticide Diazinon on olfactory function in mature male Atlantic salmon parr. Journal of Fish Biology 48: 758-775.

Montgomery, James M., Consulting Engineers, Water Treatment Principles and Design, John Wiley and Sons, 1985

Moyle, P. B., and R. M. Yoshiyama. 1994. Protection of aquatic biodiversity in California: a five-tiered approach. Fisheries 19: 6-18.

Nielsen, J. L., D. Tupper and W. K. Thomas. Mitochondrial DNA polymorphism in unique runs of
chinook salmon (Oncorhynchus tshawytscha) from the Sacramento-San Joaquin River basin. Conservation Biology 8: 882-884.

Neave, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Board Can. 9:450-491.

Nobriga, M., M. Chotkowski, and R. Baxter. 2003. Baby steps toward a conceptual model of predation in the Delta: preliminary results from the shallow water habitat predator-prey dynamics study. Interagency Ecological Program Newsletter 16(1): 19-27.

Oltman, D., 1996, Losing ground: California Farmer, June 1996.

Pacific Fishery Management Council (PFMC), 2004a. Review of 2003 Ocean Fisheries (Document prepared for the Council and its advisory entities). Portland, Oregon.

Pacific Fishery Management Council (PFMC), 2004b. Preseason Report 1 Stock Abundance Analysis for 2004 Ocean Salmon Fisheries (Document prepared for the Council and its advisory entities). Portland, Oregon.

Pereira, W.E., Domagalski, J.L., Hostettler, F.D, Brown, L.R., and Rapp, J.B., 1996, Occurrence and accumulation of pesticides and organic contaminants in river sediment, water, and clam tissues from the San JoaquinRiver and tributaries, California: Environmental Toxicology and Chemistry,vol. 15, p. 172-180.

Peterman, R. M., and M. Gatto. 1976. Estimation of functional responses of predators on juvenile salmon. J. Fish. Res. Bd. Can. 35:797-808.

Phillips, R. W., and H. J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pages 60-73 in 14th annual report of the Pacific Marine Fisheries Commission. Portland, Oregon.

Phillips, R. W., R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Trans. Am. Fish Soc. 104(3):461-466.

Pickard, A., A. M. Grover, and F. A. Hall, Jr. 1982. An evaluation of predator composition at three locations on the Sacramento River. Technical Report 2. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary.

Pickard, A., A. Baracco, and R. Kano. 1982. Occurrence, abundance and aize of dish at the Roaring River Slough Intake, Suisun Marsh, CA during the 1980-1 and 1981-2 diversion seasons. Interagency Ecological Study Program, Technical Report 3. 14 pp.

Platts, W. S., M. A. Shirazi, and D. H. Lewis. 1979. Sediment particle sizes used by salmon for spawning with methods for evaluation. Ecological Research Series EPA-600/3-79-043. U. S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Corvallis, Oregon.

Power, M.E. 1990. Indirect effects of grazers at low population density: armored catfish, algae, and sediment. Ecology 71:897-904.

Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Inland Fisheries Division, Sacramento

Rogers, D. E., L. Gilbertson, and D. Eggers. 1972. Predator-prey relationship between Arctic char and sockeye salmon smolt at the Agulowak River, Lake Aleknagik, in 1971. Fisheries Research Institute Circular 727. University of Washington, Seattle.

Ruggerone, G.T., and D.E. Rogers. 1992. Predation on sockeye salmon fry by juvenile coho salmon in the Chignik lakes, Alaska: implications for salmon management. N. Am. J. Fish. Manage. 12: 87-102.

Saiki, M. K. 1984 Environmental conditions and fish faunas in low elevation rivers on the irrigated San Joaquin Valley floor, California. California Fish and Game 70: 145-157.

San Joaquin River Group Authority (SJRGA) website, (www.sjrg.org). 2004. Annual Technical Report. Chapter 2

Silver, S. J., Warren, C. E. & Doudoroff, P. 1963 Dissolved oxygen requirements of developing steelhead trout and Chinook salmon embryos at different water velocities. Trans. Am. Fish. Soc. 92, 327–343.

Spence, J. R., D. W. Langor, J. Niemela, H. A. Carcamo, and C. R. Currie. 1996. Northern forestry and carabids: the case for concern about old-growth species. Annales Zoologici Fennici 33: 173-184.

Stevens, D. E. 1966. Food habits of striped bass, Roccus saxatilis, in the Sacramento-San Joaquin Delta. Pages 68-96 in J. L. Turner and D. W. Kelley, editors. Ecological studies of the Sacramento-San Joaquin Delta, Part II. Fish Bulletin 136. California Department of Fish and Game.

SWRCB. 1967. Water Right Decision 1275. State Water Rights Board. Sacramento, California. May 31, 1967.

SWRCB. 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Sacramento, California.

Tagart, J. V. 1976. The survival from egg deposition to emergence of coho salmon in the Clearwater River, Jefferson County, Washington. Master's thesis. University of Washington, Seattle.

Tappel, P.D. and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3: 123-135.

Thomas, J. L. 1967. The diet of juvenile and adult striped bass, Roccus saxatilis, in the Sacramento-San Joaquin river system. California Fish and Game 53: 49-62.

TID/MID. 1991 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 8 Volumes. November.

TID/MID. 1996. New Don Pedro proceeding P-2299-024 settlement agreement between California Department of Fish and Game, California Sports Fishing Protection Alliance, City and County of San Francisco, Federal Energy Regulatory Commission, Friends of the Tuolumne, Modesto Irrigation District, Tuolumne River Expeditions, Tuolumne River Preservation Trust, Turlock Irrigation District, and U. S. Fish and Wildlife Service. Submitted to the Federal Energy Regulatory Commission, February.

TID/MID. 1997. 1996 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 6 Volumes. March.

TID/MID. 1998. 1997 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299.. 2 Volumes. March.

TID/MID. 1999. 1998 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID. 2000. 1999 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID 2001. 2000 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID 2002. 2001 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID 2003. 2002 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID 2004. 2003 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 2 Volumes. March.

TID/MID 2005. 2004 Report of Turlock Irrigation District and Modesto Irrigation District Pursuant to Article 39 of the License for the Don Pedro Project, No. 2299. 1 Volumes. March.

USACE (U.S. Army Corps of Engineers). 1972. Reservoir Regulation for Flood Control, New Don Pedro Lake, Tuolumne River, California

USBR (U. S. Bureau of Reclamation). 1983. Predation of anadromous fish in the Sacramento River, California. Central Valley Fish and Wildlife Management Study. Special Report. USBR, Mid-Pacific Region, Sacramento, California.

USEPA (U.S. Environmental Protection Agency). 1997. Technical Guidance Manual for Developing Total Maximum Daily Loads; Book 2: Streams and Rivers; Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/ Eutrophication, US Environmental Protection Agency Office of Water, EPA 823-B- 97-002, March.

USFWS (U. S. Fish and Wildlife Service). 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volumes 1-3. Prepared by the Anadromous Fish Restoration Program Core Group for the USFWS, Stockton, California.

USGS (United States Geological Survey) 2004. On-Line Query of NWIS Web Data for California<http://waterdata.usgs.gov/ca/nwis/>.

Werner I, Deanovic LA, Connor V, de Vlaming V, Bailey HC, Hinton DE. 2000. Insecticide-caused toxicity to Ceriodaphnia dubia (cladocera) in the Sacramento-San Joaquin River Delta, California, USA. Environ Toxicol Chem 19:215-227.

Wickett, W. Percy. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. Journal of the Fisheries Research Board of Canada, vol. 15, no. 5, p. 1103-1126.

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18: 487–521.