TURLOCK IRRIGATION DISTRICT
MODESTO IRRIGATION DISTRICT

P. O. Box 949
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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 -- Article 58 Annual Report

Dear Secretary Salas:

Enclosed pursuant to Article 58 of the license for Project No. 2299 and Section 15 of the 1995 Don Pedro Project Settlement Agreement is the 2004 Lower Tuolumne River annual report. 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

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- FERC PROJECT NO. 2299 -
2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Turlock and Modesto Irrigation Districts

By

Tim Ford
Aquatic Biologist

2004 SUMMARY REPORT

Attachment A: Water Data and Forecasts, Flows, Water Temperature and Air Temperature, and Flow Schedule Correspondence

Report 2004-1: 2003 and 2004 Spawning Survey Reports

Report 2004-2: Spawning Survey Summary Update

Report 2004-3: 2004 Seine/Snorkel Report and Summary Update

Report 2004-4: 1998, 2002, and 2003 Grayson Screw Trap Reports

Report 2004-5: 2004 Grayson Screw Trap Report

Report 2004-6: [reserved]

Report 2004-7: Large CWT Smolt Survival Analysis Update

Report 2004-8: Coded-wire Tag Summary Update

Report 2004-9: Aquatic Invertebrate Monitoring Report (2003-2004)

Report 2004-10: 2004 Water Quality Report

Report 2004-11: [reserved]

Report 2004-12: Coarse Sediment Management Plan

Report 2004-13: Tuolumne River Floodway Restoration (Design Manual)

List of Acronym and Abbreviations

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
CBDA	California Bay-Delta Authority
CCSF	City and County of San Francisco
CDEC	California Data Exchange Center
CDRR	combined differential recovery rate
cfs	cubic feet per second, a measure of flow rate
CRRF	California Rivers Restoration Fund
CSPA	California Sportfishing Protection Alliance
CWT	coded wire tag
CVP	Central Valley Project
CY	cubic yard
CDFG	California Department of Fish and Game
DWR	Department of Water Resources
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FL	fork length
FOT or FOTT	Friends of the Tuolumne
FSA	Don Pedro Project 1995 FERC Settlement Agreement
FWS	see USFWS
HORB	Head of Old River Barrier
HRI	harvest rate index
IEP	Interagency Ecological Program
IFIM	Instream flow incremental methodology

mm	millimeter
M&T	McBain and Trush (consultants)
MID	Modesto Irrigation District
NHI	Natural Heritage Institute
NMFS	National Marine Fisheries Service
NOAA Fisheries	also National Marine Fisheries Service
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
ORNL	Oak Ridge National Laboratory
PFMC	Pacific Fishery Management Council
R(letter and/or #)	specific riffle (location identifier, e.g. RA7 is Riffle A7)
RM	river mile
RST	rotary screw trap
SJRA	San Joaquin River Agreement
SJRMP	San Joaquin River Management Program
SPCA	S. P. Cramer and Associates (consultants)
SRP	Special Run/Pool (mined area of river, usually with #, e.g. SRP 9)
SWP	State Water Project
SWS	Stillwater Sciences (consultants)
TID	Turlock Irrigation District
TRE	Tuolumne River Expeditions
TRPT	Tuolumne River Preservation Trust (also as Tuolumne River Trust)
TRTAC	Tuolumne River Technical Advisory Committee
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan
WT	water temperature
WY	Water Year

1 – Introduction

This is the ninth annual report to the Federal Energy Regulatory Commission (FERC) as required by Order Items (F) and (G) of the 31JUL96 FERC Order on Project License 2299 and by Section 15 of the 1995 Don Pedro Project FERC Settlement Agreement (FSA).

This report covers the 2004 calendar year and contains:

(1) A summary of 2004 FSA activities

(2) Monitoring and other reports.

The License 2299 Article 58 reporting requirement calls for a summary report to be filed by 01APR2005. A separate 2005 Summary Report has been prepared in addition to this 2004 annual report.

2 - Tuolumne River Technical Advisory Committee (TRTAC)

The TRTAC is a key element in implementing the 1996 FERC Order and the FSA. The TRTAC is responsible for coordinating monitoring activities and non-flow measures and developing adaptive management strategies. The TRTAC also provides input into flow schedule decisions by the Districts, CDFG, and USFWS.

Quarterly TRTAC meetings were held in 2004: 11MAR, 10JUN, 16SEP, and 15DEC. Several TRTAC subgroup meetings and conference calls were also held.

3 - Program Goals And Comparative Population Goals

FSA Section 8, the Strategy for Salmon Recovery, sets forth the Tuolumne River Chinook Salmon Program goals as (1) increase naturally occurring salmon populations; (2) protect any remaining genetic distinction; and (3) increase salmon habitat in the Tuolumne River. The program is to employ flow and non-flow measures and an adaptive management strategy.

Relating to FSA Section 8 Program Goal 1, FSA Section 9 recognized that many factors affecting the Tuolumne salmon population are beyond the control of the FSA participants. Thus the FSA established narrative comparative population 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 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 2005 Summary Report provides more information on the status of implementing the FSA strategy and meeting the FSA goals. Detailed background in this annual report is provided in summary updates in Reports 2004-2 and 8, and in other sections of this report, to further gauge progress.

3.1 - Salmon Population

The preliminary 2004 Tuolumne fall-run chinook population estimate (modified Peterson) is about 1,900 salmon (CDFG Schaefer estimate is about 1,700), a decrease from the 3,000 (CDFG Schaefer) estimated for the 2003 run (CDFG Jolly-Seber estimate was 2,200) (see Reports 2004-1 and 2). The 2004 run is estimated to have age classes of 2-5 years old, which are progeny from the 1999-2002 runs that mostly outmigrated as juveniles in the winter/spring of 2000-2003. The estimated contribution by age-class based on length frequencies is 41% 2-year old, 43% 3-year old, 15% 4-year old, and 2% 5-year old. An estimated 59% of the run were females. About 18% of the 2004 run had an adipose fin clip, indicating they were likely hatchery salmon with a coded-wire tag (CWT) – down from 21% in the 2003 run. Initial run estimates for the Stanislaus (4,400 at weir) and Merced Rivers (4,000 river and 1,000 hatchery), result in a combined 3-river total of about 11,300, as compared to about 10,800 in 2003.

Production is the total of harvest plus escapement for a given brood year (cohort). This is obtained by summing up for several years (e.g. from 2-5 years following a given fall run for the Tuolumne) the annual numbers from a single cohort. That is, the estimated harvest by cohort, plus the estimated run component by cohort. The harvest component of the Tuolumne can be approximated using the overall Central Valley Harvest Rate index. The run component also can be approximated, generally based on size distribution, which typically overlaps by age class and can vary from year to year due to factors such as ocean conditions or hatchery production. The length of known-age salmon, typically tagged salmon of hatchery origin, can be used to assist in the assignment of age classes from the carcass length data. The Districts still must obtain such information from DFG for use in refining age class distribution of the runs and hence, cohort production estimates. Although production estimates are inherently imprecise, they can be useful for identifying general trends and overall cohort-specific survival.

Hatchery fish can complicate or prevent the accurate development of natural production estimates in several ways. This is further compromised by the release of unmarked hatchery production to the Merced River by CDFG in some years. Most of the known hatchery-origin salmon in Tuolumne salmon runs are typically CWT Merced River hatchery fish used in basin smolt survival studies (Report 2004-2). Returns of prior CWT releases made through 2002 in the Tuolumne can be expected through 2006.

3.2 - Outside Factors

The FSA (Section 10) recognized there are many factors outside the control of the Districts and even outside the Tuolumne River that affect the Chinook salmon population, including juvenile mortality associated with south Delta water export operations and ocean salmon harvest. Many other outside factors, such as ocean conditions and San Joaquin River water quality, including periods of low dissolved oxygen levels near Stockton, can also affect salmon populations. Some of these outside factors are discussed in this section with further details contained in the 2005

Summary Report.

3.2.1 - Ocean Harvest

Preliminary 2004 ocean harvest and Central Valley escapement (spawning run) data are available from the Pacific Fishery Management Council (PFMC 2005). The PFMC reported a higher 2004 ocean catch of 536,700 Chinook salmon landed south of Pt. Arena as compared to 308,700 in 2003. The estimated 2004 Central Valley total “adult” escapement (including hatchery) of 334,300 salmon was much lower than the 587,100 salmon estimated for 2003.

The total Central Valley Index Abundance, comprising the sum of catch and adult (age 3+) escapement, were about the same in 2003 (895,800) and 2004 (871,000). The difference between the two years is that much more of the total was harvested in 2004 than in 2003. The 2004 catch and escapement values resulted in an estimated Central Valley “Harvest Rate Index” (HRI) of 62% in 2004, much higher than the 34% of 2002. The HRI had been lower in the six prior years (range of 26-52%). The portion of total California Chinook landings made south of Pt. Arena was up from 53% in 2003 to 74% in 2004. River-specific ocean harvest data are not available for this mixed-stock fishery.

3.2.2 - Salmon Salvage and Losses at Delta Water Export Pumps

Natural/unmarked salmon salvage and losses for JAN-JUN at the State (SWP) and Federal (CVP) Delta water export facilities were similar overall in 2003 and 2004. Combined facility estimates for JAN-JUN2004 were about 29,000 salmon salvaged and about 45,000 in losses. Monthly average density (number/1000 AF) was highest for March at the CVP and for APR at the SWP. The reported numbers do not include associated indirect losses within the Delta and the salvage and loss estimates for fry (mostly in JAN-MAR) are probably low due to reduced screening efficiency. It is not certain how many of these salmon were from the San Joaquin basin as there is presently no method to ascertain specific origins. However, comparison of salmon size and timing with tributary and mainstem seine, screw trap, and trawl catch data clearly indicate the potential interception of many San Joaquin basin salmon at the facilities.

Salmon <70mm were evident at the facilities starting in late FEB, with fry <50mm reported through the third week of MAR. Tuolumne flows increased in early MAR, which likely initiated fry/juvenile migration to the San Joaquin River. There was an extended salvage period of larger juveniles/smolts (70-110 mm) from early MAR through MAY, corresponding to the size of salmon caught after early APR at Mossdale.

Salvage and loss data on weekly intervals from late FEB through MAY were again presented in the 2004 VAMP Report (SJRGA 2005) to better identify patterns before, during, and after implementation of salmon protective measures, e.g. the Head of Old River Barrier (HORB – a rock barrier, with six culverts, installed on a temporary basis in the spring for improving survival of migrating juvenile San Joaquin River salmon) and reduced exports in mid-APR to mid-MAY. The highest salvage and losses mostly occurred during early to mid-MAR at a time when combined SWP/CVP exports exceeded flow at flow at Vernalis by about 8,000 cfs.

3.2.3 - SJRA/VAMP

CWT hatchery salmon releases to evaluate San Joaquin Delta smolt survival began in 1986. Feather River Hatchery (Sacramento basin) salmon were used during 1989-98 and Merced River Hatchery salmon have been used in 1986, 87, 89, and 1996-2004. A spring HORB has been installed for varying periods in 1992, 94, 96, 97, and 2000-2004. Culverts have been placed in the barrier since 1997 to pass limited flows into Old River for irrigation needs. Chipps Island has been a CWT salmon recovery trawl location in all years and an additional trawl site has been either at Jersey Point (1997-99) or Antioch (2000-2004).

The San Joaquin River Agreement (SJRA) and the Vernalis Adaptive Management Plan (VAMP) are elements for meeting the objectives of the 1995 State Water Resources Control Board (SWRCB) Bay-Delta Water Quality Control Plan over a 10-12 year period. 2004 was the fifth year of formal compliance with SWRCB Decision 1641, revised in MAR2000. The program includes a 31-day period, usually mid-APR to mid-MAY with an experimental combination of salmon protective measures: HORB, specified San Joaquin River flows at Vernalis, and reduced State and Federal delta exports. An additional Tuolumne River spring pulse flow volume of up to 22,000 acre-feet (AF) from TID/MID, supplemental to the FERC pulse allocation, can be required under the SJRA to help meet target flows at Vernalis. More spring pulse flow may also be added to the Tuolumne River through a water sharing arrangement with other parties to the SJRA.

As reported by the San Joaquin River Group Authority (2005), a HORB with 6 operable culverts was again installed in 2004. During the 15APR-15MAY period, the target flow at Vernalis was 3,200 cfs and the combined export target was 1,500 cfs during that 1-month period – same as in 2002 and 2003. Variable operation of the HORB culverts occurred during the period to meet downstream water needs in 2004. About 65,590 AF of total SJRA supplemental water were released for the VAMP pulse flow period, including 11,151 AF in the Tuolumne River.

"Absolute survival" indices for Mossdale and Durham Ferry releases to Jersey Point (recovered at Antioch and Chipps Island) were all very low again in 2004 and ranged from 1– 4%. The overall "combined differential recovery rate" (CDRR) of 2.6% was also very low. There is still some speculation that high disease levels in the hatchery study fish, in combination with other factors, may have contributed to low survival in 2003 and 2004, although that has not been determined. The CDRR of 15.1-19.1% for 2001-2002, although higher than for 2003-2004 all indicate low spring Delta survival for the brood year 2000-2003 salmon cohorts that will be returning to the basin over the next few years.

The spring flow conditions anticipated for 2005 are expected to be much higher and it is likely that the HORB will not be installed due to high flood management flows in excess of 5,000 cfs in the San Joaquin River. At this time, plans are being considered to conduct the VAMP studies starting May 2 without the HORB and to curtail exports to 1,500 cfs. These are factors that will bear on the spring survival on brood year 2004.

3.3 - ESA Actions

National Marine Fisheries Service (NOAA Fisheries) first determined "threatened" status for anadromous forms of rainbow trout (steelhead), *Oncorhynchus mykiss,* in the California Central Valley ESU in 1998 (63 FR 13347). Some NOAA Fisheries actions in 2004 regarding listed steelhead ESUs throughout the West Coast included:

- 03JUN: NOAA Fisheries publishes proposed hatchery listing policy
  http://www.nwr.noaa.gov/reference/frn/2004/69FR31354.pdf
- 14JUN: NOAA Fisheries published proposed rule on listing determinations
  http://www.nwr.noaa.gov/reference/frn/2004/69FR33102.pdf
- 15NOV: NOAA Fisheries published proposed revisions to 4(d) rules regarding take
  http://www.nwr.noaa.gov/reference/frn/2004/69FR65582.pdf
- 10DEC: NOAA Fisheries published proposed rule on critical habitat designations
  http://swr.ucsd.edu/salmon/69_FR_71880.pdf

Several parties, including the Districts, in DEC2002, filed a lawsuit against the listing of California Central Valley *Oncorhynchus mykiss*. The court ruling issued on 12MAY2004 found the listing to be flawed and determined that NOAA Fisheries had to reinstate a proper listing by JUN2005 or the listing would be vacated. The Districts filed the court ruling with FERC on 20 MAY2004. That filing also included a 2004 canal trout survey report, a recent CDFG Central Valley trout genetic study report, and the 1995 USFWS Tuolumne River IFIM report.

On 22DEC2003, FERC issued an order deferring action on the NOAA Fisheries petition requesting formal consultation regarding the Don Pedro Project, pending completion of the ongoing informal consultation process (involving the TRTAC and other parties). The TRTAC (or subgroup) continued work on *O. mykiss* monitoring aspects during the year. Report 2004-11 updates the *O. mykiss* data compilation first filed with FERC late in 2003. The update includes trout captured in MAR-MAY2004 in a CDFG angling survey. Related 2004 correspondence in addition to those identified above filed with FERC in 2004 included:

- 21JAN: The Turlock and Modesto Irrigation Districts submit the Temperature Tolerences of Tuolumne River Fishes: A Critique of Declaration of Carl Mesick in support of Conservations Groups' Brief Report under P-2299.
- 26FEB: The Fish & Wildlife Service informs FERC of several fish resource concerns associated with Don Pedro Project license under P-2299.
- 23MAR: The Friends of the Tuolumne file a response objecting to the JAN filing
- 23APR: NOAA Fisheries filed a letter requesting studies and flows.
- 20MAY: Districts file reply to 26FEB FWS and 23APR NOAA letters.
- 30SEP: FWS files reply to Districts 20MAY letter.
- 15OCT: Friends of the Tuolumne, Inc's comments regarding the Coarse Sediment Management Plan for the Lower Tuolumne River under P-2299.
- 29OCT: Turlock Irrigation District responds to Friends of the Tuolumne's letter dated 10/15/04 re the Course Sediment Management Plan prepared for the Tuolumne River

Technical Advisory Committee etc under P-2299.

4 - Flow Schedules and Operations

Calendar year 2004 included minimum flow and pulse flow requirements of Article 37 spanning the 2003-2004 and 2004-2005 “fish flow year” schedules, which are from about 15APR-14APR, although some spring pulse flow begins as early as 12APR to coincide with timing of flow needs at Vernalis on the San Joaquin River. **Attachment A** contains the FERC flow schedule correspondence. The 2004-2005 “fish flow year” was the fourth consecutive year with an annual Article 37 flow requirement of less than 300,923 AF; the final scheduled flow volume based on license provisions was 128,970 AF.

The 2004 calendar year included part of the 2004 and 2005 “water years (WY)” which run from OCT-SEP. WY2004 (OCT2003-SEP2004) Tuolumne River computed natural runoff volume of 1,315,572 AF was 70% of the WY1897-2004 average, down from 86% in WY 2003. The April 1 San Joaquin Basin 60-20-20 Water Supply Index 50% Exceedence Forecast was 2.5424. Due to a dry early spring, the index dropped to 2.404649 by the 20APR forecast update, corresponding to 140,373 AF of annual fish flow volume initially, with 35,514 AF being allocated to the spring pulse. The WY2004 San Joaquin Basin 60-20-20 Water Supply Index continued to decrease during the season and ended up at 2.211624, based on the provisional data through JUL2004. This change necessitated downward “true-up” adjustments to the flow schedule. The daily average computed natural flow, actual La Grange flows, and FERC minimum flow schedules for WY2004/2005 are graphed in **Attachment A**. Actual flows at other basin locations, Don Pedro Reservoir storage, and snow and precipitation data are included as well.

Base flow requirements were generally 150 cfs from 15APR through MAY, 80 cfs from JUN through SEP, and 150 cfs from 01OCT on. Operational flows due to flood space requirements in Don Pedro Reservoir were required due to the unusually warm late winter/early spring weather that led to early snowmelt runoff prior to the spring pulse flow period. Increased flows of 500-2800 cfs had to be released from 03MAR-11APR in the dry year to maintain flood conservation space in the reservoir. The 12APR-16MAY spring pulse flow period had an additional 11,150 AF of water added due to implementation of the SJRA/VAMP. The fall pulse flow of 1,807 AF was scheduled for 25-31OCT, later than usual, to accommodate CDFG request to coordinate with other basin flows.

5 - Monitoring Information

FERC License 2299 Article 58 and FSA Section 13 list several monitoring elements. Article 58 specifies that the monitoring frequencies and methods shall be agreeable to the Districts and consulted agencies. Section 13 provided the TRTAC with authorization to modify the monitoring program within the total Section 13 funding limit of $1,355,000. This funding allocation total was reached in 2004.

5.1 – Salmon Spawning Escapement

The California Department of Fish and Game (CDFG) conducts the spawning surveys under FSA Section 13a. This year assistance from the Districts was again provided to conduct the surveys. The CDFG reports for the 2003 and 2004 spawning runs are in Report 2004-1 - the long-term update based on currently available data is in Report 2004-2.

5.2 - Quality and Condition of Spawning Habitat

Consultant reports on the Coarse Sediment Management Plan and the Tuolumne River Floodway Restoration (Design Manual) are in Reports 2004-12 and 13. CDFG provided a 2-page data summary of their 1998-1999 redd count comparison study in OCT2004.

5.3 - Relative Salmon Fry Density/Female Spawners

Tuolumne River peak salmon fry density from seining in 2004 was similar in timing (early FEB) to 1998-2003, but was relatively low (Report 2004-3). Fry density was typical for the number of female spawners.

5.4 – Salmon Fry Distribution and Survival

Sustained low flows in JAN-FEB resulted in little early movement of salmon fry ($\leq$50 mm) but fry density in the middle section peaked in mid-MAR after flood management flows began to be released (Report 2004-3). Screw trap sampling at Grayson Ranch in 2004 was limited to the APR-JUN period, when fry are not as abundant. CDFG reports for 1998, 2002, and 2003 screw trap sampling were provided in 2004.

5.5 - Juvenile Salmon Distribution and Temperature Relationships

Seine sampling monitored the winter/spring distribution of juvenile salmon (>50 mm) and other fishes in the Tuolumne River (Report 2004-3). Peak juvenile density was in late MAR at a time and amount similar to 2003.

SP Cramer conducted most of the rotary screw trap monitoring at Grayson Ranch for APR-MAY in 2004 and the results are in Report 2004-5. A total of 509 wild salmon were caught – 83% were in the 70-89 mm fork length range and 93% were classified as obvious smolts. The two peak daily catches were in early and late April associated with flow decreases - only one salmon was caught after 16MAY. About 16,000 hatchery salmon were used in 8 efficiency tests at Modesto flows of about 300-1,700 cfs and capture rates from the 7 tests considered to be unbiased were from 2.4-8.9%. Estimated passage during the sampling period was about 13,000 wild salmon.

Snorkel surveys in JUN found about 491 Chinook salmon and 91 rainbow trout. A comparable SEP snorkel survey recorded no Chinook salmon and 40 rainbow trout. This followed a supplemental AUG snorkel survey that recorded 80 Chinook salmon and 76 rainbow trout

(Report 2004-3).

The thermograph data for the Tuolumne and San Joaquin Rivers, along with other monitoring data are posted at http://www.sanjoaquinbasin.com/. Figures for 2004-2005 daily average thermograph data are also in **Attachment A**.

5.6 – Salmon Smolt Survival

There were no CWT smolt survival releases made in the Tuolumne River in 2004, but ocean and adult returns from earlier releases made through 2002 will continue coming in through about 2006. Report 2004-7 finalizes the detailed review of Mossdale and other data through 2002 and Report 2004-8 updates the CWT recovery information and survival estimates.

5.7 – Project-related Monitoring

This monitoring in 2004 included electro-fishing for the SRP 9/10 project sites that had to be aborted due to the presence of adult salmon. Habitat mapping is contained in the 2005 Summary Report and its GIS appendix.

5.8 - Other Monitoring Information

Aquatic invertebrate monitoring continued by the Districts in July 2004, using the sites and methods employed in 2003. There were 3 Hess samples each taken at Riffles 4A and 23C and composite kick net samples taken in Riffles A4, 4A, 23C, 33, 57, 72. No decision has been made on when to analyze these samples. This effort is supplemental to the FSA monitoring program and a summary is in Report 2004-9.

A report on a water quality study in the upper reach is in Report 2004-10.

6 - Non-Flow Measure Activities In 2004

Primary work on non-flow measures in 2004 was related to pre-construction activities such as permitting, environmental review, design, and appraisal.

7 - Anticipated Non-Flow Measure Activities In 2005

There are 5 projects that have been developed such that field activities may proceed in 2005:

- Gravel Mining Reach Phase II (Ruddy segment)
- Gravel Addition
- River Mile 43
- Gravel Cleaning
- Gasburg Creek basin

Design and other pre-construction work may continue on the SRP 10 and Gravel Mining Reach

Phase III projects in 2005.

8 - Other FERC Settlement Agreement Activities

8.1 - Section 11 - Flood Management

Flood management releases were made in 2004 to maintain flood reservation space in Don Pedro Reservoir from early MAR to the start of the spring pulse flow period (see flow graphs and Don Pedro Reservoir storage graph in **Attachment A**).

8.2 - Section 19 – Riparian Habitat and Recreation

The East Stanislaus Resource Conservation District (ESRCD) continued as the public agency funded with the $500,000 from CCSF pursuant to FSA Section 19. The ESRCD receives assistance from the Natural Resources Conservation Service (NRCS). An unallocated balance of about $150,000 remained at the end of 2004.

8.3 - Section 20 – CDFG Staff Position

The CDFG Tuolumne River fishery biologist position funded under FSA Section 20 continued to be staffed by Dennis Blakeman working out of their La Grange office.

9 - Program Expenses Through 2004

Overall funding obligations of FSA costs shared by the Districts and City and County of San Francisco are up to $1,000,000 for non-flow options (Section 12) and $1,355,000 for monitoring (Section 13). The Section 13 allocation was reached in 2004 and the Section 12 allocation had about $24,000 remaining at the end of 2004. Assistance was again provided to DFG in 2004 in conducting the fall spawning survey.

10 - References

Pacific Fishery Management Council. 2004. *Review of 2004 Ocean Salmon Fisheries* and *Preseason Report 1: stock abundance analysis for 2005 ocean salmon fisheries*. Portland, Oregon

San Joaquin River Group Authority. 2005. *2004 Annual Technical Report*. Prepared for California State Water Resources Control Board in Compliance with D-1641.

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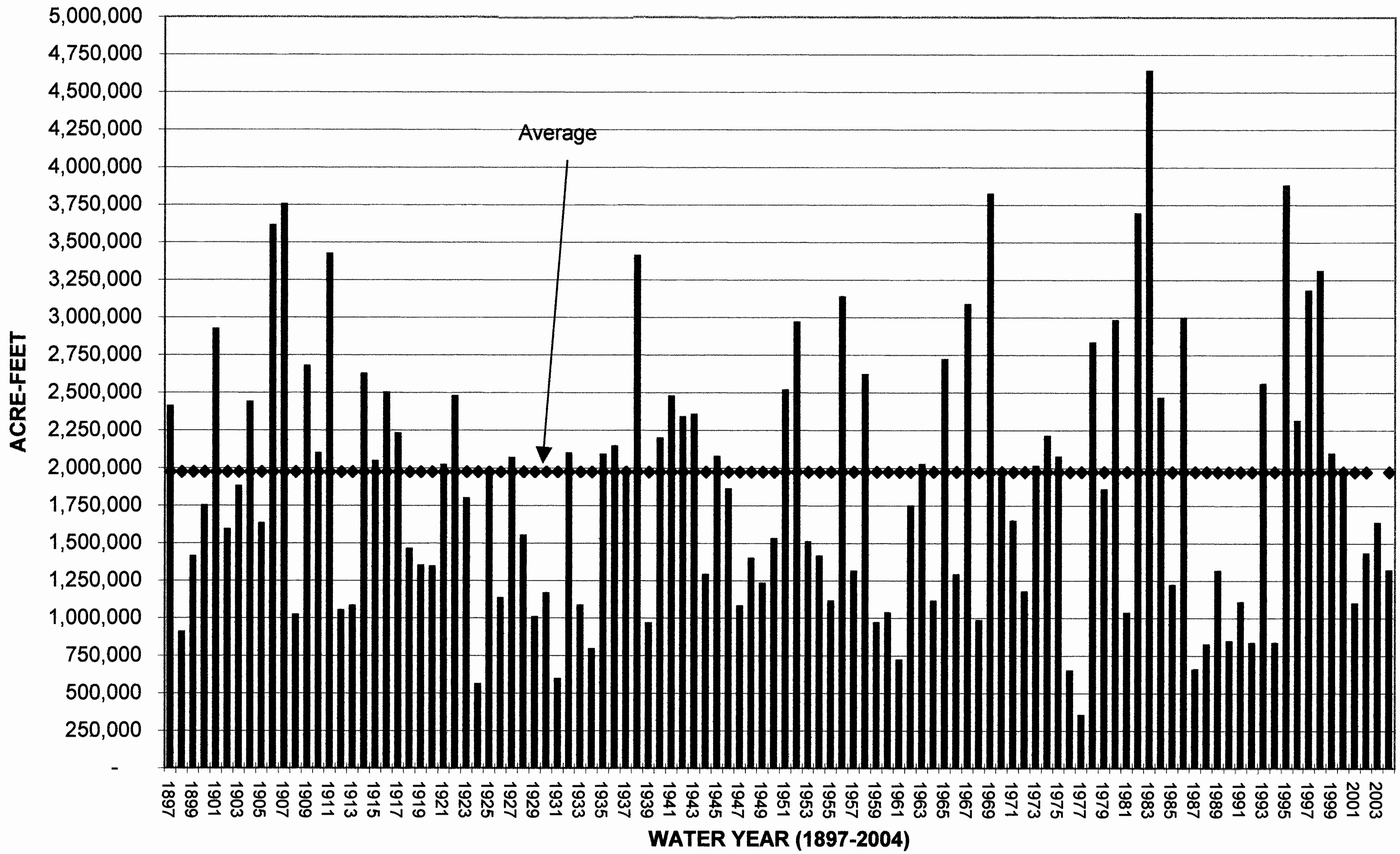
ATTACHMENT -A-

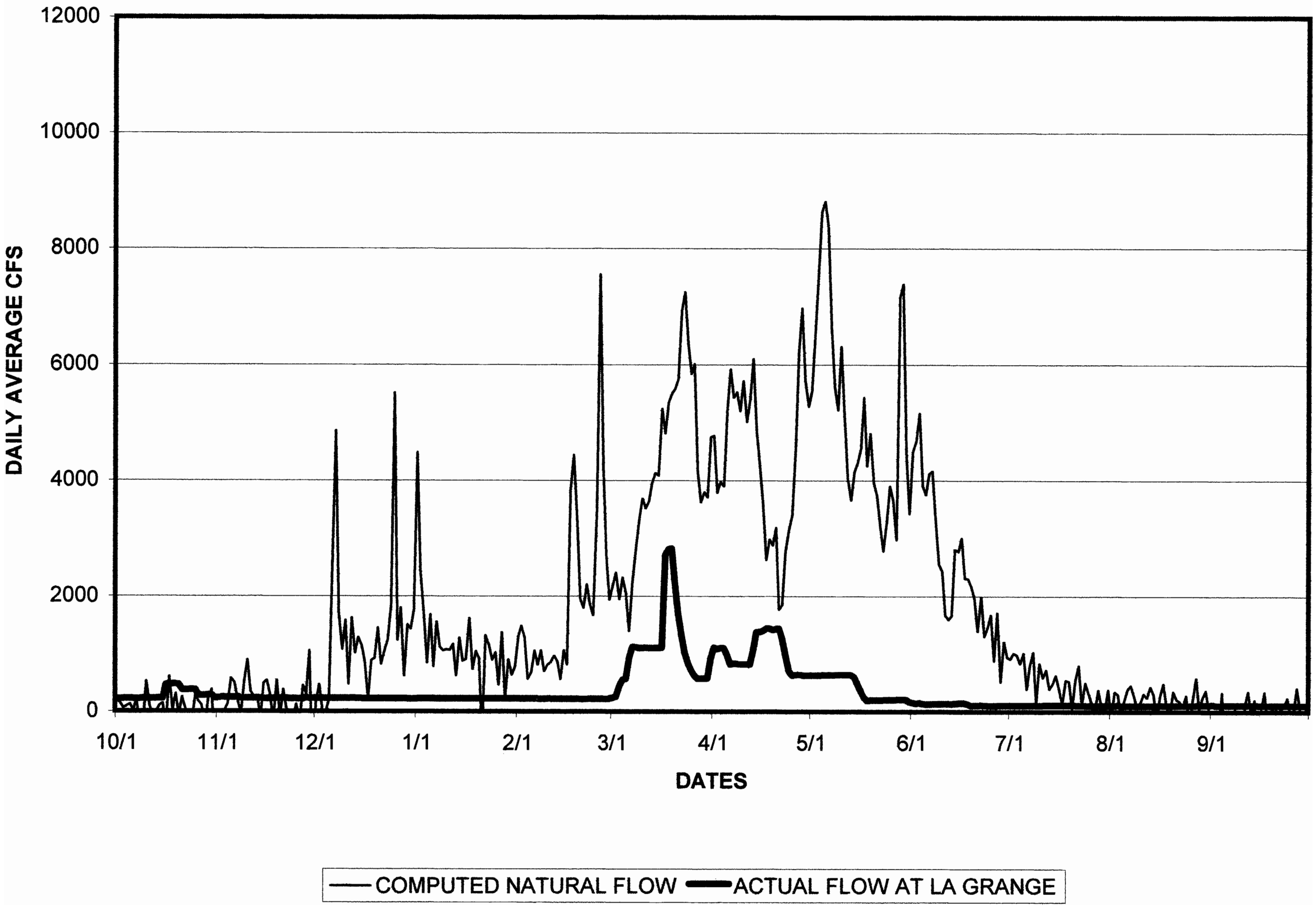
Water, Flow Schedule, Water Temperature, and Correspondence

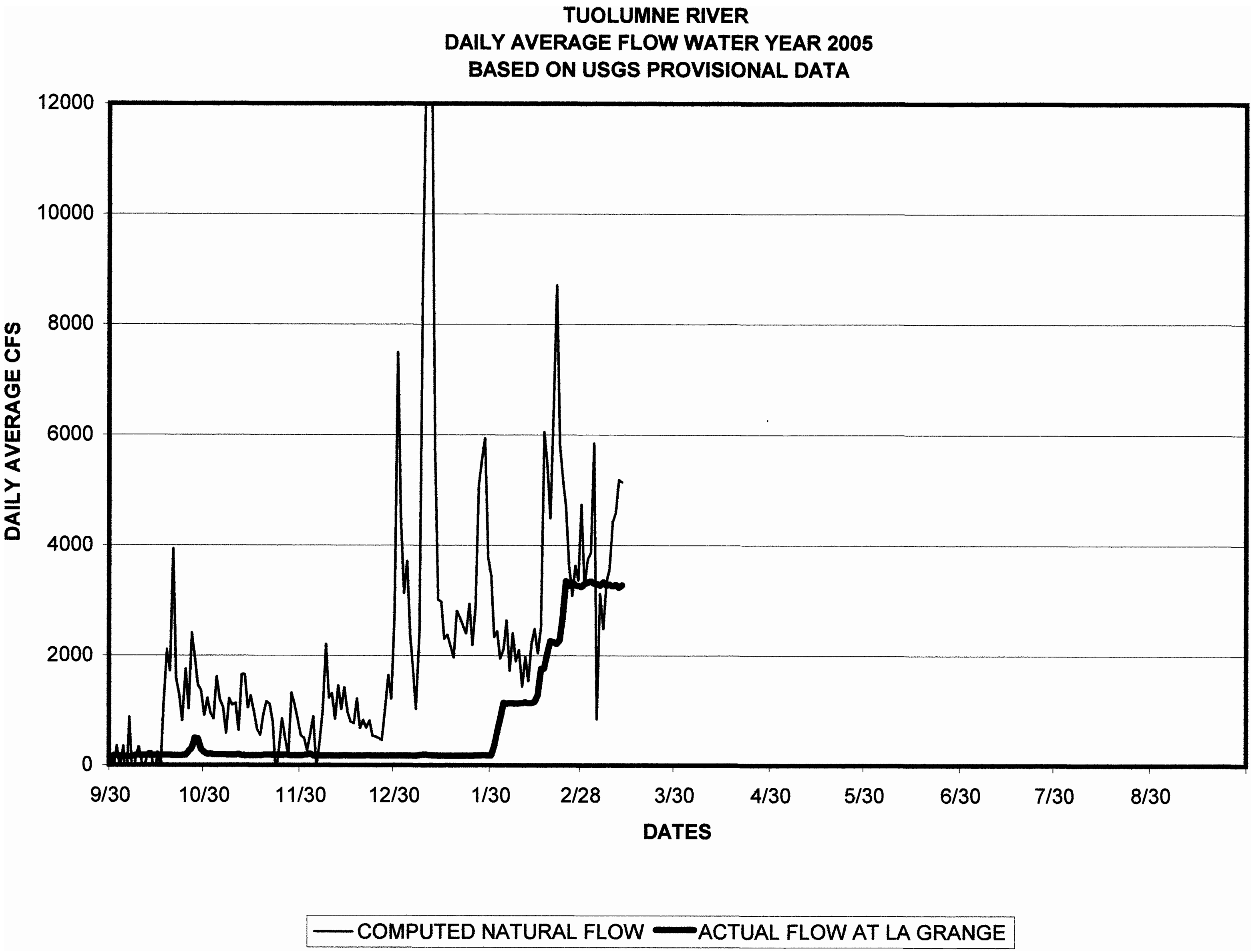
- Graphs of flows, FERC flow schedule, and reservoir data
  - Annual computed natural flow volume at La Grange
  - 2004/2005 Water Years daily average computed natural flow, actual flow, and FERC flow schedule at La Grange
  - 2004/2005 Water Years actual flow: Tuolumne at Modesto, Stanislaus at Ripon, Merced and San Joaquin at Stevinson, and San Joaquin at Vernalis
  - 2004/2005 Water Years Don Pedro Reservoir storage
  - 2004 San Joaquin basin 60-20-20 index and corresponding FERC volume
  - 2004/2005 Precipitation Years (SEP-AUG) watershed precipitation index and snow sensor water content index as percent of average
- Daily average water and air temperature graphs for OCT2003-NOV2004
- Flow schedule correspondence
  - 05APR – Initial fish flow year schedule
  - 29APR – Review of Fall 2003 pulse flow and 45-day period
  - 05MAY – Updated fish flow year volume and schedule revision
  - 10JUN --Updated fish flow year volume and schedule revision
  - 02SEP – Updated fish flow year volume and schedule revision
  - 22OCT – Final flow schedule

TUOLUMNE RIVER WATERSHED COMPUTED NATURAL FLOW



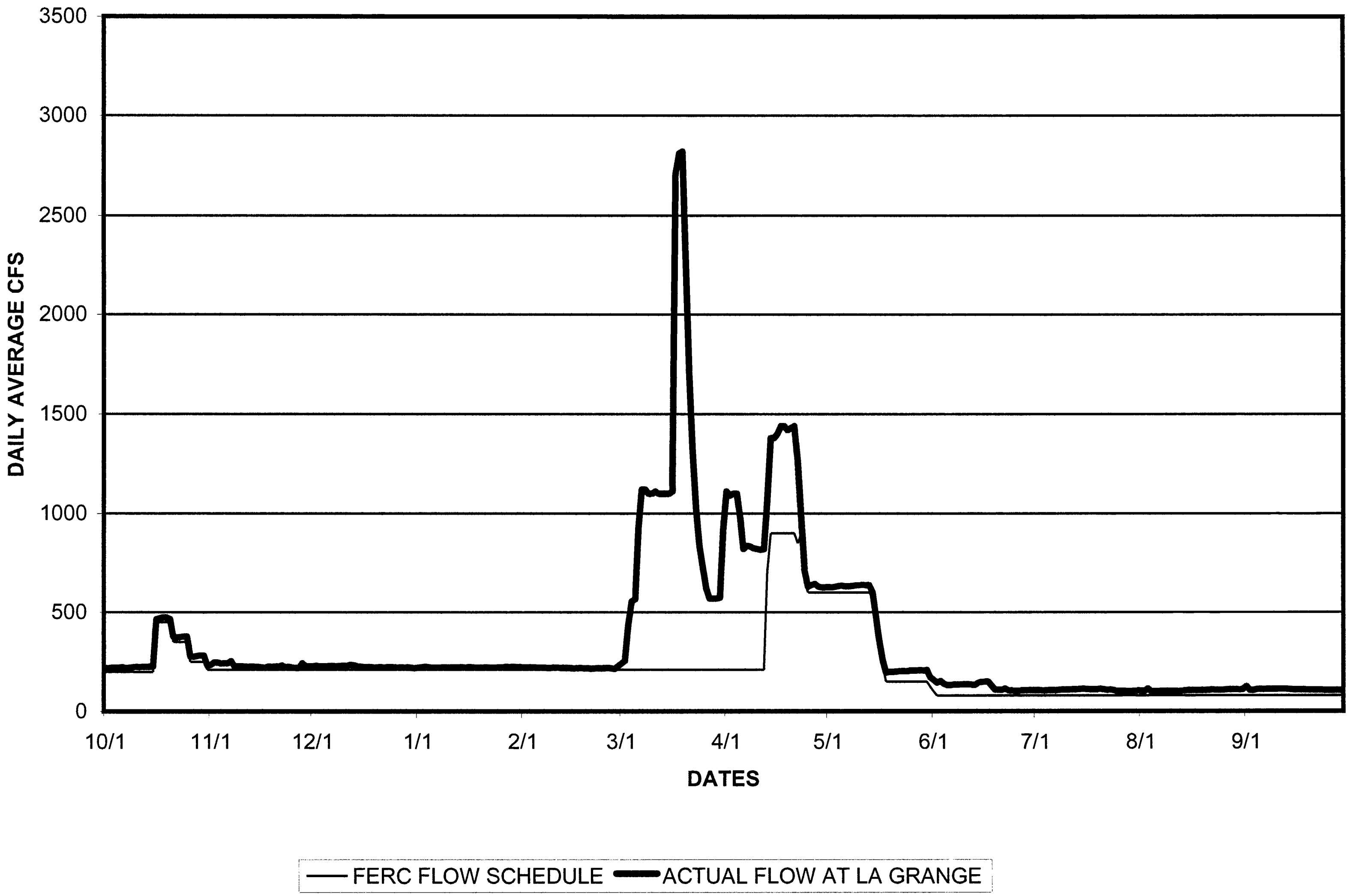
TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2004
BASED ON USGS PROVISIONAL DATA



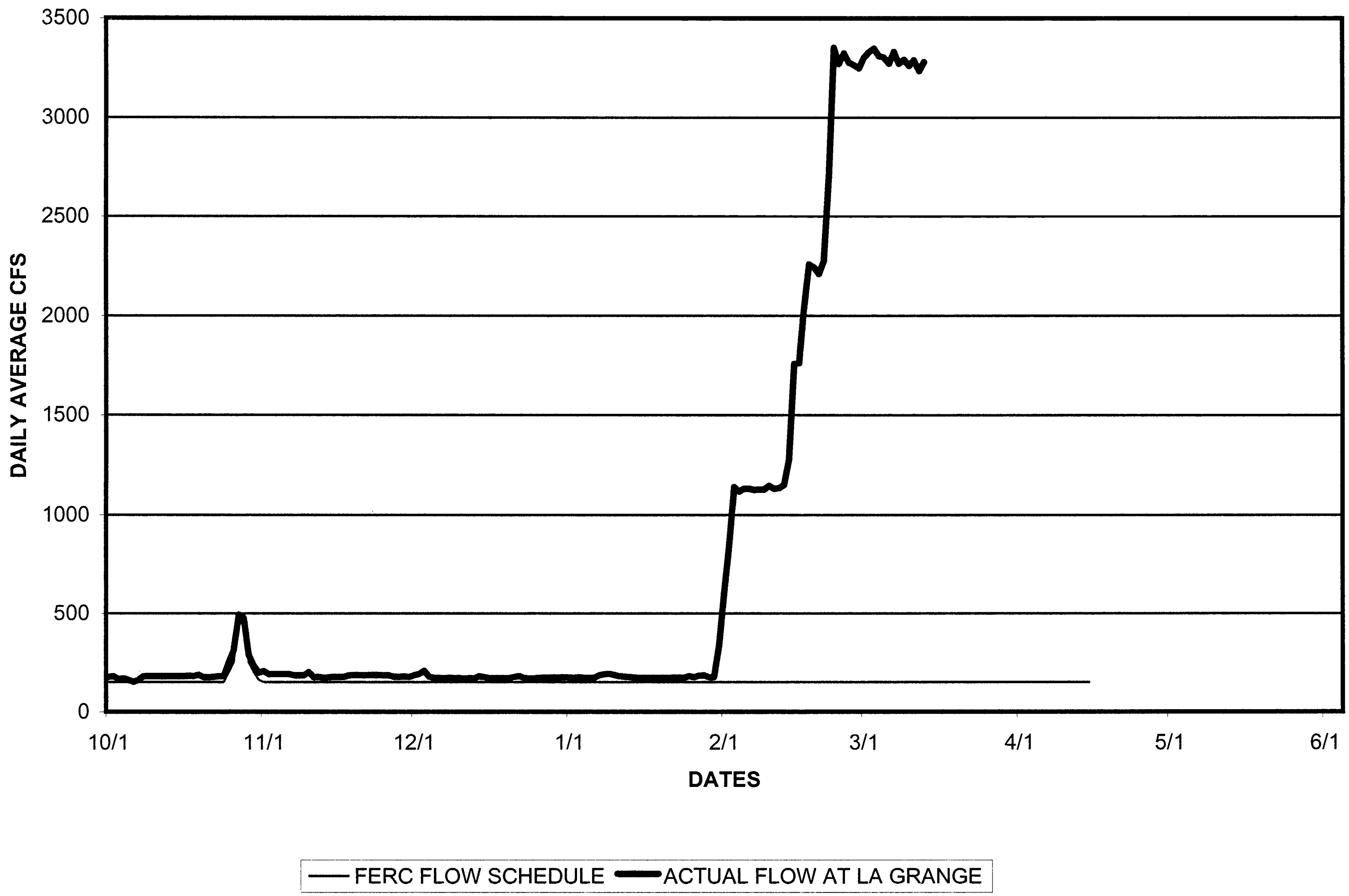


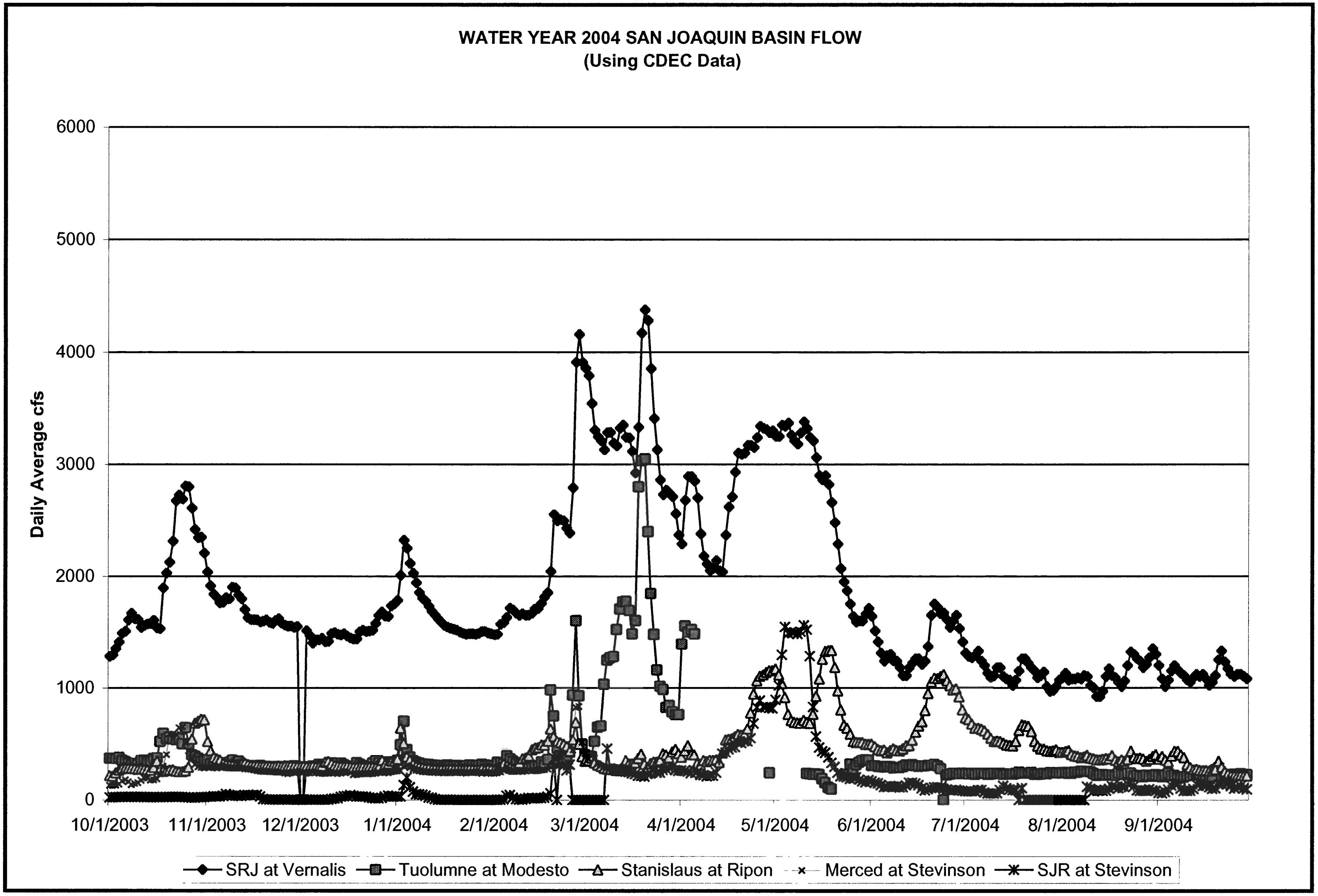
TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2005
BASED ON USGS PROVISIONAL DATA
DAILY AVERAGE CFS
12000
10000
8000
6000
4000
2000
0
9/30
10/30
11/30
12/30
1/30
2/28
3/30
4/30
5/30
6/30
7/30
8/30
DATES
COMPUTED NATURAL FLOW
ACTUAL FLOW AT LA GRANGE

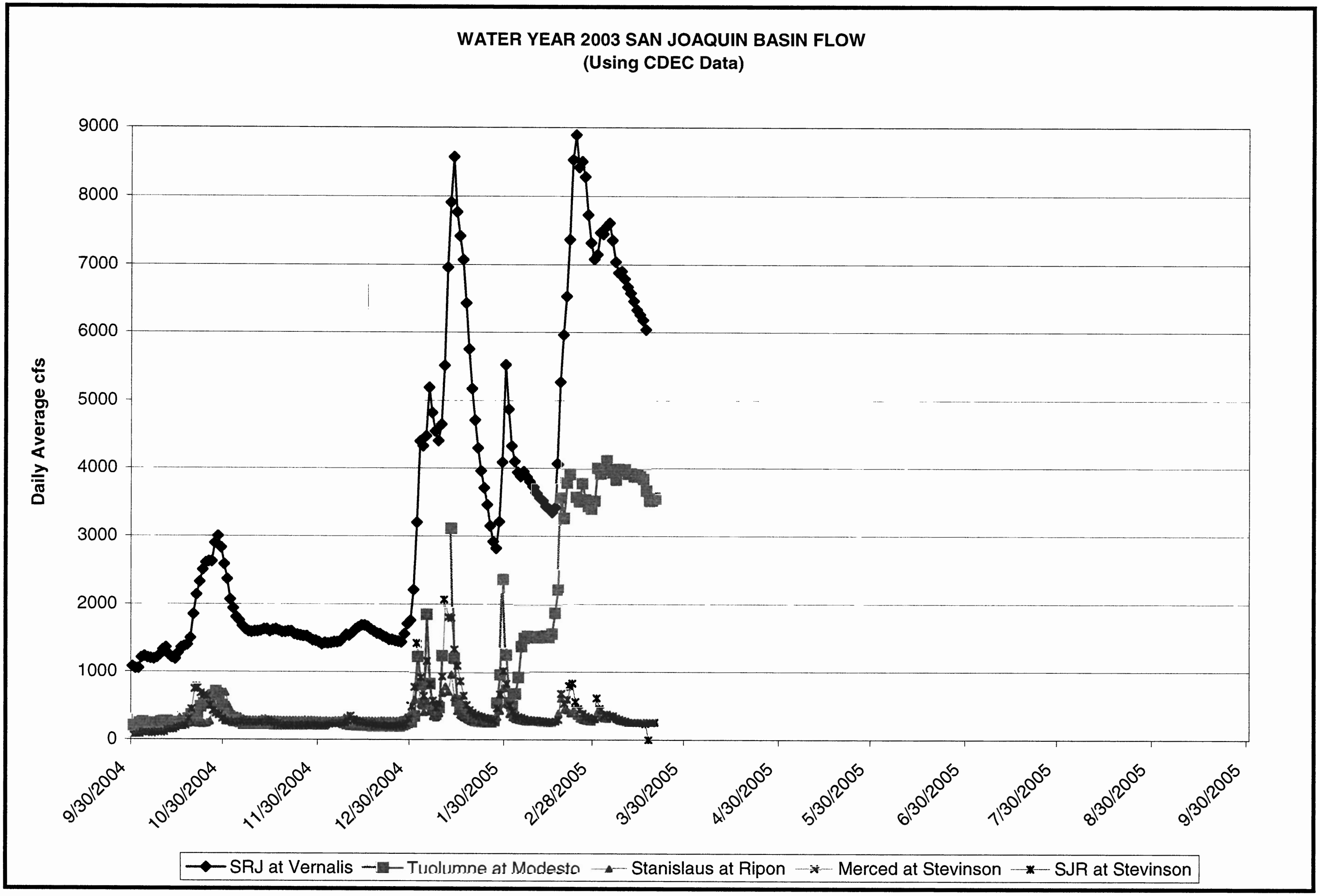
TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2004
BASED ON USGS PROVISIONAL DATA



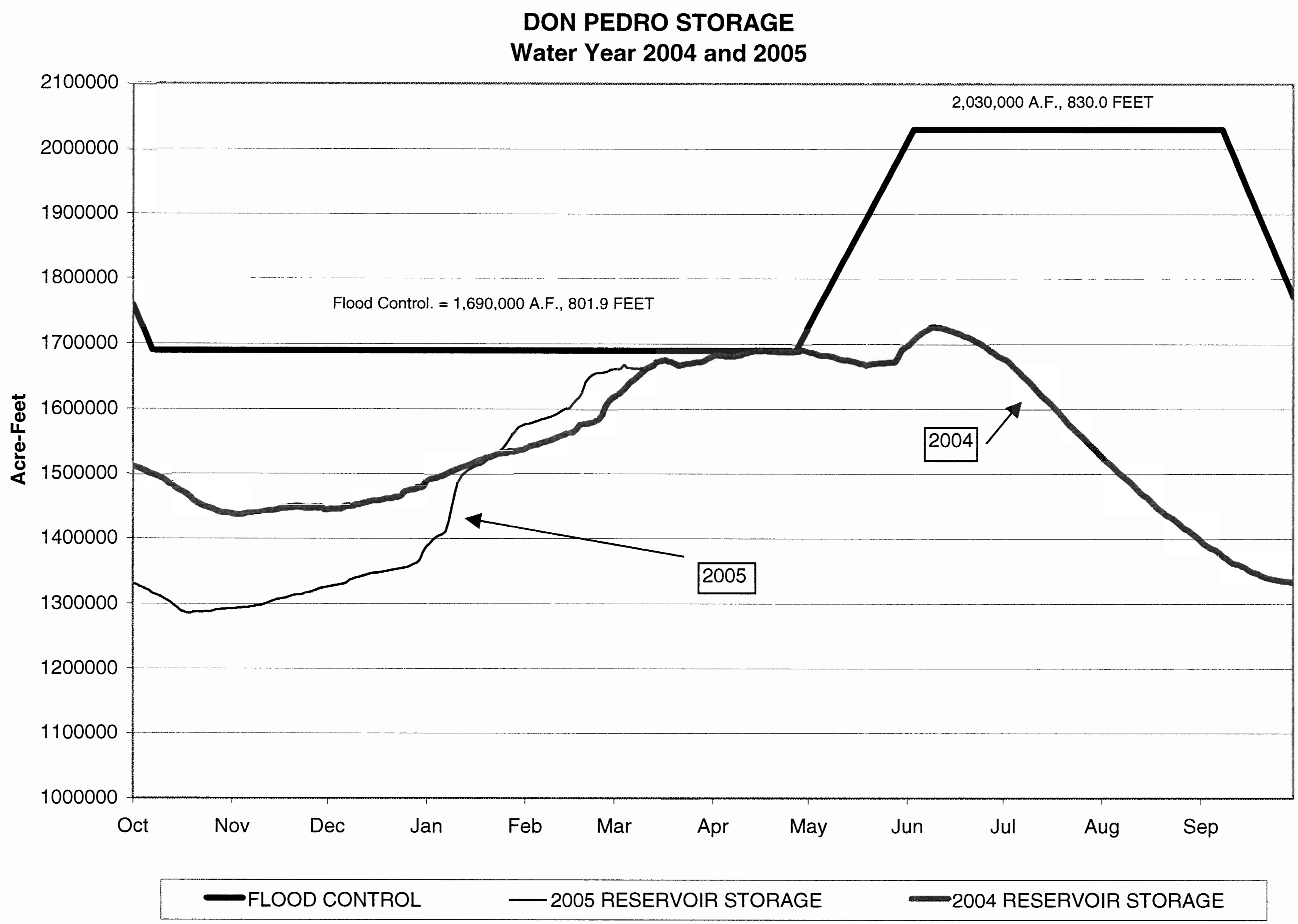
TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2005
BASED ON USGS PROVISIONAL DATA

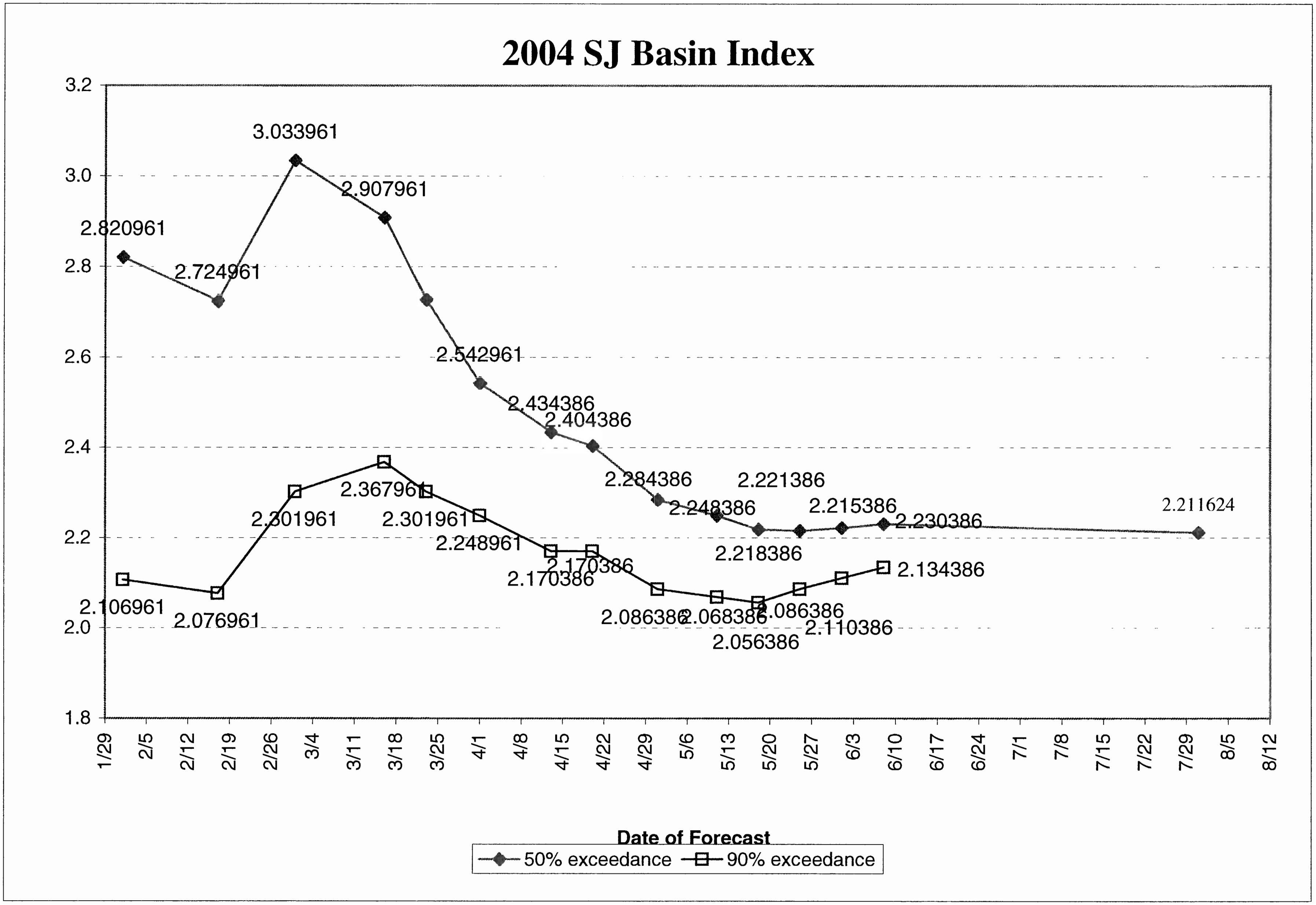



WATER YEAR 2004 SAN JOAQUIN BASIN FLOW
(Using CDEC Data)
Daily Average cfs
6000
5000
4000
3000
2000
1000
0
10/1/2003
11/1/2003
12/1/2003
1/1/2004
2/1/2004
3/1/2004
4/1/2004
5/1/2004
6/1/2004
7/1/2004
8/1/2004
9/1/2004
SRJ at Vernalis
Tuolumne at Modesto
Stanislaus at Ripon
Merced at Stevinson
SJR at Stevinson



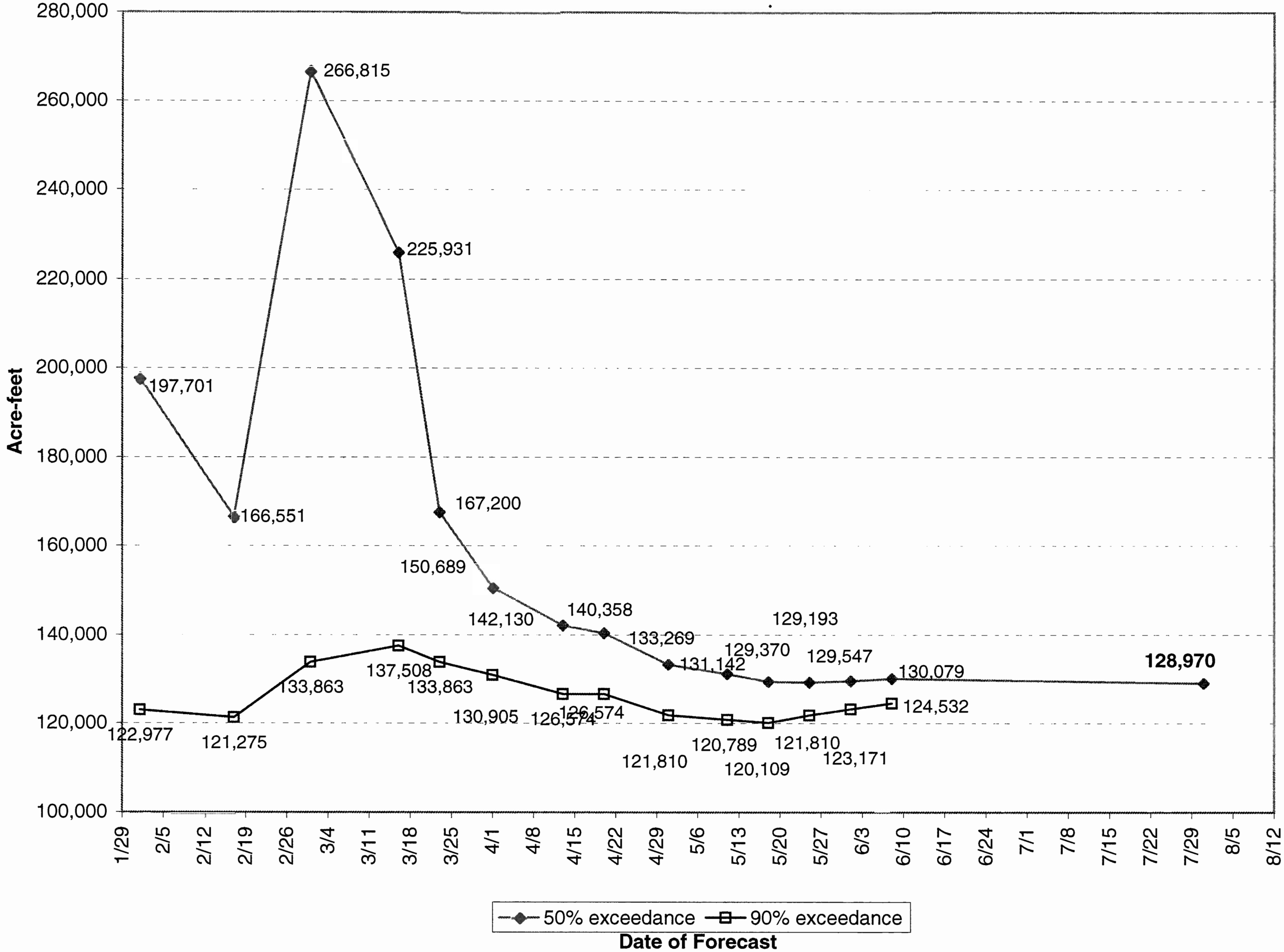
WATER YEAR 2003 SAN JOAQUIN BASIN FLOW
(Using CDEC Data)
Daily Average cfs
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
9/30/2004
10/30/2004
11/30/2004
12/30/2004
1/30/2005
2/28/2005
3/30/2005
4/30/2005
5/30/2005
6/30/2005
7/30/2005
8/30/2005
9/30/2005
SRJ at Vernalis
Tuolumne at Modesto
Stanislaus at Ripon
Merced at Stevinson
SJR at Stevinson

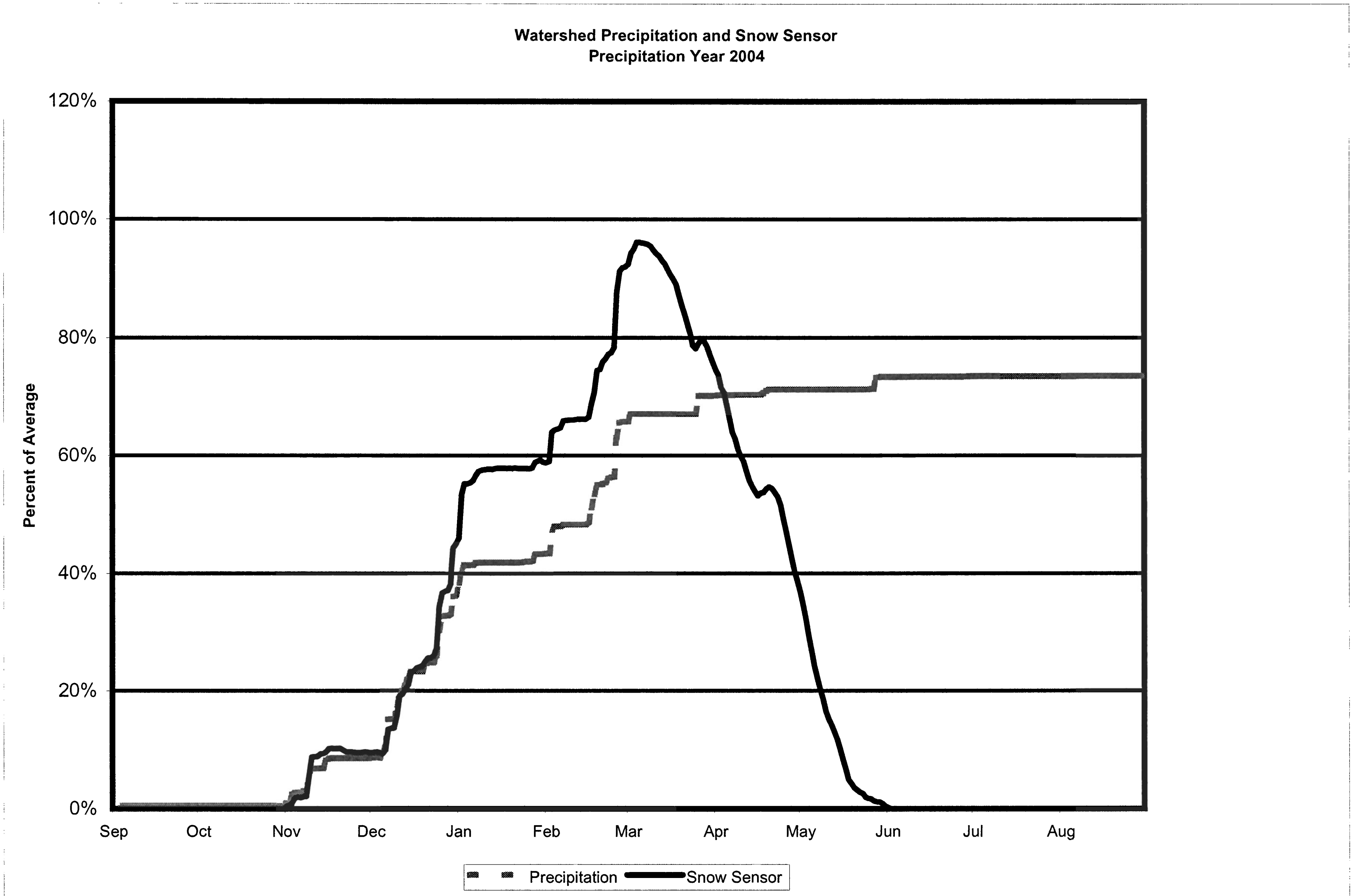

DON PEDRO STORAGE
Water Year 2004 and 2005
Acre-Feet
2100000
2000000
1900000
1800000
1700000
1600000
1500000
1400000
1300000
1200000
1100000
1000000
2,030,000 A.F., 830.0 FEET
Flood Control. = 1,690,000 A.F., 801.9 FEET
2004
2005
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
FLOOD CONTROL
2005 RESERVOIR STORAGE
2004 RESERVOIR STORAGE

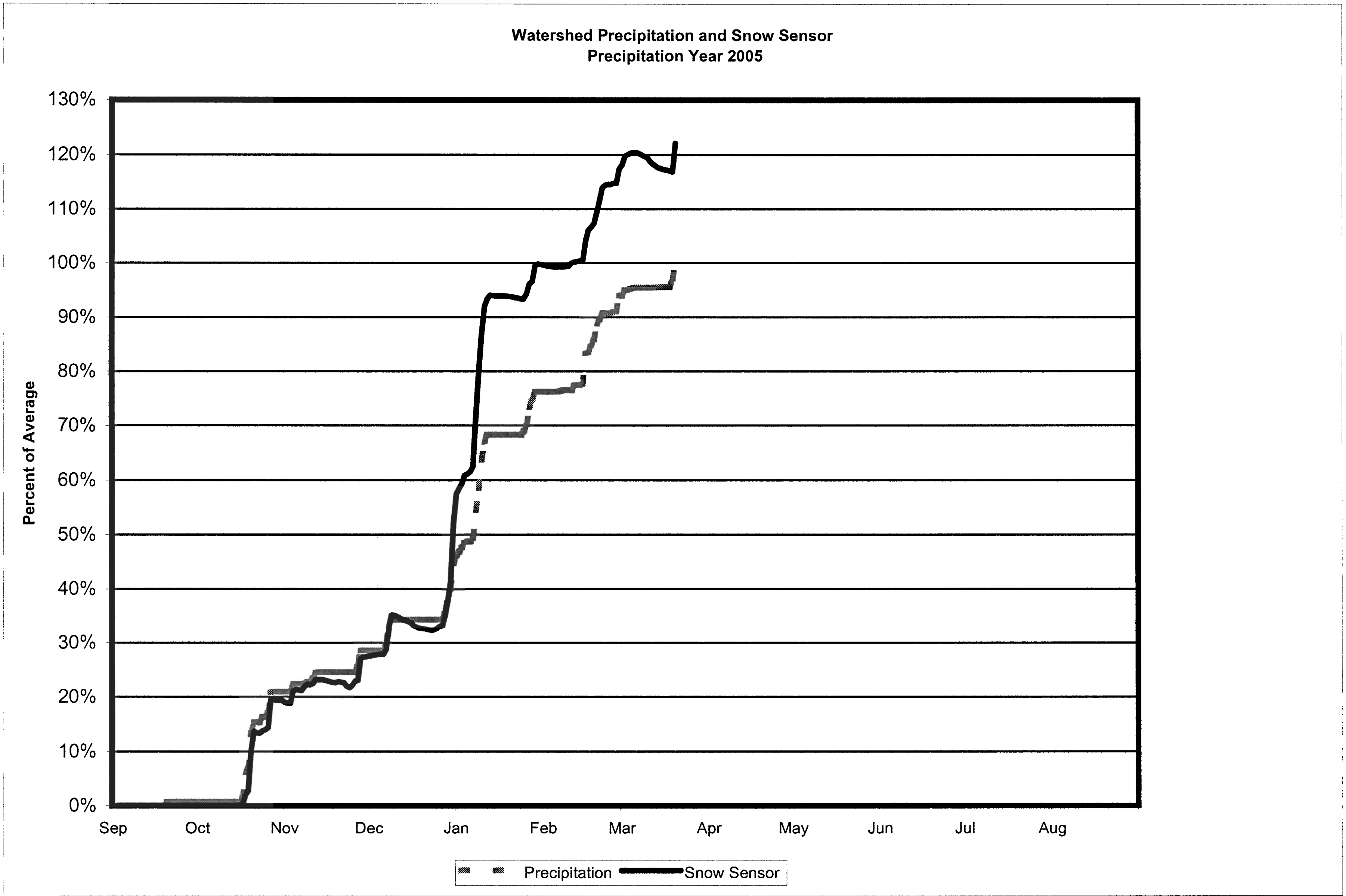


2004 SJ Basin Index
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
2.820961
2.724961
3.033961
2.907961
2.542961
2.434386
2.404386
2.284386
2.248386
2.221386
2.218386
2.215386
2.230386
2.211624
2.106961
2.076961
2.301961
2.367961
2.301961
2.248961
2.170386
2.170386
2.086386
2.068386
2.056386
2.086386
2.110386
2.134386
1/29
2/5
2/12
2/19
2/26
3/4
3/11
3/18
3/25
4/1
4/8
4/15
4/22
4/29
5/6
5/13
5/20
5/27
6/3
6/10
6/17
6/24
7/1
7/8
7/15
7/22
7/29
8/5
8/12
Date of Forecast
50% exceedance
90% exceedance

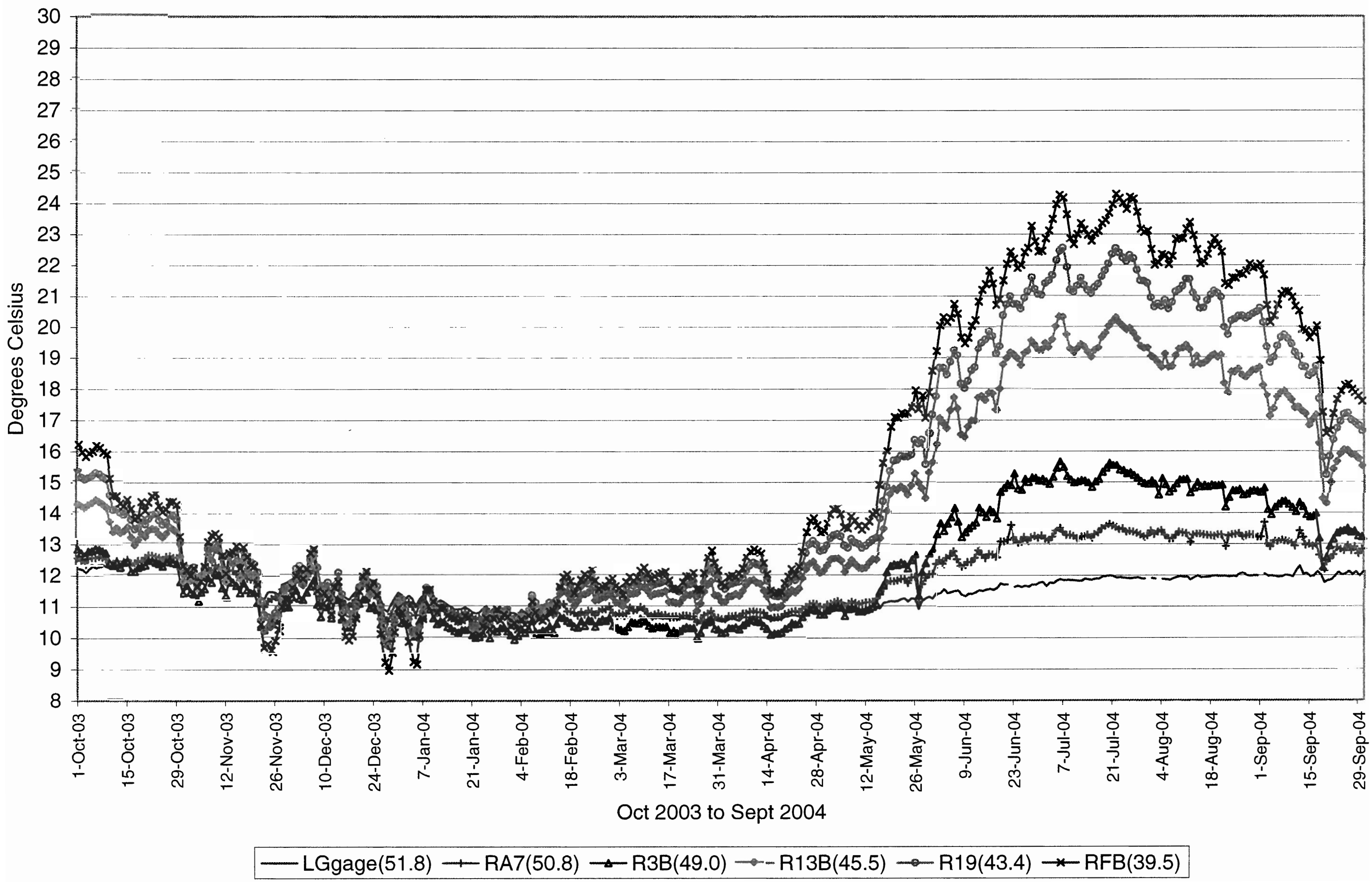
2004-05 Tuolumne FERC Flow Volume based on SJ Basin Index

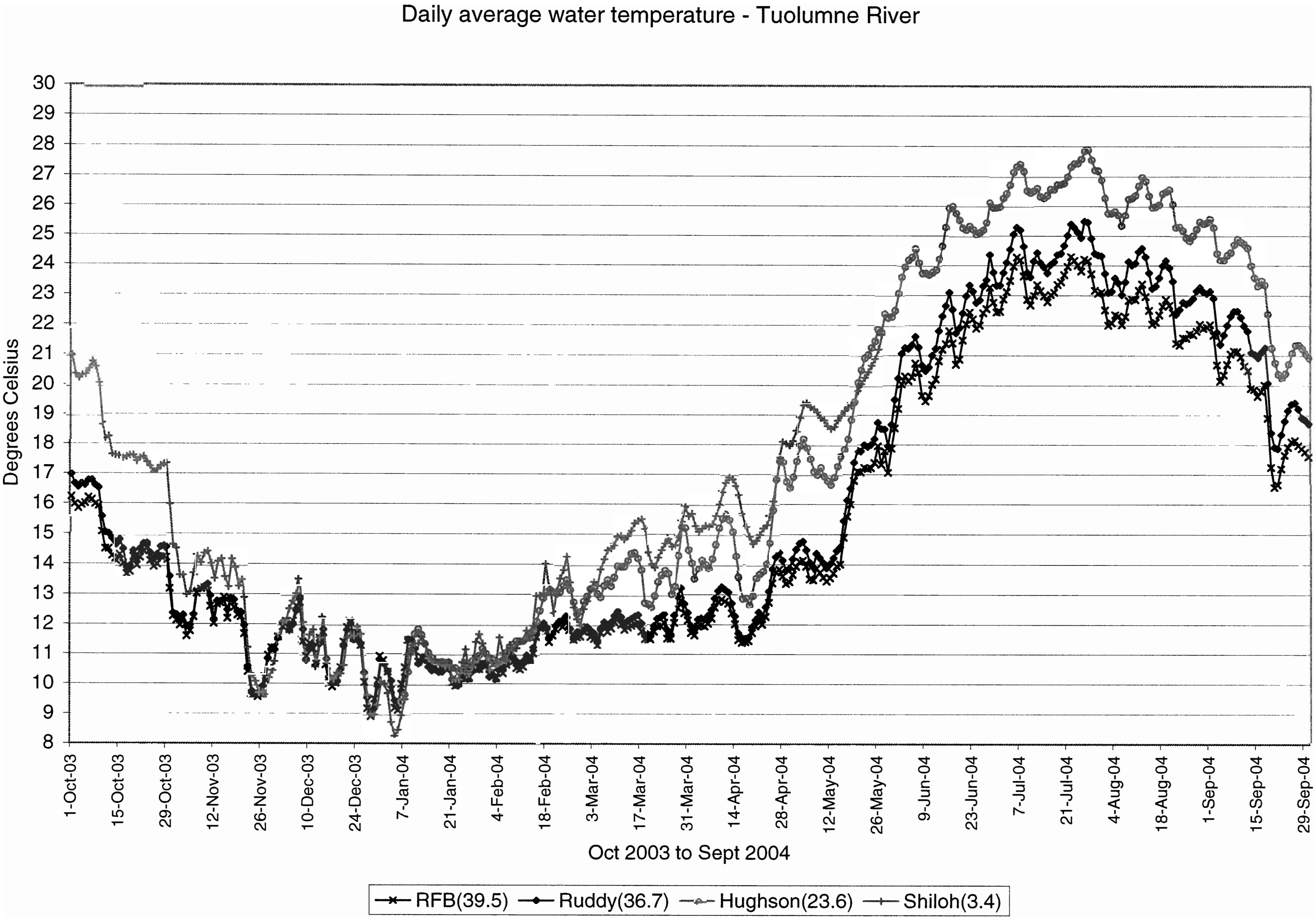


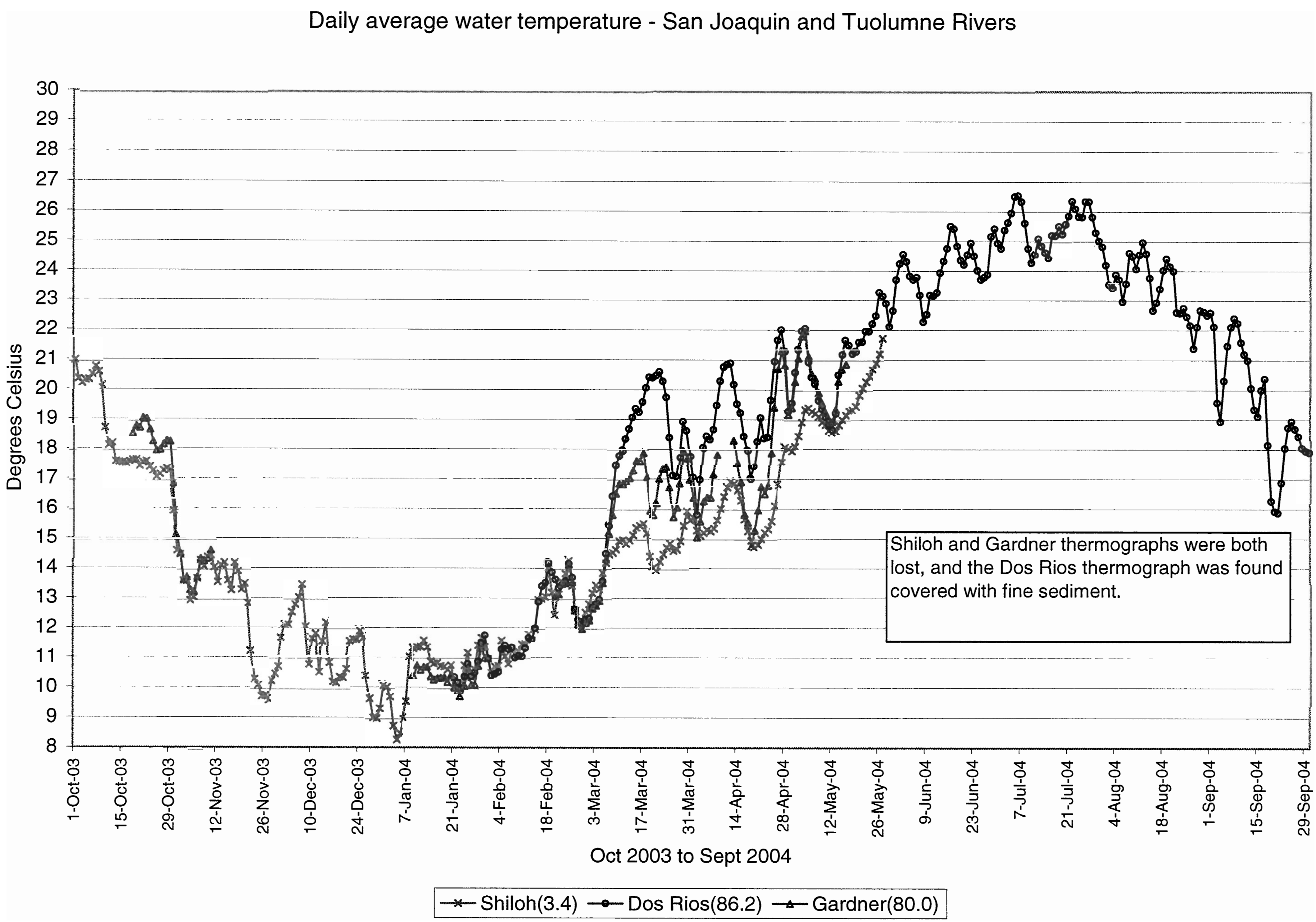

Watershed Precipitation and Snow Sensor
Precipitation Year 2004
Percent of Average
120%
100%
80%
60%
40%
20%
0%
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Precipitation
Snow Sensor


Watershed Precipitation and Snow Sensor
Precipitation Year 2005
Percent of Average
130%
120%
110%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Precipitation
Snow Sensor

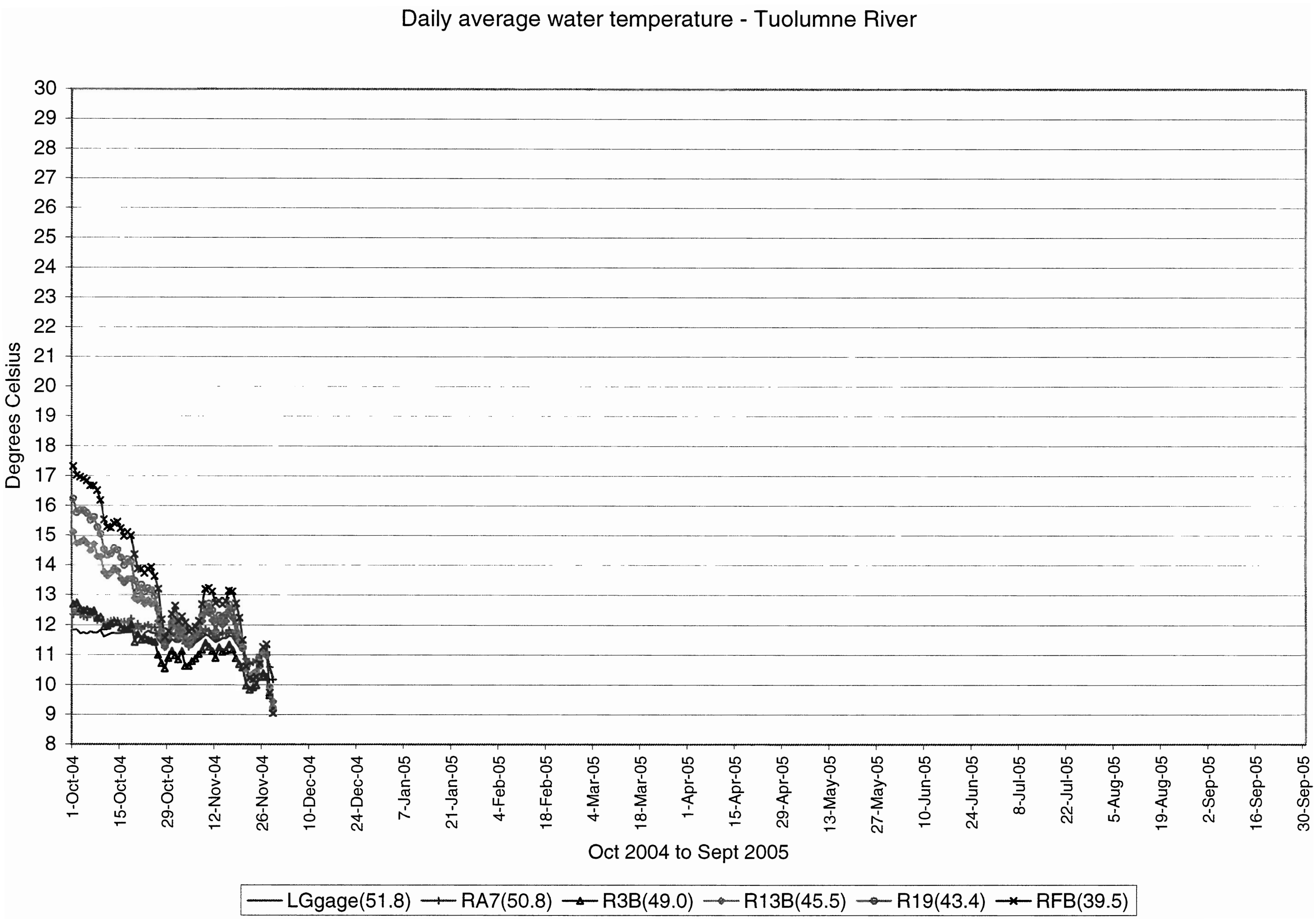
Daily average water temperature - Tuolumne River




Daily average water temperature - Tuolumne River
Degrees Celsius
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1-Oct-03
15-Oct-03
29-Oct-03
12-Nov-03
26-Nov-03
10-Dec-03
24-Dec-03
7-Jan-04
21-Jan-04
4-Feb-04
18-Feb-04
3-Mar-04
17-Mar-04
31-Mar-04
14-Apr-04
28-Apr-04
12-May-04
26-May-04
9-Jun-04
23-Jun-04
7-Jul-04
21-Jul-04
4-Aug-04
18-Aug-04
1-Sep-04
15-Sep-04
29-Sep-04
Oct 2003 to Sept 2004
RFB(39.5)
Ruddy(36.7)
Hughson(23.6)
Shiloh(3.4)



Daily average water temperature - San Joaquin and Tuolumne Rivers
Degrees Celsius
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1-Oct-03
15-Oct-03
29-Oct-03
12-Nov-03
26-Nov-03
10-Dec-03
24-Dec-03
7-Jan-04
21-Jan-04
4-Feb-04
18-Feb-04
3-Mar-04
17-Mar-04
31-Mar-04
14-Apr-04
28-Apr-04
12-May-04
26-May-04
9-Jun-04
23-Jun-04
7-Jul-04
21-Jul-04
4-Aug-04
18-Aug-04
1-Sep-04
15-Sep-04
29-Sep-04
Oct 2003 to Sept 2004
Shiloh and Gardner thermographs were both lost, and the Dos Rios thermograph was found covered with fine sediment.
Shiloh(3.4)
Dos Rios(86.2)
Gardner(80.0)


Daily average water temperature - Tuolumne River
Degrees Celsius
30
29
28
27
26
25
24
23
22
21
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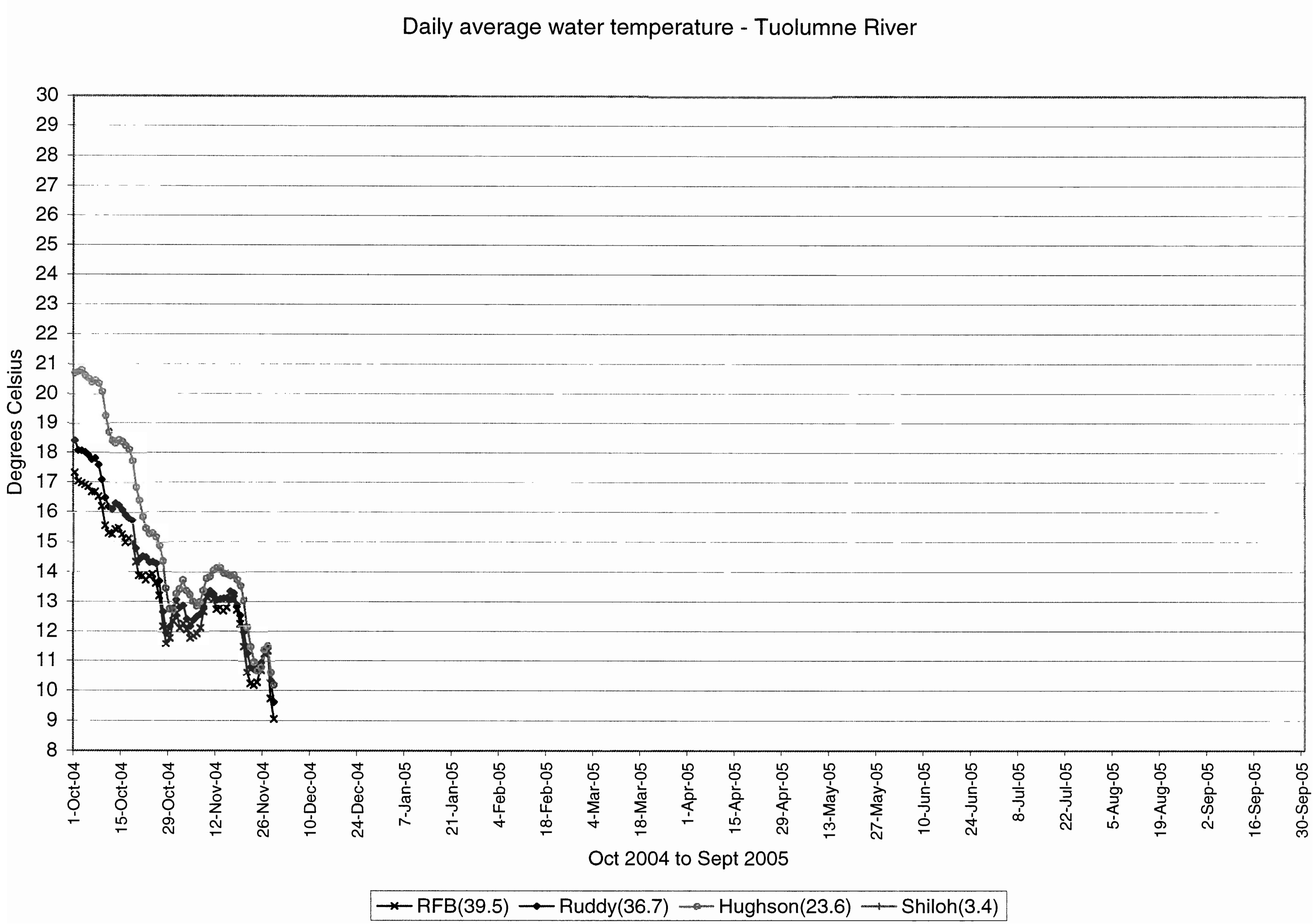
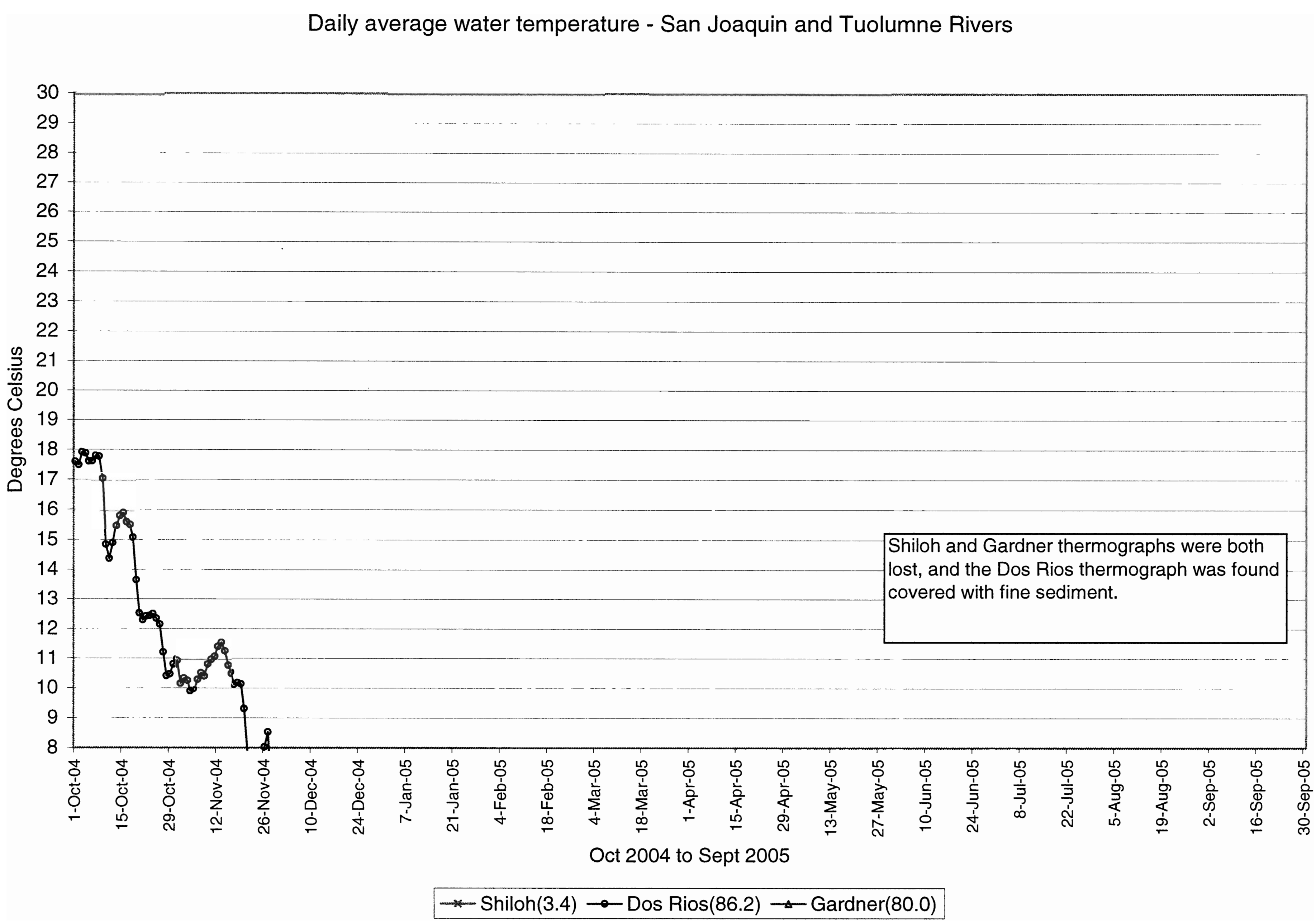
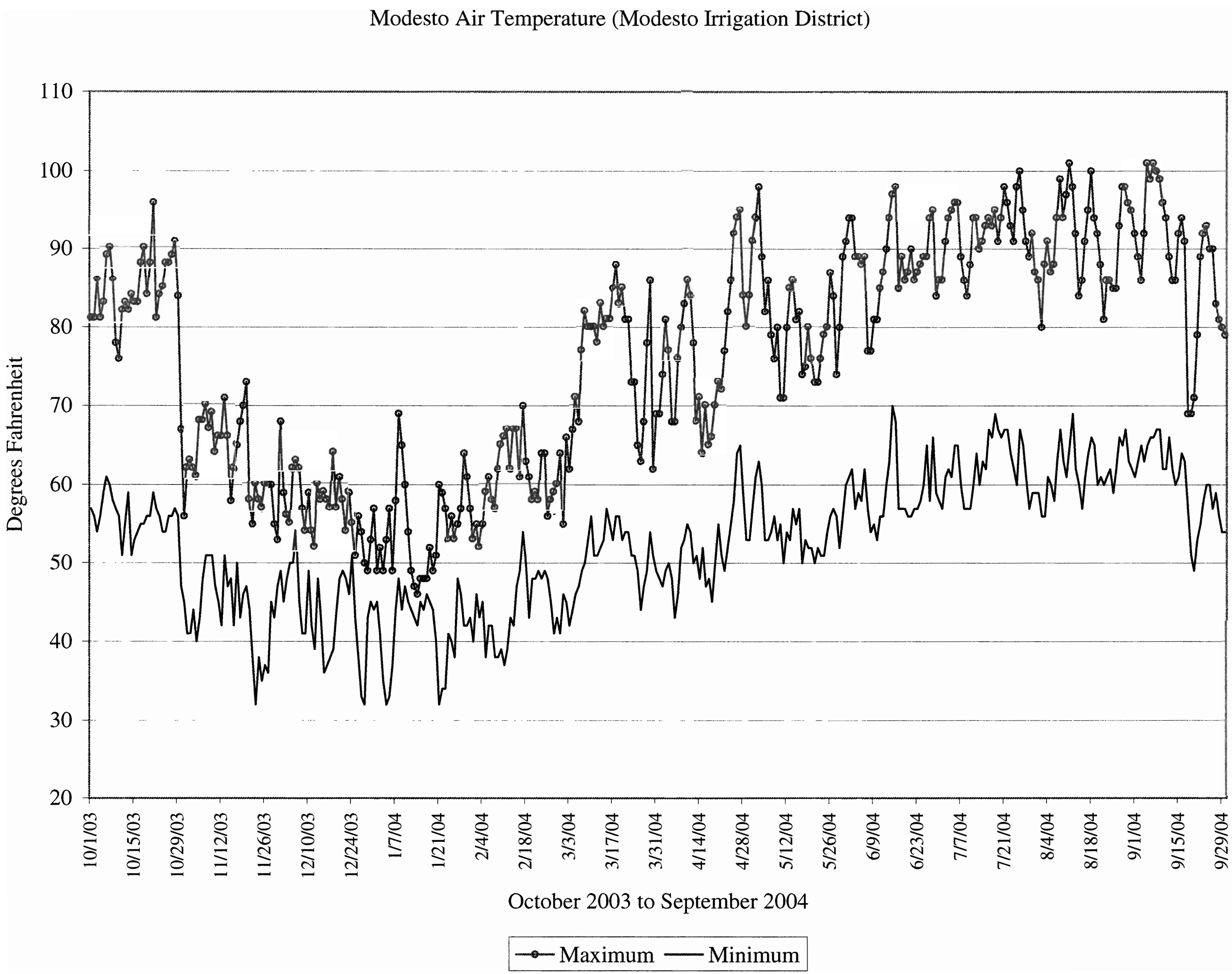
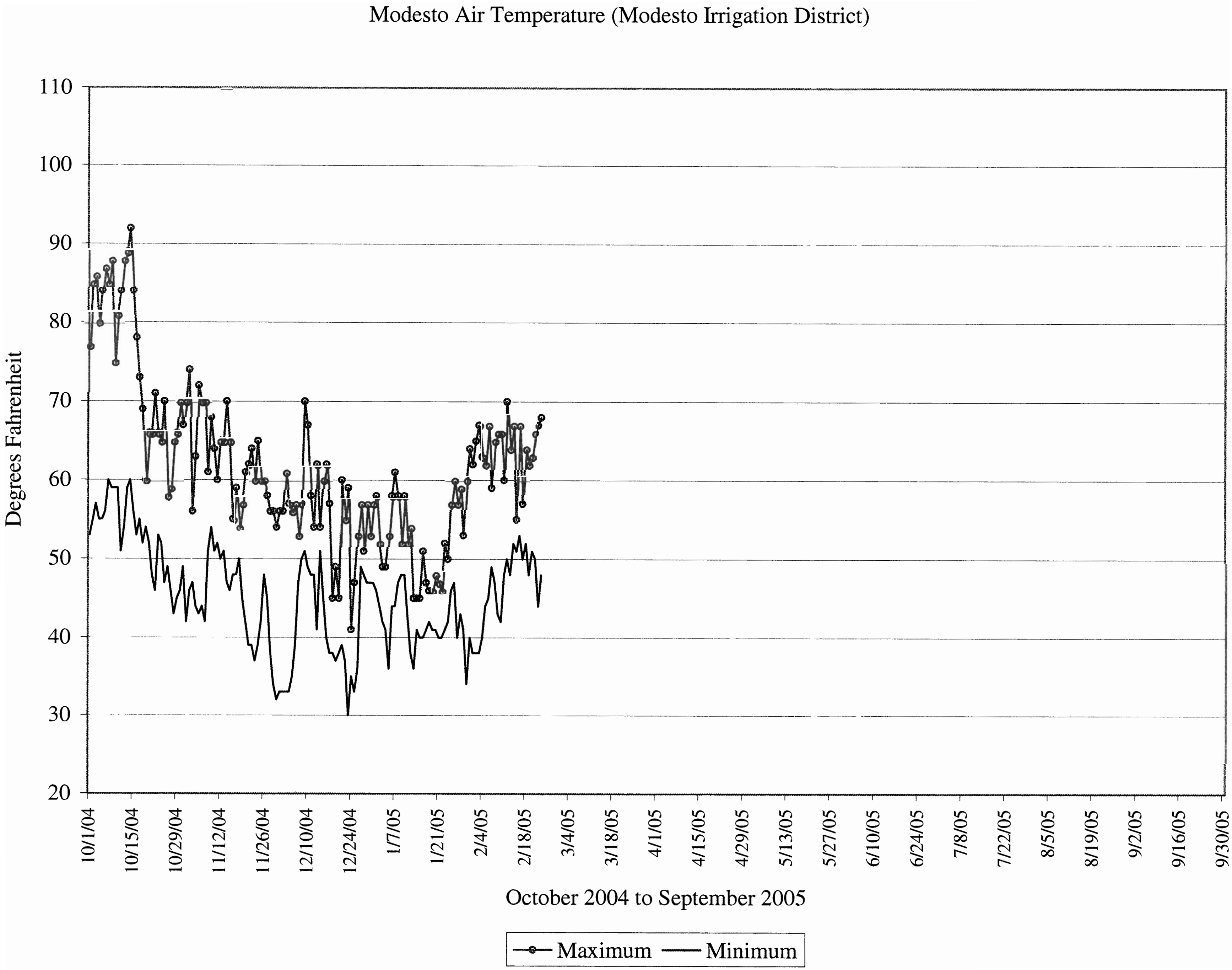
19
18
17
16
15
14
13
12
11
10
9
8
1-Oct-04
15-Oct-04
29-Oct-04
12-Nov-04
26-Nov-04
10-Dec-04
24-Dec-04
7-Jan-05
21-Jan-05
4-Feb-05
18-Feb-05
4-Mar-05
18-Mar-05
1-Apr-05
15-Apr-05
29-Apr-05
13-May-05
27-May-05
10-Jun-05
24-Jun-05
8-Jul-05
22-Jul-05
5-Aug-05
19-Aug-05
2-Sep-05
16-Sep-05
30-Sep-05
Oct 2004 to Sept 2005
LGgage(51.8)
RA7(50.8)
R3B(49.0)
R13B(45.5)
R19(43.4)
RFB(39.5)



Daily average water temperature - Tuolumne River
Degrees Celsius
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1-Oct-04
15-Oct-04
29-Oct-04
12-Nov-04
26-Nov-04
10-Dec-04
24-Dec-04
7-Jan-05
21-Jan-05
4-Feb-05
18-Feb-05
4-Mar-05
18-Mar-05
1-Apr-05
15-Apr-05
29-Apr-05
13-May-05
27-May-05
10-Jun-05
24-Jun-05
8-Jul-05
22-Jul-05
5-Aug-05
19-Aug-05
2-Sep-05
16-Sep-05
30-Sep-05
Oct 2004 to Sept 2005
RFB(39.5)
Ruddy(36.7)
Hughson(23.6)
Shiloh(3.4)


Daily average water temperature - San Joaquin and Tuolumne Rivers
Degrees Celsius
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1-Oct-04
15-Oct-04
29-Oct-04
12-Nov-04
26-Nov-04
10-Dec-04
24-Dec-04
7-Jan-05
21-Jan-05
4-Feb-05
18-Feb-05
4-Mar-05
18-Mar-05
1-Apr-05
15-Apr-05
29-Apr-05
13-May-05
27-May-05
10-Jun-05
24-Jun-05
8-Jul-05
22-Jul-05
5-Aug-05
19-Aug-05
2-Sep-05
16-Sep-05
30-Sep-05
Oct 2004 to Sept 2005
Shiloh and Gardner thermographs were both lost, and the Dos Rios thermograph was found covered with fine sediment.
Shiloh(3.4)
Dos Rios(86.2)
Gardner(80.0)


Modesto Air Temperature (Modesto Irrigation District)
Degrees Fahrenheit
110
100
90
80
70
60
50
40
30
20
10/1/03
10/15/03
10/29/03
11/12/03
11/26/03
12/10/03
12/24/03
1/7/04
1/21/04
2/4/04
2/18/04
3/3/04
3/17/04
3/31/04
4/14/04
4/28/04
5/12/04
5/26/04
6/9/04
6/23/04
7/7/04
7/21/04
8/4/04
8/18/04
9/1/04
9/15/04
9/29/04
October 2003 to September 2004
Maximum
Minimum


Modesto Air Temperature (Modesto Irrigation District)
Degrees Fahrenheit
110
100
90
80
70
60
50
40
30
20
10/1/04
10/15/04
10/29/04
11/12/04
11/26/04
12/10/04
12/24/04
1/7/05
1/21/05
2/4/05
2/18/05
3/4/05
3/18/05
4/1/05
4/15/05
4/29/05
5/13/05
5/27/05
6/10/05
6/24/05
7/8/05
7/22/05
8/5/05
8/19/05
9/2/05
9/16/05
9/30/05
October 2004 to September 2005
Maximum
Minimum

State of California – The Resources Agency
ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF FISH AND GAME
http://www.dfg.ca.gov

San Joaquin Valley and Southern Sierra Region
1234 East Shaw Avenue
Fresno, California 93710
(559) 243-4005

April 5, 2004

Mr. Robert Nees
Assistant General Manager
Water Resources and Regulatory Affairs
Post Office Box 949
Turlock, California 95381

Tuolumne River 2004-2005 FERC Article 37 Flow Schedule

Dear Mr. Nees:

Pursuant to FERC License No. 2299, Article 37, the Department of Fish and Game (Department) provides the attached flow schedule for the Tuolumne River based on the 2.7202 index which Mr. Tim Ford (Turlock Irrigation District biologist) provided to Mr. Dean Marston of my staff via e-mail on March 25, 2004.

If actual run-off is different than that which is currently forecast (e.g., result in either a higher or lower index), the Department anticipates that you will advise them of such so that we may provide you with an updated flow schedule. The Department advises you at this time that if the flow allocation index increases, the increased flow allocation should be applied to increasing fall/winter base flows and increased fall pulse flows to improve habitat quantity and quality for fall-run Chinook salmon, consistent with the FERC License No. 2299 licensing fish water management protective measures. The Department does not support, at this time, using additional water, created by an upward change in the forecast fish water allocation index, for enhanced summer flows to improve rainbow trout habitat quantity and/or quality. Should the District's (i.e., Turlock Irrigation District, Modesto Irrigation District and/or City and County of San Francisco) desire to improve summer rearing habitat for rainbow trout, they may release additional water over and above that required for minimum flows per FERC No. 22991 license requirements.

If you have any questions, please contact Mr. Dean Marston, Senior Biologist Supervisor (Marine/Fisheries) at (559) 243-4014, extension 241.

Yours sincerely,

W. E. Loudermilk

W. E. Loudermilk
Regional Manager

Attachment

cc: See page two.

cc: Mr. Dean Marston
DFG, SJVSSR

Mr. Dale Mitchell
DFG, SJVSSR

Ms. Pat Brantley
DFG, SJVSSR

Mr. Tim Heyne
DFG, SJVSSR

Mr. Tim Ford
Turlock Irrigation District

Mr. Wes Manier
Turlock Irrigation District

Mr. Jeff McLain
U. S. Fish and Wildlife Service

Ms. Madelyn Martinez
NOAA Fisheries

Lt. Phil McKay
DFG, SJVSSR

Mr. Jim White
DFG

Mr. Doug Ridgway
DFG, SJVSSR

Mr. Dennis Blakeman
DFG, SJVSSR

Table 1

Flow Schedule April 2004 through March 2005 (as of 4/5/04)

(Flow volumes interpolated according to Index Cut-off flow volumes per FERC 2299 Flow Schedule)

	Index	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**Total**
	2.442	46,631	11,068	4,463	4,612	4,612	4,463	12,744	10,711	11,068	11,068	9,997	11,068	142,505
	% Total	32.7%	7.8%	3.1%	3.2%	3.2%	3.1%	8.9%	7.5%	7.8%	7.8%	7.0%	7.8%	100%
	2.763	70,440	10,760	4,463	4,612	4,612	4,463	13,240	10,413	10,760	10,760	9,719	10,760	165,002
	% Total	42.7%	6.5%	2.7%	2.8%	2.8%	2.7%	8.0%	6.3%	6.5%	6.5%	5.9%	6.5%	100%
	Composite %	37.7%	7.1%	2.9%	3.0%	3.0%	2.9%	8.5%	6.9%	7.1%	7.1%	6.5%	7.1%	100%
2004 Index (as of 3/25/04)	**161,989**	61,080	11,572	4,727	4,885	4,885	4,727	13,742	11,199	11,572	11,572	10,453	11,572	161,989
	Base Flow (cfs)	**175**	**175**	**75**	**75**	**75**	**75**	**185**	**175**	**175**	**175**	**175**	**175**	
	Acre-feet	10,413	10,760	4,463	4,612	4,612	4,463	11,375	10,413	10,760	10,760	9,719	10,760	103,111
	Index-Base (AF)	50,667	812	265	274	274	265	2,367	786	812	812	734	812	
	Pulse Flow (AF)	**51,479**						**7,399**						58,878
	(Index-Base additional water for Apr & May)						(Index-Base additional water for June thru March)							
	To be applied Apr. 15 thru May 15						To be applied during Mid-October							

From: "Tim Ford" <tjf@tid.org>
To: <dmarston@dfg.ca.gov>, <FWM@tid.org>, <WBF@tid.org>
Date: 3/25/04 6:45PM
Subject: Re: Tuolumne River Flow Schedule

Below are my figures derived from this week's APR-JUL forecast update - still going down. I think the 01APR 50% index could slip below the 2.7202 index threshold. If so, then both the 50% and 90% would result in similar FERC spring pulse flows averaging about 700 cfs. Let me know if you have any questions.

Tim

CC: <tjf@tid.org>

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

Don Pedro Dam and Powerhouse

Thursday, April 29, 2004

Mr. William Loudermilk
Regional Manager, SJVSS Region
California Dept. of Fish and Game
1234 E. Shaw Ave.
Fresno, CA 93710

Mr. Dale Pierce
Assistant Field Supervisor
United States Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

Subject: Tuolumne River Fall 2003 Pulse Flow and Article 45-Day Period

Dear Sirs:

The following is a summary of the fall 2003 pulse flow for the Tuolumne River for the period 16 October 2003 through 20 October 2003. Provisional flow data from the USGS gage at La Grange shows that the fall pulse flow provided 1,736 acre-feet during that timeframe.

The Article 38 45-Day Period began October 17, 2003 and ended November 30, 2003. There was prior agreement by all parties to delay the start of the fall pulse flow in 2003 with the understanding there would be an overlap of four days into the 45-Day Period. In accordance with Article 38, any reduction in river height between the end of the 45-day period and March 31 shall not exceed four inches below the average height established during the 45 days. Using Provisional daily flow data from the USGS gage at La Grange for the pulse flow period, we have calculated the average flow was 273 cfs, which corresponds to a river height of 169.8 feet at the Old La Grange Bridge based on the USGS 1996 rating table. The flow during the period 1 December 2003 to 31 March 2004 never went below 154 cfs represented by a gage elevation of 169.51 feet. A table of daily USGS recorded flows for the Article 38 45-Day Period is attached (ATTACHMENT 1) as well as the final 2002-2003 Fish Flow Year Schedule (ATTACHMENT 2).

Sincerely,

Robert M. Nees
Assistant General Manager
Water Resources and Regulatory Affairs

cc: Larry Weis
Randy Baysinger
Wes Monier
John Schnagl, FERC
Allen Short, MID
William Madden, Winston and Strawn
TRTAC e-mail list

TURLOCK IRRIGATION DISTRICT

October 17 - November 30, 2003 Average Flow

In Tuolumne River at La Grange

ACTUAL FLOWS (Preliminary USGS Numbers)

DATE	FLOW CFS	DATE	FLOW CFS
16-Oct	464		
17-Oct	469	08-Nov	228
18-Oct	473	09-Nov	229
19-Oct	474	10-Nov	229
20-Oct	467	11-Nov	228
21-Oct	376	12-Nov	225
22-Oct	373	13-Nov	228
23-Oct	375	14-Nov	226
24-Oct	377	15-Nov	225
25-Oct	377	16-Nov	223
26-Oct	278	17-Nov	220
27-Oct	276	18-Nov	227
28-Oct	281	19-Nov	226
29-Oct	282	20-Nov	228
30-Oct	279	21-Nov	227
31-Oct	232	22-Nov	232
01-Nov	234	23-Nov	224
02-Nov	246	24-Nov	225
03-Nov	247	25-Nov	220
04-Nov	242	26-Nov	220
05-Nov	243	27-Nov	220
06-Nov	243	28-Nov	242
07-Nov	254	29-Nov	229
		30-Nov	228
		TOTAL RELEASE=	12,307

45 day average = 273.5 cfs = 169.84 ft elevation *

Less 4 inches -0.33

Minimum Flow = 153.6 CFS = 169.51 ft elevation *

* From U.S.G.S. table 22

October 16-20 Pulse Flow Period

Attachment 2

Tuolumne River Flow Schedule

30SEP2003 Final

SCHEDULE FOR 2003 - 2004 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW			ADDITIONAL FLOW			TOTAL FERC FLOW	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
12-Apr-2003	12-Apr-2003	1	150	298		275	545	545	0	0	0	425	545
13-Apr-2003	13-Apr-2003	1	150	298		550	1,091	1,636	0	0	0	700	1,636
14-Apr-2003	14-Apr-2003	1	150	298		856	1,699	3,335	0	0	0	1,006	3,335
15-Apr-2003	15-Apr-2003	1	150	298	298	856	1,699	5,034	0	0	0	1,006	5,332
16-Apr-2003	16-Apr-2003	1	150	298	595	856	1,699	6,733	0	0	0	1,006	7,328
17-Apr-2003	17-Apr-2003	1	150	298	893	856	1,699	8,432	0	0	0	1,006	9,324
18-Apr-2003	18-Apr-2003	1	150	298	1,190	856	1,699	10,130	0	0	0	1,006	11,321
19-Apr-2003	19-Apr-2003	1	150	298	1,488	856	1,699	11,829	0	0	0	1,006	13,317
20-Apr-2003	20-Apr-2003	1	150	298	1,785	856	1,699	13,528	0	0	0	1,006	15,313
21-Apr-2003	21-Apr-2003	1	150	298	2,083	856	1,699	15,227	0	0	0	1,006	17,310
22-Apr-2003	22-Apr-2003	1	150	298	2,380	856	1,699	16,926	0	0	0	1,006	19,306
23-Apr-2003	23-Apr-2003	1	150	298	2,678	630	1,250	18,175	0	0	0	780	20,853
24-Apr-2003	24-Apr-2003	1	150	298	2,975	430	853	19,028	0	0	0	580	22,003
25-Apr-2003	25-Apr-2003	1	150	298	3,273	280	555	19,584	0	0	0	430	22,856
26-Apr-2003	26-Apr-2003	1	150	298	3,570	280	555	20,139	0	0	0	430	23,709
27-Apr-2003	27-Apr-2003	1	150	298	3,868	280	555	20,694	0	0	0	430	24,562
28-Apr-2003	28-Apr-2003	1	150	298	4,165	280	555	21,250	0	0	0	430	25,415
29-Apr-2003	29-Apr-2003	1	150	298	4,463	280	555	21,805	0	0	0	430	26,268
30-Apr-2003	30-Apr-2003	1	150	298	4,760	280	555	22,360	0	0	0	430	27,121
1-May-2003	1-May-2003	1	150	298	5,058	280	555	22,916	0	0	0	430	27,974
2-May-2003	2-May-2003	1	150	298	5,355	280	555	23,471	0	0	0	430	28,827
3-May-2003	3-May-2003	1	150	298	5,653	280	555	24,027	0	0	0	430	29,679
4-May-2003	4-May-2003	1	150	298	5,950	280	555	24,582	0	0	0	430	30,532
5-May-2003	5-May-2003	1	150	298	6,248	280	555	25,137	0	0	0	430	31,385
6-May-2003	6-May-2003	1	150	298	6,545	420	833	25,970	0	0	0	570	32,516
7-May-2003	7-May-2003	1	150	298	6,843	420	833	26,803	0	0	0	570	33,646
8-May-2003	8-May-2003	1	150	298	7,140	420	833	27,637	0	0	0	570	34,777
9-May-2003	9-May-2003	1	150	298	7,438	420	833	28,470	0	0	0	570	35,908
10-May-2003	10-May-2003	1	150	298	7,736	420	833	29,303	0	0	0	570	37,038
11-May-2003	11-May-2003	1	150	298	8,033	420	833	30,136	0	0	0	570	38,169
12-May-2003	12-May-2003	1	150	298	8,331	380	754	30,889	0	0	0	530	39,220
13-May-2003	13-May-2003	1	150	298	8,628	250	496	31,385	0	0	0	400	40,013
14-May-2003	14-May-2003	1	150	298	8,926	250	496	31,881	0	0	0	400	40,807
15-May-2003	15-May-2003	1	150	298	9,223	175	347	32,228	0	0	0	325	41,451
16-May-2003	16-May-2003	1	150	298	9,521	125	248	32,476	0	0	0	275	41,997
17-May-2003	17-May-2003	1	150	298	9,818	72	143	32,619	0	0	0	222	42,437
18-May-2003	19-May-2003	2	150	595	10,413		0	32,619	0	0	0	150	43,032
20-May-2003	20-May-2003	1	175	347	10,760		0	32,619	175	347	347	350	43,726
21-May-2003	28-May-2003	8	175	2,777	13,537		0	32,619	375	5,950	6,298	550	52,454
29-May-2003	29-May-2003	1	75	149	13,686		0	32,619	400	793	7,091	475	53,396
30-May-2003	30-May-2003	1	75	149	13,835		0	32,619	225	446	7,537	300	53,991
31-May-2003	31-May-2003	1	75	149	13,983		0	32,619	175	347	7,884	250	54,487
1-Jun-2003	12-Jun-2003	12	75	1,785	15,769		0	32,619	175	4,165	12,050	250	60,437
13-Jun-2003	13-Jun-2003	1	75	149	15,917		0	32,619	135	268	12,317	210	60,854
14-Jun-2003	24-Jun-2003	11	75	1,636	17,554		0	32,619	105	2,291	14,608	180	64,781
25-Jun-2003	29-Jun-2003	5	75	744	18,298		0	32,619	160	1,587	16,195	235	67,112
30-Jun-2003	2-Jul-2003	3	75	446	18,744		0	32,619	120	714	16,909	195	68,272
3-Jul-2003	6-Jul-2003	4	75	595	19,339		0	32,619	160	1,269	18,179	235	70,136
7-Jul-2003	8-Jul-2003	2	75	298	19,636		0	32,619	120	476	18,655	195	70,910
9-Jul-2003	31-Jul-2003	23	75	3,421	23,058		0	32,619	160	7,299	25,954	235	81,631
1-Aug-2003	16-Aug-2003	16	75	2,380	25,438		0	32,619	120	3,808	29,762	195	87,819
17-Aug-2003	19-Aug-2003	3	75	446	25,884		0	32,619	160	952	30,714	235	89,217
20-Aug-2003	23-Aug-2003	4	75	595	26,479		0	32,619	120	952	31,666	195	90,764
24-Aug-2003	25-Aug-2003	2	75	298	26,777		0	32,619	160	635	32,301	235	91,697
26-Aug-2003	28-Aug-2003	3	75	446	27,223		0	32,619	120	714	33,015	195	92,857
29-Aug-2003	5-Sep-2003	8	75	1,190	28,413		0	32,619	160	2,539	35,554	235	96,586
6-Sep-2003	11-Sep-2003	6	75	893	29,306		0	32,619	120	1,428	36,982	195	98,907
12-Sep-2003	14-Sep-2003	3	75	446	29,752		0	32,619	160	952	37,934	235	100,305
15-Sep-2003	19-Sep-2003	5	75	744	30,496		0	32,619	120	1,190	39,124	195	102,239
20-Sep-2003	24-Sep-2003	5	75	744	31,240		0	32,619	160	1,587	40,711	235	104,569
25-Sep-2003	30-Sep-2003	6	75	893	32,132		0	32,619	120	1,428	42,139	195	106,890
1-Oct-2003	15-Oct-2003	15	200	5,950	38,083		0	32,619	0	0	42,139	200	112,840
16-Oct-2003	20-Oct-2003	5	175	1,736	39,818	175	1,736	34,355	100	991	43,130	450	117,303
21-Oct-2003	25-Oct-2003	5	175	1,736	41,554		0	34,355	175	1,736	44,866	350	120,774
26-Oct-2003	30-Oct-2003	5	175	1,736	43,289		0	34,355	75	744	45,609	250	123,254
31-Oct-2003	30-Nov-2003	31	175	10,760	54,050		0	34,355	35	2,160	47,770	210	136,174
1-Dec-2003	31-Dec-2003	31	175	10,760	64,810		0	34,355	35	2,160	49,930	210	149,095
1-Jan-2004	31-Jan-2004	31	175	10,760	75,570		0	34,355	35	2,160	52,091	210	162,016
1-Feb-2004	29-Feb-2004	29	175	10,066	85,636		0	34,355	35	2,021	54,112	210	174,103
1-Mar-2004	31-Mar-2004	31	175	10,760	96,397		0	34,355	35	2,160	56,272	210	187,024
1-Apr-2004	14-Apr-2004	14	175	4,860	101,256		0	34,355	35	976	57,248	210	192,859

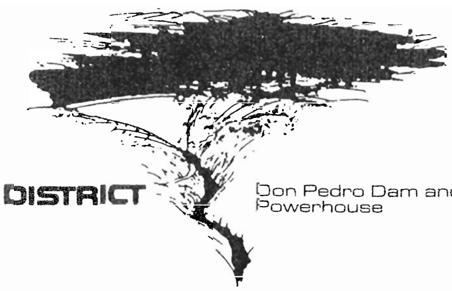
No. of days 366 (April 15 through April 14)

1 cfs day = 1.983471 acre-feet (af) 0.785953 90

Notes: 1. Based on 60-20-20 Index is 2,815,099 July 31, 1996 FERC Order Flow Interpolated as 192,859 AF fish flow year requirement. 70

2. The pulse flows are a target that represents a daily average. 192,859

2004


Don Pedro Dam and Powerhouse

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

May 5, 2004

Mr. Dean Marston
California Dept. of Fish and Game
1234 E. Shaw Ave.
Fresno, CA 93710

Ms. Deborah Giglio
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

RE: Tuolumne River 2004-2005 FERC Article 37 Flow Schedule

Dear Fishery Agency representatives:

The 1996 FERC Order, Amended Article 37, contained a Water Year Classification Index for determining the volume of scheduled stream flows for each fish flow year. The classifications were based on the San Joaquin Basin 60-20-20 Indices for water years 1906-1995. The order stated, "60-20-20 index numbers used each year shall be updated to incorporate subsequent water years pursuant to standard Water Resources Department procedures so as to maintain approximately the same frequency distribution of water year types." The index is updated to incorporate water years 1996 through 2003 (TABLE 1). While the frequency distribution remains the same, some index numbers may change slightly with each annual update to maintain the frequency distribution.

The DWR April 1, 2004 60-20-20 San Joaquin Basin Index 50% exceedence forecast of 2.5424 corresponded to 150,689 acre-feet (AF) of volume for the fish flow year, based on accepted interpolation of the updated FERC Article 37 Flow Requirements table (TABLE 3). The 90% exceedence forecast index was 2.2484, corresponding to 130,905 AF. These figures were provided to the TRTAC via e-mail on April 8, along with a projection of a lower April 13 50% exceedence forecast of 2.424786 based on the continued dry conditions, and corresponding projections of 141,563 acre-feet in FERC volume. The April 20 DWR update did have a 50% index reduced down to 2.404649, corresponding to 140,373 AF, and a 90% index of 2.1706, corresponding to 126,588 AF. Attached is the initial Tuolumne River flow schedule for the 2004-2005 FERC fish flow year (TABLE 2). The schedule will be updated later to reflect changes in the basin index and the total annual volume, as has been done in recent years.

Implementation of the spring pulse flow portion of the schedule began on April 13, 2003 as part of basin-wide flow coordination within the Vernalis Adaptive Management Plan (VAMP) process. The attached schedule reflects a spring pulse flow schedule in accordance with the VAMP target flows at Vernalis beginning on April 15 and is subject to change. Extended multi-day flow transition periods are planned for mid and late May flow reductions in the current schedule.

Attachment 1 is the April 5 letter received from the Department of Fish and Game, based on information prior to the April 1 forecast.

If you have any questions, please contact Wes Monier at 209-883-8321.

Sincerely,

Robert Nees
Assistant General Manager
Water Resources and Regulatory Affairs Administration

C: Larry Weis - TID
Allen Short - MID
Walt Ward - MID
Magalie Salas – FERC Secretary
George Taylor - FERC

TABLE 1
DETERMINATION OF WATER YEAR CLASSIFICATION THRESHOLDS
Water Year Classification

Water Year Classification	Cumulative Occurrence				602020 INDEX (x 1000)								
					Settlement Agreement	1996	1997	1998	1999	2000	2001	2002	2003
Critical Water Year and Below	0.0%	-	6.4%	<	1500	1,441	1,441	1,441	1,476	1,476	1,476	1,476	1,476
Median Critical Water Year	6.4%	-<	14.4%	>=	1500	1,441	1,441	1,441	1,476	1,476	1,476	1,476	1,476
Intermediate Critical Dry Water Year	14.4%	-<	20.5%	>=	2000	1,964	1,964	1,964	1,964	1,964	1,964	1,964	2,002
Median Dry	20.5%	-<	31.3%	>=	2200	2,159	2,159	2,183	2,183	2,183	2,183	2,183	2,187
Intermediate Dry-Below Normal	31.3%	-<	40.4%	>=	2400	2,441	2,441	2,442	2,442	2,442	2,442	2,441	2,441
Median Below Normal	40.4%	-<	50.7%	>=	2700	2,698	2,720	2,720	2,720	2,763	2,720	2,720	2,720
* Intermediate Below Normal-Above Normal	50.7%	-<	66.2%	>=	3100	3,139	3,139	3,183	3,183	3,225	3,183	3,183	3,139
Median Above Normal	66.2%	-<	71.3%	>=	3100	3,689	3,689	3,740	3,740	3,689	3,689	3,689	3,669
Intermediate Above Normal-Wet	71.3%	-<	86.7%	>=	3100	3,898	3,903	4,028	4,028	3,903	3,903	3,903	3,898
Median Wet/Maximum	86.7%	-<	100.0%	>=	3100	4,593	4,593	4,653	4,653	4,653	4,653	4,653	4,593

* Maximum index value for fish flow year is not to go above value shown in this row.
** The index in the Settlement Agreement was based on Water Years 1906-1995

TABLE 2

Tuolumne River Flow Schedule

19APR2004

SCHEDULE FOR 2004 - 2005 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW			ADDITIONAL FLOW			TOTAL FERC FLOW	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
12-Apr-2004	12-Apr-2004	1	210	417			0	0	0	0	0	210	0
13-Apr-2004	13-Apr-2004	1	210	417		490	972	972	0	0	0	700	972
14-Apr-2004	14-Apr-2004	1	210	417		690	1,369	2,340	0	0	0	900	2,340
15-Apr-2004	15-Apr-2004	1	150	298	298	750	1,488	3,828	0	0	0	900	4,126
16-Apr-2004	16-Apr-2004	1	150	298	595	750	1,488	5,316	0	0	0	900	5,911
17-Apr-2004	17-Apr-2004	1	150	298	893	750	1,488	6,803	0	0	0	900	7,696
18-Apr-2004	18-Apr-2004	1	150	298	1,190	750	1,488	8,291	0	0	0	900	9,481
19-Apr-2004	19-Apr-2004	1	150	298	1,488	750	1,488	9,779	0	0	0	900	11,266
20-Apr-2004	20-Apr-2004	1	150	298	1,785	750	1,488	11,266	0	0	0	900	13,051
21-Apr-2004	21-Apr-2004	1	150	298	2,083	750	1,488	12,754	0	0	0	900	14,836
22-Apr-2004	22-Apr-2004	1	150	298	2,380	700	1,388	14,142	0	0	0	850	16,522
23-Apr-2004	23-Apr-2004	1	150	298	2,678	750	1,488	15,630	0	0	0	900	18,307
24-Apr-2004	24-Apr-2004	1	150	298	2,975	500	992	16,621	0	0	0	650	19,597
25-Apr-2004	25-Apr-2004	1	150	298	3,273	450	893	17,514	0	0	0	600	20,787
26-Apr-2004	26-Apr-2004	1	150	298	3,570	450	893	18,407	0	0	0	600	21,977
27-Apr-2004	27-Apr-2004	1	150	298	3,868	450	893	19,299	0	0	0	600	23,167
28-Apr-2004	28-Apr-2004	1	150	298	4,165	450	893	20,192	0	0	0	600	24,357
29-Apr-2004	29-Apr-2004	1	150	298	4,463	450	893	21,084	0	0	0	600	25,547
30-Apr-2004	30-Apr-2004	1	150	298	4,760	450	893	21,977	0	0	0	600	26,737
1-May-2004	1-May-2004	1	150	298	5,058	450	893	22,869	0	0	0	600	27,927
2-May-2004	2-May-2004	1	150	298	5,355	450	893	23,762	0	0	0	600	29,117
3-May-2004	3-May-2004	1	150	298	5,653	450	893	24,655	0	0	0	600	30,307
4-May-2004	4-May-2004	1	150	298	5,950	450	893	25,547	0	0	0	600	31,498
5-May-2004	5-May-2004	1	150	298	6,248	450	893	26,440	0	0	0	600	32,688
6-May-2004	6-May-2004	1	150	298	6,545	450	893	27,332	0	0	0	600	33,878
7-May-2004	7-May-2004	1	150	298	6,843	450	893	28,225	0	0	0	600	35,068
8-May-2004	8-May-2004	1	150	298	7,140	450	893	29,117	0	0	0	600	36,258
9-May-2004	9-May-2004	1	150	298	7,438	450	893	30,010	0	0	0	600	37,448
10-May-2004	10-May-2004	1	150	298	7,736	450	893	30,902	0	0	0	600	38,638
11-May-2004	11-May-2004	1	150	298	8,033	450	893	31,795	0	0	0	600	39,828
12-May-2004	12-May-2004	1	150	298	8,331	450	893	32,688	0	0	0	600	41,018
13-May-2004	13-May-2004	1	150	298	8,628	450	893	33,580	0	0	0	600	42,208
14-May-2004	14-May-2004	1	150	298	8,926	425	843	34,423	0	0	0	575	43,349
15-May-2004	15-May-2004	1	150	298	9,223	300	595	35,018	0	0	0	450	44,241
16-May-2004	16-May-2004	1	150	298	9,521	175	347	35,365	0	0	0	325	44,886
17-May-2004	17-May-2004	1	150	298	9,818	75	149	35,514	0	0	0	225	45,332
18-May-2004	18-May-2004	1	150	298	10,116		0	35,514	0	0	0	150	45,630
19-May-2004	19-May-2004	1	150	298	10,413		0	35,514	0	0	0	150	45,927
20-May-2004	20-May-2004	1	150	298	10,711		0	35,514	0	0	0	150	46,225
21-May-2004	21-May-2004	1	150	298	11,008		0	35,514	0	0	0	150	46,522
22-May-2004	22-May-2004	1	150	298	11,306		0	35,514	0	0	0	150	46,820
23-May-2004	23-May-2004	1	150	298	11,603		0	35,514	0	0	0	150	47,117
24-May-2004	24-May-2004	1	150	298	11,901		0	35,514	0	0	0	150	47,415
25-May-2004	25-May-2004	1	150	298	12,198		0	35,514	0	0	0	150	47,712
26-May-2004	26-May-2004	1	150	298	12,496		0	35,514	0	0	0	150	48,010
27-May-2004	27-May-2004	1	150	298	12,793		0	35,514	0	0	0	150	48,307
28-May-2004	28-May-2004	1	150	298	13,091		0	35,514	0	0	0	150	48,605
29-May-2004	29-May-2004	1	150	298	13,388		0	35,514	0	0	0	150	48,902
30-May-2004	30-May-2004	1	150	298	13,686		0	35,514	0	0	0	150	49,200
31-May-2004	31-May-2004	1	125	248	13,934		0	35,514	0	0	0	125	49,448
1-Jun-2004	1-Jun-2004	1	100	198	14,132		0	35,514	0	0	0	100	49,646
2-Jun-2004	30-Jun-2004	29	75	4,314	18,446		0	35,514	0	0	0	75	53,960
1-Jul-2004	31-Jul-2004	31	75	4,612	23,058		0	35,514	0	0	0	75	58,572
1-Aug-2004	31-Aug-2004	31	75	4,612	27,669		0	35,514	0	0	0	75	63,183
1-Sep-2004	30-Sep-2004	30	75	4,463	32,132		0	35,514	0	0	0	75	67,646
1-Oct-2004	15-Oct-2004	15	150	4,463	36,595		0	35,514	0	0	0	150	72,109
16-Oct-2004	20-Oct-2004	5	150	1,488	38,083	0	0	35,514	0	0	0	150	73,597
21-Oct-2004	25-Oct-2004	5	150	1,488	39,570		0	35,514	0	0	0	150	75,084
26-Oct-2004	31-Oct-2004	6	150	1,785	41,355		0	35,514	0	0	0	150	76,869
1-Nov-2004	30-Nov-2004	30	150	8,926	50,281		0	35,514	0	0	0	150	85,795
1-Dec-2004	31-Dec-2004	31	150	9,223	59,504		0	35,514	0	0	0	150	95,018
1-Jan-2005	31-Jan-2005	31	150	9,223	68,727		0	35,514	0	0	0	150	104,241
1-Feb-2005	28-Feb-2005	28	150	8,331	77,058		0	35,514	0	0	0	150	112,572
1-Mar-2005	31-Mar-2005	31	150	9,223	86,281		0	35,514	0	0	0	150	121,795
1-Apr-2005	14-Apr-2005	14	150	4,165	90,446		0	35,514	0	0	0	150	125,960
No. of days		365	(April 15 through April 14)										

Available Interpolation= 14,413 A.F.
Total = 140,373 A.F.

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index is 2,404,649 July 31, 1996 FERC Order Flow Interpolated as 140,373 AF fish flow year requirement.

2. The pulse flows are a target that represents a daily average.

3. Base flow amounts shown prior to April 15 are not included in this year's total.

ATTACHMENT 3

SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION

602020 INDEX

YEAR	APRIL-JULY RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	OCTOBER-MARCH RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	602020 INDEX	TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT	San Joaquin Index (not the FERC Index)	RANKING
Apr 1 Forecast														
Dry	430,000	790,000	380,000	710,000	2,310,000	338,677	538,010	245,088	375,360	1,497,135	2,248,649	131,157	Dry	
Wet	660,000	1,090,000	560,000	1,030,000	3,340,000	338,677	538,010	245,088	375,360	1,497,135	2,866,649	212,526	Below Normal	
Apr 20 Update														
DRY	410,000	750,000	340,000	680,000	2,180,000	338,677	538,010	245,088	375,360	1,497,135	2,170,649	126,588	Dry	
AVE	485,000	870,000	405,000	810,000	2,570,000	338,677	538,010	245,088	375,360	1,497,135	2,404,649	140,373	Dry	
WET	630,000	1,060,000	520,000	980,000	3,190,000	338,677	538,010	245,088	375,360	1,497,135	2,776,649	183,323	Below Normal	

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

Don Pedro Dam and Powerhouse

June 10, 2004

Mr. Dean Marston
California Dept. of Fish and Game
1234 E. Shaw Ave.
Fresno, CA 93710

Ms. Deborah Giglio
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

RE: Don Pedro Project #2299 - Revised Tuolumne River 2004-2005 FERC Article 37 Flow Schedule

Dear Fishery Agency Representatives:

The DWR June 1, 2004 60-20-20 San Joaquin Basin Index 50% exceedence forecast of 2.2216 corresponded to 129,562 acre-feet (AF) of volume for the fish flow year, based on accepted interpolation of the updated FERC Article 37 Flow Requirements table (TABLE 1). These figures were provided to the TRTAC via e-mail on June 4. Attached is the current Tuolumne River flow schedule for the 2004-2005 FERC fish flow year (TABLE 2). The schedule reflects allocation of the present interpolation volume over the remaining fish flow year from June 2, 2004 to April 14, 2005. The flow schedule is subject to change based on: (1) additional changes in the annual volume that won't be final until August and (2) such variations as may be agreed to by the Turlock and Modesto Irrigation Districts, the California Department of Fish and Game, and the U. S. Fish and Wildlife Service, as specified in 1996 FERC Order, amending Article 37.

If you have any questions, please contact Wes Monier at 209-883-8321.

Sincerely,

Robert M. Nees
Assistant General Manager
Water Resources and Regulatory Affairs Administration

C: Larry Weis - TID
Allen Short - MID
Walt Ward - MID
Magalie Salas – FERC Secretary
George Taylor - FERC

TID

Table 1

SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION

602020 INDEX

	APRIL-JULY RUNOFF (AF)					OCTOBER-MARCH RUNOFF (AF)					602020	TUOLUMNE RIVER	San Joaquin Index (not the FERC Index)	
YEAR	STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	INDEX	MINIMUM FLOW REQUIREMENT		RANKING
03	684,381	1,166,478	584,993	1,057,868	3,493,720	291,361	415,905	203,049	346,167	1,256,482	2,816,111	196,128	Below Normal	42
June 1 Update														
90%	390,000	690,000	320,000	680,000	2,080,000	338,677	538,010	245,088	375,360	1,497,135	2,110,649	123,185	Dry	
50%	410,000	760,000	355,000	740,000	2,265,000	338,677	538,010	245,088	375,360	1,497,135	2,221,649	129,562	Dry	
10%	440,000	850,000	390,000	800,000	2,480,000	338,677	538,010	245,088	375,360	1,497,135	2,350,649	137,183	Dry	

TABLE 2

Tuolumne River Flow Schedule

10JUN2004

SCHEDULE FOR 2004 - 2005 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW			ADDITIONAL FLOW			TOTAL FERC FLOW	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
12-Apr-2004	12-Apr-2004	1	210	417			0	0	0	0	0	210	0
13-Apr-2004	13-Apr-2004	1	210	417		490	972	972	0	0	0	700	972
Wed-14-Apr-2004	Wed-14-Apr-2004	1	210	417		690	1,369	2,340	0	0	0	900	2,340
Thu-15-Apr-2004	Thu-15-Apr-2004	1	150	298	298	750	1,488	3,828	0	0	0	900	4,126
Fri-16-Apr-2004	Fri-16-Apr-2004	1	150	298	595	750	1,488	5,316	0	0	0	900	5,911
Sat-17-Apr-2004	Sat-17-Apr-2004	1	150	298	893	750	1,488	6,803	0	0	0	900	7,696
Sun-18-Apr-2004	Sun-18-Apr-2004	1	150	298	1,190	750	1,488	8,291	0	0	0	900	9,481
Mon-19-Apr-2004	Mon-19-Apr-2004	1	150	298	1,488	750	1,488	9,779	0	0	0	900	11,266
Tue-20-Apr-2004	Tue-20-Apr-2004	1	150	298	1,785	750	1,488	11,266	0	0	0	900	13,051
Wed-21-Apr-2004	Wed-21-Apr-2004	1	150	298	2,083	750	1,488	12,754	0	0	0	900	14,836
Thu-22-Apr-2004	Thu-22-Apr-2004	1	150	298	2,380	700	1,388	14,142	0	0	0	850	16,522
Fri-23-Apr-2004	Fri-23-Apr-2004	1	150	298	2,678	750	1,488	15,630	0	0	0	900	18,307
Sat-24-Apr-2004	Sat-24-Apr-2004	1	150	298	2,975	500	992	16,621	0	0	0	650	19,597
Sun-25-Apr-2004	Sun-25-Apr-2004	1	150	298	3,273	450	893	17,514	0	0	0	600	20,787
Mon-26-Apr-2004	Mon-26-Apr-2004	1	150	298	3,570	450	893	18,407	0	0	0	600	21,977
Tue-27-Apr-2004	Tue-27-Apr-2004	1	150	298	3,868	450	893	19,299	0	0	0	600	23,167
Wed-28-Apr-2004	Wed-28-Apr-2004	1	150	298	4,165	450	893	20,192	0	0	0	600	24,357
Thu-29-Apr-2004	Thu-29-Apr-2004	1	150	298	4,463	450	893	21,084	0	0	0	600	25,547
Fri-30-Apr-2004	Fri-30-Apr-2004	1	150	298	4,760	450	893	21,977	0	0	0	600	26,737
Sat-01-May-2004	Sat-01-May-2004	1	150	298	5,058	450	893	22,869	0	0	0	600	27,927
Sun-02-May-2004	Sun-02-May-2004	1	150	298	5,355	450	893	23,762	0	0	0	600	29,117
Mon-03-May-2004	Mon-03-May-2004	1	150	298	5,653	450	893	24,655	0	0	0	600	30,307
Tue-04-May-2004	Tue-04-May-2004	1	150	298	5,950	450	893	25,547	0	0	0	600	31,498
Wed-05-May-2004	Wed-05-May-2004	1	150	298	6,248	450	893	26,440	0	0	0	600	32,688
Thu-06-May-2004	Thu-06-May-2004	1	150	298	6,545	450	893	27,332	0	0	0	600	33,878
Fri-07-May-2004	Fri-07-May-2004	1	150	298	6,843	450	893	28,225	0	0	0	600	35,068
Sat-08-May-2004	Sat-08-May-2004	1	150	298	7,140	450	893	29,117	0	0	0	600	36,258
Sun-09-May-2004	Sun-09-May-2004	1	150	298	7,438	450	893	30,010	0	0	0	600	37,448
Mon-10-May-2004	Mon-10-May-2004	1	150	298	7,736	450	893	30,902	0	0	0	600	38,638
Tue-11-May-2004	Tue-11-May-2004	1	150	298	8,033	450	893	31,795	0	0	0	600	39,828
Wed-12-May-2004	Wed-12-May-2004	1	150	298	8,331	450	893	32,688	0	0	0	600	41,018
Thu-13-May-2004	Thu-13-May-2004	1	150	298	8,628	450	893	33,580	0	0	0	600	42,208
Fri-14-May-2004	Fri-14-May-2004	1	150	298	8,926	425	843	34,423	0	0	0	575	43,349
Sat-15-May-2004	Sat-15-May-2004	1	150	298	9,223	300	595	35,018	0	0	0	450	44,241
Sun-16-May-2004	Sun-16-May-2004	1	150	298	9,521	175	347	35,365	0	0	0	325	44,886
Mon-17-May-2004	Mon-17-May-2004	1	150	298	9,818	75	149	35,514	0	0	0	225	45,332
Tue-18-May-2004	Tue-18-May-2004	1	150	298	10,116		0	35,514	0	0	0	150	45,630
Wed-19-May-2004	Wed-19-May-2004	1	150	298	10,413		0	35,514	0	0	0	150	45,927
Thu-20-May-2004	Thu-20-May-2004	1	150	298	10,711		0	35,514	0	0	0	150	46,225
Fri-21-May-2004	Fri-21-May-2004	1	150	298	11,008		0	35,514	0	0	0	150	46,522
Sat-22-May-2004	Sat-22-May-2004	1	150	298	11,306		0	35,514	0	0	0	150	46,820
Sun-23-May-2004	Sun-23-May-2004	1	150	298	11,603		0	35,514	0	0	0	150	47,117
Mon-24-May-2004	Mon-24-May-2004	1	150	298	11,901		0	35,514	0	0	0	150	47,415
Tue-25-May-2004	Tue-25-May-2004	1	150	298	12,198		0	35,514	0	0	0	150	47,712
Wed-26-May-2004	Wed-26-May-2004	1	150	298	12,496		0	35,514	0	0	0	150	48,010
Thu-27-May-2004	Thu-27-May-2004	1	150	298	12,793		0	35,514	0	0	0	150	48,307
Fri-28-May-2004	Fri-28-May-2004	1	150	298	13,091		0	35,514	0	0	0	150	48,605
Sat-29-May-2004	Sat-29-May-2004	1	150	298	13,388		0	35,514	0	0	0	150	48,902
Sun-30-May-2004	Sun-30-May-2004	1	150	298	13,686		0	35,514	0	0	0	150	49,200
Mon-31-May-2004	Mon-31-May-2004	1	125	248	13,934		0	35,514	0	0	0	125	49,448
Tue-01-Jun-2004	Tue-01-Jun-2004	1	100	198	14,132		0	35,514	0	0	0	100	49,646
Wed-02-Jun-2004	Wed-30-Jun-2004	29	75	4,314	18,446		0	35,514	5	288	288	80	54,248
Thu-01-Jul-2004	Sat-31-Jul-2004	31	75	4,612	23,058		0	35,514	5	307	595	80	59,167
Sun-01-Aug-2004	Tue-31-Aug-2004	31	75	4,612	27,669		0	35,514	5	307	902	80	64,086
Wed-01-Sep-2004	Thu-30-Sep-2004	30	75	4,463	32,132		0	35,514	5	298	1,200	80	68,846
Fri-01-Oct-2004	Fri-15-Oct-2004	15	150	4,463	36,595		0	35,514	5	149	1,349	155	73,458
Sat-16-Oct-2004	Wed-20-Oct-2004	5	150	1,488	38,083	0	0	35,514	5	50	1,398	155	74,995
Thu-21-Oct-2004	Mon-25-Oct-2004	5	150	1,488	39,570		0	35,514	5	50	1,448	155	76,532
Tue-26-Oct-2004	Sun-31-Oct-2004	6	150	1,785	41,355		0	35,514	5	60	1,507	155	78,377
Mon-01-Nov-2004	Tue-30-Nov-2004	30	150	8,926	50,281		0	35,514	5	298	1,805	155	87,600
Wed-01-Dec-2004	Fri-31-Dec-2004	31	150	9,223	59,504		0	35,514	5	307	2,112	155	97,131
Sat-01-Jan-2005	Mon-31-Jan-2005	31	150	9,223	68,727		0	35,514	5	307	2,420	155	106,661
Tue-01-Feb-2005	Mon-28-Feb-2005	28	150	8,331	77,058		0	35,514	5	278	2,698	155	115,269
Tue-01-Mar-2005	Thu-31-Mar-2005	31	150	9,223	86,281		0	35,514	5	307	3,005	155	124,800
Fri-01-Apr-2005	Thu-14-Apr-2005	14	150	4,165	90,446		0	35,514	21	597	3,602	171	129,562
No. of days		365	(April 15 through April 14)										

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index is 2,221,649 July 31, 1996 FERC Order Flow Interpolated as 129,562 AF fish flow year requirement.

2. The pulse flows are a target that represents a daily average.

3. Base flow amounts shown prior to April 15 are not included in this year's total.

4. April 2005 period contains the balance of the interpolation volume.

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

Don Pedro Dam and Powerhouse

September 2, 2004

Mr. Dean Marston
California Dept. of Fish and Game
1234 E. Shaw Ave.
Fresno, CA 93710

Ms. Deborah Giglio
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

RE: Don Pedro Project No. 2299 -- Tuolumne River 2003-2004 FERC Article 37 Flow Schedule

Dear Fishery Agency representatives:

Attached is the Tuolumne River flow schedule for the remainder of the 2004-2005 FERC fish flow year (Table 1). The annual volume is based on the DWR 60-20-20 San Joaquin Basin Index of 2.211624, which results in 128,970 acre-feet for this fish flow year.

The difference from the prior schedule of June 10, 2004 is the 150 cfs for the period of April 1-14, 2005.

If you have any questions please feel free to contact Wes Monier at 209-883-8321.

Sincerely,

Robert M. Nees
Assistant General Manager
Water Resources and Regulatory Affairs

C: Larry Weis – TID
Allen Short – MID
TRTAC (via e-mail)
Wes Monier- TID
Magalie Salas – FERC Secretary

TID

TABLE 1

Tuolumne River Flow Schedule

10JUN2004

SCHEDULE FOR 2004 - 2005 Fish Flow Year

DATE From:	DATE To:	Number of DAYS	BASE FLOW CFS	BASE FLOW AF	BASE FLOW ACCUM. A.F.	PULSE FLOW CFS	PULSE FLOW AF	PULSE FLOW ACCUM. A.F.	ADDITIONAL FLOW CFS	ADDITIONAL FLOW AF	ADDITIONAL FLOW ACCUM. A.F.	TOTAL FERC FLOW CFS	TOTAL FERC FLOW ACCUM. A.F.
12-Apr-2004	12-Apr-2004	1	210	417			0	0	0	0	0	210	0
13-Apr-2004	13-Apr-2004	1	210	417		490	972	972	0	0	0	700	972
14-Apr-2004	14-Apr-2004	1	210	417		690	1,369	2,340	0	0	0	900	2,340
15-Apr-2004	15-Apr-2004	1	150	298	298	750	1,488	3,828	0	0	0	900	4,126
16-Apr-2004	16-Apr-2004	1	150	298	595	750	1,488	5,316	0	0	0	900	5,911
17-Apr-2004	17-Apr-2004	1	150	298	893	750	1,488	6,803	0	0	0	900	7,696
18-Apr-2004	18-Apr-2004	1	150	298	1,190	750	1,488	8,291	0	0	0	900	9,481
19-Apr-2004	19-Apr-2004	1	150	298	1,488	750	1,488	9,779	0	0	0	900	11,266
20-Apr-2004	20-Apr-2004	1	150	298	1,785	750	1,488	11,266	0	0	0	900	13,051
21-Apr-2004	21-Apr-2004	1	150	298	2,083	750	1,488	12,754	0	0	0	900	14,836
22-Apr-2004	22-Apr-2004	1	150	298	2,380	700	1,388	14,142	0	0	0	850	16,522
23-Apr-2004	23-Apr-2004	1	150	298	2,678	750	1,488	15,630	0	0	0	900	18,307
24-Apr-2004	24-Apr-2004	1	150	298	2,975	500	992	16,621	0	0	0	650	19,597
25-Apr-2004	25-Apr-2004	1	150	298	3,273	450	893	17,514	0	0	0	600	20,787
26-Apr-2004	26-Apr-2004	1	150	298	3,570	450	893	18,407	0	0	0	600	21,977
27-Apr-2004	27-Apr-2004	1	150	298	3,868	450	893	19,299	0	0	0	600	23,167
28-Apr-2004	28-Apr-2004	1	150	298	4,165	450	893	20,192	0	0	0	600	24,357
29-Apr-2004	29-Apr-2004	1	150	298	4,463	450	893	21,084	0	0	0	600	25,547
30-Apr-2004	30-Apr-2004	1	150	298	4,760	450	893	21,977	0	0	0	600	26,737
01-May-2004	01-May-2004	1	150	298	5,058	450	893	22,869	0	0	0	600	27,927
02-May-2004	02-May-2004	1	150	298	5,355	450	893	23,762	0	0	0	600	29,117
03-May-2004	03-May-2004	1	150	298	5,653	450	893	24,655	0	0	0	600	30,307
04-May-2004	04-May-2004	1	150	298	5,950	450	893	25,547	0	0	0	600	31,498
05-May-2004	05-May-2004	1	150	298	6,248	450	893	26,440	0	0	0	600	32,688
06-May-2004	06-May-2004	1	150	298	6,545	450	893	27,332	0	0	0	600	33,878
07-May-2004	07-May-2004	1	150	298	6,843	450	893	28,225	0	0	0	600	35,068
08-May-2004	08-May-2004	1	150	298	7,140	450	893	29,117	0	0	0	600	36,258
09-May-2004	09-May-2004	1	150	298	7,438	450	893	30,010	0	0	0	600	37,448
10-May-2004	10-May-2004	1	150	298	7,736	450	893	30,902	0	0	0	600	38,638
11-May-2004	11-May-2004	1	150	298	8,033	450	893	31,795	0	0	0	600	39,828
12-May-2004	12-May-2004	1	150	298	8,331	450	893	32,688	0	0	0	600	41,018
13-May-2004	13-May-2004	1	150	298	8,628	450	893	33,580	0	0	0	600	42,208
14-May-2004	14-May-2004	1	150	298	8,926	425	843	34,423	0	0	0	575	43,349
15-May-2004	15-May-2004	1	150	298	9,223	300	595	35,018	0	0	0	450	44,241
16-May-2004	16-May-2004	1	150	298	9,521	175	347	35,365	0	0	0	325	44,886
17-May-2004	17-May-2004	1	150	298	9,818	75	149	35,514	0	0	0	225	45,332
18-May-2004	18-May-2004	1	150	298	10,116		0	35,514	0	0	0	150	45,630
19-May-2004	19-May-2004	1	150	298	10,413		0	35,514	0	0	0	150	45,927
20-May-2004	20-May-2004	1	150	298	10,711		0	35,514	0	0	0	150	46,225
21-May-2004	21-May-2004	1	150	298	11,008		0	35,514	0	0	0	150	46,522
22-May-2004	22-May-2004	1	150	298	11,306		0	35,514	0	0	0	150	46,820
23-May-2004	23-May-2004	1	150	298	11,603		0	35,514	0	0	0	150	47,117
24-May-2004	24-May-2004	1	150	298	11,901		0	35,514	0	0	0	150	47,415
25-May-2004	25-May-2004	1	150	298	12,198		0	35,514	0	0	0	150	47,712
26-May-2004	26-May-2004	1	150	298	12,496		0	35,514	0	0	0	150	48,010
27-May-2004	27-May-2004	1	150	298	12,793		0	35,514	0	0	0	150	48,307
28-May-2004	28-May-2004	1	150	298	13,091		0	35,514	0	0	0	150	48,605
29-May-2004	29-May-2004	1	150	298	13,388		0	35,514	0	0	0	150	48,902
30-May-2004	30-May-2004	1	150	298	13,686		0	35,514	0	0	0	150	49,200
31-May-2004	31-May-2004	1	125	248	13,934		0	35,514	0	0	0	125	49,448
01-Jun-2004	01-Jun-2004	1	100	198	14,132		0	35,514	0	0	0	100	49,646
02-Jun-2004	30-Jun-2004	29	75	4,314	18,446		0	35,514	5	288	288	80	54,248
01-Jul-2004	31-Jul-2004	31	75	4,612	23,058		0	35,514	5	308	596	80	59,168
01-Aug-2004	31-Aug-2004	31	75	4,612	27,669		0	35,514	5	308	904	80	64,087
01-Sep-2004	30-Sep-2004	30	75	4,463	32,132		0	35,514	5	298	1,202	80	68,848
01-Oct-2004	15-Oct-2004	15	150	4,463	36,595		0	35,514	5	149	1,351	155	73,460
16-Oct-2004	20-Oct-2004	5	150	1,488	38,083	0	0	35,514	5	50	1,401	155	74,997
21-Oct-2004	25-Oct-2004	5	150	1,488	39,570		0	35,514	5	50	1,450	155	76,535
26-Oct-2004	31-Oct-2004	6	150	1,785	41,355		0	35,514	5	60	1,510	155	78,379
01-Nov-2004	30-Nov-2004	30	150	8,926	50,281		0	35,514	5	298	1,808	155	87,603
01-Dec-2004	31-Dec-2004	31	150	9,223	59,504		0	35,514	5	308	2,116	155	97,134
01-Jan-2005	31-Jan-2005	31	150	9,223	68,727		0	35,514	5	308	2,424	155	106,665
01-Feb-2005	28-Feb-2005	28	150	8,331	77,058		0	35,514	5	278	2,702	155	115,274
01-Mar-2005	31-Mar-2005	31	150	9,223	86,281		0	35,514	5	308	3,010	155	124,805
01-Apr-2005	14-Apr-2005	14	150	4,165	90,446		0	35,514	0	0	3,010	150	128,970
No. of days		365 (April 15 through April 14)											

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index is 2,211,624 July 31, 1996 FERC Order Flow Interpolated as 128,970 AF fish flow year requirement.

2. The pulse flows are a target that represents a daily average.

3. Base flow amounts shown prior to April 15 are not included in this year's total.

4. April 2005 period contains the balance of the interpolation volume.

TURLOCK IRRIGATION DISTRICT
333 EAST CANAL DRIVE
POST OFFICE BOX 949
TURLOCK, CALIFORNIA 95381
(209) 883-8300

Don Pedro Dam and Powerhouse

October 22, 2004

Mr. Dean Marston
California Dept. of Fish and Game
1234 E. Shaw Ave.
Fresno, CA 93710

Ms. Deborah Giglio
U.S. Fish and Wildlife Service
2800 Cottage Way, W-2605
Sacramento, CA 95825

RE: Don Pedro Project No. 2299 -- Tuolumne River 2003-2004 FERC Article 37 Flow Schedule

Dear Fishery Agency representatives:

Attached is the revised Tuolumne River flow schedule for the 2004-2005 FERC fish flow year (Table 1) that was recently agreed to, effective on October 1.

The difference from the prior schedule is: (1) the required flow for October through mid-April is at 150 cfs, down from the previous 155 cfs, and (2) the inclusion of a fall pulse flow later this month using the reallocated water.

If you have any questions please feel free to contact Wes Monier at 209-883-8321.

Sincerely,

Robert M. Nees
Assistant General Manager
Water Resources and Regulatory Affairs

C: Larry Weis – TID
Allen Short – MID
TRTAC (via e-mail)
Wes Monier- TID
Magalie Salas – FERC Secretary

TABLE 1

Tuolumne River Flow Schedule

30SEP2004

SCHEDULE FOR 2004 - 2005 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW			ADDITIONAL FLOW			TOTAL FERC FLOW	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
12-Apr-2004	12-Apr-2004	1	210	417			0	0	0	0	0	210	0
13-Apr-2004	13-Apr-2004	1	210	417		490	972	972	0	0	0	700	972
14-Apr-2004	14-Apr-2004	1	210	417		690	1,369	2,340	0	0	0	900	2,340
15-Apr-2004	15-Apr-2004	1	150	298	298	750	1,488	3,828	0	0	0	900	4,126
16-Apr-2004	16-Apr-2004	1	150	298	595	750	1,488	5,316	0	0	0	900	5,911
17-Apr-2004	17-Apr-2004	1	150	298	893	750	1,488	6,803	0	0	0	900	7,696
18-Apr-2004	18-Apr-2004	1	150	298	1,190	750	1,488	8,291	0	0	0	900	9,481
19-Apr-2004	19-Apr-2004	1	150	298	1,488	750	1,488	9,779	0	0	0	900	11,266
20-Apr-2004	20-Apr-2004	1	150	298	1,785	750	1,488	11,266	0	0	0	900	13,051
21-Apr-2004	21-Apr-2004	1	150	298	2,083	750	1,488	12,754	0	0	0	900	14,836
22-Apr-2004	22-Apr-2004	1	150	298	2,380	700	1,388	14,142	0	0	0	850	16,522
23-Apr-2004	23-Apr-2004	1	150	298	2,678	750	1,488	15,630	0	0	0	900	18,307
24-Apr-2004	24-Apr-2004	1	150	298	2,975	500	992	16,621	0	0	0	650	19,597
25-Apr-2004	25-Apr-2004	1	150	298	3,273	450	893	17,514	0	0	0	600	20,787
26-Apr-2004	26-Apr-2004	1	150	298	3,570	450	893	18,407	0	0	0	600	21,977
27-Apr-2004	27-Apr-2004	1	150	298	3,868	450	893	19,299	0	0	0	600	23,167
28-Apr-2004	28-Apr-2004	1	150	298	4,165	450	893	20,192	0	0	0	600	24,357
29-Apr-2004	29-Apr-2004	1	150	298	4,463	450	893	21,084	0	0	0	600	25,547
30-Apr-2004	30-Apr-2004	1	150	298	4,760	450	893	21,977	0	0	0	600	26,737
01-May-2004	01-May-2004	1	150	298	5,058	450	893	22,869	0	0	0	600	27,927
02-May-2004	02-May-2004	1	150	298	5,355	450	893	23,762	0	0	0	600	29,117
03-May-2004	03-May-2004	1	150	298	5,653	450	893	24,655	0	0	0	600	30,307
04-May-2004	04-May-2004	1	150	298	5,950	450	893	25,547	0	0	0	600	31,498
05-May-2004	05-May-2004	1	150	298	6,248	450	893	26,440	0	0	0	600	32,688
06-May-2004	06-May-2004	1	150	298	6,545	450	893	27,332	0	0	0	600	33,878
07-May-2004	07-May-2004	1	150	298	6,843	450	893	28,225	0	0	0	600	35,068
08-May-2004	08-May-2004	1	150	298	7,140	450	893	29,117	0	0	0	600	36,258
09-May-2004	09-May-2004	1	150	298	7,438	450	893	30,010	0	0	0	600	37,448
10-May-2004	10-May-2004	1	150	298	7,736	450	893	30,902	0	0	0	600	38,638
11-May-2004	11-May-2004	1	150	298	8,033	450	893	31,795	0	0	0	600	39,828
12-May-2004	12-May-2004	1	150	298	8,331	450	893	32,688	0	0	0	600	41,018
13-May-2004	13-May-2004	1	150	298	8,628	450	893	33,580	0	0	0	600	42,208
14-May-2004	14-May-2004	1	150	298	8,926	425	843	34,423	0	0	0	575	43,349
15-May-2004	15-May-2004	1	150	298	9,223	300	595	35,018	0	0	0	450	44,241
16-May-2004	16-May-2004	1	150	298	9,521	175	347	35,365	0	0	0	325	44,886
17-May-2004	17-May-2004	1	150	298	9,818	75	149	35,514	0	0	0	225	45,332
18-May-2004	18-May-2004	1	150	298	10,116		0	35,514	0	0	0	150	45,630
19-May-2004	19-May-2004	1	150	298	10,413		0	35,514	0	0	0	150	45,927
20-May-2004	20-May-2004	1	150	298	10,711		0	35,514	0	0	0	150	46,225
21-May-2004	21-May-2004	1	150	298	11,008		0	35,514	0	0	0	150	46,522
22-May-2004	22-May-2004	1	150	298	11,306		0	35,514	0	0	0	150	46,820
23-May-2004	23-May-2004	1	150	298	11,603		0	35,514	0	0	0	150	47,117
24-May-2004	24-May-2004	1	150	298	11,901		0	35,514	0	0	0	150	47,415
25-May-2004	25-May-2004	1	150	298	12,198		0	35,514	0	0	0	150	47,712
26-May-2004	26-May-2004	1	150	298	12,496		0	35,514	0	0	0	150	48,010
27-May-2004	27-May-2004	1	150	298	12,793		0	35,514	0	0	0	150	48,307
28-May-2004	28-May-2004	1	150	298	13,091		0	35,514	0	0	0	150	48,605
29-May-2004	29-May-2004	1	150	298	13,388		0	35,514	0	0	0	150	48,902
30-May-2004	30-May-2004	1	150	298	13,686		0	35,514	0	0	0	150	49,200
31-May-2004	31-May-2004	1	125	248	13,934		0	35,514	0	0	0	125	49,448
01-Jun-2004	01-Jun-2004	1	100	198	14,132		0	35,514	0	0	0	100	49,646
02-Jun-2004	30-Jun-2004	29	75	4,314	18,446		0	35,514	5	288	288	80	54,248
01-Jul-2004	31-Jul-2004	31	75	4,612	23,058		0	35,514	5	308	596	80	59,168
01-Aug-2004	31-Aug-2004	31	75	4,612	27,669		0	35,514	5	308	904	80	64,087
01-Sep-2004	30-Sep-2004	30	75	4,463	32,132		0	35,514	5	298	1,202	80	68,848
01-Oct-2004	15-Oct-2004	15	150	4,463	36,595		0	35,514	0	0	1,202	150	73,311
16-Oct-2004	24-Oct-2004	9	150	2,678	39,273	0	0	35,514	0	0	1,202	150	75,989
25-Oct-2004	25-Oct-2004	1	150	298	39,570	50	99	35,613	0	0	1,202	200	76,385
26-Oct-2004	26-Oct-2004	1	150	298	39,868	100	198	35,812	0	0	1,202	250	76,881
27-Oct-2004	27-Oct-2004	1	150	298	40,165	300	595	36,407	0	0	1,202	450	77,774
28-Oct-2004	28-Oct-2004	1	150	298	40,463	300	595	37,002	0	0	1,202	450	78,666
29-Oct-2004	29-Oct-2004	1	150	298	40,760	100	198	37,200	0	0	1,202	250	79,162
30-Oct-2004	30-Oct-2004	1	150	298	41,058	50	99	37,299	0	0	1,202	200	79,559
31-Oct-2004	31-Oct-2004	1	150	298	41,355	11	22	37,321	0	0	1,202	161	79,879
01-Nov-2004	30-Nov-2004	30	150	8,926	50,281		0	37,321	0	0	1,202	150	88,804
01-Dec-2004	31-Dec-2004	31	150	9,223	59,504		0	37,321	0	0	1,202	150	98,027
01-Jan-2005	31-Jan-2005	31	150	9,223	68,727		0	37,321	0	0	1,202	150	107,251
01-Feb-2005	28-Feb-2005	28	150	8,331	77,058		0	37,321	0	0	1,202	150	115,581
01-Mar-2005	31-Mar-2005	31	150	9,223	86,281		0	37,321	0	0	1,202	150	124,804
01-Apr-2005	14-Apr-2005	14	150	4,165	90,446		0	37,321	0	0	1,202	150	128,970
No. of days		365 (April 15 through April 14)											

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index is 2,211,624 July 31, 1996 FERC Order Flow Interpolated as 128,970 AF fish flow year requirement.

2. The pulse flows are a target that represents a daily average.

3. Base flow amounts shown prior to April 15 are not included in this year's total

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

<u>Report 2004-1</u>

2003 and 2004 Spawning Survey Reports

Prepared by

Dennis Blakeman

California Department of Fish and Game
Anadromous Fisheries Program
San Joaquin Valley Southern Sierra Region (Region 4)

March 2005

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2003 Tuolumne River Fall Chinook Salmon Escapement Survey

Prepared by:
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March 2004

INTRODUCTION

The San Joaquin fall-run Chinook salmon is currently a candidate species under the Federal and State Endangered Species Acts. Population levels in the Tuolumne River have declined in the latter half of the 20th century from a high of approximately 130,000 returning adults in 1944 (Fry 1961) to a low of 77 in 1991 (Neillands et al. 1993). Current levels of 7,916 in 1998 (Heyne 1998), 7,685 in 1999 (Heyne 2000), 17,873 in 2000 (Vasques 2001), 9,222 in 2001 and 7,125 in 2002, indicate a slight recovery period. The decline of the species is believed to be caused by many factors. In general, reduction of spawning and rearing habitat and stream flow management practices are thought to be the major factors limiting overall population numbers. Numerous additional factors including but not limited to predation, streambed alteration, pump diversion, gravel mining, land use practices, and ocean angler harvest contribute to a web of complex population dynamics which effect population numbers within the habitat currently available to Tuolumne River Chinook salmon.

The California Department of Fish and Game (CDFG) has conducted escapement surveys on the Tuolumne River since 1940 (Fry 1961). The Schaefer mark recapture escapement estimation model (Schaefer 1951) has been utilized since 1971. The 2003 escapement survey will begin using the Jolly-Seber (Seber 1973) escapement model but will continue to report Schaefer estimates. Beginning in 1992, CDFG escapement surveys have been utilized as part of the New Don Pedro FERC Project No. 2299 license monitoring program and annual reporting.

The primary objectives of the Tuolumne River escapement survey are to:

- Estimate the escapement of fall run Chinook salmon on the Tuolumne River.
- Collect fork length and sex data.
- Collect scale and otolith samples with which to conduct age determination analysis and subsequent cohort analysis.
- Collect and analyze coded wire tag data from marked hatchery fish.
- Evaluate the distribution of salmon redds through the study area.
- Collect DNA samples for storage at the CDFG Salmonid Tissue Archive for subsequent analysis.

STUDY AREA

Approximately 26.5 river miles were surveyed during the Tuolumne River escapement survey in 2003 (Figure 1). The survey area was divided into 4 sections with Section 1 being the upstream most reach. Section 1, also referred to as the primary spawning reach, extends from riffle A1 at river mile 51.6 near La Grange Dam downstream to Basso Bridge at river mile 47.5. Section 2 extends from Basso Bridge down to the Turlock Lake State Recreation Area (TLSRA) at river mile 41.9. Section 3 covers the area between TLSRA and riffle S1 at river mile 34. Section 4 extends downstream to Fox Grove (river mile 26).

All riffles in the study area have been identified and mapped using a Trimble GPS unit and the GIS computer program ArcView. Each riffle has been systematically re-named upstream to downstream using sequential letter/number designations for river mile and riffle number, respectively. For example, the first riffle immediately below La Grange Dam in the first river mile (56) is named A1. This numbering system is a departure from the historical riffle numbering system. However, the new riffle identification system is more logical and is more conducive to editing as river morphology changes. The riffle identification cross-reference is located in Table 1.

METHODS

Population Estimation

The Schaefer (1951) and Jolly-Seber (Seber 1972) mark recapture models were used to estimate fall salmon escapement on the lower Tuolumne River. These methods utilize marked and subsequently recovered carcasses during weekly surveys of the spawning reach. A ratio of marked to unmarked fish is used to calculate weekly population estimates, which are then summed to estimate the total spawning population. The CDFG began the survey on 30 September 2003 (Week 1) and concluded on 6 January 2004 (Week 15). Carcasses were tagged for the first 13 weeks. Weeks 14 and 15 no carcasses were tagged, these were strictly carcass recovery weeks. During the two recovery weeks, carcasses were collected and examined for jaw tags and all carcasses collected were chopped in half.

All carcasses encountered were handled during weekly drift boat surveys of the study area. Carcasses were gaffed as the sampling crew drifted past and held in the boat until the end of the riffle and adjacent downstream pool. Subsequent to drifting the riffle and downstream pool the riverbanks were walked to collect carcasses that could not be seen or collected from the drift boat. Every carcass handled was designated as fresh, decayed, skeleton or recovery, depending on the degree of decomposition or the presence of an aluminum jaw tag in the case of recoveries. The fresh carcass designation criteria during 2003 was at least one clear eye (Figure 2). Decayed fish had cloudy eyes. Skeletons were carcasses judged to be in an advanced state of decay and unlikely to have the same probability of recapture as fresh and decayed specimens. Criteria for skeleton designation during the 2003 survey included the presence of fungus covering the entire body at the freshest end of skeleton designation (dead approximately one week) to actual skeletons at the most decayed end (Figures 3 and 4).

All fresh and decayed carcasses were given a unique number by attaching a numbered aluminum tag to the lower jaw. These newly tagged carcasses were redistributed to river current near the lower end of the riffle for recovery in subsequent weeks. For tag recoveries, the unique tag number was noted and the carcass was chopped and returned to the river. All skeletons were enumerated, chopped, and returned to the river to avoid double counting despite findings by Law (1994) suggesting that untagged carcasses not removed after initial count only slightly affected Schaefer's (1951) population estimate. Estimates were made using the Schaefer (1951) equation as presented in Ricker (1975) and also using the Jolly-Seber equation (Seber 1973). Law (1994) found in simulations of various models, using a similar protocol as this survey, that the Peterson model (see Ricker, 1975) drastically over estimated, while the Schaefer model consistently overestimated the population and the Jolly-Seber model most accurately estimated the population. Therefore, Peterson's model was not used in this analysis and the Jolly-Seber model will now be included with Schaefer estimates.

Weekly Fish Distribution and Redd Counts

Weekly live fish observation and redd counts were conducted during the survey (Table 2, Figure 5). These counts are conducted for each riffle and pool using the riffle identification system noted earlier. Counts are made using tally counters as field crews drifted through riffles and pools.

Individual Fish Data Collection

Fork length (to the nearest 1 centimeter) and sex data are collected for all tagged carcasses. Scale and otolith samples are collected from a percentage of specimens to determine the size and age composition of annual spawning runs. Coded wire tags (CWTs) are collected from hatchery produced, marked (adipose fin clipped), carcasses as part of long term survival testing of releases of marked outmigrating smolts. This also allows for determining the incidence of straying from other river systems. CWT specimens are also used to validate scale and otolith age determination work. Genetic samples: caudal, dorsal, or pectoral fin clips were collected, and delivered to the CDFG Salmonid Tissue Archive at the end of the survey. Scale and otolith samples were collected from both wild and CWT carcasses and are catalogued at the CDFG La Grange Field Office. CWTs and otoliths are collected via removal of the head minus the lower jaw. Extraction and analysis of otoliths and CWTs is conducted after the spawning season. All fish samples are catalogued by the fish's unique jaw tag number, which allows the samples to be tracked to the specific data and riffle number of collection.

RESULTS

Population Estimate

Based on the Jolly-Seber model using all fish the 2003 escapement estimate was **2,163 salmon**. The Jolly-Seber model using all tagged fish and recoveries yields the most accurate estimate. The Schaefer model utilize the number of recoveries of tagged carcasses that were fresh when tagged, the total number of fresh tagged fish, and the total number carcasses handled each week to generate weekly escapement estimates (Table 3). Weekly estimates are summated to estimate total escapement over the course of the survey. Table 4 shows the total number of fresh tagged each week in relation to the number of recoveries made in subsequent weeks. Weekly estimates are presented in Table 5. The Jolly-Seber calculation matrix required that tagging and recapture numbers be shifted to reflect a continuous recovery period. Thus, the one recovery in week three was moved to week five, and for calculation purposes recovery week five became recovery week two (Table 4-5). Weekly cumulative Schaefer and Jolly-Seber estimates are graphed in Figure 6. The fresh tagged recovery rate was 55.0% which is slightly lower than the overall recovery rate of 56.8% and the overall recovery rates of 64.4% in 2002 and 61.3% encountered during the 2001 escapement survey.

Weekly Counts

Live fish counts increased steadily, peaked in weeks 7 and 8 , and declined steadily through the remainder of the survey (Table 2, Figure 5). Carcass counts exhibited a similar incline, peak, and decline which were offset from live counts by about one week. The carcass count peaked in weeks 8 and 9. Redd counts increased through Week 8 when the total number of observations was 349.

Spawning Distribution

The results of total weekly redd counts clearly indicate that the majority of spawning activity is concentrated in the riffles of Section 1 (Figures 7 and 8). The maximum number of redds counted in a particular riffle over the course of the season are listed in Table 6. The maximum redd count represents the redd count made when external factors like visibility were at optimum conditions. During the 2003 survey 649, 356, 477, and 145 redds were counted for Sections 1 through 4 respectively. Maximum number of redds per section declined from 203 in Section 1 to 102, 122, and 46 in Sections 3, 4, and 5 respectively.

Population Composition

Coded wire tagged fish comprised 21 % of the total tagged carcasses based on the ratio of adipose fin clipped fish to total tagged carcasses (Table 3). Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. However, it is likely that ratios calculated for tagged fish are representative for skeletons as well. The total contributions (tagged fish only) to the spawning population were 32% for natural males, 9% for CWT males, 47% for natural females, and 12% for CWT females (Figure 9). CWT verification and tag reading will be conducted at a later date therefore all CWT data presented here are preliminary.

Length frequency histograms of male and female fish (both natural and CWT) display bimodal peaks (Figures 10 - 13). The first peaks are likely grilse (age 1 and 2 fish) and the second peaks are likely adult (age 3, 4, and 5 year fish). Total grilse composition was 10% of the Tuolumne River escapement estimate. Breakpoints between grilse and adult were determined from basin wide fork length data. Breakpoints used were <60 cm for natural females, <62 for adipose fin clipped females, 68 cm for natural males and 68 cm for adipose fin clipped males. Further breakdown of grilse is presented in Table 7.

Sample Collection

Scales, otolith, and DNA samples were collected from both natural and adipose fin clipped fish throughout the survey period and survey area (Tables 8, 9 and 10). Distribution of sampling is intended to best represent the spawning population over time, space, and origin. Scale and otolith samples will be utilized in the CDFG age determination program and for subsequent cohort analysis of San Joaquin River Basin Chinook salmon populations. One-hundred DNA samples were collected and delivered to the CDFG Salmonid Tissue Archives.

Egg Production Estimate

An estimate of egg production by the 2003 fall run Chinook salmon is done using the relationship of fork length to fecundity. The relationship was developed using 48 San Joaquin fall run Chinook females ranging from fork length 62.5 to 94.0 cm (Loudermilk et al. 1990). The number of eggs was calculated for natural females (n=277, average FL=77.1) and CWT females (n=71, average FL=78.3) and then expanded to the entire estimate. Natural females made up 47% of the 2003 estimate and produced approximately 6,194,673 eggs. Adipose fin clipped females (12%) produced approximately 1,628,784 eggs.

Tuolumne River Flows

Tuolumne River flows at the La Grange guage ranged from approximately 210cfs to 470cfs during the 2003 spawning season (Figure 14). To attract fish into the Tuolumne from the San Joaquin River and improve spawning habitat a pulse flow was initiated on 15 October 2003. Flow increased to approximately 470cfs on 16 October 2003 and ramped down to 230cfs on 28 October 2003 and then decreased to about 210cfs for the remainder of the spawning season.

Tuolumne River Temperature

Water temperatures are recorded in several locations throughout the spawning reach using data loggers placed and maintained by CDFG. Four sites are plotted in Figure 14.

DISCUSSION

Spawning Distribution

Redd counts are strongly affected by time of day, visibility, sunlight , wind rippling the water surface, redd superimposition, and other physical factors as well as the natural variability between observers. Furthermore, redd counts are conducted with a single pass as opposed to an intensive systematic approach beyond the scope of this study. In the primary spawning riffles of Section 1 the problem of redd superimposition is acute and leads to undercounting. On the other hand, redds in Section 2, 3, and 4 are easily delineated as clean patches of freshly worked gravel among patches of darker undisturbed gravel. In these sections redd counts are accurate indicators of spawning density. For these reasons, the disparity between spawning density in Section 1 versus Sections 2, 3, and 4 is likely greater than displayed in Figures 10 and 11.

Population Estimate

The 2003 tag recovery rate of 55.3% is lower than the 64.4 % in 2002 and the 61.3% reported in 2001, which are high tag recovery rates, but still higher compared to the recovery rate of 41.7% encountered in 2000 (Vasques 2001). The difference in recovery rates is likely a function of the difference in stream flow between 2000, (over 300cfs) and 2001 - 2003, (under 200cfs). Stream flow dynamics affects the likelihood of collecting carcasses in that it effects both how carcasses are distributed in the system and the effectiveness in recovering carcasses by field crews. During the lower flows encountered during the 2002 and 2003 surveys carcasses were easily visible and the lower flows allowed for collection in specific locations which were too deep or too swift to survey in 2000. Furthermore, the banks of riffles were walked in an effort to collect carcasses that could not be seen or collected during the initial float through the riffle and subsequent pool. During 2000 bank efforts were not nearly so extensive. The Tuolumne River escapement estimate for 2003 of 2,163 salmon is the lowest since the 1996 estimate of 4,550 salmon.

Population Composition

Coded wire tagged fish comprised 21 % of the total tagged carcasses based on the ratio of adipose fin clipped fish to total tagged carcasses (Table 3). Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. However, it is likely that ratios calculated for tagged fish are representative for skeletons as well. The total contributions (tagged fish only) to the spawning population were 32% for natural males, 9% for adipose fin clipped males, 47% for natural females, and 12% for adipose fin clipped females (Figure 12). CWT verification and tag reading will be conducted at a later date therefore all CWT data presented here are preliminary.

Length frequency histograms of male and female fish (both natural and CWT) display bimodal peaks (Figures 10,11,12 and 13). The first peaks are likely grilse (age 1 and 2 fish) and the second peaks are likely adult (age 3, 4, and 5 year fish). Total grilse composition was 10 % of the Tuolumne River escapement estimate. Breakpoints between grilse and adult were determined from basin wide fork length data and applied to Tuolumne River fork length data to determine grilse composition. Breakpoints used were <66 cm for natural females, <68 cm for adipose fin clipped females, <72 cm for natural males and <67 cm for adipose fin clipped males. Further breakdown of grilse is presented in Table 7.

Tuolumne River Flows

Low dissolved oxygen levels in the San Joaquin River are believed to be a barrier for fall-run salmon migrating up the San Joaquin stem to spawn in the Merced, Tuolumne and Stanislaus Rivers. A fall pulse flow regime has been developed to lower river temperatures and elevate levels of dissolved oxygen in the San Joaquin River in order to attract salmon and prevent straying. Live salmon counts on the Tuolumne River peaked in week 7 and coincided with the end of the elevated dissolved oxygen levels, derived from the fall pulse flows, in the San Joaquin River. The flow, temperatures, observed live fish and redds are presented in Figure 16.

Tuolumne River Temperatures

Temperatures in the upper sections (Section 1 and 2) down to Tuolumne River State Recreation Area (TRSRA)(RM 41.7) remained below the maximum thermal limit of 13.3^{o}C for most all of the spawning season except for a few days in early October. This temperature is considered to be the upper thermal limit for successful egg incubation (Myrick and Cech 1998). River temperatures at Hickman Bridge fell below the 13.3^{o}C level in the beginning of November and coincided with the first redd observations in week 5 of the survey. Temperatures remained below the benchmark 13.3^{o}C for about a week and the decreased further which coincided with the peak of redd observations in weeks 8 and 9. A slight increase in temperature seen at the Hickman Bridge location also saw slight decrease in live fish observations.

Table 1. Tuolumne River riffle identification cross-reference, 2003 to 2002.

Section 1		Section 2		Section 3		Section 4	
New ID	Old ID	New ID	Old ID	New ID	Old ID	New ID	Old ID
1a	A1A	F1	F1	K1	K1	S1	S1
A1n	A1	F2	F2	K2	K2	S2	S2
A1s	A1	F3	F3	L1	L1	S3	S3
A2	A2	G1N	G1	L2	L2	T1	T2
B1	B1	G1S	G1	L3	L3	T2	T3
B2	B2	G2	G2	M1	None	T3	T4
B3	B3	G3	G3	M2	None	T4	T5
C1	C1	G4	G4	N1	None	T5	None
C2	C1	H1	H1	N2	None	U1	U1
C3	C3	H2	H2	N3	N3	U2	U2
D1	D1	H3N	H3	N4	N4	U3	U3
D2	D2	H3S	H4	O1	O1	V1	V1
D3	D3	H4	H5	O2	O3	V2	V2
D4	D4	H5	H6	O3	None	V3	V3
D5	D5	H6	H7	O4	O4	V4	V4
E1	E1	I1	I1	O5	O5	W1	W1
		I2	I2	P1	P1	W2	W2
		I3	I3	P2	P2	W3	W3
		J1	J1	P3	P3	X1	X1
		J2	J2	P4	P4	X2	X2
		J3	J3	Q1	Q1		
		J4	J4	Q2	Q2		
		J5	J5	Q3	Q3		
				R1	R1		
				R2	R2		
				R3	R3		

Table 2. Total weekly counts of live fish, redds, and carcasses.

Week	Live	Redds	Carcasses
1	2	0	1
2	38	0	2
3	66	0	1
4	203	3	2
5	395	99	17
6	343	180	100
7	462	217	164
8	463	349	367
9	342	255	364
10	196	149	237
11	151	215	117
12	89	131	87
13	52	24	28
14	6	4	12
15	2	1	9
Total	**2810**	**1627**	**1508**

[a] Carcasses includes all tagged carcasses and skeletons but does not include recoveries.

Table 3. Weekly totals.

Week	Total Tagged	Skeletons	Fresh Recoveries[1]	Total Counted[2]	Fresh Tagged	CWT's
1	0	1	0	1	0	0
2	1	1	0	2	1	0
3	0	1	1	2	0	0
4	1	1	0	2	1	0
5	16	1	0	17	15	1
6	52	48	4	104	51	13
7	78	85	19	182	67	22
8	157	210	42	409	129	42
9	134	230	93	457	101	33
10	80	157	52	289	62	10
11	34	83	26	143	28	1
12	21	66	24	111	19	0
13	10	18	2	30	10	1
14	0	12	2	14	0	0
15	0	9	1	10	0	0
Total	**584**	**923**	**266**	**1773**	**484**	**123**

[1]Includes only fish that were deemed fresh when tagged.
[2]Includes total tagged, skeletons, and fresh recoveries.

Table 4. Distribution of fresh tagged fish, tag week versus recovery week.

Recovery Week	Tag Week of Recovered Tags												
	1	2	3	4	5	6	7	8	9	10	11	12	13
2	0												
3	0	1											
4	0	0	0										
5	0	0	0	0									
6	0	0	0	0	4								
7	0	0	0	0	0	19							
8	0	0	0	0	0	4	38						
9	0	0	0	0	0	2	8	83					
10	0	0	0	0	0	0	1	2	49				
11	0	0	0	0	0	0	0	2	8	16			
12	0	0	0	0	0	0	0	0	3	8	13		
13	0	0	0	0	0	0	0	0	0	1	0	1	
14	0	0	0	0	0	0	0	0	0	0	0	1	1
15	0	0	0	0	0	0	0	0	0	0	0	1	0
Fresh Recoveries	0	1	0	0	4	25	47	87	60	25	13	3	1
Fresh Tagged Carcasses	0	1	0	1	15	51	67	129	101	62	28	19	10
Percent Recovery	0.0	100.0	0.0	0.0	26.7	49.0	70.1	67.4	59.4	40.3	46.4	15.8	10.0

Table 5. Weekly Shaefer and Jolly-Seber estimates.

Recovery Week	Number of Tags recovered	Total Carcasses Handled	Fresh Fish		All Fish
			Shaefer Estimate	Jolly-Seber Estimate	Jolly-Seber Estimate
1	0	6	0	32	32
2	1	24	33	159	164
3	4	104	339	319	315
4	19	182	304	504	534
5	42	409	478	364	349
6	93	457	580	402	372
7	52	289	421	198	171
8	26	143	281	60	86
9	24	111	226	155	128
10	2	30	122	-4	5
11	2	14	114	6	6
12	1	10	63	0	0
	Total Estimate		Shaefer (Fresh) 2,961	Jolly-Seber (Fresh) 2,195	Jolly-Seber (All) 2,163

Table 6. Maximum redd count for each riffle over the course of the escapement survey by section.

Section 1		Section 2		Section 3		Section 4	
Riffle	Maximum # of Redds	Riffle	Maximum # of Redds	Riffle	Maximum # of Redds	Riffle	Maximum # of Redds
1a	1	F1	10	K1	8	S1	5
A1	3	F2	9	K2	11	S2	3
A1n	5	F3	5	L1	6	S3	5
A1s	6	G1N	1	L2	6	T1	1
A2	1	G1S	7	L3	4	T2	4
B1	28	G2	6	M1	1	T3	2
B2	20	G3	4	M2	2	T4	4
B3	18	G4	2	N1	3	T5	4
C1	16	G4p	1	N2	5	U1	5
C2	0	H1	3	N3	1	U2	2
C3	28	H2	7	N4	6	U3	0
D1	12	H3N	1	O1	5	V1	4
D2	22	H3S	7	O2	4	V2	0
D3	16	H4	2	O3	6	V3	1
D4	13	H5	4	O4	1	V4	2
D5	6	H6	4	O5	5	W1	0
E1	8	I1	3	P1	0	W2	4
		I2	3	P2	7	W3	0
		I3	2	P3	7	X1	0
		J1	2	P4	2	X2	0
		J2	5	Q1	10		
		J3	4	Q2	5		
		J4	8	Q3	6		
		J5	2	R1	4		
				R2	2		
				R3	5		
Subtotal	**203**		**102**		**122**		**46**
Total Redds	**473**						

Table 7. Grilse composition of Chinook salmon.

	Male	Female	Male (n=235)		Female (n=349)	
			Adclip	Natural	Adclip	Natural
Grilse	**7%** (n=40)	**3%** (n=19)	**5%** (n=12)	**12%** (n=28)	**1%** (n=4)	**4%** (n=15)
Adult	**33%** (n=195)	**57%** (n=330)	**17%** (n=39)	**66%** (n=156)	**19%** (n=67)	**75%** (n=263)

Table 8. Distribution of scale samples collected by section and week for natural and adipose fin clipped salmon.

Week	Section				Weekly Total
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	4	0 (1)	0	0	5
6	12(3)	1	0	0	16
7	12(7)	2(1)	1(2)	0	25
8	28(12)	5	2(2)	2	51
9	24(7)	4(3)	2(2)	0	42
10	14(3)	5	2	2	26
11	7	1	0	2	10
12	5	0	1	1	7
13	1	1	0	1	3
Section Totals	139	24	14	8	185

Parenthesis indicate number of samples from adipose fin-clipped carcasses.

Table 9. Distribution of heads collected from Chinook salmon.

Week	Section				Weekly Total
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	1	0	0	1
6	13	0	0	0	13
7	19	1	2	0	22
8	36	2	4	0	42
9	22	6	5	0	33
10	9	0	1	0	10
11	1	0	0	0	1
12	0	0	0	0	0
13	0	0	0	0	1
Section Totals	101	10	12	0	123

Heads were taken only from adipose fin-clipped carcasses.

Table 10. Distribution of DNA samples collected from natural and adipose fin clipped salmon.

Week	Section				Weekly Total
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	1	0	1
6	5 (1)	0	0	0	6
7	11 (5)	3	2 (1)	0	22
8	12 (4)	3	2	1	22
9	9	2	1	1	13
10	3	9	3	4	19
11	11	2	0	3	16
12	1	0	0	0	1
13	0	0	0	0	0
Section Totals	62	19	10	9	100

Parenthesis indicate number of samples from adipose fin-clipped carcasses.

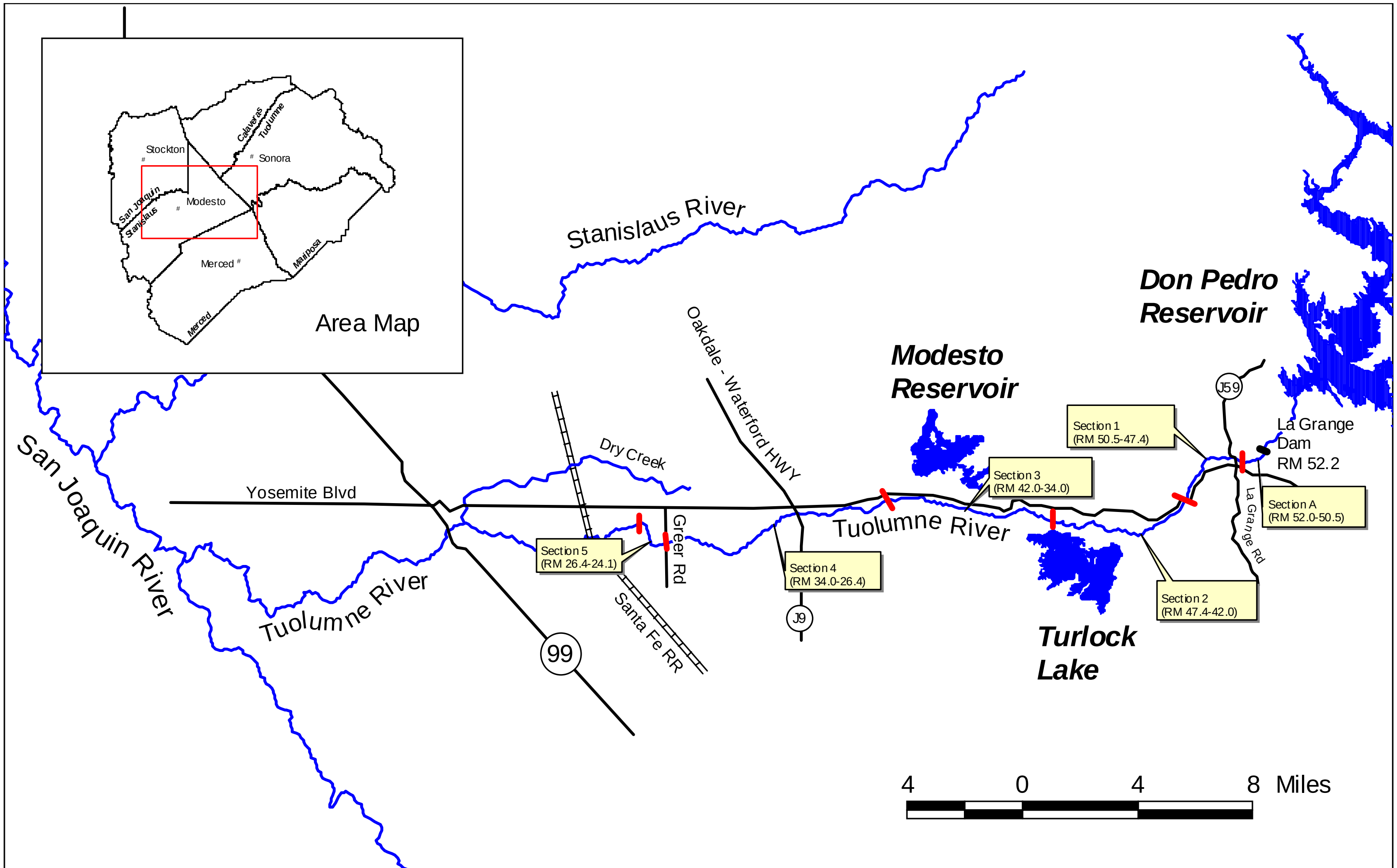

Figure 1. Salmon survey study areas, lower Tuolumne River.

California Department of Fish & Game

Prepared by: Gerald Hatler 01/18/2000

Figure 2. Fresh carcass indicated by clear eye.

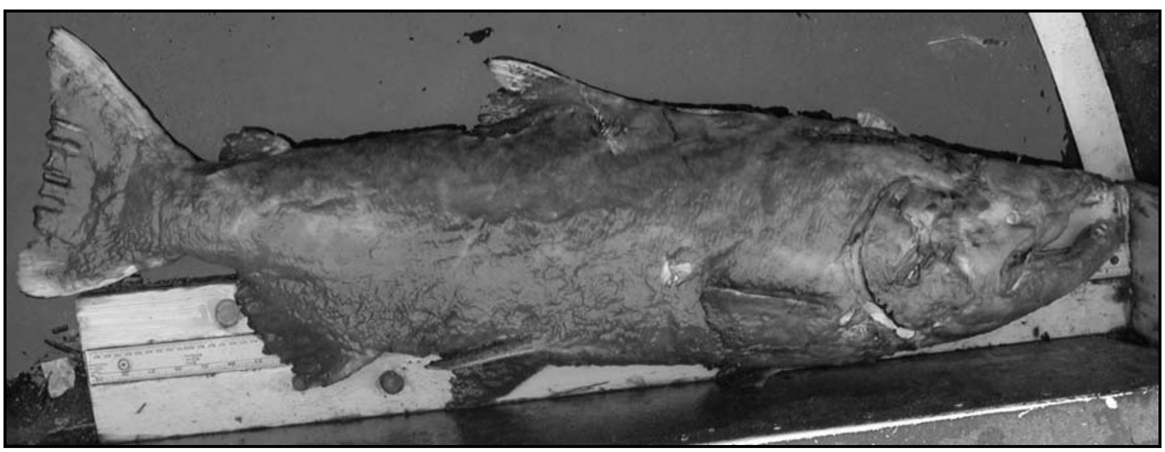

Figure 3. Fungus covered skeleton.

Figure 4. Two skeletons showing varied degrees of decomposition and a fresh carcass.

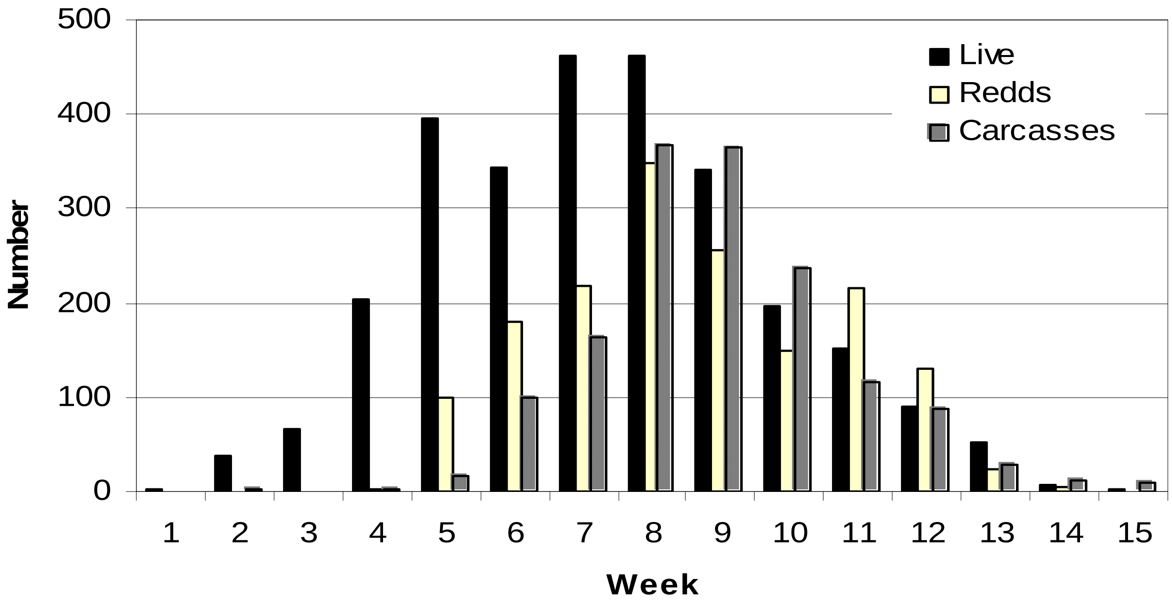

Figure 5. Live fish observation, redd, and total carcass weekly counts. Total carcasses includes all tagged carcasses and skeletons.

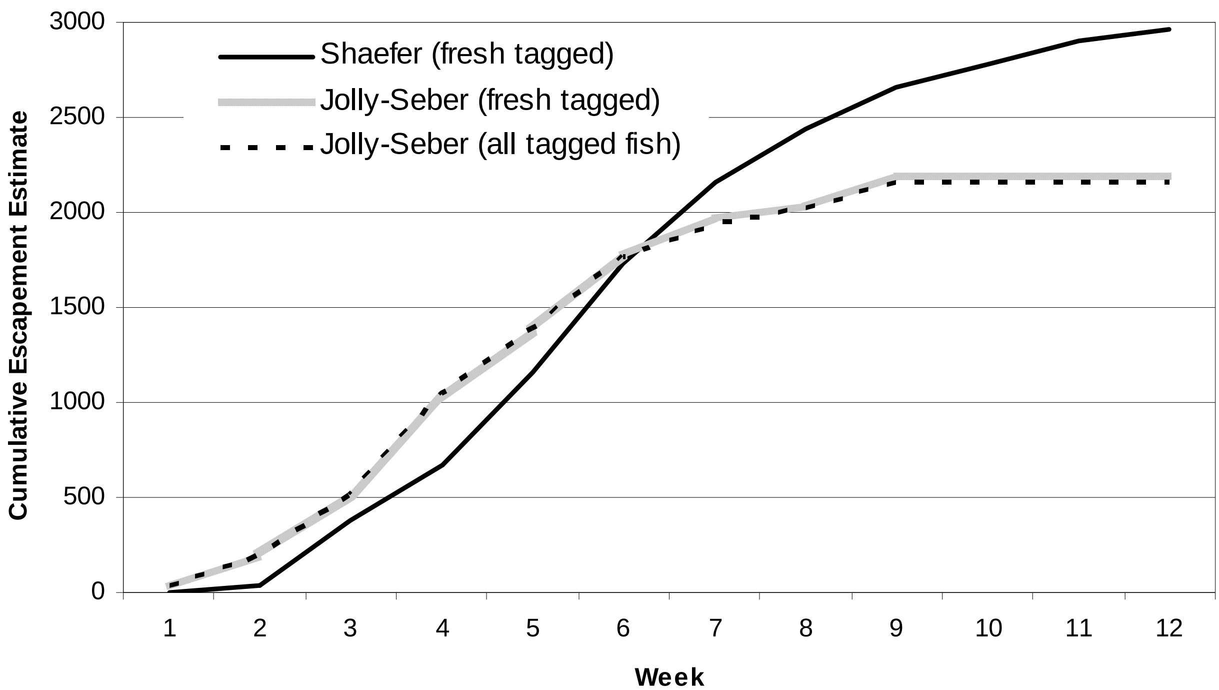

Figure 6. Weekly cumulative Schaeffer and Jolly-Seber escapement estimates.

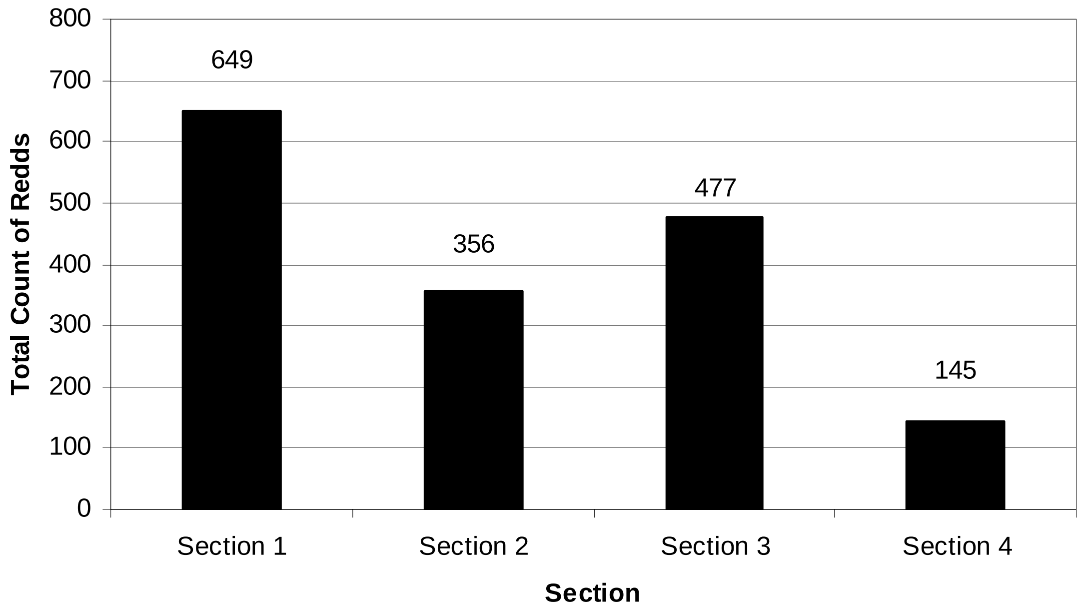

Figure 7. Total number of redds counted per section.

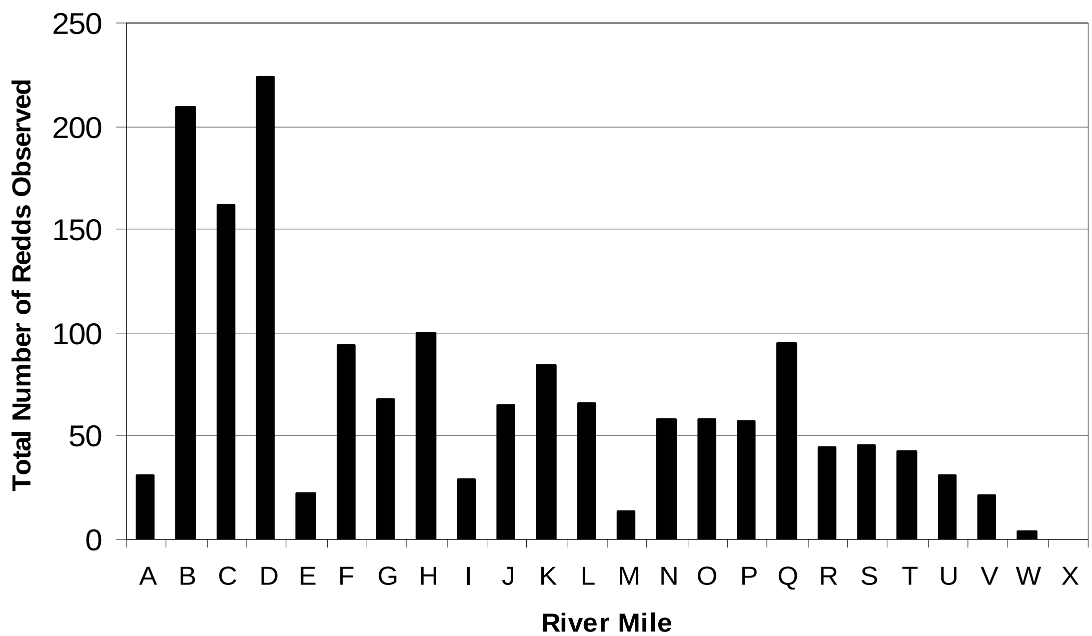

Figure 8. Total redds observed by riffle section. Each letter represents one river mile.

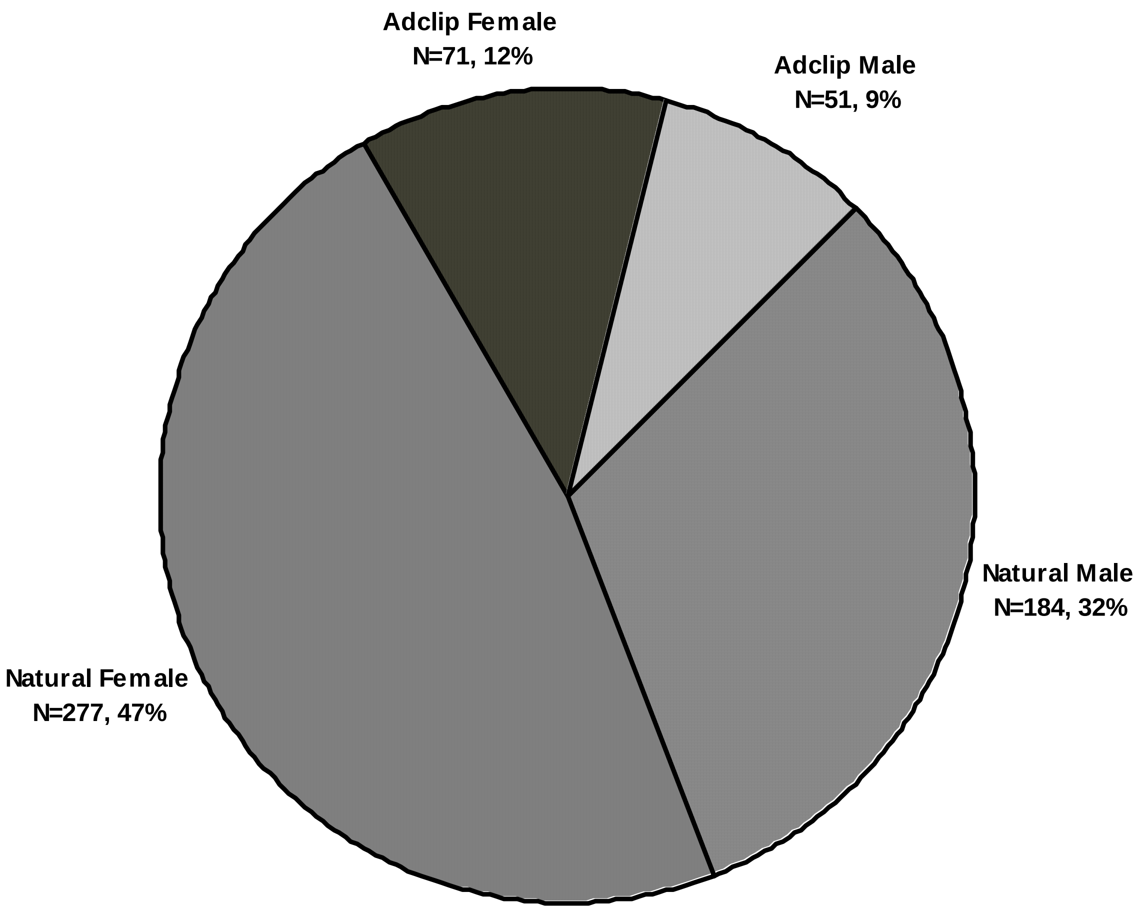

Figure 9. Contribution of natural female, adipose clipped female, natural male, and adipose fin clipped male to the 2003 Tuolumne River escapement.

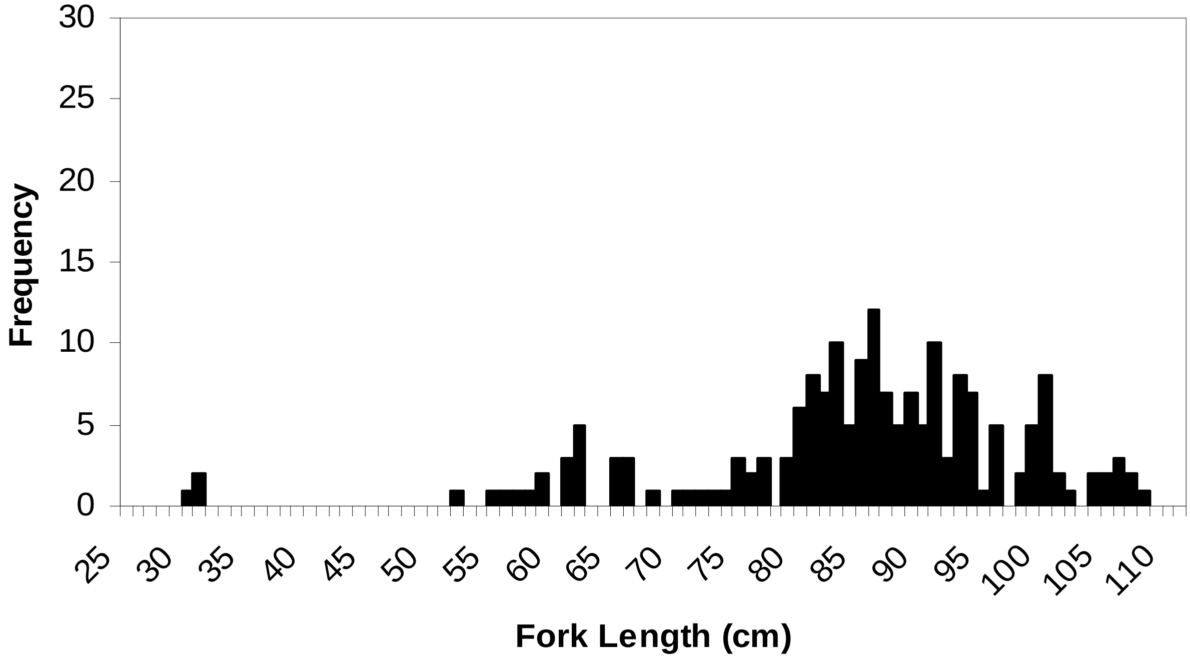

Figure 10. Length frequency histogram of natural male Chinook salmon.

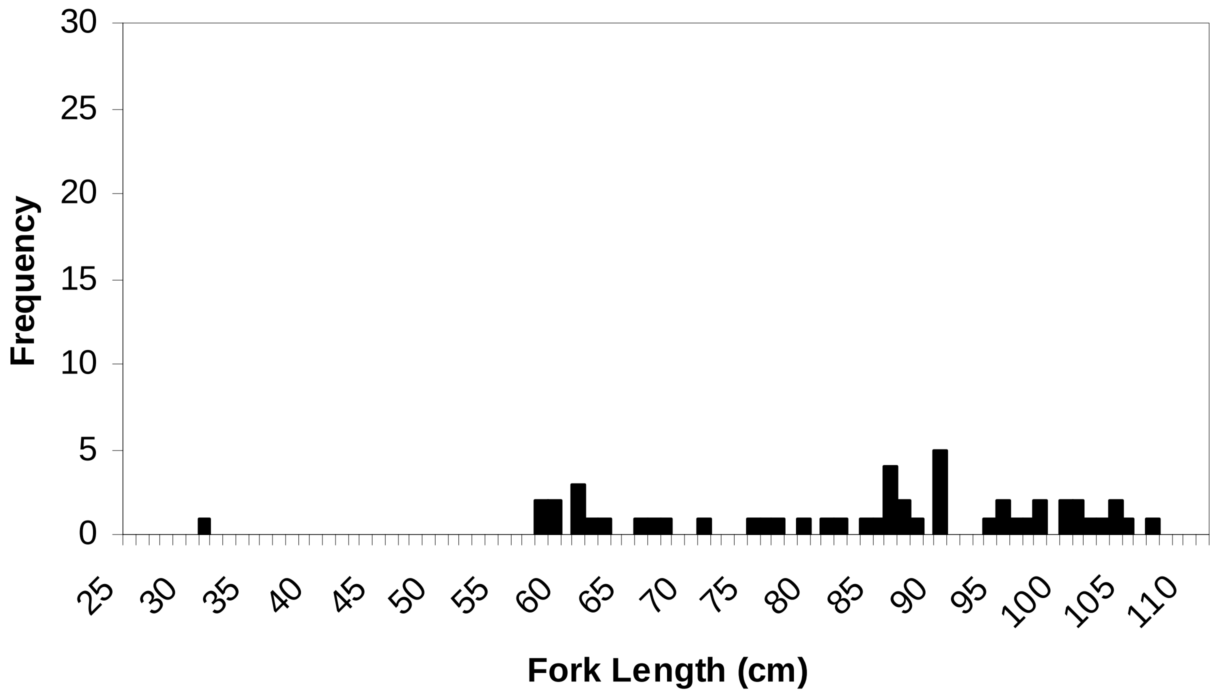

Figure 11. Length frequency histogram of adipose fin clipped male Chinook salmon.

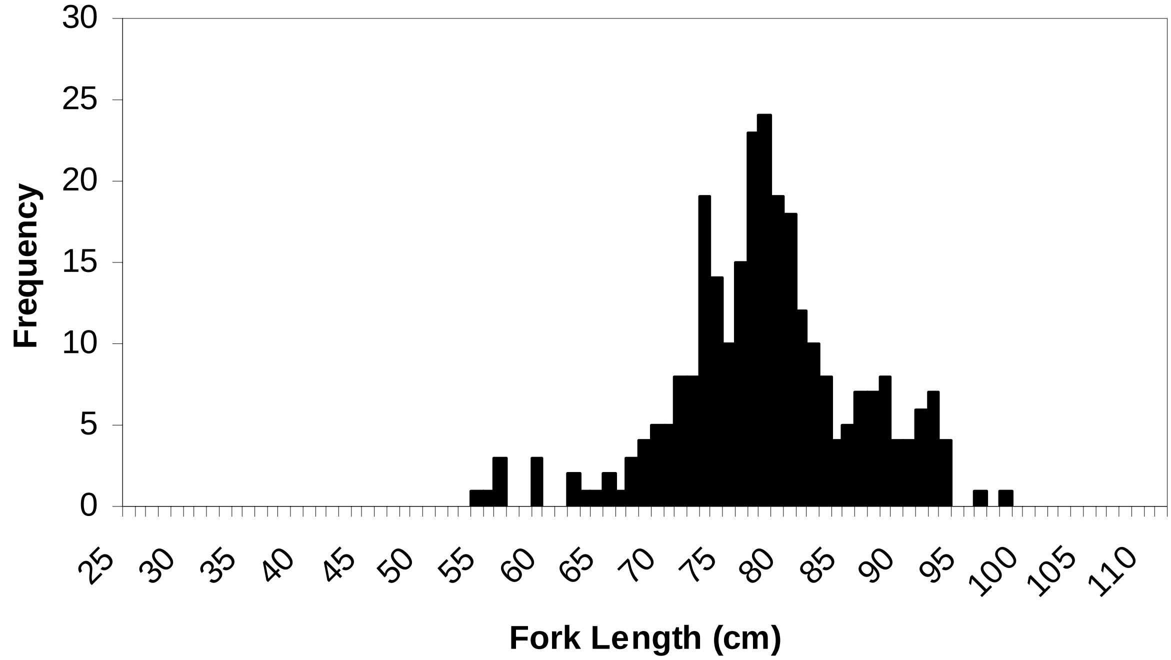

Figure 12. Length frequency histogram of natural female Chinook salmon.

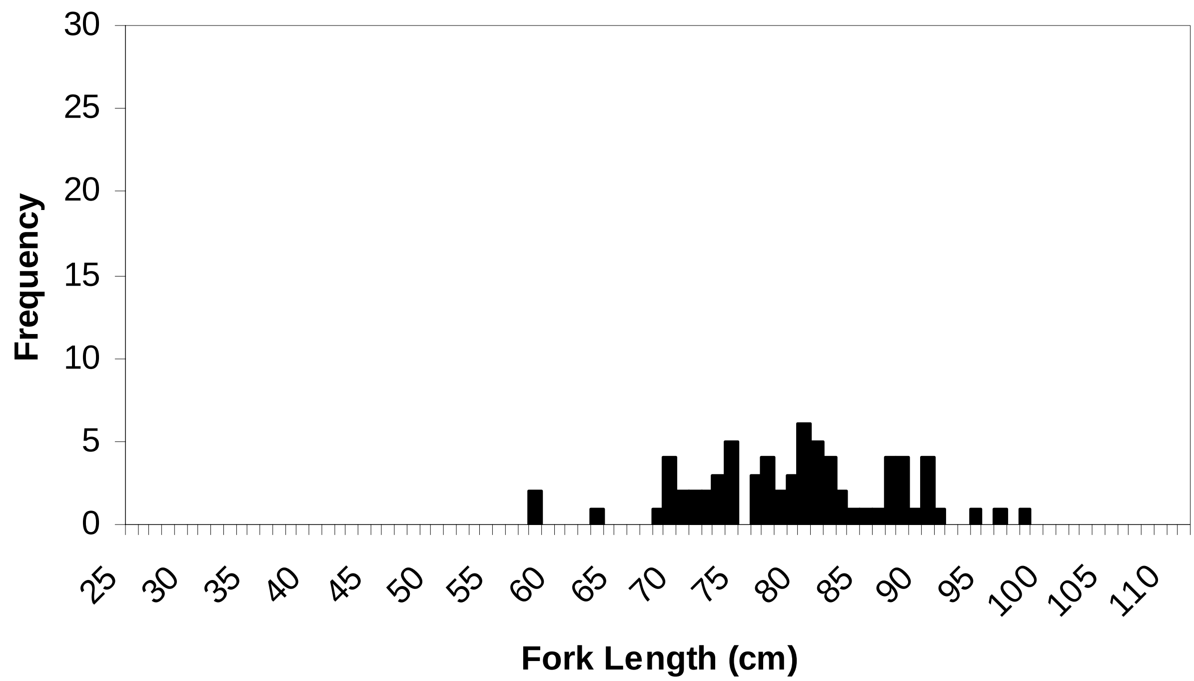

Figure 13. Length frequency histogram of adipose fin clipped female Chinook salmon.

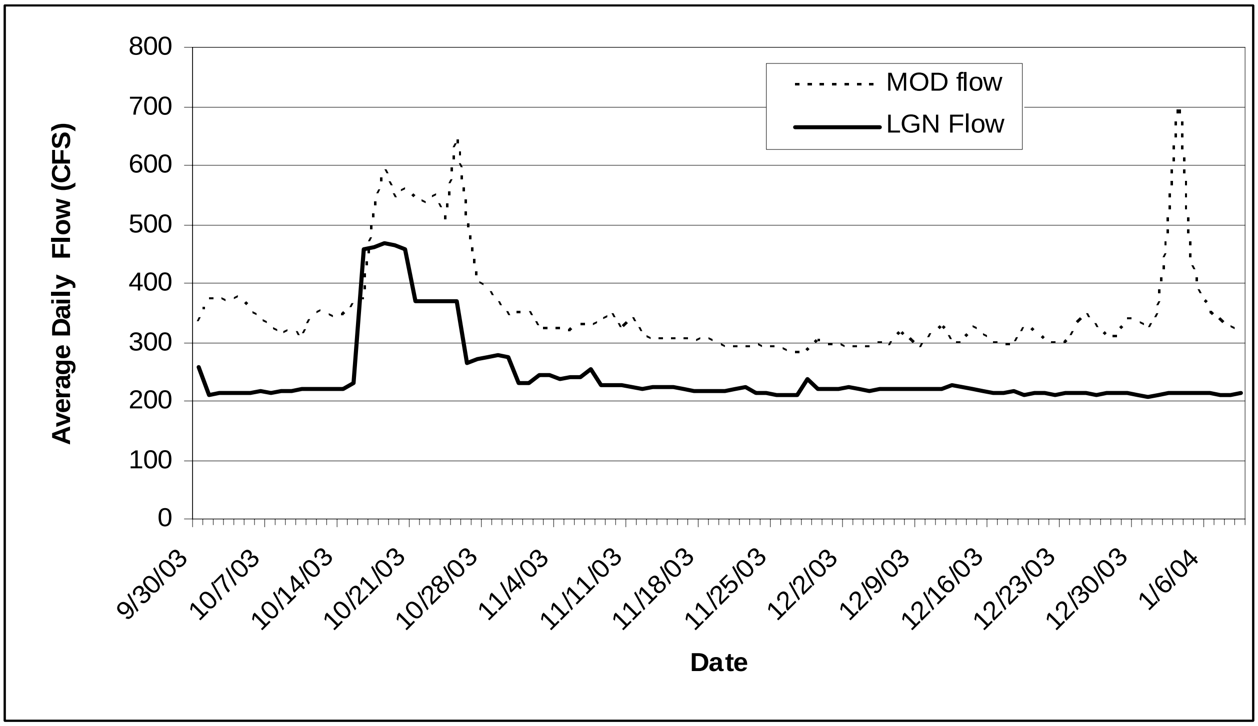

Figure 14. Average daily flow in the Tuolumne River (cubic feet per second) at the Modesto, and La Grange gauges. Preliminary data obtained from California Data Exchange Center (CDEC) website.

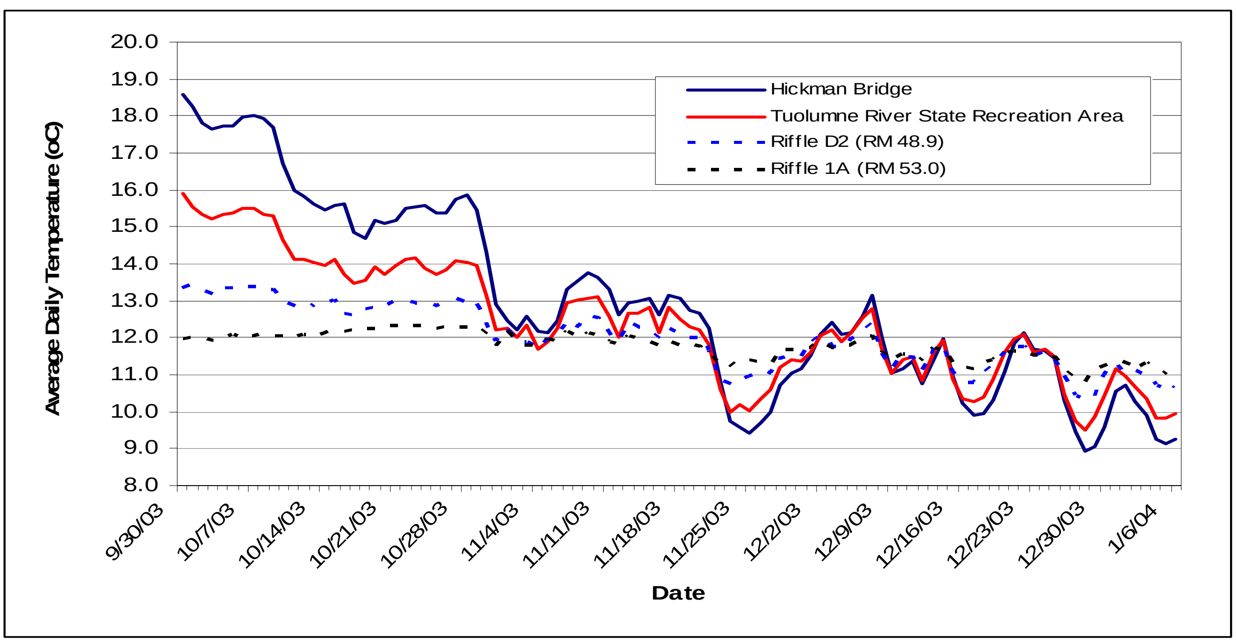

Figure 15. Average daily temperature (^{o}C) in the Tuolumne River at Hickman Bridge , RM 37.1, Turlock State Recreation Area, RM 41.8, Riffle D2, RM 48.9, and Riffle 1A, RM 53.0. Temperatures where obtained from thermograph data collected by CDFG.

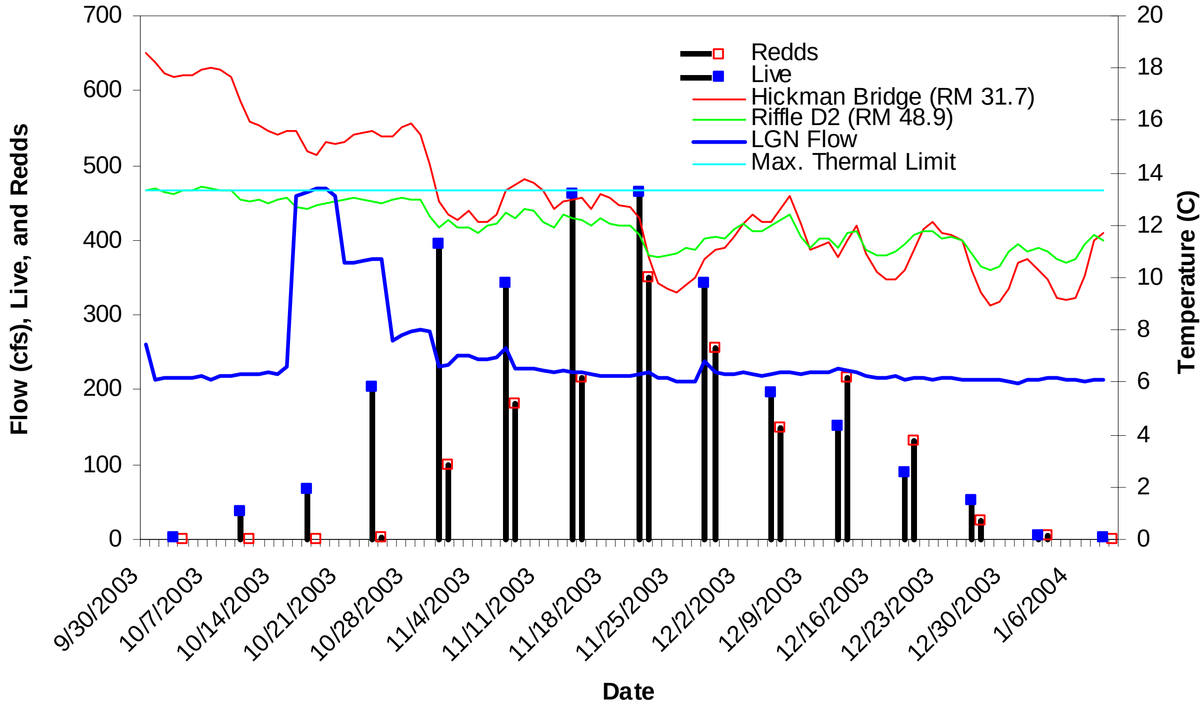

Figure 16. Weekly live salmon counts for the Tuolumne River escapement survey. Flow (cfs) at La Grange guage, temperatures from CDFG monitoring sites, maximum thermal limit.

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2004 Tuolumne River Fall Chinook Salmon Escapement Survey

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INTRODUCTION

The San Joaquin fall-run Chinook salmon is currently a candidate species under the Federal and State Endangered Species Acts. Population levels in the Tuolumne River have declined in the latter half of the 20th century from a high of approximately 130,000 returning adults in 1944 (Fry 1961) to a low of 77 in 1991 (Neillands et al. 1993). Population levels increased to 7,916 in 1998 (Heyne 1998), 7,685 in 1999 (Heyne 2000), 17,873 in 2000 (Vasques 2001) and 9,222 in 2001 (CDFG 2001), indicating a slight recovery period. Current levels are once again declining from 7,125 in 2002 (Blakeman 2003) and 2,163 in 2003 (Blakeman 2004) with this years estimate continuing this trend. The decline of the species is believed to be caused by many factors. In general, reduction of spawning and rearing habitat and stream flow management practices are thought to be the major factors limiting overall population numbers. Numerous additional factors including but not limited to predation, streambed alteration, pump diversion, gravel mining, land use practices, and ocean angler harvest contribute to a web of complex population dynamics which effect population numbers within the habitat currently available to Tuolumne River Chinook salmon.

The California Department of Fish and Game (CDFG) has conducted escapement surveys on the Tuolumne River since 1940 (Fry 1961). The Schaefer mark recapture escapement estimation model (Schaefer 1951) has been utilized since 1971. The 2003 escapement survey used the Jolly-Seber (Seber 1973) escapement model as well as reporting Schaefer estimates. The 2004 escapement estimate once again used the Schaefer model but will continue to report Jolly-Seber estimate. Beginning in 1992, CDFG escapement surveys have been utilized as part of the New Don Pedro FERC Project No. 2299 license monitoring program and annual reporting.

The primary objectives of the Tuolumne River escapement survey are to:

- Estimate the escapement of fall run Chinook salmon on the Tuolumne River.
- Collect fork length and sex data.
- Collect scale and otolith samples with which to conduct age determination analysis and subsequent cohort analysis.
- Collect and analyze coded wire tag data from marked hatchery fish.
- Evaluate the distribution of salmon redds through the study area.
- Collect DNA samples for storage at the CDFG Salmonid Tissue Archive for subsequent analysis.

STUDY AREA

Approximately 26.5 river miles were surveyed during the Tuolumne River escapement survey in 2004 (Figure 1). The survey area was divided into 4 sections with Section 1 being the upstream most reach. Section 1, also referred to as the primary spawning reach, extends from riffle 1a at river mile 52.0 near La Grange Dam downstream to Basso Bridge at river mile 47.5. Section 2 extends from Basso Bridge down to the Turlock Lake State Recreation Area (TLSRA) at river mile 41.9. Section 3 covers the area between TLSRA and riffle S1 at river mile 34. Section 4 extends downstream to Fox Grove (river mile 26).

All riffles in the study area have been identified and mapped using a Trimble GPS unit and the GIS computer program ArcView. Each riffle has been systematically re-named upstream to downstream using sequential letter/number designations for river mile and riffle number, respectively. For example, the first riffle surveyed below La Grange Dam in the first river mile (51) is named A1. The riffle immediately below La Grange Dam (riffle 1a) is surveyed by foot and only redd and fish counts are made. This numbering system is a departure from the historical riffle numbering system. However, the new riffle identification system is more logical and is more conducive to editing as river morphology changes. The riffle identification cross-reference is located in Table 1.

METHODS

Population Estimation

The Schaefer (1951) and Jolly-Seber (Seber 1972) mark recapture models were used to estimate fall salmon escapement on the lower Tuolumne River. These methods utilize marked and subsequently recovered carcasses during weekly surveys of the spawning reach. A ratio of marked to unmarked fish is used to calculate weekly population estimates, which are then summed to estimate the total spawning population. The CDFG began the survey on 4 October 2004 (Week 1) and concluded on 6 January 2005 (Week 14). Carcasses were tagged for the first 12 weeks. Weeks 13 and 14 no carcasses were tagged, these were strictly carcass recovery weeks. During the two recovery weeks, carcasses were collected and examined for jaw tags and all carcasses collected were chopped in half.

All carcasses encountered were handled during weekly drift boat surveys of the study area. Carcasses were gaffed as the sampling crew drifted past and held in the boat until the end of the riffle and adjacent downstream pool. Subsequent to drifting the riffle and downstream pool the riverbanks were walked to collect carcasses that could not be seen or collected from the drift boat. Every carcass handled was designated as fresh, decayed, skeleton or recovery, depending on the degree of decomposition or the presence of an aluminum jaw tag in the case of recoveries. The fresh carcass designation criteria during 2003 was at least one clear eye (Figure 2). Decayed fish had cloudy eyes. Skeletons were carcasses judged to be in an advanced state of decay and unlikely to have the same probability of recapture as fresh and decayed specimens. Criteria for skeleton designation during the 2003 survey included the presence of fungus covering the entire body at the freshest end of skeleton designation (dead approximately one week) to actual skeletons at the most decayed end (Figures 3 and 4).

All fresh and decayed carcasses were given a unique number by attaching a numbered aluminum tag to the lower jaw. These newly tagged carcasses were redistributed to river current near the lower end of the riffle for recovery in subsequent weeks. For tag recoveries, the unique tag number was noted and the carcass was chopped and returned to the river. All skeletons were enumerated, chopped, and returned to the river to avoid double counting. Estimates were made using the Schaefer (1951) equation as presented in Ricker (1975) and also using the Jolly-Seber equation (Seber 1973). Law (1994) found in simulations of various models, using a similar protocol as this survey, that the Peterson model (see Ricker, 1975) drastically over estimated, while the Schaefer model consistently overestimated the population and the Jolly-Seber model most accurately estimated the population. Therefore, Peterson's model was not used in this analysis and estimates using the Schaefer and Jolly-Seber models will be reported.

Weekly Fish Distribution and Redd Counts

Weekly live fish observation and redd counts were conducted during the survey (Table 2, Figure 5). These counts are conducted for each riffle and pool using the riffle identification system noted earlier. Counts are made using tally counters as field crews drifted through riffles and pools. For consistency the same observer was used each week to make live fish and redd counts.

Individual Fish Data Collection

Fork length (to the nearest 1 centimeter) and sex data are collected for all tagged carcasses. Scale and otolith samples are collected from a percentage of specimens to determine the size and age composition of annual spawning runs. Coded wire tags (CWTs) are collected from hatchery produced, marked (adipose fin clipped), carcasses as part of long term survival testing of releases of marked outmigrating smolts. This also allows for determining the incidence of straying from other river systems. CWT specimens are also used to validate scale and otolith age determination work. Genetic samples: caudal, dorsal, or pectoral fin clips were collected, and delivered to the CDFG Salmonid Tissue Archive at the end of the survey. Scale and otolith samples were collected from both wild and CWT carcasses and are catalogued at the CDFG La Grange Field Office. CWTs and otoliths are collected via removal of the head minus the lower jaw. Extraction and analysis of otoliths and CWTs is conducted after the spawning season. All fish samples are catalogued by the fish's unique jaw tag number, which allows the samples to be tracked to the specific data and riffle number of collection.

RESULTS

Population Estimate

Based on the Schaefer model using all tagged fish and recoveries the 2004 escapement estimate was **1,634 salmon**. The Jolly-Seber model using all tagged fish yielded an estimate of 1,532. Past estimates from carcass surveys conducted by CDFG have utilized the Schaefer model using only fresh tagged carcasses despite Law's (1994) findings that including all carcasses (fresh and decayed) only slightly effect the estimate for all models. Schaefer and Jolly-Seber estimates using only fresh fish in 2004 were 1,693 and 1,519, respectively. The Schaefer model utilizes the number of recoveries of tagged carcasses, the total number of tagged fish, and the total number carcasses handled each week to generate weekly escapement estimates (Table 3). Weekly estimates are summated to estimate total escapement over the course of the survey. Table 4 shows the total number tagged each week in relation to the number of recoveries made in subsequent weeks. Weekly estimates are presented in Table 5. Weekly cumulative Schaefer and Jolly-Seber estimates are graphed in Figure 6. The fresh tagged recovery rate was 63.6% which is slightly lower than the overall recovery rate of 65.4%.

Weekly Counts

Live fish counts increased steadily, peaked in week 6 , and declined steadily through the remainder of the survey (Table 2, Figure 5). Carcass counts exhibited a similar incline, peak, and decline which were offset from live counts by about two weeks. The carcass count peaked in week 8. Redd counts increased through week 7 when the total number of observations was 455.

Spawning Distribution

The results of total weekly redd counts clearly indicate that the majority (greater than 53%) of spawning activity is concentrated in the riffles of Section 1 (Figures 7 and 8). The maximum number of redds counted in a particular riffle over the course of the season are listed in Table 6. The maximum redd count represents the redd count made when external factors like visibility were at optimum conditions. During the 2004 survey 262, 85, 106, and 38 maximum redds were counted for sections 1 through 4 respectively (Figure 7).

Population Composition

Coded wire tagged fish comprised 18% of the total tagged carcasses based on the ratio of adipose fin clipped fish to total tagged carcasses (Table 3). Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. However, it is likely that ratios calculated for tagged fish are representative for skeletons as well. The total contributions (tagged fish only) to the spawning population were 36% for natural males, 5% for CWT males, 47% for natural females, and 12% for CWT females (Figure 9). CWT verification and tag reading will be conducted at a later date therefore all CWT data presented here are preliminary.

Length frequency histograms of male and female fish (both natural and CWT) display bimodal peaks (Figures 10 - 13). The first peaks are likely grilse (age 1 and 2 fish) and the second peaks are likely adult (age 3, 4, and 5 year fish). Total grilse composition was 37% of the Tuolumne River escapement estimate. Breakpoints between grilse and adult were determined from basin wide fork length data. Breakpoints used were 66 cm for natural females, 63 cm for adipose fin clipped females, 74 cm for natural males and 70 cm for ad-clipped males. Further breakdown of grilse is presented in Table 7.

Sample Collection

Scales and otolith samples were collected from both natural and adipose fin clipped fish. DNA samples were collected from non ad-clipped fish. Samples were collected throughout the survey period and survey area (Tables 8, 9 and 10). Distribution of sampling is intended to best represent the spawning population over time, space, and origin. Scale and otolith samples will be utilized in the CDFG age determination program and for subsequent cohort analysis of San Joaquin River Basin Chinook salmon populations. Ninety-five DNA samples were collected and delivered to the CDFG Salmonid Tissue Archives.

Egg Production Estimate

An estimate of egg production by the 2004 fall run Chinook salmon is done using the relationship of fork length to fecundity. The relationship was developed using 48 San Joaquin fall run Chinook females ranging from fork length 62.5 to 94.0 cm (Loudermilk et al. 1990). The number of eggs was calculated for natural females (n=245, average FL=72.2) and CWT females (n=65, average FL=75.8) and then expanded to the entire estimate. Natural females made up 47% of the 2004 estimate and produced approximately 4,074,180 eggs. Adipose fin clipped females (12%) produced approximately 1,149,869 eggs.

Tuolumne River Flows

Tuolumne River flows at the La Grange gage ranged from approximately 167cfs to 495cfs during the 2004 spawning season (Figure 14). To attract fish into the Tuolumne from the San Joaquin River and improve spawning habitat a pulse flow was initiated on 26 October 2003. Flow increased to approximately 490cfs on 27 October 2003 and was reduced to approximately 200cfs on 30 October 2003 and then further decreased to about 175cfs for the remainder of the spawning season.

Tuolumne River Temperature

Water temperatures are recorded in several locations throughout the spawning reach using data loggers placed and maintained by CDFG. Three sites are plotted in Figure 15.

DISCUSSION

Spawning Distribution

Redd counts are strongly affected by time of day, visibility, sunlight , wind rippling the water surface, redd superimposition, and other physical factors as well as the natural variability between observers. Furthermore, redd counts are conducted with a single pass as opposed to an intensive systematic approach beyond the scope of this study. In the primary spawning riffles of Section 1 the problem of redd superimposition is acute and leads to undercounting. On the other hand, redds in Section 2, 3, and 4 are easily delineated as clean patches of freshly worked gravel among patches of darker undisturbed gravel. In these sections redd counts are accurate indicators of spawning density. For these reasons, the disparity between spawning density in Section 1 versus Sections 2, 3, and 4 is likely greater than displayed in Figures 10 and 11.

Population Estimate

The 2004 tag recovery rate of 65.4% is the highest reported since the 2000 recovery rate of 41.7% (Vasques 2001). From 2001 to 2003 recovery rates have been relatively high ranging from 55.3% to 64.4%. The difference in recovery rates is likely a function of the difference in stream flow between 2000, (over 300cfs) and 2001 - 2004, (under 200cfs). Stream flow dynamics affects the likelihood of collecting carcasses in that it effects both how carcasses are distributed in the system and the effectiveness in recovering carcasses by field crews. During the lower flows encountered during the 2002 - 04 surveys carcasses were easily visible and the lower flows allowed for collection in specific locations which were too deep or too swift to survey in 2000. Furthermore, the banks of riffles were walked in an effort to collect carcasses that could not be seen or collected during the initial float through the riffle and subsequent pool. During 2000 bank efforts were not nearly so extensive. The Tuolumne River escapement estimate for 2004 of 1,634 salmon is the lowest since the 2003 estimate of 2,163 and the 1996 estimate of 4,550 salmon.

Population Composition

Coded wire tagged fish comprised 17 % of the total tagged carcasses based on the ratio of adipose fin clipped fish to total tagged carcasses (Table 3). Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. However, it is likely that ratios calculated for tagged fish are representative for skeletons as well. The total contributions (tagged fish only) to the spawning population were 36% for natural males, 5% for adipose fin clipped males, 47% for natural females, and 12% for adipose fin clipped females (Figure 9). CWT verification and tag reading will be conducted at a later date therefore all CWT data presented here are preliminary.

Length frequency histograms of male and female fish (both natural and CWT) display bimodal peaks (Figures 10,11,12 and 13). The first peaks are likely grilse (age 1 and 2 fish) and the second peaks are likely adult (age 3, 4, and 5 year fish). Total grilse composition was 37 % of the Tuolumne River escapement estimate. Breakpoints between grilse and adult were determined from basin wide fork length data and applied to Tuolumne River fork length data to determine grilse composition. Breakpoints used were 66 cm for natural females, 63 cm for adipose fin clipped females, 74 cm for natural males and 70 cm for adipose fin clipped. Further breakdown of grilse is presented in Table 7. Grilse made up 57% of all males with 53% being natural males.

Tuolumne River Flows

Low dissolved oxygen levels in the San Joaquin River are believed to be a barrier for fall-run salmon migrating up the San Joaquin stem to spawn in the Merced, Tuolumne and Stanislaus Rivers. A fall pulse flow regime has been developed to lower river temperatures and elevate levels of dissolved oxygen in the San Joaquin River in order to attract salmon and prevent straying. Redd counts on the Tuolumne River started in week 4 which coincided with temperatures dropping below the thermal limit of 13^{o}C. The flow, temperatures and observed redds are presented in Figure 15.

Tuolumne River Temperatures

Temperatures in the upper sections (Section 1 and 2) down to Tuolumne River State Recreation Area (TRSRA, RM 41.7) remained below the maximum thermal limit of 13.3^{o}C for most all of the spawning season except for a few days in early October. This temperature is considered to be the upper thermal limit for successful egg incubation (Myrick and Cech 1998). River temperatures at Turlock Lake State Recreation Area Campground fell below the 13.3^{o}C level in the beginning of November and coincided with the first few redd observations in week 5 of the survey.

Table 1. Tuolumne River riffle identification cross-reference, 2004 to 2003.

Section 1		Section 2		Section 3		Section 4	
New ID	**Old ID**	**New ID**	**Old ID**	**New ID**	**Old ID**	**New ID**	**Old ID**
1a	1a	F1	F1	K1	K1	S1	S1
A1	A1	F2	F2	K2	K2	S2	S2
A2	A2	F3	F3	L1	L1	S3	S3
B1	B1	G1	G1S	L2	L2	T1	T1
B2	B2	None	G1N	L2N	L2	T2	T2
B3	B3	G2	G2	L3	L3	T3	T3
C1	C1	G3	G3	M1	M1	T4	T4
C2	C2	G4	G4	M2	M2	T5	T5
C3	C3	H1	H1	N1	N1	U1	U1
D1	D1	H2	H2	N2	N2	U2	U2
D2	D2	H3N	H3N	N3	N3	U3	U3
D3	D3	H3S	H3S	N4	N4	V1	V1
D4	D4	H4	H4	O1	O1	V2	V2
D5	D5	H5	H5	O2	O2	V3	V3
E1	E1	H6	H6	O3	O3	V4	V4
		I1	I1	O4	O4	W1	W1
		I2	I2	O5	O5	W2	W2
		I3	I3	P1	P1	W3	W3
		J1	J1	P2	P2	X1	X1
		J2	J2	P3	P3	X2	X2
		J3	J3	P4	P4		
		J4	J4	Q1	Q1		
		J5	J5	Q2	Q2		
				Q3	Q3		
				R1	R1		
				R2	R2		
				R3	R3		

Table 2. Total weekly counts of live fish, redds, and carcasses.

Week	Live	Redds	Carcasses
1	6	0	0
2	39	0	0
3	26	0	0
4	157	13	1
5	591	176	1
6	618	353	34
7	528	455	290
8	379	422	391
9	189	325	238
10	130	232	119
11	63	131	99
12	35	51	32
13	14	16	13
14	2	2	6
Totals	**2777**	**2176**	**1224**

[a] Carcasses includes all tagged carcasses and skeletons but does not include recoveries.

Table 3. Weekly totals.

Week	Total Tagged	Skeletons	Fresh Recoveries	Total Counted	Fresh Tagged	CWT's
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	1	0	1	0	0
5	1	0	0	1	1	1
6	24	10	0	34	21	7
7	146	144	11	301	116	36
8	175	216	69	460	152	31
9	112	126	97	335	99	9
10	38	81	71	190	32	3
11	16	83	26	125	13	4
12	11	21	6	38	11	1
13	0	13	3	16	0	0
14	0	6	0	6	0	0
Totals	**523**	**701**	**283**	**1507**	**445**	**92**

[1]Includes only fish that were deemed fresh when tagged.
[2]Includes total tagged, skeletons, and fresh recoveries.

Table 4. Distribution of all tagged fish, tag week versus recovery week.

Recovery Week	Tag Week of Recovered Tags												Weekly Total
	1	2	3	4	5	6	7	8	9	10	11	12	
2	0												0
3	0	0											0
4	0	0	0										0
5	0	0	0	0									0
6	0	0	0	0	0								0
7	0	0	0	0	0	13							13
8	0	0	0	0	0	1	88						89
9	0	0	0	0	0	0	9	107					116
10	0	0	0	0	0	0	2	13	61				76
11	0	0	0	0	0	0	1	5	8	19			33
12	0	0	0	0	0	0	0	1	2	3	4		10
13	0	0	0	0	0	0	0	0	0	3	0	2	5
14	0	0	0	0	0	0	0	0	0	0	0	0	0
All Recoveies	0	0	0	0	0	14	100	126	71	25	4	2	342
Total Tagged Carcasses	0	0	0	0	1	24	146	175	112	38	16	11	Overall Recovery
Percent Recovery	0.0	0.0	0.0	0.0	0.0	58.3	68.5	72.0	63.4	65.8	25.0	18.2	65.4%

Table 5. Weekly Schaefer and Jolly-Seber estimates.

Week	Number of Tags Recovered	Total Carcasses Handled	Schaefer Estimate	Jolly-Seber Estimate
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	1	11	3	55
6	24	144	94	46
7	146	216	386	220
8	175	126	472	370
9	112	81	442	354
10	38	83	141	357
11	16	21	96	59
12	11	19	0	71
13	0	0	0	0
14	0	0	0	0
Total Estimate			1634	1532

Table 6. Maximum redd count for each riffle over the course of the escapement survey by section.

Section 1		Section 2		Section 3		Section 4	
Riffle	Maximum Redd count	Riffle	Maximum Redd count	Riffle	Maximum Redd count	Riffle	Maximum Redd count
1A	10	F1	13	K1	9	S1	2
A1	10	F2	4	K2	9	S2	2
A2	1	F3	5	L1	5	S3	6
B1	17	G1	5	L2	6	T1	0
B2	40	G2	2	L3	8	T2	4
B3	19	G3	1	M1	0	T3	3
C1	46	G4	1	M2	2	T4	4
C2	0	H1	2	N1	5	T5	1
C3	38	H2	4	N2	5	U1	4
D1	8	H3	3	N3	3	U2	3
D2	30	H4	3	N4	5	U3	1
D3	1	H5	4	O1	2	V1	2
D4	35	H6	6	O2	1	V2	0
D5	4	I1	4	O3	2	V3	0
E1	3	I2	4	O4	0	V4	1
		I3	3	O5	6	W1	0
		J1	3	P1	0	W2	2
		J2	3	P2	4	W3	1
		J3	4	P3	6	X1	0
		J4	5	P4	1	X2	0
		J5	6	Q1	10		
				Q2	3		
				Q3	8		
				R1	4		
				R2	0		
				R3	2		
Subtotal	**262**		**85**		**106**		**36**
Total	**523**						

Table 7. Grilse composition of Chinook salmon.

	Male	Female	Male (n=235)		Female (n=349)	
			Adclip	Natural	Adclip	Natural
Grilse	**23%** (n=122)	**14%** (n=74)	**4%** (n=9)	**53%** (n=113)	**1%** (n=2)	**23%** (n=72)
Adult	**18%** (n=91)	**45%** (n=236)	**9%** (n=18)	**34%** (n=73)	**20%** (n=63)	**56%** (n=173)

Table 8. Distribution of scale samples collected by section and week for natural and adipose fin clipped salmon.

Week	Section				Weekly Totals
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0(1)	0	1
6	8(3)	1	0	0	12
7	48(16)	4(1)	3	0	72
8	65(15)	3	4	2	89
9	39(3)	5	17	3(1)	68
10	17(1)	5	10(1)	2(1)	37
11	5(4)	0	6	1	16
12	3(1)	1	3	3	11
13	0	0	0	0	0
14	0	0	0	0	0
Totals	228	20	45	13	306

Parenthesis indicate number of samples from adipose fin-clipped carcasses.

Table 9. Distribution of heads collected from Chinook salmon.

Week	Section				Weekly Totals
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	1	0	1
6	6	1	0	0	7
7	33	2	1	0	36
8	31	0	0	0	31
9	6	2	0	1	9
10	1	0	1	1	3
11	4	0	0	0	4
12	1	0	0	0	1
13	0	0	0	0	0
14	0	0	0	0	0
	82	5	3	2	92

Heads were taken only from adipose fin-clipped carcasses.

Table 10. Distribution of DNA samples collected from non adipose clipped salmon.

Week	Section				Weekly Totals
	1	2	3	4	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	2	0	0	0	2
7	6	1	1	0	8
8	20	2	5	0	27
9	14	5	0	0	19
10	7	2	9	2	20
11	3	0	5	1	9
12	3	1	3	3	10
13	0	0	0	0	0
14	0	0	0	0	0
	55	11	23	6	95

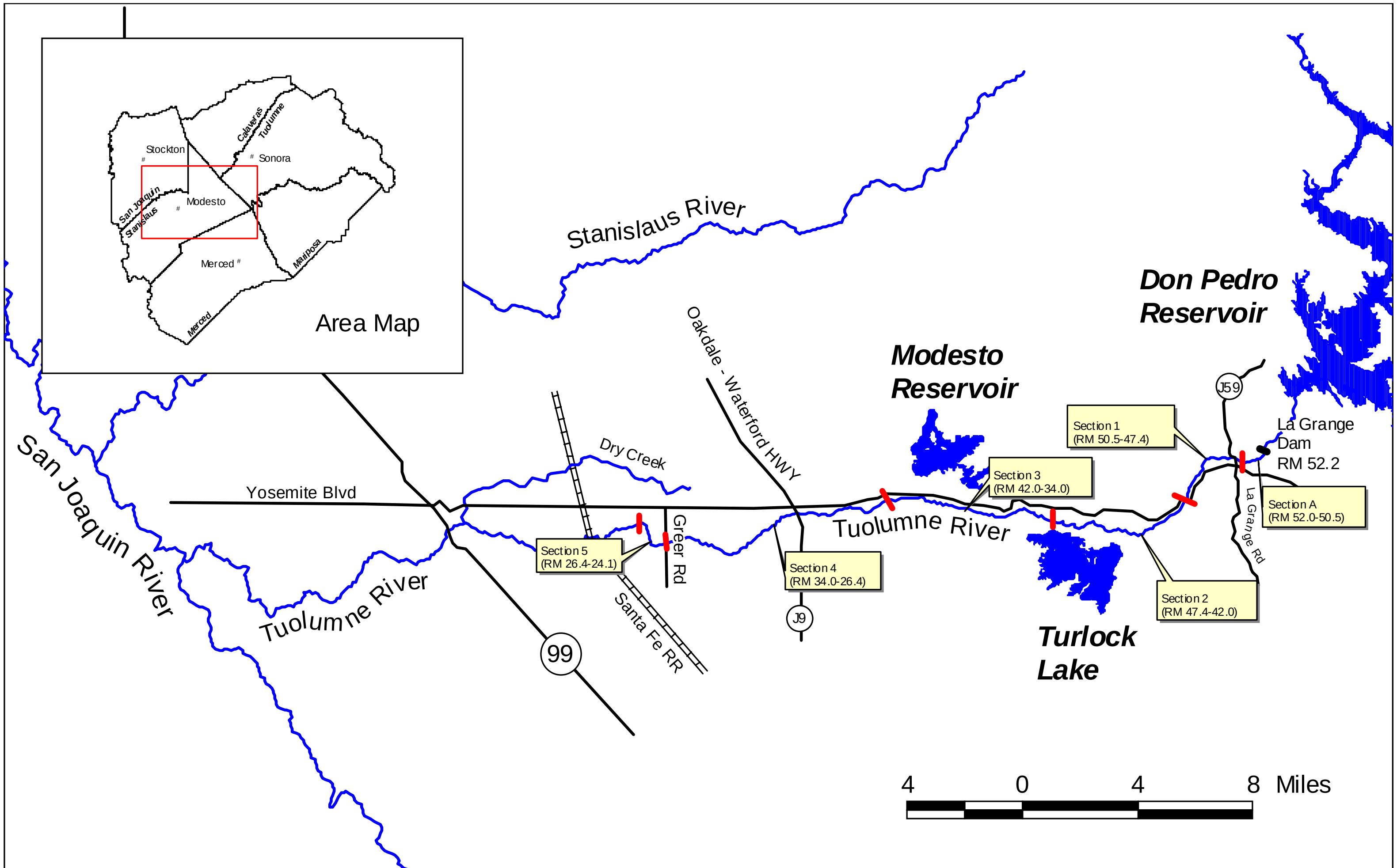

Figure 1. Salmon survey study areas, lower Tuolumne River.

California Department of Fish & Game

Prepared by: Gerald Hatler 01/18/2000

Figure 2. Fresh carcass indicated by clear eye.

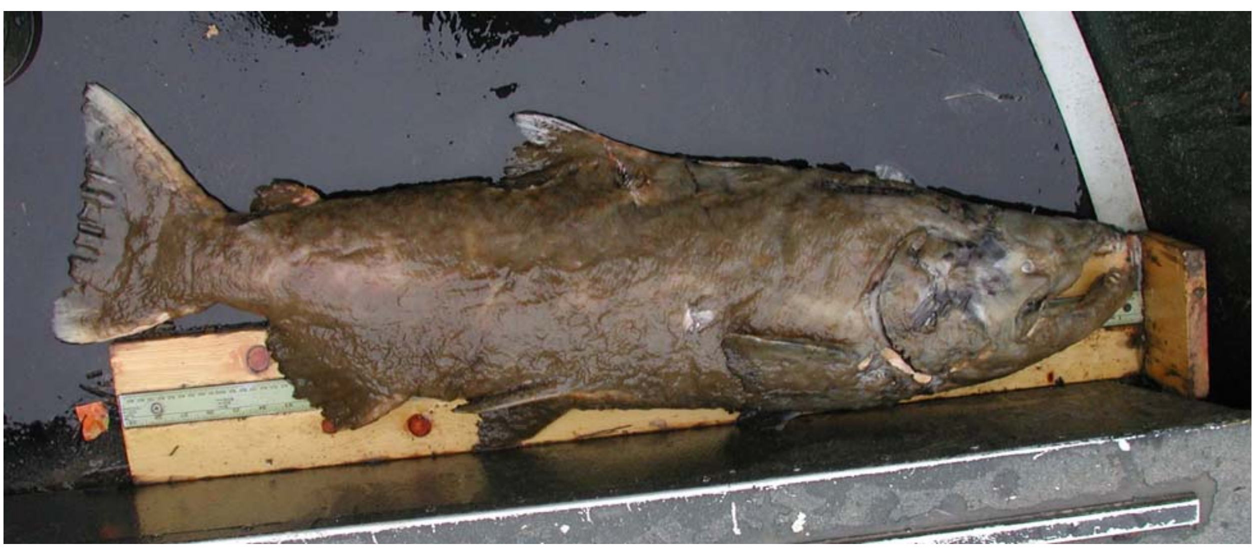

Figure 3. Fungus covered skeleton.

Figure 4. Two skeletons showing varied degrees of decomposition and a fresh carcass.

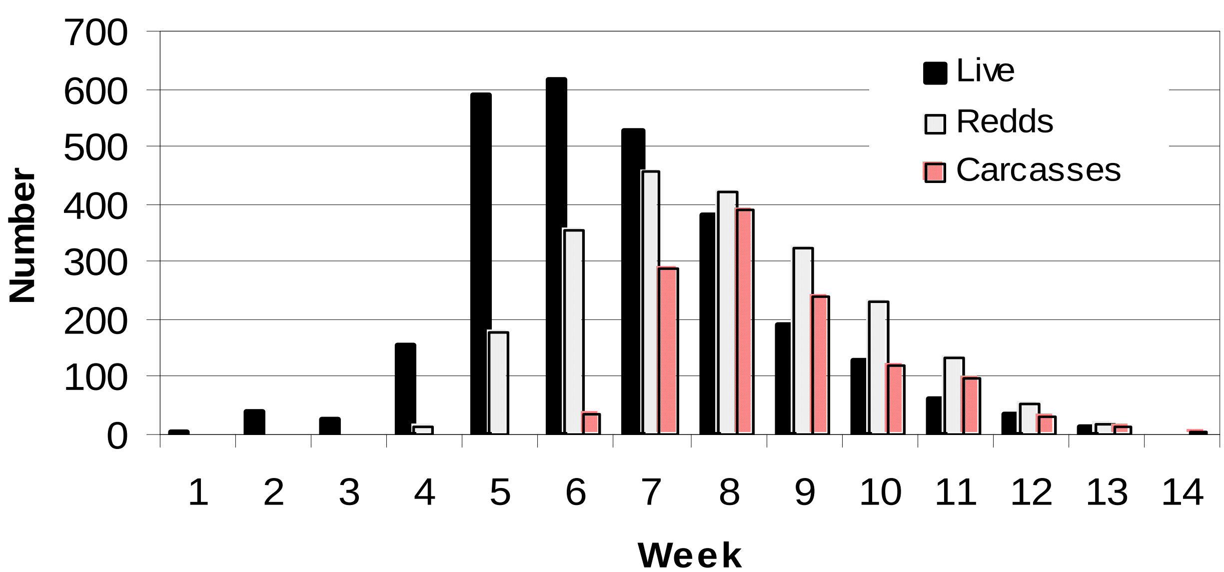

Figure 5. Live fish observation, redd, and total carcass weekly counts. Carcasses include all tagged carcasses and skeletons.

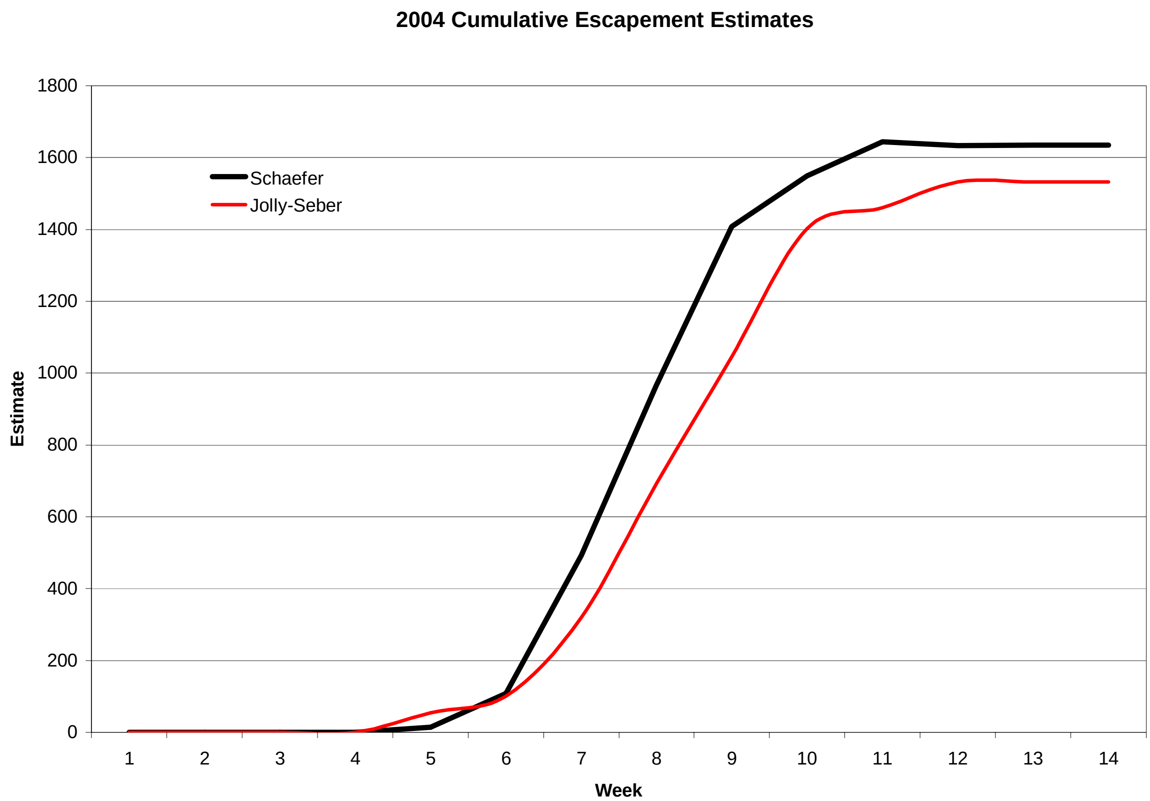

Figure 6. Weekly cumulative Schaeffer and Jolly-Seber escapement estimates.

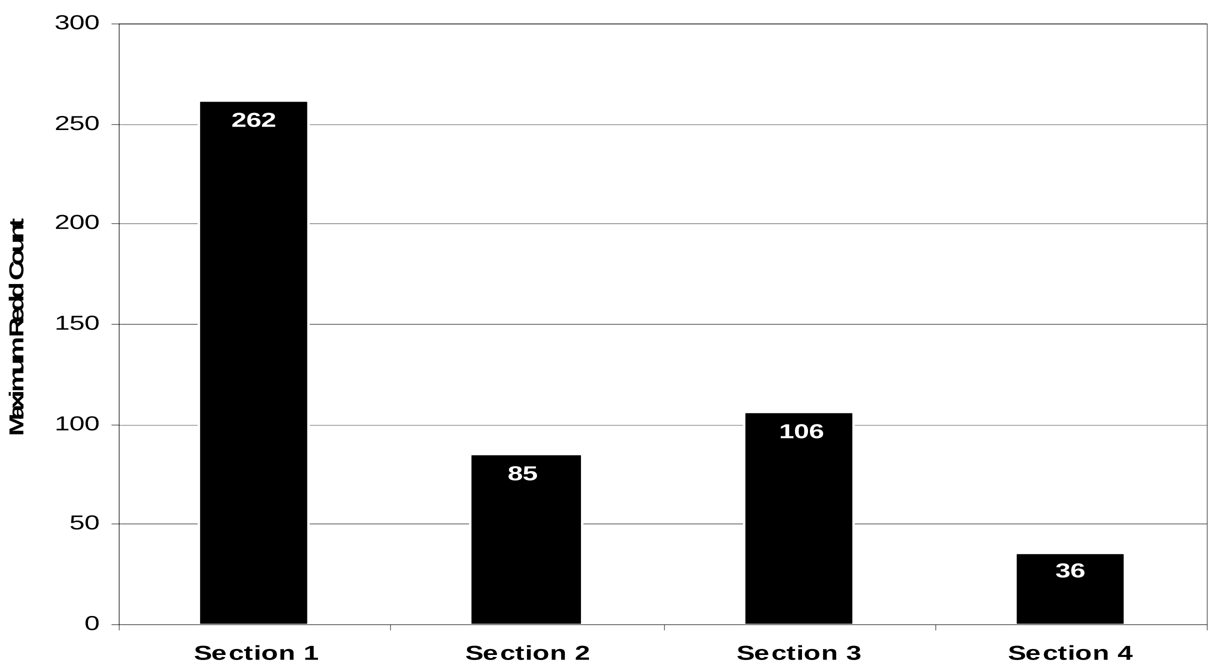

Figure 7. Total number of redds counted per section.

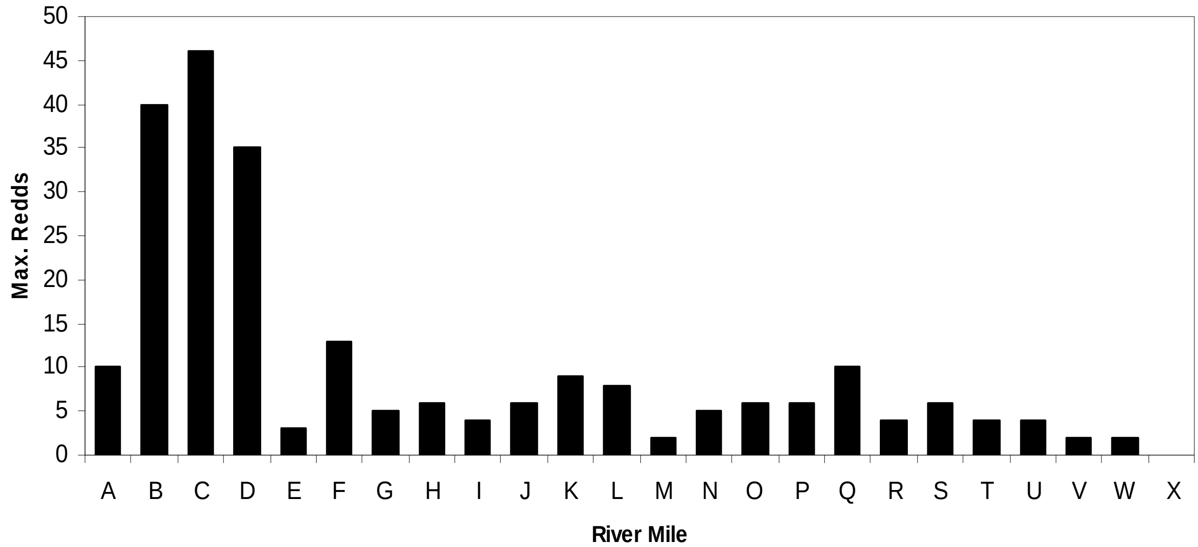

Figure 8. Maximum redds observed by riffle section. Each letter represents one river mile.

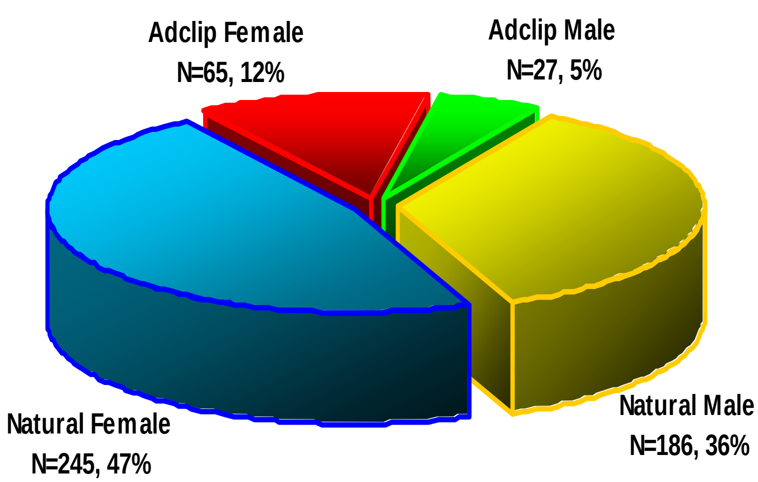

Figure 9. Contribution of natural female, adipose clipped female, natural male, and adipose fin clipped male to the 2003 Tuolumne River escapement.

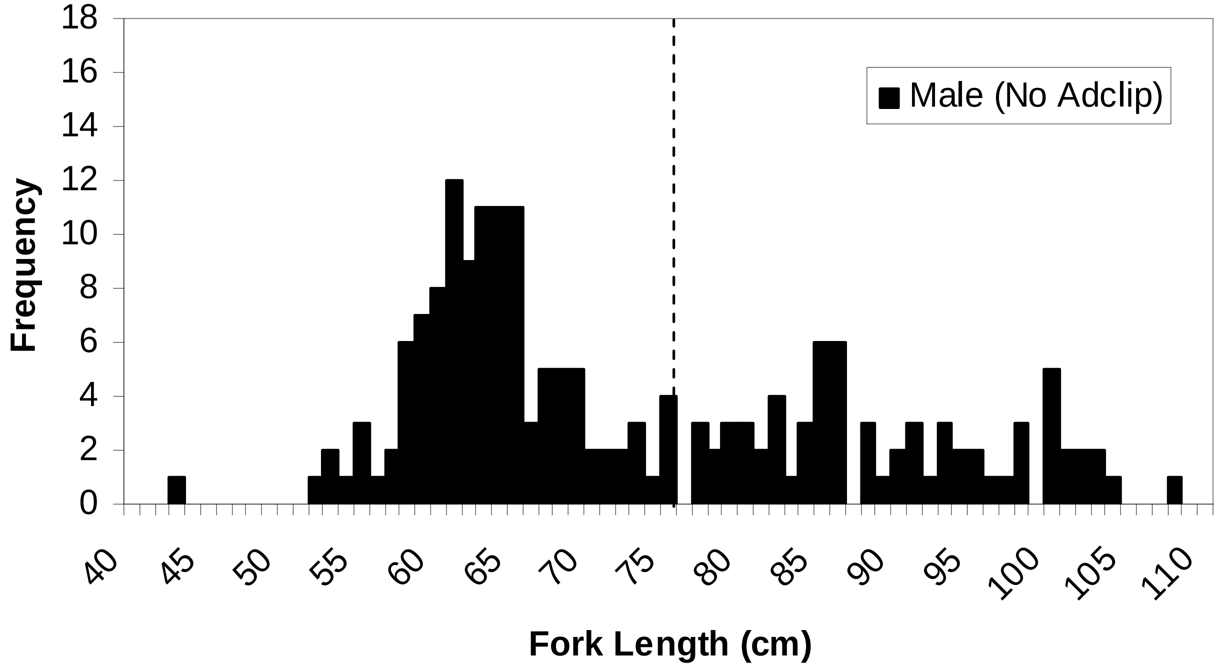

Figure 10. Length frequency histogram of natural male Chinook salmon.

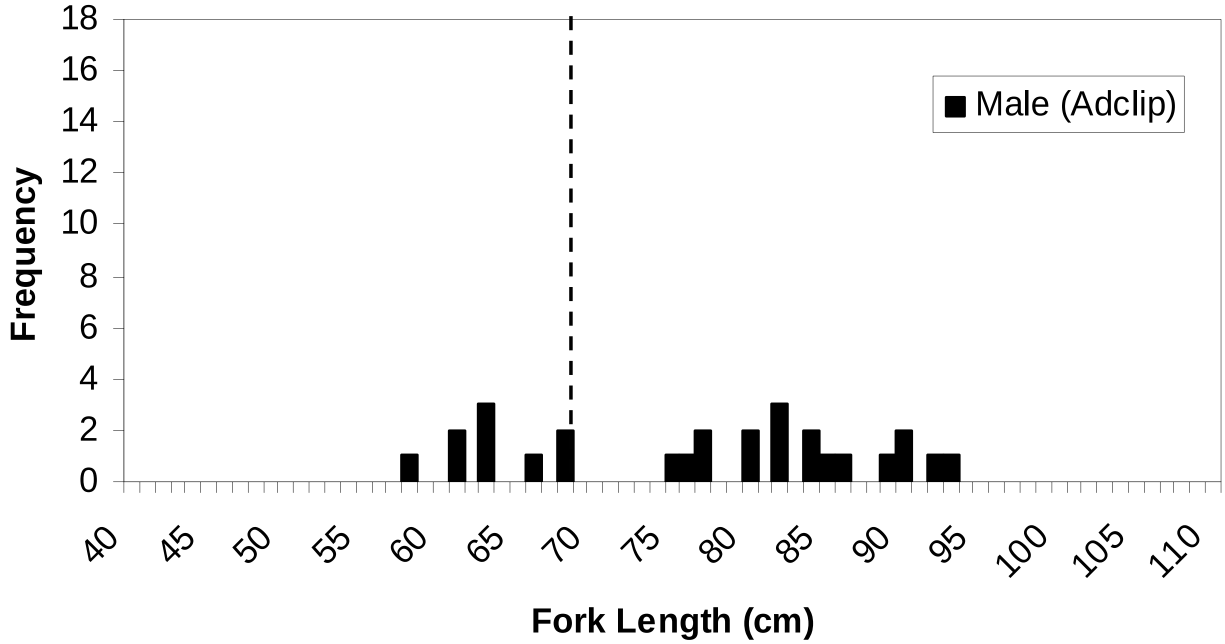

Figure 11. Length frequency histogram of adipose fin clipped male Chinook salmon.

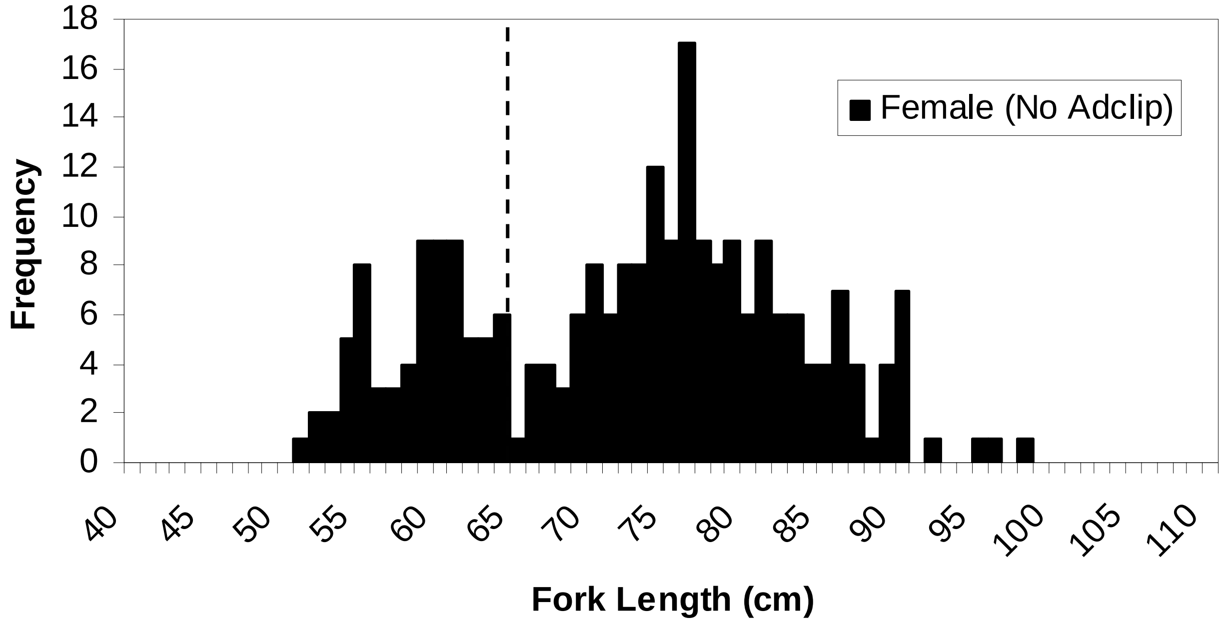

Figure 12. Length frequency histogram of natural female Chinook salmon.

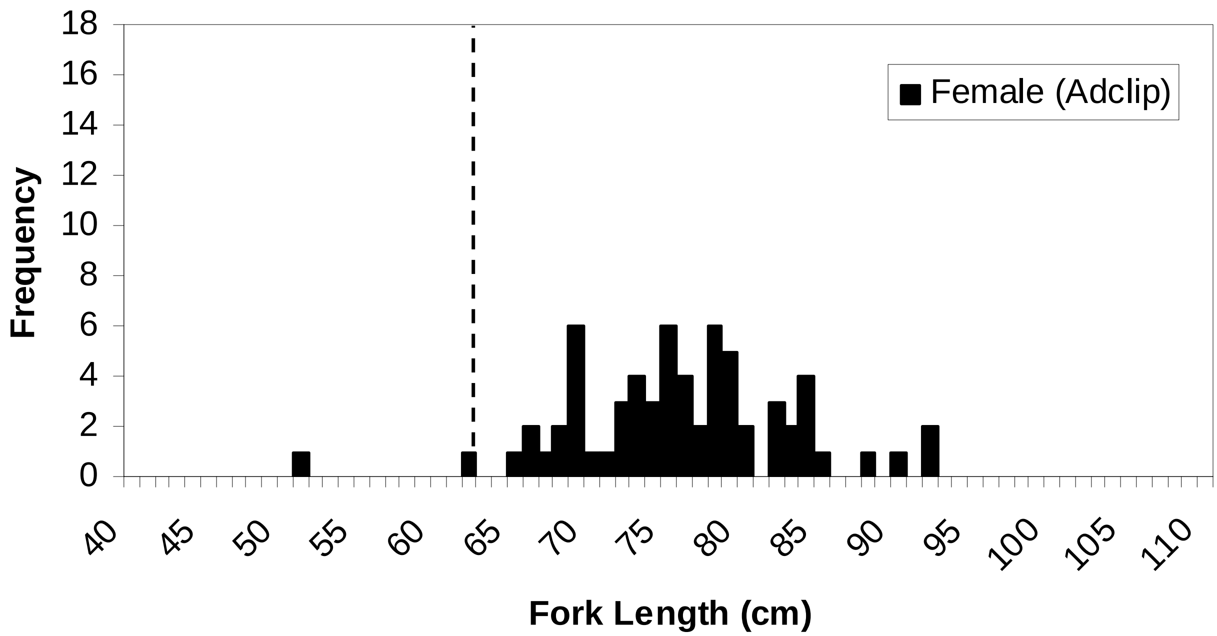

Figure 13. Length frequency histogram of adipose fin clipped female Chinook salmon.

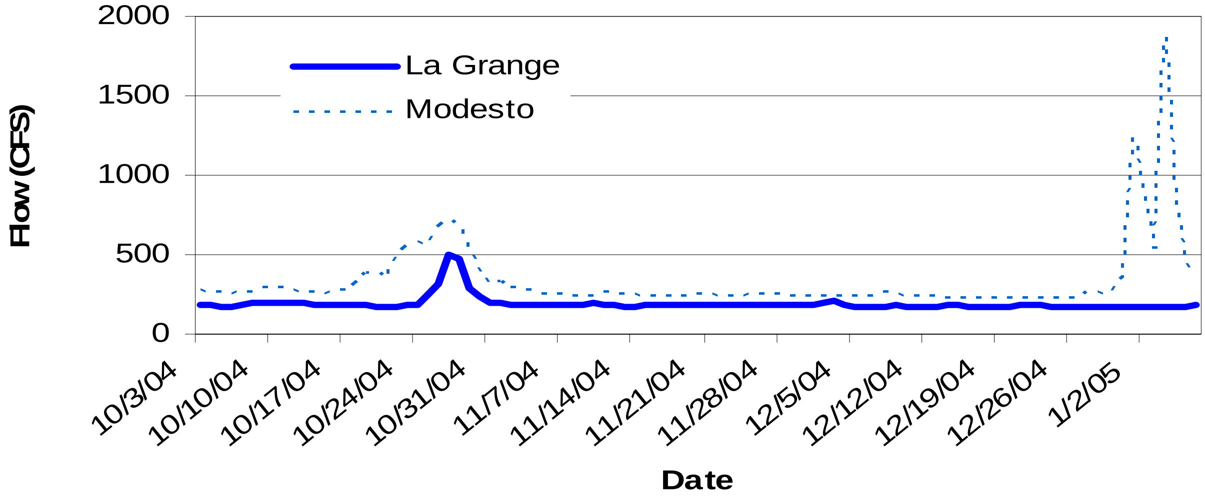

Figure 14. Average daily flow in the Tuolumne River (cubic feet per second) at the Modesto, and La Grange gauges. Preliminary data obtained from California Data Exchange Center (CDEC) website.

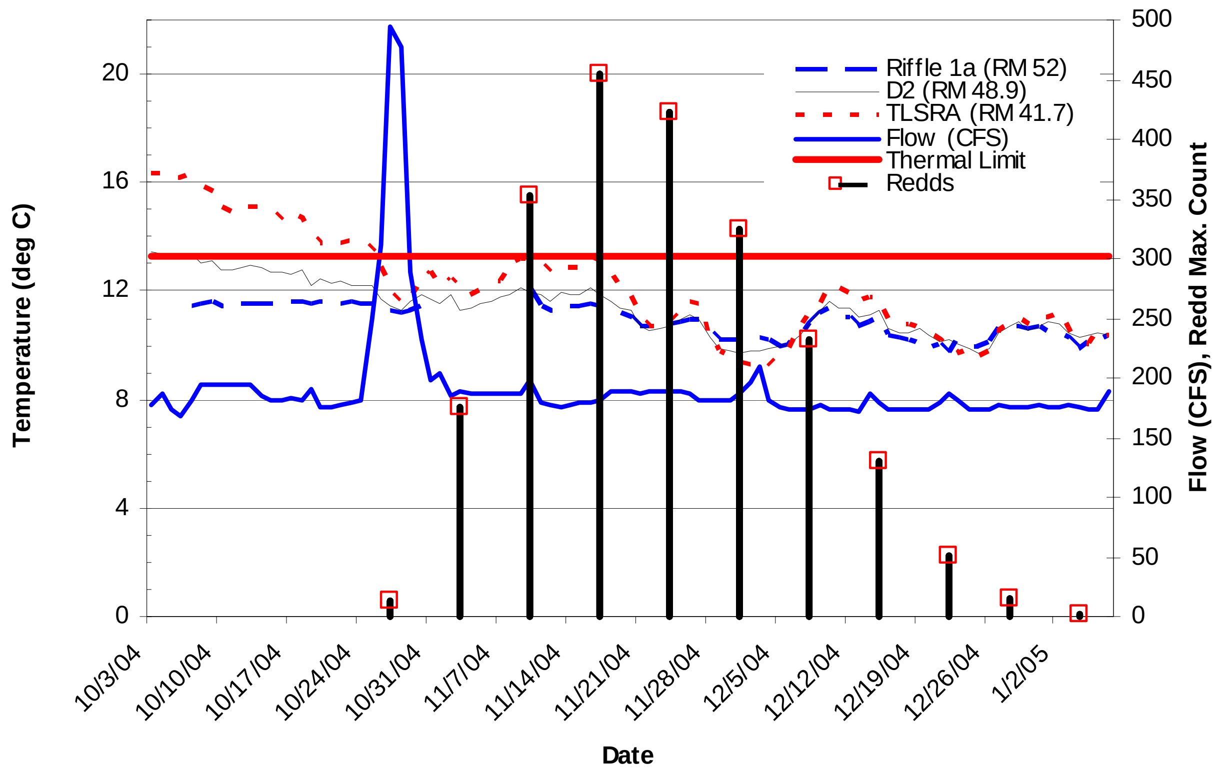

Figure 15. Weekly redd counts for the Tuolumne River escapement survey. Flow (cfs) at La Grange gage, temperatures from CDFG monitoring sites, maximum thermal limit.

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-2

Spawning Survey Summary Update

Prepared by

Tim Ford
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March 2005

SPAWNING SURVEY SUMMARY UPDATE

1. INTRODUCTION

The California Department of Fish and Game (CDFG) have conducted fall-run Chinook salmon spawning surveys on the Tuolumne River since 1971 as required under the cooperative fish study program for the Don Pedro Project FERC license. TID/MID (1992) reviewed the 1971-1988 period and TID/MID (1997) summarized the 1989-1995 period. This report updates TID/MID (2004) and summarizes the 1971-2004 period, including new data for 2003 and partial data for 2004. Sections with missing 2004 data will be completed when CDFG provides the required data.

2. SUMMARY UPDATE

2.1 Population Estimates, Sex Composition, and Potential Eggs

Population estimates for each year are in Table 1 and Figure 1. Estimates for the Tuolumne River and the San Joaquin basin are available since1940 (Table 2). Tuolumne salmon runs for the 1971-2004 period have ranged from less than 100 salmon in 1990 and 1991 to 40,300 fish in 1985. The 2004 run estimate was about 1,900 using the adjusted Petersen estimate and 1,693 using the modified Schaefer estimate (Blakeman, 2005), the lowest number since 1995.

The percentage of females in the 1971-2004 runs has ranged from 25% in 1983 to 67% in 1978 (Figure 2). The years with less than 40% females had runs containing a large percentage of 2-year-old males. 2004 had about 59% females in the run that was about the same as 2003, which had about 60%.

The estimated number and average size of females were used to estimate the potential egg deposition for the run. Beginning in 1981, the potential egg deposition for each year has been estimated. This is based on a formula from CDFG Los Banos trap data collected in 1988 using a female size to egg number relationship. These potential egg deposition values have ranged from 145,000 in 1991 to 128.6 million in 1985 (Figure 3, Table 3). The estimated 2004 potential egg number was about 6.1 million based on approximately 1,127 females with an average fork length of 73.0 cm.

2.2 Spawning Distribution and Timing

The highest number of redds counted for each riffle was summarized each year for the 1981-2004 period (Table 4). The patterns from redd counts shows the most heavily used riffles are usually found in the upper river, upstream of Basso Bridge (RM 47.5). For the period of years from 1981-2004, this upper reach of river (4.5 miles) averaged 44.3% of the total number of redds. In 2003, about 43% of the total number of redds counted were in this reach and in 2004 about 54%. Sections 2-4, averaged about 25%, 23%, and 8% respectively for the same period of years and section 5 was only surveyed in 1988 and 1989. Changes in personnel conducting the surveys and survey conditions could account for some uncertainty in yearly comparisons of redd count data.

The first reported arrival of salmon at the La Grange powerhouse area has been noted since 1981 (Table 5). Although this is not a definitive record for arrival timing, it provides some information on the variation in the onset of the runs. For the 1981-2004 period, the earliest arrival date was 05SEP01 and the latest date was 06NOV91 (Figure 4). The arrival date for 2004 was 29OCT although salmon had been observed downstream during the first week (04OCT) of the 2004 Tuolumne spawning surveys.

The earliest date of peak weekly live count for the 1971-2004 period was 31OCT 96 and the latest peak was 27NOV72 with a median date of 12 NOV (Table 5). The 2004 run had a peak live count of 718 salmon during the week of 08 NOV.

2.3 Length Frequency Distribution and Age Class Composition

Fork length measurements have been recorded for carcasses since 1981. The size distribution is different for males and females 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 (Figure 5,Table 6). Estimation of age-class composition based on visual examination of the length frequency distribution of fresh measured carcasses was made for the 1981-2004 surveys (Table 7). These imprecise estimates are made for comparative purposes and will be modified when age analysis of scale and otolith samples collected by CDFG and lengths of known age hatchery fish become available. The estimated female maximum fork lengths for ages two, three, and four were typically about 65, 85, and 95 cm respectively. Male fork length maximums 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 El Niño (warm water) conditions that affected food resources.

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 (Figure 6). The 1998, 1999, and 2004 runs were estimated to have fairly 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 the1986, 1989, 1990, and 1997-2004 runs. 2001 had the highest estimated percentage of four-year-old salmon in the 1981-2004 study period. Five-year-olds are estimated to have comprised from 0-5% of the runs.

2.4 Linear Regression Analysis of 2-year old salmon vs. following year 3-year olds

A linear regression analysis of the logarithmic values for all estimated 2-year old salmon and the following year estimated 3-year olds resulted in an $r^2 = .87$ for the 1981-2003 period (excluding the 1984 outlier). A similar analysis for estimated 2-year old female salmon only and the following year estimated 3-year old females resulted in an $r^2 = .84$ (Figure 7). These analyses indicate a high degree of correlation for both all 2-year old salmon and for 2-year old females returning the following year as 3-year olds of that brood year.

2.5 Coded Wire Tagged Salmon

Large numbers of coded wire tagged (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 (Figure 8). The last CWT releases in the Tuolumne occurred in 2002. A small percentage of these fish shed their tags but still have the external mark of a clipped adipose fin. In addition, smaller numbers of untagged salmon have been released since 1995 as part of the rotary screw trap evaluations (and other survival evaluations in 1998). Nearly all of these artificially reared salmon have been from the Merced River Hatchery (TID/MID, 2003). Other large releases of CWT salmon are 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.

From 1981 to 1986, the estimated proportion of adult CWT salmon in the run was less than 2% (Figure 9). That proportion began increasing with the first return of 1986 CWT study fish in the 1987 run. Since 1989, the proportion of CWT salmon has generally ranged from 10-25% with the exception of a higher percentage in 1990 and 1991 with runs of less than 100 salmon and with a lesser percentage in the 2000 run. The 2003 run was estimated to have 21.0% CWT based on the ratio of adipose clipped fish to total tagged carcasses and 17.6% CWT in 2004.

For the 1981-2004 period, the estimated number of CWT in the runs ranged from a low of 0 in 1981 and 1982 to high of about 2175 in 2002 (Figure 9). The 2003 run was estimated to include about 600 CWT fish and the 2004 run about 334. Most of the Tuolumne River CWT's are of Merced River Hatchery origin, specifically the Tuolumne River and south delta smolt study releases (Figure 10, Table 8). The 2003 run had a large percentage of CWT's that originated in the south delta and Jersey Point releases similar to 2002. Unweighted returns from Tuolumne River upper and lower smolt survival release groups have been roughly equal (Figure 11).

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TABLE 1. TUOLUMNE RIVER SPAWNING SALMON SURVEY COUNTS AND ESTIMATES, 1971-2004.

YEAR	TOTAL CARCASSES	% FEMALE	TAGGED CARCASSES NUMBER TAGGED	NUMBER RECOVERED	% RECOVERED		(WEEKLY) MAXIMUM LIVE COUNT	(1) (WEEKLY) MAXIMUM REDD COUNT	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	59	523	344	65.8		718	455	1,900

(1) 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 2. SAN JOAQUIN BASIN CHINOOK SALMON SPAWNING STOCK ESTIMATES (in 1000's of fish)

Year	STANISLAUS	TUOLUMNE	MERCED (river)	MERCED (hatchery)	MERCED (total)	Trib. Total	SJ RIVER	Basin Total	Event
1939							5.00		No tributary estimates
1940	3.00	122.00			1.00	126.00		126.00	
1941	1.00	27.00			1.00	29.00	9.00	38.00	
1942		44.00				44.00		44.00	No Stan. or Merced estimates
1943							35.00		No tributary estimates
1944		130.00				130.00	5.00	135.00	No Stan. or Merced estimates
1945							56.00		No tributary estimates
1946		61.00				61.00	30.00	91.00	Friant Dam on San Joaquin River
1947	13.00	50.00				63.00	6.00	69.00	
1948	15.00	40.00				55.00	2.00	57.00	
1949	8.00	30.00				38.00	8.00	46.00	
1950							0.50		Last SJ run; Early flood - no trib. estimates
1951	4.00	3.00				7.00		7.00	Tracy Pumping Plant, No Merced estimate
1952	10.00	10.00				20.00		20.00	
1953	35.00	45.00			0.50	80.50		80.50	
1954	22.00	40.00			4.00	66.00		66.00	
1955	7.00	20.00				27.00		27.00	No Merced estimate
1956	5.00	6.00			0.00	11.00		11.00	
1957	4.00	8.00			0.40	12.40		12.40	Inland gill-netting banned
1958	6.00	32.00			0.50	38.50		38.50	
1959	4.00	46.00			0.40	50.40		50.40	Drought
1960	8.00	45.00			0.40	53.40		53.40	Drought
1961	2.00	0.50			0.05	2.55		2.55	Drought
1962	0.30	0.20			0.06	0.56		0.56	
1963	0.20	0.10			0.02	0.32		0.32	Lowest total of record
1964	4.00	2.10			0.04	6.14		6.14	First Old River fall rock barrier
1965	2.00	3.20			0.09	5.29		5.29	
1966	3.00	5.10			0.04	8.14		8.14	New Exchequer Dam on Merced
1967	11.89	6.80			0.60	19.29		19.29	
1968	6.39	8.60			0.60	15.59		15.59	State Pumping Plant
1969	12.33	32.20			0.60	45.13		45.13	
1970	9.30	18.40	4.70	0.10	4.80	32.50		32.50	Merced River Hatchery
1971	13.62	21.89	3.45	0.10	3.55	39.06		39.06	New Don Pedro Dam on Tuolumne
1972	4.30	5.10	2.53	0.12	2.65	12.05		12.05	
1973	1.23	1.99	0.80	0.20	1.00	4.22		4.22	
1974	0.75	1.15	1.00	0.40	1.40	3.30		3.30	
1975	1.20	1.60	1.70	0.40	2.10	4.90		4.90	
1976	0.60	1.70	1.20	0.30	1.50	3.80		3.80	Drought
1977	0.00	0.45	0.35	0.20	0.55	1.00		1.00	Drought
1978	0.05	1.30	0.53	0.10	0.63	1.98		1.98	New Melones Dam on Stanislaus
1979	0.10	1.18	1.92	0.30	2.22	3.50		3.50	
1980	0.10	0.56	2.85	0.16	3.01	3.67		3.67	
1981	1.00	14.25	9.49	0.92	10.42	25.67		25.67	
1982		7.13	3.07	0.19	3.26	10.39		10.39	No Stanislaus estimate
1983	0.50	14.84	16.45	1.80	18.25	33.58		33.58	
1984	11.44	13.69	27.64	2.11	29.75	54.88		54.88	
1985	13.47	40.32	14.84	1.21	16.05	69.85		69.85	
1986	6.50	7.40	6.79	0.65	7.44	21.34		21.34	
1987	6.29	14.75	3.17	0.96	4.13	25.17		25.17	Drought
1988	10.21	6.35	4.14	0.46	4.59	21.15	2.30	23.45	Drought
1989	1.51	1.28	0.35	0.08	0.43	3.21	0.33	3.54	Drought
1990	0.48	0.10	0.04	0.05	0.08	0.66	0.28	0.94	Drought
1991	0.39	0.08	0.08	0.04	0.12	0.59	0.18	0.77	Drought
1992	0.26	0.13	0.62	0.37	0.99	1.37	0.00	1.37	Drought; Electric barrier on SJR
1993	0.68	0.47	1.27	0.41	1.68	2.83	0.00	2.83	Start of Annual Physical barrier on SJR
1994	1.03	0.51	2.65	0.94	3.59	5.13	0.00	5.13	
1995	0.62	0.83	1.96	0.58	2.54	3.99	0.00	3.99	
1996	0.17	4.36	3.29	1.14	4.43	8.96	0.00	8.96	
1997	5.59	7.15	2.71	0.95	3.66	16.39	0.00	16.39	Prelim. estimates
1998	3.09	8.91	3.29	0.80	4.09	16.09	0.00	16.09	Prelim. estimates
1999	4.35	8.23	3.13	1.64	4.77	17.35	0.00	17.35	Prelim. estimates
2000	11.00	17.87	11.00	2.00	13.00	41.87	0.00	41.87	Prelim. estimates
2001	6.00	9.25	9.20	1.30	10.50	25.75	0.00	25.75	Prelim. estimates
2002	6.90	7.13	7.90	1.80	9.70	23.73	0.00	23.73	Prelim. estimates
2003	4.50	2.85	2.90	0.50	3.40	10.75	0.00	10.75	Prelim. estimates
2004	4.40	1.90	4.00	1.00	5.00	11.30	0.00	11.30	Prelim. estimates
2005									
	(1940 Stan. and Merced, and 1941 Stan., Tuol., and Merced, are partial counts)								
Average:									
1940-2004	5.50	17.14			3.69	25.44	5.95	26.46	
1940-1949	8.00	63.00			1.00	68.25	18.88	75.75	40's
1950-1959	10.78	23.33			0.97	34.76	0.50	34.76	50's
1960-1969	5.01	10.38			0.25	15.64		15.64	60's
1970-1979	3.12	5.48	1.82	0.22	2.04	10.63		10.63	70's
1980-1989	5.67	12.06	8.88	0.85	9.73	26.89	1.32	27.15	80's
1990-1999	1.66	3.08	1.90	0.69	2.59	7.34	0.05	7.38	90's
2000-2010	5.47	7.80	7.00	1.32	8.32	22.68	0.00	22.68	2000's
1967-1991	4.74	8.92	4.87	0.49	5.36	18.26	0.77	18.38	CVPIA baseline period
1973-2004	3.71	6.24	4.70	0.75	5.45	14.95	0.18	15.05	Post-New Don Pedro period

TABLE 3. Number and % of females in the Tuolumne River salmon runs, 1971-2003.

Year	Estimate Run	# of Female:	% females	Ave. FL females (cm)	(Y) Eggs pe: female	Potential egg deposition (millions)
1971	21,885	12,693	58			
1972	5,100	2,652	52			
1973	1,989	1,174	59			
1974	1,150	633	55			
1975	1,600	960	60			
1976	1,700	867	51			
1977	450	279	62			
1978	1,300	871	67			
1979	1,184	604	51			
1980	559	341	61			
1981	14,253	6,271	44	64.2	4034	25.30
1982	7,126	4,276	60	76.9	6046	25.85
1983	14,836	3,709	25	54.8	2544	9.44
1984	13,689	4,654	34	64.7	4113	19.14
1985	40,322	22,580	56	74.7	5697	128.65
1986	7,288	3,498	48	81.0	6696	23.42
1987	14,751	4,573	31	60.4	3431	15.69
1988	6,349	3,809	60	73.8	5548	21.14
1989	1,274	662	52	79.2	6410	4.25
1990	96	31	32	77.8	6189	0.19
1991	77	35	45	71.3	5159	0.18
1992	132	56	43	64.2	4034	0.23
1993	431	264	61	68.8	4762	1.26
1994	513	255	50	71.9	5254	1.34
1995	928	502	54	70.0	4953	2.49
1996	4,362	1,518	35	65.6	4255	6.46
1997	7,548	4,423	59	72.1	5285	23.38
1998	8,967	4,537	51	70.2	4983	22.61
1999	7,730	3,548	46	70.2	4983	17.68
2000	17,873	11,188	63	77.5	6141	68.71
2001	9,222	4,971	54	80.6	6632	32.97
2002	7,125	3,876	54	76.6	5998	23.25
2003	2,961	1,768	60	77.3	6109	10.80
2004	1,900	1,127	59	73.0	5428	6.12

Y=158.45(ave. FL females)-6138.91 based on 1988 Los Banos trap data

TABLE 4 TUOLUMNE RIVER SPAWNING SURVEYS - MAXIMUM REDD COUNTS BY RIFFLE

SECTION A (La Grange Dam to OLGB)

Riffle	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
A1																								1	
A2	1				1							1	0	0										3	
A3	20	13		8	33	40		17	40	15	0	0	4	8	12	7	10	11	8	14	22	29	7	5	10
A4	20	12		21	29	28		23	0	2	0	0	0	1	4	9	8	12	11	3	32	39	5	6	10
A5	51	37	1	9	78	19		31	58	18	0	0	2	15	13	6	14	9	3	2	10	4		1	1
A6	1	11		4	14	8		14	5	5	0	1	0	1	4	5	9				1	0			
A7	35	33		13	30	21		17	38	8	0	4	6	20	12	12	16	76	46	41	122	189	26	28	17
Total:	128	106	2	55	185	116		102	141	48	0	6	12	45	45	39	57	108	68	60	187	261	38	44	38
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	29.2
Redd/1,000 ft^2	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	0.50
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	8

SECTION 1 (OLGB to Basso Bridge)

Riffle	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
1A	72	83	10	103	278	85	120	56	116	59	6	7	9	43	28	20	28	54	39	43	241	132	41	20	40
1B,C	5	54	0	15	73	4	5	3	0	0	1	0	0	0	0	0	7	17	15	23	83	71	32	18	19
2	77	63	6	77	150	47	100	35	138	47	1	5	1	16	15	13	37	126	35	54	212	187	35	16	46
3A	31	10	0	6	38	7	13	8	50	5	0	0	0	9	5	0	1	3	2	15	40	10	3	0	0
3B	10	36	0	33	102	14	25	32	19	9	0	0	1	0	4	4	9	53	41	72	240	254	44	40	46
4A	102	57	7	56	238	48	60	42	106	22	1	2	2	0	7	3	17	56	44	45	260	168	35	22	30
4B	40	38	1	36	219	36	65	44	72	24	1	1	3	8	8	4	16	52	37	43	319	174	38	29	36
5A,B	173	126	2	32	132	19	40	26	51	15	0	1	1	2	12	4	10	43	30	46	108	80	13	14	7
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	224
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	89.6
Redd/1,000 ft^2	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	0.34
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	46

TABLE 4 (CONTINUED)

SECTION 2 (Basso Bridge to TLSRA)

Riffle	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
6	28	27	8	30	46	12	15	13	15	9	0	0	1	7	12	7	12				5	0	0		
7	71	17	8	57	147	27	50	37	75	20	0	1	1	15	16	9	10	67	28	43	92	30	6	10	13
8A,B	9	8	0	16	48	13	20	4	16	4	1	2	0	5	10	9	5	14	11	16	191	55	15	14	9
9A,B	20	8	4	27	68	18	26	20	43	13	4	2	1	2	2	3	2					0			
10	47	17	1	14	^	^		0	0	0	0	0	0	0	2	1	1								
11A,B	6	3	1	12	41	10		6	19	6	0	0	0	0	1	0	0								
12A,B	11	0	0	5	8	13		1	8	4	5	1	0	3	4	1	2	19	19	14	75	24	9	8	5
13A	7	3	1	4	16	6		4	44	6	0	0	2	1	2	1	3	10	11	13	50	17	7	6	2
13B	22	9	1	42	77	4	12	26	^	^	1	0	1	2	3	2	2	3	3	6	16	12	7	4	1
13C,D	4	17	1	8	7	2	11	3	3	2	1	0	0	0	0	0	0	2	1	3	15	4	1	3	1
14	7	7	0	5	13	7		6	10	3	1	0	0	1	3	3	3	8	11	5	10	3	5	3	2
15	8	12	0	4	41	7		8	13	6	0	0	0	0	2	0	2	6	8	4	10	20	6	7	4
16N,S	8	2	0	17	8	9		9	18	9	0	0	0	2	5	1	2	15	10	12	49	42	19	8	3
17A	15	26	0	10	18	12		7	20	5	0	0	0	4	3	1		4	5	8	8	6	6	2	3
17B,C	14	6	4	15	26	10		11	14	7	4	0	0	3	4	6	6	9	11	12	18	24	22	8	10
18A,B	9	15	5	24	40	7		5	7	5	0	2	0	4	4	5	11	12	10	17	43	33	14	6	8
19	20	17	5	25	34	12		7	14	5	0	0	0	1	4	2	3	15	9	6	8	0			
20	27	9	0	8	5	6		3	11	5	0	0	0	2	2	0	1	(?)	0		3	1			
21	14	8	1	17	29	6		8	12	4	2	0	0	2	3	1	3	27	10	3	22	11	6	2	3
22N, (A,B)	7	7	0	8	13	5		4	5	4	0	0	0	3	1	2	5	8	9	2	15	22	14	7	6
22S	9	10	0	7	14	4		3	^	^	0	0	0	0		0	^	^							
23A	21	27	12	73	48	10		9	22	4	0	0	1	2	2	2	4	7	8	6	15				
23B	16	19	0	^	127	^		^	^	^	0	0	0	2	3	2	1	11	5	3	16	7	2	4	4
23C	38	28	10	^	^	33		22	33	9	1	1	0	0	5	2	3	10	4	4	17	11	10	8	5
23D	23	6	0	^	^	^		^	^	^	1	0	0	0	2	1	3	25	7	6	32	11	6	2	6
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	85
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	17
Redd/1,000 ft^2	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	0.21
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	17

TABLE 4 (CONTINUED)

SECTION 3 (TLSRA TO Reed Gravel)																									
Riffle	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
24A N,S	38	21	10	28	16	28		24	22	14	2	0	0	8	1	3	8	37	13	8	7	29	18	8	9
24B	12	0	0	7	39	^		2	4	2	0	0	0	0	0	3	3	(?)			20				
25	23	28	1	18	41	24		11	11	7	0	0	0	2	1	3	4	13	15	6	27	21	13	11	9
26	21	17	6	21	31	20		18	17	12	3	1	2	3	5	5	5	11	12	6	30	19	9	6	5
27	17	7	2	8	29	9		11	17	6	2	0	1	2	3	4	2	9	9	2	28	20	12	6	6
28A,B	11	14	16	13	37	13		4	17	5	0	0	0	1	2	2	1		4	1	20	7	7	7	10
29	28	21	18	26	36	19		14	22	5	1	0	1	4	8	5	5	6	7	3	11	14	4	3	5
30A	24	22	7	28	39	12		12	38	16	2	1	0	0	3	2	3			5	10	8	10	5	5
30B	18	21	18	14	19	10		13	^	^	2	3	1	3	4	2	3	6	5		5				
31	20	5	0	15	19	12		3	19	3	2	0	0	0	3	2	2	11	10	9	19	47	15	7	8
32A,B	46	4	0	2	28	4		6	20	4	2	2	0	2	2	0		6	2	1	7	10	2	5	2
33	15	1	2	11	33	11		7	16	7	0	1	0	0	1	2		12	5	2	16	24	9	11	3
34	17	9	0	6	26	10		8	4	5	0	0	1	0	12	0		5	0		3	7	4	5	6
35A,B	27	3	0	10	14	14		10	26	7	0	1	0	0	7	4		10	11	5	51	17	6	0	0
36A	14	1	6	13	14	7		6	11	10	1	0	1	4	3	0	3	7	6	6	9	15	0	7	4
36B	4	5	^	0	18	7		5	15	0	0	2	0	4	2	3	4	4	5	1	11	19	8	7	6
37	12	0	0	1	4	9	15	3	4	2	0	0	0	0	1	1	3	4	3	1	7	8	10	2	1
38N,S	6	9	15	13	9	8	6	7	11	4	0	0	0	1	2	4	2	10	3	7	20	19	31	10	10
39N,S	8	7	^	7	14	11	20	6	14	6	2	1	0	1	3	0	3	6			1				
40N,S	14	0	^	9	39	25	20	9	14	12	0	0	0	1	4	0									
41	7	4	^	5	11	5	20	9	33	4	0	1	0	2	3	1	2	6	6	2	5	12	7	5	3
42A,B	34	7	^	2	56	58		15	59	12	0	0	0	0	2	2		3	2	1	8	35	15	6	8
43A,B,C	6	5	0	1	33	4		0	2		0	0	0	7	6	3	2	3	2		10				
44	7	2	0	1	^	13		4	3	4	0	0	0	1	1	0					8	7	20	4	4
45	9	5	2	6	^	^		^	^	^	0	0	0	1	2	3	2	(?)			5	13	4	2	0
46	2	0	0	0	0	9		2	32	2	2	0	0	2	1	2	1	2	5	3	7	10	6	5	2
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	106
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	13.8
Redd/1,000 ft^2	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	0.15
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	22

TABLE 4 (CONTINUED)

SECTION 4 (Reed Gravel to Fox Grove)																									
							Aerial																		
Riffle	1981	1982	1983[a]	1984	1985[b]	1986	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
47A,B	8		11	13	12		6	6	28	3	0	1	0	1	2	5					10				
48A	17		^	1			2	2	17	2	0	0	0	0	1	0		4	6	3	4	7	7	5	2
48B	0		^	0			2	3	^	^	0	1	0	2	3	2	1	4	5	3	9	19	17	3	2
49A,B	4		^	1			0	4	0	1	0	0	0	1	0	1	1	0			1				
50	7		^	1				7	7	2	0	0	0	0	2	3	3	3	2	6	7	7	1	5	6
51	2		^	0				2	10	3	0	0	0	0	2	0	2	1			8				
52A	9		^	3				3	74	16	0	0	1	3	1	2	6	4	2	4	8	3	4	1	0
52B	13		^	0				2	^	^	1	0	1	1	1	3	1	2	2	3	4	2	0	4	4
53	4		^	3	8		5	3	12	7	1	0	1	0	0	0					4	1	13	2	3
54	6		^	0	^		5	9	24	6	0	1	1	0	1	0	2				3	1	0	4	4
55	5		^	0	6		20	9	17	4	0	0	0	0	1	3	1	2	2	3	11	16	8	9	5
56	8		4	3	15		1	1	15	8	1	1	0	3	1	2	1	3	3	2	9	7	11	2	3
57	8		^	0	^		4	3	17	7	0	0	0	0	0	0			3						
58	5		^	4			7	13	19	3	0	0	0	0	0	0						1	9		1
59	13		^	4			3	2	2		0	1	0	0	0	1		(?)	1		3			0	
60N,S	7		^	1			6	8	62	2	0	1	5	4	3	0		2	1	3	7	11	12	4	2
61	1		^	0			0	0	18	5	0	0	0	0	0	0		(?)			2	9	10	0	0
62	2		^	0			0	0	3	2	0	0	0	0	0	0		1	0						
63	6		^	0			3	0	10	2	0	0	0	0	1	1			1		2	7	4	3	1
64	9		^	0			4	0	15	0	0	0	0	0	0	0		(?)	1		1	3	4	0	0
65	0		^	3				0	14	2	1	1	1	2	2	2	1	0	2	2	3	5	3	4	2
66N,S	1		^	0				0	6	1	0	0	0	0	0	0		0	0	2	4	2	8	0	1
67	2		^	0				0	5	0	2	0	0	0	0	0		0	0		2		0	0	0
68	0		^	0				0	1	0	0	0	0	0	0	0		0	0				0	0	0
Total:	137		18	37	~140		68	77	376	76	6	7	10	17	21	25	19	26	31	31	102	101	111	46	36
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	5.9
Redd/1,000 ft^2	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	0.04
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	7

TABLE 4 (CONTINUED)

SECTION 5 (Below Fox Grove)																									
Riffle	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
69									1	0															
70									0	0															
71									0	0															
72									5	0															
73									9	3															
74									2	0															
75									9	0															
76										1															
77										0															
78										0															
Total:									26	4															
Redd/Mile									9.6	1.5															
Redd/1,000 ft^2									0.11	0.02															
Percent of Total									1	1															
	1981	1982	1983[a]	1984	1985[b]	1986	Aerial 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[c]	1996[d]	1997[e]	1998	1999	2000	2001	2002	2003	2004
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	489
# of Females	6300	4200	3700	4700	22600		3498	4600	3809	663	31	35	55	264	255	502	1518	4423	4537	3548	11188	4980	3876	1768	1127
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	3.7	2.3
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	190

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.

Table 5. Tuolumne River salmon survey periods, peak live counts, and arrival dates.

Year	Survey Period Start Date	Survey Period End Date	Peak Live Count Date	Peak Live Count Number	Tuolumne Estimate (x 1,000)	Peak Live / Pop.est. (%)	La Grange Powerhouse Observed Arrival
1940	26-Sep	02-Dec	04-Nov	5,447	122.0	4.5%	
1941	21-Sep	18-Nov	13-Nov	2,807	27.0	10.4%	
1942	13-Sep	30-Nov	01-Nov	3,386	44.0	7.7%	
1944	30-Sep	30-Nov	06-Nov	10,039	130.0	7.7%	
1946	11-Oct	20-Nov	04-Nov	6,002	61.0	9.8%	
1957	05-Nov	03-Jan			8.0		
1958	06-Nov	09-Jan			32.0		
1959	03-Nov	01-Jan			46.0		
1960	12-Nov	13-Jan			45.0		
1961					0.5		
1962	08-Nov	04-Jan			0.2		
1963	10-Feb				0.1		
1964	04-Nov	18-Dec			2.1		
1965	19-Nov	12-Jan			3.2		
1966	08-Nov	18-Jan	09-Nov	271	5.1	5.3%	
1967	18-Oct	13-Jan	21-Nov	184	6.8	2.7%	
1968	11-Nov	15-Dec	22-Nov	1,490	8.6	17.3%	
1969	20-Nov	12-Jan			32.2		
1970	19-Nov	20-Jan	20-Nov	1,517	18.4	8.2%	
1971	15-Nov	27-Dec	16-Nov	2,128	21.9	9.7%	
1972	13-Nov	23-Jan	27-Nov	349	5.1	6.8%	
1973	05-Nov	17-Jan			2.0		
1974					1.2		
1975	06-Nov	31-Dec	06-Nov	154	1.6	9.6%	
1976	03-Nov	29-Dec	15-Nov	241	1.7	14.2%	
1977	29-Nov	20-Dec			0.5		
1978	26-Oct	19-Dec	24-Nov	81	1.3	6.2%	
1979	05-Nov	17-Dec	02-Nov	153	1.2	12.8%	
1980	12-Nov	18-Dec	12-Nov	112	0.6	18.7%	
1981	04-Nov	16-Dec			14.3		14-Oct
1982	08-Nov	29-Nov	15-Nov	545	7.1	7.7%	29-Sep
1983	07-Nov	01-Dec	15-Nov	263	14.8	1.8%	13-Oct
1984	01-Nov	30-Nov	01-Nov	1,084	13.7	7.9%	04-Oct
1985	29-Oct	20-Dec	12-Nov	2,986	40.3	7.4%	24-Sep
1986	27-Oct	05-Dec	03-Nov	1,123	7.3	15.4%	10-Sep
1987	28-Oct	16-Dec	17-Nov	2,155	14.8	14.6%	06-Oct
1988	25-Oct	29-Dec	14-Nov	1,066	6.3	16.8%	17-Oct
1989	24-Oct	29-Dec	09-Nov	291	1.3	22.8%	15-Oct
1990	23-Oct	26-Dec	19-Nov	44	0.1	45.8%	24-Oct
1991	22-Oct	02-Jan	25-Nov	24	0.1	31.2%	06-Nov
1992	05-Nov	21-Dec	19-Nov	49	0.1	37.1%	31-Oct
1993	14-Oct	18-Dec	06-Nov	94	0.4	21.8%	26-Sep
1994	03-Nov	05-Jan	21-Nov	226	0.5	44.1%	26-Oct
1995	27-Oct	30-Dec	03-Nov	270	0.9	29.1%	05-Oct
1996	22-Oct	04-Dec	31-Oct	636	4.4	14.6%	
1997	14-Oct	23-Dec	12-Nov	1,258	7.5	16.7%	09-Oct
1998	07-Oct	22-Dec	02-Nov	1,058	9.0	11.8%	17-Sep
1999	04-Oct	28-Dec	01-Nov	1,403	7.7	18.2%	16-Sep
2000	02-Oct	05-Jan	06-Nov	3,269	17.9	18.3%	18-Sep
2001	04-Oct	05-Jan	05-Nov	1,865	9.2	20.2%	05-Sep
2002	01-Oct	02-Jan	04-Nov	1,366	7.1	19.2%	22-Sep
2003	30-Sep	30-Dec	18-Nov	463	3.0	15.6%	13-Oct
2004	04-Oct	06-Jan	08-Nov	718	1.9	37.8%	29-Oct
For period 1971-2004:							1981-2004
Minimum	30-Sep	29-Nov	31-Oct	---	---	---	05-Sep
Maximum	29-Nov	23-Jan	27-Nov	---	---	---	06-Nov
Median	27-Oct	26-Dec	12-Nov	---	---	---	06-Oct

TABLE 6. TUOLUMNE RIVER CHINOOK SALMON FORK LENGTHS (cm) OF FRESH CARCASSES MEASURED DURING SPAWNING SURVEYS, 1981-2004.

FEMALES	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
NUMBER	289	153	92	286	524	251	349	222	193	11	9	20
MIN.	47	56	41	43	47	53	45	49	52	73	68	43
MAX.	86	97	85	77	90	99	93	90	99	89	74	88
AVG.	64.2	76.9	54.8	64.7	74.7	81.0	60.4	73.8	79.2	77.8	71.3	64.2
STD. DEV.	8.5	5.2	11.4	6.2	6.8	8.5	7.0	5.9	6.6	4.4	2.3	13.2
VARIANCE	72.5	27.0	130.9	38.0	46.7	72.0	48.6	35.4	43.8	19.4	5.1	173.6
MALES	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
NUMBER	372	121	302	560	407	267	785	149	174	20	11	27
MIN.	37	29	34	30	54	35	39	50	46.5	44	52	46
MAX.	107	113	103	92	102	112	100	104	110.5	105	98	98
AVG.	65.9	81.8	52.2	60.2	83.0	89.4	62.5	83.1	89.0	79.8	77.7	60.6
STD. DEV.	10.0	14.5	11.7	10.5	9.6	16.1	7.3	9.6	12.2	17.2	15.5	12.3
VARIANCE	100.5	211.5	135.8	109.2	92.4	260.6	53.2	92.2	149.9	296.7	240.4	150.1

FEMALES	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
NUMBER	56	78	79	150	232	378	382	594	844	658	278	245
MIN.	49.5	50	51	48	51	46	43	53	48	50	54	51
MAX.	87.5	88.5	87	89	95	93	93	105	105	104	98	98
AVG.	68.9	71.9	70.0	65.5	73.1	70.3	70.6	77.5	80.6	76.2	78.1	72.2
STD. DEV.	6.6	8.3	9.0	8.9	6.5	10.7	9.3	6.1	9.1	8.7	7.6	10.5
VARIANCE	44.0	69.2	81.4	79.3	41.8	113.6	86.6	37.0	83.7	76.5	57.5	110.3
MALES	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
NUMBER	36	79	66	279	164	358	476	305	672	589	184	186
MIN.	47.5	52	49	41	45	46	43	46	47	31	30	43
MAX.	96	100.5	106	101	100	105	105	110	115	111	108	108
AVG.	72.9	73.6	69.3	64.7	79.0	70.6	68.1	84.2	83.1	81.2	84.4	72.9
STD. DEV.	12.6	12.6	13.6	11.3	11.7	15.1	12.4	10.5	15.6	14.5	13.7	14.2
VARIANCE	159.5	157.9	184.7	127.9	138.0	226.9	153.0	109.1	243.4	211.3	187.5	201.8

TABLE 7. ESTIMATED AGE CLASS COMPOSITION FROM LENGTH FREQUENCY DISTRIBUTIONS OF TUOLUMNE RIVER SALMON BASED ON FRESH MEASURED CARCASSES (1981-2003)

			2 YR. OLD			3 YR. OLD			4 YR. OLD		5 YR. OLD	
YEAR	SEX	MAX.	% OF TOT.	% OF SEX	MAX.	% OF TOT.	% OF SEX	MAX.	% OF TOT.	% OF SEX	% OF TOT.	% OF SEX
1981	FEMALE	68	32.5%	74.4%	85	10.4%	23.9%		0.8%	1.7%		
	MALE	75	49.5%	87.9%	95	5.6%	9.9%	105	1.1%	1.9%	0.2%	0.3%
	TOTAL		82.0%			16.0%			1.8%		0.2%	
1982	FEMALE	65	1.5%	2.6%	85	53.6%	96.1%		0.7%	1.3%		
	MALE	70	8.8%	19.8%	95	30.3%	68.6%	105	4.4%	9.9%	0.7%	1.7%
	TOTAL		10.2%			83.9%			5.1%		0.7%	
1983	FEMALE	60	16.0%	68.5%	74	5.6%	23.9%	83	1.3%	5.4%	0.5%	2.2%
	MALE	65	70.8%	92.4%	87	3.0%	4.0%	99	1.8%	2.3%	1.0%	1.3%
	TOTAL		86.8%			8.6%			3.0%		1.5%	
1984	FEMALE	62	11.3%	33.6%	74	20.3%	60.1%		2.1%	6.3%		
	MALE	65	49.4%	74.6%	87	16.1%	24.3%		0.7%	1.1%		
	TOTAL		60.8%			36.4%			2.8%		0.0%	
1985	FEMALE	65	4.8%	8.6%	85	49.4%	87.8%		2.0%	3.6%		
	MALE	70	5.3%	12.0%	95	35.6%	81.3%		2.9%	6.6%		
	TOTAL		10.1%			85.0%			4.9%		0.0%	
1986	FEMALE	67	2.3%	4.8%	85	31.1%	64.1%	93	12.0%	24.7%	3.1%	6.4%
	MALE	75	9.3%	18.0%	95	20.7%	40.1%	107	19.3%	37.5%	2.3%	4.5%
	TOTAL		11.6%			51.7%			31.3%		5.4%	
1987	FEMALE	68	27.2%	88.5%	85	3.3%	10.6%		0.3%	0.9%		
	MALE	75	66.5%	96.1%	95	2.2%	3.2%		0.5%	0.8%		
	TOTAL		93.7%			5.5%			0.8%		0.0%	
1988	FEMALE	65	4.1%	6.8%	85	54.9%	91.9%		0.8%	1.4%		
	MALE	70	3.2%	8.1%	95	33.8%	83.9%		3.2%	8.1%		
	TOTAL		7.3%			88.6%			4.1%		0.0%	
1989	FEMALE	67	2.5%	4.7%	85	41.1%	78.2%	94	8.7%	16.6%	0.3%	0.5%
	MALE	70	4.1%	8.6%	95	28.1%	59.2%	107	14.4%	30.5%	0.8%	1.7%
	TOTAL		6.5%			69.2%			23.2%		1.1%	
1990	FEMALE	65	0.0%	0.0%	85	32.3%	90.9%		3.2%	9.1%		
	MALE	70	19.4%	30.0%	94	29.0%	45.0%		16.1%	25.0%		
	TOTAL		19.4%			61.3%			19.4%		0.0%	
(1) 1991	FEMALE	65	0.0%	0.0%	85	45.0%	100.0%		0.0%	0.0%		
	MALE	70	15.0%	27.3%	95	30.0%	54.5%		10.0%	18.2%		
	TOTAL		15.0%			75.0%			10.0%		0.0%	
(1) 1992	FEMALE	65	21.3%	50.0%	85	19.1%	45.0%		2.1%	5.0%		
	MALE	70	46.8%	81.5%	95	8.5%	14.8%		2.1%	3.7%		
	TOTAL		68.1%			27.7%			4.3%		0.0%	
1993	FEMALE	65	13.0%	21.4%	85	46.7%	76.8%		1.1%	1.8%		
	MALE	70	16.3%	41.7%	95	21.7%	55.6%		1.1%	2.8%		
	TOTAL		29.3%			68.5%			2.2%		0.0%	
1994	FEMALE	65	8.9%	17.9%	85	39.5%	79.5%		1.3%	2.6%		
	MALE	70	21.0%	41.8%	95	27.4%	54.4%		1.9%	3.8%		
	TOTAL		29.9%			66.9%			3.2%		0.0%	
1995	FEMALE	65	15.2%	27.8%	85	37.9%	69.6%		1.4%	2.5%		
	MALE	70	26.2%	57.6%	95	17.9%	39.4%	105	0.7%	1.5%	0.7%	1.5%
	TOTAL		41.4%			55.9%			2.1%		0.7%	
1996	FEMALE	65	17.7%	50.7%	85	17.0%	48.7%		0.2%	0.7%		
	MALE	70	50.8%	78.1%	95	13.1%	20.1%	105	1.2%	1.8%		
	TOTAL		68.5%			30.1%			1.4%		0.0%	
(2) 1997	FEMALE	65	7.1%	12.2%	77	38.7%	66.7%	90	11.7%	20.1%	0.6%	1.1%
	MALE	70	9.2%	21.9%	88	24.2%	57.7%	100	8.6%	20.4%		
	TOTAL		16.3%			62.9%			20.2%		0.6%	
(2) 1998	FEMALE	63	14.1%	27.5%	78	23.4%	45.5%	92	13.7%	26.7%	0.1%	0.3%
	MALE	68	26.5%	54.5%	87	13.0%	26.8%	99	7.1%	14.5%	2.0%	4.2%
	TOTAL		40.6%			36.4%			20.8%		2.2%	
(2) 1999	FEMALE	63	11.1%	24.9%	78	24.6%	55.2%	91	8.6%	19.4%	0.2%	0.5%
	MALE	70	37.9%	68.3%	87	12.7%	22.9%	99	4.4%	8.0%	0.5%	0.8%
	TOTAL		49.0%			37.3%			13.1%		0.7%	
(2) 2000	FEMALE	65	2.3%	3.5%	79	37.0%	56.1%	90	25.6%	38.7%	1.1%	1.7%
	MALE	70	3.4%	10.2%	88	17.5%	51.5%	99	11.6%	34.1%	1.4%	4.3%
	TOTAL		5.7%			54.5%			37.2%		2.5%	
(2) 2001	FEMALE	65	4.2%	7.5%	81	24.1%	43.2%	95	26.3%	47.3%	1.1%	2.0%
	MALE	70	12.8%	28.9%	90	15.4%	34.7%	105	14.2%	32.0%	2.0%	4.5%
	TOTAL		17.0%			39.5%			40.5%		3.1%	
(2) 2002	FEMALE	65	6.7%	12.8%	82	35.4%	67.0%	94	9.9%	18.7%	0.8%	1.5%
	MALE	70	13.1%	27.7%	92	24.1%	50.9%	104	8.7%	18.5%	1.4%	2.9%
	TOTAL		19.8%			59.4%			18.6%		2.2%	
(2) 2003	FEMALE	65	3.0%	5.0%	82	42.9%	71.2%	94	13.9%	23.0%	0.4%	0.7%
	MALE	70	5.6%	14.1%	90	20.8%	52.2%	103	11.3%	28.3%	2.2%	5.4%
	TOTAL		8.7%			63.6%			25.1%		2.6%	
(2) 2004	FEMALE	65	16.7%	29.4%	82	30.6%	53.9%	94	8.8%	15.5%	0.7%	1.2%
	MALE	70	24.6%	57.0%	90	11.8%	27.4%	102	5.8%	13.4%	0.9%	2.2%
	TOTAL		41.3%			42.5%			14.6%		1.6%	

(1) BASED ON ALL MEASURED CARCASSES
(2) EXCLUDES ADIPOSE FIN CLIPPED CARCASSES

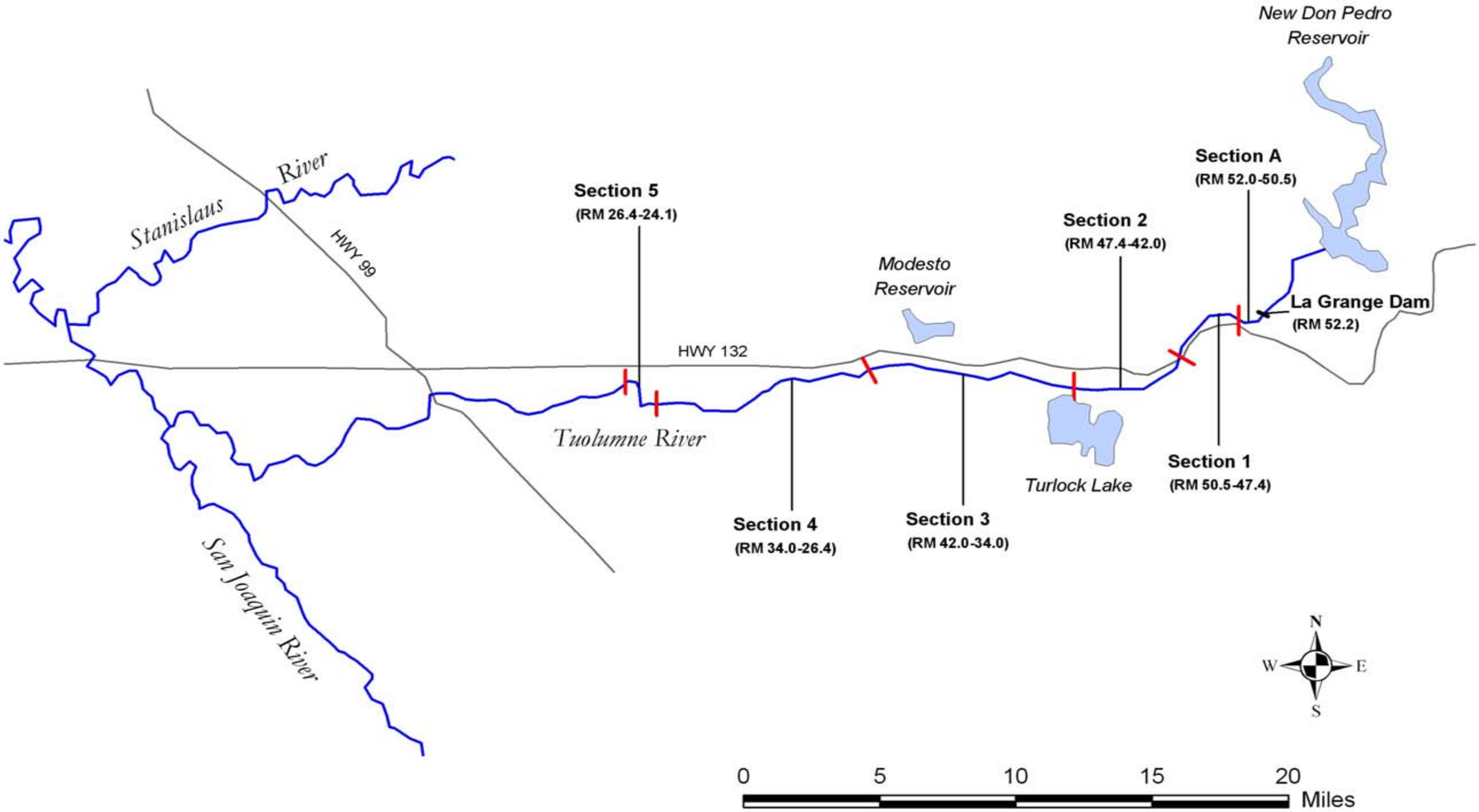
TABLE 8. HATCHERY CONTRIBUTION TO THE TUOLUMNE RIVER SALMON RUNS (BY RELEASE LOCATIONS)

RUN YEAR	TOTAL POP. EST.	ACTUAL DECODED CWT	SAMPLE POP.	ACTUAL % DECODED CWT	TID/MID EST. BASED ON ACTUAL % DECODED CWT	SMOLT RELEASE LOCATIONS: MERCED	TUOL.	STAN.	MERCED S. DELTA + JERSEY PT.	FEATHER S. DELTA + JERSEY PT.	FEATHER OTHER DELTA	FEATHER	AMERICAN OTHER DELTA	MOKEL.	MOKEL. OTHER DELTA	BATTLE CR. OTHER DELTA	YEARLING RELEASE LOCATIONS: MERCED	TUOL.	MERCED S. DELTA	MERCED OTHER DELTA	MOKEL. OTHER WILD
1981	14,253	0	-	0.0	0																
1982	7,126	0	-	0.0	0																
1983	14,836	6	347	1.7	257				2		3								1		
1984	13,689	2	944	0.2	29				2												
1985	40,322	7	1052	0.7	268	1				1							4		1		
1986	7,288	12	806	1.5	109						1								9	2	
1987	14,751	100	1446	6.9	1020		87	7	3			1					2				
1988	6,349	29	719	4.0	256		25	1	3												
1989	1,274	64	625	10.2	130		32	4	25	1			1		1						
1990	96	13	22	59.1	57		6	1	4		1		1								
1991	77	5	20	25.0	19			2	2	1											
1992	132	8	47	17.0	22		1	1			2					1		3			
1993	431	35	169	20.7	89					13				3			1	18			
1994	513	16	81	19.8	101												6	9			1
1995	928	56	415	13.5	125		46			4	2				1		3				
1996	4,362	233	1186	19.6	857	19	196			9	1				3		5				
1997	7,548	164	1056	15.5	1172	37	106		4	15					1		1				
1998	8,967	259	2170	11.9	1070	3	147		25	79	1				2						
1999	7,730	229	2375	9.6	745	9	122	0	77	17					3						
2000	17,873	109	2162	5.0	901	19	55	0	28	4	0	0			2	1					
2001	9,222	243	1808	13.4	1239	15	150	0	76	1	0				1						
2002	7,125	449	1795	25.0	1782	7	181	3	217		12		1		28						
2003	2,961	107	585	18.3	542	2	37	1	54		6		1		6						

The estimated total number of CWT's by DFG (taken from Job #2, Pg 15 of the 1992-93 Region 4 annual report) for the 1988 to 1992 period were 85, 312, 52, 21, and 14 respectively.

*The 1988 sample population was determined from TID/MID data analysis.

**1989 has been reported with different numbers by DFG. (If CWT were all fresh, the sample pop. of 288 would yield 289 estimated CWT.)



Map of the Tuolumne River salmon spawning survey areas.

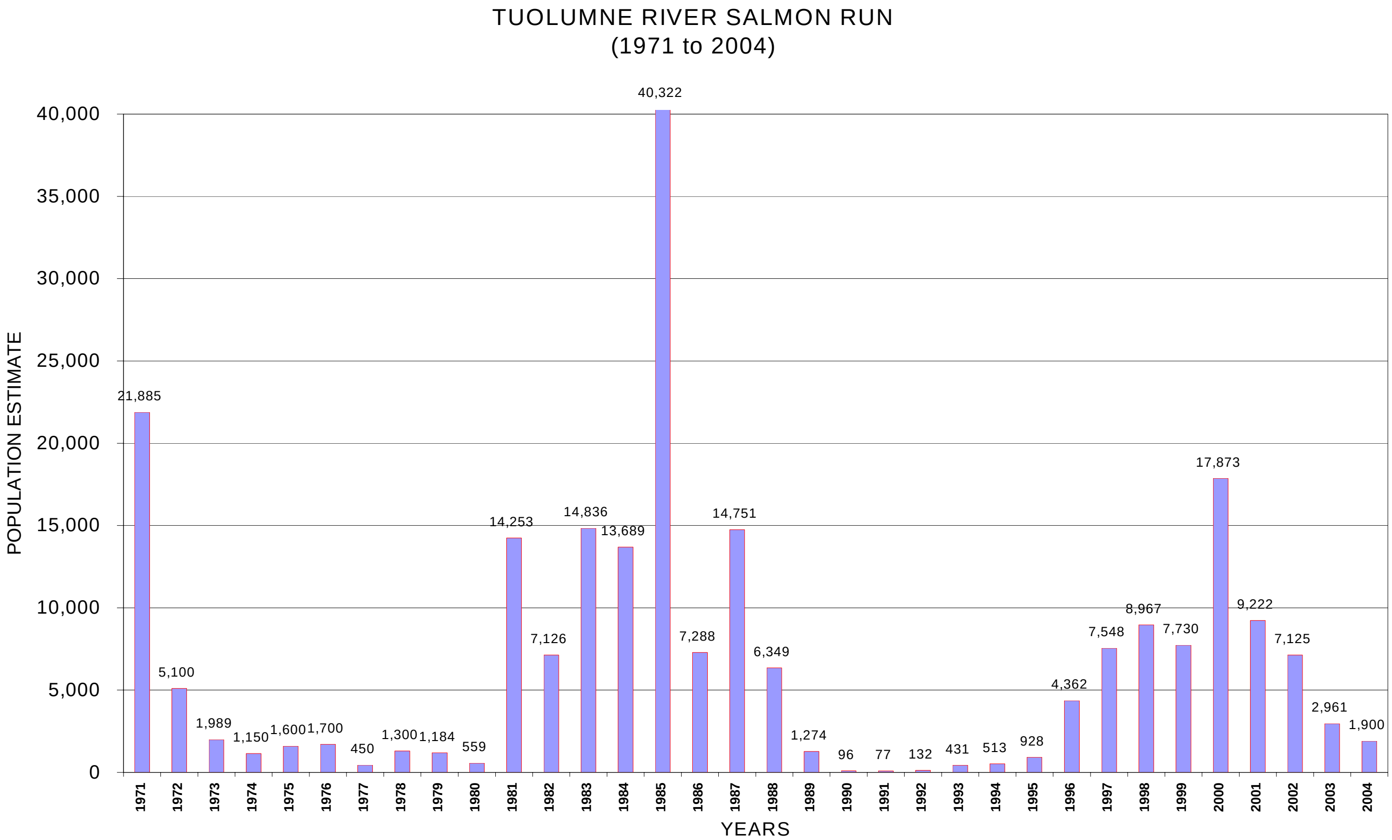


Figure 1. Estimated population of adult Chinook salmon for the Tuolumne River.

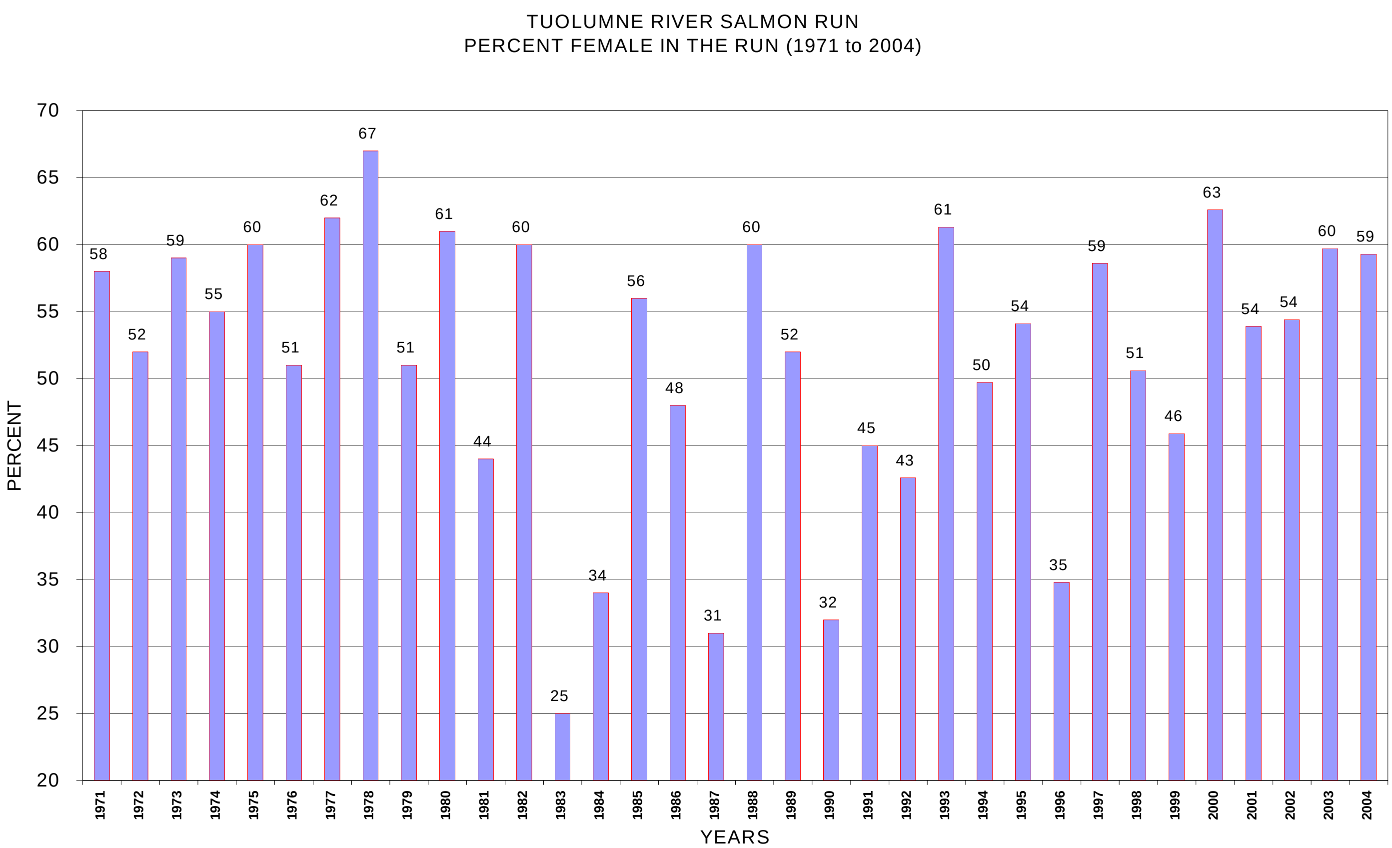


Figure 2. Percent female salmon in the Tuolumne River runs.

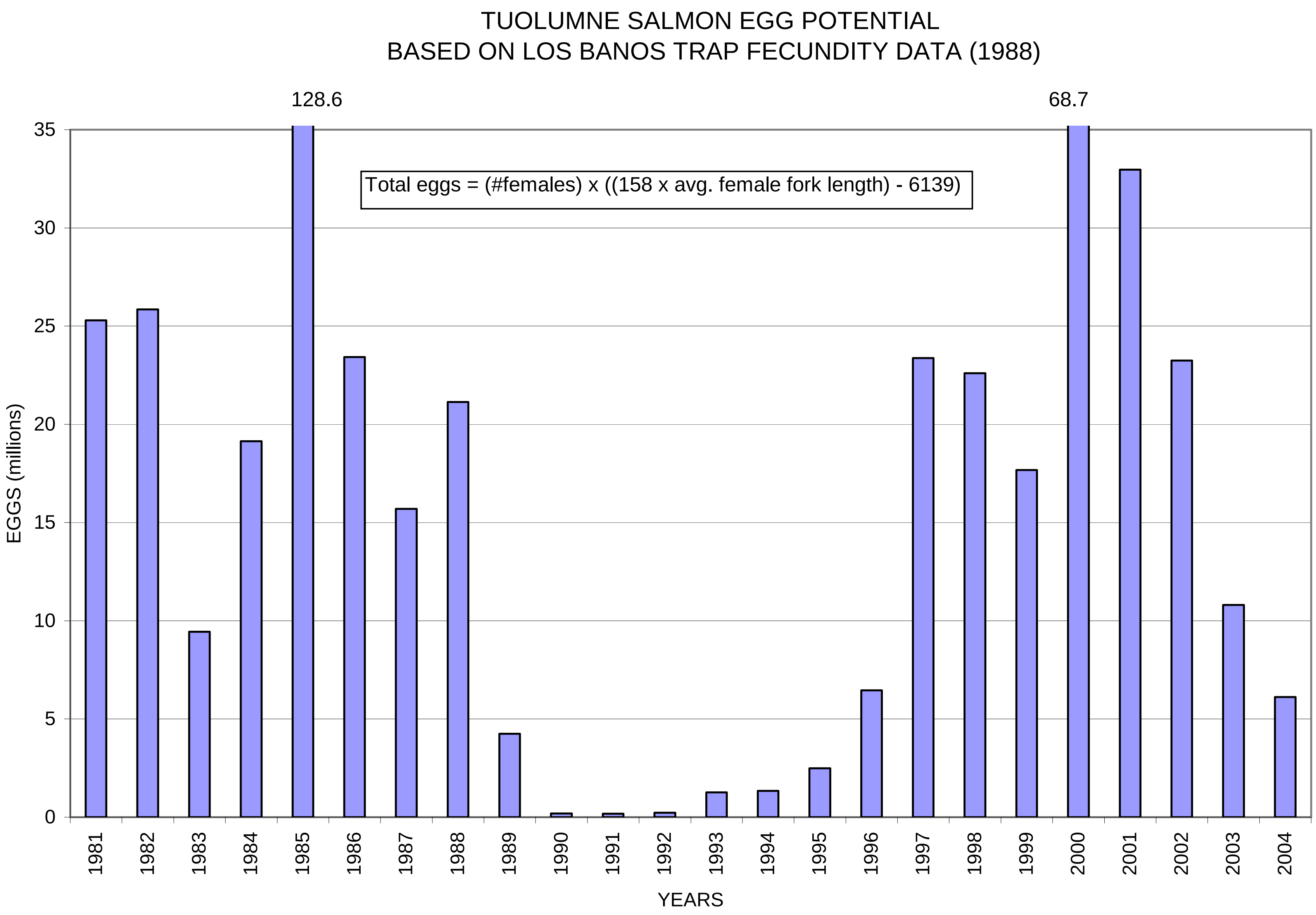


Figure 3. Potential egg deposition for Tuolumne River Chinook salmon, 1981-2004.

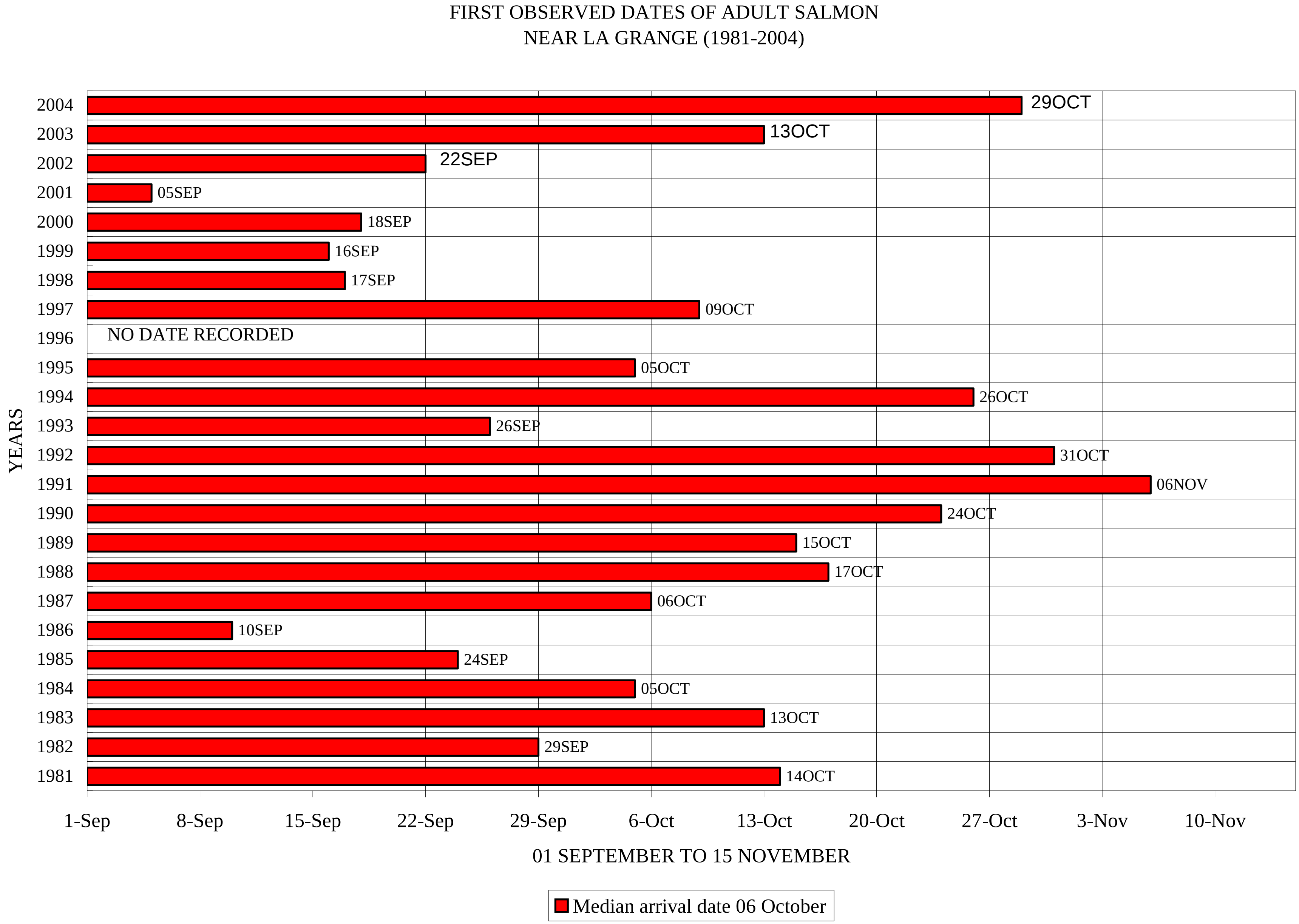


Figure 4. Tuolumne River salmon arrival near La Grange (1981-2004)

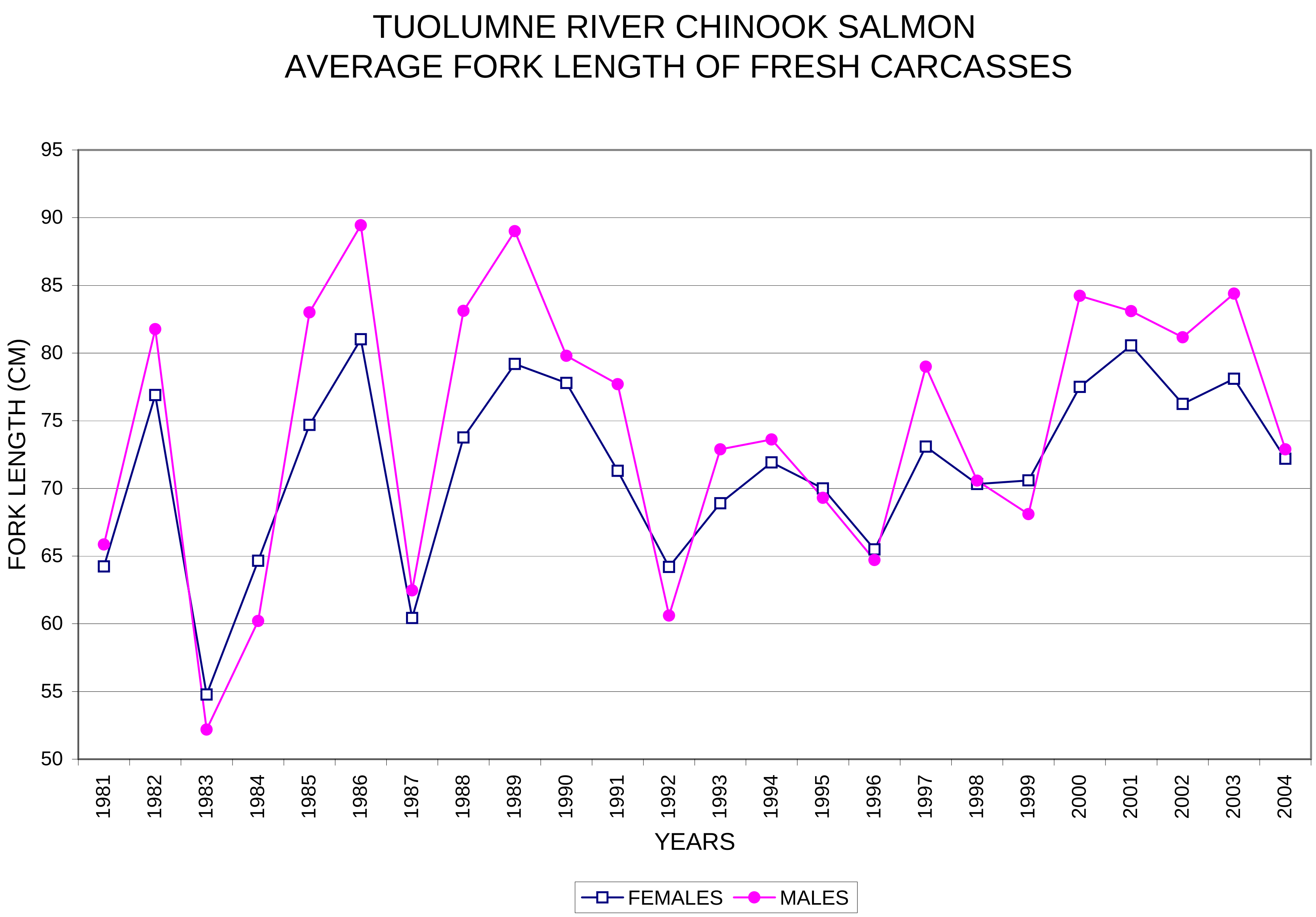
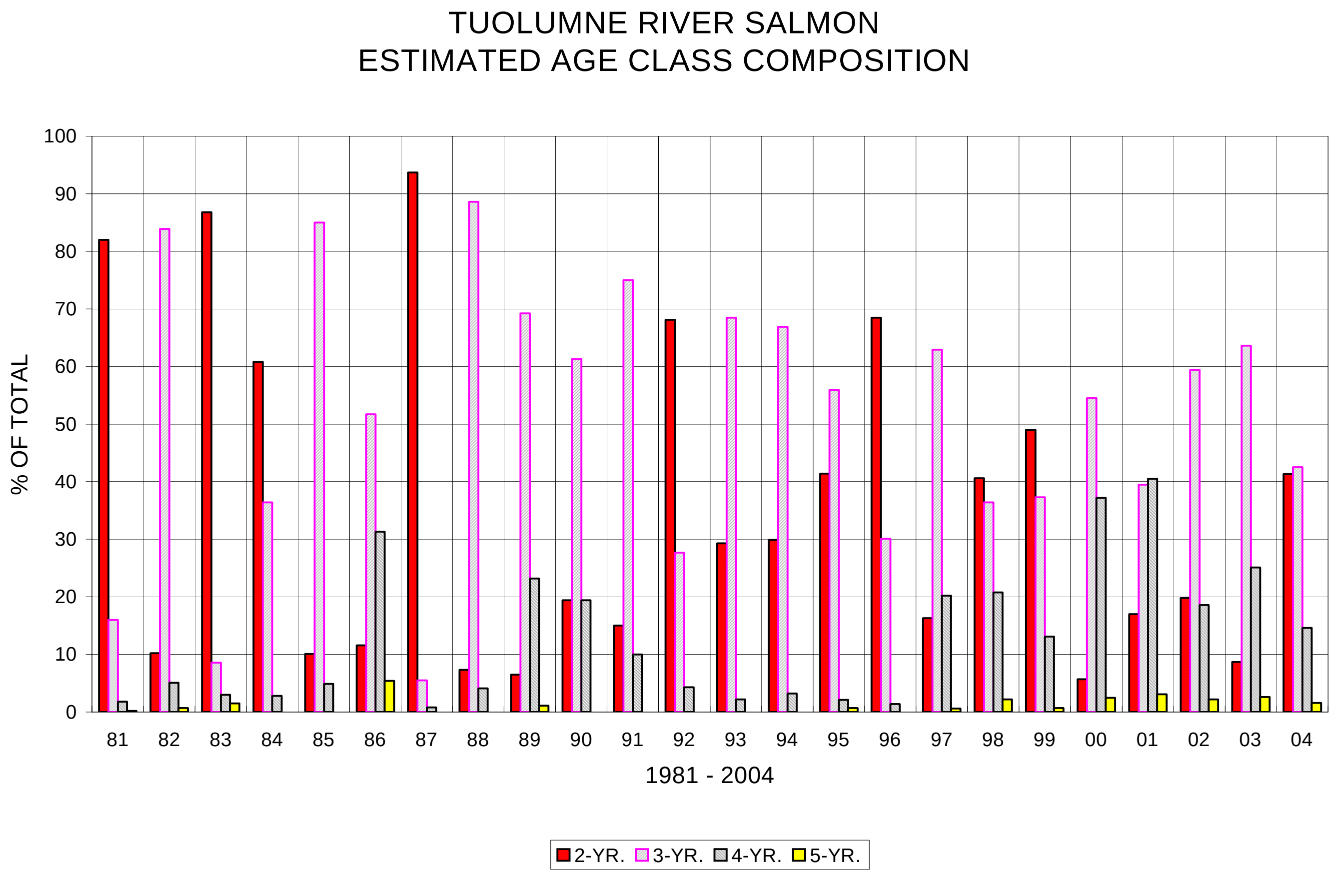


Figure 5. Average fork length of Tuolumne River salmon based on fresh measured carcasses.



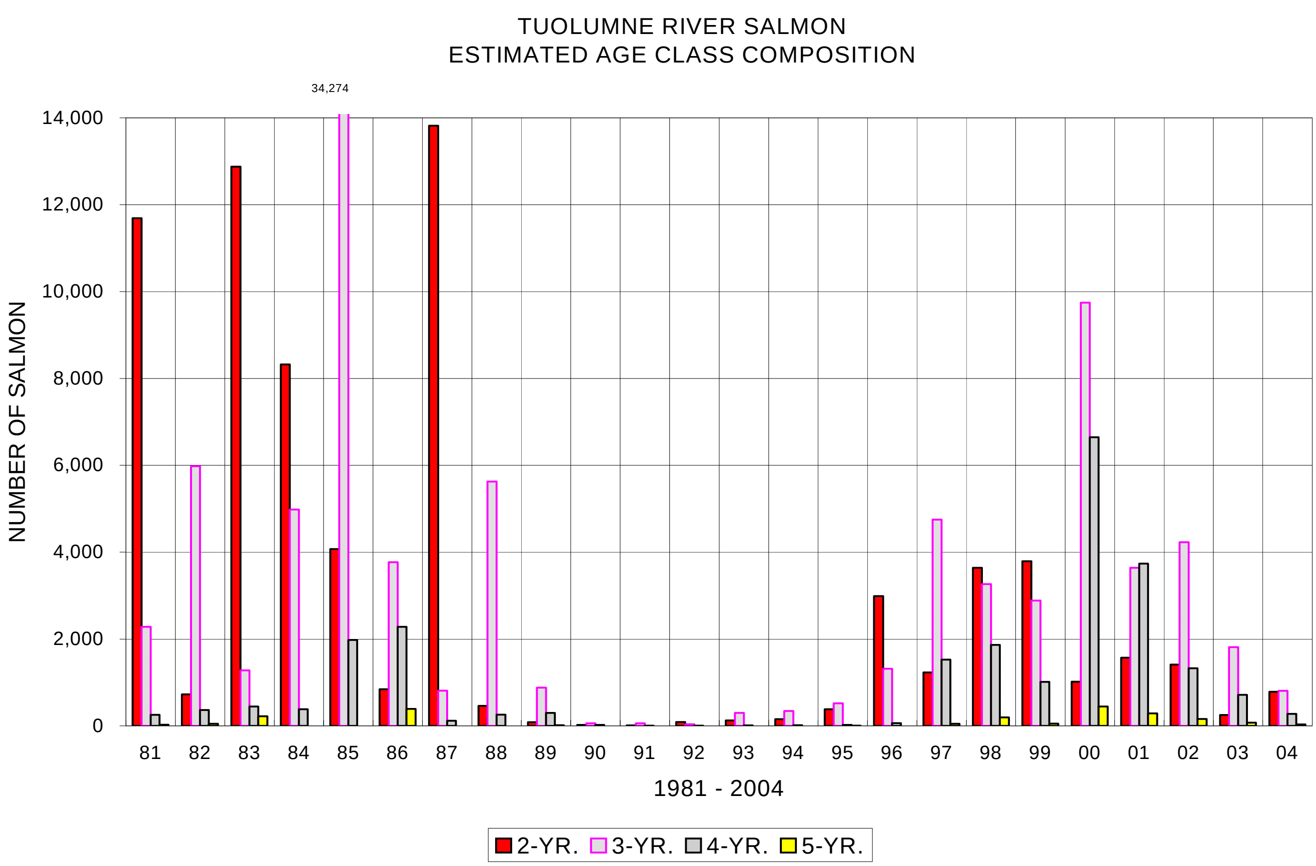
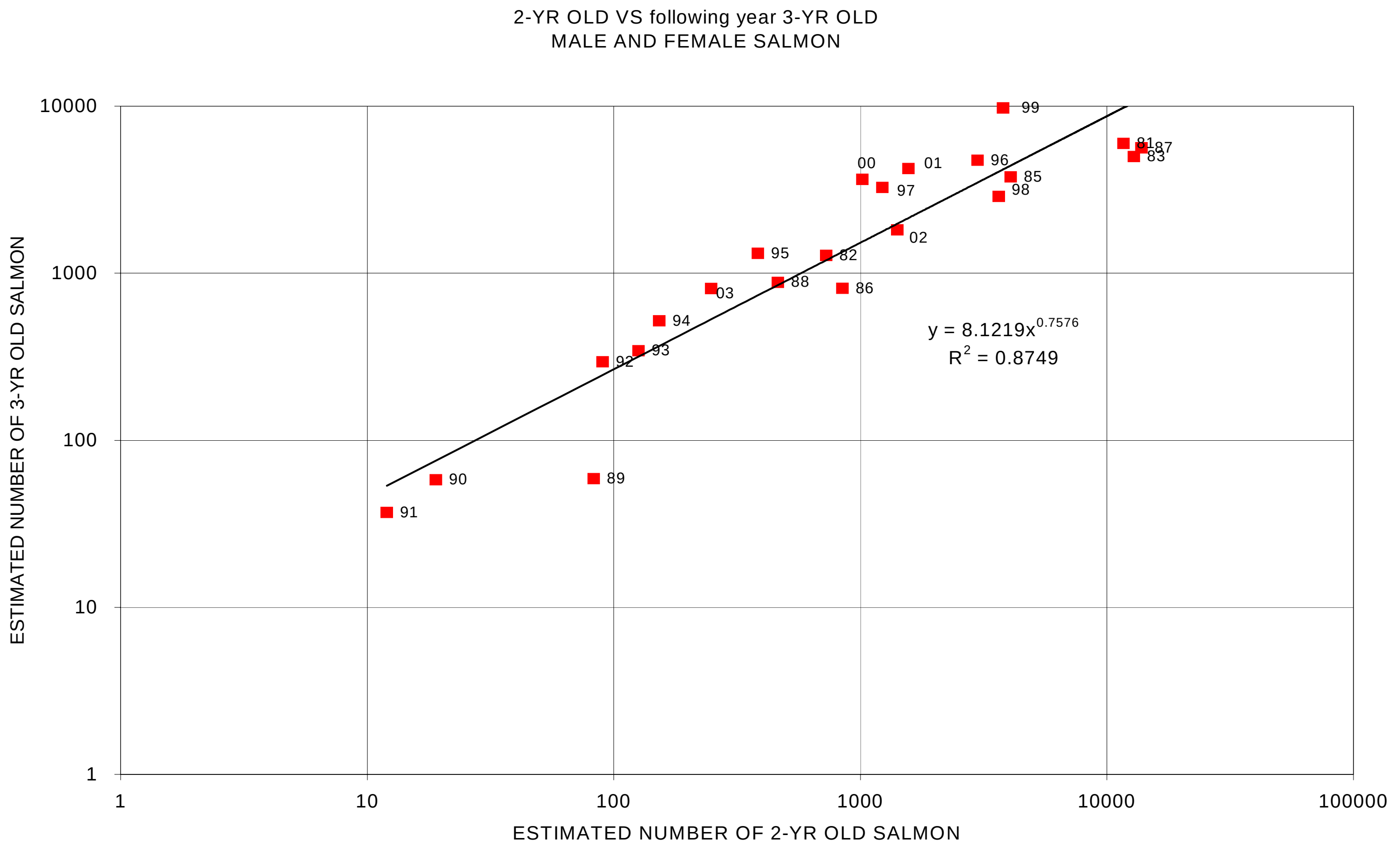


Figure 6. Estimated percent and number by age class for Tuolumne River salmon.



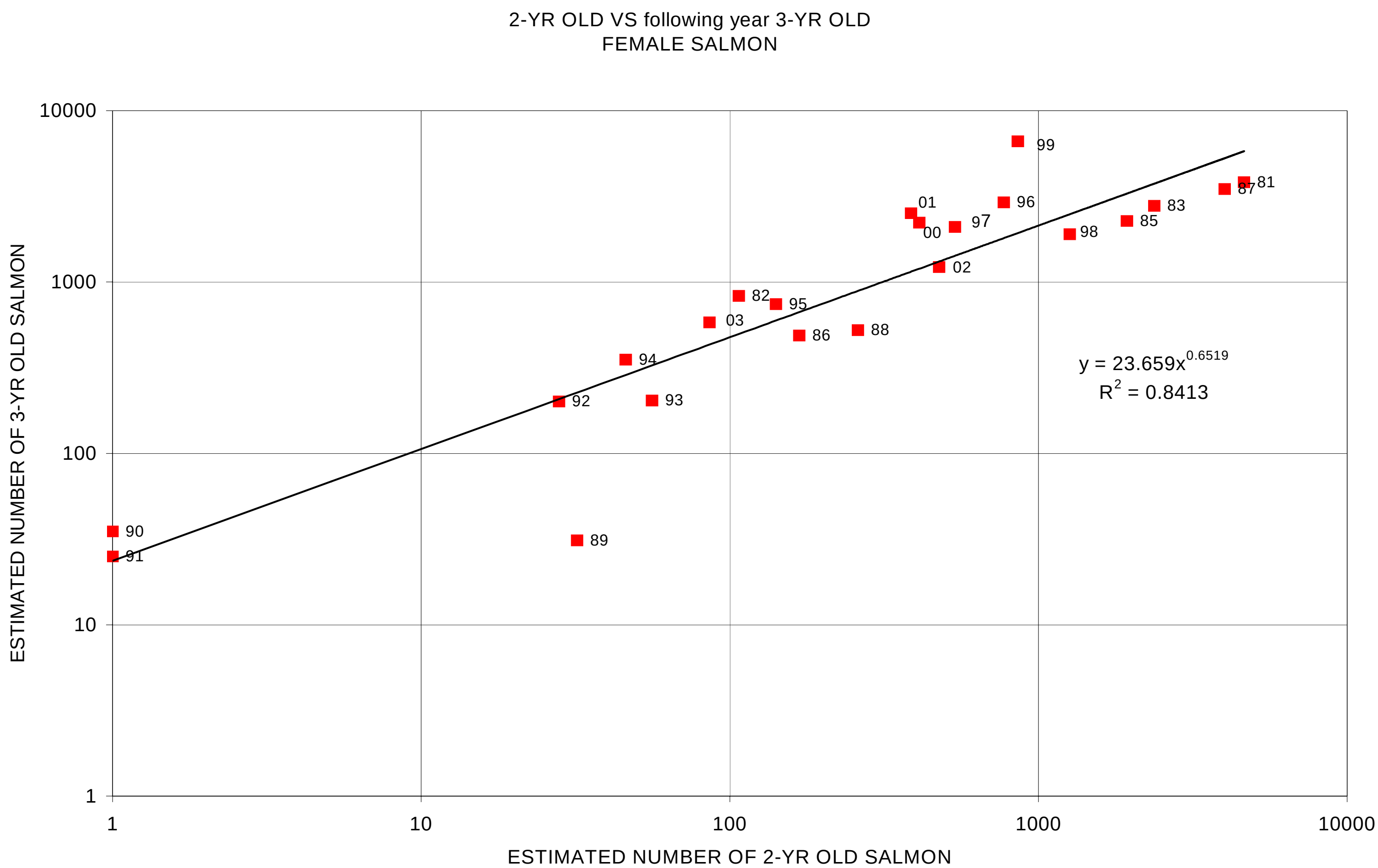


Figure 7. Estimated 2-yr old salmon VS following year 3-yr old (1981-2003 Tuolumne River runs) excluding 1984 outlier, run years are for the 2-yr olds.

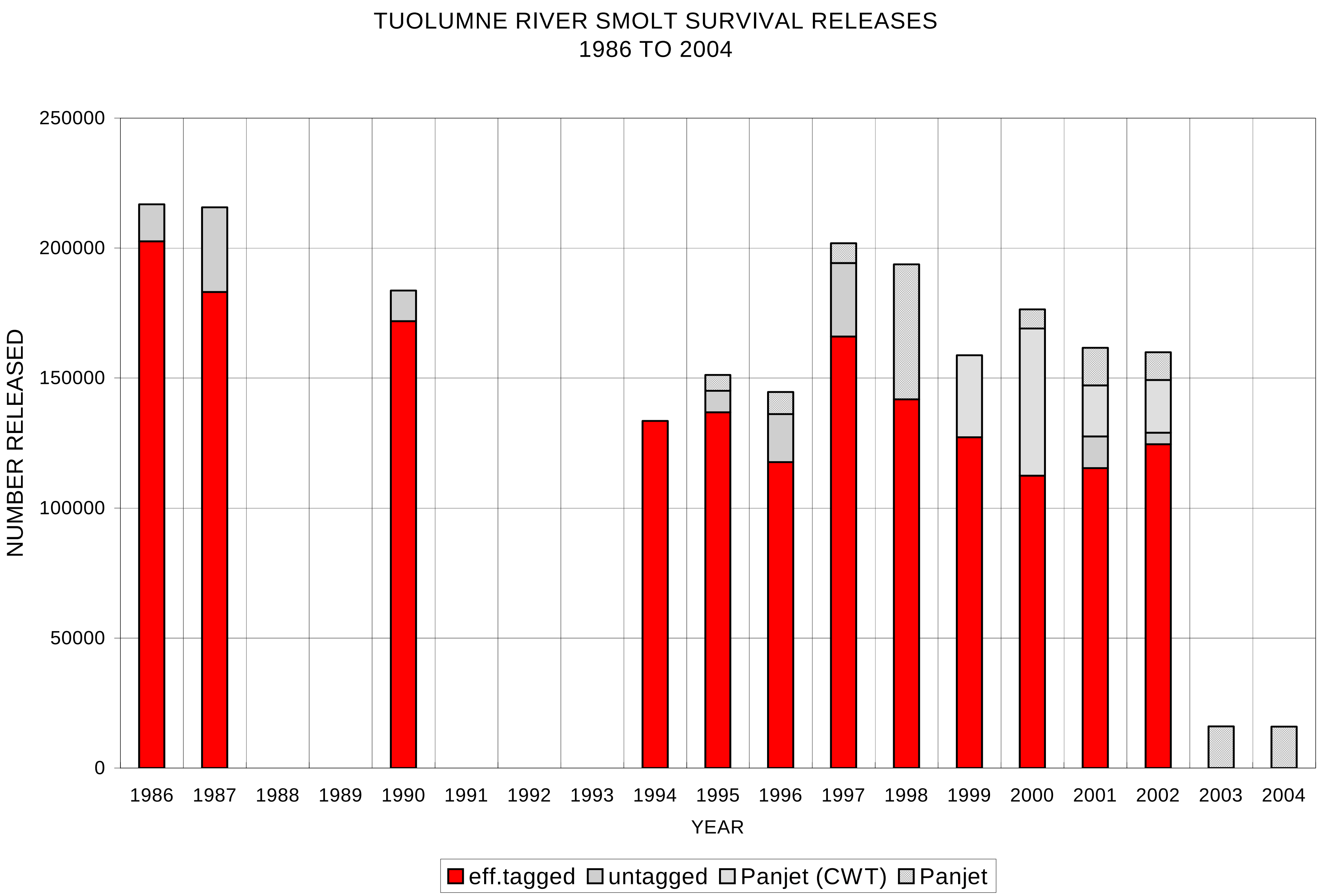
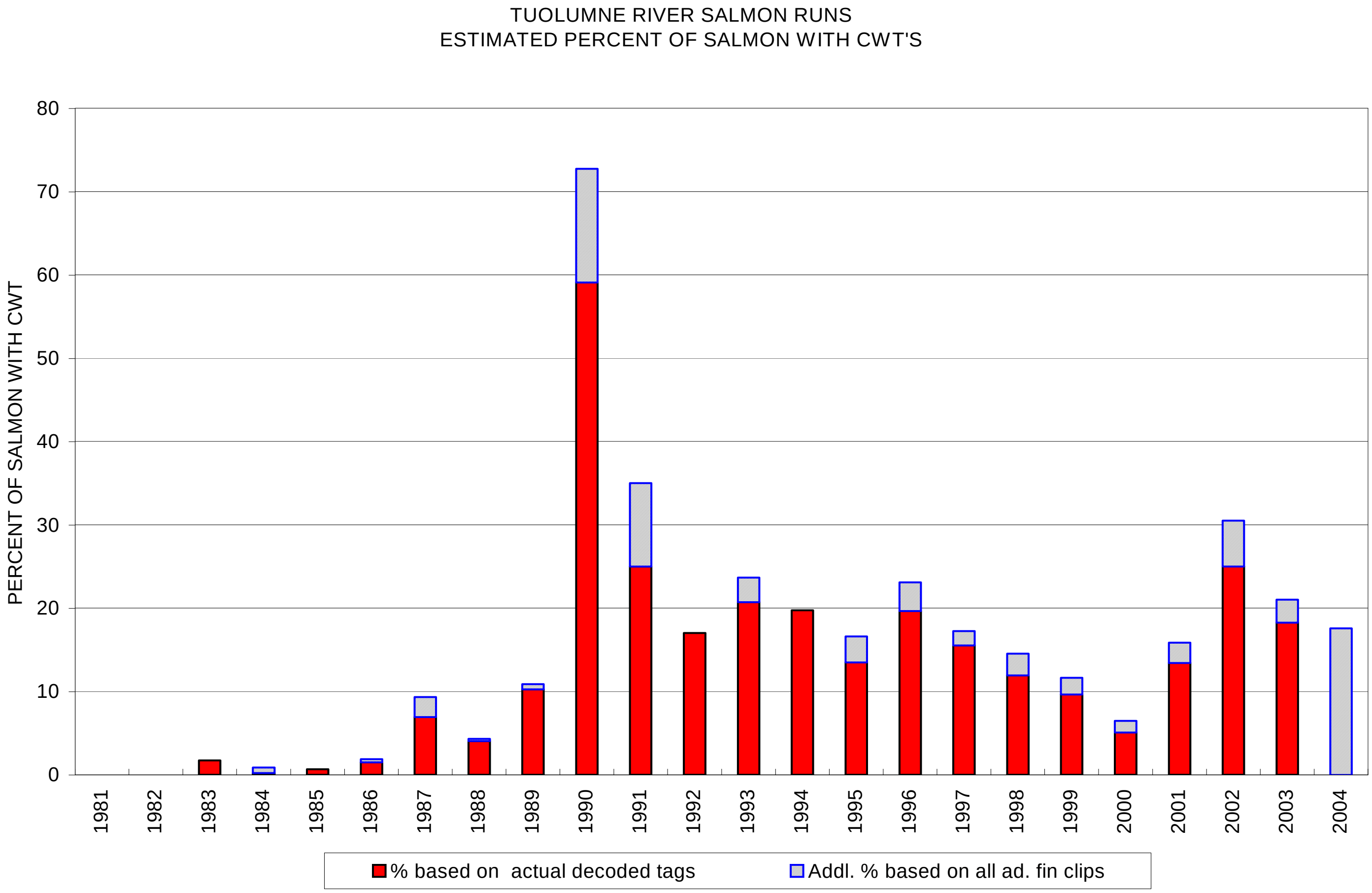


Figure 8. Tuolumne River salmon smolt release numbers (accounting for tag loss).



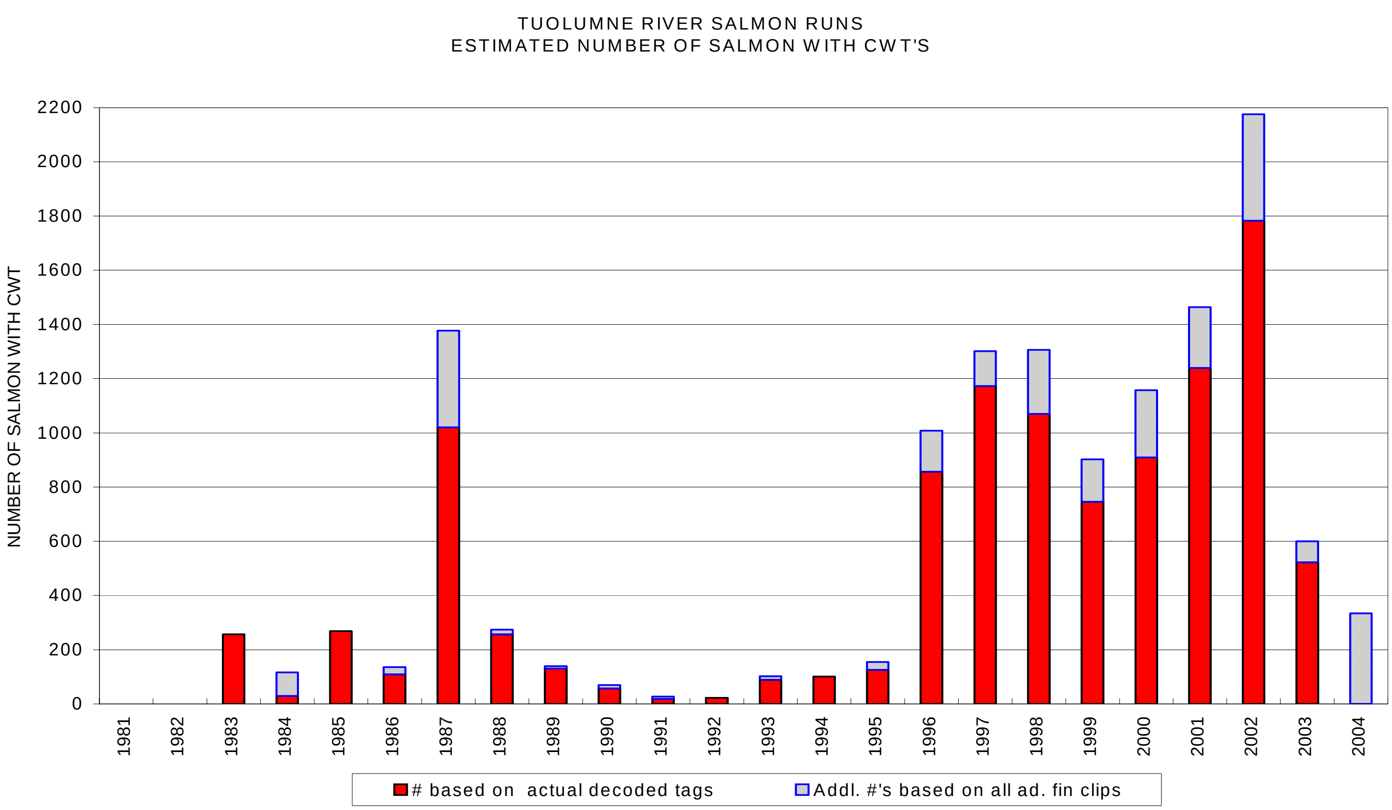


Figure 9. Estimated % and number of Coded-Wire-Tag salmon in the Tuolumne runs, 1981-2004.

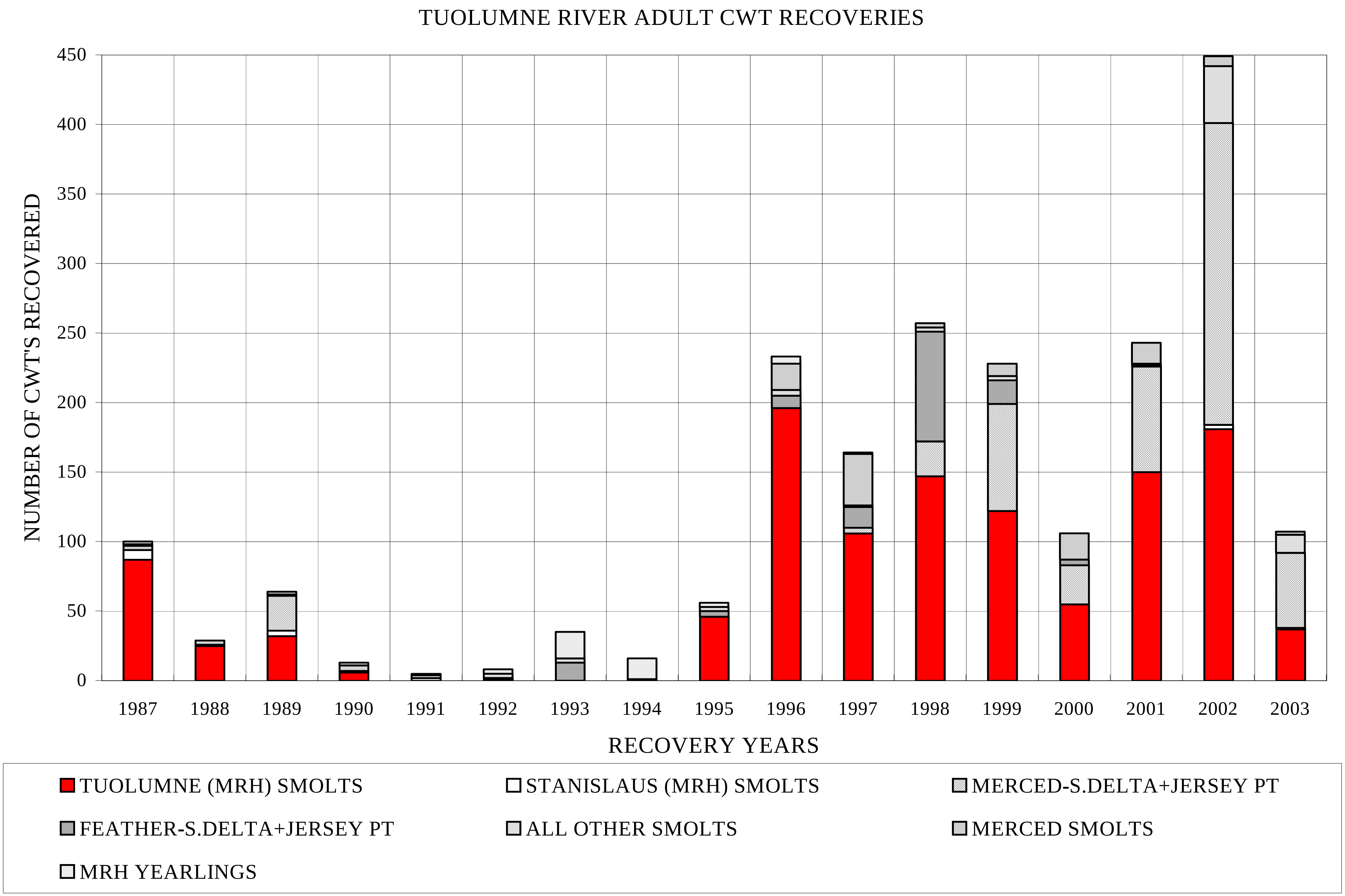


Figure 10. Actual number of CWT salmon recovered in the Tuolumne River based on release origin.

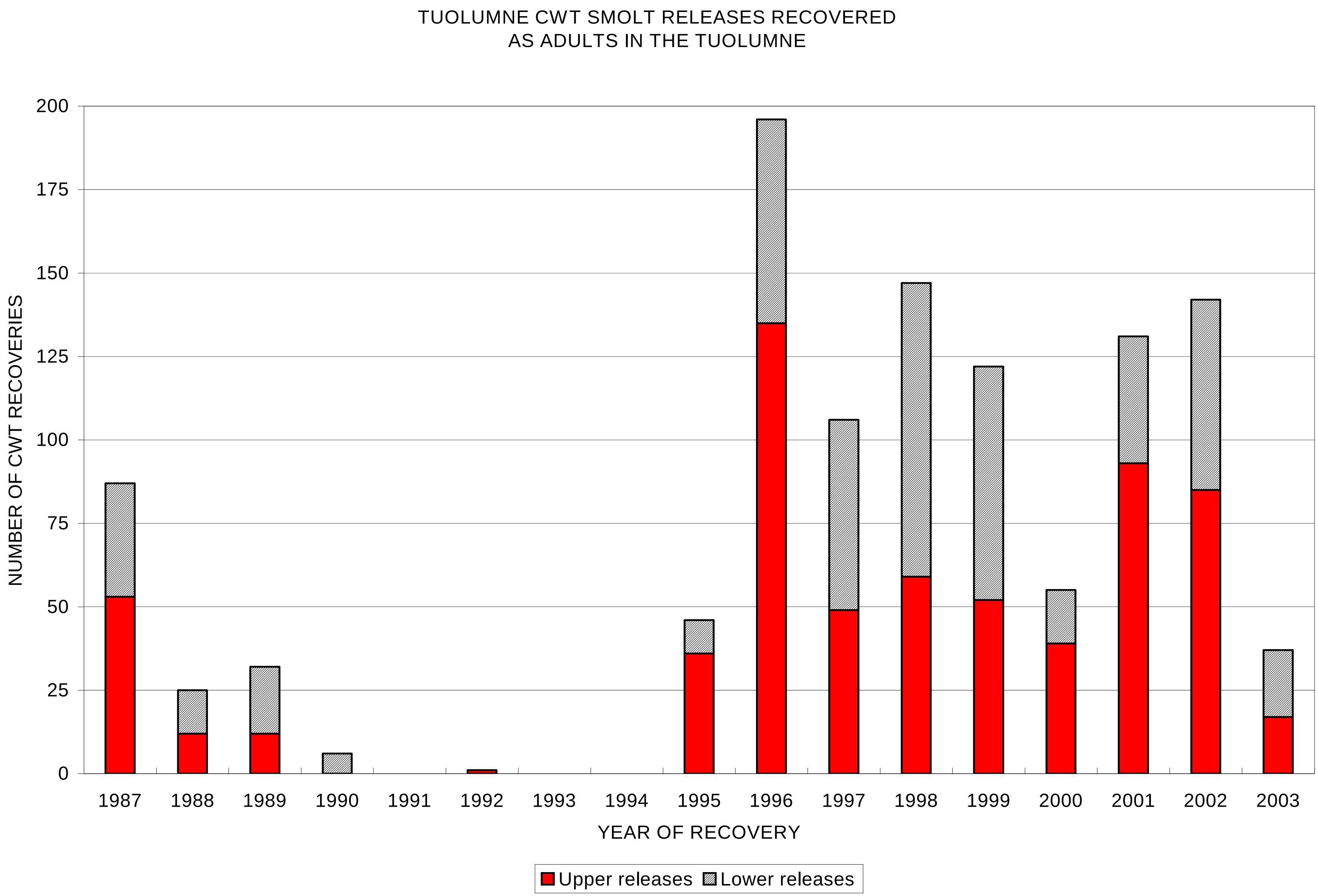


Figure 11. Number of adult CWT recovered in the Tuolumne River based on release group origin.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-3

2004 Seine/Snorkel Report and Summary Update

Prepared by

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and

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EXECUTIVE SUMMARY

The 2004 seining survey was conducted at two-week intervals from 20 January to 25 May for a total of 11 sample periods. One additional survey was conducted on 23 March to better evaluate a pulse flow period of 3,000 cfs. This was the 19th consecutive annual monitoring study on the Tuolumne River conducted by the Turlock and Modesto Irrigation Districts.

A total of 3,280 natural Chinook salmon were caught in the Tuolumne River and none in the San Joaquin River. Peak density of salmon caught in the Tuolumne was 40.5 salmon per 1,000 square feet on 03 February. Maximum fork length (FL) in the Tuolumne River increased from 56 mm FL to 95 mm FL from 03 February to 14 April and overall FL ranged from 31 mm to 98mm.

Flows during the sampling period ranged from about 170 to 3,030 cubic feet per second (cfs) in the Tuolumne River at La Grange and from about 1,500 to 4,400 cfs in the San Joaquin River at Vernalis.

Water temperature in the Tuolumne ranged from 10.0°C to 23.0°C and in the San Joaquin from 10.8°C to 23.4°C. Conductivity in the Tuolumne River ranged from 38 to 205 µS and in the San Joaquin from 360 to 1,632 µS.

A comparative analysis of fork length and salmon density for the 1999-2004 period is included. Increase in average fork length in 2004 was typical in timing and magnitude to the pattern observed in other years. The peak in fry (≤ 50 mm) density on 03 February was similar in timing to 1999-2000 and 2003, but was significantly lower in magnitude than the other years as a result of a smaller run size. The density of juveniles (> 50 mm) peaked on 23 March and was similar in timing to 2000 and 2003. In 2004, the average density of salmon in the Tuolumne River was 19.3 salmon per 1,000 ft^2 and was about in the middle of the range of values for the entire 1986-2004 period.

Snorkel surveys were conducted on 16-18 June, 03-06 August and 15-17 September, within a 20-mile section below La Grange Dam. The August survey was an additional mid summer survey that included 4 extra survey locations. Preliminary USGS flow at La Grange was about 150 cfs and water temperature ranged from 12.5°C to 24.0°C in June. Flow was about 108 cfs with water temperature ranging from 12.2°C to 25.0°C in August. In September, flow was about 106 cfs with water temperature ranging from 12.4 to 23.3°C. About 491 juvenile salmon and 91 rainbow trout were observed in June and 80 juvenile salmon and 75 rainbow trout were observed in August. In September, no Chinook salmon were observed and 40 rainbow trout were seen. Other species seen were Sacramento sucker, Sacramento pikeminnow, hardhead, riffle sculpin, largemouth bass, smallmouth bass, redear sunfish, bluegill, Pacific lamprey, and white catfish.

CONTENTS

1 INTRODUCTION

Stillwater Sciences, with assistance of SP Cramer and Associates, conducted seine and snorkel fishery monitoring in the Tuolumne and San Joaquin Rivers in 2004 for the Turlock and Modesto irrigation districts (TID/MID).

Seine sampling was done in both rivers pursuant to the 1995 Don Pedro Project FERC Settlement Agreement (FSA) and 1996 FERC Order as an aspect of the river-wide monitoring program. A primary objective was to document juvenile salmonid size, abundance and distribution, including the relationship of flow and other environmental variables. The 2004 salmon were the progeny of the 2003 fall spawning run, estimated to be about 2,900 fish. The effort corresponds to monitoring components of Sections 13c, d, and e of the FSA. This was the 19th consecutive annual seining study and a summary of salmonid data since 1986 is contained in this report.

Tuolumne River snorkel surveys began in 1982 with the number, location, and area sampled by site having varied over the years. Summer surveys occurring within the June to September period have been conducted in most years since 1988, although very wet years with high summer flows, such as 1995 and 1998, were not sampled. Locations were selected to include a range of habitat types (i.e., riffles, runs, pools) at sites where salmonids may occur and are spaced at intervals down the river in areas of suitable vehicle access. The overall river section examined is limited to the reach with suitable underwater visibility, this generally being in the 20-mile section from La Grange Dam downstream to near Waterford.

A single June or July snorkel survey had been done as part of the FSA monitoring since 1996 to evaluate the abundance, size, and distribution of salmonids and other fish species - 12 sites per survey have been done since 2001. An additional September snorkel survey has been done since 2001, primarily to augment information on rainbow trout. A third (midsummer) survey at 16 sites was done in August 2004, again to further augment information on rainbow trout. The 2004 surveys were conducted on 16-18 June, 03-06 August and 15-17 September. A comparison of the salmonids observed in the 1996-2003 period is included.

1.1 STUDY SITES

1.1.1 Seine

The area studied was the Tuolumne River from La Grange Dam (river mile [RM] 52.0) to its confluence (RM 0) with the San Joaquin River at RM 83.8, and the San Joaquin River from Laird Park (RM 90.2) to Gardner Cove (RM 77.8) (Figure 1). A total of ten sites were sampled, eight on the Tuolumne and two on the San Joaquin. The locations of the sites were as follows:

Site	Location	River Mile
	Tuolumne River	
1	Old La Grange Bridge (OLGB)	50.5[a]
2	Riffle 5 (R5)	48.0
3	Tuolumne River Resort (TRR)	42.4
4	Hickman Bridge	31.6

5	Charles Road	24.9
6	Legion Park	17.2
7	Venn Ranch	7.4
8	Shiloh Road	3.4
	San Joaquin River	
9	Laird Park	90.2[b]
10	Gardner Cove	79.4

a. From the confluence with the San Joaquin River.
b. From the confluence with the Sacramento River.

The Tuolumne River was stratified into three sections. The upper section (RM 52 to 34), sites 1-3, is a higher gradient area that includes most of the primary spawning riffles in the river. The middle section (RM 34 to 17), sites 4-6, is the transitional area from the gravel-bedded to sand-bedded river reaches. This section contains much of the in-channel sand/gravel mined areas. The lower section (RM 17 to 0), sites 7-8, is a lower gradient, mostly sand-bottom reach downstream of the Dry Creek confluence.

1.1.2 Snorkel

The snorkel surveys were at in a 20-mile reach from Riffle A3/A4 (RM 51.6) downstream to Riffle 57 (RM 31.5) below Hickman Bridge near Waterford.

1.2 2004 TUOLUMNE AND SAN JOAQUIN RIVER SAMPLING CONDITIONS

1.2.1 Seine

Flows in the Tuolumne River below La Grange Dam were approximately 212 cfs in January when the surveys began. Flows were steady until early March when releases were increased to maintain Don Pedro Reservoir flood storage space. Flows were about 1,100 cfs for 10 days followed by a pulse flow of near 3,000 cfs from 17-19 March (Figure 2). Flows were then varied from about 600-1400 cfs until mid-May, after which flows were reduced to about 200 cfs and then down to near 100 cfs in June.

Flows in the San Joaquin River at Vernalis (RM 72.5) ranged from 1,500-4,400 cfs from mid-January to mid-April. Flows were maintained at about 3,400 cfs from mid-April to mid-May during the Vernalis Adaptive Management Plan period. Flows then decreased to about 1,300 cfs through June.

Flows upstream of Vernalis, at Patterson Bridge (RM 98.5) and Maze Road (RM 77.3), represent flow levels at the sampling locations of Laird Park upstream of the Tuolumne and Gardner Cove downstream of the Tuolumne, respectively.

The minimum water temperature recorded in the Tuolumne River during the study period, based on hand-held temperature measurements, was 10.0 °C (50.0 °F) at Hickman Br. on 03 February, and the maximum temperature was 23.0 °C (73.4 °F) at Shiloh Road on 25 May (Figure 3). The lowest San Joaquin River water temperature, 10.8°C (51.4°F) was at Laird Park and Gardner Cove on 20 January; the highest was 23.4°C (74.1°F) at Laird Park on 25 May.

1.2.2 Snorkel

The flow at La Grange during the snorkel surveys in June was about 150 cfs. Water temperature ranged from 12.5 °C (54.5 °F) at Riffle A7 on 16 June to 24.0 °C (75.2 °F) at Riffle 57 on 18 June. The additional mid-summer survey in August had flow at La Grange of 108 cfs with water temperatures ranging from 12.2 °C (54.0 °F) at Riffle A3/A4 on 03 August to 25.0 °C (77.0 °F) at Riffle 57 on 06 August. The flow at La Grange during the snorkel surveys in September was about 106 cfs. Water temperature ranged from 12.4 °C (54.3 °F) at Riffle A7 on 15 September to 23.3 °C (73.9 °F) at Riffle 57 on 17 September.

2 METHOD OF THE STUDY

2.1 STUDY TIMING

The 2004 seining study began on 20 January and ended on 25 May. Sampling was done at two-week intervals, with a total of 11 sampling dates. Snorkel surveys were conducted on 16-18 June, 03-06 August, and 15-17 September.

2.2 SAMPLING METHODS AND DATA RECORDING

2.2.1 Seine

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 taken were area sampled, (determined from estimating average length and width of a seine haul) water temperature, visibility, conductivity, 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.

2.2.2 Snorkel

Underwater observations were conducted using an effort-based method where a snorkeler examined within a specified area for a given period of time and recorded the species, numbers, and size estimates 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 a 20-mile section below La Grange Dam downstream to Waterford. The snorkeling method employed provides an index of species abundance.

Each habitat type sampled mostly involves one observer snorkeling a specified habitat area for a certain time period. Whenever feasible, the surveys are conducted moving upstream against the current - a side-to-side (zigzag) pattern is used if the width of the survey section dictates. Occasionally, two snorkelers move 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 is carefully surveyed. The only exceptions are the habitat areas that are too wide to effectively cover. If high water velocity precludes upstream movement, snorkelers may float downstream with the current, remaining as motionless as possible through the study area, although stream margins at those sites may still be viewed in an upstream direction.

Usually the total length of an observed fish is estimated using a ruler outlined on the diving slate to the nearest 10 mm. For some larger fish, the lengths may be 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 estimates of the length range and number of fish in the group. Care is taken to observe and count each fish just once in the survey area.

Other data recorded for each location include water temperature, electrical conductivity, turbidity, and horizontal visibility. Site-specific data that is recorded includes area sampled, average depth, sample time, general habitat type and substrate type. Maps of surveyed areas are m

2.3 DATA ANALYSIS

Seining catch data was examined by site (see Figure 1 for locations), by river section, and by river. Catch densities of salmon were divided into two size groups for analysis. The density index for "fry" (fish ≤50 mm FL) and for "juveniles" (>50 mm), by site and by section, were computed by multiplying the number of salmon caught by 1,000 and dividing it by the area sampled. These are taken as indices of population density (relative abundance), and used for comparisons. Densities and sizes of salmon fry and juveniles by upper, middle, and lower river sections were examined.

3 RESULTS AND DISCUSSION

3.1 SEINE CATCH

A total of 3,280 salmon were caught in the Tuolumne River and none in the San Joaquin (Table 1). Of these, 1,781 salmon were measured and riverwide peak density for the Tuolumne was 40.5 salmon per 1,000 ft^2 on 03 February.

3.1.1 Density of Fry and Juvenile Salmon

Salmon up to 65 mm fork length (FL) were caught in the Tuolumne River on 20 January in the first sampling period. The highest density of salmon fry in the Tuolumne was 38.8 fry/1,000 ft^2 found on 03 February (Table 2). The highest density of juvenile salmon in the Tuolumne was 13.2 juveniles/1,000 ft^2 found on 23 March.

The density of salmon fry by location exhibited a peak for most sites from 20 January to 02 March. The density of juveniles by location generally peaked from 16 March to 14 April for most locations (Figure 4).

The density of salmon fry in sections of the Tuolumne River had a peak in the upper section on 03 February and in the middle section on 16 March (Figure 5). The density of juveniles by section shows a peak in the upper section on 30 March and a peak in the middle section on 23 March. Only 3 salmon were caught in the lower section of the Tuolumne River and none in the San Joaquin River.

3.1.2 Size, Growth, and Smoltification

The fork length of salmon from the Tuolumne River caught in 2004 ranged from 31 mm to 98 mm. The average fork length (FL) of salmon generally showed a steady increase from 21 January to 01 April (Figure 6).

An indirect method to estimate growth rate was made by dividing the amount of increase in maximum FL, over an extended period of time, by the number of days during the period. Maximum FL in the Tuolumne River increased from 56 to 95 mm during the 03 February to 14 April period (Figure 6). This indicates a potential FL increase of approximately .55 mm per day (39 mm / 71 days).

Length frequency distributions reflect the change in average fork length through the entire study period (Figure 7 & 8). The change in FL by location generally shows an increase from late January to late May at most of the Tuolumne River sampling locations (Figure 9). Salmon estimated to be large enough to undergo smoltification (> 70 mm FL) were present by early March. The first salmon exhibiting smolting characteristics was caught on 16 March. Fry were present through the entire seine survey period.

3.1.3 Conductivity and Turbidity

Conductivity in the Tuolumne River generally increased with increasing distance below La Grange Dam, from a low of 38 µS at Old La Grange Bridge to a high of 205 µS at Shiloh Road (Table 3). Conductivity also increased as flows were reduced (Figure 10).

Conductivity in the San Joaquin River was much higher than in the Tuolumne and ranged from a low of 360 µS at Gardner Cove to a high of 1632 µS at Laird Park.

Turbidity in the Tuolumne River was less than 9.3 Nephelometric Turbidity Units (NTU's) except for two readings at Venn Ranch and Shiloh Road on 02 March. Turbidity also generally increased with increasing distance below La Grange Dam and generally decreased with higher flows.

Turbidity in the San Joaquin River ranged from 15.0 at Gardner Cove to 67.8 NTU at Laird Park.

3.1.4 Other Fish Species Caught

The numbers of other fish species caught during the seining study are tabulated by species, location, and date in Table 4. Fifteen species other than Chinook salmon were caught in the Tuolumne River and 18 other species in the San Joaquin River. Eleven of these species were common to both rivers and 22 species were caught overall. Six rainbow trout fry (29-38 mm FL) were caught in the Tuolumne River from 16 March to 14 April. The distribution of species in the Tuolumne was generally determined by habitat and water temperature with coldwater species such as rainbow trout and riffle sculpin found in the upper third of the river. The San Joaquin River had a greater number of species present that favor warmer water temperatures.

3.1.5 Coded-Wire-Tagged Salmon

No coded-wire-tag (CWT) salmon were released in the Tuolumne River in 2004 and no CWT salmon were caught in the San Joaquin River.

3.2 SNORKEL SURVEY

Survey conditions and fish observations from the snorkel surveys conducted on 16-18 June, 03-06 August, and 15-17 September are summarized in Table 5. The fish species observed were all native species characteristic of the lower elevation zone adjacent to the Sierra foothills with the exception of the largemouth bass, smallmouth bass, redear sunfish, bluegill, and white catfish. The same species were also observed in previous snorkel surveys.

In the June surveys, juvenile Chinook salmon were observed downstream to Riffle 35A (RM 37.1). 390 of the total 491 salmon observed were counted in Riffle A7. Rainbow trout were observed downstream to Riffle 21 (RM 42.9). Other species seen were Sacramento sucker, Sacramento pikeminnow, hardhead, riffle sculpin, largemouth bass, smallmouth bass, redear sunfish, bluegill and lamprey.

In the August surveys, Chinook salmon were observed downstream to Riffle 3B (RM 49.1). Rainbow trout were observed downstream to Riffle 23C (RM 42.3). The same other species seen in June, except redear sunfish, bluegill, lamprey and white catfish were observed in August.

In the September surveys, Chinook salmon were not observed. Rainbow trout were observed downstream to Riffle 21 (RM 42.9). The same other species seen in June, except riffle sculpin, redear sunfish, and lamprey, were observed in September.

4 COMPARATIVE ANALYSIS

4.1 SEINE: 1986-2004

Annual TID/MID Tuolumne River seining surveys began in 1986. The number, location, and sampling frequency of sites have varied over the years (Tables 6 and 7). The total number of salmon captured in 2004 (3,280) is most similar to the 1999, 2000 and 2002 totals in recent years. The number of salmon captured in the Tuolumne has ranged from 120 (1991) to 14,825 (1987). In 2004, the average density of salmon in the river was 19.3 salmon per 1,000 ft^2 and was similar to densities found in 1986.

The San Joaquin River has been sampled upstream and downstream of the Tuolumne River confluence in each of the study years. The total number of salmon caught has ranged from 0 to 854 with average density much lower than the Tuolumne (Table 6). No wild salmon were caught in the San Joaquin River in 2004.

Comparative analyses of fork length and density will be mostly limited to the 1999 to 2004 study period in this report update.

4.1.1 Size and Growth

In 2004, the increase in average FL during the January to March period was similar in timing and magnitude to the pattern observed in 1999-2004 (Figure 11). The increase in average FL peaked on 28 April. Minimum FL found in 2004 remained low into May and was similar to most other years (Figure 12). Maximum FL in 2004 increased from February to late April (Figure 13). The estimated 2004 growth rate of .55 mm per day was in the middle range of growth rate values for 1986-2004 (Table 6).

4.1.2 Fry and Juvenile Salmon Density

In 2004, the density of salmon fry (≤ 50 mm) in the Tuolumne River peaked on 03 February at the lowest level for the 1999-2004 period (Figure 14). The 03 February timing of peak fry density was about the same as the late January to mid-February peaks of 1999, 2000 and 2003.

The density of salmon juveniles (>50 mm) in 2004 peaked on 23 March and was most similar in timing to 2003 (Figure 15).

Combined fry and juvenile densities for the Tuolumne River are shown for the years 1999-2004 (Figure 16). The 2004 densities peaked in early February and showed an uncharacteristic slow decline to early May.

4.1.2.1 Tuolumne River Section Density

Upper section density of fry generally peaks from mid-January to mid-February and steadily declines through March (Figure 17A). For 2004, the density of fry exhibited this general pattern. Upper section density of juveniles typically increases beginning in late February and peak in mid March to early April. In 2004, juvenile salmon density increased in mid March and peaked in late March.

Middle section density of fry generally peaks from mid January to late February about 2 weeks after the peak in the upper section (Figure 17B). In 2004, the density of fry peaked somewhat later around early to mid March. Middle section density of juveniles often peak from mid February to late March. In 2004 juvenile density, similar to fry density, also peaked in mid-March.

Lower section density of fry and juvenile salmon has been relatively low in most years. This section was often sampled only at the Shiloh Road location in prior years. Since 1999, two sites have been sampled. Peak density of both fry and juveniles were similar in timing to the middle section in the 1999-2004 period (Figure 17C). In 2004, only one fry and two juveniles were caught.

Section abundance indices of fry and juvenile salmon combined were standardized as a percent of the annual riverwide average abundance index and plotted at section midpoints for recent years (Figure 18). In general, the abundance indices decline from the upper to lower sections. There were two years that did not follow this pattern. In 1999 the middle section index, plotted at RM 27.0, was higher than the upper section. In 1998 the lower section index, plotted at RM 8.1, was highest for all sections. In 2004 the standardized section abundance indices exhibited the typical decline from the upper to lower sections and was most similar to the 2001 indices.

4.1.2.2 San Joaquin River Density

Densities of salmon caught in the San Joaquin River at Laird Park and Gardner Cove or nearby sites were analyzed to compare relative abundance of salmon upstream and downstream of the Tuolumne River confluence. The abundance indices were calculated for fry and juvenile salmon combined due to low numbers caught. The average salmon abundance at Laird Park, downstream of the Merced confluence, was extremely low for all years during the 1986-2004 period (Figure 19). The total number of wild salmon caught at Laird Park during this period was 135. The average abundance at Gardner Cove, downstream of the Tuolumne River confluence, was much higher in 1986 and 1999 and moderately higher in 1995, 1998 and 2001. A total of 1048 salmon were caught at this location during the 1986-2003 period, 509 of which were caught in 1999. No wild salmon was caught at Gardner Cove in 2004.

4.1.3 Linear Regression of Tuolumne River Fry Density Versus Number of Female Spawners

A linear regression analysis of the logarithmic values of peak fry density in the Tuolumne River and the estimated total number of female spawners (TID/MID data), from the preceding fall-run, resulted in an R-squared of .693 for the 1986-2004 period (Figure 20, Table 8). A similar result with R-squared of .699 was found using average fry density from 15JAN-15MAR (Figure 21). The R-squared value for the 1986-1996 period for peak fry density and number of female spawners was .756 (FERC Report 96-2). The reduction in R-squared values for the 1986-2004 period resulted from the relatively low number of fry captured in 1997. The low number of fry captured that year is likely due to the effects of flood releases made in early January 1997, which reduced the survival of incubating eggs / alevins in the gravel and moved fry downstream of the Tuolumne River.

4.1.4 Other Fish Species

The number of fish species, other than Chinook salmon, caught during 1986-2004 has ranged from 11 to 16 on the Tuolumne River. Table 4 has the counts from each site and date for those species. In 2004, 15 other species were caught including 6 native species; 18 fish species, including 3 native, were caught on the San Joaquin River in 2004 (Table 4a). Of native species, rainbow trout, hardhead, prickly sculpin, and riffle sculpin were caught only in the Tuolumne River and tule perch was caught only in the San Joaquin River. The only native species caught in both rivers was the Sacramento sucker and Sacramento pikeminnow. Native species not caught in either river in 2004 were Pacific lamprey, Sacramento blackfish, hitch, and Sacramento splittail.

4.2 SNORKEL: 1996-2004

Annual Tuolumne River snorkel surveys under the FSA began in 1996. The precursor to these surveys was the 1988-1994 summer flow studies. This comparative analysis of the 1996-2004 period considers the total number and density of salmonids observed during the June-July surveys and a comparative analysis of the 2001-2004 September surveys.

The number, location, and area sampled by site have varied over the years (Table 9) for early season sampling, but the recent late season sampling has been at the same locations each year (Table 10). Table 11 compares 12 current snorkel site habitats with other recent habitat mapping efforts.

The total number of salmon and rainbow trout observed in June 2004 was 491 and 91 respectively. In June the number and relative density of salmon observed were similar to most other years since 2000. The total number and relative density of rainbow trout were similar to 2003 with the exception of fewer trout observed at Riffle A7 (RM 50.7). Rainbow trout were observed downstream to Riffle 21 (RM 42.9).

The absence of salmon in September 2004 was similar to the low numbers observed in 2001-03 as there has been a decrease observed between the June and September sampling periods each of the past 4 years. The pattern of fewer rainbow trout observed in September in 2004 was similar to the other years.

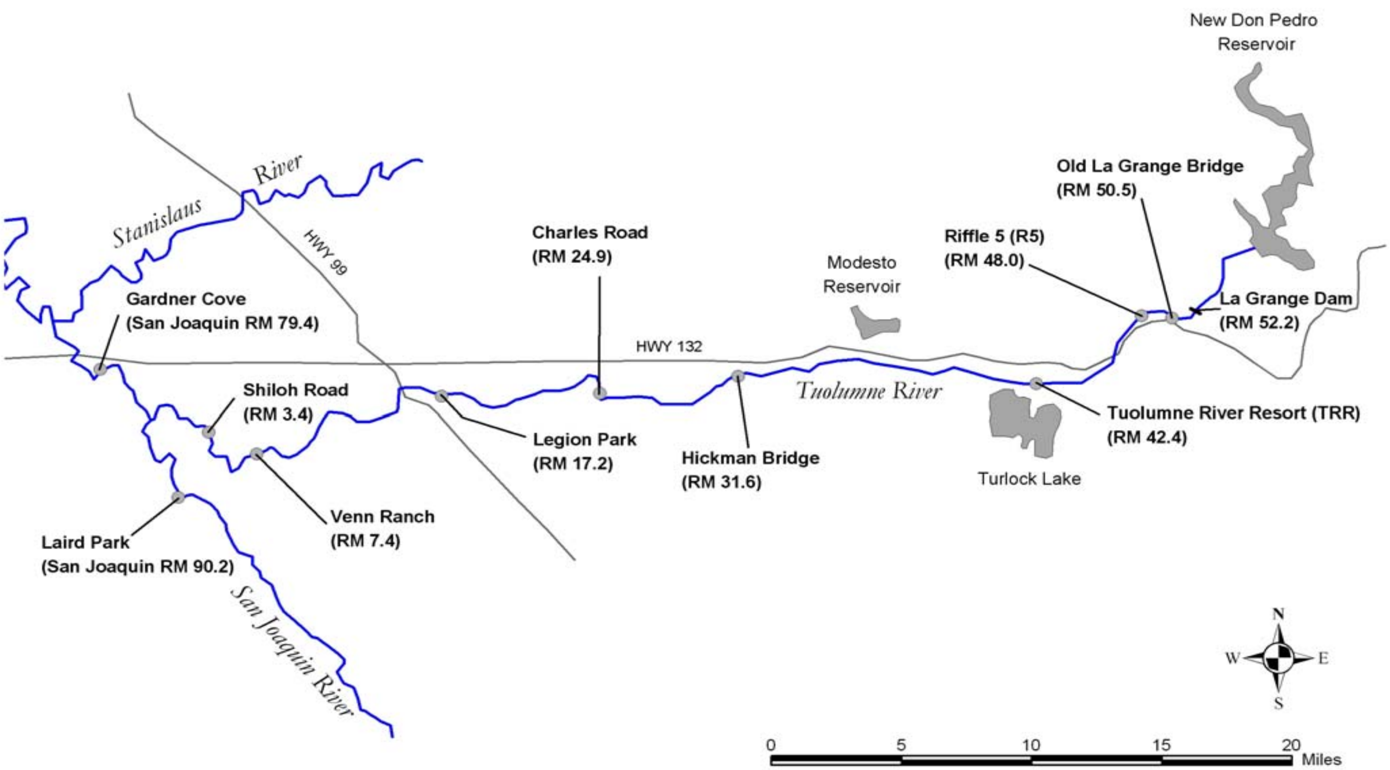

Figure 1. Locations of seine sampling sites on the lower Tuolumne and San Joaquin Rivers, 2004.

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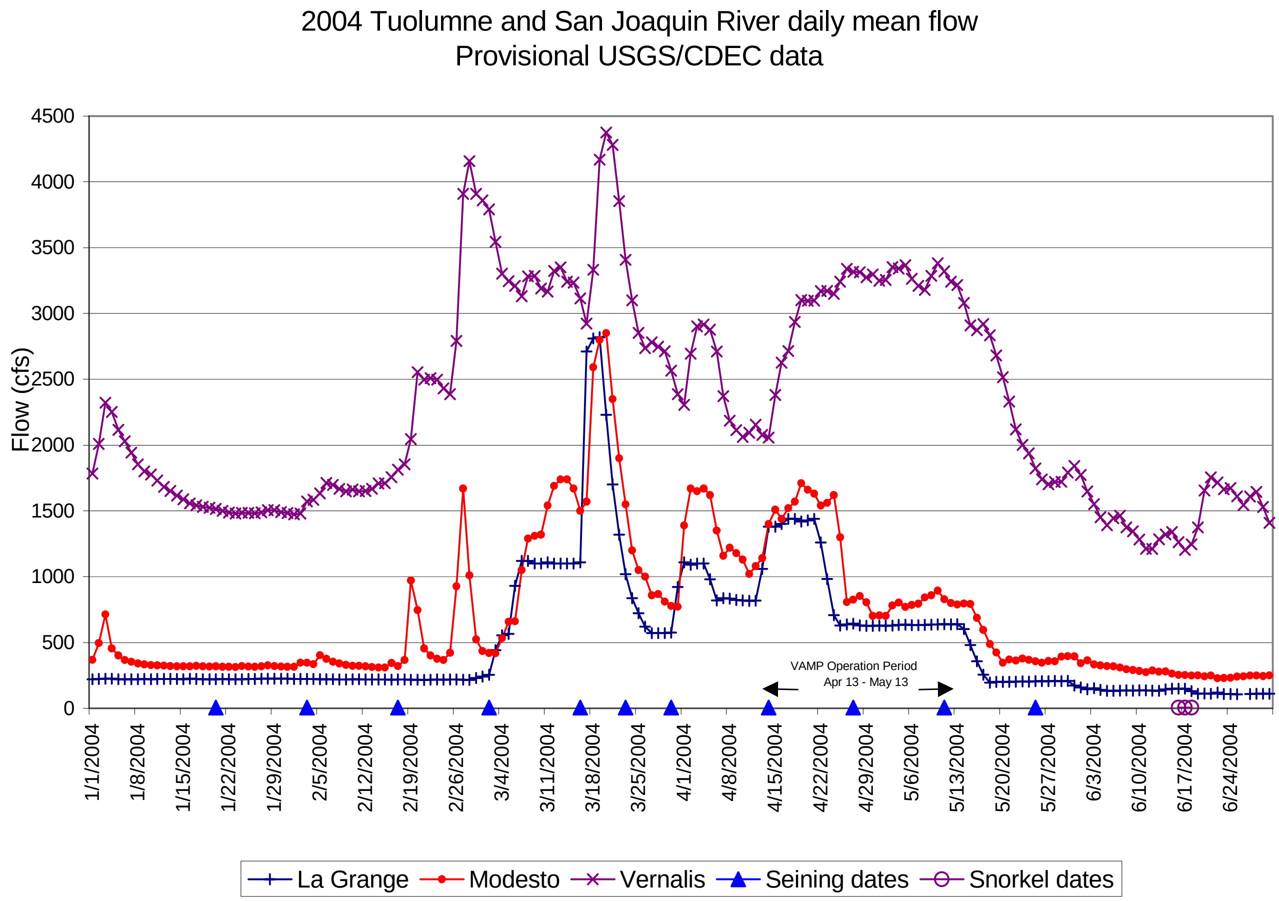


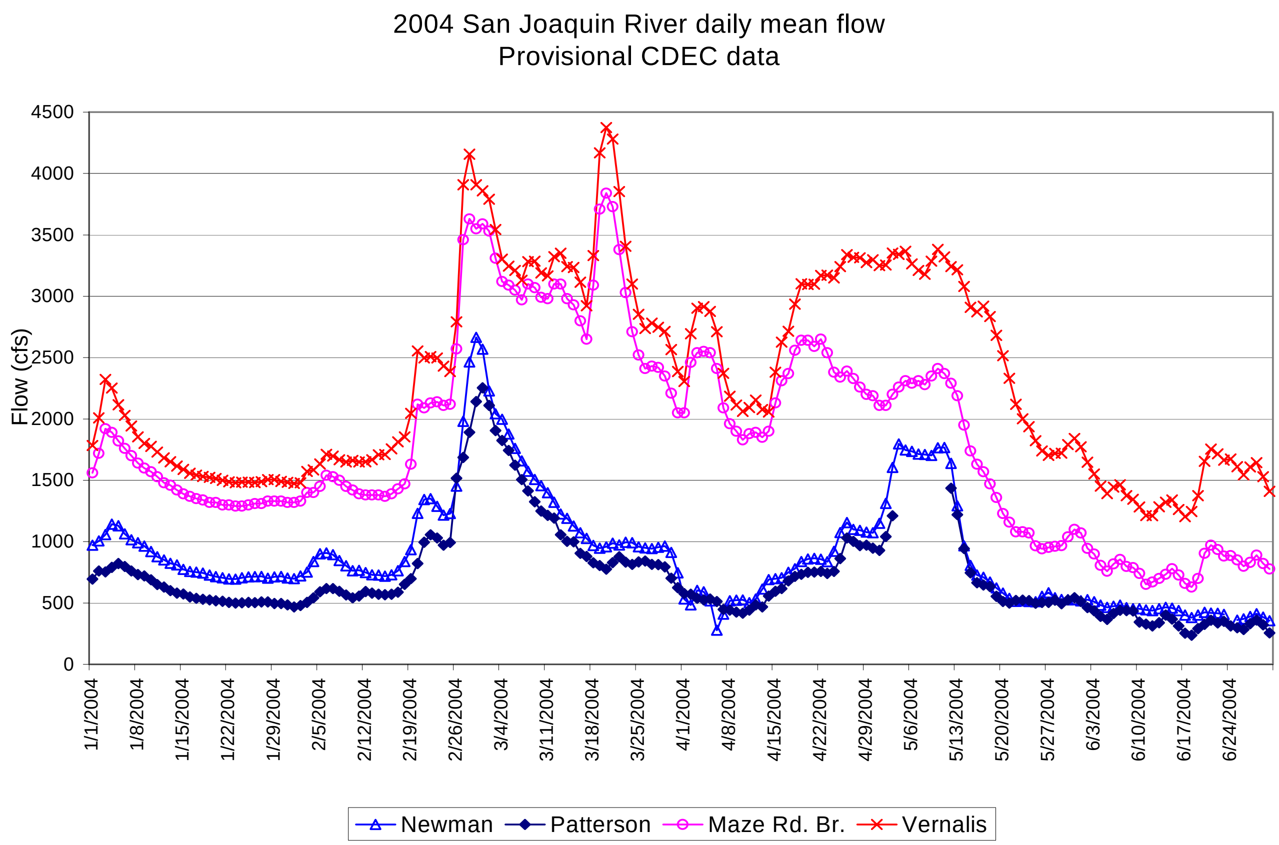


Figure 2. Tuolumne and San Joaquin River daily average flow.

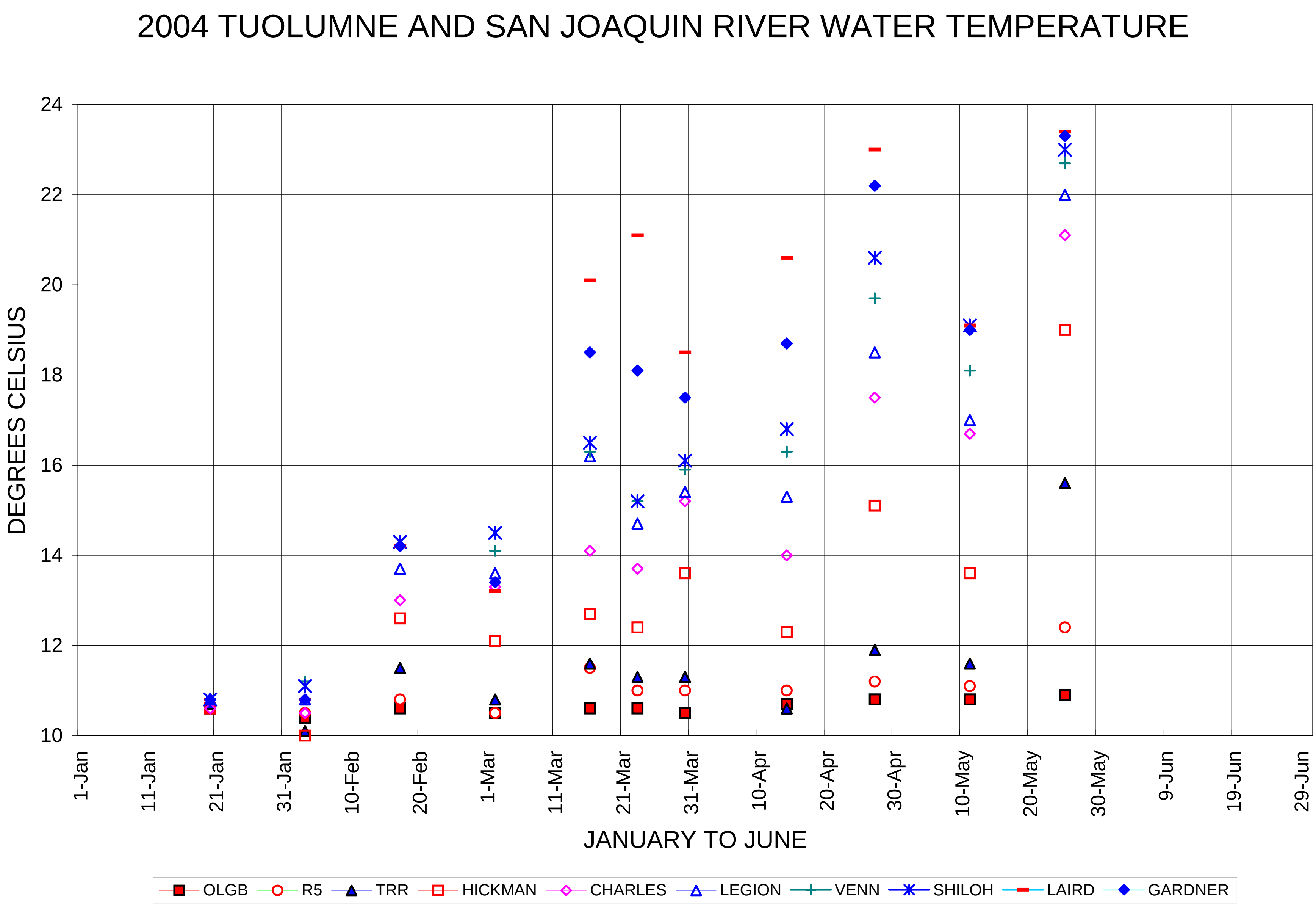
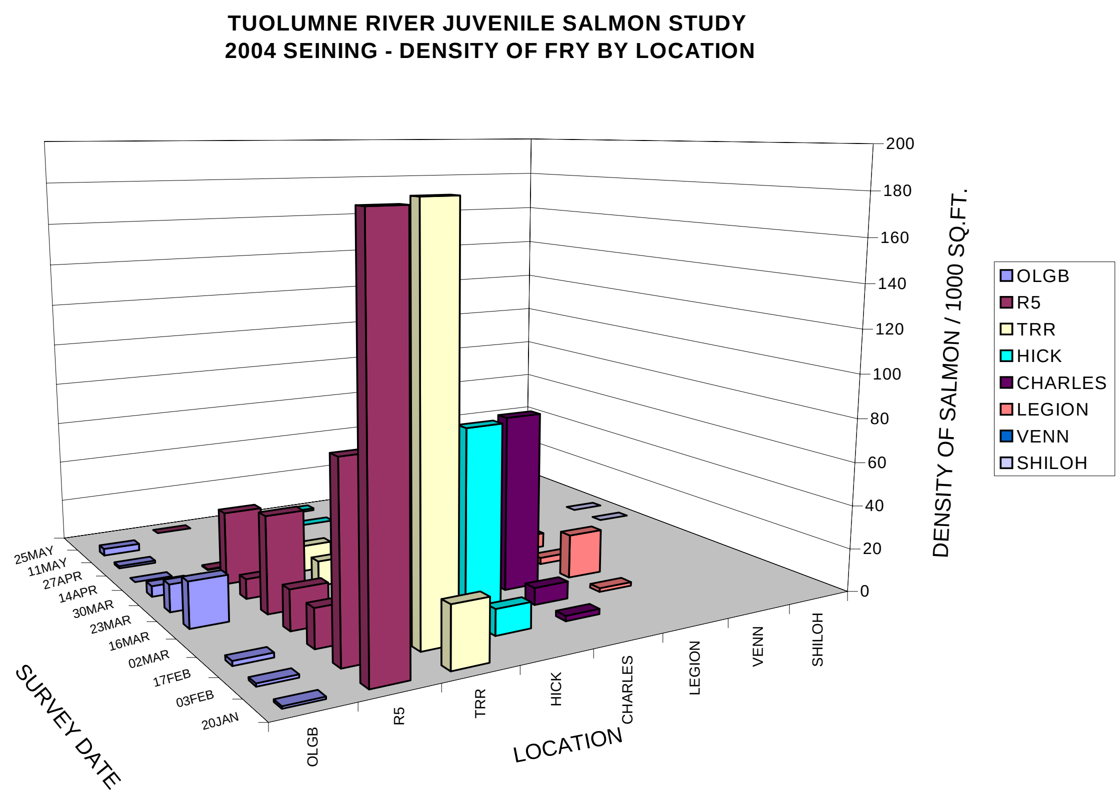


Figure 3. 2004 San Joaquin and Tuolumne River water temperature



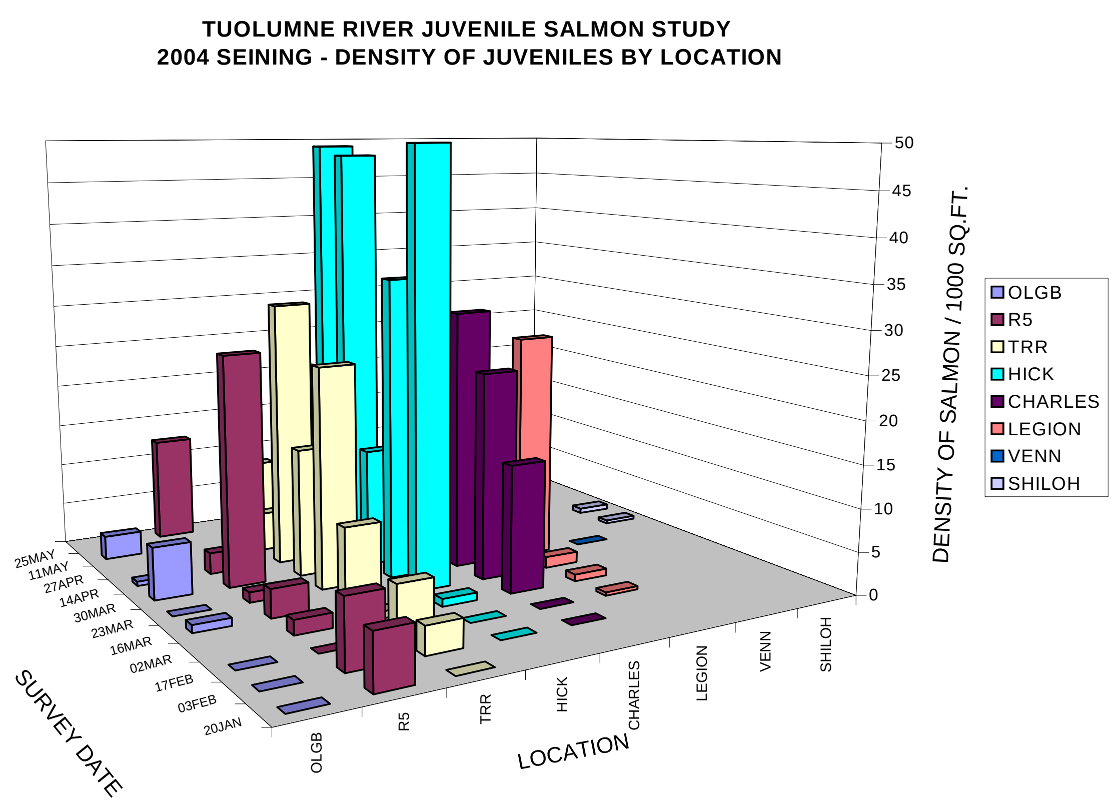


Figure 4. Tuolumne River density of fry and juvenile salmon by location.

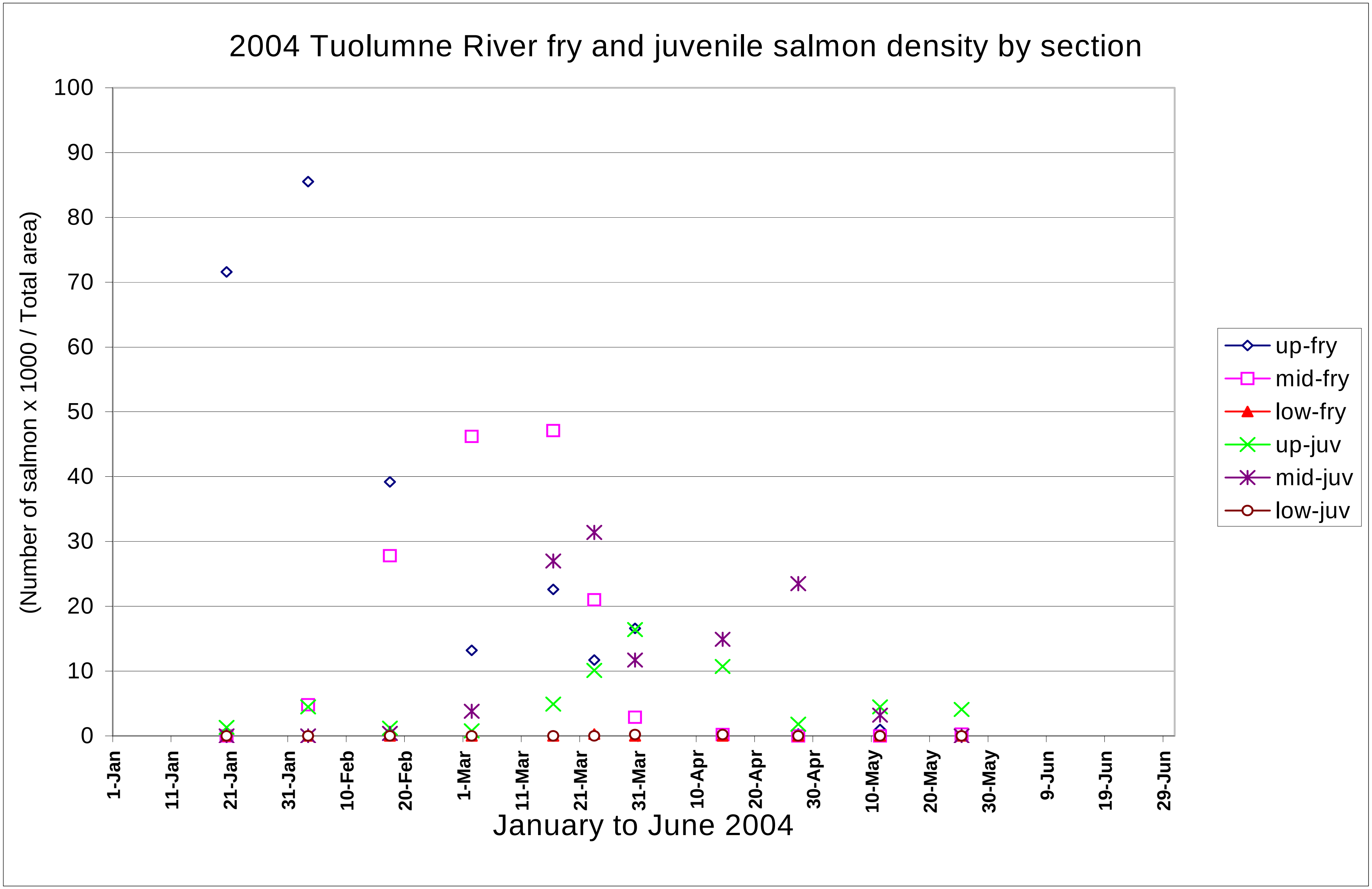


Figure 5. 2004 Tuolumne River fry and juvenile salmon density by section.

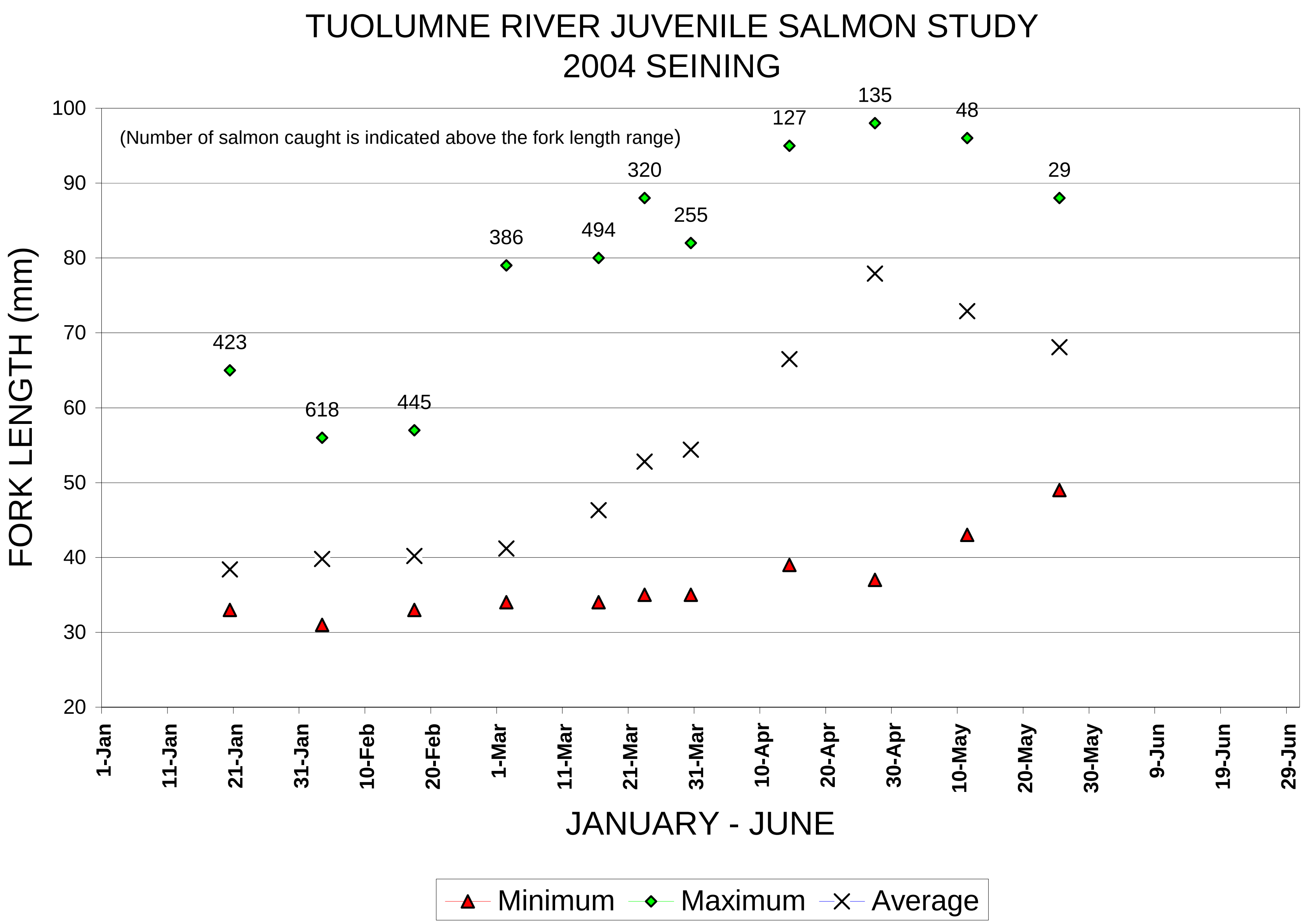
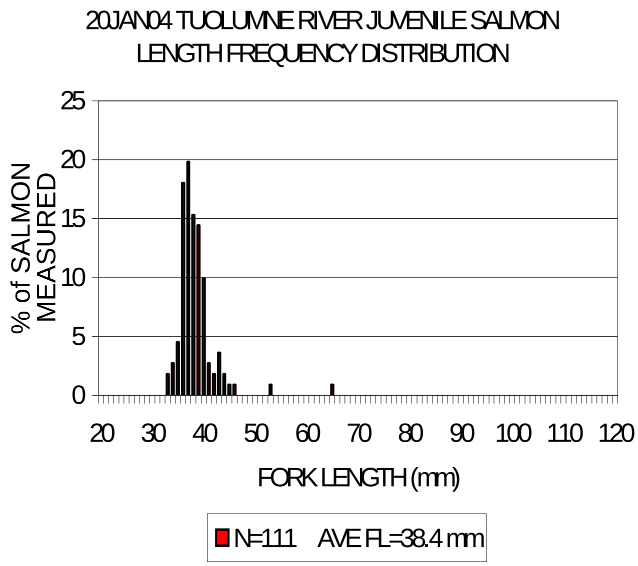
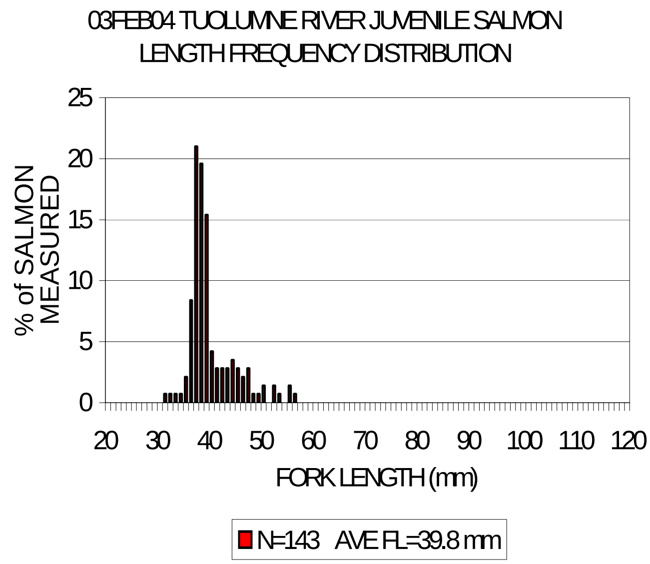
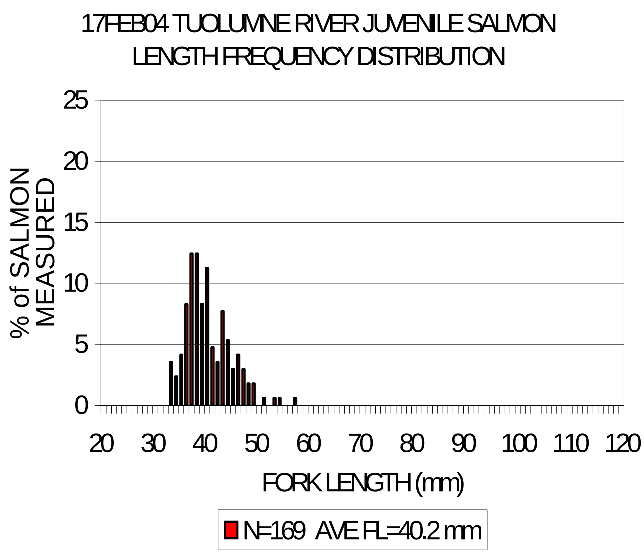
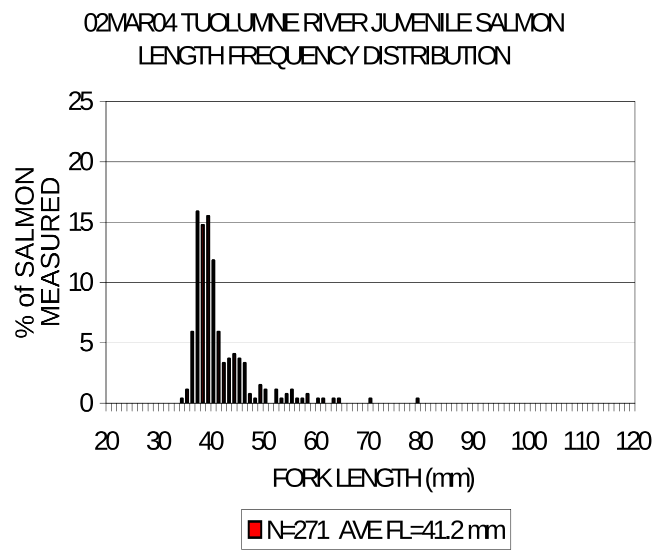


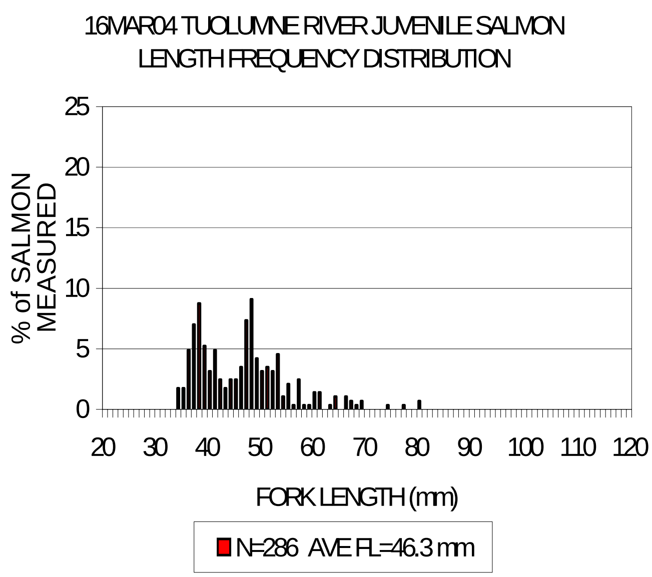
Figure 6. Fork length ranges of wild salmon in the Tuolumne River, 2004.











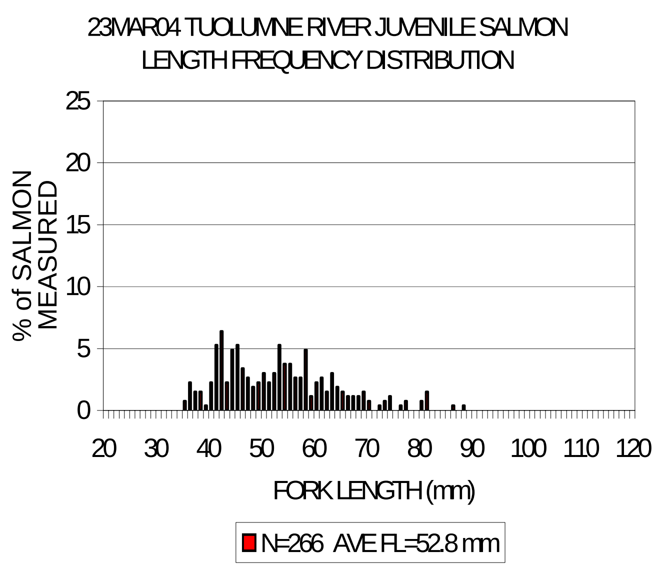


Figure 7. Length frequency distribution by date of salmon in the Tuolumne River, 2004.

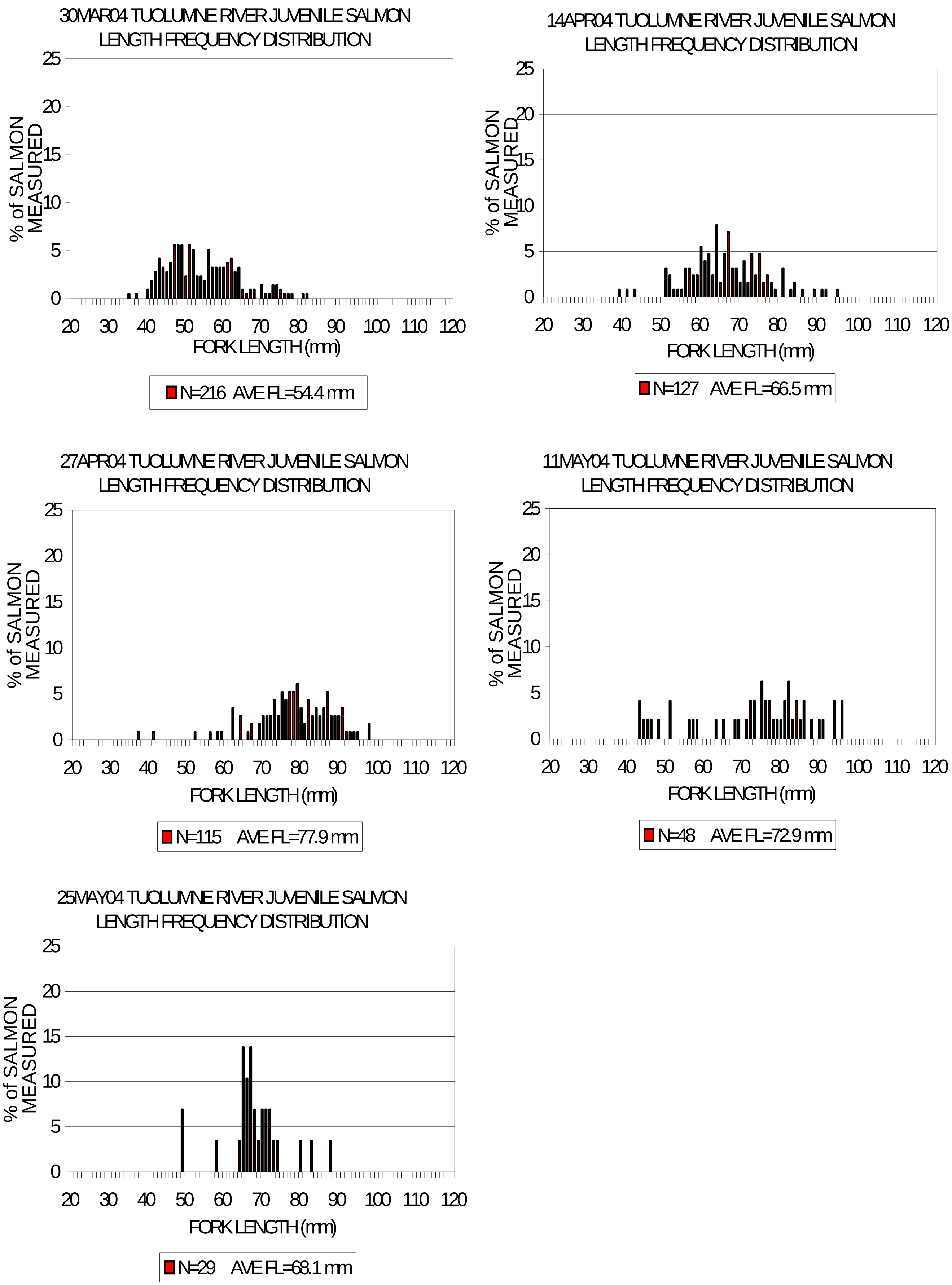
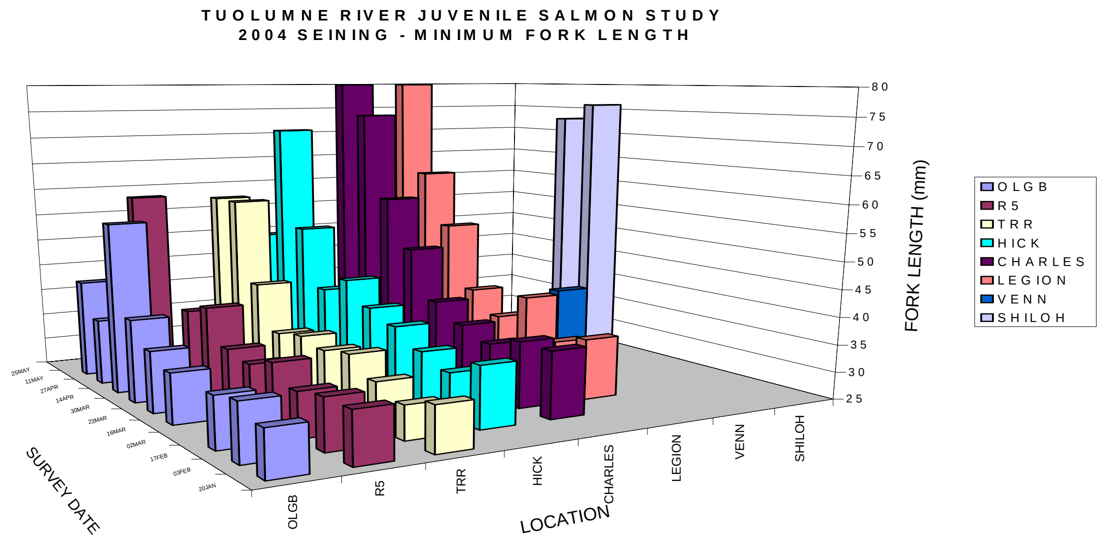
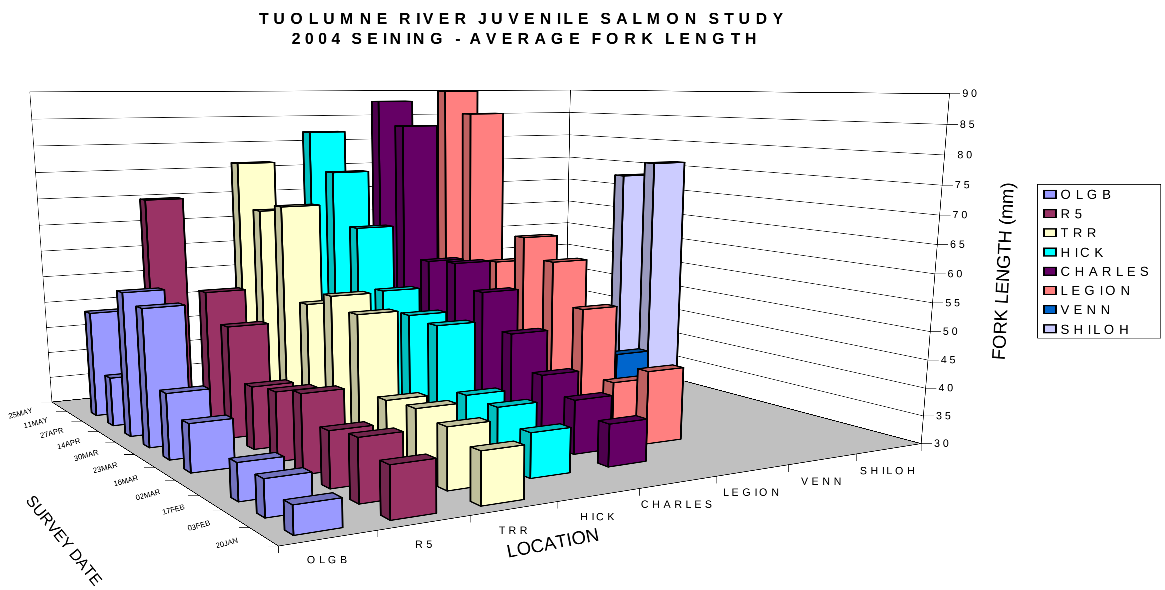


Figure 8. Length frequency distribution by date of salmon in the Tuolumne River, 2004.





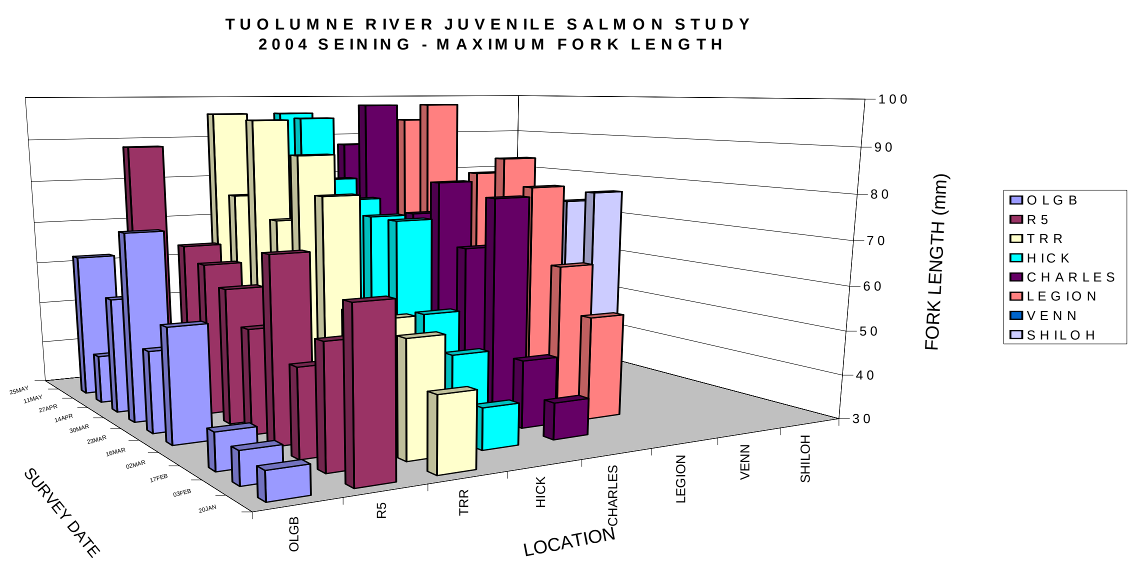
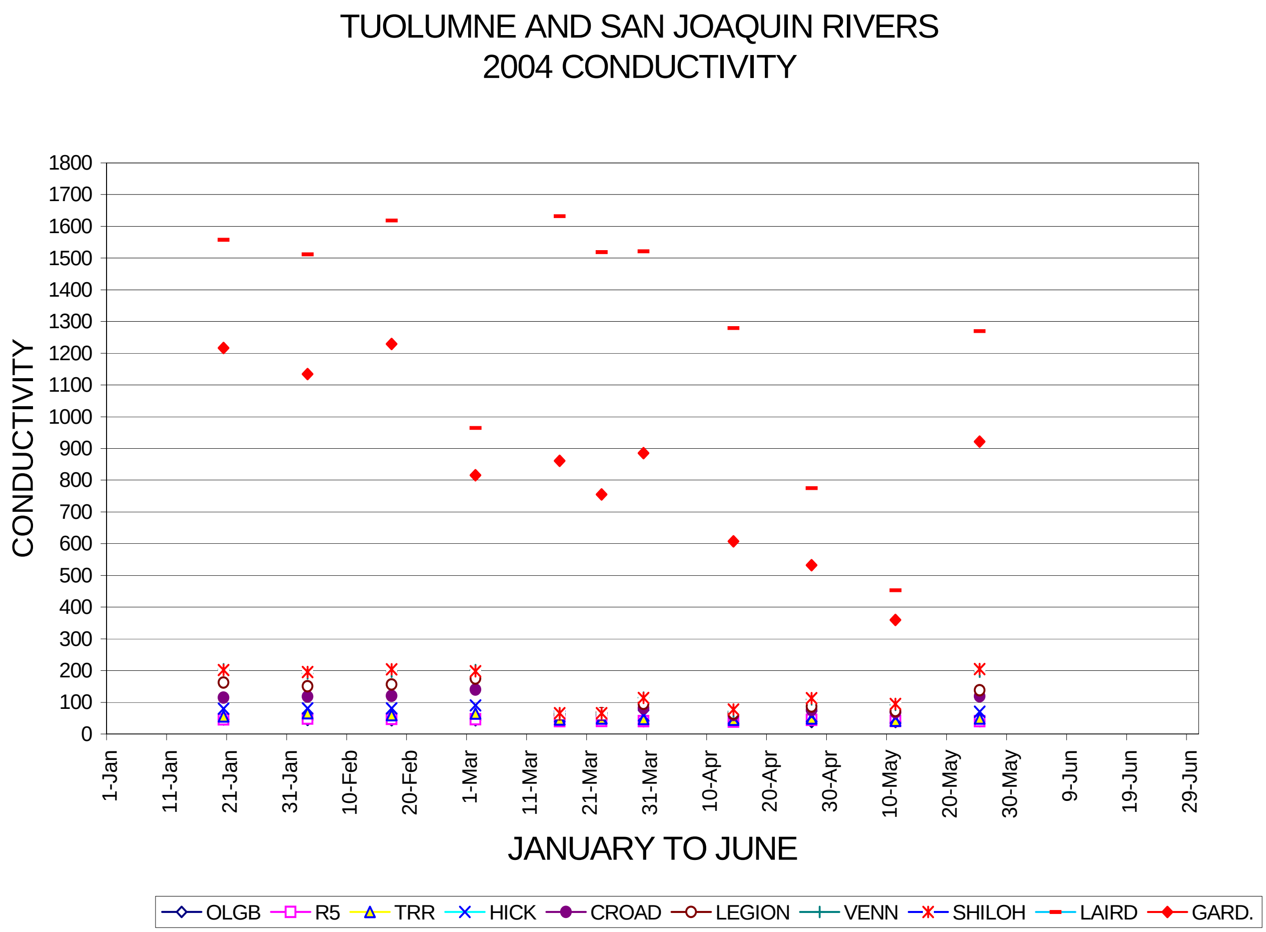


Figure 9. Minimum, average, and maximum fork length by location and survey period, 2004.



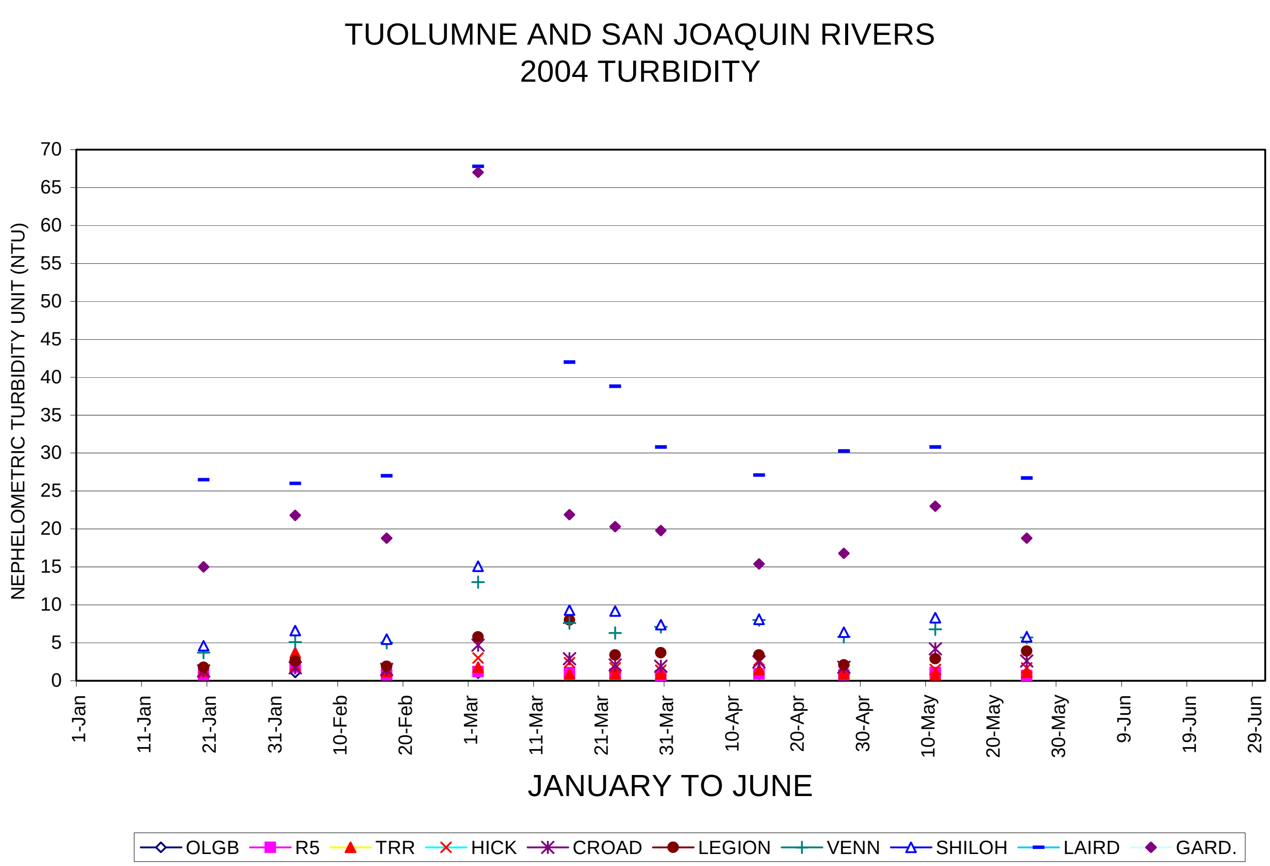
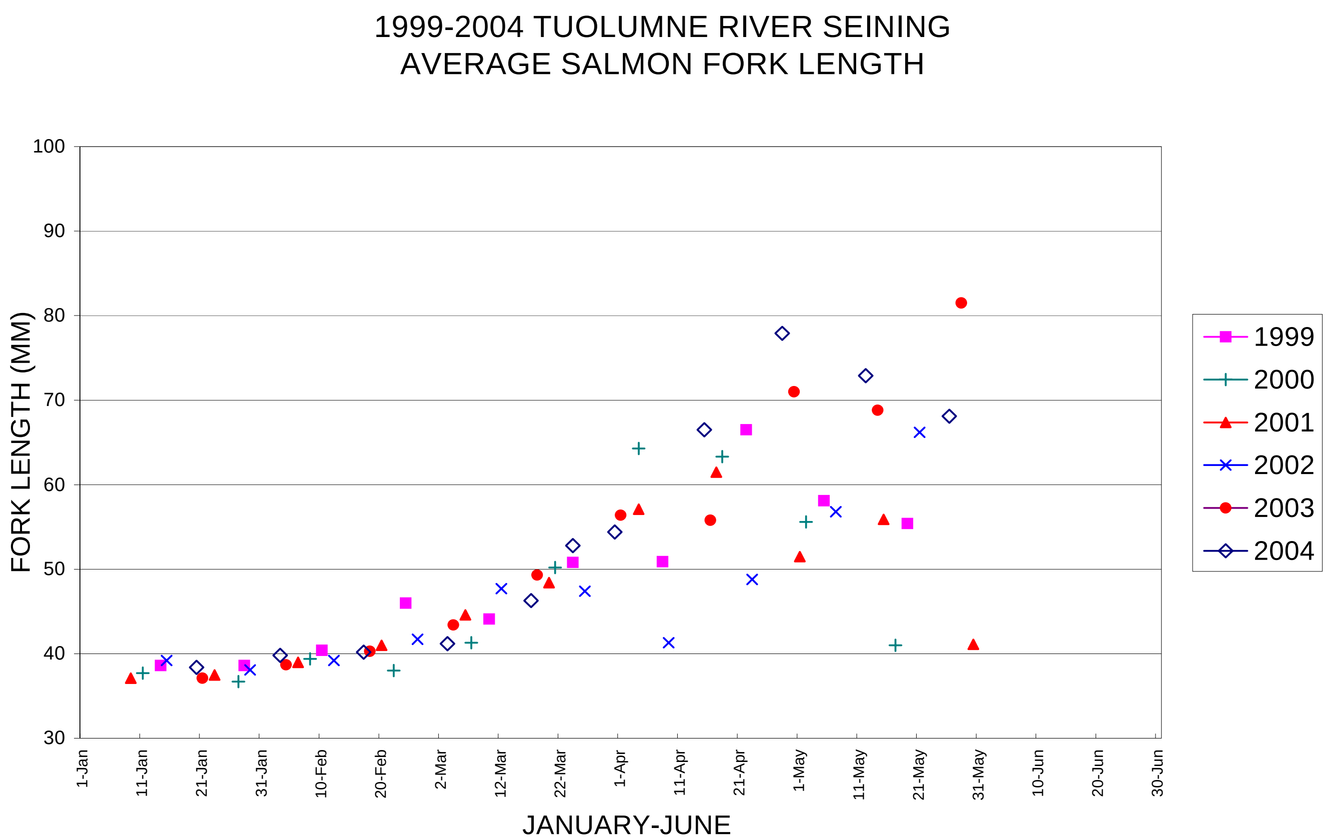
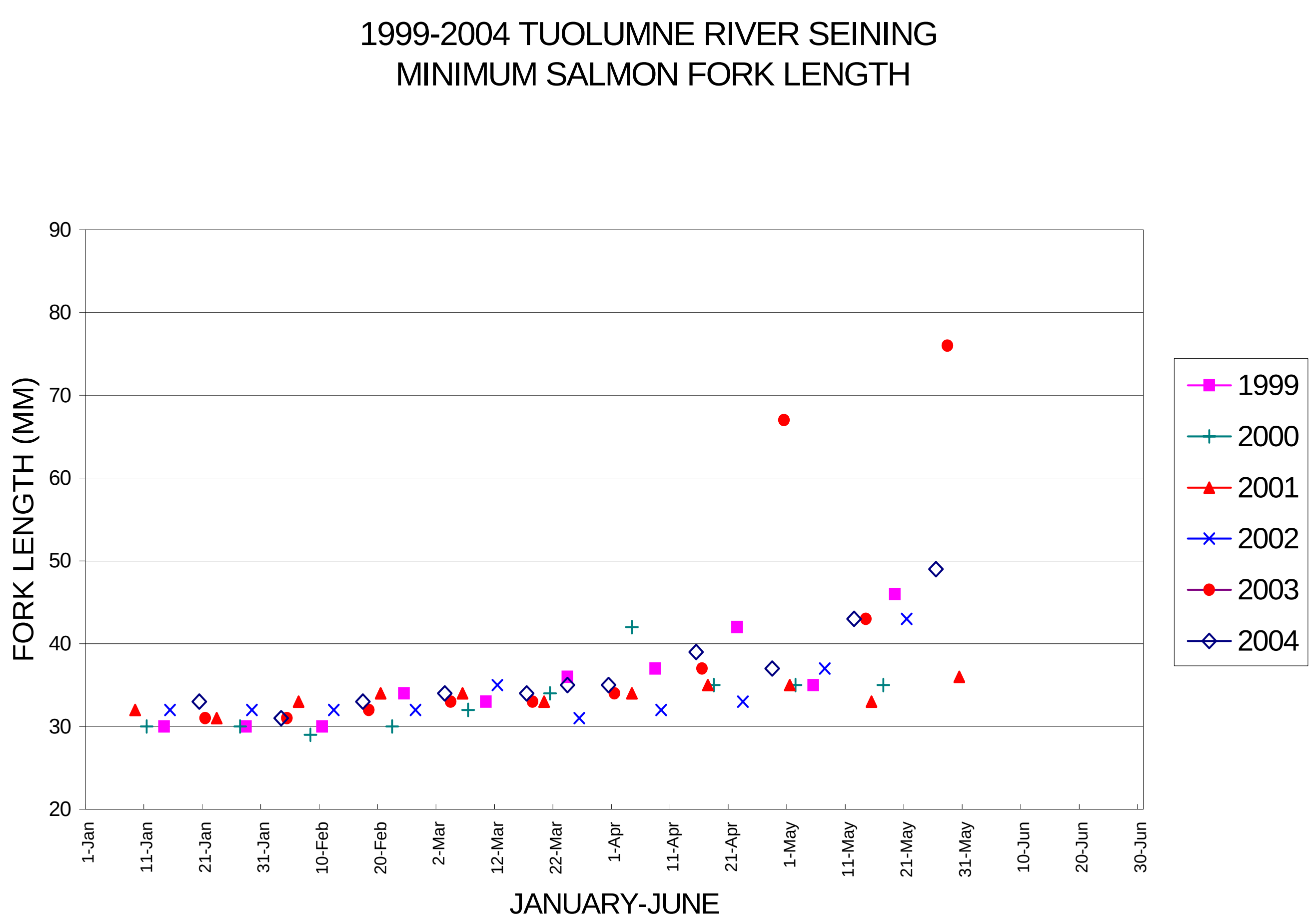
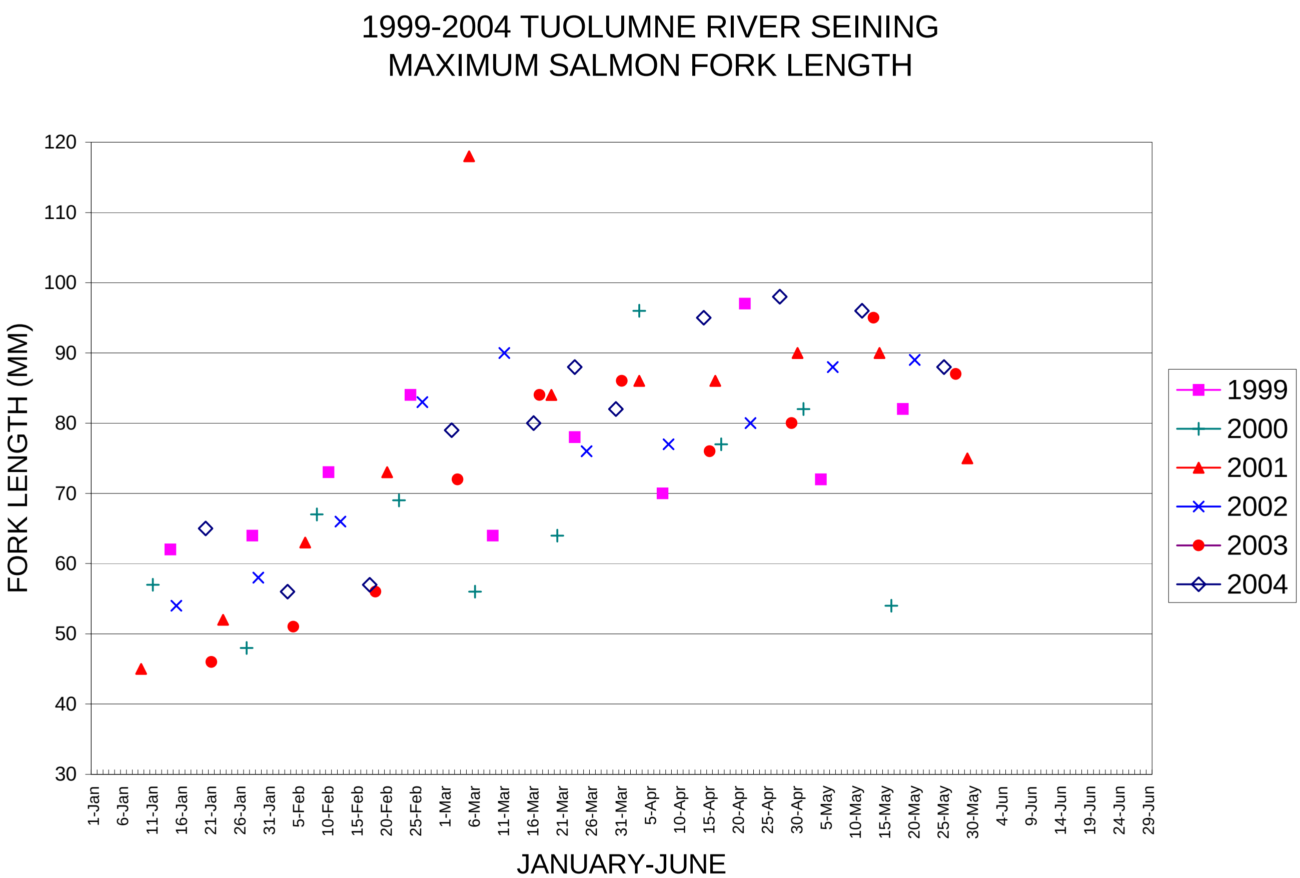


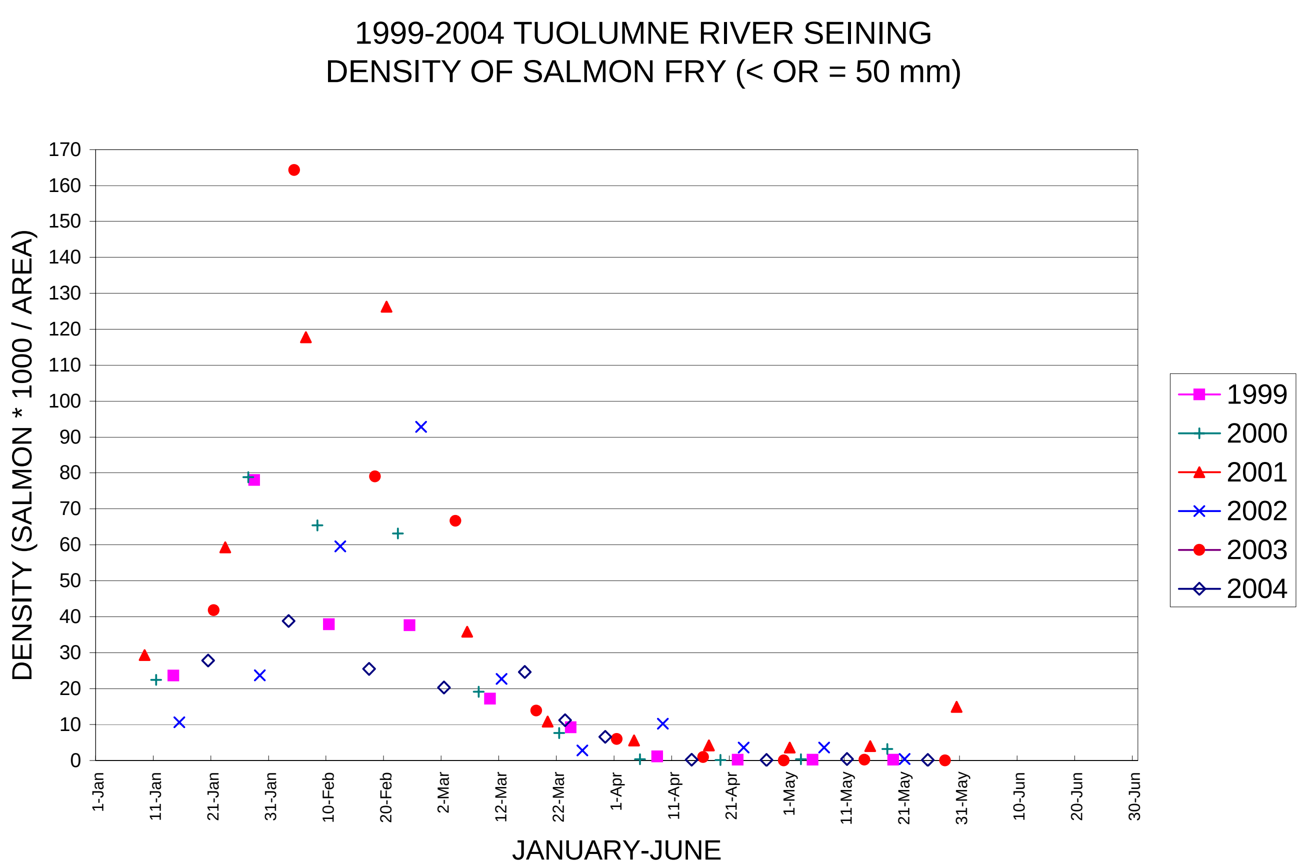
Figure 10. Conductivity and turbidity in the Tuolumne and San Joaquin Rivers, 2004.



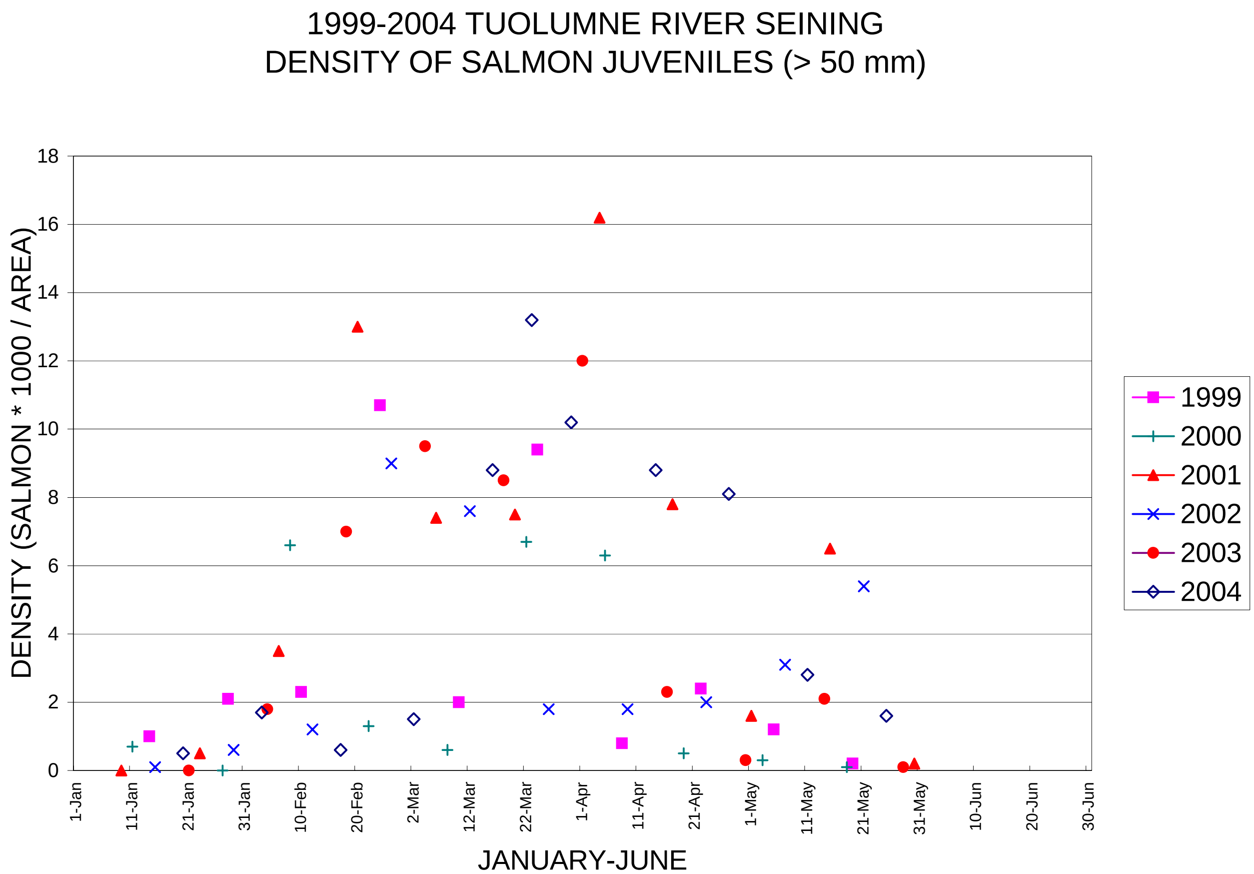


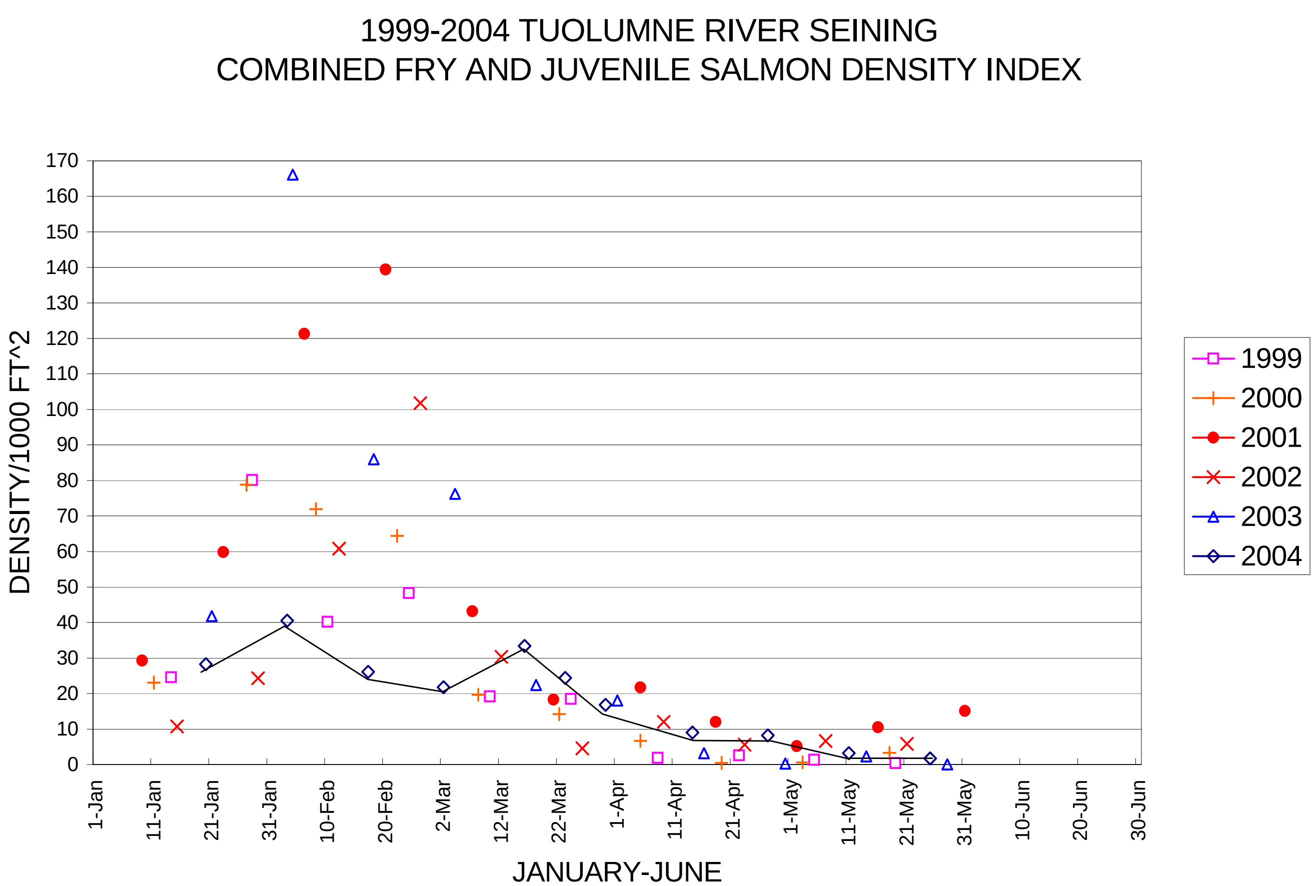
Figures 11 & 12. Average and minimum fork lengths of Tuolumne River salmon, 1999-2004.



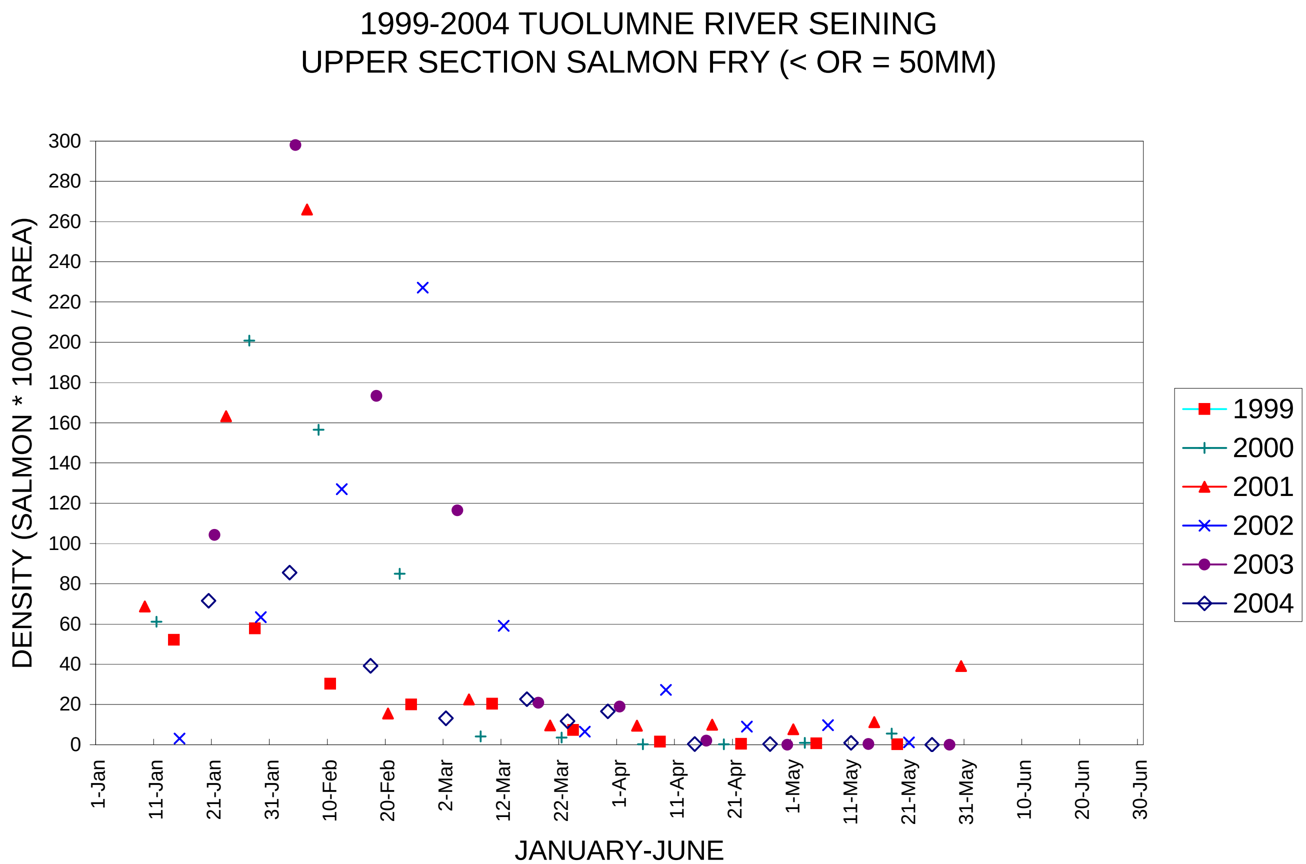


Figures 13 & 14. Maximum fork length and Density index of salmon fry, 1999-2004.





Figures 15 & 16. Density index of salmon juveniles and total river salmon catch, 1999-2004.



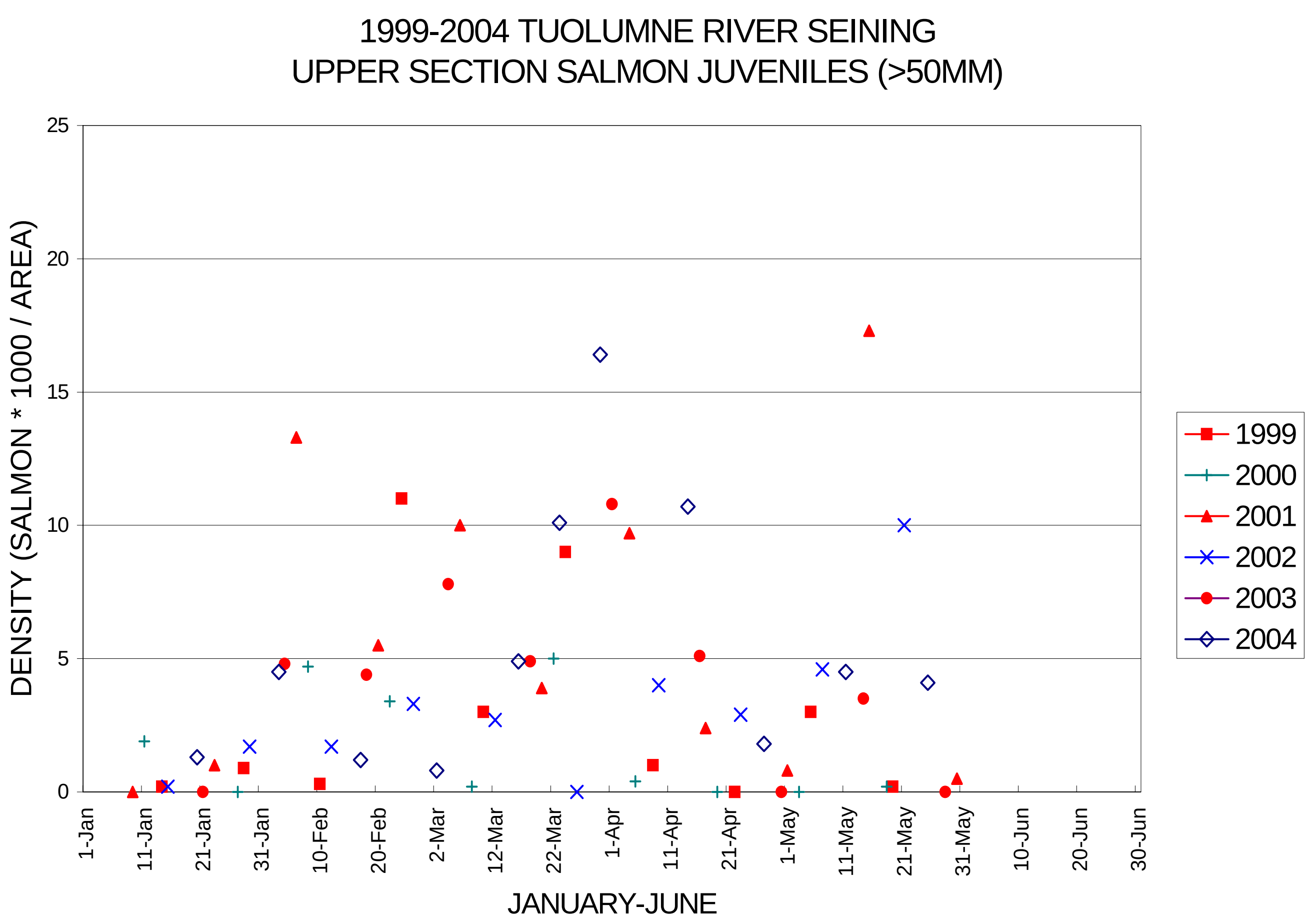
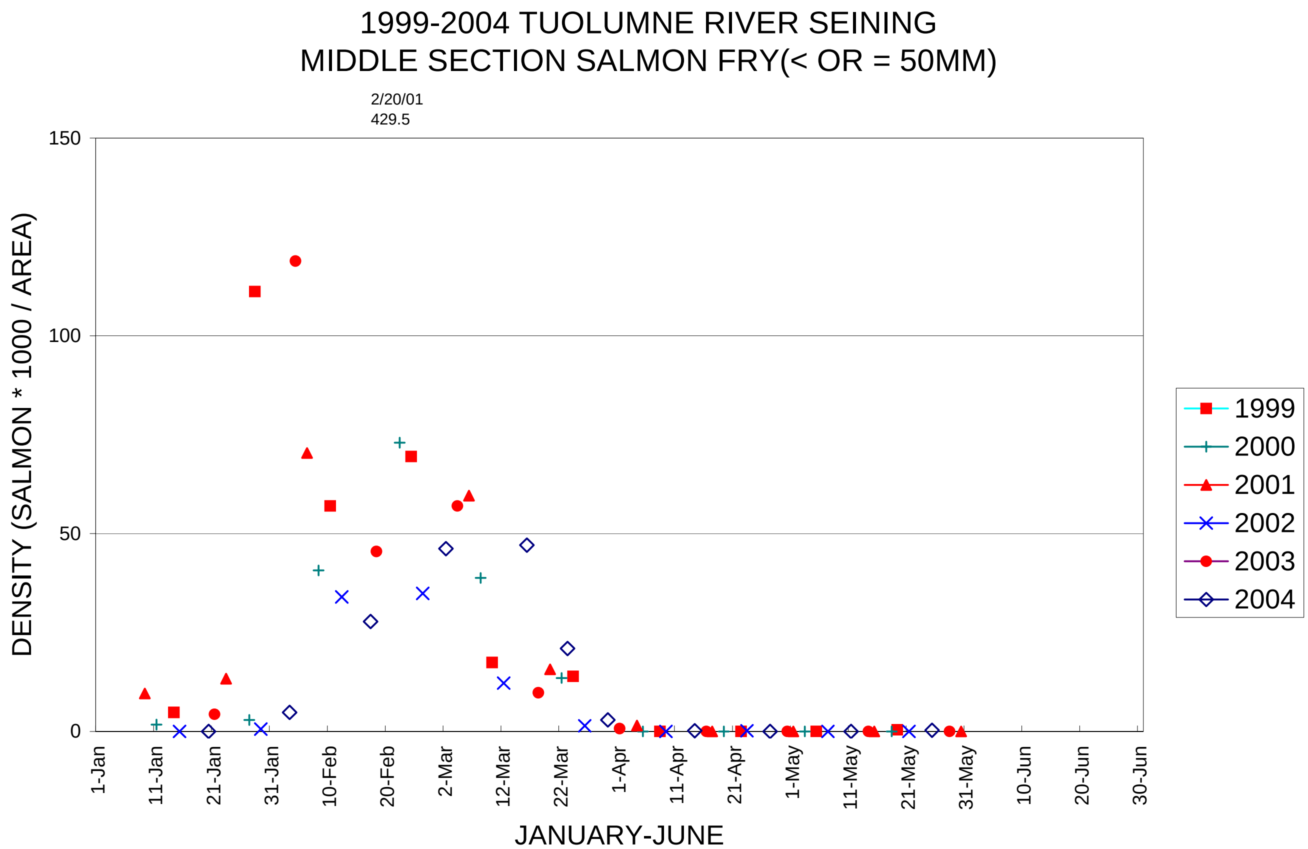


Figure 17A. Upper section density indices for salmon fry and juveniles, 1999-2004.



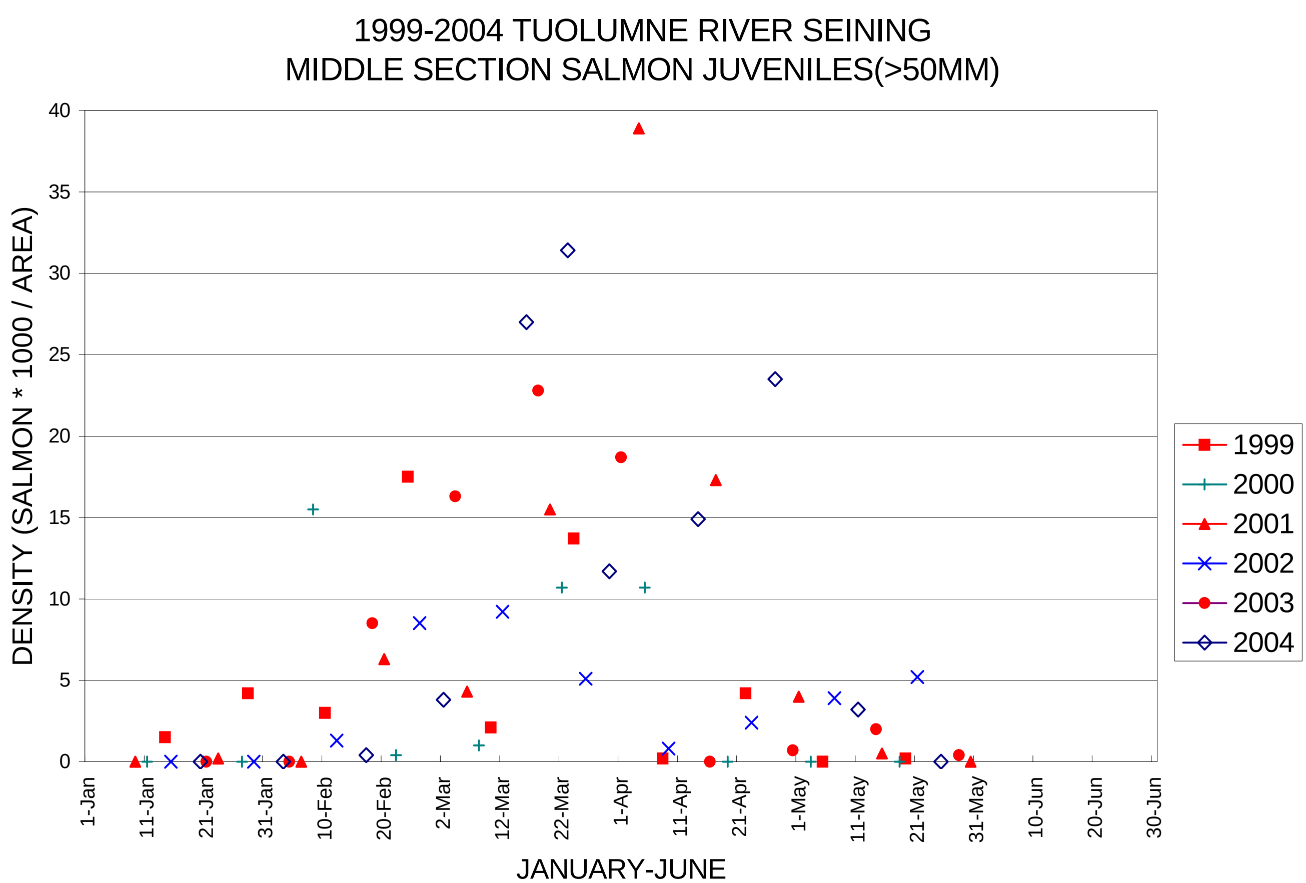
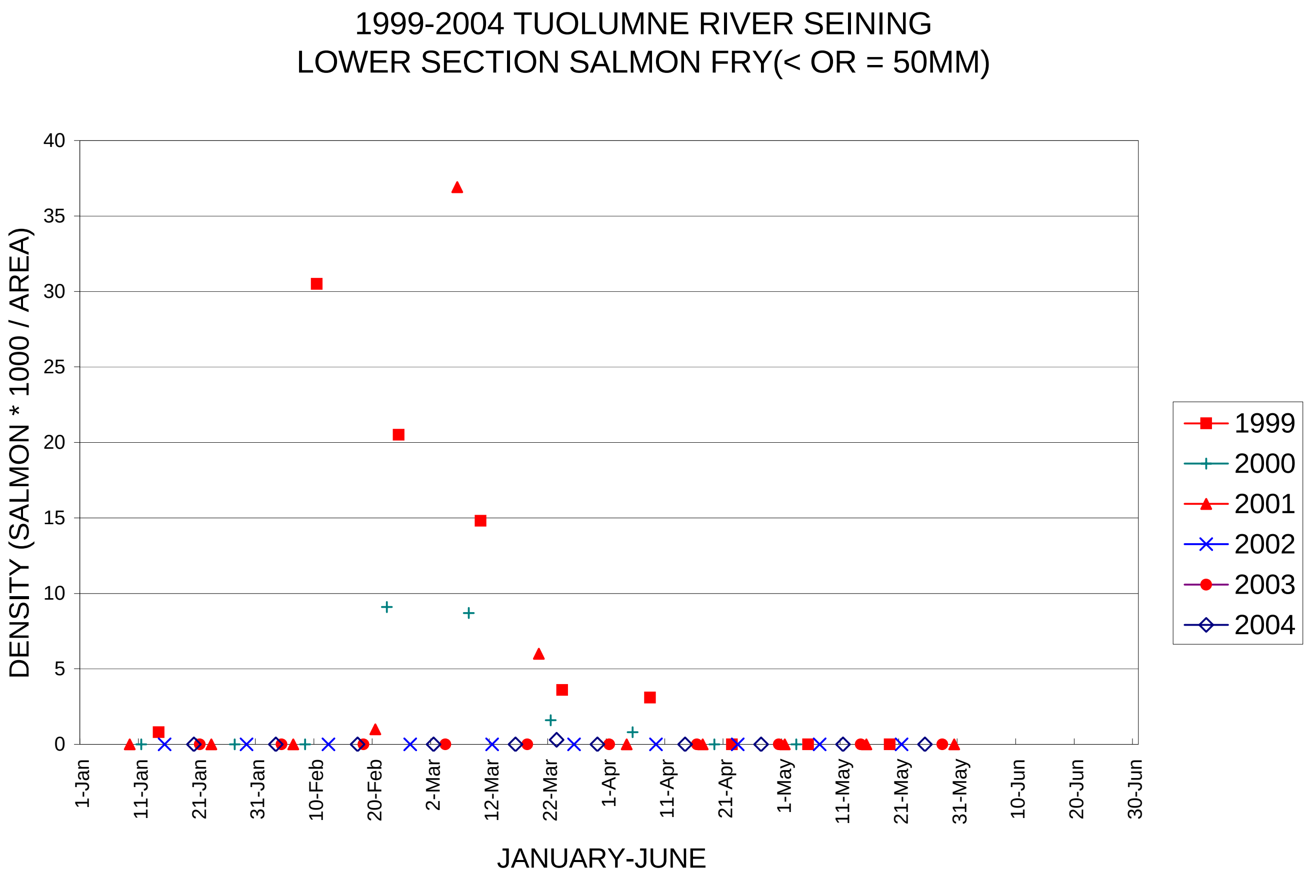


Figure 17B. Middle section density indices for salmon fry and juveniles, 1999-2004.



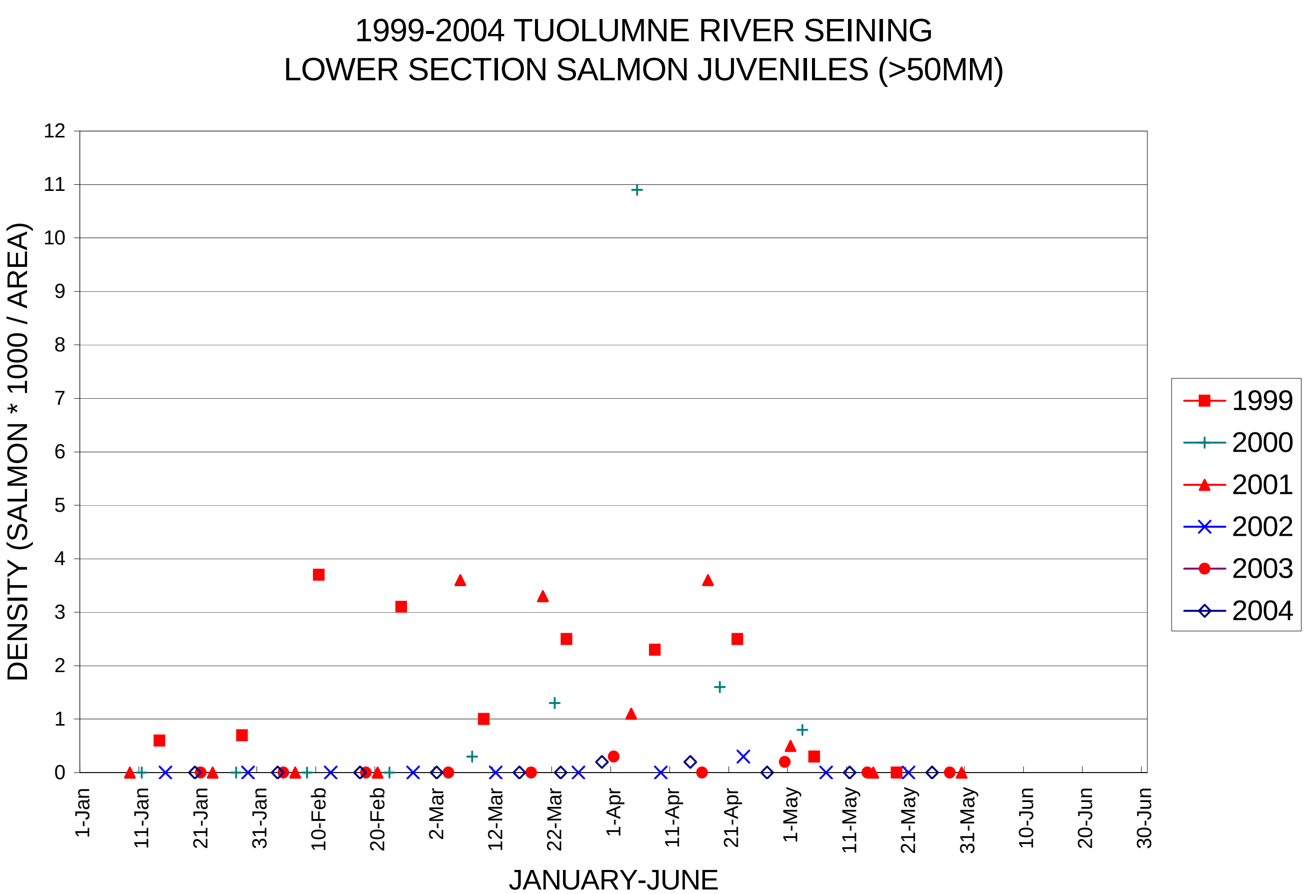


Figure 17C. Lower section density indices for salmon fry and juveniles, 1999-2004.

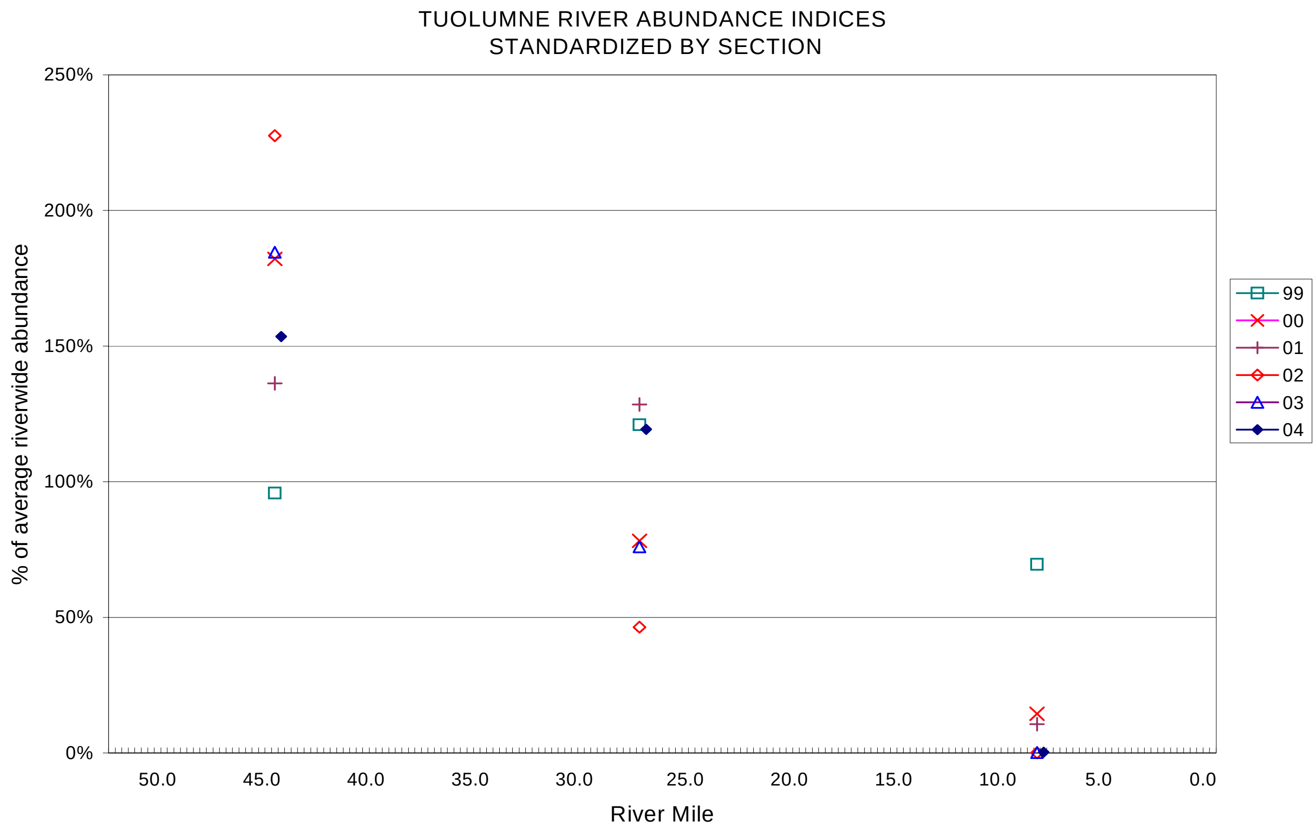


Figure 18. Tuolumne River abundance indices standardized by section, 1999-2004.

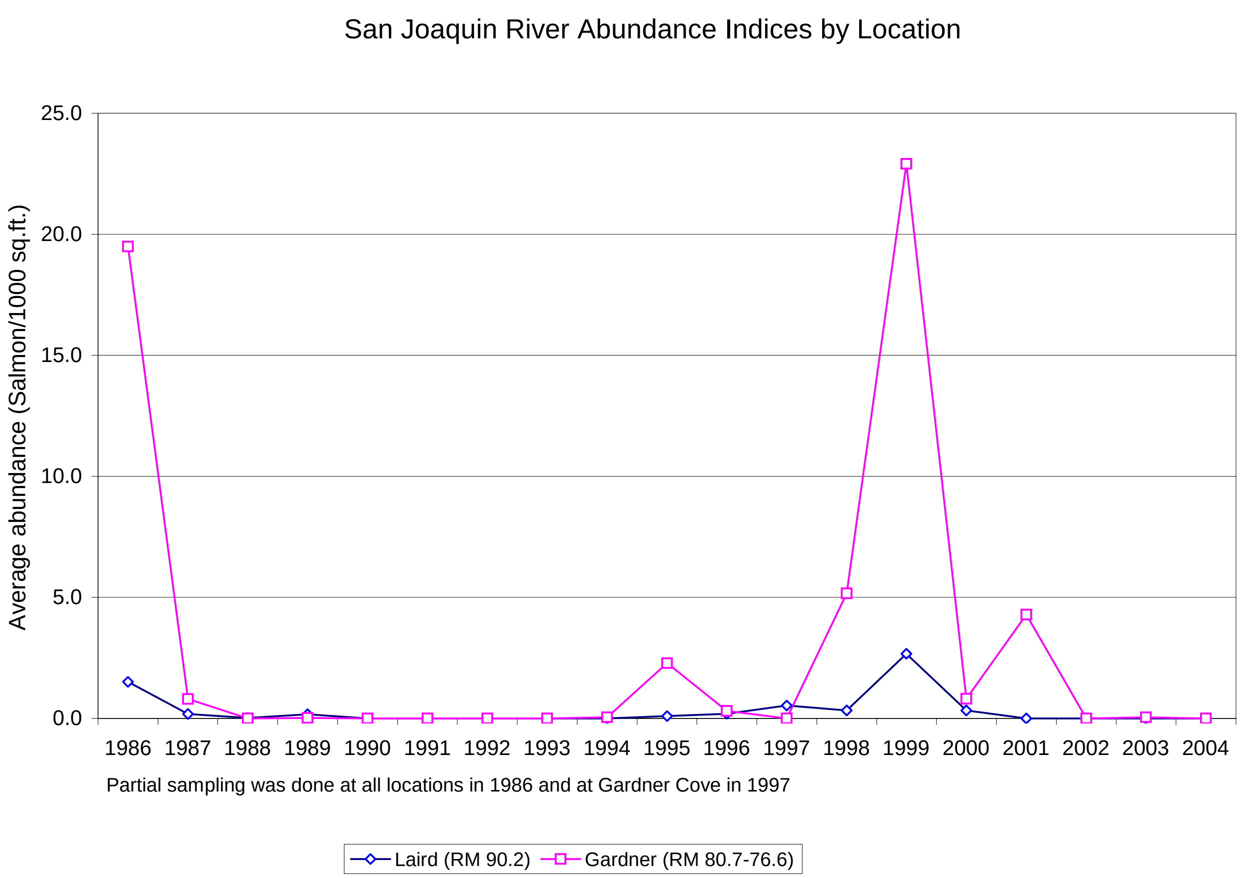


Figure 19. San Joaquin River abundance indices by location, 1986-2004.

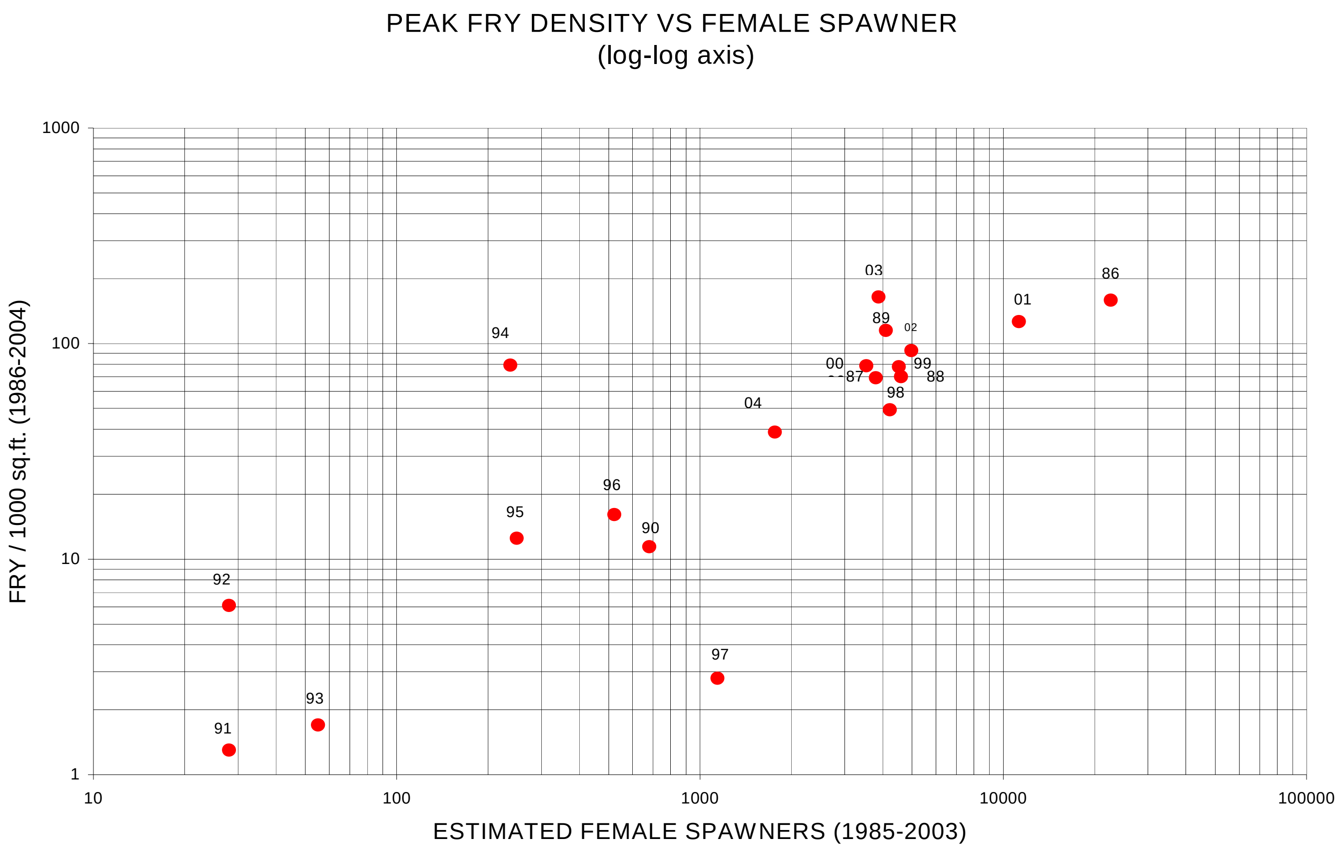


Figure 20. Tuolumne River peak fry density vs female spawners.

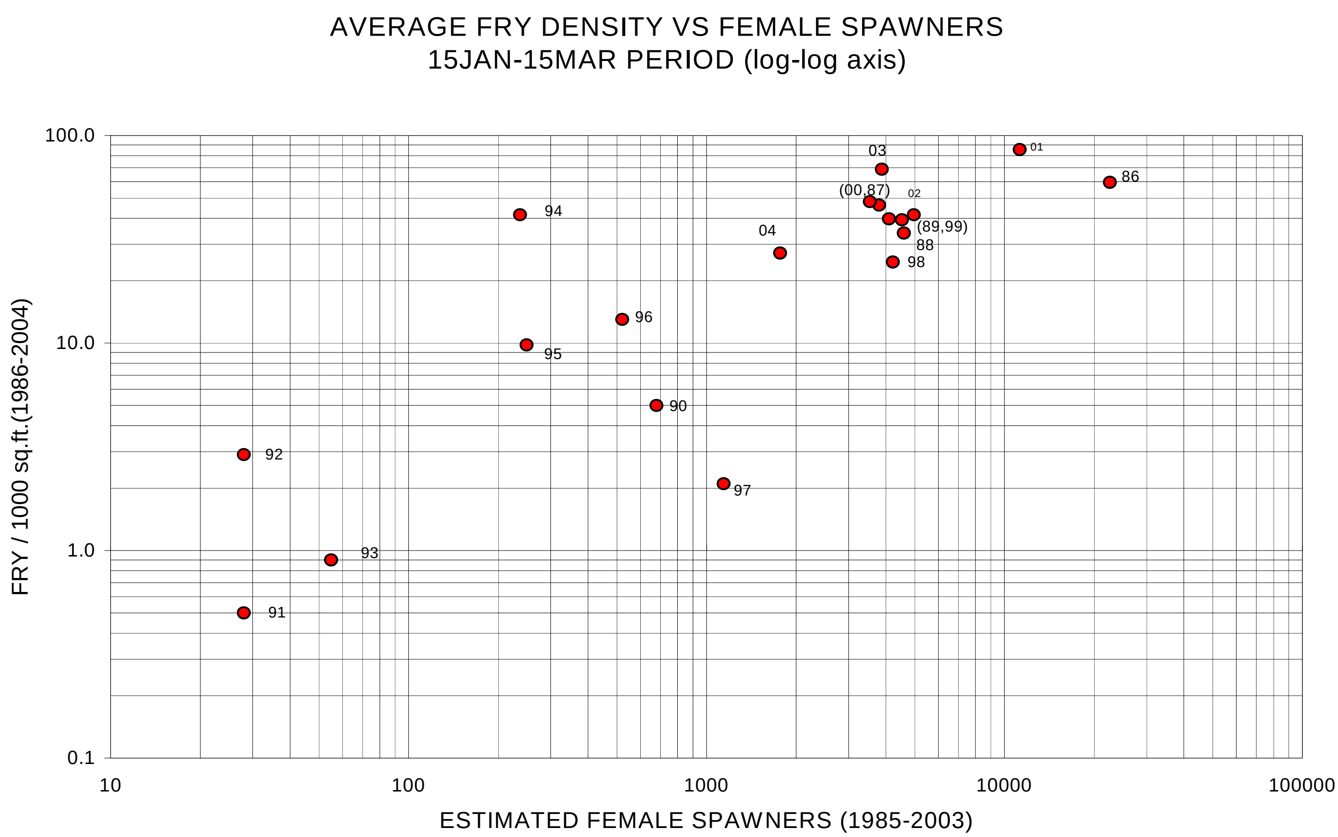


Figure 21. Tuolumne River average fry density vs female spawners.

Table 1. Summary table of weekly seine catch for the Tuolumne and San Joaquin Rivers, 2004.

2004 JUVENILE SALMON SEINING STUDY (TID/MID)

TUOLUMNE RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.	SACFRY	NUMBER KILLED
20JAN	423	14,950	28.3	33	65	38.4	111	1	1
03FEB	618	15,250	40.5	31	56	39.8	143	0	3
17FEB	445	17,050	26.1	33	57	40.2	169	1	8
02MAR	386	17,700	21.8	34	79	41.2	271	0	0
16MAR	494	14,800	33.4	34	80	46.3	286	0	0
23MAR	320	13,100	24.4	35	88	52.8	266	0	1
30MAR	255	15,200	16.8	35	82	54.4	216	0	1
14APR	127	14,100	9.0	39	95	66.5	127	0	0
27APR	135	16,400	8.2	37	98	77.9	115	0	0
11MAY	48	15,150	3.2	43	96	72.9	48	0	0
25MAY	29	16,650	1.7	49	88	68.1	29	0	0
TOTAL:	3,280	170,350	19.3				1,781	2	14

SAN JOAQUIN RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.	SACFRY	NUMBER KILLED
20JAN	0	3,450	0.0						
03FEB	0	2,550	0.0						
17FEB	0	3,600	0.0						
02MAR	0	4,050	0.0						
16MAR	0	2,850	0.0						
23MAR	0	3,000	0.0						
30MAR	0	4,000	0.0						
14APR	0	4,350	0.0						
27APR	0	3,450	0.0						
11MAY	0	2,700	0.0						
25MAY	0	3,600	0.0						
TOTAL:	0	37,600	0.0						

Table 2. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2004

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
20JAN	OLGB	2	2,000	2	0	1.0	0.0	1.0	34.5	71.6	0.0	0.0	1.3	0.0	0.0
20JAN	R5	372	2,000	58	2	179.8	6.2	186.0	38.4						
20JAN	TLSRA	49	1,800	49	0	27.2	0.0	27.2	38.6						
20JAN	HICKMAN	0	1,350					0.0							
20JAN	CHARLES	0	1,000					0.0							
20JAN	LEGION	0	2,600					0.0							
20JAN	VENN	0	1,800					0.0							
20JAN	SHILOH	0	2,400					0.0							
20JAN	LAIRD	0	1,050					0.0							
20JAN	GARDNER	0	2,400					0.0							
TUOL.TOT.		423	14950	109	2	27.8	0.5	28.3	38.4						
SJR. TOT.		0	3450					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
03FEB	OLGB	3	2400	3	0	1.3	0.0	1.3	36.0	85.5	4.8	0.0	4.5	0.0	0.0
03FEB	R5	185	2000	54	5	84.7	7.8	92.5	40.4						
03FEB	TRR	406	2200	56	1	181.3	3.2	184.5	40.3						
03FEB	HICKMAN	21	1800	21	0	11.7	0.0	11.7	37.6						
03FEB	CHARLES	3	1250	3	0	2.4	0.0	2.4	37.3						
03FEB	LEGION	0	2000					0.0							
03FEB	VENN	0	1800					0.0							
03FEB	SHILOH	0	1800					0.0							
03FEB	LAIRD	0	900					0.0							
03FEB	GARDNER	0	1650					0.0							
TUOL.TOT.		618	15250	137	6	38.8	1.7	40.5	39.8						
SJR. TOT.		0	2550					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
17FEB	OLGB	5	2400	5	0	2.1	0.0	2.1	36.2	39.2	27.8	0.0	1.2	0.4	0.0
17FEB	R5	42	2400	42	0	17.5	0.0	17.5	39.4						
17FEB	TRR	244	2400	50	3	95.9	5.8	101.7	41.3						
17FEB	HICKMAN	138	1650	53	0	83.6	0.0	83.6	39.9						
17FEB	CHARLES	11	1400	11	0	7.9	0.0	7.9	39.5						
17FEB	LEGION	5	2400	4	1	1.7	0.4	2.1	43.0						
17FEB	VENN	0	2200					0.0							
17FEB	SHILOH	0	2200					0.0							
17FEB	LAIRD	0	1200					0.0							
17FEB	GARDNER	0	2400					0.0							
TUOL.TOT.		445	17050	165	4	25.5	0.6	26.1	40.2						
SJR. TOT.		0	3600					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
02MAR	OLGB	0	2400					0.0		13.2	46.2	0.0	0.8	3.8	0.0
02MAR	R5	48	2400	44	4	18.3	1.7	20.0	43.5						
02MAR	TRR	53	2400	51	2	21.3	0.8	22.1	40.8						
02MAR	HICKMAN	92	1800	54	1	50.2	0.9	51.1	40.1						
02MAR	CHARLES	142	1500	54	10	79.9	14.8	94.7	42.1						
02MAR	LEGION	51	2400	49	2	20.4	0.8	21.3	39.3						
02MAR	VENN	0	2400					0.0							
02MAR	SHILOH	0	2400					0.0							
02MAR	LAIRD	0	1650					0.0							
02MAR	GARDNER	0	2400					0.0							
TUOL.TOT.		386	17700	252	19	20.3	1.5	21.8	41.2						
SJR. TOT.		0	4050					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
16MAR	OLGB	48	2200	46	2	20.9	0.9	21.8	38.3	22.6	47.1	0.0	4.9	27.0	0.0
16MAR	R5	97	2050	66	5	44.0	3.3	47.3	42.0						
16MAR	TRR	38	2400	17	21	7.1	8.8	15.8	53.8						
16MAR	HICKMAN	207	1500	32	28	73.6	64.4	138.0	50.7						
16MAR	CHARLES	97	1100	45	17	64.0	24.2	88.2	48.0						
16MAR	LEGION	7	1600	5	2	3.1	1.3	4.4	51.3						
16MAR	VENN	0	2000					0.0							
16MAR	SHILOH	0	1950					0.0							
16MAR	LAIRD	0	1050					0.0							
16MAR	GARDNER	0	1800					0.0							
TUOL.TOT.		494	14800	211	75	24.6	8.8	33.4	46.3						
SJR. TOT.		0	2850					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
23MAR	OLGB	21	1650	21	0	12.7	0.0	12.7	41.5	11.7	21.0	0.3	10.1	31.4	0.0
23MAR	R5	17	1650	15	2	9.1	1.2	10.3	41.1						
23MAR	TRR	82	2200	22	48	11.7	25.6	37.3	55.7						
23MAR	HICK	81	1200	30	32	32.7	34.8	67.5	51.2						
23MAR	CHARLES	78	1400	25	30	25.3	30.4	55.7	54.3						
23MAR	LEGION	40	1200	8	32	6.7	26.7	33.3	59.0						
23MAR	VENN	1	1800	1	0	0.6	0.0	0.6	40.0						
23MAR	SHILOH	0	2000					0.0							
23MAR	LAIRD	0	1200					0.0							
23MAR	GARDNER	0	1800					0.0							
TUOL.TOT.		320	13100	122	144	11.2	13.2	24.4	52.8						
SJR. TOT.		0	3000					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
30MAR	OLGB	20	1800	9	11	5.0	6.1	11.1	54.5	16.6	2.9	0.0	16.4	11.7	0.2
30MAR	R5	109	1800	39	31	33.7	26.8	60.6	50.1						
30MAR	TRR	49	1800	22	27	12.2	15.0	27.2	53.0						
30MAR	HICKMAN	32	1600	10	22	6.3	13.8	20.0	54.4						
30MAR	CHARLES	5	1400	1	4	0.7	2.9	3.6	58.6						
30MAR	LEGION	39	2200	4	35	1.8	15.9	17.7	62.7						
30MAR	VENN	0	2200					0.0							
30MAR	SHILOH	1	2400	0	1	0.0	0.4	0.4	76.0						
30MAR	LAIRD	0	1200					0.0							
30MAR	GARDNER	0	2800					0.0							
TUOL.TOT.		255	15200	85	131	6.6	10.2	16.8	54.4						
SJR. TOT.		0	4000					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
14APR	OLGB	1	2000	0	1	0.0	0.5	0.5	56.0	0.3	0.2	0.0	10.7	14.9	0.2
14APR	R5	6	2000	1	5	0.5	2.5	3.0	55.0						
14APR	TRR	57	1800	1	56	0.6	31.1	31.7	69.7						
14APR	HICKMAN	59	1200	1	58	0.8	48.3	49.2	65.1						
14APR	CHARLES	1	1100	0	1	0.0	0.9	0.9	58.0						
14APR	LEGION	2	1800	0	2	0.0	1.1	1.1	57.0						
14APR	VENN	0	2400					0.0							
14APR	SHILOH	1	1800	0	1	0.0	0.6	0.6	73.0						
14APR	LAIRD	0	1950					0.0							
14APR	GARDNER	0	2400					0.0							
TUOL.TOT.		127	14100	3	124	0.2	8.8	9.0	66.5						
SJR. TOT.		0	4350					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
27APR	OLGB	2	1800	2	0	1.1	0.0	1.1	39.0	0.3	0.0	0.0	1.8	23.5	0.0
27APR	R5	0	1800					0.0							
27APR	TRR	11	2400	0	11	0.0	4.6	4.6	68.2						
27APR	HICKMAN	74	1500	0	54	0.0	49.3	49.3	74.9						
27APR	CHARLES	14	1500	0	14	0.0	9.3	9.3	83.4						
27APR	LEGION	34	2200	0	34	0.0	15.5	15.5	85.6						
27APR	VENN	0	2400					0.0							
27APR	SHILOH	0	2800					0.0							
27APR	LAIRD	0	1050					0.0							
27APR	GARDNER	0	2400					0.0							
TUOL.TOT.		135	16400	2	113	0.1	8.1	8.2	77.9						
SJR. TOT.		0	3450					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
11MAY	OLGB	11	1800	6	5	3.3	2.8	6.1	49.7	1.0	0.0	0.0	4.5	3.2	0.0
11MAY	R5	0	1800					0.0							
11MAY	TRR	21	2200	0	21	0.0	9.5	9.5	76.6						
11MAY	HICK	12	1350	0	12	0.0	8.9	8.9	82.2						
11MAY	CHARLES	1	1200	0	1	0.0	0.8	0.8	88.0						
11MAY	LEGION	3	2400	0	3	0.0	1.3	1.3	90.7						
11MAY	VENN	0	2400					0.0							
11MAY	SHILOH	0	2000					0.0							
11MAY	LAIRD	0	900					0.0							
11MAY	GARDNER	0	1800					0.0							
TUOL.TOT.		48	15150	6	42	0.4	2.8	3.2	72.9						
SJR. TOT.		0	2700					0.0							

2004 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

EXTRAPOLATED

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
25MAY	OLGB	0	2000					0.0		0.0	0.3	0.0	4.1	0.0	0.0
25MAY	R5	27	2200	0	27	0.0	12.3	12.3	69.5						
25MAY	TRR	0	2400					0.0							
25MAY	HICK	2	1800	2	0	1.1	0.0	1.1	49.0						
25MAY	CHARLES	0	1650					0.0							
25MAY	LEGION	0	2400					0.0							
25MAY	VENN	0	1800					0.0							
25MAY	SHILOH	0	2400					0.0							
25MAY	LAIRD	0	1200					0.0							
25MAY	GARDNER	0	2400					0.0							
TUOL.TOT.		29	16650	2	27	0.1	1.6	1.7							
SJR. TOT.		0	3600					0.0							

Table 3. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2004.

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
20JAN	OLGB	50.5	2	2,000	1.0	33	36	34.5	2	1	0	10.6	46		72.9	0.0	0.0	1.0
20JAN	R5	48.0	372	2,000	186.0	34	65	38.4	60	0	0	10.6	46					0.8
20JAN	TLSRA	42.0	49	1,800	27.2	33	46	38.6	49	0	1	10.7	55					1.3
20JAN	HICK	31.6	0	1,350	0.0							10.6	80					1.1
20JAN	CHARLES	24.9	0	1,000	0.0							10.6	115					1.3
20JAN	LEGION	17.2	0	2,600	0.0							10.8	162					1.8
20JAN	VENN	7.4	0	1,800	0.0							10.8	204					3.7
20JAN	SHILOH	3.4	0	2,400	0.0							10.8	202					4.6
20JAN	LAIRD	90.2	0	1,050	0.0							10.8	1558					26.5
20JAN	GARDNER	77.8	0	2,400	0.0							10.8	1217					15.0
TR TOT.			423	14950	28.3	33	65	38.4	111	1	1							
SJR TOT.			0	3450	0.0				0									

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
03FEB	OLGB	50.5	3	2400	1.3	35	37	36.0	3	0	0	10.4	44		90.0	4.8	0.0	1.1
03FEB	R5	48.0	185	2000	92.5	34	56	40.4	59	0	0	10.5	49					1.8
03FEB	TRR	42.3	406	2200	184.5	31	55	40.3	57	0	3	10.1	66					3.7
03FEB	HICK	31.6	21	1800	11.7	36	39	37.6	21	0	0	10.0	80					2.0
03FEB	CHARLES	24.9	3	1250	2.4	37	38	37.3	3	0	0	10.5	118					1.7
03FEB	LEGION	17.2	0	2000	0.0							10.8	150					2.6
03FEB	VENN	7.4	0	1800	0.0							11.2	191					5.1
03FEB	SHILOH	3.4	0	1800	0.0							11.1	195					6.6
03FEB	LAIRD	90.2	0	900	0.0							10.8	1512					26.0
03FEB	GARDNER	77.8	0	1650	0.0							10.8	1135					21.8
TR TOT.			618	15250	40.5	31	56	39.8	143	0	3							
SJR TOT.			0	2550	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
17FEB	OLGB	50.5	5	2400	2.1	34	38	36.2	5	0	0	10.6	44		40.4	28.3	0.0	0.8
17FEB	R5	48.0	42	2400	17.5	33	49	39.4	42	1	4	10.8	48					0.8
17FEB	TRR	42.3	244	2400	101.7	33	57	41.3	53	0	4	11.5	60					1.2
17FEB	HICK	31.6	138	1650	83.6	33	48	39.9	53	0	0	12.6	81					1.4
17FEB	CHARLES	24.9	11	1400	7.9	37	45	39.5	11	0	0	13.0	120					1.5
17FEB	LEGION	17.2	5	2400	2.1	36	53	43.0	5	0	0	13.7	156					1.9
17FEB	VENN	7.4	0	2200	0.0							14.2	196					5.0
17FEB	SHILOH	3.4	0	2200	0.0							14.3	204					5.5
17FEB	LAIRD	90.2	0	1200	0.0							14.2	1619					27.0
17FEB	GARDNER	77.8	0	2400	0.0							14.2	1230					18.8
TR TOT.			445	17050	26.1	33	57	40.2	169	1	8							
SJR TOT.			0	3600	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
02MAR	OLGB	50.5	0	2400	0.0							10.5	43		14.0	50.0	0.0	1.0
02MAR	R5	48.0	48	2400	20.0	36	70	43.5	48	0	0	10.5	47					1.2
02MAR	TRR	42.3	53	2400	22.1	36	57	40.8	53	0	0	10.8	65					1.8
02MAR	HICK	31.6	92	1800	51.1	35	55	40.1	55	0	0	12.1	91					3.0
02MAR	CHARLES	24.9	142	1500	94.7	35	79	42.1	64	0	0	13.3	140					4.7
02MAR	LEGION	17.2	51	2400	21.3	34	63	39.3	51	0	0	13.6	175					5.8
02MAR	VENN	7.4	0	2400	0.0							14.1	202					13.0
02MAR	SHILOH	3.4	0	2400	0.0							14.5	198					15.1
02MAR	LAIRD	90.2	0	1650	0.0							13.2	965					67.8
02MAR	GARDNER	77.8	0	2400	0.0							13.4	816					67.0
TR TOT.			386	17700	21.8	34	79	41.2	271	0	0							
SJR TOT.			0	4050	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
16MAR	OLGB	50.5	48	2200	21.8	34	55	38.3	48	0	0	10.6	44		27.5	74.0	0.0	0.9
16MAR	R5	48.0	97	2050	47.3	34	53	42.0	71	0	0	11.5	40					1.1
16MAR	TRR	42.3	38	2400	15.8	35	80	53.8	38	0	0	11.6	46					0.9
16MAR	HICK	31.6	207	1500	138.0	38	74	50.7	60	0	0	12.7	55					2.4
16MAR	CHARLES	24.9	97	1100	88.2	37	67	48.0	62	0	0	14.1	62					2.9
16MAR	LEGION	17.2	7	1600	4.4	41	80	51.3	7	0	0	16.2	62	80				8.0
16MAR	VENN	7.4	0	2000	0.0							16.3	65					7.6
16MAR	SHILOH	3.4	0	1950	0.0							16.5	66					9.3
16MAR	LAIRD	90.2	0	1050	0.0							20.1	1632					42.0
16MAR	GARDNER	77.8	0	1800	0.0							18.5	861					21.9
TR TOT.			494	14800	33.4	34	80	46.3	286	0	0			1				
SJR TOT.			0	2850	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
23MAR	OLGB	50.5	21	1650	12.7	36	48	41.5	21	0	0	10.6	45		21.8	52.4	0.3	1.0
23MAR	R5	48.0	17	1650	10.3	35	60	41.1	17	0	0	11.0	41					0.9
23MAR	TRR	42.3	82	2200	37.3	36	88	55.7	70	0	0	11.3	49					0.9
23MAR	HICK	31.6	81	1200	67.5	40	74	51.2	62	0	1	12.4	51					1.7
23MAR	CHARLES	24.9	78	1400	55.7	40	81	54.3	55	0	0	13.7	60					2.1
23MAR	LEGION	17.2	40	1200	33.3	36	86	59.0	40	0	0	14.7	66	81,81,86				3.4
23MAR	VENN	7.4	1	1800	0.6	40	40	40.0	1	0	0	15.2	65					6.3
23MAR	SHILOH	3.4	0	2000	0.0							15.2	66					9.2
23MAR	LAIRD	90.2	0	1200	0.0							21.1	1519					38.8
23MAR	GARDNER	77.8	0	1800	0.0							18.1	755					20.3
TR TOT.			320	13100	24.4	35	88	52.8	266	0	1			3				
SJR TOT.			0	3000	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
30MAR	OLGB	50.5	20	1800	11.1	40	72	54.5	20	0	0	10.5	40		33.0	14.6	0.2	1.2
30MAR	R5	48.0	109	1800	60.6	41	64	50.1	70	0	0	11.0	40					0.7
30MAR	TRR	42.3	49	1800	27.2	35	73	53.0	49	0	1	11.3	48					0.9
30MAR	HICK	31.6	32	1600	20.0	44	77	54.4	32	0	0	13.6	58					1.4
30MAR	CHARLES	24.9	5	1400	3.6	49	73	58.6	5	0	0	15.2	81					1.9
30MAR	LEGION	17.2	39	2200	17.7	40	82	62.7	39	0	0	15.4	95	7(73-82)				3.7
30MAR	VENN	7.4	0	2200	0.0							15.9	115					7.1
30MAR	SHILOH	3.4	1	2400	0.4	76	76	76.0	1	0	0	16.1	114	76				7.4
30MAR	LAIRD	90.2	0	1200	0.0							18.5	1527					30.8
30MAR	GARDNER	77.8	0	2800	0.0							17.5	886					19.8
TR TOT.			255	15200	16.8	35	82	54.4	216	0	1			8				
SJR TOT.			0	4000	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
14APR	OLGB	50.5	1	2000	0.5	56	56	56.0	1	0	0	10.7	40		11.0	15.1	0.2	0.9
14APR	R5	48.0	6	2000	3.0	39	67	55.0	6	0	0	11.0	39					0.9
14APR	TRR	42.3	57	1800	31.7	43	95	69.7	57	0	0	10.6	45	11(81-95)				1.5
14APR	HICK	31.6	59	1200	49.2	41	81	65.1	59	0	0	12.3	50	10(72-81)				2.7
14APR	CHARLES	24.9	1	1100	0.9	58	58	58.0	1	0	0	14.0	59					2.5
14APR	LEGION	17.2	2	1800	1.1	52	62	57.0	2	0	0	15.3	64					3.4
14APR	VENN	7.4	0	2400	0.0							16.3	71					8.0
14APR	SHILOH	3.4	1	1800	0.6	73	73	73.0	1	0	0	16.8	78	73				8.1
14APR	LAIRD	90.2	0	1950	0.0							20.6	1280					27.1
14APR	GARDNER	77.8	0	2400	0.0							18.7	607					15.4
TR TOT.			127	14100	9.0	39	95	66.5	127	0	0			22				
SJR TOT.			0	4350	0.0				0									

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
27APR	OLGB	50.5	2	1800	1.1	37	41	39.0	2	0	0	10.8	38		2.2	23.5	0.0	0.9
27APR	R5	48.0	0	1800	0.0							11.2	45					0.8
27APR	TRR	42.3	11	2400	4.6	58	77	68.2	11	0	0	11.9	49	4(70-77)				0.9
27APR	HICK	31.6	74	1500	49.3	52	95	74.9	54	0	0	15.1	56	33(71-95)				1.4
27APR	CHARLES	24.9	14	1500	9.3	74	98	83.4	14	0	0	17.5	76	14(74-98)				1.8
27APR	LEGION	17.2	34	2200	15.5	62	98	85.6	34	0	0	18.5	87	33(75-98)				2.1
27APR	VENN	7.4	0	2400	0.0							19.7	109					5.8
27APR	SHILOH	3.4	0	2800	0.0							20.6	113					6.4
27APR	LAIRD	90.2	0	1050	0.0							23.0	775					30.3
27APR	GARDNER	77.8	0	2400	0.0							22.2	532					16.8
TR TOT.			135	16400	8.2	37	98	77.9	115	0	0			84				
SJR TOT.			0	3450	0.0													

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
11MAY	OLGB	50.5	11	1800	6.1	43	63	49.7	11	0	0	10.8	38		5.5	3.2	0.0	0.8
11MAY	R5	48.0	0	1800	0.0				0			11.1	41					1.1
11MAY	TRR	42.3	21	2200	9.5	58	96	76.6	21	0	0	11.6	42	19(65-96)				0.8
11MAY	HICK	31.6	12	1350	8.9	71	96	82.2	12	0	0	13.6	51	11(76-96)				1.5
11MAY	CHARLES	24.9	1	1200	0.8	88	88	88.0	1	0	0	16.7	68	88				4.2
11MAY	LEGION	17.2	3	2400	1.3	84	94	90.7	3	0	0	17.0	72	3(84-94)				2.9
11MAY	VENN	7.4	0	2400	0.0				0			18.1	92					6.8
11MAY	SHILOH	3.4	0	2000	0.0				0			19.1	95					8.3
11MAY	LAIRD	90.2	0	900	0.0				0			19.1	453					30.8
11MAY	GARDNER	77.8	0	1800	0.0				0			19.0	360					23.0
TR TOT.			48	15150	3.2	43	96	72.9	48					34				
SJR TOT.			0	2700	0.0				0									

2004 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.
25MAY	OLGB	50.5	0	2000	0.0							10.9	40		4.1	0.3	0.0	0.7
25MAY	R5	48.0	27	2200	12.3	58	88	69.5	27	0	0	12.4	40	20(65-88)				0.7
25MAY	TRR	42.3	0	2400	0.0							15.6	49					1.1
25MAY	HICK	31.6	2	1800	1.1	49	49	49.0	2	0	0	19.0	70					1.7
25MAY	CHARLES	24.9	0	1650	0.0							21.1	119					2.6
25MAY	LEGION	17.2	0	2400	0.0							22.0	138					3.9
25MAY	VENN	7.4	0	1800	0.0							22.7	196					5.7
25MAY	SHILOH	3.4	0	2400	0.0							23.0	205					5.8
25MAY	LAIRD	90.2	0	1200	0.0							23.4	1270					26.7
25MAY	GARDNER	77.8	0	2400	0.0							23.3	922					18.8
TR TOT.			29	16650	1.7	49	88	68.1	29	0	0							
SJR TOT.			0	3600	0.0													

Table 4. Key to other species caught and distribution

KEY TO OTHER SPECIES SAMPLED AND DISTRIBUTION
(List includes all species caught during 1986-2004 seining studies)

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	SAN JOAQUIN	TUOL.
Petromyzontidae	Pacific lamprey	N	LP		
Clupeidae	threadfin shad		TFS		
Salmonidae	Chinook salmon	N	CS		X
Salmonidae	rainbow trout	N	RT		X
Cyprinidae	carp		CP	X	
Cyprinidae	goldfish		GF	X	
Cyprinidae	golden shiner		GSH	X	X
Cyprinidae	Sacramento blackfish	N	SBF		
Cyprinidae	hitch	N	HCH		
Cyprinidae	hardhead	N	HH		X
Cyprinidae	Sacramento pikeminnow	N	PM	X	X
Cyprinidae	Sacramento splittail	N	ST		
Cyprinidae	red shiner		PRS	X	X
Cyprinidae	fathead minnow		FHM	X	
Catostomidae	Sacramento sucker	N	SKR	X	X
Ictaluridae	channel catfish		CCF		
Ictaluridae	white catfish		WCF		
Ictaluridae	brown bullhead		BBH		
Poeciliidae	western mosquitofish		GAM	X	X
Atherinidae	inland silverside		ISS	X	X
Percichthyidae	striped bass		SB	X	
Centrarchidae	white/black crappie		WCR/BCR	X	
Centrarchidae	warmouth		WM		
Centrarchidae	green sunfish		GSF	X	X
Centrarchidae	bluegill		BG	X	X
Centrarchidae	redear sunfish		RSF	X	X
Centrarchidae	largemouth bass		LMB	X	X
Centrarchidae	smallmouth bass		SMB	X	X
Percidae	bigscale logperch		BLP	X	
Embiotocidae	tule perch	N	TP	X	
Cottidae	prickly sculpin	N	PSCP		X
Cottidae	riffle sculpin	N	RSCP		X
TOTAL:	32			18	16

2004 species presence designated with 'X'

Table 4. 2004 OTHER SPECIES SAMPLED DURING SEINING STUDIES ON JUVENILE SALMON

OTHER SPECIES SAMPLED (ACTUAL COUNTS OR ESTIMATED ABUNDANCE)

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
20JAN	1	OLGB	50.5																													
20JAN	2	R5	48.0														1															
20JAN	3	TRR	42.3										1																			
20JAN	4	HICK	31.6																1													
20JAN	5	CHARLES	24.9																10						1							
20JAN	6	LEGION	17.2																						2							
20JAN	7	VENN	7.4																25	1				2	1							
20JAN	8	SHILOH	3.4																20													
20JAN	9	LAIRD	90.2												500	15										1						
20JAN	10	GARDNER	77.8						5											4				7	1					2		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
03FEB	1	OLGB	50.5																													
03FEB	2	R5	48.0																										1			
03FEB	3	TRR	42.3								4						3															
03FEB	4	HICK	31.6																													
03FEB	5	CHARLES	24.9																10					1								
03FEB	6	LEGION	17.2																1						4							
03FEB	7	VENN	7.4																20						1							
03FEB	8	SHILOH	3.4																10						1							
03FEB	9	LAIRD	90.2												500	6																
03FEB	10	GARDNER	77.8						4											1				10	1					3		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
17FEB	1	OLGB	50.5																													
17FEB	2	R5	48.0										3				2		1													
17FEB	3	TRR	42.3										8																			
17FEB	4	HICK	31.6																1													
17FEB	5	CHARLES	24.9																				1		1							
17FEB	6	LEGION	17.2																													
17FEB	7	VENN	7.4																10					1	4							
17FEB	8	SHILOH	3.4																20													
17FEB	9	LAIRD	90.2												6									3								
17FEB	10	GARDNER	77.8						1												4		1	6	3	1				1		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
02MAR	1	OLGB	50.5																													
02MAR	2	R5	48.0										1				4															
02MAR	3	TRR	42.3										5				1															
02MAR	4	HICK	31.6																2													
02MAR	5	CHARLES	24.9																1													
02MAR	6	LEGION	17.2																													
02MAR	7	VENN	7.4																5					1	3					1		
02MAR	8	SHILOH	3.4																1						4							
02MAR	9	LAIRD	90.2												200	15				1	1				1							
02MAR	10	GARDNER	77.8												50	4				5			2	30	6		1					

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
16MAR	1	OLGB	50.5			1											2															
16MAR	2	R5	48.0										2				3												1			
16MAR	3	TRR	42.3			1					1																					
16MAR	4	HICK	31.6																2													
16MAR	5	CHARLES	24.9										1																			
16MAR	6	LEGION	17.2																													
16MAR	7	VENN	7.4																6													
16MAR	8	SHILOH	3.4																6					1	3							
16MAR	9	LAIRD	90.2												500	5							2	1	1							
16MAR	10	GARDNER	77.8												30					1				7	3							

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
23MAR	1	OLGB	50.5														1															
23MAR	2	R5	48.0								2		1				4		2													
23MAR	3	TRR	42.3														1												PRSCP			
23MAR	4	HICK	31.6																2													
23MAR	5	CHARLES	24.9														1															
23MAR	6	LEGION	17.2																2						3							
23MAR	7	VENN	7.4																10					1								
23MAR	8	SHILOH	3.4												10					1					2							
23MAR	9	LAIRD	90.2												50									1								
23MAR	10	GARDNER	77.8												30	2				6				2	6			1				

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
30MAR	1	OLGB	50.5										1																			
30MAR	2	R5	48.0																1													
30MAR	3	TRR	42.3			2					7		5						1													
30MAR	4	HICK	31.6																													
30MAR	5	CHARLES	24.9																													
30MAR	6	LEGION	17.2																						6							
30MAR	7	VENN	7.4																						7					1		
30MAR	8	SHILOH	3.4						1										2					2	1							
30MAR	9	LAIRD	90.2				1								20								1	2	3							
30MAR	10	GARDNER	77.8												10					40				15	2					1		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
14APR	1	OLGB	50.5																													
14APR	2	R5	48.0			2											7		12													
14APR	3	TRR	42.3														1															
14APR	4	HICK	31.6																													
14APR	5	CHARLES	24.9																													
14APR	6	LEGION	17.2																													
14APR	7	VENN	7.4																					2	1							
14APR	8	SHILOH	3.4																													
14APR	9	LAIRD	90.2												20				20	20	1			1								
14APR	10	GARDNER	77.8												6					10	2			15						1		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
27APR	1	OLGB	50.5																													
27APR	2	R5	48.0																													
27APR	3	TRR	42.3								2																					
27APR	4	HICK	31.6																						1							
27APR	5	CHARLES	24.9																	1												
27APR	6	LEGION	17.2														yoy								2							
27APR	7	VENN	7.4																					4	6					1		
27APR	8	SHILOH	3.4																30					1	1							
27APR	9	LAIRD	90.2					1							50																	
27APR	10	GARDNER	77.8				1								50					20				6	4							

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
11MAY	1	OLGB	50.5														1		2										2			
11MAY	2	R5	48.0														yoy															
11MAY	3	TRR	42.3								1						yoy															
11MAY	4	HICK	31.6														yoy								1							
11MAY	5	CHARLES	24.9														yoy															
11MAY	6	LEGION	17.2																						13							
11MAY	7	VENN	7.4																					6	2							
11MAY	8	SHILOH	3.4												1		yoy		1					2	2							
11MAY	9	LAIRD	90.2												500	1			5													
11MAY	10	GARDNER	77.8												30					40		BCR-1		4				1				

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
25MAY	1	OLGB	50.5																													
25MAY	2	R5	48.0			1											12															
25MAY	3	TRR	42.3														YOY															
25MAY	4	HICK	31.6								2						YOY		20						1							
25MAY	5	CHARLES	24.9																													
25MAY	6	LEGION	17.2																						18	1						
25MAY	7	VENN	7.4																20	1				8	4							
25MAY	8	SHILOH	3.4														YOY															
25MAY	9	LAIRD	90.2												100	12	2			20	1											
25MAY	10	GARDNER	77.8					1					1		50					10				25	5	1		4		2		

Table 5. Tuolumne River snorkel summary, 2004.

2004 TUOLUMNE RIVER SNORKEL SUMMARY (TID/MID)

														NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM)												
DATE	START TIME	LOCATION	RIVER MILE	SITE	AREA (Sq. Ft.)	AVG. DEPTH (FEET)	TIME (Min.)	HABITAT	SUBSTRATE	WATER TEMP. (C)	EC	TURB. (NTU)	HORIZ. VISIB. (FEET)	CHINOOK count/est.	CHINOOK size	RAINBOW count/est.	RAINBOW size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	LARGEMOUTH BASS	SMALLMOUTH BASS	REDEAR SUNFISH	BLUEGILL	LAMPREY
16JUN	0950	Riffle A7	50.7	1	6,250	1.3	32.0	Riffle	cobble,gravel,bedrock	12.5	38	0.6	20.0	45	(45-80)			(YOY)								
	0955			2	4,400	4.0	31.0	Run	cobble,gravel,sand					340	(50-90)	11	(50-80)	(YOY)								
														5	(100-110)	1	(420)									
16JUN	1130	Riffle 2	49.9	1	6,000	1.2	36.0	Riffle	cobble,gravel,boulder	14.9	38	0.8	20.0	16	(80-110)	15	(80-100)	(YOY)			(60,80)					
																5	(110-130)									
	1157			2	3,000	7.5	21.0	Pool	bedrock,boulder,sand							2	(180,320)	30(300-500)								
																1	(400)	20(550-700)								
	1203			3	6,000	3.0	19.0	Run-Pool	cobble,sand,boulder									26(450-750) (YOY)								
16JUN	1351	Riffle 3B	49.1	1	4,400	1.5	25.0	Riffle	cobble,gravel,sand	16.4	46	0.8	15.0	4	(60-70)	6	(80-130)	6(400-600) (YOY)								
																1	(480)									
	1358			2	4,500	2.8	22.0	Run-Riffle	cobble,gravel,bedrock					55	(60-110)	15	(90-130)	48(450-700) (YOY)								
16JUN	1509	Riffle 5B	47.9	1	2,500	1.5	24.0	Riffle	cobble,gravel,sand	18.7	48	0.9	15.0	4	(90-100)	9	(90-130)	20(450-650) (YOY)								
																1	(300)	4(700-800)								
	*			2				Run																		
	1510			3	7,000	5.0	23.0	Run-Pool	bedrock,cobble,sand							1	(370)	18(600-800) (YOY)					(220)			
					44,050		233.0			**Subtotal**				**469**		**68**		**172**			**2**		**1**			
17JUN	1026	Riffle 7	46.9	1	3,500	1.5	22.0	Riffle	cobble,gravel,sand	14.8	51	1.4	14.0	3	(85-90)	13	(110-140)	(600,600)								
	1025			2	6,000	3.5	23.0	Run	bedrock,cobble,sand					1	(110)			30(400-650) 5(700-800)	(220,260,400,460)							
17JUN	1144	Riffle 13B	45.5	1	5,200	2.3	22.0	Run-Riffle	cobble,gravel,sand	17.8	49	1.0	16.0			5	(110-125)	12(600-750)	(500)							
	1143			2	4,000	1.3	20.0	Riffle	gravel,cobble,sand					3	(100-120)			7(600-750) (YOY)			(70)					(110)
17JUN	1400	Riffle 21	42.9	1	3,900	1.5	28.0	Riffle	cobble,gravel,sand	20.0	42	1.4	9.5	7	(80-90)	5	(110-130)	8(600-800) (YOY)	22(200-275)							
	1357			2	4,000	4.5	19.0	Run-Pool	cobble,sand,vegetation									15(500-750)	40(100-200) 60(200-350)	10(100-200)		(100)	(110)			
																			20(360-500)	30(220-450)						
17JUN	1515	Riffle 23C	42.3	1	2,700	2.2	16.0	Run-Riffle	cobble,gravel,bedrock	21.2	46	1.4	10.0	1	(85)			6(600-800) (YOY)	70(200-300)	25(175-275)						
																			12(300-375)							
	1514			2	3,500	1.5	18.0	Riffle	cobble,bedrock,gravel										13(50-70) 30(120-180) (30	10(120-160)						
					32,800		168.0			**Subtotal**				**15**		**23**		**85**	**273**	**75**	**1**	**1**	**1**			**1**
18JUN	0930	Riffle 31	38.0	1	4,000	2.0	20.0	Riffle-Run	cobble,gravel,sand	20.0	63	1.9	11.0					32(400-750) (YOY)	(80) 5(180-280) (320,360)	(220)						
	0934			2	8,000	3.0	17.0	Run-Pool	cobble,sand,vegetation									15(600-800)	12(170-270)	(150,160)		3(150-180)				
18JUN	1050	Riffle 35A	37.1	1	2,500	1.0	19.0	Riffle	cobble,gravel,sand	20.8	67	1.7	11.0	7	(100-110)			(400,480)	7(100-220)							
	1054			2	7,200	2.5	18.0	Run	cobble,sand,vegetation									6(600-800)	12(200-250) 13(250-375)			10(175-275) (330)	(270)	(75)	(90,120)	
18JUN	1316	Riffle 41A	35.3	1	2,000	2.4	17.0	Run-Riffle	cobble,gravel,sand	21.6	71	1.8	10.0						(200,240,320,400,420)	(240,300)			(110,130)			
	1312			2	2,400	5.0	8.0	Pool	gravel,sand,bedrock									18(50-70)	(200)				(120,140)			
	1320			3	4,500	2.5	10.0	Run-Riffle	cobble,gravel,sand									22(75-125) 24(375-750)	16(90-125) 20(150-270)							
18JUN	1437	Riffle 57	31.5	1	4375	1.8	14.0	Riffle	cobble,gravel,sand	24.0	81	2.1	8.0					(575,600)			(80)					
	1433			2	6000	2.0	15.0	Run-Riffle	cobble,bedrock,sand									4(50-70)	6(120-140)							
					40,975		138.0			**Subtotal**				**7**				**125**	**100**	**5**	**1**	**14**	**5**	**1**	**2**	
										TOTAL#				**491**		**91**		**382**	**373**	**80**	**4**	**15**	**7**	**1**	**2**	**1**

* Swimmers were at the site location during the survey

Young-of-the-year sucker were commonly observed along the margins at most sites.

2004 TUOLUMNE RIVER SNORKEL SUMMARY (TID/MID)

														NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM)												
DATE	START TIME	LOCATION	RIVER MILE	SITE	AREA (Sq. Ft.)	AVG. DEPTH (FEET)	TIME (Min.)	HABITAT	SUBSTRATE	WATER TEMP. (C)	EC	TURB. (NTU)	HORIZ. VISIB. (FEET)	CHINOOK count/est.	CHINOOK size	RAINBOW count/est.	RAINBOW size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	LARGEMOUTH BASS	SMALLMOUTH BASS	REDEAR SUNFISH	BLUEGILL	WHITE CATFISH
03AUG	1045	Riffle A3/A4	51.6	1	6,250	5.0	19.0	Pool	cobble,boulder,bedrock	12.2	41	0.5	30.0	No fish observed												
(1)				2	2,625	1.2	11.0	Riffle	cobble,gravel,boulder							5	(170-275)									
				3	14,400	5.0	31.0	Pool-Run	cobble,sand,bedrock									(60)								
03AUG	1230	Riffle A7	50.7	1	7,200	1.5	30.0	Riffle	cobble,gravel,sand	13.6	41	1.2	21.0	7	(60-80)											
				2	4,500	4.0	28.0	Run	cobble,gravel,sand					70	(80-110)	6	(120-200)									
03AUG	1415	Riffle 1A	50.5	1	3,000	2.0	15.0	Riffle	cobble,gravel,sand	14.2	40	0.5	20.5					4(425-450)								
(1)				2	2,400	4.0	15.0	Run	cobble,gravel,sand					No fish observed												
				3	13,125	5.0	24.0	Pool-Run	cobble,sand,gravel							4	(300-425)									
03AUG	1540	Riffle 2	49.9	1	8,400	1.2	35.0	Riffle	cobble,gravel,sand	15.9	41	0.6	13.0					3(450-575)			(60)					
				2	4,500	7.5	25.0	Pool	bedrock,boulder,sand									41(300-450) (700)	(320,450)							
				3	7,500	3.5	21.0	Run-Pool	sand,cobble,boulder							2	(290,320)	60(400-700)	(320,330)							
					73,900		254			**Subtotal**				**77**		**17**		**110**	**4**		**1**					
04AUG	1100	Riffle 3B	49.1	1	6,000	1.5	26.0	Riffle	cobble,gravel,sand	15.7	43	0.7	15.0			3	(160,350,525)	25(40-60)								
				2	10,000	2.0	30.0	Run	cobble,boulder,bedrock					3	(75,80,85)	2	(140,150)	(600)								
04AUG	1300	Riffle 4B	48.4	1	5,000	2.0	26.0	Run-Riffle	cobble,gravel,sand	18.3	43	0.5	13.0			6	(100-200)	5(40-60) (YOY)	(120)							
(1)				2	12,000	1.5	31.0	Riffle-Run	cobble,sand,algae							2	(90,350)	80(400-700)			(90)					
04AUG	0900	Riffle 5B	47.9	1	2,500	1.5	24.0	Riffle	cobble,gravel,sand	15.4	44	0.7	15.0			14	(150-225)	50(450-700)								
				2	12,000	4.0	23.0	Run	cobble, bedrock,sand							1	(60)	47(40-100) (YOY)								
				3	13,500	3.5	21.0	Run-Pool	boulder,bedrock,cobble									7(500-700)	(425)							
04AUG	1430	Riffle 7	46.9	1	3,750	1.1	22.0	Riffle	cobble,gravel,sand	17.6	44	0.7	13.0			5	(140-160)	(375)								
				2	12,500	4.0	20.0	Run	bedrock,cobble,sa nd									6(40-60) 60(400-700)	(380,420,500)							
					77,250		223			**Subtotal**				**3**		**33**		**282**	**5**		**1**					
05AUG	1030	Riffle 10	46.2	1	6,400	8.0	60.0	Pool	sand,cobble,vegetation	17.2	44	1.1	10.0			3	(340,400,450)	(450,500,600)				(320,340,360,360)	(350)			
(1)																										
05AUG	1150	Riffle 13B	45.5	1	8,750	1.5	25.0	Run-Riffle	cobble,sand,gravel	19.0	44	1.4	15.0			13	(100-210)	3(200-240) 9(475-600)	(190)							
				2	4,050	1.1	16.0	Riffle	cobble,gravel,sand									(80) 25(400-600)								
05AUG	1300	Riffle 21	42.9	1	4,500	1.2	20.0	Riffle	cobble,gravel,sand	21.2	48	0.8	12.0			9	(100-170)	(90) 3(210-230) 10(500-700)	8(90-120) 7(150-240)							
				2	6,000	4.5	19.0	Pool-Run	cobble,sand,vegetation									(70,120,180)	8(110-140) 5(200-320)	17(90-160) 3(200-300)		(180,220)				
05AUG	1500	Riffle 23C	42.3	1	3,150	2.5	19.0	Run	cobble,algae,sand	22.2	51	1.2	12.0					(250,260) 5(400-500)	15(80-120) 45(125-350)	20(125-200) 15(210-350)		(310)				
				2	3,600	1.2	19.0	Riffle	cobble,gravel,sand							1	(200)		17(150-180) (220,240)	13(150-180)						
					36,450		178.0			**Subtotal**				**0**		**26**		**65**	**108**	**68**		**7**	**1**			
06AUG	0915	Riffle 31	38.0	1	3,600	2.0	20.0	Run-Riffle	cobble,gravel,sand	21.2	81	0.9	12.0					150(400-700)	60(200-300) 3(340-400)	40(180-280) (320,340)						
				2	8,750	3.5	20.0	Run-Pool	cobble,sand,vegetation									75(50-100) 22(400-700)	300(40-90)			7(75-125)	(140,140,160)			
06AUG	1030	Riffle 35A	37.1	1	3,000	0.8	20.0	Riffle	cobble,gravel,sand	22.1	84	0.9	12.0					35(50-80)	25(100-120)				(90,100)			
				2	9,000	2.5	24.0	Run	cobble,sand,algae									(600)	(180,220,300)		(110)	13(75-175)	11(75-125)			(330)
06AUG	1200	Riffle 41A	35.3	1	3,125	2.2	18.0	Run-Riffle	cobble,gravel,sand	22.8	87	1.0	12.0					45(50-100) 5(500-700)	8(75-100) 7(280-320)	(280,300,310)		(90,110)	8(75-125)			
				2	2,800	5.0	9.0	Pool	cobble,gravel,bedrock										10(320-400) (450,500)	8(300-350)		(200)	5(100-220)			
				3	6,000	1.5	13.0	Run-Riffle	cobble,gravel,sand									14(600-700)				(90)	3(70-90) (320,360)			
06AUG	1400	Riffle 57	31.5	1	8,750	1.5	21.0	Riffle	cobble,gravel,sand	25.0	93	0.8	12.0									(80)	3(70-80) (180)			
				2	8,400	2.0	20.0	Run-Riffle	cobble,sand,gravel									18(500-700)	(180,220,310)	(280,320,330)		(310)	7(110-220)			
					53,425		165.0			**Subtotal**				**0**		**0**		**365**	**421**	**56**	**1**	**26**	**45**			**1**
										TOTAL#				**80**		**76**		**822**	**538**	**124**	**3**	**33**	**46**	**0**	**0**	**1**

(1) Additional survey locations

2004 TUOLUMNE RIVER SNORKEL SUMMARY (TID/MID)

DATE	START TIME	LOCATION	RIVER MILE	SITE	AREA (Sq. Ft.)	AVG. DEPTH (FEET)	TIME (Min.)	HABITAT	SUBSTRATE	WATER TEMP. (C)	DO (mg/l)	EC	TURB. (NTU)	HORIZ. VISIB. (FEET)	CHINOOK count/est.	CHINOOK size	RAINBOW count/est.	RAINBOW size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	LARGEMOUTH BASS	SMALLMOUTH BASS	REDEAR SUNFISH	BLUEGILL	CARP
															NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM)												
15SEP	0936	Riffle A7	50.7	1	6,000	1.2	20.0	Riffle	cobble,gravel,sand	12.4	12.2	41	0.8	21.0			8	(40-60)									
	0939			2	4,400	3.5	22.0	Run	cobble,gravel,sand								3	(100-110)									
15SEP	1050	Riffle 2	49.9	1	10,500	1.3	36.0	Riffle	gravel,cobble,sand	14.3	13.2	42	0.8	20.0			1	(100)									
	1117			2	4,000	6.5	26.0	Pool	bedrock,boulder,cobble								6	(200-380)	(70,400,450,500)	(420)							
	1120			3	8,000	3.0	20.0	Run-Pool	cobble,sand,boulder											(475)							
15SEP	1317	Riffle 3B	49.1	1	4,400	1.5	20.0	Riffle	cobble,gravel,sand	15.5	14.4	41	0.4	15.0			3	(60,360,400)									
	1317			2	7,200	2.3	21.0	Run-Riffle	cobble,gravel,boulder								4	(80,100,110,425)	(60,60,70)								
15SEP	1428	Riffle 5B	47.9	1	3,600	1.5	20.0	Riffle	cobble,gravel,sand	17.6	11.4	42	0.5	14.0			4	(140,160,200,360)	(80) 15(400-550)								
	1456			2	12,000	4.5	36.0	Run	cobble,bedrock,sand								1	(45)	41(40-80)	9(30-70)							
	1425			3	7,500	3.5	22.0	Run-Pool	sand,boulder,cobble								1	(260)		(175,180,375,400)	(480)						
					67,600		243.0			**Subtotal**					**0**		**31**		**64**	**15**	**1**						
16SEP	1028	Riffle 7	46.9	1	5,000	1.1	20.0	Riffle	cobble,gravel,algae	14.6	11.8	44	0.9	16.0			2	(180,300)									
	1028			2	8,000	3.0	20.0	Run	bedrock,cobble,sand										130(350-750) 10(50-70)	10(40-50) 5(260-600)							
16SEP	1200	Riffle 13B	45.5	1	4,500	1.2	22.0	Riffle-Run	cobble,gravel,algae	17.0	12.2	44	0.9	15.0					12(40-70) 60(300-500)	60(30-50)							
	1200			2	3,000	1.2	14.0	Riffle	cobble,gravel,bedrock										(60)	(40,50)							
16SEP	1323	Riffle 21	42.9	1	4,375	1.1	15.0	Riffle	cobble,gravel,sand	18.8	N.A.	50	1.0	13.0			4	(160-180)									
																	3	(280,300,310)									
	1318			2	9,000	3.5	20.0	Run-Pool	cobble,sand,vegetation											(110,120,130)							
16SEP	1439	Riffle 23C	42.3	1	3,750	1.8	15.0	Run-Riffle	cobble,sand,algae	19.6	13.0	52	0.8	13.0					15(60-90) 8(150-300)	20(60-90) 55(150-300)	45(150-300)						
	1445			2	3,500	1.2	17.0	Riffle	cobble,bedrock,gravel											10(100-140) 27(150-300)	15(150-220)						
					41,125		143.0			**Subtotal**					**0**		**9**		**236**	**192**	**60**						
17SEP	0926	Riffle 31	38.0	1	3,150	2.5	17.0	Riffle	cobble,gravel,sand	19.3	10.5	80	1.3	13.0					29(500-650)	7(240-400)							
	0926			2	16,000	3.0	20.0	Run-Pool	cobble,sand,gravel														(150,280)				
17SEP	1034	Riffle 35A	37.1	1	3,000	1.2	20.0	Riffle	cobble,gravel,sand	20.0	8.5	84	1.2	12.0					(110,120)	32(70-110) 16(120-220)	5(120-150)		(100,110)	(110,110,120)			
	1034			2	7,875	2.0	25.0	Run	cobble,sand,gravel											15(75-125) 22(125-240)	12(80-125)		(90,140)	(180)			
17SEP	1257	Riffle 41A	35.3	1	3,125	1.8	16.0	Run-Riffle	cobble,gravel,sand	21.3	9.4	86	1.2	14.0					20(80-120) (400)	40(80-120) 38(125-300)	40(80-200)		(140,160,370)	11(80-120)		(110)	
	1255			2	2,400	5.0	9.0	Pool	gravel,sand,bedrock										(320,400)	8(200-380) (460,520)	(220,240)			4(90-140 3(180-210)			
	1305			3	5,000	2.5	12.0	Run-Riffle	cobble,gravel,sand										30(450-650)	6(120-160)			(90,100,110)	9(90-140) (340,360)			
17SEP	1437	Riffle 57	31.5	1	8,750	1.8	18.0	Riffle	cobble,gravel,sand	23.3	12.0	94	1.1	13.0					13(300-500)	8(150-250)	11(150-250)		9(80-140)	23(80-140) 8(150-280)		5(90-150)	
	1437			2	6,000	2.0	20.0	Run-Riffle	cobble,bedrock,sand														10(70-100)	21(80-180)			
					55,300		157.0			**Subtotal**					**0**		**0**		**97**	**194**	**70**		**31**	**85**		**6**	
										TOTAL#					**0**		**40**		**397**	**401**	**131**	**0**	**31**	**85**	**0**	**6**	**0**

Young of the year pikeminnow and sucker were commonly observed along the banks.

Table 6. Yearly seining summary for the Tuolumne, San Joaquin, and Stanislaus Rivers, 1986-2004.

Tuolumne River Seining Study Summary (Tuolumne, San Joaquin and Stanislaus Rivers)

	TUOLUMNE RIVER					SAN JOAQUIN			STANISLAUS				
Sampling Year	Sampling Periods	Salmon Captured	Sites Sampled	Average Density	Growth Rate Index (mm/day)	Salmon Captured	Sites Sampled	Average Density	Salmon Captured	Sites Sampled	Average Density	Start Date	End Date
1986	18	5514	8	20.7	0.45	854	3	14.2	---	---		22JAN	27JUN
1987	21	14825	11	22.4	0.45	734	6	1.9	---	---		05JAN	04JUN
1988	14	6134	11	14.3	0.58	295	4	2.1	84	1	2.9	05JAN	17MAY
1989	13	10043	11	27.0	0.64	83	3	0.6	1206	1	45.4	05JAN	12MAY
1990	14	2286	11	6.0	0.57	48	3	0.5	---	---		04JAN	11MAY
1991	8	120	11	0.5	No estimate	0	3	0	3	1	0.2	15JAN	24MAY
1992	5	144	7	1.2	No estimate	0	3	0	54	1	3.9	27JAN	13MAY
1993	7	124	8	0.8	0.68	0	3	0	6	1	0.3	26JAN	12MAY
1994	7	2068	5	21.6	0.65	2	2	0	---	---		25JAN	20MAY
1995	8	512	5	6.1	0.79	43	2	1.1	---	---		09FEB	12JUL
1996	8	785	6	7.6	0.66	7	2*	0.2	---	---		17JAN	13JUN
1997	10	379	7	2.7	0.48	11	2*	0.4	---	---		14JAN	28MAY
1998	10	1950	7	14.4	0.46	99	2	2.5	---	---		14JAN	21MAY
1999	10	3443	8	24.6	0.54	560	2	13.6	---	---		14JAN	19MAY
2000	10	3213	8	27.0	0.46	19	2	0.6	---	---		11JAN	17MAY
2001	11	5567	8	41.3	0.67	83	2	2.6	---	---		09JAN	30MAY
2002	10	3486	8	25.6	0.64	0	2	0	---	---		15JAN	21MAY
2003	10	5983	8	39.3	0.68	1	2	0	---	---		21JAN	28MAY
2004	11	3280	8	19.3	0.55	0	2	0	---	---		20JAN	25MAY

--- Not Sampled

*All San Joaquin River locations were not always sampled

Table 7. Summary table of locations sampled, 1986-2004

1986 TO 2004 SEINING LOCATIONS
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																	

STANISLAUS RIVER

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
19	Caswell State Park	8.5			X	X		X	X	X											

DRY CREEK

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
20	Beard Brook Park	0.5							X	X											

In 1987 additional sites on the Tuolumne, San Joaquin, Merced and Stanislaus Rivers were sampled occasionally (1987 annual report).

Table 8. Tuolumne River analysis of female spawners to fry density.

TUOLUMNE RIVER ANALYSIS OF FEMALE SPAWNERS TO FRY DENSITY (TID/MID)

TUOL.R. FALL-RUN	TOTAL FEMALE SPAWNERS	JUVENILE SEINING	PEAK FRY DENSITY	AVERAGE FRY DENSITY 15JAN-15MAR	LOG TRANSFORMATION TOTAL FEMALE SPAWNERS	LOG TRANSFORMATION PEAK FRY DENSITY	LOG TRANSFORMATION AVERAGE FRY DENSITY 15JAN-15MAR
1985	22600	86	158.8	59.5	4.4	2.2	1.8
1986	3800	87	69.3	46.2	3.6	1.8	1.7
1987	4600	88	70.2	33.9	3.7	1.8	1.5
1988	4100	89	115.1	39.7	3.6	2.1	1.6
1989	680	90	11.4	5.0	2.8	1.1	0.7
1990	28	91	1.3	0.5	1.4	0.1	-0.3
1991	28	92	6.1	2.9	1.4	0.8	0.5
1992	55	93	1.7	0.9	1.7	0.2	0.0
1993	237	94	79.5	41.5	2.4	1.9	1.6
1994	249	95	12.5	9.8	2.4	1.1	1.0
1995	522	96	16.1	13.0	2.7	1.2	1.1
1996	1142	97	2.8	2.1	3.1	0.4	0.3
1997	4224	98	49.3	24.6	3.6	1.7	1.4
1998	4527	99	78.0	39.3	3.7	1.9	1.6
1999	3535	00	78.8	48.0	3.5	1.9	1.7
2000	11260	01	126.3	85.6	4.1	2.1	1.9
2001	4970	02	92.8	41.5	3.7	2.0	1.6
2002	3876	03	164.3	68.8	3.6	2.2	1.8
2003	1768	04	38.8	27.2	3.2	1.6	1.4

LINEAR REGRESSION ON LOG VALUES
Total females to peak fry density (1986-2004)
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.832668282
R Square	0.693336468
Adjusted R Square	0.675297437
Standard Error	0.38556338
Observations	19

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5.713765209	5.713765209	38.43535	9.7019E-06
Residual	17	2.527205046	0.14865912		
Total	18	8.240970255			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.54622703	0.338767249	-1.612396207	0.125284	-1.260964446	0.16851039	-1.260964446	0.16851039
X Variable 1	0.656929802	0.10596283	6.199624928	9.7E-06	0.43336746	0.880492143	0.43336746	0.880492143

LINEAR REGRESSION ON LOG VALUES
Total females to average fry density (1986-2004)
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.835771078
R Square	0.698513295
Adjusted R Square	0.680778782
Standard Error	0.376800361
Observations	19

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5.592140224	5.592140224	39.38723	8.36787E-06
Residual	17	2.413634709	0.141978512		
Total	18	8.005774933			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.79953316	0.331067805	-2.415013334	0.027284	-1.49802615	-0.10104018	-1.49802615	-0.101040176
X Variable 1	0.649900387	0.103554525	6.27592458	8.37E-06	0.431419132	0.868381641	0.431419132	0.868381641

Table 9. Summary table of salmonids observed during the 1996-2004 (June/July) snorkel surveys.

	TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF SALMONIDS OBSERVED								TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF O. mykiss OBSERVED							
	CHINOOK 1996	**CHINOOK 1997**	**CHINOOK 1999**	**CHINOOK 2000**	**CHINOOK 2001**	**CHINOOK 2002**	**CHINOOK 2003**	**CHINOOK 2004**	**RAINBOW 1996**	**RAINBOW 1997**	**RAINBOW 1999**	**RAINBOW 2000**	**RAINBOW 2001**	**RAINBOW 2002**	**RAINBOW 2003**	**RAINBOW 2004**
DATES	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	June 11-13	June 18-20	June 16-18	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	June 11-13	June 18-20	June 16-18
LOCATIONS																
Riffle A7 (RM 50.7)	20	0	23	211	277	429	426	390	0	2	14	14	7	5	66	12
Riffle 1A (RM 50.4)	29	-	-	47					2	-	-	3				
Riffle 2 (RM 49.9)	16	0	3	-	4	10	72	16	88	2	0	-	3	1	8	23
Riffle 3B (RM 49.1)	4	0	108	34	52	83	16	59	127		31	14	8	11	5	22
Riffle 5B (RM 47.9)	56	0	20	35	47	17	4	4	25	0	10	19	4	3	6	11
Sec. Total	**125**	**0**	**154**	**327**	**380**	**539**	**518**	**469**	**242**	**4**	**55**	**50**	**22**	**20**	**85**	**68**
Riffle 7 (RM 46.9)	20	1	57	0	17	15	0	4	4	0	15	52	4	5	14	13
Riffle 12 (RM 45.8)	-	-	-	6					-	-		5				
Riffle 13A-B (RM 45.6)	-	-	-	5	6	10	9	3	-	-		20	3	2	1	5
Riffle 17A2 (RM 44.4)	-	-	-	0					-	-		14				
Riffle 21 (RM 42.9)	2	-	-	0	0	1	0	7	0	-		27	2	1	0	5
Riffle 23B-C (RM 42.3)	-	2	1	0	1	2	8	1	-	0	9	4	0	0	1	0
Sec. Total	**22**	**3**	**58**	**11**	**24**	**28**	**17**	**15**	**4**	**0**	**24**	**122**	**9**	**8**	**16**	**23**
Riffle 26 (RM 40.9)	-	-	-	0					-	-	-	4				
Riffle 27 (RM 40.3)	-	-	-	0					-	-	-	2				
Riffle 30B (RM 38.5)	-	-	0	-			0		-	-	0	-			0	
Riffle 31 (RM 38.1)	-	-	-	0	0			0	-	-	-	2	0			0
Riffle 35A (RM 37.0)	0	-	-	0		0	2	7	0	-	-	0		0	0	0
Riffle 36A (RM 36.7)	0	0	0	-					0	0	0	-				
Riffle 37 (RM 36.2)	-	-	-	0	0				-	-	-	0	0			
Sec. Total	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**7**	**0**	**0**	**0**	**8**	**0**	**0**	**0**	**0**
Riffle 41A (RM 35.3)	-	-	-	0	0	0	0	0	-	-	-	0	0	0	0	0
Riffle 46 (RM 34.0)	-	-	-	0					-	-	-	0				
Riffle 52B (RM 32.2)	-	-	-	0					-	-	-	0				
Riffle 57 (RM 31.5)	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. Total	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Grand Total	**148**	**3**	**213**	**338**	**404**	**567**	**537**	**491**	**246**	**4**	**79**	**180**	**31**	**28**	**101**	**91**

	TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF DENSITY INDICES (SALMONIDS OBSERVED / 1000 SQ. FT.)								TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF DENSITY INDICES (O. mykiss OBSERVED / 1000 SQ. FT.)							
	CHINOOK 1996	**CHINOOK 1997**	**CHINOOK 1999**	**CHINOOK 2000**	**CHINOOK 2001**	**CHINOOK 2002**	**CHINOOK 2003**	**CHINOOK 2004**	**RAINBOW 1996**	**RAINBOW 1997**	**RAINBOW 1999**	**RAINBOW 2000**	**RAINBOW 2001**	**RAINBOW 2002**	**RAINBOW 2003**	**RAINBOW 2004**
DATES	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	June 11-13	June 18-20	June 16-18	July 02-09	June 25-26	June 15-16	June 5-21	June 18-20	June 11-13	June 18-20	June 16-18
LOCATIONS																
Riffle A7 (RM 50.7)		0.00	5.44	37.02	44.68	45.20	40.09	36.62		0.42	3.31	2.46	1.13	0.50	6.21	1.13
Riffle 1A (RM 50.4)		-	-	9.40						-	-	0.60				
Riffle 2 (RM 49.9)		0.00	0.43	-	0.38	0.60	5.96	1.07		0.19	0.00	-	0.29	0.06	0.66	1.53
Riffle 3B (RM 49.1)		0.00	24.55	7.08	4.77	9.40	1.56	6.63			7.05	2.92	0.73	1.20	0.49	2.47
Riffle 5B (RM 47.9)		0.00	3.09	5.67	4.53	0.80	0.27	0.42		0.00	1.55	3.08	0.39	0.10	0.40	1.16
Sec. Total		**0.00**	**6.95**	**15.09**	**10.02**	**9.76**	**10.83**	**10.65**		**0.15**	**2.48**	**2.31**	**0.58**	**0.36**	**1.78**	**1.54**
Riffle 7 (RM 46.9)	13.33	0.21	21.92	0.00	2.36	2.40	0.00	0.42	2.67	0.00	5.77	8.78	0.56	0.80	1.78	1.37
Riffle 12 (RM 45.8)	-	-	-	1.13					-	-		0.94				
Riffle 13A (RM 45.6)	-	-	-	2.94	1.64	1.50	1.18	0.33	-	-		11.76	0.82	0.30	0.13	0.54
Riffle 17A2 (RM 44.4)	-	-	-	0.00					-	-		4.12				
Riffle 21 (RM 42.9)	1.14	-	-	0.00	0.00	0.20	0.00	0.89	0.00	-		15.00	0.61	0.20	0.00	0.63
Riffle 23B-C (RM 42.3)	-	0.53	0.70	0.00	0.21	0.50	1.68	0.16	-	0.00	6.32	1.60	0.00	0.00	0.21	0.00
Sec. Total	**6.77**	**0.35**	**14.41**	**0.53**	**1.27**	**1.29**	**0.67**	**0.46**	**1.23**	**0.00**	**5.96**	**5.92**	**0.48**	**0.37**	**0.63**	**0.70**
Riffle 26 (RM 40.9)	-	-	-	0.00					-	-	-	2.00				
Riffle 27 (RM 40.3)	-	-	-	0.00					-	-	-	0.67				
Riffle 30B (RM 38.5)	-	-	0.00	-			0.00		-	-	0.00	-			0.00	
Riffle 31 (RM 38.1)	-	-	-	0.00	0.00			0.00	-	-	-	1.00	0.00			0.00
Riffle 35A (RM 37.0)	0.00	-	-	0.00		0.00	0.26	0.72	0.00	-	-	0.00		0.00	0.00	0.00
Riffle 36A (RM 36.7)	0.00	0.00	0.00	-					0.00	0.00	0.00	-				
Riffle 37 (RM 36.2)	-	-	-	0.00	0.00				-	-	-	0.00	0.00			
Sec. Total	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.12**	**0.32**	**0.00**	**0.00**	**0.00**	**0.70**	**0.00**	**0.00**	**0.00**	**0.00**
Riffle 41A (RM 35.3)	-	-	-	0.00	0.00	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00
Riffle 46 (RM 34.0)	-	-	-	0.00					-	-	-	0.00				
Riffle 52B (RM 32.2)	-	-	-	0.00					-	-	-	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	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**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

CDFG did not provide area measurements needed to calculate density indices

CDFG did not provide area measurements needed to calculate density indices

Table 10. Summary table of salmonids observed druing the 2001-2004 (September) snorkel surveys.

Late summer snorkel survey comparison

	TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF SALMONIDS OBSERVED								TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF O. mykiss OBSERVED					
	CHINOOK 2001	**CHINOOK 2002**	**CHINOOK 2003**	**CHINOOK 2004**					**RAINBOW 2001**	**RAINBOW 2002**	**RAINBOW 2003**	**RAINBOW 2004**		
DATES	Sept. 18-20	Sept. 24-26	Sept. 17-19	Sept. 15-17					Sept. 18-20	Sept. 24-26	Sept. 17-19	Sept. 15-17		
LOCATIONS														
Riffle A7 (RM 50.7)	21	2	2	0					3	1	16	11		
Riffle 2 (RM 49.9)	0	0	1	0					3	4	2	7		
Riffle 3B (RM 49.1)	0	0	3	0					1	1	21	7		
Riffle 5B (RM 47.9)	0	0	4	0					2	0	10	6		
Sec. Total	**21**	**2**	**10**	**0**	**0**	**0**			**9**	**6**	**49**	**31**	**0**	**0**
Riffle 7 (RM 46.9)	0	1	0	0					0	2	9	2		
Riffle 13B,13A (RM 45.5 / 45.6)	0	0	0	0					0	4	6	0		
Riffle 21 (RM 43.1)	0	0	1	0					3	0	6	7		
Riffle 23B-C (RM 42.3)	0	0	0	0					0	0	1	0		
Sec. Total	**0**	**1**	**1**	**0**	**0**	**0**			**3**	**6**	**22**	**9**	**0**	**0**
Riffle 31 / 30B (RM 38.1 / 38.5)	0	0	0	0					0	0	0	0		
Riffle 37 / 35A (RM 36.2 / 37.1)	0	0	1	0					0	0	0	0		
Sec. Total	**0**	**0**	**1**	**0**	**0**	**0**			**0**	**0**	**0**	**0**	**0**	**0**
Riffle 41A (RM 35.3)	0	0	1	0					0	0	0	0		
Riffle 57 (RM 31.5)	0	0	0	0					0	0	0	0		
Sec. Total	**0**	**0**	**1**	**0**	**0**	**0**			**0**	**0**	**0**	**0**	**0**	**0**
Grand Total	**21**	**3**	**13**	**0**	**0**	**0**			**12**	**12**	**71**	**40**	**0**	**0**

	TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF DENSITY INDICES (SALMONIDS OBSERVED / 1000 SQ. FT.)								TUOLUMNE RIVER SNORKEL SUMMARY -- YEARLY COMPARISON OF DENSITY INDICES (O. mykiss OBSERVED / 1000 SQ. FT.)					
	CHINOOK 2001	**CHINOOK 2002**	**CHINOOK 2003**	**CHINOOK 2004**					**RAINBOW 2001**	**RAINBOW 2002**	**RAINBOW 2003**	**RAINBOW 2004**		
DATES	Sept. 18-20	Sept. 24-26	Sept. 17-19						Sept. 18-20	Sept. 24-26	Sept. 17-19	Sept. 15-17		
LOCATIONS														
Riffle A7 (RM 50.7)	2.97	0.14	0.21						0.42	0.07	1.68	1.06		
Riffle 2 (RM 49.9)	0	0	0.09						0.20	0.21	0.19	0.31		
Riffle 3B (RM 49.1)	0	0	0.33						0.08	0.12	2.33	0.60		
Riffle 5B (RM 47.9)	0	0	0.32						0.16	0	0.80	0.26		
Sec. Total	**0.45**	**0.03**	**0.24**						**0.19**	**0.09**	**1.18**	**0.46**		
Riffle 7 (RM 46.9)	0	0.19	0.00						0	0.38	1.15	0.15		
Riffle 13B,13A (RM 45.5 / 45.6)	0	0	0.00						0	0.48	0.74	0.00		
Riffle 21 (RM 43.1)	0	0	0.17						0.67	0	1.03	0.52		
Riffle 23B-C (RM 42.3)	0	0	0.00						0	0	0.19	0		
Sec. Total	**0.00**	**0.04**	**0.04**						**0.12**	**0.22**	**0.82**	**0.22**		
Riffle 31 (RM 38.1)	0	0	0.00						0	0	0.00	0		
Riffle 37 (RM 36.2)	0	0	0.14						0	0	0.00	0		
Sec. Total	**0.00**	**0.00**	**0.07**						**0.00**	**0.00**	**0.00**	**0.00**		
Riffle 41A (RM 35.3)	0	0	0.13						0	0	0.00	0		
Riffle 57 (RM 31.5)	0	0	0.00						0	0	0.00	0		
Sec. Total	**0.00**	**0.00**	**0.05**						**0.00**	**0.00**	**0.00**	**0**		
Grand Total														

Table 11. Comparison of habitat designations

Tuolumne River snorkel locations							
LOCATION	**RIVER MILE**	**SITE**	**AREA (Sq. Ft.)**	**AVG. DEPTH (FEET)**	**General Habitat type**	**McBain & Trush 2002 Mesohabitat map types**	**CRRF March 2004 O. mykiss habitat locations**
Riffle A7	50.7	1	4,500	1.5	Riffle	Spawning area / riffle	upper section of Box 2
(1)		2	5,000	3.0	Riffle-Run	Formerly Pool (Gravel added by DFG)	Box 2
Riffle 2	49.9	1	3,700	1.3	Riffle	Spawning area / riffle	
		2	3,000	8.0	Pool	Pool / run	Box 8
		3	4,000	5.0	Run	Pool	Box 9
Riffle 3B	49.1	1	4,000	2.0	Riffle	Spawning area / riffle	Box 11
		2	5,000	2.5	Run-Riffle	Pool / spawning area	upper section of Box 12
Riffle 5B	47.9	1	1,500	1.8	Riffle	Riffle	Box 16
		2	6,000	4.5	Run	Pool	lower section of Box 16
		3	5,000	5.0	Run-Pool	Pool	Box 17
			41,700				
Riffle 7	46.9	1	1,800	1.3	Riffle	Spawning area / riffle	lower section of Box 18
		2	6,000	3.5	Run	Run	Box 19
Riffle 13B	45.5	1	4,500	2.5	Riffle-Run	Spawning area / run	Box 23
		2	3,600	2.0	Riffle	Spawning area / run	Box 23
Riffle 21	42.9	1	1,800	2.2	Riffle	Riffle	Box 34
		2	4,000	4.5	Run	Pool	
Riffle 23C	42.3	1	2,250	2.0	Riffle-Run	Run / Pool	Box 39
		2	3,000	1.5	Riffle	Riffle	Box 40
			26,950				
Riffle 31	38.0	1	4,000	1.5	Riffle	Riffle	
(2)		2	3,750	3.0	Run-Pool	Riffle / Pool	
Riffle 35A	37.1	1	2,100	1.2	Riffle	Riffle	
		2	5,250	3.0	Run	Riffle / Pool	
Riffle 41A	35.3	1	2,400	2.0	Run-Riffle		
		2	2,400	5.0	Pool		
		3	3,000	2.5	Run-Riffle		
Riffle 57	31.5	1	5,000	1.5	Riffle		
		2	7,000	2.0	Run		
			34,900				

(1) Location 2 was modified by CDFG in 2003

(2) New snorkel site (replacing Riffle 30B) due to 7/11 project

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-4

1998 Shiloh Rotary Screw Trap Report

and

2002 and 2003 Grayson Rotary Screw Trap Reports

Prepared by

Dennis Blakeman

California Department of Fish and Game
Anadromous Fisheries Program
San Joaquin Valley Southern Sierra Region (Region 4)

March 2005

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1998 Juvenile Chinook Salmon Capture and Production Indices Using Rotary-Screw Traps on the Lower Tuolumne River

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October 2004

INTRODUCTION

The Tuolumne River, California, originates in Yosemite National Park, flows through the San Joaquin Valley and into the San Joaquin River draining a 1,900 square mile basin of the western Sierra Nevada Mountains (Figure 1). The Lower Tuolumne River has been severely impacted by the construction of dams, which impede fish passage, large scale historical gold dredging, in-channel gravel mining, and water withdrawals. Declines in salmon stocks along the Pacific Coast, and particularly in the San Joaquin Valley, California, starting in the late 1800 led to increasing efforts at conservation and protective measures. Historically, California boasted strong pacific salmon stocks with runs of winter, spring, fall, and late-fall chinook salmon, and the Tuolumne River at times had the largest runs of fall run salmon in the Central Valley except for the Sacramento River (Yoshiyama, 2000; Fry, 1961). The San Joaquin Basin runs have declined appreciably and the Tuolumne River has experienced similar declines in the various stocks. Over fishing, habitat loss, and water quality degradation have jointly led to the decline of chinook salmon stocks in the Tuolumne River. The National Marine Fisheries Service (NMFS) currently lists the fall run chinook salmon as a candidate species for federal ESU listing in the central valley.

The Central Valley Project Improvement Act (CVPIA) requires the USFWS to take measures to restore native anadromous fisheries stocks to sustainable levels. The Comprehensive Assessment and Monitoring Program (CAMP) was implemented to evaluate success towards achieving this requirement. The California Department of Fish and Game (CDFG) operate one rotary-screw trap on the Tuolumne River for CAMP. The monitoring is also a component of the New Don Pedro FERC Settlement Agreement (Sections 13d, e, f, and g).

Rotary-screw traps (RST) are used in many studies of salmon along the Pacific Coast (Demko et al., 1999; Roper and Scarnecchia, 1996; Thedinga et al., 1994). RST have been operated on the Tuolumne River near the confluence with the San Joaquin River since 1995 (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001).

Several factors affect juvenile salmon migration rate and timing. Studies on the Columbia River indicate that the rate of migration (Giorgi et al., 1997; NMFS, 2000) and survival (NMFS, 2000) both increase with increasing flow. Previous studies on the Tuolumne River (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001) present preliminary assessments of smolt migration and production using rotary-screw traps. This paper attempts to expand the existing data by examining the 1998 juvenile outmigrant data. The 1998 sample season used only one RST to conduct sampling. Previous and subsequent sampling seasons have used two traps operating side by side. The objectives of this study are to: 1) estimate the production of juvenile chinook salmon and 2) determine the timing of juvenile Chinook salmon migration during the 1998 sampling season.

METHODS

Site Description

One rotary screw trap was operated at the Shiloh Bridge, approximately 4 river miles from the confluence of the San Joaquin and the Tuolumne Rivers (Figure 1). No attempt was made to enhance trap efficiency by altering the river channel. The trap was attached by cable to the Shiloh Bridge. The north bank of this section of river is a steep bank armored by natural shrubs and trees. The south bank is a gentle sloping sandbar with natural riparian vegetation and a walnut tree orchard. The substrate through this area is dominated by sand. The thalweg generally runs near the north bank but varies at low flows.

Rotary Screw Traps and Operations

The rotary screw trap has an 8 ft. diameter cone, screened with 3 mm diameter perforated plate and mounted between two pontoons. The perforated plate effectively sieves fish from the water. An internal helical aluminum plate transfers water flow into rotational energy causing the cone to turn. As the cone rotates, migrating fish which swim into the mouth of the cone are directed toward the back and into the attached live box where they are held until processed. The helical design of the cone prevents fish from escaping the live box and exiting through the entrance of the cone.

Trap checks were performed on a daily basis, four times per day, beginning on 15 March 1998. Figure 2 displays catch of non-marked and marked salmon, flow, vulnerability releases, and days sampled. The trap sampled weekdays (cone raised on Friday and lowered again on Sunday) from 15 March – 12 April and again from 14 June – 1 July. The trap sampled everyday from 12 April – 14 June. Trap checks were scheduled to minimize time between each check. The last check was conducted on the morning of 1 July, and traps removed the following week. Data collection for each trap check included: (1) fish capture data, (2) environmental variable data, and (3) trap operation data. Fish were identified, enumerated and fork length measured to the nearest millimeter. All fish held in the live box were removed and data recorded. All salmon captured were separated, checked for marks, and measured to the nearest millimeter. A smoltification index code was assigned to each measured salmon (marked and unmarked) and recorded. The smolt index criteria assign a number from 1 to 3 for different stages of development:

parr; silvery parr; and smolt respectively. When non-marked salmon captures were large (greater than 100) approximately 100 salmon fork lengths were measured and recorded. The remaining salmon were counted and recorded as plus counts. Non salmonid captures were identified to species and a maximum of 20 individuals measured with extras recorded as plus counts. Air and water temperatures (^{o}C), water turbidity, water velocity and conductivity data were collected for each trap check. Turbidity (NTU) was measured with a Hach portable turbidity meter. Conductivity (μs cm^{-1}) was measured with a Cole-Palmer CON 5 conductivity meter. Water velocities were taken at the mouth of each trap at a depth of 1.5 ft using a Global Water Flow Probe flow meter. Unidentifiable fish were labeled as unknown and preserved for later identification in the laboratory. Table 1 summarizes capture of all non-salmon catches.

Vulnerability Tests

Vulnerability tests were conducted weekly beginning on 18 March with the last test on 14 May (Table 2). Vulnerability tests consist of releasing a known number of dye marked fish approximately 0.5 miles upstream of the rotary-screw trap. Marked fish were held for 24 hours prior to release in live cars placed in the river at the release site. This allowed the fish ample time to acclimate to the river conditions and account for handling mortality. Releases were conducted close to or after sunset prior to the routine trap check. Fish were released into the river over a 5-10 minute period, approximately one half mile upstream from the trap site. Recaptures generally occurred the night of the test through the morning check the following day. The test release groups were approximately 2,000 fish per test. All of the fish used in the vulnerability tests were of Merced River Fish Facility (MRFF) origin. The test fish were marked at the hatchery with subcutaneous dye. Marks consisted of a subcutaneous dye mark on the dorsal, anal or upper or lower lobe of the caudal fin.

Vulnerability, also referred to as trap efficiency, is the ratio of total number of marked fish released to the total number of recaptured marked fish during a vulnerability test. The data and prior information (Demko et al., 1999; Vasques and Kundargi, 2001) suggest that juvenile salmon exhibit varying degrees of vulnerability to capture by size.

Hatchery produced marked fish were used to determine trap vulnerabilities as a function of flow. Estimated numbers of naturally produced salmon passing the trap was determined by dividing the number of juveniles caught during one sample period (trap check to trap check) by the estimated vulnerability for that sample period. Vulnerability (V) was determined by first creating a relationship (R) between trap efficiency and flow (Equation 1). This was done using the trap efficiency (*% recapture*) and average flow over three days at release ($flow_{release}$), from the day before to the day after each release test.

$$R = \frac{\%recapture}{flow_{release}} \qquad \textbf{Equation 1}$$

Daily vulnerabilities (V_{daily}) were determined by applying the relationship (*R*) to the daily average river flow ($Flow_{avg.daily}$) passing the trap on each day and dividing by the percent of day (*%D*) the trap fished for that day (Equation 2).

$$V_{daily} = \frac{Flow_{avg.daily} * R}{\%D} \qquad \textbf{Equation 2}$$

The percent day fished was determined by dividing trap revolutions by theoretical revolutions. Theoretical revolutions was calculated by multiplying the average revolutions per minute for the sample period (readings taken daily) by the minutes fished. Using the percent of day the trap sampled accounts for days which the cone may have stopped rotating during the sample period. The number of naturally produced salmon (N_{daily}) passing the trap during each sample period was then divided by the daily vulnerability (V_{daily}) to obtain a total daily estimate (E_{daily}) of naturally produced juvenile fish passing the trap each day (Equation 3).

$$E_{daily} = \frac{N_{daily}}{V_{daily}} \qquad \textbf{Equation 3}$$

Estimates developed for weekday sampling were expanded to weekends not sampled by multiplying the weekday estimates by 7/5. Daily estimates were then summed to obtain a total juvenile production estimate for 2003.

RESULTS AND DISCUSSION

Catch and Timing of Outmigration

Figure 2 shows fork length distribution for all captured Chinook salmon, and also indicates dates of vulnerability releases and days sampled.

The total catch of unmarked juvenile chinook salmon in 1998 was 2,521 fish (Figure 3). The estimated total catch of naturally produced juvenile chinook in 1998 was 1,615,673 (Figure 4). There were two releases of CWT marked fish conducted on 15 April (n=51,660 and n=48,634) at Old La Grange Bridge. Dye marked fish were of hatchery origin, but none were CWT marked fish.

Catches of juvenile salmon appear to correlate to changes in river flow. Heyne and Loudermilk (1998) made a similar observation in previous sampling with rotary screw traps. Peaks in fry captures occur temporally with early peaks of fry occurring in January and February. Similar studies (Vick et al., 1998; Heyne and Loudermilk, 1999) indicate similar temporal peaks in outmigration. This data indicates that on the Tuolumne River, fry migrate down river in January and early to mid February. Additionally, it appears that changes in flow, particularly flow increases, may initiate this movement downstream.

The 1998 survey season started on 15 February, just after the time during which fry migration begins. Fry migration usually occurs January and February during freshets in wetter years. River flows in 1998 reached nearly 7,000 cfs in late February and early March. Fry migration occurred through March with over 99% of captured fry passing the trap before 30 March and declined in concurrence with dropping flows. Flows dropped to about 3,000 cfs in mid March and increased again to over 5,500 cfs in mid April.

Smolt migration appears to occur mid-April through early May. Fork length frequency of juvenile chinook captured in 1998 is displayed in Figure 5, and represents fork lengths only, not the number of chinook captured.

Vulnerability Tests

There are inherent problems conducting vulnerability tests to estimate trap efficiencies. Accuracy of estimating trap efficiencies is dependent on conducting numerous test releases to completely and adequately quantify how vulnerability changes over time as flows change and juvenile salmon size increases. Personnel, financial, and other logistical constraints (e.g. hatchery fish availability, etc.) limit the number of efficiency tests which can be effectively conducted during the sampling period. Accurate efficiency estimates and expanded daily estimates assume the trap operated throughout 100% of the sample period. This is rarely, if ever, the case. It is often impossible to estimate the actual amount of time sampled, so here again estimates must be calculated. In 1998 there were eight vulnerability tests conducted (Table 2). One release (on 6 May, n=1,954) was not used in the analysis because there were no recaptures for the release. The first vulnerability release (18 March, n=1,954) was used to calculate estimates of all previous sample days because there were no vulnerability tests conducted earlier. This was done because the relationship of flow to vulnerability did not accurately represent vulnerabilities of the traps from 15 February – 15 March when mainly fry were migrating past the trap. The relationship of flow to vulnerability for smolt size fish is quite different from fry size fish.

Juvenile Production Estimate

Expanded catch of naturally produced juvenile Chinook salmon was 1,615,673 for 1998 (Figure 4). Production estimates for 1998 were made using only one trap. Previous sampling was conducted using two traps fishing side by side. In 1998 the single trap fished in nearly the same location within the channel as did the north trap in previous years. The north trap (north side of channel and usually in the thalweg) usually captures more fish in relation to the south trap. Using just one trap for sampling in 1998 while not as good as using two, is still sufficient to develop a reasonable estimate. Sampling did not start early enough to encompass the entire fry migration period. An earlier start date could yield more data on the timing of early fry migration as well as produce a more accurate estimate. Vulnerability tests conducted January and February using fry captured in RST and marked with Bismarck brown dye could give more accurate trap vulnerabilities for fry size fish.

Table 1. Non-salmonid fish captures in the Tuolumne River rotary screw trap in 1998.

Common Name	Count
American shad	1
Bluegill sunfish	8
Black bullhead	3
Brown bullhead	1
Carp	7
Channel catfish	8
Goldfish	73
Largemouth bass	2
Mosquitofish	34
Mississippi silverside	18
Pacific lamprey	3
Prickly sculpin	4
Redear sunfish	1
Red shiner	19
Sacramento pikeminnow	46
Sacramento sucker	2
Smallmouth bass	1
Threadfin shad	46
Unknown	2
Warmouth	15
Wakasagi	19
White catfish	64
Yellow bullhead	1

Table 2. Vulnerability tests for 1998 Shiloh rotary screw trap with release numbers and number recaptured for each test.

Release Date	Mark Code[1]	Effective Release	Mean FL (range)	Number Recaptured	Vulnerability	Flow (cfs) @ Modesto[2]
3/18/1998	BLUC	1956	57 (47-67)	2	0.0010	3014
4/3/1998	BLLC	2005	65 (54-75)	2	0.0010	4998
4/8/1998	BLAN	1962	68 (62-70)	5	0.0025	5177
4/15/1998	RDLC	2000	77 (69-86)	4	0.0020	5402
4/22/1998	RDUC	1998	79 (68-90)	6	0.0030	3568
4/29/1998	RDAN	1979	85 (74-98)	1	0.0005	3368
5/6/1998	RDUC	1954	89 (81-98)	0	0.0000	2711
5/14/1998	RDUC	1974	88 (78-102)	1	0.0005	2731

[1] BL indicates blue dye mark, RD indicates red dye mark, UC - upper caudal, LC - lower caudal and AN - anal fin.

[2] Flow data are from California Data Exchange Center website, and is the 3 day average flow from 1 day before to 1 day after release date.

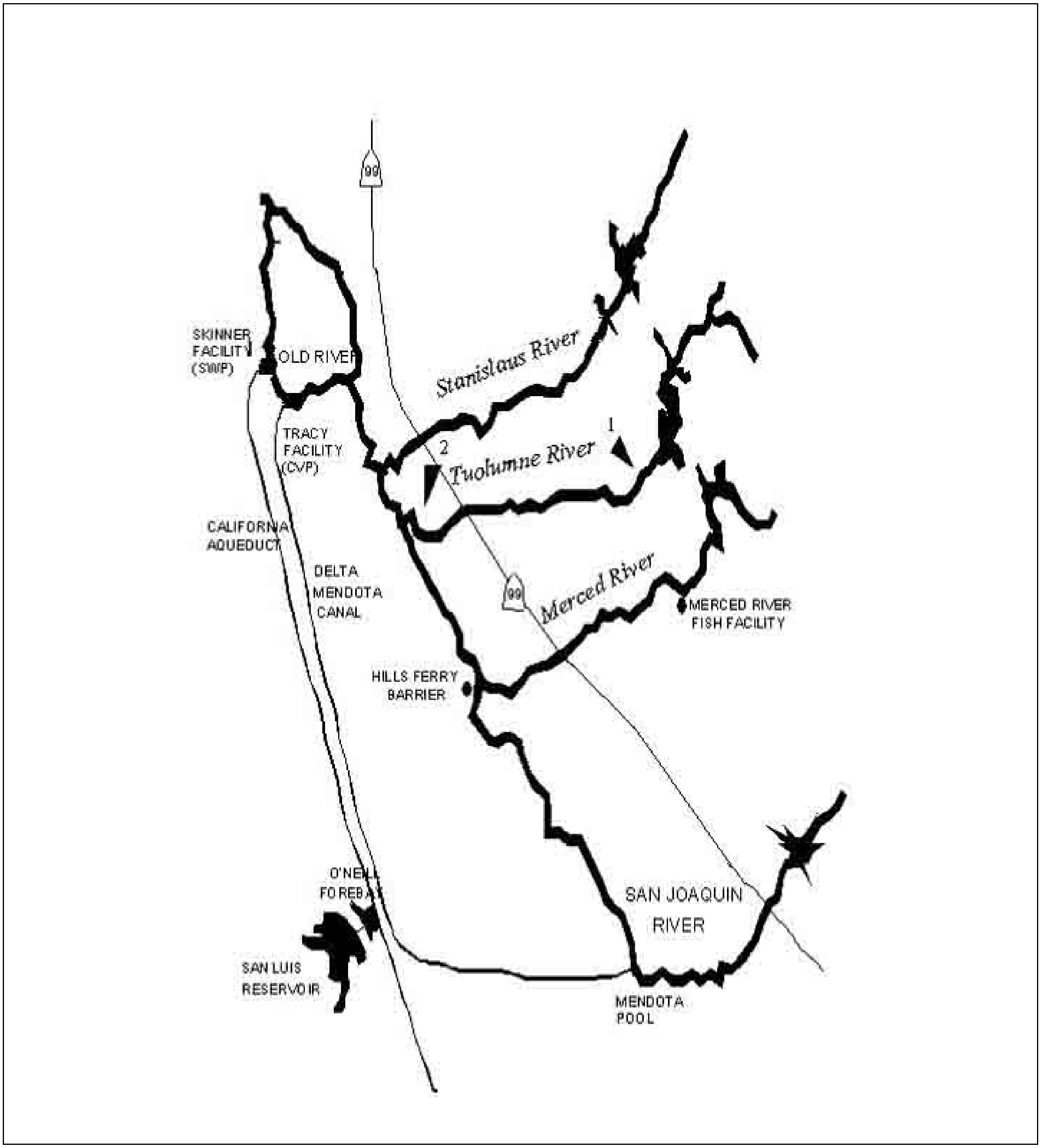

Figure 1. Map of San Joaquin River system with 1. La Grange and 2. Shiloh referenced for orientation.

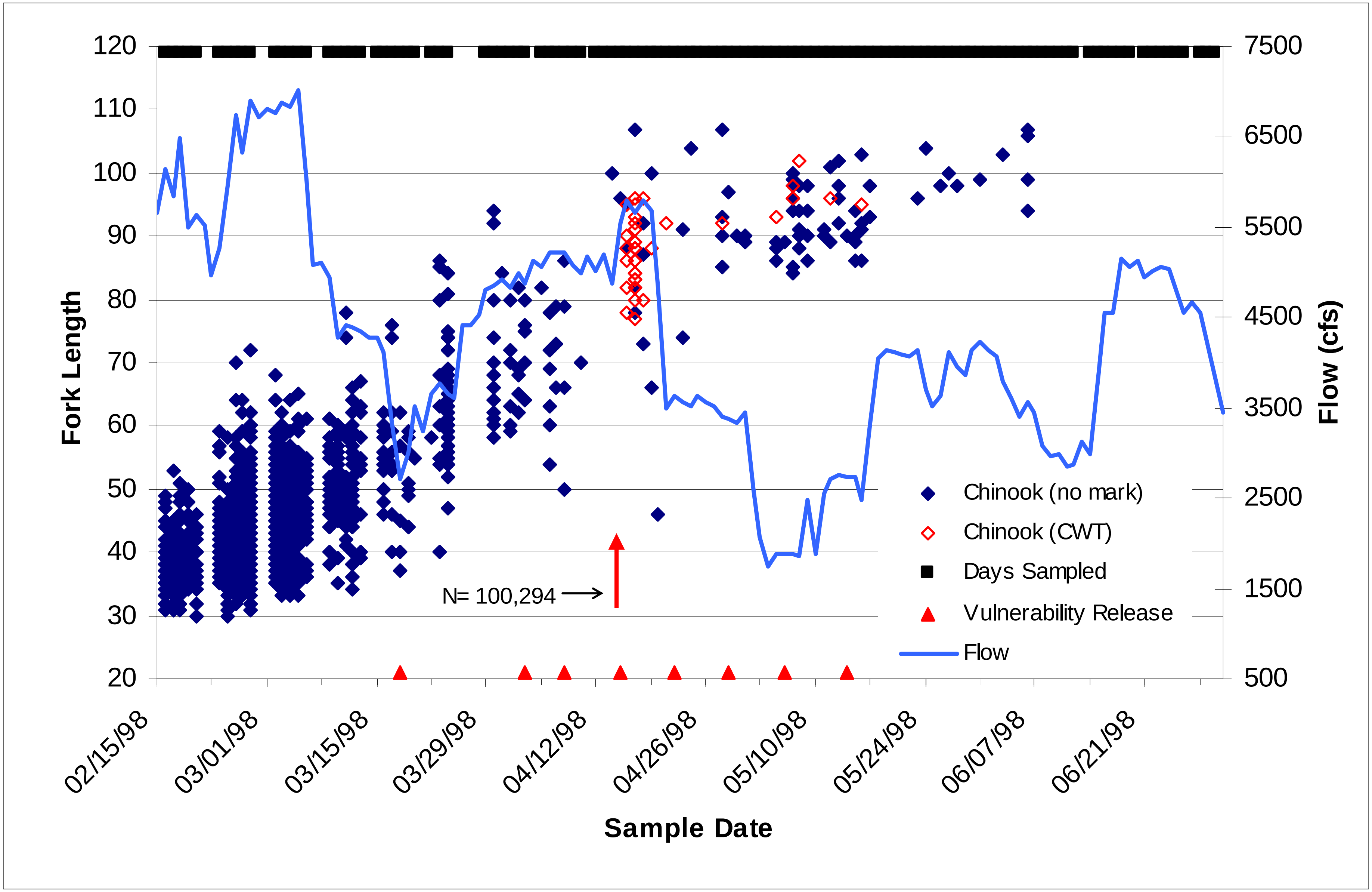

Figure 2. Fork length frequency of marked and unmarked Chinook salmon (CHN), flow (CFS, Modesto gage), vulnerability releases, CWT release on 15 April (N=100,294) and days which trap sampled.

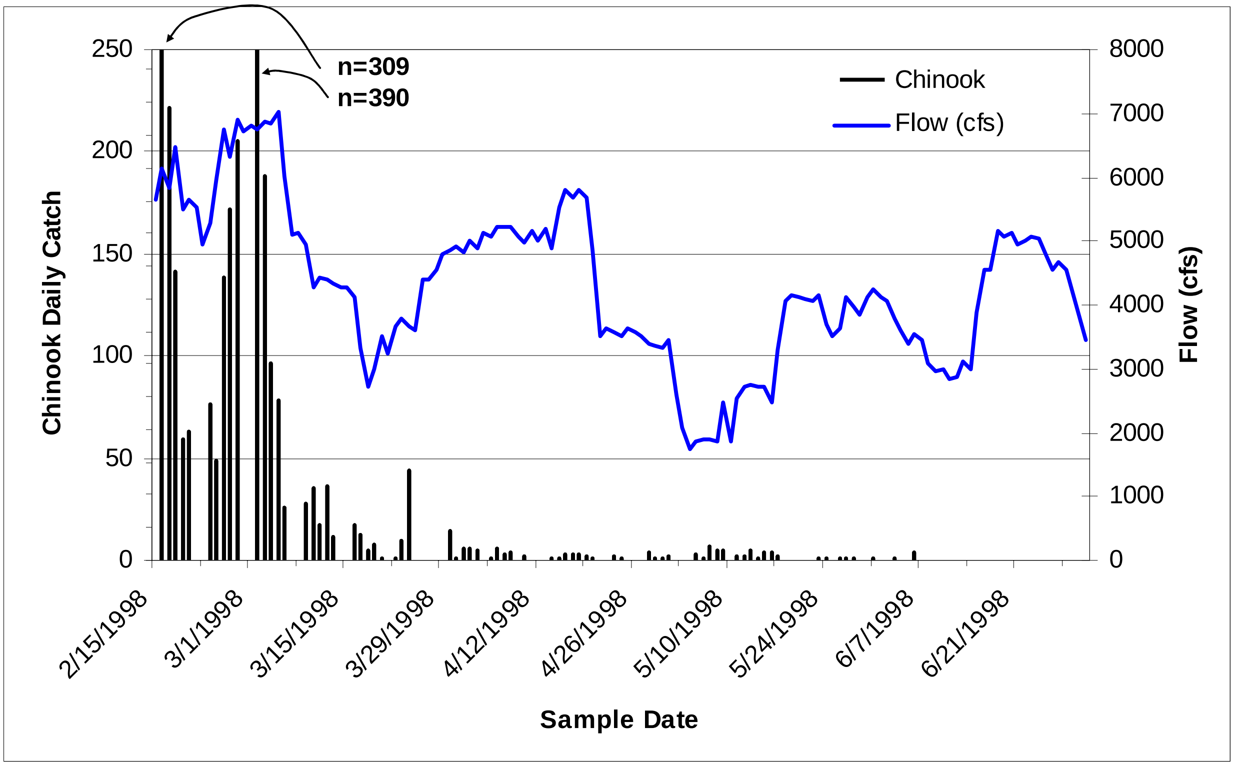

Figure 3. Daily catch of non adipose fin clipped juvenile chinook salmon with flow (cfs) at Modesto.

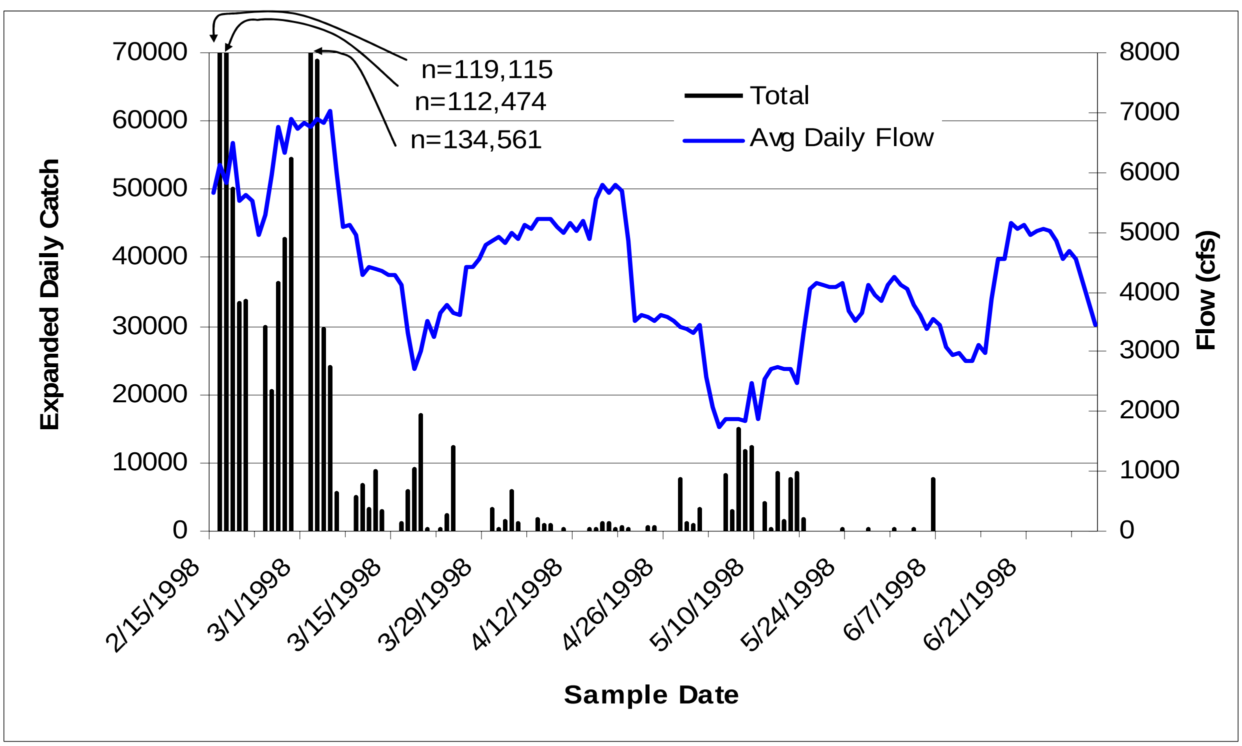

Figure 4. Expanded daily catch of naturally produced chinook salmon juveniles with flow (cfs) at Modesto gage.

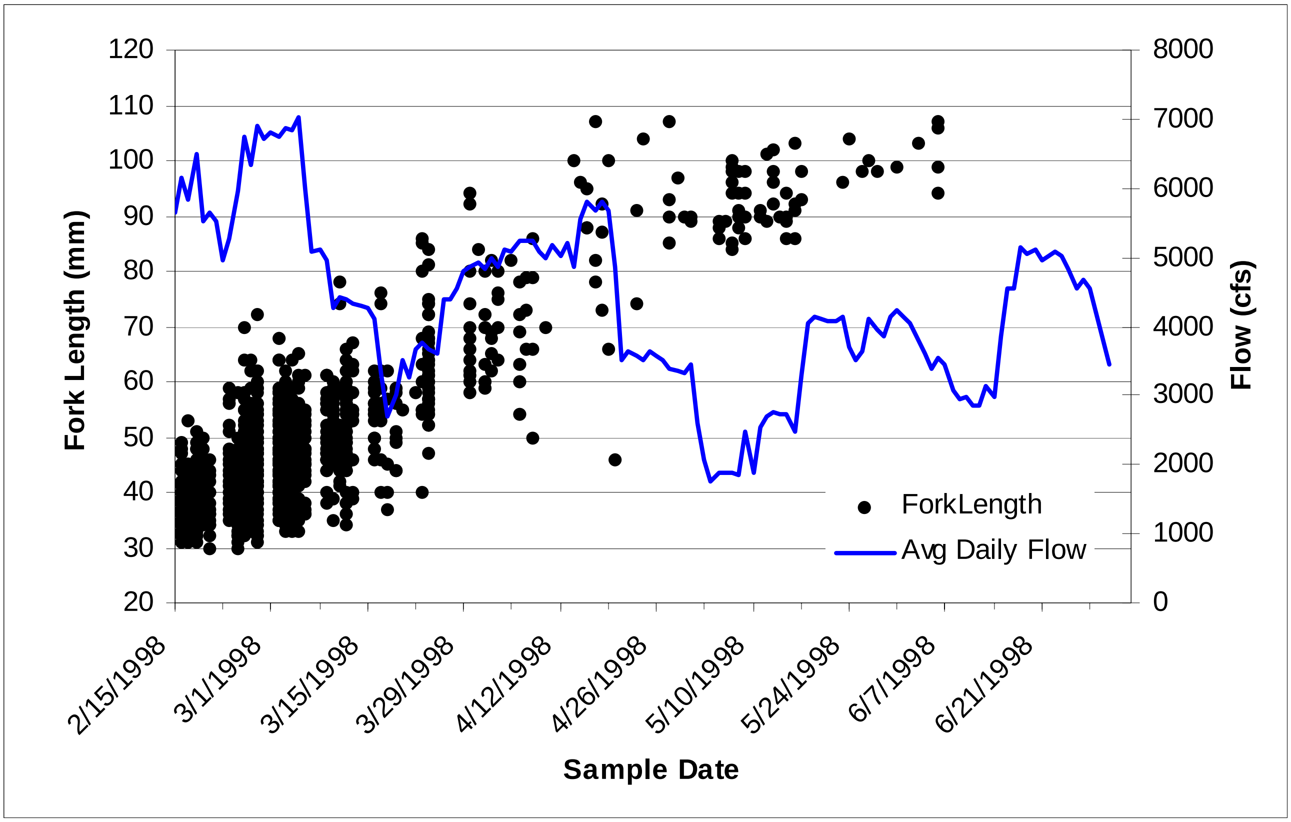

Figure 5. Fork lengths of non adipose fin clipped juvenile Chinook salmon captured in 1998. (Number of fish caught at each length is not represented.)

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2002 Juvenile Chinook Salmon Capture and Production Indices Using Rotary-Screw Traps on the Lower Tuolumne River

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INTRODUCTION

The Tuolumne River, California, originates in Yosemite National Park, flows through the San Joaquin Valley and into the San Joaquin River draining a 1,900 square mile basin of the western Sierra Nevada Mountains (Figure 1). The Lower Tuolumne River has been severely impacted by the construction of dams, which impede fish passage, large scale historical gold dredging, in-channel gravel mining, and water withdrawals. Declines in salmon stocks along the Pacific Coast, and particularly in the San Joaquin Valley, California, starting in the late 1800 led to increasing efforts at conservation and protective measures. Historically, California boasted strong pacific salmon stocks with runs of winter, spring, fall, and late-fall chinook salmon, and the Tuolumne River at times had the largest runs of fall run salmon in the Central Valley except for the Sacramento River (Fry, 1961). The San Joaquin Basin runs have declined appreciably and the Tuolumne River has experienced similar declines in the various stocks. Over fishing, habitat loss, and water quality degradation have jointly led to the decline of chinook salmon stocks in the Tuolumne River. The National Marine Fisheries Service (NMFS) currently lists the fall run chinook salmon as a candidate species for federal ESU listing in the central valley.

The Central Valley Project Improvement Act (CVPIA) requires the USFWS to take measures to restore native anadromous fisheries stocks to sustainable levels. The Comprehensive Assessment and Monitoring Program (CAMP) was implemented to evaluate success towards achieving this requirement. The California Department of Fish and Game (CDFG) operate two rotary-screw traps on the Tuolumne River for CAMP. One of the traps is provided by Turlock and Modesto Irrigation Districts (TID and MID, respectively) as part of the juvenile salmon monitoring component to CAMP. The monitoring is also a component of the New Don Pedro FERC Settlement Agreement (Sections 13d, e, f, and g).

Rotary-screw traps (RST) are used in many studies of salmon along the Pacific Coast (Demko et al., 1999; Roper and Scarnecchia, 1996; Thedinga et al., 1994). RST's have been operated on the Tuolumne River near the confluence with the San Joaquin River since 1995 (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001).

Several factors affect juvenile salmon migration rate and timing. Studies on the Columbia River indicate that the rate of migration (Giorgi et al., 1997; NMFS, 2000) and survival (NMFS, 2000) both increase with increasing flow. Previous studies on the Tuolumne River (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001) present preliminary assessments of smolt migration and production using rotary-screw traps. This paper attempts to expand the existing data by examining the 2002 juvenile outmigrant data. The objectives of this study are to: 1) estimate the production of juvenile chinook salmon and 2) determine the timing of juvenile Chinook salmon migration during the 2002 sampling season.

METHODS

Site Description

Two rotary screw traps were operated side by side at the Grayson River Ranch, approximately 5.2 river miles from the confluence of the San Joaquin and the Tuolumne Rivers (Figure 1). No attempt was made to enhance trap efficiency by altering the river channel. In the summer of 2000 some riparian restoration efforts began on the Grayson River Ranch, but there were no alterations to the channel. The traps were located approximately one mile upstream of the Shiloh Bridge anchored by a cable crossing the river. The north bank of this section of river is a steep riprap bank. The south bank has a gentle slope with heavy riparian vegetation. The substrate through this area is dominated by sand. The thalweg generally runs near the north bank but varies at low flows.

Rotary Screw Traps and Operations

The rotary screw traps have an 8 ft. diameter cone, screened with 3 mm diameter perforated plate and mounted between two pontoons. The perforated plate effectively sieves fish from the water. An internal helical aluminum plate transfers water flow into rotational energy causing the cone to turn. As the cone rotates, migrating fish which swim into the mouth of the cone are directed toward the back and into the attached live box where they are held until processed. The helical design of the cone prevents fish from escaping the live box and exiting through the entrance of the cone.

Trap checks were performed on a daily basis, although, at the start of the 2002 season the cones were raised so that traps did not sample on the weekends. Figure 2 displays catch of non marked and marked salmon, flow, vulnerability releases, and days which cones were not rotating when RST crew members arrived for trap checks.   When the traps were not sampled on the weekend the cones were raised after the Friday evening check and lowered on Sunday afternoon. From 15 January 2002 – 24 March 2002 traps were not sampled on weekends, and were checked once per day when operating. Trap checks were increased to 7 days per week and two checks per day from 1 April through 6 June 2002, the end of the sample period. Trap checks were scheduled for morning and evening checks to minimize time between each check. The last check was conducted on the morning of 6 June, and traps removed the following week. Personnel shortages due to the states hiring freeze, prohibited any further increase in trap checks at critical times, such as increases in flows and increases in salmonid captures. Data collection for each trap check included: (1) fish capture data, (2) environmental variable data, and (3) trap operation data. Fish were identified, enumerated and fork length measured to the nearest millimeter. All fish held in the live boxes were removed and recorded for each respective trap. All salmon captured were separated, checked for marks, and measured to the nearest millimeter. A smoltification index code as specified in the Interagency Ecological Program Steelhead Project Work Team, Steelhead Life-stage Assessment Protocol was assessed for every measured salmon (marked and unmarked) and recorded. The smolt index criteria assign a number from 1 to 5 for different stages of development: yolk sac fry; fry; parr; silvery parr; and smolt respectively. When non-marked salmon captures were large (greater than 100) approximately 100 salmon fork lengths were measured and recorded. The remaining salmon were counted and recorded as plus counts. In 2002, captures of non marked salmon were low and there was no need to implement the plus count protocol as has been needed in past years. Non salmonid captures were identified to species and a maximum of 20 individuals measured with extras recorded as plus counts. Air and water temperatures (^{o}C), water turbidity, water velocity and conductivity data were collected for each trap check. Turbidity (NTU) was measured with a Hach portable turbidity meter. Conductivity (μs cm^{-1}) was measured with a Cole-Palmer CON 5 conductivity meter. Water velocities were taken at the mouth of each trap at a depth of 1.5 ft using a Global Water Flow Probe flow meter. Unidentifiable fish were labeled as unknown and preserved for later identification in the laboratory. Table 1 summarizes capture of all non-salmon catches.

Vulnerability Tests

Vulnerability tests were conducted weekly beginning on 20 February with the last test on 30 May (Table 2). The last vulnerability release was discarded due to a high number of mortalities from high river temperatures. Vulnerability tests consist of releasing a known number of dye marked fish approximately 0.5 miles upstream of the rotary-screw traps. Marked fish were held for 24 hours prior to release in live cars placed in the river at the release site. This allowed the fish ample time to acclimate to the river conditions and account for handling mortality. Releases were conducted close to or after sunset prior to the routine trap check. Fish were released into the river over a 5-10 minute period, approximately one half mile upstream from the trap site. Recaptures generally occurred the night of the test through the morning check the following day. The test release groups ranged in number from approximately 2,000 to 4,000 fish per test. All of the fish used in the vulnerability tests were of Merced River Fish Facility (MRFF) origin. The test fish were marked at the hatchery with subcutaneous dye. Marks consisted of red dye mark on the dorsal, anal or upper or lower lobe of the caudal fin. The first five vulnerability release groups were dye marked only, the remaining vulnerability releases used coded wire tag (CWT) marked fish in combination with the dye mark.

Vulnerability, also referred to as trap efficiency, is the ratio of total number of marked fish released to the total number of recaptured marked fish during a vulnerability test. The data and prior information (Demko et al., 1999; Vasques and Kundargi, 2001) suggest that juvenile salmon exhibit varying degrees of vulnerability to capture by size. There was no obvious peak in fry captures, therefore vulnerability calculations were not separated for fry and smolt size classes. Peak fry captures occur during freshets in wetter water years, which did not occur during the drier 2002 season.

Hatchery produced marked fish were used to determine trap vulnerabilities as a function of flow. Estimated numbers of naturally produced salmon passing the trap was determined by dividing the number of juveniles caught during one sample period (trap check to trap check) by the estimated vulnerability for that sample period. Vulnerability (*V*) was determined by first creating a relationship (*R*) between trap efficiency and flow (Equation 1). This was done using the trap efficiency (*% recapture*) and average flow over three days at release ($flow_{release}$), from the day before to the day after each release test.

$$R = \frac{\%recapture}{flow_{release}}$$ **Equation 1**

Daily vulnerabilities (V_{daily}) were determined by applying the relationship (*R*) to the daily average river flow ($Flow_{avg.daily}$) passing the trap on each day and dividing by the percent of day (*%D*) the trap fished for that day (Equation 2).

$$V_{daily} = \frac{Flow_{avg.daily} * R}{\%D}$$ **Equation 2**

The percent day fished was determined by dividing trap revolutions by theoretical revolutions. Theoretical revolutions was calculated by multiplying the average revolutions per minute for the sample period (readings taken daily) by the minutes fished. Using the percent of day the trap sampled accounts for days which the cone may have stopped rotating during the sample period. The number of naturally produced salmon (N_{daily}) passing the trap during each sample period was then divided by the daily vulnerability (V_{daily}) to obtain a total daily estimate (E_{daily}) of naturally produced juvenile fish passing the trap each day (Equation 3).

$$E_{daily} = \frac{N_{daily}}{V_{daily}} \qquad \textbf{Equation 3}$$

Daily estimates were then summed to obtain a total juvenile production estimate for 2002. When sampling only occurred five days per week, weekly catch was expanded to the entire week by simply multiplying the weekly catch by $^7/_5$.

RESULTS AND DISCUSSION

Catch and Timing of Outmigration

Figure 2 shows fork length distribution for all captured Chinook salmon. Marked salmon captured are grouped together (i.e. dye marks and CWT). Other releases shown in Figure 2 include a small, (N=36) live box evaluation release and a large CWT survivability release at Old La Grange Bridge conducted over a two day period. Figure 2 also indicates dates of vulnerability releases and dates which cone rotation was stopped by debris or other obstruction.

The total catch of non adipose fin clipped chinook salmon in 2002 was a meager 438 fish (Figure 3). The total catch of naturally produced juveniles in 1999 was 19,327, in 2000 was 2,250 and in 2001 was 6,478. A total of 1008 CWT marked salmon were recaptured from the smolt survival test releases of 75,109 (effective release number) at the Old La Grange Bridge. Daily CWT captures are presented in Figure 4.

The length frequency of non-marked and CWT marked salmon is displayed in Figure 5. This figure represents fork lengths only, not the number of fish caught at each length. In other words, each point is a length that was recorded for that day but may contain any number of fish at that given length. This graph represents the fish sizes passing the traps throughout the season. This figure also shows the lack of an obvious fry peak migration from January to March which has been seen in the past (e.g. 1999 to 2001), as well as an increase of out migration with an increase of flow. In the 1999 and 2000 sample year's flows reached 2,000 cfs in late February and March. An increase to 7,000 cfs occurred mid February of 1999 and early March of 2000. The 2001 sample year saw flows over 3,500 cfs in late February and over 2,500 cfs in early March (Figure 6). Flows during the 2002 sampling season remained below 350 cfs from mid January through the first week of April and never got above 1,220 cfs, only increasing in mid April with the scheduled FERC spring pulse flow. Large concentrations of salmon fry (FL<65mm) were captured during freshets which occurred in previous years, but not in 2002, probably as a result of the lack of freshets and substantially lower flow levels.

Catches of juvenile salmon appear to correlate to changes in river flow. Heyne and Loudermilk (1998) made a similar observation when the screw traps were located under the Shiloh Bridge approximately 1.5 miles downstream. Peaks in fry captures occur temporally with early peaks of fry occurring in January and February. Similar studies (Vick et al., 1998; Heyne and Loudermilk, 1999) in previous years indicate similar temporal peaks in outmigration. This data indicates that on the Tuolumne River, fry migrate down river in January and early to mid February. Additionally, it appears that changes in flow, particularly flow increases, may initiate this movement downstream.

Smolt migration appears to occur mid-April through early May. Smolt size class fish (FL>65mm) are better able to avoid capture in rotary screw traps. Without the January and February high flows and freshets, fry migration essentially did not occur in 2002. Salmon fry that might have migrated downstream as a result of elevated flow conditions may have remained in the river and outmigrated as smolts. Since a lower juvenile salmon smolt catch occurred in 2002 concurrent with lower flow conditions, it is presumed that holdover fry did not migrate as smolts. Possibly they held over in the river as yearlings. Scale and otolith analysis from escapement surveys conducted 3 to 4 years later will determine whether or not an elevated fraction of juvenile salmon left the river as yearlings.

Vulnerability Tests

There are inherent problems conducting vulnerability tests to estimate trap efficiencies. Accuracy of estimating trap efficiencies is dependent on conducting numerous test releases to completely and adequately quantify how vulnerability changes over time as flows change and juvenile salmon size increases. Personnel, financial, and other logistical constraints (e.g. hatchery fish availability, etc.) limit the number of efficiency tests which can be effectively conducted during the sampling period. Accurate efficiency estimates and expanded daily estimates assume the trap operated throughout 100% of the sample period. This is rarely, if ever, the case. It is often impossible to estimate the actual amount of time sampled, so here again estimates must be calculated. The more estimates that are used, the less accurate the result. To minimize trap stoppages during critical times (i.e. increases in catch and or flow) more personnel could be used to monitor traps 24 hours per day. In 2002 there were fourteen vulnerability tests conducted (Table 2). One release was discarded due to high mortalities during the release and was not included in Table 2.

Juvenile Production Estimate

Expanded catch of non marked (naturally produced) juvenile Chinook salmon was 14,540 for 2002 (Figure 7). This is a marked decrease from previous years. The total estimate of juvenile Chinook production in 1999 was 1,133,887, in 2000 was 139,024 and in 2001 was 111,644. The 1999 – 2001 sampling seasons saw much higher estimates due mostly to the large numbers of fry passing the traps in January and February. Higher flows and freshets seen during this time flush Chinook salmon juveniles from the spawning reach out into the delta. During normal to dry years when Tuolumne River flows are strictly controlled, flows need to be allocated in sufficient quantities to actually aide in juvenile outmigration and survival. Pulse flows must also be timed properly to gain the most benefit for juvenile salmon.

Table 1. Non-salmonid fish captures in the Tuolumne River rotary screw trap in 2002.

Common Name	Number Captured
American Shad	2
Bluegill sunfish	169
Black crappie	66
Channel catfish	12
Fathead minnow	1
Goldfish	3
Green sunfish	8
Golden shiner	5
Largemouth bass	474
Bigscale logperch	3
Mosquito fish	60
Inland silverside	48
Pacific lamprey	215
Prickly sculpin	3
Redear sunfish	3
Red shiner	225
Sacramento pikeminnow	23
Sacramento sucker	58
Sacramento blackfish	2
Smallmouth bass	510
Spotted bass	125
Splittail	3
Striped bass	1
Threadfin shad	43
Unknown centrarchid	30
Unknown cyprinid	10
Unknown	1
Unknown ammocoete	76
Warmouth	9
White catfish	2141
White crappie	1

Table 2. Vulnerability tests for 2002 Grayson rotary screw traps with release numbers and number recaptured for each test. Vulnerability values represent both traps combined. *Note-last release of 4062 on 30 May was not included due to high mortality of fish.

Date	Mark[1]	Effective No. Released	Mean FL (range)	No. Recaptured	Vulnerability	Flow (cfs) @ Modesto[2]
2/20/2002	RDLC	2094	57 (45-72)	444	0.21	280
3/6/2002	RDAN	2331	68 (58-87)	316	0.14	283
3/13/2002	RDUC	2042	65 (51-81)	324	0.16	311
3/20/2002	RDDO	2105	68 (56-77)	242	0.11	307
3/27/2002	RDLC	2121	68 (57-77)	147	0.07	307
4/3/2002	ac-RDAN	1962	76 (63-89)	130	0.07	298
4/9/2002	ac-RDUC	1995	79 (65-91)	56	0.03	322
4/17/2002	ac-RDDO	2048	84 (74-97)	40	0.02	788
4/25/2002	ac-RDLC	2001	86 (78-89)	22	0.01	1027
5/1/2002	ac-RDAN	2033	89 (68-99)	14	0.01	1182
5/8/2002	ac-RDDO	2021	95 (82-105)	31	0.02	746
5/15/2002	ac-RDUC	2047	97 (74-107)	26	0.01	645
5/22/2002	ac-RDLC	2043	94 (68-114)	10	0.004	403

[1] ac indicates adipose fin clip and CWT, RD indicates red dye mark. UC indicates upper caudal, LC indicates lower caudal, DO indicates dorsal, and AN indicates anal fin.

[2]Flow data are from California Data Exchange Center website, and is the average of the flow 1 day before and 1 day after release date.

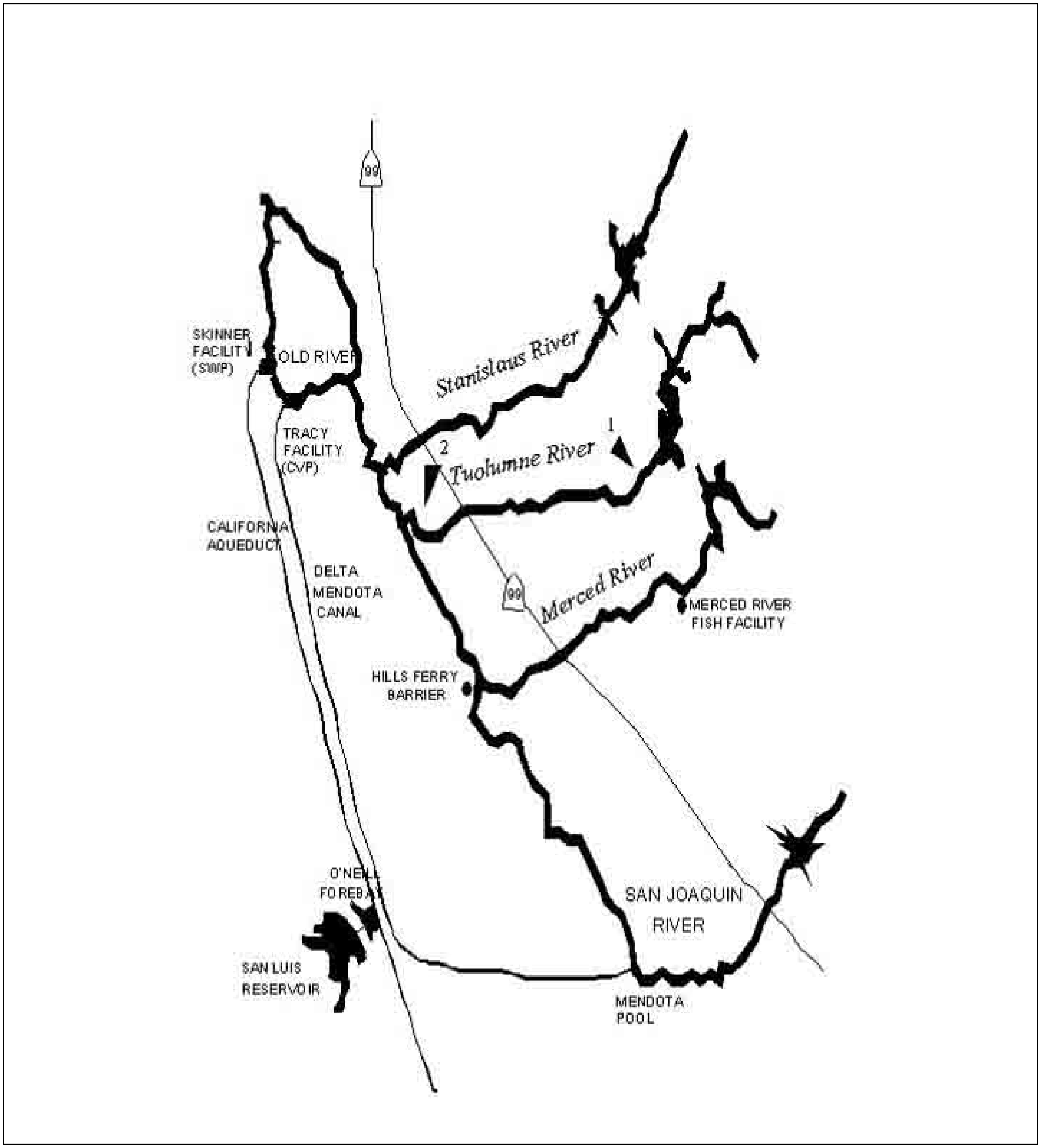

Figure 1. Map of San Joaquin River with 1. La Grange and 2. Shiloh referenced for orientation.

Tuolumne River RSTR 2002

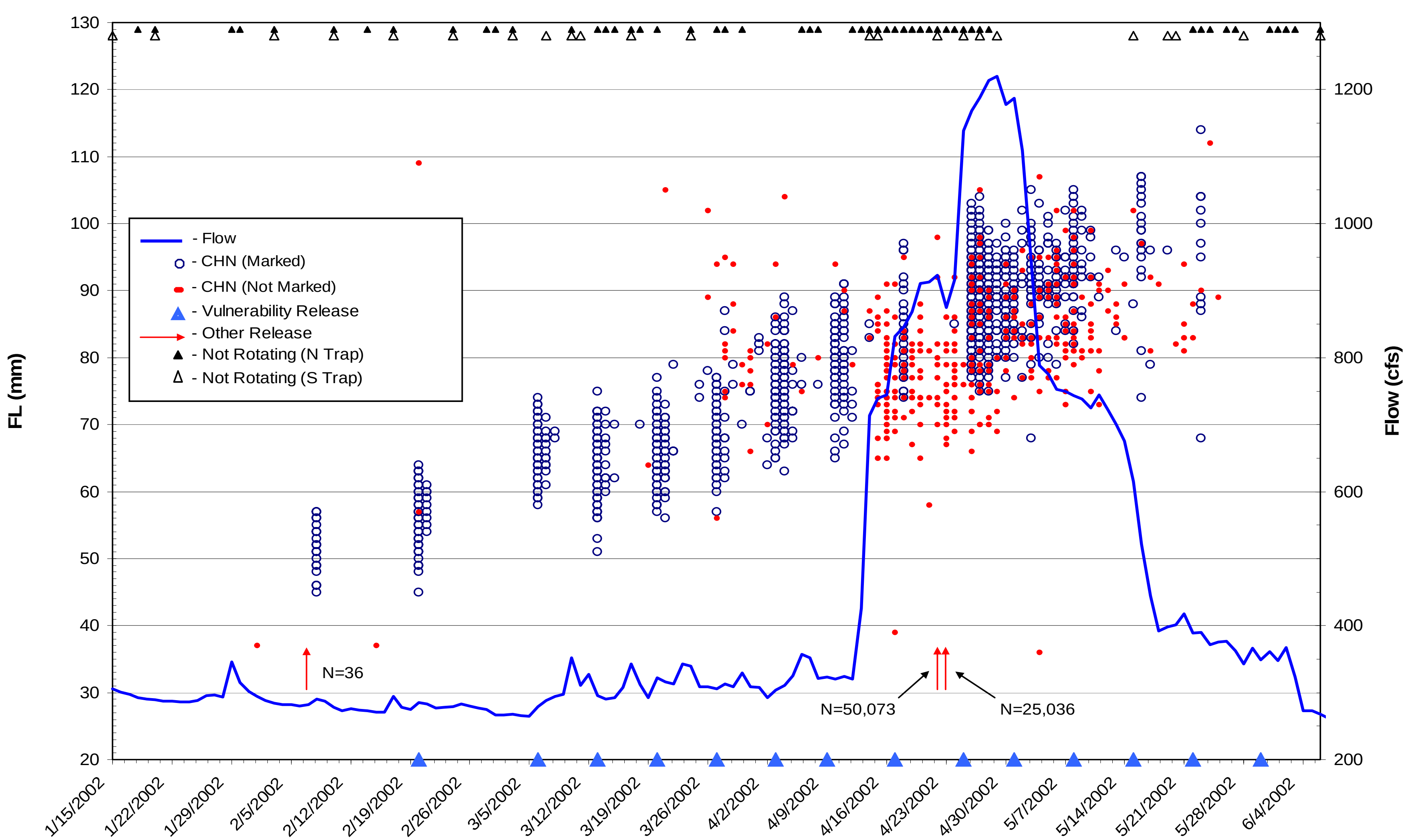

Figure 2. Fork length frequency of marked and unmarked Chinook salmon (CHN), flow (CFS, Modesto gage), vulnerability releases, and cones stopped rotating (N- north trap, S-south trap) at time of trap check. Other releases conducted were for live box integrity (N=36) on 7 February, and two releases for upper Tuolumne survival tests, (N=50,073 and N=25,036).

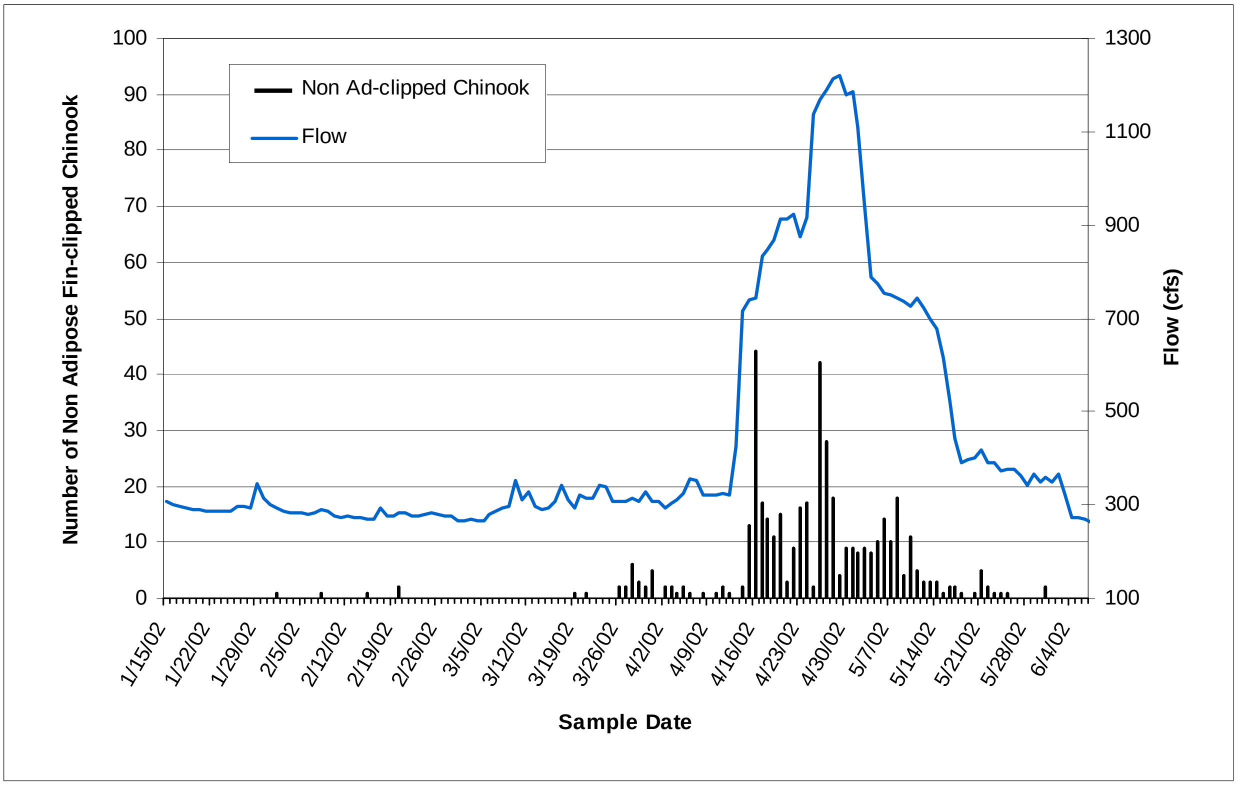

Figure 3. Daily catch of non adipose fin clipped juvenile chinook salmon with flow (cfs) at Modesto.

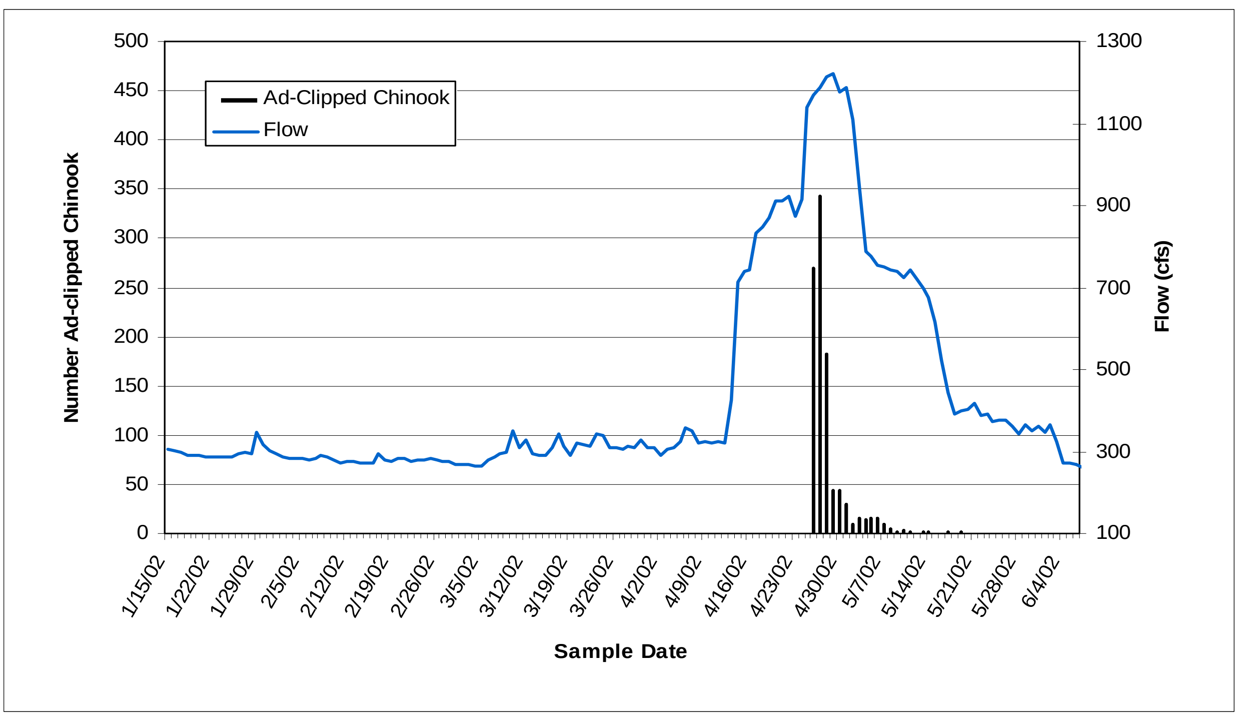

Figure 4. Daily catch of coded wire-tagged juvenile chinook salmon used in survival studies with flow at Modesto.

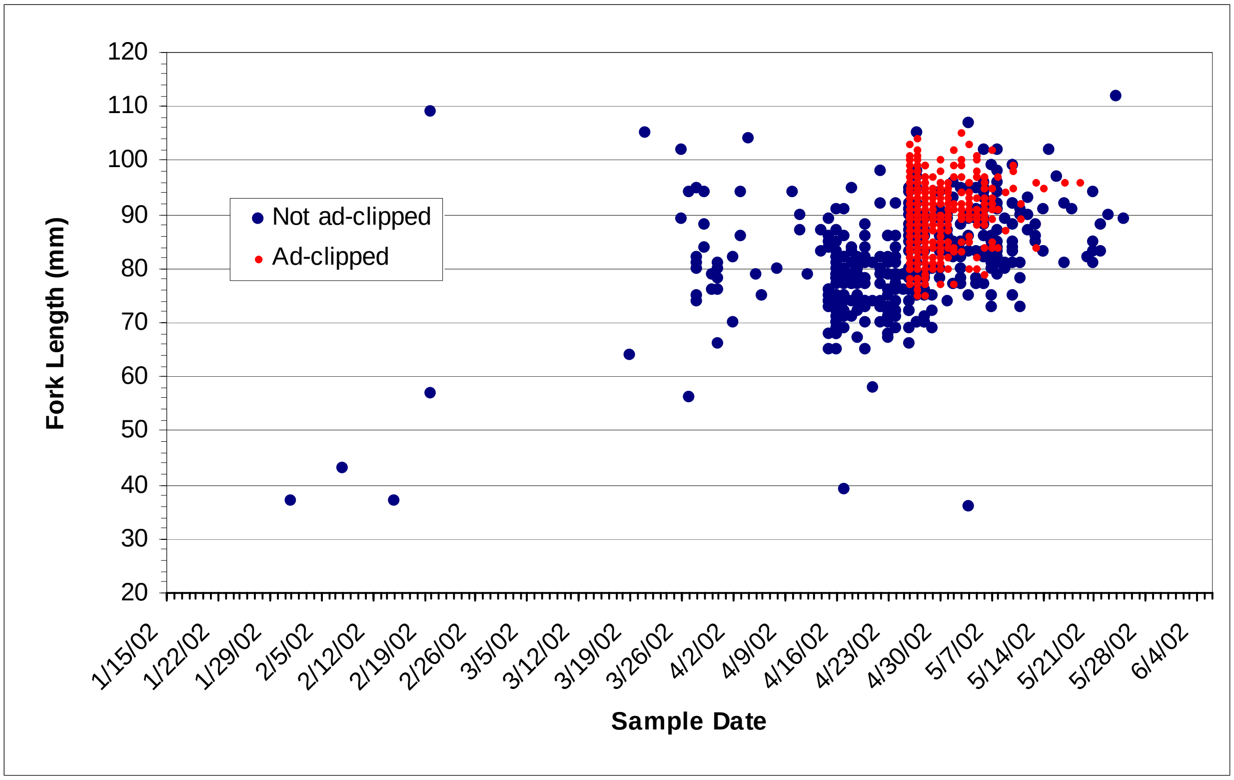

Figure 5. Fork lengths of non adipose fin clipped and adipose fin clipped Chinook salmon captured in 2002. Note the number of fish caught at each length is not represented in this figure.

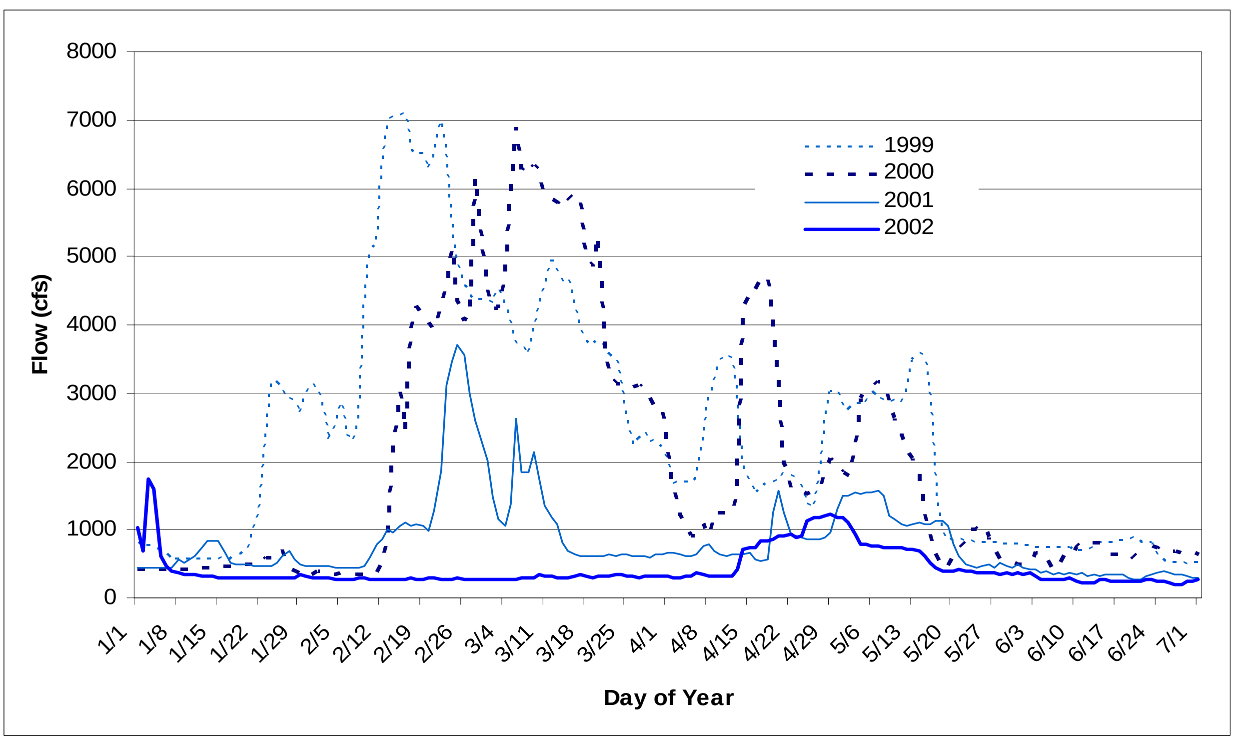

Figure 6. Tuolumne River flow at Modesto gage during RST sampling period, 1999-2002.

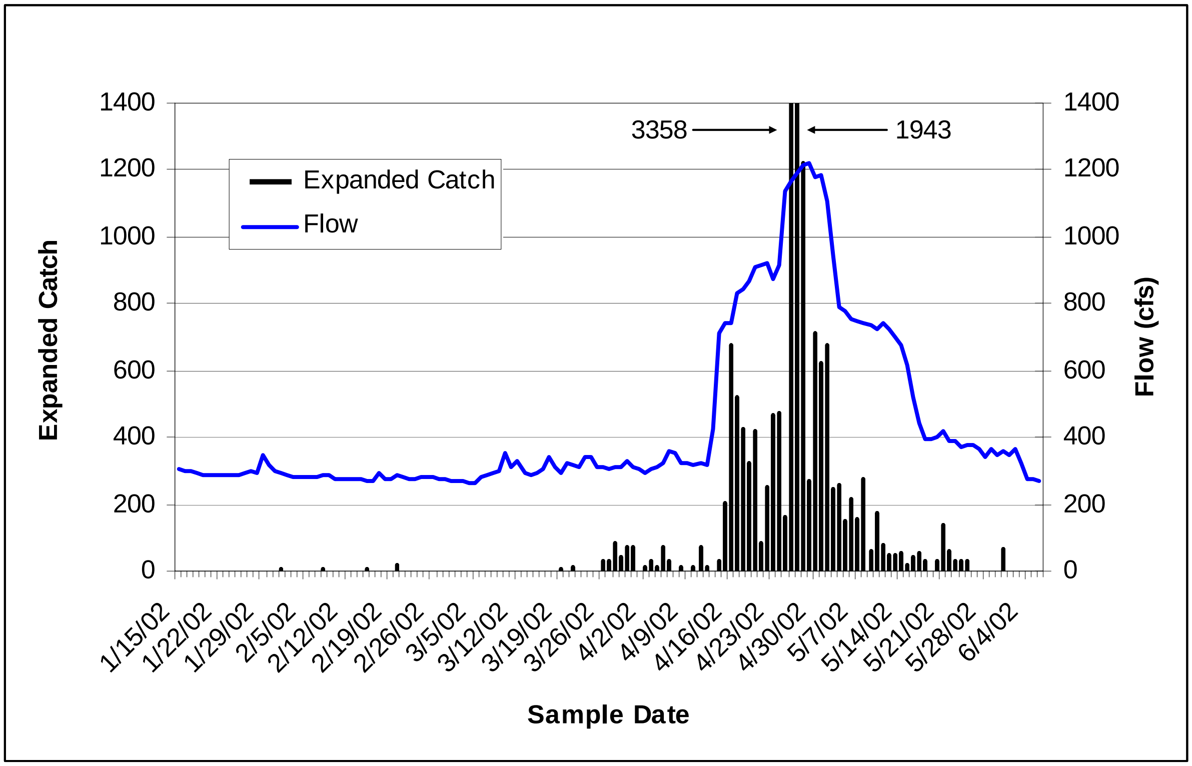

Figure 7. Expanded daily catch of naturally produced chinook salmon juveniles with flow at Modesto.

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2003 Juvenile Chinook Salmon Capture and Production Indices Using Rotary-Screw Traps on the Lower Tuolumne River

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INTRODUCTION

The Tuolumne River, California, originates in Yosemite National Park, flows through the San Joaquin Valley and into the San Joaquin River draining a 1,900 square mile basin of the western Sierra Nevada Mountains (Figure 1). The Lower Tuolumne River has been severely impacted by the construction of dams, which impede fish passage, large scale historical gold dredging, in-channel gravel mining, and water withdrawals. Declines in salmon stocks along the Pacific Coast, and particularly in the San Joaquin Valley, California, starting in the late 1800 led to increasing efforts at conservation and protective measures. Historically, California boasted strong pacific salmon stocks with runs of winter, spring, fall, and late-fall chinook salmon, and the Tuolumne River at times had the largest runs of fall run salmon in the Central Valley except for the Sacramento River (Yoshiyama, 2000; Fry, 1961). The San Joaquin Basin runs have declined appreciably and the Tuolumne River has experienced similar declines in the various stocks. Over fishing, habitat loss, and water quality degradation have jointly led to the decline of chinook salmon stocks in the Tuolumne River. The National Marine Fisheries Service (NMFS) currently lists the fall run chinook salmon as a candidate species for federal ESU listing in the central valley.

The Central Valley Project Improvement Act (CVPIA) requires the USFWS to take measures to restore native anadromous fisheries stocks to sustainable levels. The Comprehensive Assessment and Monitoring Program (CAMP) was implemented to evaluate success towards achieving this requirement. The California Department of Fish and Game (CDFG) operate two rotary-screw traps on the Tuolumne River for CAMP. One of the traps is provided by Turlock and Modesto Irrigation Districts (TID and MID, respectively) as part of the juvenile salmon monitoring component to CAMP. The monitoring is also a component of the New Don Pedro FERC Settlement Agreement (Sections 13d, e, f, and g).

Rotary-screw traps (RST) are used in many studies of salmon along the Pacific Coast (Demko et al., 1999; Roper and Scarnecchia, 1996; Thedinga et al., 1994). RST's have been operated on the Tuolumne River near the confluence with the San Joaquin River since 1995 (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001).

Several factors affect juvenile salmon migration rate and timing. Studies on the Columbia River indicate that the rate of migration (Giorgi et al., 1997; NMFS, 2000) and survival (NMFS, 2000) both increase with increasing flow. Previous studies on the Tuolumne River (Heyne and Loudermilk, 1997; 1998; Vasques and Kundargi, 2001) present preliminary assessments of smolt migration and production using rotary-screw traps. This paper attempts to expand the existing data by examining the 2003 juvenile outmigrant data. The objectives of this study are to: 1) estimate the production of juvenile chinook salmon and 2) determine the timing of juvenile Chinook salmon migration during the 2003 sampling season.

METHODS

Site Description

Two rotary screw traps were operated side by side at the Grayson River Ranch, approximately 5.2 river miles from the confluence of the San Joaquin and the Tuolumne Rivers (Figure 1). No attempt was made to enhance trap efficiency by altering the river channel. The traps were located approximately one mile upstream of the Shiloh Bridge anchored by a cable crossing the river. The north bank of this section of river is a steep riprap bank. The south bank has a gentle slope with heavy riparian vegetation. The substrate through this area is dominated by sand. The thalweg generally runs near the north bank but varies at low flows.

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Trap checks were performed on a daily basis beginning on 1 April 2003. Figure 2 displays catch of non-marked and marked salmon, flow, vulnerability releases, and days which cones were not rotating when RST crew members arrived for trap checks.   Traps were checked two times per day from 12 April - 25 April 2003. Trap checks were scheduled for morning and evening checks to minimize time between each check. The last check was conducted on the morning of 6 June, and traps removed the following week. Personnel shortages due to the states hiring freeze, prohibited any further increase in trap checks at critical times, such as increases in flow and debris, and increases in salmonid captures. Data collection for each trap check included: (1) fish capture data, (2) environmental variable data, and (3) trap operation data. Fish were identified, enumerated and fork length measured to the nearest millimeter. All fish held in the live boxes were removed and recorded for each respective trap. All salmon captured were separated, checked for marks, and measured to the nearest millimeter. A smoltification index code as specified in the Interagency Ecological Program Steelhead Project Work Team, Steelhead Life-stage Assessment Protocol was assessed for every measured salmon (marked and unmarked) and recorded. The smolt index criteria assign a number from 1 to 5 for different stages of development: yolk sac fry; fry; parr; silvery parr; and smolt respectively. When non-marked salmon captures were large (greater than 100) approximately 100 salmon fork lengths were measured and recorded. The remaining salmon were counted and recorded as plus counts. In 2003, captures of non marked salmon were low and there was no need to implement the plus count protocol as has been needed in past years. Non salmonid captures were identified to species and a maximum of 20 individuals measured with extras recorded as plus counts. Air and water temperatures (^{o}C), water turbidity, water velocity and conductivity data were collected for each trap check. Turbidity (NTU) was measured with a Hach portable turbidity meter. Conductivity ($\mu s\ cm^{-1}$) was measured with a Cole-Palmer CON 5 conductivity meter. Water velocities were taken at the mouth of each trap at a depth of 1.5 ft using a Global Water Flow Probe flow meter. Unidentifiable fish were labeled as unknown and preserved for later identification in the laboratory. Table 1 summarizes capture of all non-salmon catches.

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Vulnerability, also referred to as trap efficiency, is the ratio of total number of marked fish released to the total number of recaptured marked fish during a vulnerability test. The data and prior information (Demko et al., 1999; Vasques and Kundargi, 2001) suggest that juvenile salmon exhibit varying degrees of vulnerability to capture by size.

Hatchery produced marked fish were used to determine trap vulnerabilities as a function of flow. Estimated numbers of naturally produced salmon passing the trap was determined by dividing the number of juveniles caught during one sample period (trap check to trap check) by the estimated vulnerability for that sample period. Vulnerability (V) was determined by first creating a relationship (R) between trap efficiency and flow (Equation 1). This was done using the trap efficiency (*% recapture*) and average flow over three days at release ($flow_{release}$), from the day before to the day after each release test.

$$R = \frac{\%recapture}{flow_{release}} \qquad \textbf{Equation 1}$$

Daily vulnerabilities (V_{daily}) were determined by applying the relationship (R) to the daily average river flow ($Flow_{avg.daily}$) passing the trap on each day and dividing by the percent of day ($\%D$) the trap fished for that day (Equation 2).

$$V_{daily} = \frac{Flow_{avg.daily} * R}{\%D} \qquad \textbf{Equation 2}$$

The percent day fished was determined by dividing trap revolutions by theoretical revolutions. Theoretical revolutions was calculated by multiplying the average revolutions per minute for the sample period (readings taken daily) by the minutes fished. Using the percent of day the trap sampled accounts for days which the cone may have stopped rotating during the sample period. The number of naturally produced salmon (N_{daily}) passing the trap during each sample period was then divided by the daily vulnerability (V_{daily}) to obtain a total daily estimate (E_{daily}) of naturally produced juvenile fish passing the trap each day (Equation 3).

$$E_{daily} = \frac{N_{daily}}{V_{daily}} \qquad \textbf{Equation 3}$$

Daily estimates were then summed to obtain a total juvenile production estimate for 2003.

RESULTS AND DISCUSSION

Catch and Timing of Outmigration

Figure 2 shows fork length distribution for all captured Chinook salmon, and also indicates dates of vulnerability releases and dates which cone rotation was stopped by debris or other obstruction.

The total catch of unmarked juvenile chinook salmon in 2003 was 359 fish (Figure 3). The estimated total catch of naturally produced juvenile chinook in 2003 was 7,261 (Figure 4). There were no coded wire tagged (CWT) fish released in the Tuolumne River in 2003. Dye marked fish were of hatchery origin, but none were CWT marked fish.

Catches of juvenile salmon appear to correlate to changes in river flow. Heyne and Loudermilk (1998) made a similar observation when the screw traps were located under the Shiloh Bridge approximately 1.5 miles downstream. Peaks in fry captures occur temporally with early peaks of fry occurring in January and February. Similar studies (Vick et al., 1998; Heyne and Loudermilk, 1999) in previous years indicate similar temporal peaks in outmigration. This data indicates that on the Tuolumne River, fry migrate down river in January and early to mid February. Additionally, it appears that changes in flow, particularly flow increases, may initiate this movement downstream.

The 2003 survey season started on 1 April, well after the time during which fry migration would have occurred. Fry migration usually occurs January and February during freshets (in wetter years) which did not occur in 2002 or 2003. River flows in 2003 remained below 325 cfs from 1 January to 11 April 2003 when flows increased to about 1200 cfs. Flows were reduced to about 700 cfs on 12 April. Flows then ranged from 350 - 700 cfs through the end of the sample season. The 2002 and 2003 sample seasons had nearly the same flows during the fry migration period. Parr, silver parr and smolt size fish captures were low in 2002 and 2003 (438, 359 respectively). The escapement estimates from the previous fall surveys were also low for each year (2002 – 7,125 adults, 2003 – 2,163 adults). These factors most likely indicate that the fry migration was similarly low in both years. Essentially, fry migration most likely did not occur in 2003, therefore the juvenile production estimate would essentially be the same or similar if traps were fished throughout the entire outmigration season.

Smolt migration appears to occur mid-April through early May. Since sampling did not begin until 1 April, some smolt outmigrant may not have been sampled. For reason stated previously the number of fish which may have been missed was most likely small. The 2002 survey season caught only 27 fish from 15 January - 1 April (21 smolt, 6 fry). Smolt size class fish (FL>65mm) are better able to avoid capture in rotary screw traps. Fork length frequency of juvenile chinook captured in 2003 is displayed in Figure 5, and represents fork lengths only, not the number of chinook captured.

Vulnerability Tests

There are inherent problems conducting vulnerability tests to estimate trap efficiencies. Accuracy of estimating trap efficiencies is dependent on conducting numerous test releases to completely and adequately quantify how vulnerability changes over time as flows change and juvenile salmon size increases. Personnel, financial, and other logistical constraints (e.g. hatchery fish availability, etc.) limit the number of efficiency tests which can be effectively conducted during the sampling period. Accurate efficiency estimates and expanded daily estimates assume the trap operated throughout 100% of the sample period. This is rarely, if ever, the case. It is often impossible to estimate the actual amount of time sampled, so here again estimates must be calculated. The more estimates that are used, the less accurate the result. To minimize trap stoppages during critical times (i.e. increases in catch and or flow) more personnel could be used to monitor traps 24 hours per day. In 2003 there were eight vulnerability tests conducted (Table 2).

Juvenile Production Estimate

Expanded catch of naturally produced juvenile Chinook salmon was 7,261 for 2003 (Figure 4). This is a marked decrease from previous years. The total estimate of juvenile Chinook production in 1999 was 1,133,887, in 2000 was 139,024, in 2001 was 111,644 and in 2002 was 14,450. The 1999 – 2001 sampling seasons saw much higher estimates due somewhat to the large numbers of fry passing the traps in January and February. Higher flows and freshets seen during this time flush Chinook salmon juveniles from the spawning reach out into the delta. The 2002 and 2003 seasons had low flows and no early freshets to aide in fry migration. During normal to dry years when Tuolumne River flows are strictly controlled, flows need to be allocated in sufficient quantities and correct timing to actually aide in juvenile outmigration and survival. Pulse flows must also be timed properly to gain the most benefit for juvenile salmon.

Table 1. Non-salmonid fish captures in the Tuolumne River rotary screw trap in 2003.

Common Name	Number Captured
Bluegill sunfish	169
Black bullhead	2
Common carp	1
Channel catfish	12
Green sunfish	10
Golden shiner	14
Hardhead	1
Mosquito fish	53
Inland silverside	99
Pacific lamprey	788
Prickly sculpin	1
Redear sunfish	1
Red shiner	140
Sacramento pikeminnow	3
Sacramento sucker	12
Smallmouth bass	17
Spotted bass	2
Splittail	2
Threadfin shad	13
Unknown catfish	12
Unknown centrarchid	306
Unknown cyprinid	4
Unknown	1
Unknown ammocoete	3
Warmouth	2
White catfish	1197
White crappie	1

Table 2. Vulnerability tests for 2003 Grayson rotary screw traps with release numbers and number recaptured for each test. Vulnerability values represent both traps combined.

Release Date	Mark[1]	Effective No. Release	Mean FL (range)	No. Recaptured	Vulnerability	Flow (cfs) @ Modesto[2]
04/10/03	GRUC	1956	77 (62-91)	138	0.071	294
04/17/03	GRLC	2047	77 (61-95)	65	0.032	1178
04/24/03	GRAN	1979	88 (66-102)	31	0.016	1022
05/01/03	GRDO	2044	96 (80-108)	113	0.055	662
05/08/03	GRUC	2078	83 (63-101)	206	0.099	755
05/15/03	GRLC	1996	83 (68-95)	125	0.063	598
05/20/03	GRAN	1989	89 (72-103)	60	0.030	491
05/28/03	GRUC	1950	94 (75-108)	125	0.064	740

[1] GR indicates green dye mark, UC - upper caudal, LC - lower caudal, DO - dorsal and AN - anal fin.

[2] Flow data are from California Data Exchange Center website, and is the 3 day average flow from 1 day before to 1 day after release date.

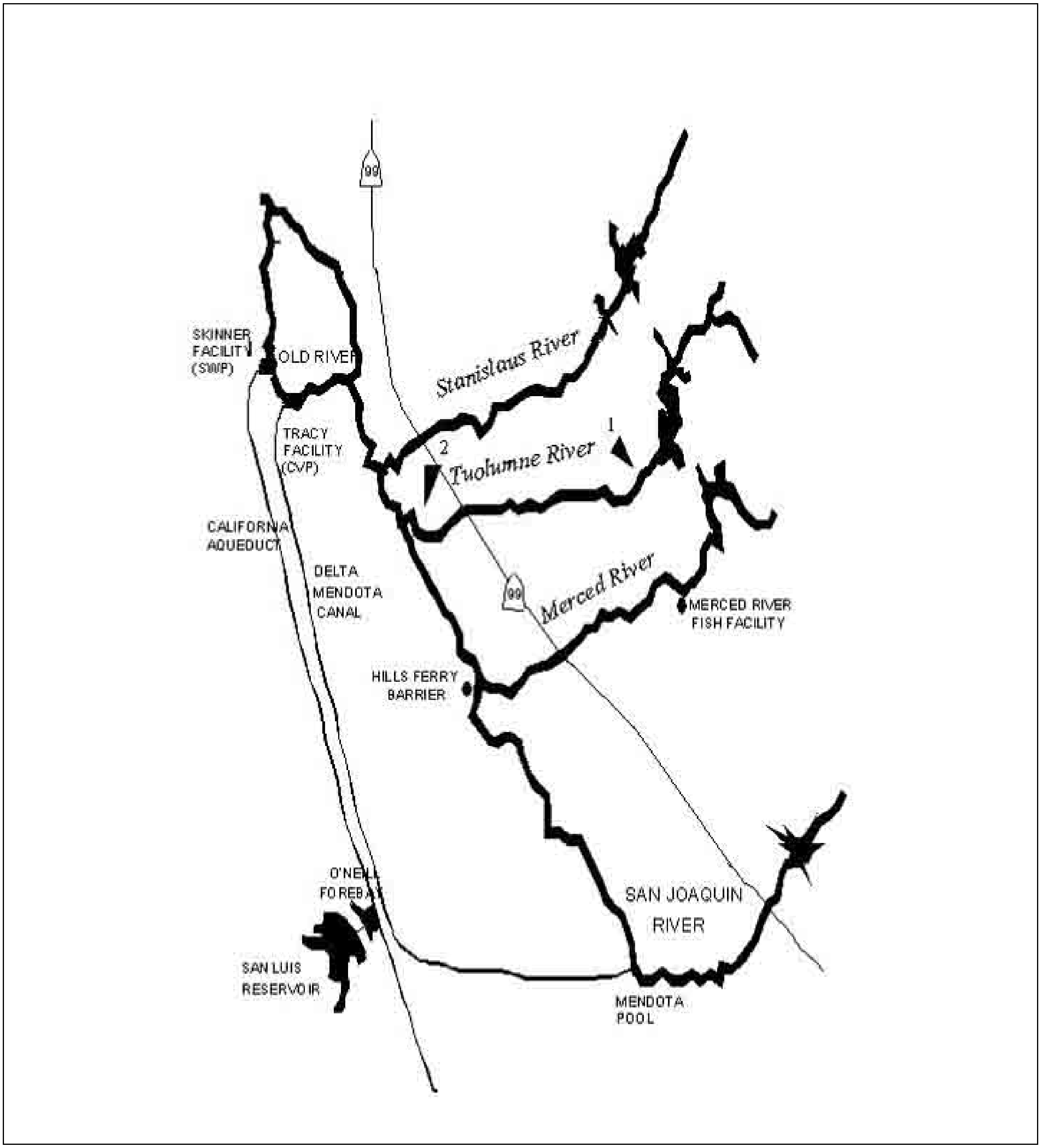

Figure 1. Map of San Joaquin River system with 1. La Grange and 2. Shiloh referenced for orientation.

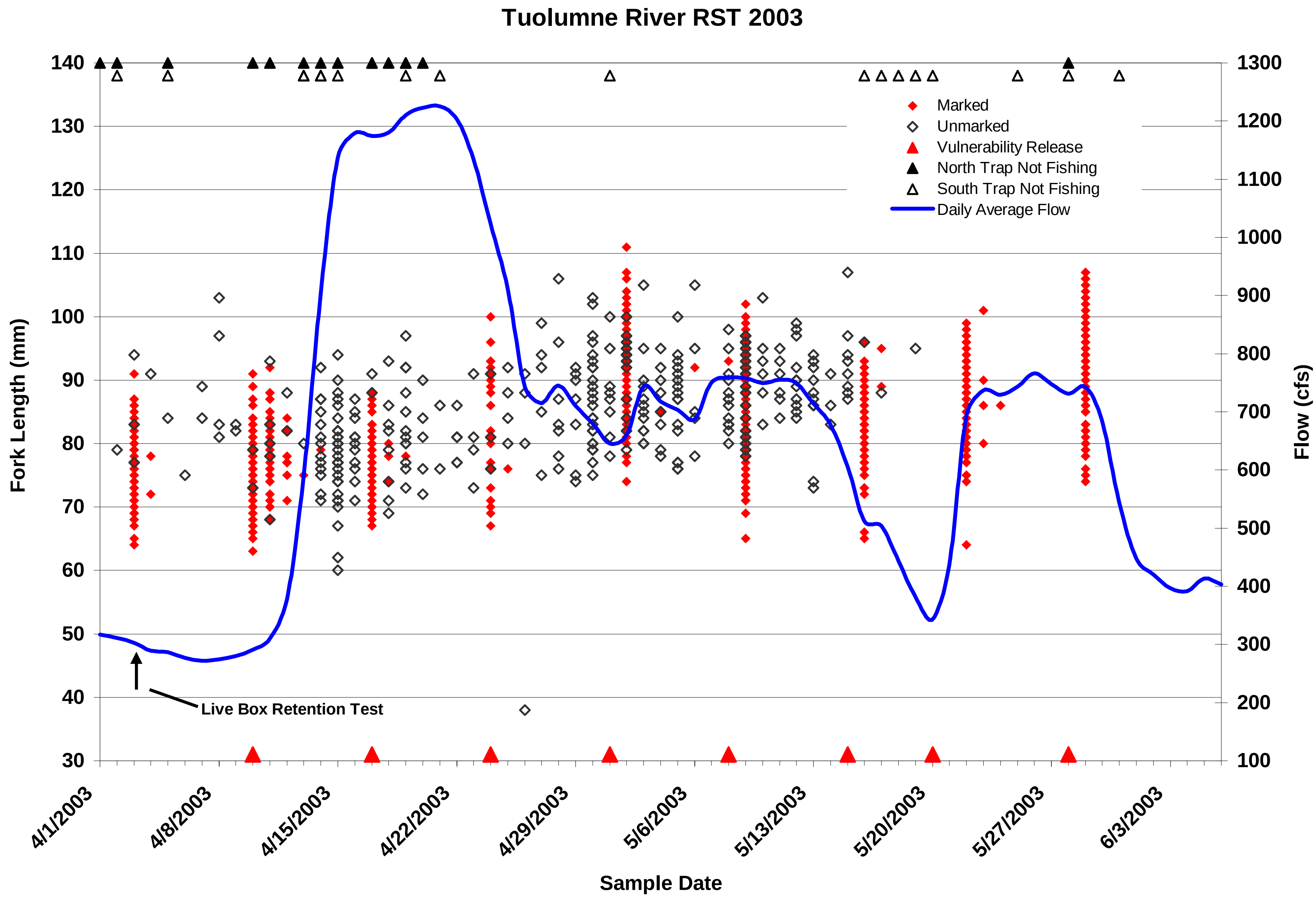

Figure 2. Fork length frequency of marked and unmarked Chinook salmon (CHN), flow (CFS, Modesto gage), vulnerability releases, and days which cones had stopped rotating at time of trap check.

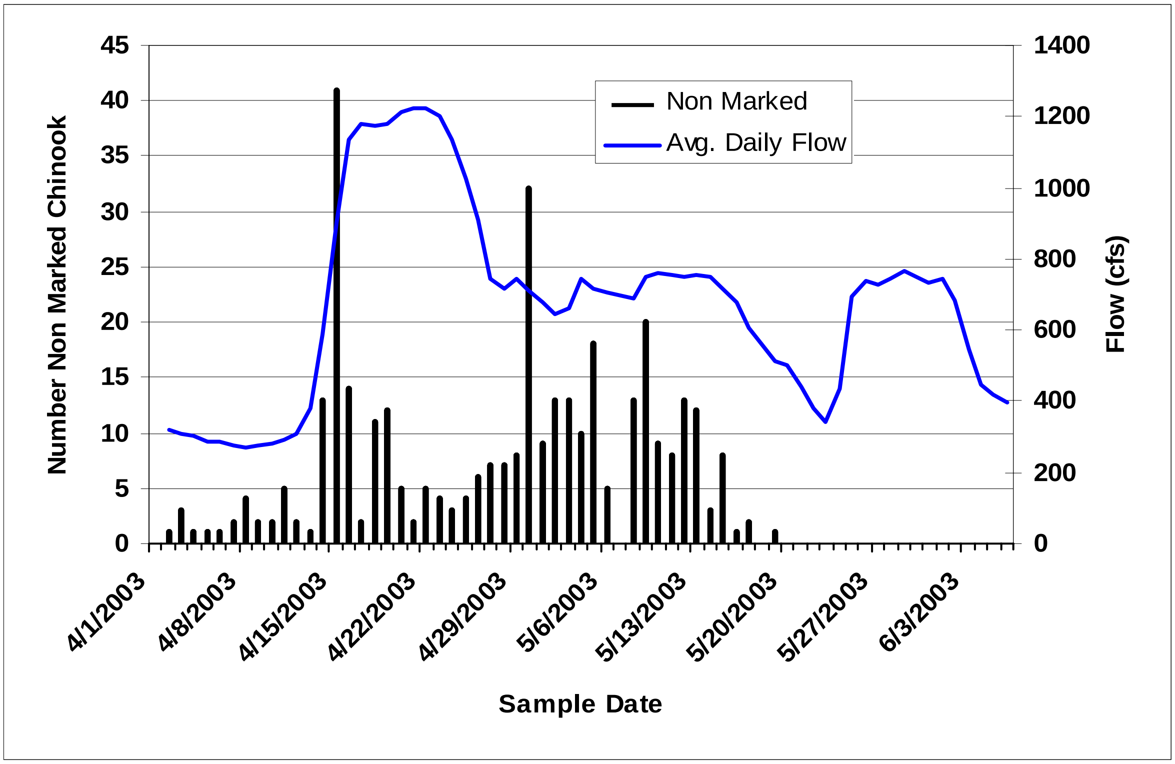

Figure 3. Daily catch of non adipose fin clipped juvenile chinook salmon with flow (cfs) at Modesto.

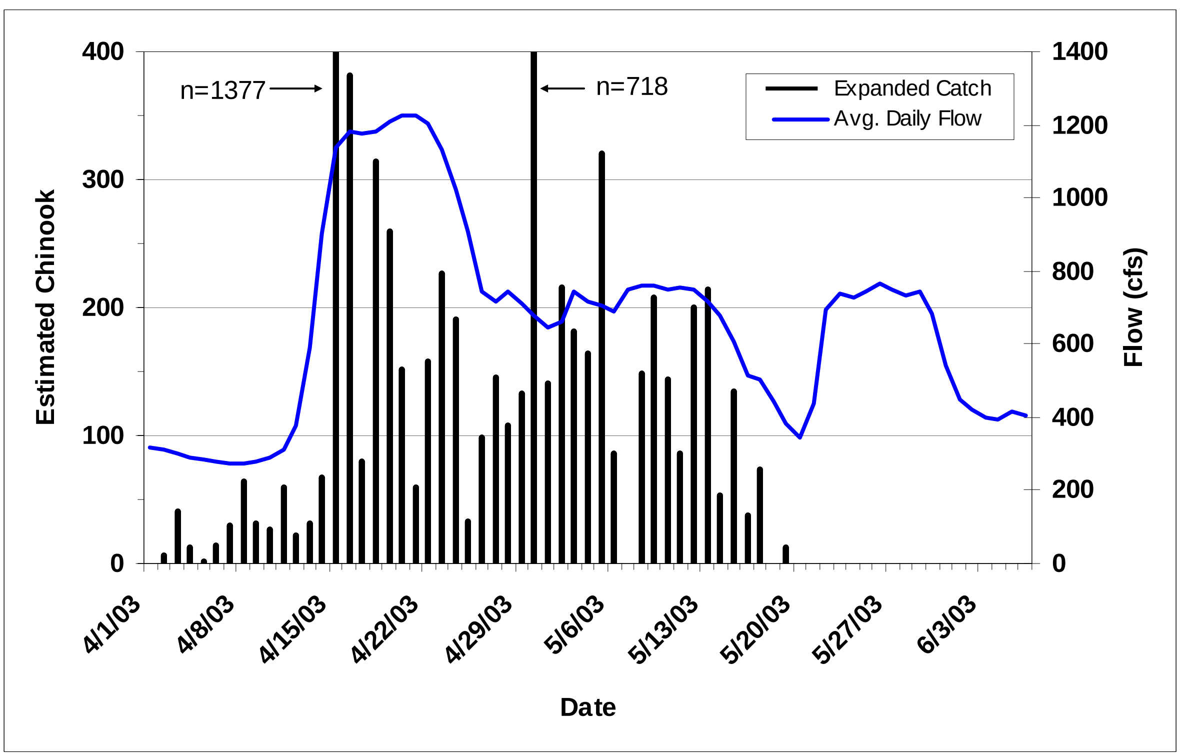

Figure 4. Expanded daily catch of naturally produced chinook salmon juveniles with flow (cfs) at Modesto guage.

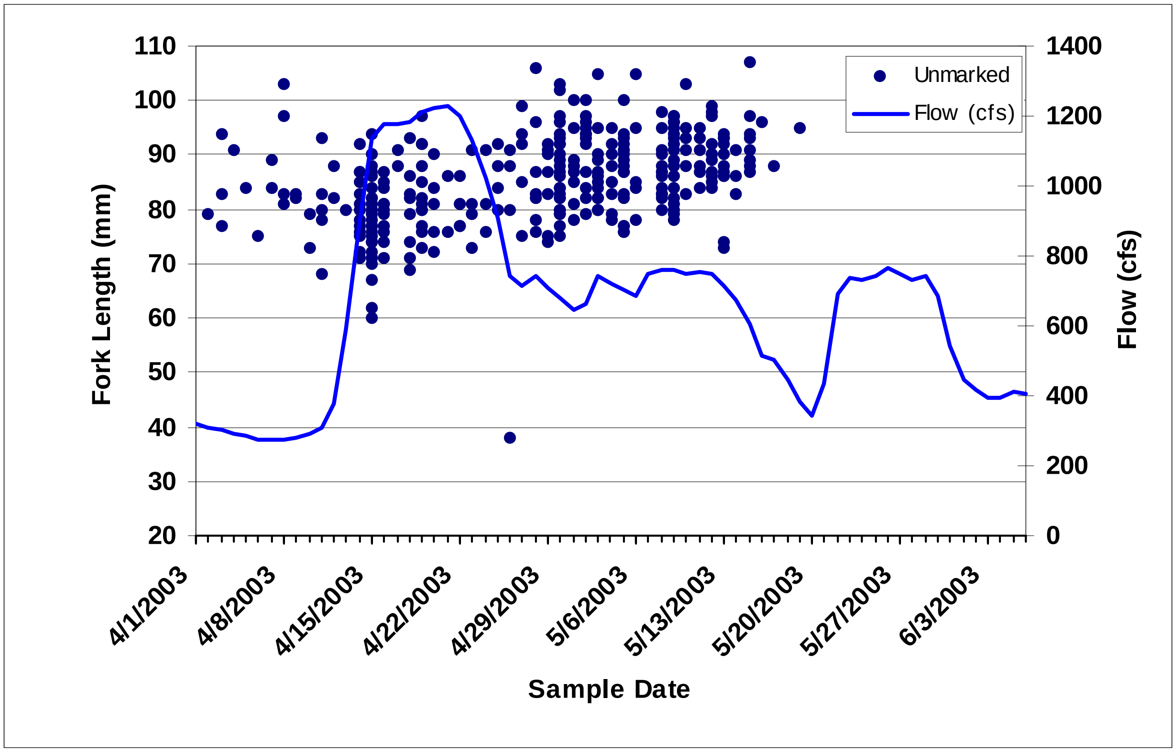

Figure 5. Fork lengths of non adipose fin clipped juvenile Chinook salmon captured in 2003. (Number of fish caught at each length is not represented.)

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-5

2004 Grayson Rotary Screw Trap Report

Prepared by

Andrea Fuller
S. P. Cramer and Associates

March 2005

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Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River at Grayson 2004

FINAL REPORT
9 March 2005

Prepared by
Andrea N. Fuller

Submitted to
Turlock and Modesto Irrigation Districts

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INTRODUCTION

Study Area Description

The Tuolumne River is the largest of the three major tributaries (the Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River, originating in the central Sierra Nevada and flowing west between the Merced River to the south and the Stanislaus River to the north (Figure 1). The San Joaquin River flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta. The Tuolumne River is dammed at several locations for generation of power, water supply, and flood control – the largest impoundment is Don Pedro Reservoir.

The lower Tuolumne River corridor extends from La Grange Dam to its confluence with the San Joaquin River. The site of La Grange Dam, approximately 52.2 river miles upstream from the San Joaquin River confluence, has been the limit of the upstream migration of anadromous fish since 1871.

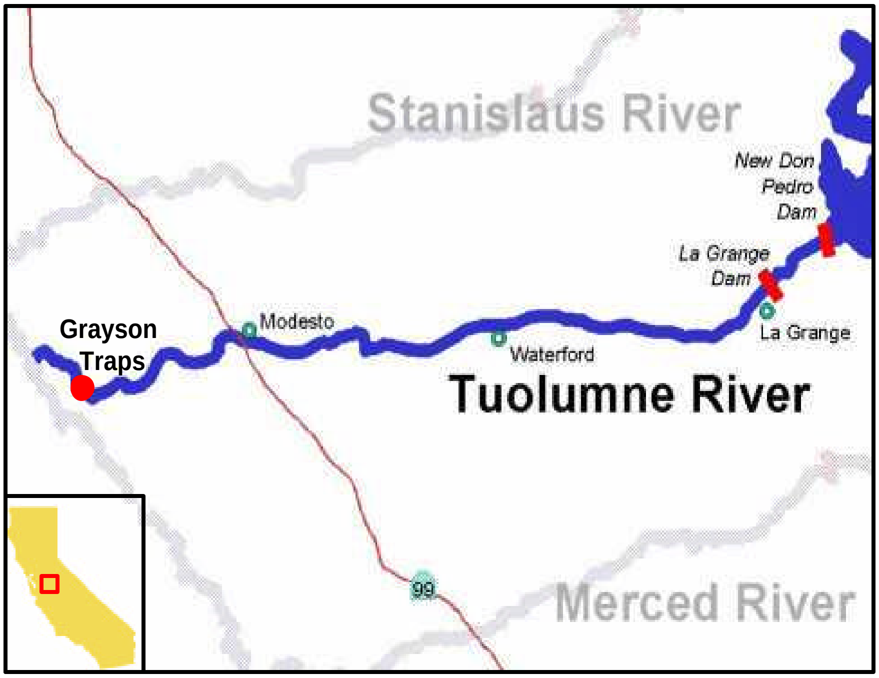

Figure 1. Location map of study area on the Tuolumne River.

Purpose and History of Study

Rotary screw trap monitoring has been conducted annually near the mouth of the Tuolumne River since 1995 for the purpose of monitoring the abundance and migration characteristics of juvenile Chinook salmon and other fishes. Trapping was conducted by the Turlock and Modesto Irrigation Districts (Districts) and the California Department of Fish and Game (CDFG) at the Shiloh Bridge (RM 3.4) from 1995 through 1998 and by CDFG at Grayson (RM 5.2) from 1999 through 2003. The sampling periods have varied greatly between years with monitoring starting as early as January 3 or as late as April 18, and ending as early as May 24 or as late as July 1 (Table 1).

Table 1. Lower Tuolumne River outmigrant trapping history.

Year	*Location*	*Start Date*	*End Date*	*Results Reported In*
1995	Shiloh (RM 3.4)	April 25	June 1	Heyne and Loudermilk 1997
1996	Shiloh (RM 3.4)	April 18	May 29	Heyne and Loudermilk 1997
1997	Shiloh (RM 3.4)	April 18	May 24	Heyne and Loudermilk 1998
1998	Shiloh (RM 3.4)	February 15	July 1	Blakeman 2004
1999	Grayson (RM 5.2)	January 12	June 6	Vasques and Kundargi 2001
2000	Grayson (RM 5.2)	January 9	June 12	Vasques and Kundargi 2001
2001	Grayson (RM 5.2)	January 3	May 29	Vasques and Kundargi 2002
2002	Grayson (RM 5.2)	January 15	June 6	Blakeman 2004
2003	Grayson (RM 5.2)	April 1	June 6	Blakeman 2004

METHODS

Juvenile Outmigrant Monitoring

Trapping Site and Sampling Gear

In 2004, two rotary screw traps were fished side-by-side in the mainstem of the lower Tuolumne River near Grayson (RM 5.2) to sample juvenile salmonids and other fishes as they migrated downstream. The screw traps, manufactured by E.G. Solutions, consisted of a funnel shaped core suspended between two pontoons. Each trap was positioned in the current so that water entered the eight-foot wide funnel mouth. Water entered the funnel and struck the internal screw core, causing the funnel to rotate. As the funnel rotated, fish were trapped in pockets of water and forced rearward into a livebox, where they could not escape.

The traps were held in place by an overhead cable strung between an anchor in the north bank levee and a tree on the south bank. Leader cables descended from the overhead cable and were attached to the front of each of the four trap pontoons. The downstream force of the water on the traps kept the leader cables taut.

Trap Monitoring

Initially, CDFG installed two rotary screw traps at Grayson on March 31 and sampling began the morning of April 1. CDFG monitored catches the morning of April 2 and from April 5 through April 9 at which time CDFG removed their traps. SPC subsequently installed the Districts' traps and continued the monitoring effort from April 9 through

June 9. During the sampling period, the traps were operated continuously (24 hours per day, 7 days per week) from April 5 to June 8. An exception was made from May 29 through June 1 when the traps were raised for the Memorial Day holiday.

The traps were checked twice daily during the sampling period, once in the morning and once in the evening. During each trap check, we removed the contents of the liveboxes and identified and counted all fish captured. Random samples of up to 50 Chinook and 20 of each other species were measured and their lengths recorded in millimeters during morning trap checks. Subsamples of up to 20 Chinook and 10 of each other species were examined during all evening trap checks. Chinook smolting appearance was rated on a scale of 1 to 3, with 1 an obvious parr (highly visible parr marks) and 3 an obvious smolt (silvery appearance, easily shed scales, blackened fin tips).

Chinook catch for a given day is the sum of the catches removed from the liveboxes during the morning check plus the catches removed during the evening check on the preceding day. For example, the daily Chinook catch for April 10 is the sum of the catches from the morning trap check on April 10 and the evening trap check conducted on April 9.

After all fish were recorded, we cleaned the traps to prevent accumulation of debris that might impair trap rotation or cause fish mortality within the liveboxes. Trap cleaning included removal of debris from against the trap and from within the liveboxes. The amount of debris load in the liveboxes was estimated and recorded whenever the traps were checked.

Trap Efficiency Tests

Experimental Releases

Trap efficiency evaluations were conducted weekly from April 7 through May 25, with a total of eight groups of marked Chinook salmon released to estimate trap efficiency. All release groups consisted of fish reared and marked at Merced River Hatchery by CDFG. Fish were marked by dye inoculation, sampled for length and mark retention, and delivered to the release site by CDFG. Fish were delivered to the release site and placed in net pens on the morning of the release day. All efficiency groups were released at the same site used in previous years by CDFG, which lies about one-quarter mile upstream of the traps on the south bank. Releases groups ranged from 1,941 to 2,013 smolts, with mean fork length at release ranging from 79.1 mm to 91.9 mm. All groups were released after dark.

To facilitate comparison between years, release procedures were the same as those used in past years as described by CDFG staff. Marked fish were released directly from the net pens. The time required to release each marked group was approximately 30 minutes. Following the release of marked fish, the traps were not checked again until the following morning.

Abundance Estimates

Daily fish passage was estimated by multiplying the day's catch by a trap efficiency estimate. Daily passage estimates were then summed to obtain total estimated outmigrant passage for the entire sampling period.

Trap efficiency estimates were derived by two different methods and were used to calculate two separate outmigration passage estimates. The first method was used to facilitate comparison of abundance estimates between years and applied an approach previously employed by CDFG (Vasques and Kundargi 2001). This trap efficiency estimate was obtained by regressing the observed trap efficiency test results against river flow at Modesto. The resulting regression equation was then used to predict trap efficiency for a given day based on the daily average river flow at Modesto.

The second method does not require establishing a relationship of trap efficiency to flow. Rather, the observed trap efficiency from each weekly test was applied to the daily catches from the date that the test was conducted until the day before the next test was conducted. For example, trap efficiency tests were conducted on April 13 and April 20 so the observed trap efficiency on April 13 was used to expand daily catches from April 13 through April 19.

Monitoring Environmental Factors

Flow Measurements and Trap Speed

Daily average flow in the Tuolumne River at the Modesto gauging station was obtained at http://waterdata.usgs.gov/ca/nwis/dv/?&site_no=11290000. Two methods were used to measure the velocity of water entering the traps. First, we measured the water velocity entering the traps each day with a Global Flow Probe, manufactured by Global Water (Fair Oaks, CA). Second, each morning we calculated an average daily trap rotation speed for each trap by measuring the time, in seconds, for three contiguous revolutions. Separate measurements were taken each morning before and after the traps were cleaned. The average time per revolution before and after cleaning was then calculated for each trap.

River Temperature and Relative Turbidity

Instantaneous water temperature was measured daily with a mercury thermometer at the trap site. An hourly recording thermograph was also maintained by the Districts near the Grayson trapping site at Shiloh (RM 3.4). This thermograph was stolen during the study period and data was not available from May 28 through the end of sampling on June 9. Instantaneous turbidity was measured daily with a LaMotte turbidity meter, model 2020. A water sample was collected each morning and later tested at the field station. Turbidity was recorded in nephelometric turbidity units (NTU).

RESULTS

Chinook Salmon

Number of Chinook Captured

Juvenile Chinook salmon outmigration in the San Joaquin Basin typically extends from January through May (Vasques and Kundargi 2001; SRFG 2004). Since no sampling occurred at Grayson from January through March, the 2004 outmigration data is incomplete.

Daily catches of juvenile Chinook at Grayson between April 1 and June 9 ranged from 0 to 42 fish and totaled 509 fish during 2004 (Figure 2). Peak catches occurred on April 8-9 and April 28-29 following declines in river flow a few days prior. Most fish were captured between April 6 and May 16 and only one unmarked Chinook salmon was captured after May 16. From May 16 through the end of sampling on June 8 flows gradually declined from approximately 650 cfs to 250 cfs. The origin of the single fish captured on May 26 is questionable because it coincides with the release and recapture of marked fish for a trap efficiency test and no unmarked fish were captured during the 9 days preceding or during the 11 sampling days that followed. There is no way of confidently determining whether this fish was of Tuolumne River origin or was an unmarked individual from the trap efficiency release group.

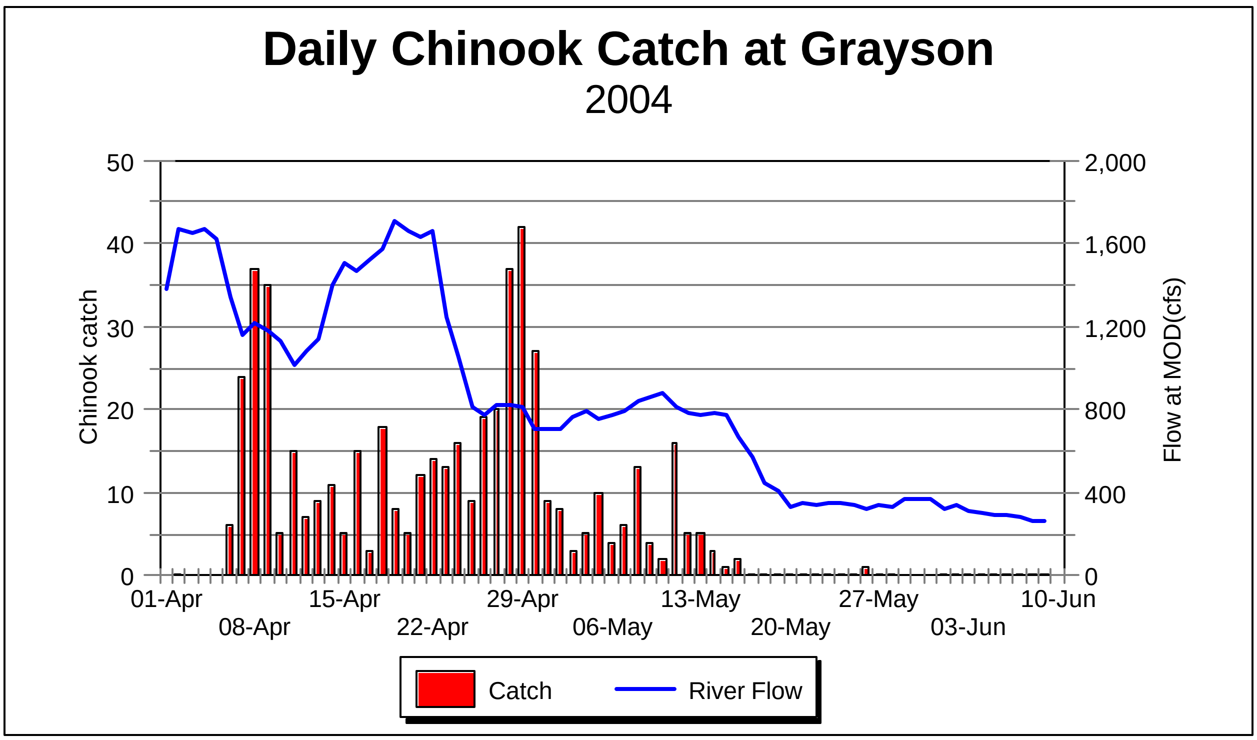

Figure 2. Daily Chinook catch at Grayson and flow at Modesto (MOD) during 2004.

Trap Efficiency

We released 8 groups of marked juvenile Chinook, all of hatchery origin, between April 7 and May 25, 2004 to estimate trapping efficiency (Table 2). All releases during 2004 occurred at night in flows ranging from 337 cfs to 1,660 cfs as measured at Modesto.

Table 2. Trap efficiency releases conducted at Grayson during 2004.

Release Date	Mark	Release Time	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
07-Apr-04	Bottom caudal green	nd	2006.0	7	0.3%	nd	75.4	1160
13-Apr-04	Dorsal fin green	2030	1991.9	84	4.2%	79.1	73.6	1140
20-Apr-04	Anal fin green	2000	1979.8	48	2.4%	81.2	78.9	1660
27-Apr-04	Top caudal green	2020	1941.0	118	6.1%	85.7	85.1	826
04-May-04	Bottom caudal green	2030	2007.9	50	2.5%	89.9	87.5	789
11-May-04	Anal fin green	2040	1971.5	104	5.3%	86.0	78.6	815
18-May-04	Dorsal fin green	2045	1996.0	178	8.9%	88.2	76.7	446
25-May-04	Top caudal green	2045	2013.0	59	2.9%	91.9	89.9	337

Trap efficiencies ranged from 0.3% to 8.9% (Table 2, Figure 3). Since mark-recapture estimates can be biased when recaptures are few (Robson and Regier 1964; Jensen 1981), abundance estimates were based on estimates of trap efficiency when the total number of recaptures exceeded seven (Roper and Scarnecchia 1999). Therefore, the trap efficiency test conducted on April 7 was excluded from abundance estimate calculations.

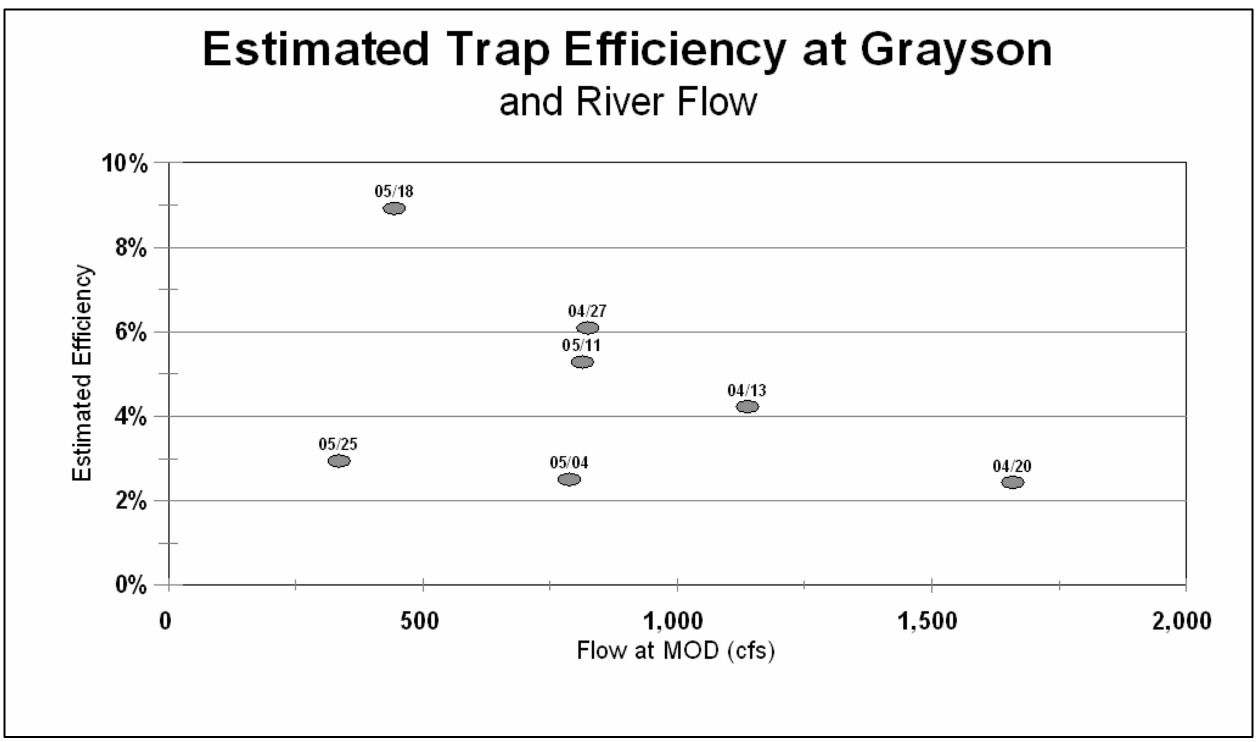

Figure 3. Estimated trap efficiency at Grayson and river flow at Modesto (MOD).

Estimated Abundance of Chinook Outmigrants

Based on weekly trap efficiency estimates, a total of 13,134 Chinook salmon were estimated to have passed Grayson between April 1 and June 9. Estimated daily trap efficiencies predicted by linear regression yielded a very similar estimate of 12,567 Chinook salmon.

River flow at Modesto gradually increased from approximately 1,000 cfs on April 12 and to approximately 1,700 cfs on April 19 and remained at this level until April 22 before gradually declining to 700 cfs on April 30 (Figure 4). No apparent increase in migration activity was observed in association with increasing flow; however, increases in migration activity were observed following reductions in flow. Peak estimated passages of 786 to 976 Chinook per day occurred on April 8-9 and on April 28-29, both following reductions in flow. With the exception of one Chinook of uncertain origin captured on May 26, passage ceased after May 16 when flows declined to less than 650 cfs.

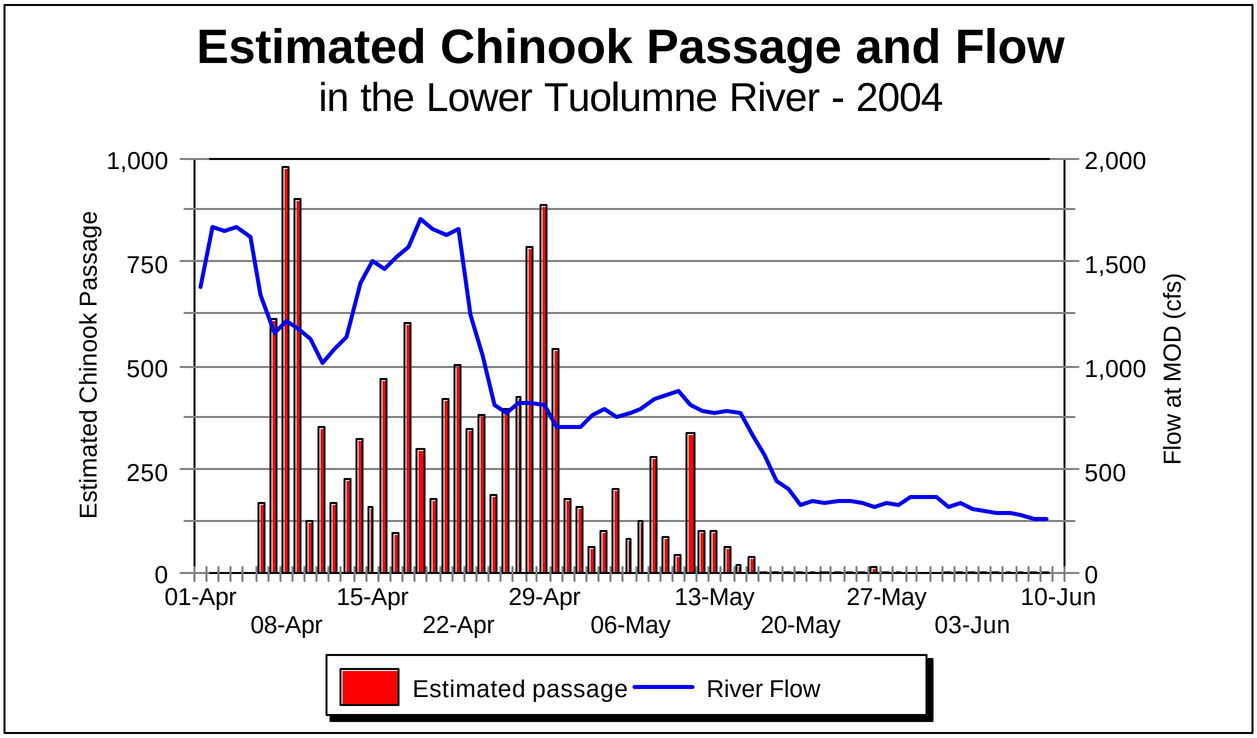

Figure 4. Daily estimated Chinook passage at Grayson using linear regression and flow at Modesto (MOD) during 2004.

During the first couple weeks of monitoring, daily average water temperature at Shiloh fluctuated between 59°F and 62°F and then gradually increased to approximately 70°F by late May (Figure 5). All but one Chinook were captured when water temperatures were at or below 67°F.

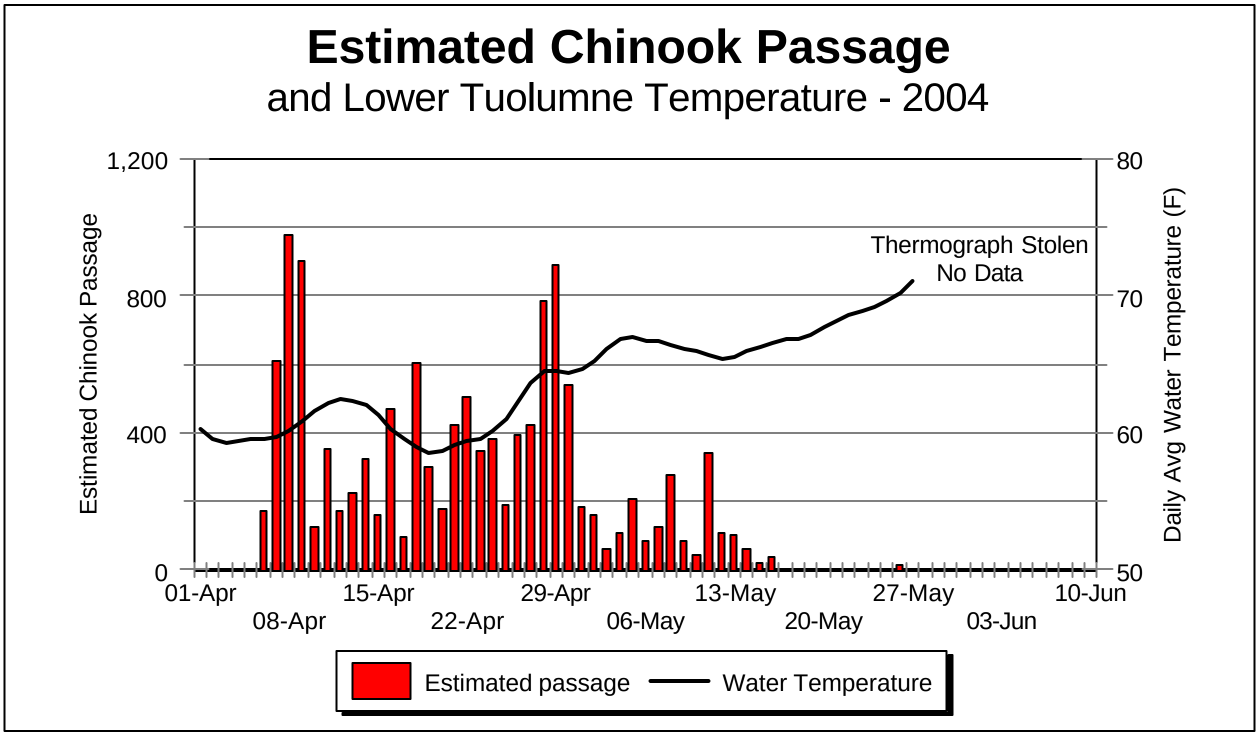

Figure 5. Daily estimated Chinook passage at Grayson using linear regression and daily average water temperature at Shiloh during 2004.

Turbidity data collected by CDFG from April 1 through April 9 and by S.P. Cramer & Associates (SPC) from April 10 through the remainder of the sampling period appeared to be very different (Figure 6) and does not appear to be flow related. The disparity between the two datasets is likely due to differences in the turbidity meters used by CDFG and SPC. Ideally, the same meter and vial should be used to obtain turbidity readings throughout the sampling period. Based on data collected by SPC during the majority of the sampling period, turbidity ranged from 1.7 NTU to 5.6 NTU. Fluctuations in turbidity do not appear to correspond to fluctuations in Chinook passage.

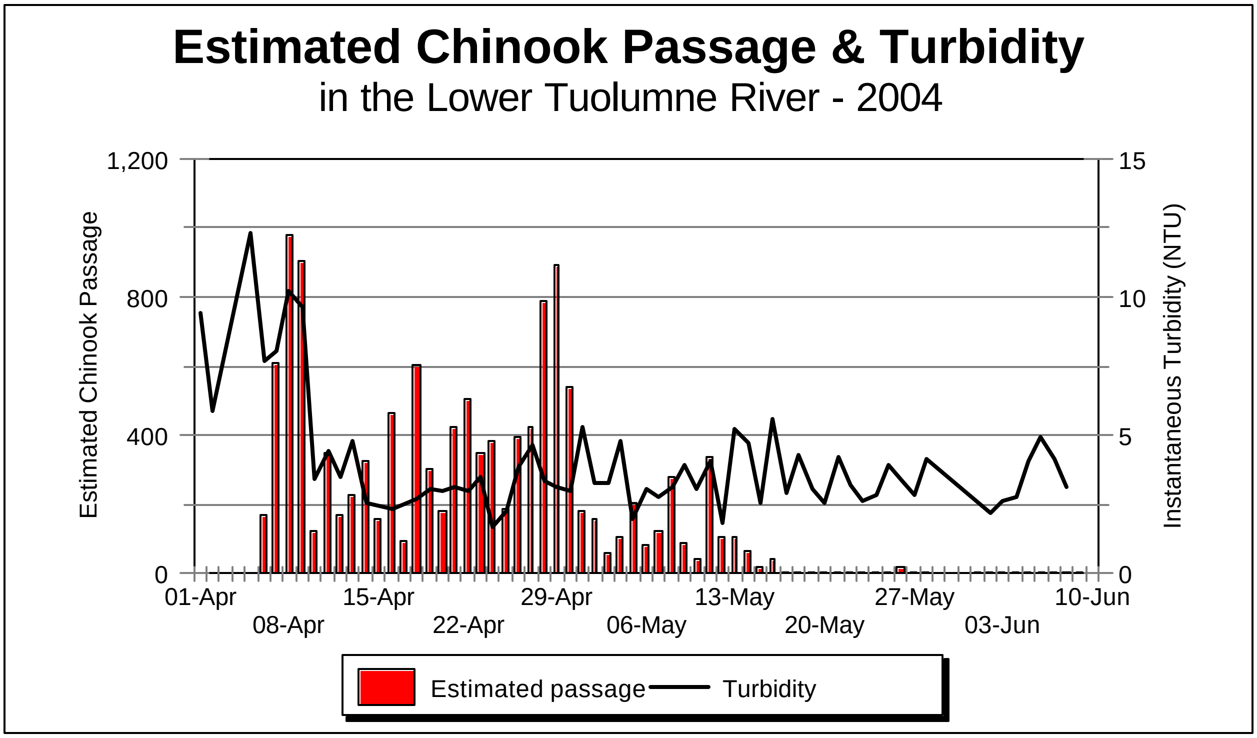

Figure 6. Daily estimated Chinook passage using linear regression and instantaneous turbidity at Grayson during 2004.

Chinook Length at Migration

Individual forklengths of Chinook salmon captured at Grayson during 2004 ranged from 37 mm to 110 mm (Figure 7). Chinook measuring 80 mm to 89 mm were most common (53%), followed by those measuring 70 mm to 79 mm (30%) and 90 mm to 99 mm (11%; Figure 8). Less than 5% of the Chinook captured at Grayson during 2004 were smaller than 70 mm forklength and 1% were larger than 99 mm fork length.

Chinook Developmental Stage at Migration

All Chinook captured at Grayson during 2004 appeared to be smolting, with 93% classified as obvious smolts (e.g., smolt index 3). The remaining 7% were at an intermediate stage of smolting and classified as smolt index 2.

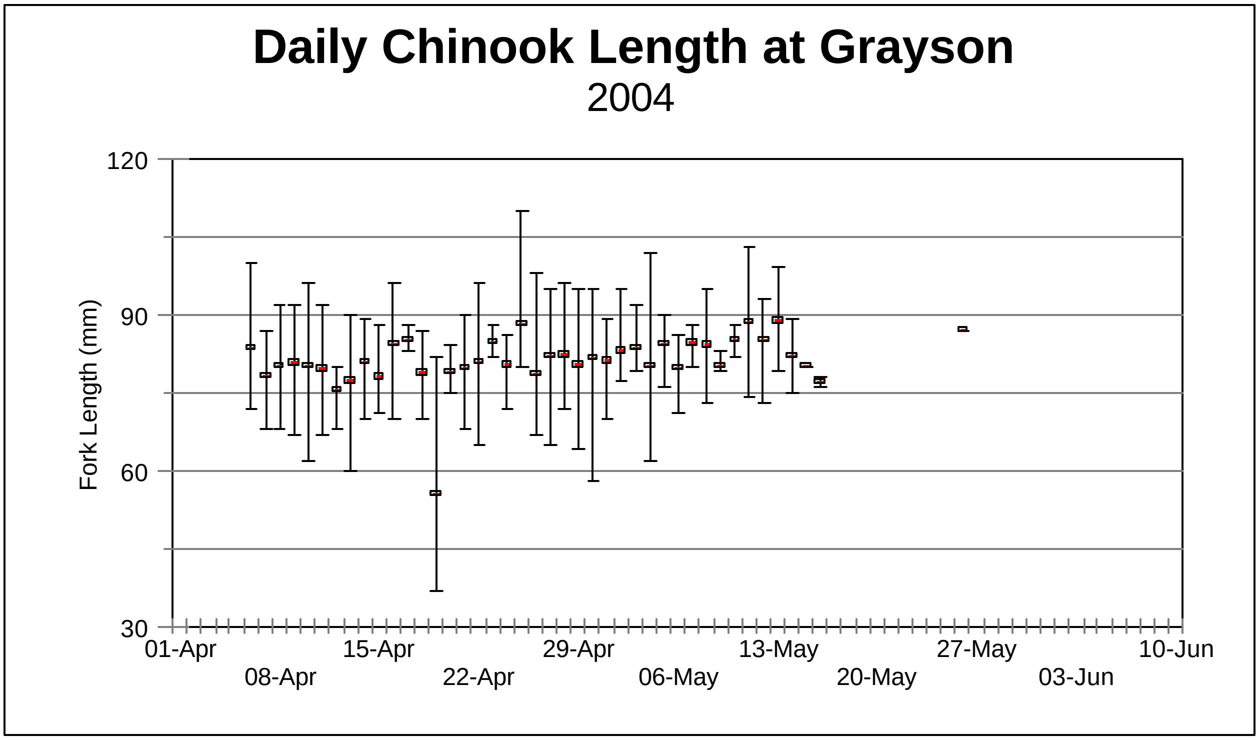

Figure 7. Daily minimum, average, and maximum fork lengths of Chinook salmon captured at Grayson during 2004.

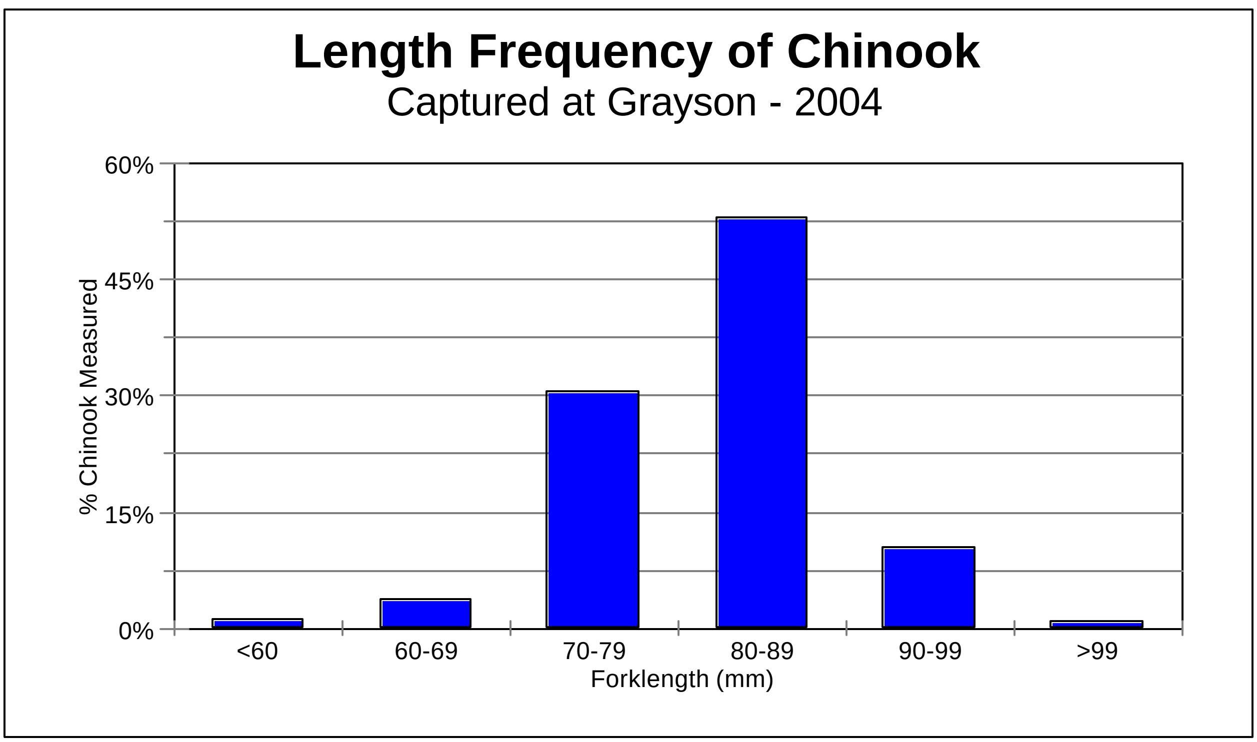

Figure 8. Length frequency of Chinook salmon captured at Grayson during 2004.

Species Incidentally Captured

A total of 2,365 non-salmonids representing at least 19 species (5 native, 14 introduced) were captured incidentally during operation of the Grayson trap during 2004 (Table 3, Appendix B). Incidental catch of non-salmonids was dominated by introduced species including white catfish, channel catfish, carp, golden shiner, red shiner, fathead minnow, mosquitofish, inland silverside, American and threadfin shad, bluegill, green sunfish, and largemouth and smallmouth bass. Native non-salmonid species captured included Pacific lamprey, hitch, Sacramento sucker, Sacramento pikeminnow, and Sacramento blackfish. No rainbow/steelhead trout were captured at Grayson during the 2004 sampling period.

Table 3. Non-salmonid species incidentally captured at Grayson during 2004.

Common Name	Scientific Name	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Catfish Family					
Channel catfish	*Ictalurus punctatus*	12	34	85.7	290
White catfish	*Ictalurus catus*	625	29	62.3	315
Unidentified catfish	-	29	10	12.7	18
Herring Family					
American shad	*Alosa sapidissima*	1	480	480.0	480
Threadfin shad	*Dorosoma petenense*	3	115	123.3	135
Lamprey Family					
Pacific lamprey	*Lampetra tridentata*	4	128	140.3	151
Lamprey - unidentified	-	4			
Livebearer Family					
Mosquitofish	*Gambusia affinis*	68	22	33.9	49
Minnow Family					
Carp	*Cyprinus carpio*	1	185	185.0	185
Fathead minnow	*Pimephales promelas*	3	41	53.0	72
Hitch	*Lavinia exilicauda*	1	46	46.0	46
Golden shiner	*Notemigonus crysoleucas*	5	41	81.0	125
Red shiner	*Cyprinella lutrennsis*	56	21	44.6	116
Sac. blackfish	*Orthodon microlepidotus*	2	90	90.0	90
Sac. pikeminnow	*Ptychochelius grandis*	2	32	32.0	32
Silverside Family					
Inland silverside	*Menidia beryllina*	15	18	45.4	89
Sucker Family					
Sacramento sucker	*Catostomus occidentalis*	17	20	27.6	35
Sunfish Family					
Bass– unid. species	-	29	15	37.9	223
Bluegill	*Lepomis macrochirus*	37	30	97.3	145
Green sunfish	*Lepomis cyanellus*	2	121	130.5	140
Largemouth bass	*Micropterus salmoides*	638	15	23.6	72
Smallmouth bass	*Micropterus dolomieu*	785	17	27.9	148
Unidentified sunfish	-	8	15	18.4	23
Unidentified species	-	18	18	20.3	22

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Appendix A. Daily Chinook catch, length, and passage at Grayson and environmental data from 2004.

		Fork Length (mm)			Weekly Method		Regression Method		Flow	Temperature	
Date	Catch	Min	Avg	Max	Efficiency	Passage	Efficiency	Passage	at Modesto	at Shiloh	Turbidity
01-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1380	60.3	9.4
02-Apr-04	0	-	-	-	-	-	-	-	1670	59.6	5.9
03-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1650	59.2	ns
04-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1670	59.4	ns
05-Apr-04	ns	ns	ns	ns	ns	ns	ns	ns	1620	59.6	12.3
06-Apr-04	6	72.0	83.7	100.0	4.2%	142.3	3.5%	170.8	1340	59.5	7.7
07-Apr-04	24	68.0	78.3	87.0	4.2%	569.1	3.9%	611.1	1160	59.7	8
08-Apr-04	37	68.0	80.2	92.0	4.2%	877.4	3.8%	976.4	1220	60.2	10.2
09-Apr-04	35	67.0	80.7	92.0	4.2%	830.0	3.9%	901.7	1180	60.9	9.6
10-Apr-04	5	62.0	80.0	96.0	4.2%	118.6	4.0%	125.1	1130	61.6	3.43
11-Apr-04	15	67.0	79.5	92.0	4.2%	355.7	4.3%	351.1	1010	62.2	4.46
12-Apr-04	7	68.0	75.4	80.0	4.2%	166.0	4.1%	170.3	1080	62.5	3.49
13-Apr-04	9	60.0	77.2	90.0	4.2%	213.4	4.0%	226.5	1140	62.4	4.8
14-Apr-04	11	70.0	80.9	89.0	4.2%	260.8	3.4%	325.9	1400	62.0	2.57
15-Apr-04	5	71.0	78.0	88.0	4.2%	118.6	3.1%	160.1	1510	61.3	ns
16-Apr-04	15	70.0	84.4	96.0	4.2%	355.7	3.2%	466.6	1470	60.2	2.37
17-Apr-04	3	83.0	85.0	88.0	4.2%	71.1	3.1%	96.8	1520	59.5	ns
18-Apr-04	18	70.0	78.8	87.0	4.2%	426.8	3.0%	603.0	1570	58.9	2.69
19-Apr-04	8	37.0	55.5	82.0	4.2%	189.7	2.7%	300.4	1710	58.5	3.06
20-Apr-04	5	75.0	79.0	84.0	2.4%	206.2	2.8%	180.0	1660	58.7	2.97
21-Apr-04	12	68.0	79.8	90.0	2.4%	495.0	2.8%	421.5	1630	59.0	3.11
22-Apr-04	14	65.0	80.9	96.0	2.4%	577.4	2.8%	504.0	1660	59.4	3
23-Apr-04	13	82.0	84.7	88.0	2.4%	536.2	3.7%	347.3	1240	59.6	3.5
24-Apr-04	16	72.0	80.3	86.0	2.4%	659.9	4.2%	382.8	1050	60.1	1.7
25-Apr-04	9	80.0	88.2	110.0	2.4%	371.2	4.7%	190.2	810	61.0	2.25
26-Apr-04	19	67.0	78.6	98.0	2.4%	783.7	4.8%	393.9	770	62.3	3.88
27-Apr-04	20	65.0	82.1	95.0	6.1%	329.0	4.7%	426.0	826	63.7	4.67
28-Apr-04	37	72.0	82.2	96.0	6.1%	608.6	4.7%	785.7	820	64.6	3.34
29-Apr-04	42	64.0	80.2	95.0	6.1%	690.9	4.7%	888.9	813	64.5	3.14
30-Apr-04	27	58.0	81.7	95.0	6.1%	444.1	5.0%	542.1	702	64.3	2.97
01-May-04	9	70.0	81.1	89.0	6.1%	148.0	5.0%	181.0	705	64.6	5.3
02-May-04	8	77.0	83.0	95.0	6.1%	131.6	5.0%	160.7	703	65.3	3.3
03-May-04	3	79.0	83.7	92.0	6.1%	49.3	4.8%	62.0	765	66.1	3.3
04-May-04	5	62.0	80.0	102.0	2.5%	200.8	4.8%	104.6	789	66.9	4.75
05-May-04	10	76.0	84.3	90.0	2.5%	401.6	4.9%	205.8	755	67.0	1.98
06-May-04	4	71.0	79.8	86.0	2.5%	160.6	4.8%	82.9	769	66.7	3.04
07-May-04	6	80.0	84.5	88.0	2.5%	240.9	4.8%	125.8	794	66.6	2.79
08-May-04	13	73.0	84.1	95.0	2.5%	522.1	4.7%	279.1	842	66.4	3.16
09-May-04	4	79.0	80.0	83.0	2.5%	160.6	4.6%	86.5	858	66.1	3.89

		Fork Length (mm)			Weekly Method		Regression Method		Flow	Temperature	
Date	Catch	Min	Avg	Max	Efficiency	Passage	Efficiency	Passage	at Modesto	at Shiloh	Turbidity
10-May-04	2	82.0	85.0	88.0	2.5%	80.3	4.6%	43.8	882	65.9	3.03
11-May-04	16	74.0	88.6	103.0	5.3%	303.3	4.7%	339.0	815	65.6	4.05
12-May-04	5	73.0	85.0	93.0	5.3%	94.8	4.8%	104.4	785	65.4	1.84
13-May-04	5	79.0	88.8	99.0	5.3%	94.8	4.8%	103.8	773	65.6	5.21
14-May-04	3	75.0	82.0	89.0	5.3%	56.9	4.8%	62.5	781	65.9	4.71
15-May-04	1	80.0	80.0	80.0	5.3%	19.0	4.8%	20.8	776	66.2	2.56
16-May-04	2	76.0	77.0	78.0	5.3%	37.9	5.1%	39.5	667	66.5	5.58
17-May-04	0	-	-	-	5.3%	0.0	5.3%	0.0	572	66.8	2.88
18-May-04	0	-	-	-	8.9%	0.0	5.6%	0.0	446	66.8	4.29
19-May-04	0	-	-	-	8.9%	0.0	5.7%	0.0	409	67.1	3.07
20-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	327	67.7	2.57
21-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	349	68.1	4.19
22-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	341	68.5	3.24
23-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	355	68.9	2.6
24-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	346	69.2	2.85
25-May-04	0	-	-	-	8.9%	0.0	5.8%	0.0	337	69.6	3.94
26-May-04	1	87.0	87.0	87.0	2.9%	34.1	5.8%	17.1	325	70.2	3.39
27-May-04	0	-	-	-	2.9%	0.0	5.8%	0.0	338	71.1	2.83
28-May-04	0	-	-	-	2.9%	0.0	5.8%	0.0	336	ns	4.11
29-May-04	ns	ns	ns	ns	ns	ns	ns	ns	369	ns	ns
30-May-04	ns	ns	ns	ns	ns	ns	ns	ns	373	ns	ns
31-May-04	ns	ns	ns	ns	ns	ns	ns	ns	372	ns	ns
01-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	323	ns	ns
02-Jun-04	0	-	-	-	2.9%	0.0	5.8%	0.0	343	ns	2.22
03-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	315	ns	2.62
04-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	304	ns	2.79
05-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	296	ns	4.04
06-Jun-04	0	-	-	-	2.9%	0.0	5.9%	0.0	291	ns	4.94
07-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	280	ns	4.12
08-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	265	ns	3.11
09-Jun-04	0	-	-	-	2.9%	0.0	6.0%	0.0	259	ns	ns

Appendix B. Non-salmonids captured at Grayson during 2004.

Date	AMS	BAS	BGS	C	CAT	CHC	FHM	GSF	GSN	HCH	LAM	LMB	MQK	MSS	PL	RSN	SASQ	SASU	SCB	SMB	SNF	TFS	UNID	WHC
01-Apr-04																								
02-Apr-04																								
03-Apr-04																								
04-Apr-04																								
05-Apr-04																								
06-Apr-04						1							3		1									31
07-Apr-04			2										14		1					1				27
08-Apr-04			1										3		2	1								18
09-Apr-04			1			1							2											17
10-Apr-04		1																						4
11-Apr-04			2											3										18
12-Apr-04								1		1			1											8
13-Apr-04			1																					14
14-Apr-04				1																				9
15-Apr-04																								13
16-Apr-04																								15
17-Apr-04													1											1
18-Apr-04														1										7
19-Apr-04																								1
20-Apr-04			1			1							1	1										17
21-Apr-04																								8
22-Apr-04																					1			16
23-Apr-04													1											8
24-Apr-04		1										1												16
25-Apr-04		1											2			4		1						16
26-Apr-04											1					1								13
27-Apr-04												1												28
28-Apr-04													1	1					1					27
29-Apr-04						1										1				1				23
30-Apr-04		1				1						37	1					1						9
01-May-04			1									56	2	1				1						6
02-May-04									1			28	2											9
03-May-04												9	1											8
04-May-04												7	1					1						6
05-May-04													1					1		1				23
06-May-04						2			1			1	1											2

Date	AMS	BAS	BGS	C	CAT	CHC	FHM	GSF	GSN	HCH	LAM	LMB	MQK	MSS	PL	RSN	SASQ	SASU	SCB	SMB	SNF	TFS	UNID	WHC
07-May-04																1								9
08-May-04												1												15
09-May-04						1						1											1	6
10-May-04						1						1						1						1
11-May-04			1											1			1	2						20
12-May-04			1															3						12
13-May-04																								4
14-May-04						1						2						2		1		1		9
15-May-04																								12
16-May-04			1									2		2								1	1	9
17-May-04											1		1			1		1						17
18-May-04			1						2			25	1			6		3				1		8
19-May-04												4		2		1							1	6
20-May-04			1				1					9	5			5	1							17
21-May-04			1			1						11	5			4								7
22-May-04			1				1		1		1			2									12	8
23-May-04							1					2	1			3							3	2
24-May-04			1									1	1											3
25-May-04			1									1	2											4
26-May-04			2									6												9
27-May-04	1	24	2									24	1			1				12				3
28-May-04			2									5	2							8				9
29-May-04																								
30-May-04																								
31-May-04																								
01-Jun-04																								
02-Jun-04		1										1	2			11				174				
03-Jun-04			3			1						6	5			2			1	118				3
04-Jun-04			2									2	2			1				111				2
05-Jun-04			2		5							4	1			3				96				3
06-Jun-04			4					1			1	360	1	1		1				113				3
07-Jun-04			1		18							24				6				112				2
08-Jun-04			1		6							6				3				28	7			3
09-Jun-04																				9				1
Total	1	29	37	1	29	12	3	2	5	1	4	638	68	15	4	56	2	17	2	785	8	3	18	625

Key to species codes

AMS	American shad
BAS	Bass, unidentified species
BGS	Bluegill
C	Carp
CAT	Catfish, unidentified species
CHC	Channel catfish
FHM	Fathead minnow
GSF	Green sunfish
GSN	Golden shiner
HCH	Hitch
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PL	Pacific lamprey
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SCB	Sacramento blackfish
SMB	Smallmouth bass
SNF	Sunfish, unidentified species
TFS	Threadfin shad
UNID	Unidentified species
WHC	White catfish

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-6

Rotary Screw Trap Summary Update

[REPORT TO BE SUBMITTED SEPARATELY]

Prepared by

Andrea Fuller
S. P. Cramer and Associates

March 2005

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

<u>Report 2004-7</u>

Large CWT Smolt Survival Analysis Update (1987–2002)

Prepared by

Stillwater Ecosystem, Watershed & Riverine Sciences
Berkeley, CA

and

Tuolumne River Technical Advisory Committee

March 2005

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INTRODUCTION AND OVERVIEW OF THE CWT EVALUATION

Pursuant to an agreement by TRTAC representatives at a meeting on 16 December 1999, a TAC Subcommittee ("Subgroup") was assigned the task of reviewing and evaluating the smolt-survival studies that have been conducted by the California Department of Fish Game (CDFG) in the Tuolumne River since the mid-1980s. Those CDFG studies entail the marking with coded-wire tags (CWTs) and release of large numbers of hatchery-reared juvenile salmon at specified locations, followed by attempted recaptures of the marked fish by intensive sampling at localities downstream of the release sites. The purpose of the CWT-based studies (henceforth, "CWT studies") is to estimate smolt survival rates as the fish travel downstream and to relate those survival rates to conditions that were experienced by the migrating fish.

After initial discussion, the Subgroup decided that the objectives of its evaluation would be to address the following questions.

(1) Does the implementation of the experimental design meet the critical underlying assumptions of the mark-and-release procedure in each year of the studies?
(2) Can the survival estimate obtained for each year be related to a specific flow or range of flows in the Tuolumne River?

The need for an evaluation of the CWT studies and the general philosophy in conducting it was described in an earlier document within the 2001 Annual FERC Report (Report 2001-5, "Rationale for Conducting the CWT Evaluation in Progress by the TRTAC Subgroup"). That document noted the exploratory nature of the evaluation, the progress and justification of which was subject to periodic assessment by the Subgroup.

Conducting the CWT Evaluation. The strategy adopted by the Subgroup in conducting the evaluation consisted of two steps: (a) delegate to CDFG the responsibility of checking the completeness and accuracy of its databases and consolidating all relevant data from its CWT program into electronic format: (b) contract Stillwater Sciences of Berkeley California to perform data organization and analysis, subject to ongoing review by the Subgroup as phases of the evaluation are completed.

As described in detail in the 2001 Annual FERC Report (Report 2001-5, "Rationale for Conducting the CWT Evaluation in Progress by the TRTAC Subgroup"), the evaluation of the CWT data was conducted in segments. The evaluation of the first set of data (for years 1994-1998) was largely completed by November 2001 and followed by evaluation of the second data set comprising years 1987, 1990, 1999-2001 and of the third data set for year 2002. Results from the latest evaluation encompassing all data-set years are given in the present report

Present Status of the CWT Evaluation. One significant accomplishment of the CWT evaluation to date has been the completion of data-quality checking and consolidation of data sets relevant to the CWT field studies. That effort was largely conducted by CDFG staff and provides at least two benefits. (1) There is now a better understanding of how much data, and of what quality, are available from all the years of CWT studies. (2) The data are better organized and more accessible for future analyses, whether for smolt-survival estimates or other issues.

As described in detail in this report, smolt-survival estimates have been computed and an assessment of the reliability, or validity, of the underlying data has been made. Also, consonant with the original goal of the CWT studies, the relationship between the estimated survival values and corresponding river flows has been tentatively explored. The task that must now be confronted is for the TRTAC biologists and stakeholders to discuss and interpret the putative relationship between smolt survival and flows.

BACKGROUND

Since 1986, the California Department of Fish and Game (CDFG) has conducted a series of paired release experiments of coded wire tagged (CWT) chinook salmon smolts to estimate survival rates and to quantify the relationship between smolt survival and flow in the Tuolumne River as part of the Don Pedro Project study plan. At the request of the TRTAC, the Monitoring Subcommittee has conducted a multi-year review of the CDFG coded wire tag (CWT) smolt release experiments. Its purpose is 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.

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, 1994–2001 (TID/MID 2002, 2003, and 2004). This report includes an expanded analysis of one additional year of data collected in 2002 (Appendix A) and constitutes an addendum to the previous reports on the CWT study review.

METHODS

Update for 2002 Data. Test flows at La Grange were near 1,300 cfs in 2002, with 74,924 smolts released at Old La Grange Bridge on April 24–25. The two lower release groups of 23,871 and 25,701 were released at the Old Fisherman’s Club in the San Joaquin River on April 26 and April 29. Preliminary review of the daily recaptures at Mossdale indicated a large discrepancy in recaptures totals for first and second lower release groups (Tag Codes 06-44-61 and 06-44-69). The three days difference in release timing and a missed day of sampling at the Mossdale trawl on April 30 were sufficient to cause a large difference in recovery totals (116 total vs. 25 for first and second groups, respectively). Based upon discussions within the Monitoring Subcommittee, it was suggested that the peak recapture period for the second lower release group may have been on the missed trawl day, whereas the peak recapture period had already occurred for the other release codes (Appendix A). A decision was made to exclude the recovery data from the second lower release group, changing the calculated smolt survival index from over 80% to 53%.

Overall Data Quality Review. The prior reviews of the CDFG CWT experiments (TID/MID 2002) assessed fifteen factors that may have affected the paired release assumptions (*e.g.,* fish size, exposure to similar conditions, equality of capture effort, etc.). Table 1 shows the relative importance of each study factor, where each matrix cell (i,j) represents the outcome of comparing factor i and factor j with regard to the relative importance of the two factors, as judged by the CWT-evaluation Subgroup members (TID/MID 2003). Table 2 presents an evaluation of the fifteen experimental factors the CWT Subgroup used to assess the data quality underlying each year's survival index. The scores in Table 2 reflect a zero for circumstances in which study assumptions were clearly not met, 1 when study assumptions may not have been met, and 2 when study assumptions were satisfied. Table 3 shows the relative importance of each study factor and data quality in each year combined as a product. These products are then summed in the bottom row of the Table 3 to give a confidence weight for each year (column) that represents an index of confidence in the data validity for that year. Higher weights indicated greater confidence in data validity.

Smolt Survival Estimates. Table 4 shows the total numbers of tagged smolts released and recaptured both as raw and expanded numbers for capture effort at Mossdale, along with the relevant flows for each smolt survival experiment as presented in prior year CWT evaluation reports (TID/MID 2002, 2003). To calculate the smolt survival index, the CWT experiments conducted by CDFG use a paired release-recapture design (Burnham et. al. 1987) of upstream (treatment) and downstream (control) fish. The in-river survival is estimated by comparing the rates at which the two groups are recovered further downstream (*e.g.,* Mossdale, CVP and SWP Fish Protection Facilities, Chipps Island Trawl, etc.). 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:

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

Where $\hat{\sigma}_t^2$ and $\hat{\sigma}_c^2$ are the estimates of the variances of m_c and m_t, respectively. Table 4 shows the smolt survival indices for each year calculated on both actual recaptures as well as those calculated on a capture effort expansion basis.

Flow vs. Survival Regressions. To arrive at flow vs. survival regressions, survival indices from Table 4 were paired with various estimates of the flows best representing test conditions. In addition to the flows at La Grange on the day of release, average flows during the experiments at La Grange were combined as a single average calculated by multiplying 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 at Mossdale.

RESULTS

Linear Flow vs. Survival Regressions. Figure 1 shows a linear model between flow and survival along with its associated uncertainty (shaded confidence band), representing actual smolt recoveries and the recovery-weighted mean flow (cfs) at La Grange from the day of release to the last recapture. Because survival estimates in the annual FERC reports do not reflect adjustments for capture effort, daily recaptures and trawl effort at Mossdale (Appendix A) were used to calculate a capture effort expansion of the apparent survival estimates (Table 4). Figure 2 shows a modified linear relationship between recovery weighted mean flow at La Grange and capture effort adjusted survival with only validated points from Table 3 included (*i.e.*, excluding 1990, 1994 and 1997).

The confidence band of Figures 1 and 2 are large enough that it is clear that the linear regression model cannot be used in any meaningful way as a management tool without the inclusion of more data points to narrow the associated uncertainty. For example, Equation 1 shows that the relationship between the raw survival data and release flows shown in Figure 1 is not statistically significant ($p=0.49$). Although the capture effort and flow adjusted smolt survival relationship shown in Figure 2 is marginally significant ($p=0.1$) after removing the excluded survival estimates (*i.e.*, 1990, 1994 and 1997), the two linear regression models fall within each of their associated confidence intervals and thus Equations 1 and 2 cannot be treated as significantly different from one another.

$SI = 0.453 + 4.86 \times 10^{-5} * Flow$, $p = 0.49$ (all years) Equation 1
$SI = 0.257 + 8.30 \times 10^{-5} * Flow$, $p = 0.10$ (validated points) Equation 2

Logistic Flow vs. Survival Model. In addition to the marginal significance of the linear flow vs. survival relationship shown in Figure 2, the use of linear regression conceals a number of hidden assumptions in developing an acceptable relationship. Use of a linear regression model assumes:

1. For each experiment, the capture effort adjusted survival estimate is a sample from a Gaussian distribution.
2. The expected value of each of these distributions is a linear function of the recapture-weighted flow at LaGrange for the experiment.
3. All of these distributions have the same standard deviation.

Whether or not the first and third assumptions are met, one may still employ the tool of linear regression analysis to determine model parameters. However, the second assumption above is biologically unsound, since it violates the clear requirement that true smolt survival must be between zero and one.

To clarify the effect of these assumptions, an alternate analysis was conducted, using a relationship between flow and survival which respects the limits on survival and considers the underlying statistical assumptions more carefully. In this model:

1. All fish from the upper release group of a given experiment have the same probability of surviving to the downstream release location. This probability is a logistic function of the recapture-weighted flow at LaGrange for the experiment.
2. The expanded recoveries at the Mossdale trap from each group are samples from a gamma distribution (interpreted as an overdispersed Poisson distribution). The expected value of this distribution is proportional to the number of fish from the group which is present at the downstream release location. The constant of proportionality is assumed to be the same for both the treatment and control groups in any given experiment.

This model was fitted using the validated experiments only (i.e., omitting the 1990, 1994, and 1997 data). A highly significant ($p < 0.01$) relationship was found between flow and survival. The fitted flow-survival relationship is given in Equation 3. Figure 3 displays this relationship with 95% prediction confidence intervals, and with the simple "point" estimates of survival from each experiment for reference.

$$SI = 1/(1 + \exp(1.271 - 3.819\text{x}10^{-4}*\text{Flow})),\ p< 0.01 \text{ (validated pts.)} \quad \text{Equation 3}$$

DISCUSSION

A number of factors have been discussed during the CWT evaluation and it is recognized that the analysis conducted to date using flow as the primary factor in determining smolt survival may not completely address other study factors or environmental conditions, ranging from changing release locations to flow and temperature variations. Below we summarize the major points of discussion for the purposes of improving the CWT evaluation to date.

Test Flows. The primary goal of the CWT studies was to attempt to gain an understanding of the flows required to ensure adequate smolt survival during spring outmigration. However, a number of conditions have called into question how well the test flows represent flows experienced by the CWT fish while in the study reach of the lower Tuolumne River. For example, test flows did not arrive at the lower release site in 1990 before the control group fish were released. In most years, the combination of extended CWT recovery periods of up to 30 days with varying flows after the few days following release means that using the initial release flow may misrepresent study conditions.

Although the Subgroup's decision to use recovery weighted average flow conditions produced large changes in the flow estimates for 1997 and 1998, the advantage of the selected method is that it weights the study flow towards the highest recovery period, typically the first few days after release of the CWT-marked fish. The primary disadvantage is that like the 70% and 90% recapture averaging periods used previously (TID/MID 2002, 2003); using recovery weighting instead of a fixed period after release may bias the flow towards conditions representing higher CWT recovery (i.e. either high survival or high capture probability). In the end, this decision recognizes a trade-off between determining appropriate release flows at La Grange and accurately representing flows experienced by outmigrating smolts.

Annual Variations in Meteorology and Temperature. While flow is widely accepted as a surrogate for many other environmental factors, it was noted that during low flow conditions the juvenile and smolt survival rates may be affected by high or variable water temperatures. It was noted by the Subgroup that although water temperatures would be fairly constant during high flows, it is possible that variable and stressful temperatures occur during low flow conditions and hot weather. Further, in some years excessively cold water temperatures in the study reach may affect smoltification and outmigration cues sufficiently to cause “residualization” or hold up of the test group relative to the controls. In addition to photo-period and other environmental causes, there is evidence to support this temperature hypothesis (McCormick and Saunders 1987 as cited in Hogasen 1998). In addition, Appendix A Tables show that with the exception of 1995, low water temperatures were associated with extended recovery periods in most years (e.g., 1996, 1998, 2000).

Although differential exposure to higher or lower temperatures was implicit in the data quality review (Tables 2 and 3), as an interim data analysis, the survival estimates and test flows were fit to a two parameter model by adding temperature as an effect. In general, adding temperature to the linear smolt survival model did not improve the significance over the logistic model. It is possible that a much larger data set may improve the significance of a combined flow and temperature model, given the small data set collected to date; these results do not warrant the inclusion of temperature in the model.

Use of survival estimates calculated from other recovery locations. To address the broad confidence interval developed to date, the Subgroup has discussed using the additional survival estimates already calculated based upon recaptures at other locations (e.g., Chipps Island, Ocean Harvest estimates, etc.). Although these other estimates for salvage, trawl, and ocean harvest sources have been adjusted for sample effort, additional data quality verification and evaluation procedures may need to precede this analysis. Low recovery numbers of CWT fish at some distant sites will increase the uncertainty of the individual survival estimates. However, the increased replication of independent estimates may improve (i.e., narrow) the confidence intervals of the models developed to date.

CONCLUSIONS

- Based upon the analyses to date, the large CWT smolt survival experiments for the validated years meet the majority of paired release study assumptions set forth by the TRTAC Monitoring Subcommittee.

- The resulting logistic relationship between Chinook salmon smolt survival and flow in the Tuolumne River is sufficient to provide only a broad estimate of survival-specific flow ranges. Attempts at reducing this prediction interval by one-half through additional experiments would require four times the current number of smolt survival estimates used (i.e., 4 x 8 or 32 additional survival/flow estimates). Incorporation of survival estimates from the other recovery locations (two Delta fish salvage operations, Chipps Island and Antioch/Jersey Point trawls, ocean harvest and San Joaquin basin spawning surveys) would increase the replication without the need for additional experiments. For this reason, the greatest leverage in improving the existing flow vs. survival relationship would be to complete the broader assessment using all existing Tuolumne data.

- Although some in the Subgroup have expressed a desire to gain an understanding at flows below those tested to date (i.e., below 500 cfs), the uncertainty in the current prediction interval based on Mossdale recaptures increases markedly at flows above 4,000 cfs. In addition to the increased replication provided by additional recapture locations discussed above, incorporation of survival estimates from other locations would allow the 1986 study data to be used at a test flow of 6,600 cfs since no trawls were conducted at Mossdale in that year.

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Table 1: Assignment of Relative Importance of Experimental Factors of Tuolumne River CWT Studies as determined by TRTAC Monitoring SubCommittee on October 17, 2001

Note: Matrix values in each cell (i,j) indicate importance of each factor in comparison with all others.

Factor	*i* \ *j*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	$\Sigma_{j=1-15}$
Control and treatment group fish > 75 mm FL at release	1	x															0
Control and treatment group fish were the same size (<5% Diff.) at release	2	2	x														1
Control and treatment group fish were of the same origin?	3	1	3	x													1
Control and treatment group fish were of the same egg lot?	4	1	2	3	x												0
Below 3^{o}C Difference in hatchery water temperatures.	5	1	2	5	5	x											2
Below 3^{o}C Difference in transport water temperatures.	6	1	2	3	6	5	x										1
Same potential for thermal shock at release site.	7	7	7	7	7	7	7	x									6
Control and treatment group fish exposed to temperatures >20^{o}C at different times?	8	8	8	8	8	8	8	8	x								7
Control and treatment group fish traveled together out of lower Tuolumne river?	9	1	2	3	9	5	9	7	8	x							2
Low Temp. variation at Modesto (Range/Target < 20%) during 70% Shiloh recapture period	10	1	2	10	10	5	10	7	8	10	x						4
Low flow variation (Range/Target < 20%) at Modesto during 70% Shiloh recapture period	11	1	2	11	11	5	11	7	8	11	11	x					5
Control and treatment group fish traveled together through San Joaquin river?	12	1	2	12	12	5	12	7	8	12	12	11	x				5
Control and treatment group fish experienced similar Temp variations at Vernalis during 70% Mossdale recapture period.	13	1	2	13	13	5	13	7	8	13	10	11	12	x			4
Control and treatment group fish experienced similar Flow variations at Vernalis during 70% Mossdale recapture period.	14	1	2	14	14	5	14	7	8	14	10	11	12	14	x		5
Control and treatment group fish were subjected to similar capture effort at Mossdale	15	1	2	15	15	5	15	7	8	15	10	11	12	15	14	x	5
	$\Sigma_{i=1-15}$	11	10	3	0	8	0	7	7	0	3	4	3	0	1	0	
	$\Sigma_{(i,j)}$	11	11	4	0	10	1	13	14	2	7	9	8	4	6	5	
	Overall Importance (0 -15):	***12***	***13***	***4***	***1***	***11***	***2***	***14***	***15***	***3***	***8***	***10***	***9***	***5***	***7***	***6***	

Table 2: Evaluation of Data Quality of Experimental Factors of Tuolumne River CWT Studies between 1987-2002

ID	Factors Necessary to Meet CWT Study Assumptions	Assumptions Met in Year?										
		1987	1990	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fish in the control and treatment groups were biologically similar and experienced similar handling, especially with regard to water temperatures at the hatchery, in the trailer, and at the release site.												
1	Control and treatment group fish were larger than 75 mm FL (Table 2).	2	0	2	2	2	0	2	2	1	2	2
2	Control and treatment group fish were the same size (<5% Diff.) at release (Table 2).	2	0	2	2	2	1	2	2	2	2	2
3	Control and treatment group fish were of the same origin?	2	2	2	2	2	2	2	2	2	2	2
4	Control and treatment group fish were of the same egg lot? (Table 2).	1	0	2	2	2	2	2	2	2	2	2
5	Below 3^oC Difference in hatchery water temperatures (Table 2).	2	1	2	2	2	2	2	2	2	2	2
6	Below 3^oC Difference in transport water temperatures (Table 2).	0	2	2	1	2	2	0	2	2	0	2
7	Same potential for thermal shock at release site (Table 2)	0	0	0	0	0	0	2	2	2	0	0
8	Were either treatment or control fish exposed to temperatures $>20^oC$ at different times (Table 5)	2	0	1	2	2	0	1	2	2	2	2
Did treatment and control fish experience similar conditions in Tuolumne River reach?												
9	70% recovery timing at lower Tuolumne site (Table 3) indicates treatment and control fish migrated out of the Tuolumne River under uniform conditions	0	0	0	0	0	0	0	1	0	1	0
10	Low Temperature variation at Modesto (Range/Target < 20%) during 70% Lower Tuolumne capture period (Table 5).	0	0	0	2	2	2	2	0	0	0	0
11	Low flow variation (Range/Target < 20%) at Modesto during 70% Lower Tuolumne capture period (Table 4).	2	0	0	2	2	0	2	0	0	2	0
Did treatment and control fish experience similar conditions in the San Joaquin River reach?												
12	70% Mossdale recovery timing (Table 3) indicates treatment and controls migrated together through the San Joaquin River.	0	0	2	1	0	0	0	0	1	2	2
13	Temperature variations at Vernalis during 70% Mossdale recapture period (Table 5) were similar for treatment and control fish.	2	2	2	1	2	1	2	2	2	2	2
14	Flow variations at Vernalis during 70% Mossdale recapture period (Table 4) were similar for treatment and control fish..	2	1	2	2	2	2	2	1	2	2	2
15	Control and treatment group fish were subjected to similar capture effort at Mossdale (Task 2).	1	2	1	1	0	0	0	1	1	2	2

2 Study Assumption Met
1 Study Assumption May Not Have Been Met
0 Factor Caused Violation in Study Assumption
(shaded) Inferred assumption based on entry with no data.

Table 3: Relative Weights of Tuolumne River CWT Studies Survival Indices between 1987-2002

Note: Survival weights are calculated as the product of Study Factor Importance and Quality for each year.

ID	Importance	Factors Necessary to Meet CWT Study Assumptions	Assumptions Met in Year?										
			1987	1990	1994	1995	1996	1997	1998	1999	2000	2001	2002
Fish in the control and treatment groups were biologically similar and experienced similar handling, especially with regard to water temperatures at the hatchery, in the trailer, and at the release site.													
1	12	Control and treatment group fish were larger than 75 mm FL (Table 2).	24	0	24	24	24	0	24	24	12	12	24
2	13	Control and treatment group fish were the same size (<5% Diff.) at release (Table 2).	26	0	26	26	26	13	26	26	26	26	26
3	4	Control and treatment group fish were of the same origin?	8	8	8	8	8	8	8	8	8	8	8
4	1	Control and treatment group fish were of the same egg lot? (Table 2).	1	0	2	2	2	2	2	2	2	2	2
5	11	Below 3^{o}C Difference in hatchery water temperatures (Table 2).	22	11	22	22	22	22	22	22	22	22	22
6	2	Below 3^{o}C Difference in transport water temperatures (Table 2).	0	4	4	2	4	4	0	4	4	4	4
7	14	Same potential for thermal shock at release site (Table 2)	0	0	0	0	0	0	28	28	28	28	0
8	15	Were either treatment or control fish exposed to temperatures >20^{o}C at different times (Table 5)	30	0	15	30	30	0	15	30	30	30	30
Did treatment and control fish experience similar conditions in Tuolumne River reach?													
9	3	70% Shiloh recovery timing (Table 3) indicates treatment and control fish migrated out of the Tuolumne River under Uniform conditions	0	0	0	0	0	0	0	3	0	0	0
10	8	Low Temperature variation at Modesto (Range/Target < 20%) during 70% Lower Tuolumne capture period (Table 5).	0	0	0	16	16	16	16	0	0	0	0
11	10	Low flow variation (Range/Target < 20%) at Modesto during 70% Lower Tuolumne capture period (Table 4).	20	0	0	20	20	0	20	0	0	0	0
Did treatment and control fish experience similar conditions in the San Joaquin River reach?													
12	9	70% Mossdale recovery timing (Table 3) indicates treatment and controls migrated together through the San Joaquin River.	0	0	18	9	0	0	0	0	9	9	18
13	5	Temperature variations at Vernalis during 70% Mossdale recapture period (Table 5) were similar for treatment and control fish.	10	10	10	5	10	5	10	10	10	10	10
14	7	Control and treatment group fish experienced similar Flow variations at Vernalis during 70% Mossdale recapture period.	14	7	14	14	14	14	14	7	14	14	14
15	6	Control and treatment group fish were subjected to simila capture effort at Mossdale (Task 2).	6	12	6	6	0	0	0	6	6	6	12
Relative weight of survival estimate for each year to be used in developing a La Grange flow vs. river-wide survival regression.													
Overall Weighting of Confidence in Survival Estimate for each Year (0 = None, 225 = Moderate, 450 = High)			***161***	***52***	***149***	***184***	***176***	***84***	***185***	***170***	***171***	***171***	***170***

Table 4: Comparison of Tuolumne River smolt survival between 1987 and 200 using actual and capture-effort-expanded CWT smolt recoverie

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 (^{o}C) at Modesto weighted by daily recaptures at Mossdale	Actual Recovery Results		Capture Effort Expanded Results	
				Recaptures	Survival (%)	Recaptures	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	

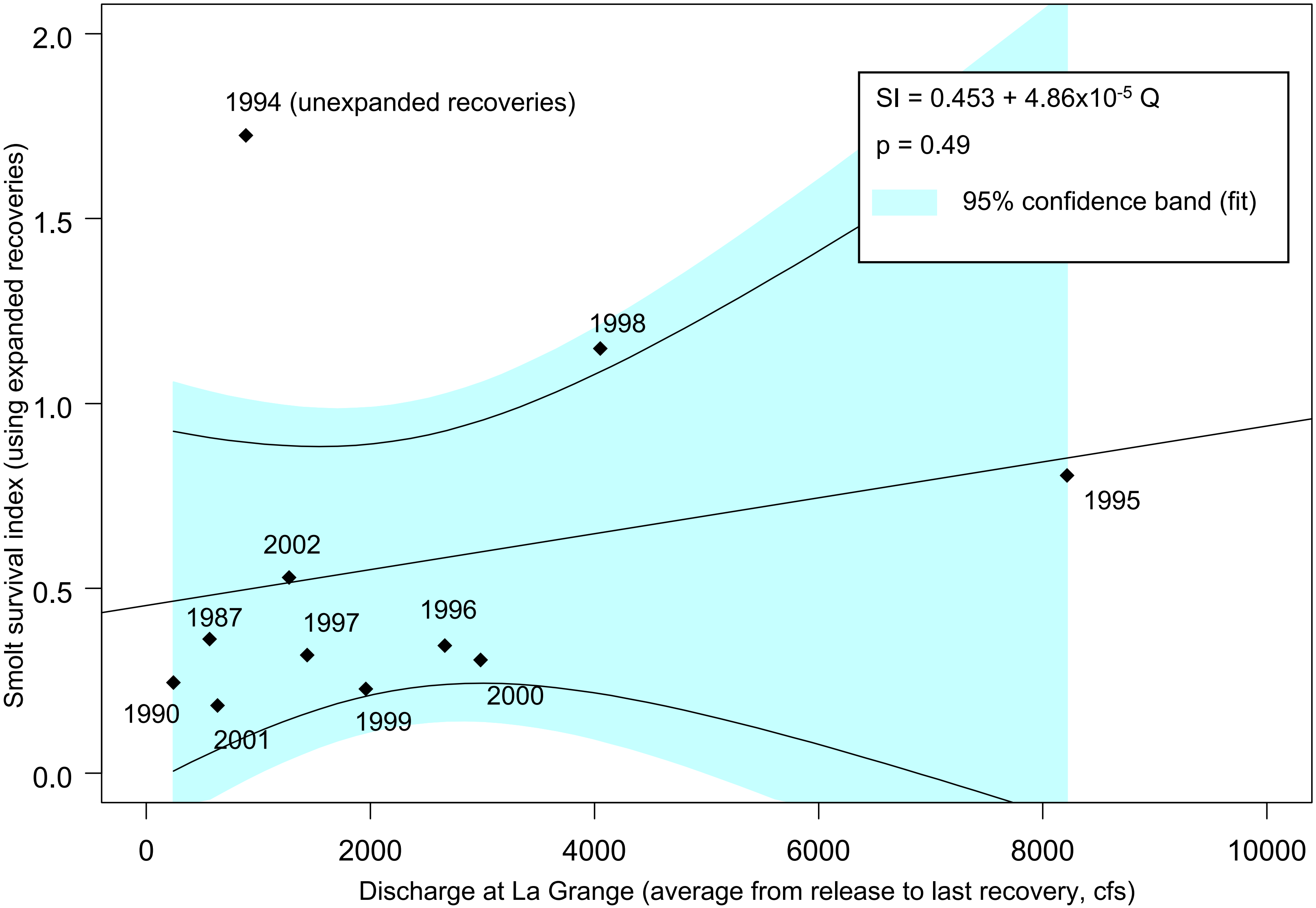

Figure 1: Linear regression of validated smolt survival indices by the recovery-weighted flow (cfs) at La Grange from release to last recapture at Mossdale Trawl

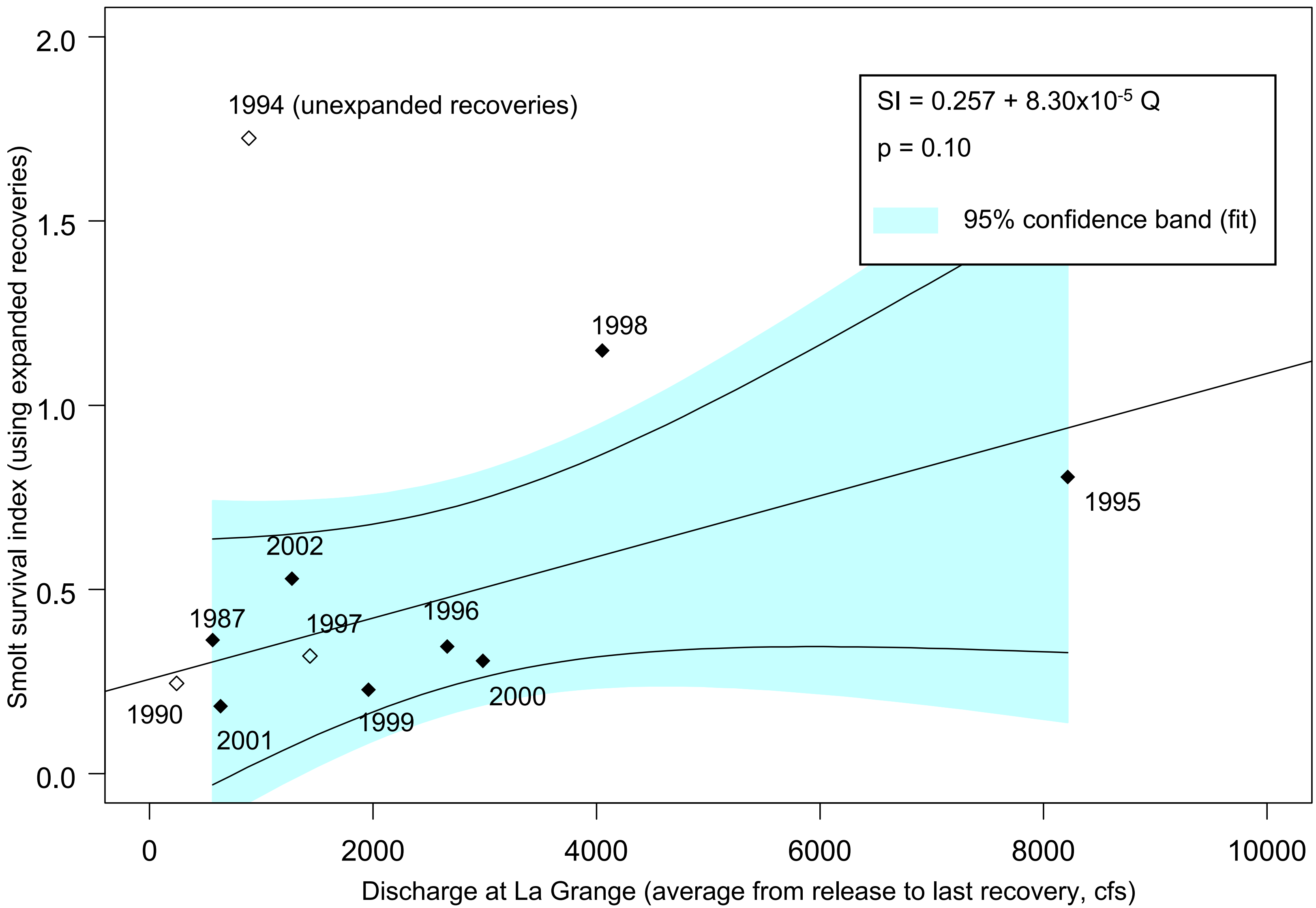

Figure 2: Linear regression of validated smolt survival indices by the recovery-weighted flow (cfs) at La Grange from release to last recapture at Mossdale Trawl

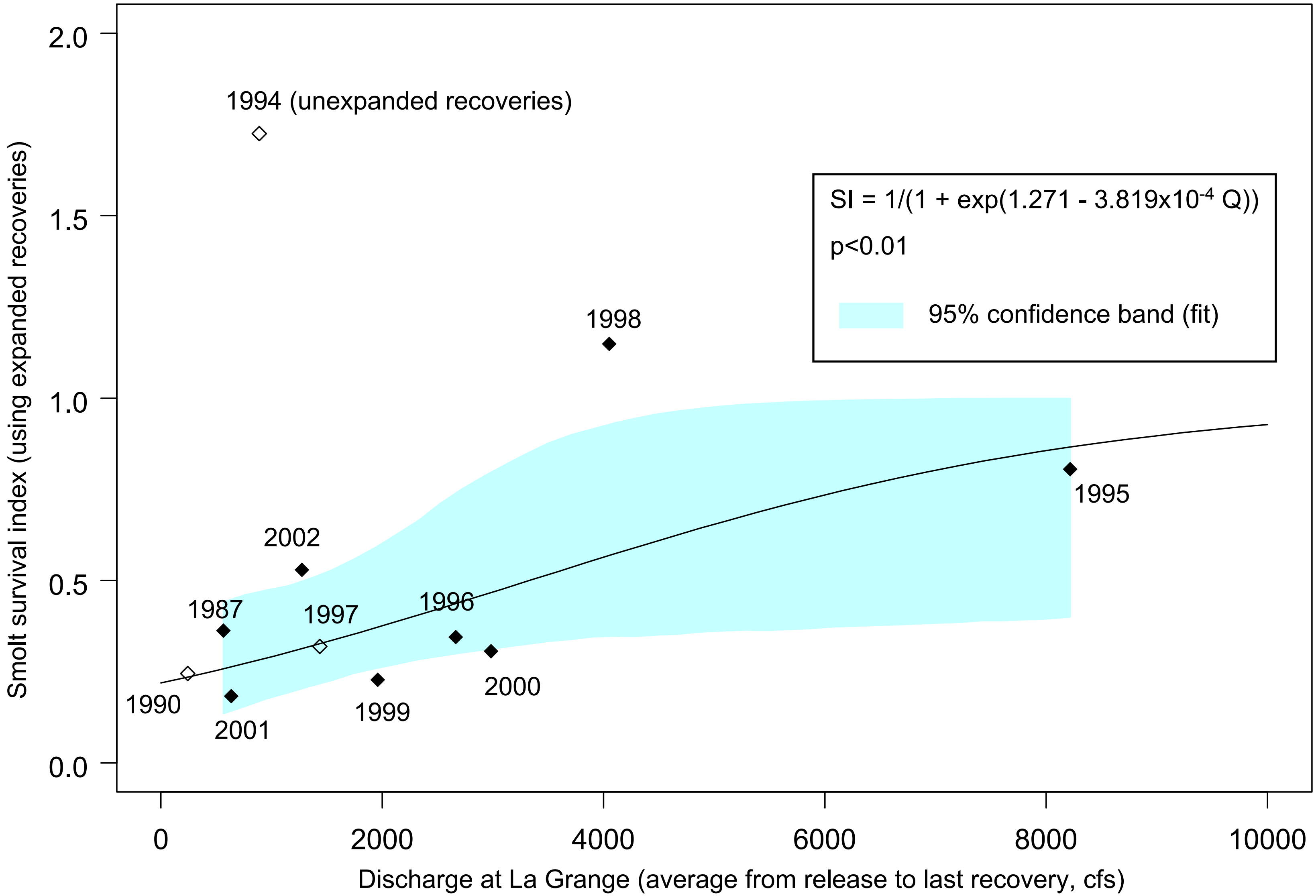

Figure 3: Logistic regression of validated smolt survival indices by the recovery-weighted flow (cfs) at La Grange from release to last recapture at Mossdale Trawl

APPENDIX A

DATA SUMMARY

TUOLUMNE RIVER CHINOOK SALMON CODED WIRE TAG PROGRAM EVALUATION 1987, 1990, 1994–2002

Table A1
Tuolumne River CWT Smolt Release Data

Release Year	Release Date [a]	Tag Code [a]	Release Location		Total River Miles Evaluated	Effective # released [a]	Average Fork Length (mm) [a]		Temperature (°C)						
			Site Name	RM			at release	at recovery	hatchery [a]	trailer [a]	release site [a]	difference between trailer & release site	La Grange [b]	Modesto [c-i]	Vernalis [h]
1987	16-Apr	06-46-60	OLGB	50.5	38	29,953	85	NA	14	14.5	13.0	1.50	11.5	18.0 [c]	17.50
	16-Apr	06-46-61	OLGB	50.5		30,609	85		14	14.5	13.0	1.50	11.5	18.0 [c]	17.50
	16-Apr	06-46-62	OLGB	50.5		29,037	85		14	14.5	13.0	1.50	11.5	18.0 [c]	17.50
	16-Apr	06-46-63	RDP	12.3		30,703	82		14	10.0	18.0	-8.00	11.5	18.0 [c]	17.50
	16-Apr	06-45-01	RDP	12.3		31,869	82		14	10.0	18.0	-8.00	11.5	18.0 [c]	17.50
	16-Apr	06-45-02	RDP	12.3		30,937	82		14	10.0	18.0	-8.00	11.5	18.0 [c]	17.50
1990	30-Apr	11-02-01	OLGB	50.5	50	23,494	83	NA	NA	13.5	11.0	2.50	10.1	19.6 [c]	20.0
	30-Apr	11-02-02	OLGB	50.5		21,766	83			13.5	11.0	2.50	10.1	19.6 [c]	20.0
	30-Apr	11-02-14	OLGB	50.5		24,134	83			13.5	11.0	2.50	10.1	19.6 [c]	20.0
	30-Apr	11-02-15	OLGB	50.5		24,259	83			13.5	11.0	2.50	10.1	19.6 [c]	20.0
	1-May	11-02-03	MAPES	1		27,263	72			13.0	20.0	-7.00	10.0	19.3 [c]	20.6
	1-May	11-02-04	MAPES	1		26,067	72			13.0	20.0	-7.00	10.0	19.3 [c]	20.6
	1-May	11-02-05	MAPES	1		24,905	72			13.0	20.0	-7.00	10.0	19.3 [c]	20.6
1994	23-Apr	601110302	OLGB	50.5	49.5	27,803	85*	85.55	11.56	11.67	10.56	-1.11	10.50	17.75 [b]	17.75
	23-Apr	601110303	OLGB	50.5		27,803	85*	86.64	11.56	11.67	10.56	-1.11	10.50	17.75 [b]	17.75
	23-Apr	601110304	OLGB	50.5		27,802	85*	85.00	11.56	11.67	10.56	-1.11	10.50	17.75 [b]	17.75
	24-Apr	601110305	MAPES	1		25,029	82	89.40	11.39	8.89	16.67	7.78	10.50	15.50 [b]	16.00
	24-Apr	601110306	MAPES	1		25,029	82	86.00	11.39	8.89	16.67	7.78	10.50	15.50 [b]	16.00
1995	4-May	601110311	OLGB	50.5	41.25	29,989	86	107.20	10.28	no data	8.89	- -	10.00	12.15 [d]	18.00
	4-May	601110312	OLGB	50.5		28,988	86	105.69	10.28	no data	8.89	- -	10.00	12.15 [d]	18.00
	4-May	601110313	OLGB	50.5		30,287	86	103.94	10.28	no data	8.89	- -	10.00	12.15 [d]	18.00
	5-May	601110314	SERVICE	9.25		27,770	89	105.23	10.28	8.89	12.00	3.11	10.00	11.60 [d]	17.25
	5-May	601110315	SERVICE	9.25		29,139	89	104.00	10.28	8.89	12.00	3.11	10.00	11.60 [d]	17.25
1996	26-Apr	601110506	OLGB	50.5	41.25	21,501	88	97.05	11.50	9.44	11.67	2.23	11.25	13.45 [f]	17.25
	26-Apr	601110507	OLGB	50.5		22,761	88	94.69	11.50	9.44	11.67	2.23	11.25	13.45 [f]	17.25
	26-Apr	601110508	OLGB	50.5		22,893	88	96.65	11.50	9.44	11.67	2.23	11.25	13.45 [f]	17.25
	27-Apr	601110509	SERVICE	9.25		22,715	90	90.38	11.50	10.00	13.89	3.89	11.00	13.30 [f]	17.00
	27-Apr	601110510	SERVICE	9.25		27,745	90	90.63	11.50	10.00	13.89	3.89	11.00	13.30 [f]	17.00
1997	22-Apr	601110607	OLGB	50.5	41.25	35,004	71	91.25	11.39	12.78	8.89	-3.89	9.75	13.50 [e]	17.50
	22-Apr	601110608	OLGB	50.5		33,695	71	94.17	11.39	12.78	8.89	-3.89	9.75	13.50 [e]	17.50
	22-Apr	601110609	OLGB	50.5		27,622	71	88.10	11.39	12.78	8.89	-3.89	9.75	13.50 [e]	17.50
	22-Apr	601110610	OLGB	50.5		8,882	71	89.00	11.39	12.78	8.89	-3.89	9.75	13.50 [e]	17.50
	23-Apr	601110604	SERVICE	9.25		31,739	75	79.71	11.39	13.33	13.33	0	10.00	12.35 [e]	16.75
	23-Apr	601110605	SERVICE	9.25		32,297	75	81.45	11.39	13.33	13.33	0	10.00	12.35 [e]	16.75
	23-Apr	601110606	SERVICE	9.25		27,075	75	81.75	11.39	13.33	13.33	0	10.00	12.35 [e]	16.75
1998	15-Apr	601110703	OLGB	50.5	53.5	32,787	83	92.78	10.00	10.00	10.56	0.56	10.25	10.95 [e]	13.25
	15-Apr	601110704	OLGB	50.5		26,633	83	94.20	10.00	10.00	10.56	0.56	10.25	10.95 [e]	13.25
	15-Apr	601110705	OLGB	50.5		27,404	83	98.53	10.00	10.00	10.56	0.56	10.25	10.95 [e]	13.25
	15-Apr	601110706	OLGB	50.5		7,234	83	96.33	10.00	10.00	10.56	0.56	10.25	10.95 [e]	13.25
	16-Apr	601110707	CLUB	-3		25,754	86	88.82	10.00	no data	no data	n/a	10.25	11.05 [e]	14.00
	17-Apr	601110708	CLUB	-3		22,006	86	90.83	10.00	13.33	15.00	1.67	10.25	11.15 [e]	14.75

Table A1
Tuolumne River CWT Smolt Release Data

Release Year	Release Date [a]	Tag Code [a]	Release Location: Site Name	Release Location: RM	Total River Miles Evaluated	Effective # released [a]	Average Fork Length (mm) [a]: at release	Average Fork Length (mm) [a]: at recovery	Temperature (°C): hatchery [a]	Temperature (°C): trailer [a]	Temperature (°C): release site [a]	Temperature (°C): difference between trailer & release site	Temperature (°C): La Grange [b]	Temperature (°C): Modesto [c-i]	Temperature (°C): Vernalis [h]
1999	17-Apr	06-46-01	OLGB	50.5	53.5	25,534	86 (73-98)	92	11	13.3	11.1	2.22	10.8	13.3 [e]	16.72
	18-Apr	06-46-02	OLGB	50.5		25,679	86 (76-99)	90	11	12.8	11.1	1.67	10.50	13.1 [e]	16.80
	19-Apr	06-46-03	OLGB	50.5		25,008	86 (68-95)	88	11	12.2	12.8	-0.56	10.50	12.8 [e]	16.46
	18-Apr	06-46-04	OFC (SJR)	-3		25,121	86 (71-94)	85	11	15.0	18.9	-3.89	10.50	14.3 [g]	16.80
	19-Apr	06-46-05	OFC (SJR)	-3		25,836	85 (73-99)	85	11	13.9	18.3	-4.44	10.50	14.0 [g]	16.46
2000	13-Apr	06-45-56	OLGB (CWT)	50.5	53.5	23,603	74 (4.09)	85	12	13.3	11.1	2.19	11.00	15.8 [e]	17.36
	15-Apr	06-45-57	OLGB (CWT)	50.5		22,096	74 (4.81)	83	12	13.3	11.1	2.20	11.00	12.2 [e]	14.27
	15-Apr	06-45-58	OLGB (CWT)	50.5		26,975	75 (4.42)	85	12	12.2	10.6	1.60	11.00	12.2 [e]	14.27
	16-Apr	06-45-59	OFC (SJR)	-3		21,698	73 (4.47)	84	12	12.2	13.3	-1.10	11.00	12.3 [g]	13.93
	14-Apr	06-45-60	OFC (SJR)	-3		23,071	75 (5.08)	80	12	12.2	15.6	-3.40	11.00	14.2 [g]	16.80
2001	22-Apr	06-44-12	OLGB	50.5	53.5	24,600	82	86	12	10.0	11.0	-1.00	11.34 [i]	13.2 [e]	14.27
	22-Apr	06-44-13	OLGB	50.5		22,758	82	85	12	13.0	12.0	1.00	11.34 [i]	13.2 [e]	14.27
	23-Apr	06-44-14	OLGB	50.5		21,527	82	86	12	10.0	11.0	-1.00	11.34 [i]	13.2 [e]	14.27
	28-Apr	06-44-43	OFC (SJR)	-3		22,051	82	84	13	13.0	19.0	-6.00	11.38 [i]	13.2 [e]	17.48
	26-Apr	06-44-44	OFC (SJR)	-3		24,393	85	85	13	14.0	21.0	-7.00	11.57 [i]	13.2 [e]	18.63
2002	24-Apr	06-44-67	OLGB	50.5	53.5	24,770	86	NA	15	13.3	11.8	1.50	10.50	16.00	17.61
	24-Apr	06-44-68	OLGB	50.5		25,176	86		15	13.3	11.8	1.50	10.50	16.00	17.61
	25-Apr	06-44-06	OLGB	50.5		24,978	86		15	13.3	11.8	1.50	10.50	15.06	17.40
	29-Apr	06-44-69	OFC (SJR)	-3		23,871	86		15	13.0	16.0	-3.00	10.50	12.89	14.66
	26-Apr	06-44-61	OFC (SJR)	-3		25,701	85		15	13.0	16.7	-3.70	10.25	14.33	16.84

* Regional Mark Information Systems (RMIS) maintained by Pacific States Marine Fisheries Council (PSMFC) report 71 mm for these fish.

indicates violation of assumption of <5% variability.

sources:
a. California Department of Fish and Game, La Grange, CA.
b. USGS gauge 11289650 - Tuolumne River below La Grange Dam, near La Grange, CA
c. USGS gauge 11290000 - Tuolumne River at Modesto, CA
d. TID thermograph Riverdale Park (RM 12.3)
e. TID thermograph Hughson (RM 23.6)
f. TID thermograph Charles Road (RM 24.9)
g. TID thermograph Shiloh Road (RM 3.4)
h. USGS gauge San Joaquin River near Vernalis, CA (11303500)
i. TID thermograph Riffle 3B (RM 49.0)

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Table A2
Tuolumne River CWT Smolt Recovery Data

Year	Tag Code [a]	Release Location		Release Date [a]	Release Totals (upper & lower) [a]	Lower Tuolumne Recapture Period (days)		Mossdale Recapture Period					
		Site Name	RM			from Release to 70% of Total Recovery	from Release to 90% of Total Recovery	First Recovery Date	Days to 70% Recapture (Expanded)	Days to 90% Recapture (Expanded)	Last Recovery Date	Actual Smolt Recovery (Expanded)	Percentage of Smolts Recovered at Mossdale
1987	06-46-60 06-46-61 06-46-62	OLGB	50.5	16-Apr	89,599	NA	NA	16-Apr	6 days (5 days)	7 days (7 days)	29-Apr	128 (2,494)	0.14%
	06-46-63 06-45-01 06-45-02	RDP	12.3	16-Apr	93,509			19-Apr	2 days (2 days)	6 days (3 days)	7-May	317 (7,174)	0.34%
1990	11-02-01 11-02-02 11-02-14 11-02-15	OLGB	50.5	30-Apr	93,653	NA	NA	2-May	3 days (5 days)	8 days (9 days)	21-May	63 (698)	0.07%
	11-02-03 11-02-04 11-02-05	MAPES	1	1-May	77,425			2-May	11 days (12 days)	19 days (20 days)	29-May	173 (2,357)	0.22%
1994	601110302 601110303 601110304	OLGB	50.5	23-Apr	83,408	NA	NA	25-Apr	10 days (NA)	13 days (NA)	12-May	207 (NA)	0.25%
	601110305 601110306	MAPES	1	24-Apr	50,058			25-Apr	9 days (NA)	15 days (NA)	15-May	72 (NA)	0.14%
1995	601110311 601110312 601110313	OLGB	50.5	4-May	89,264 [b]	14	21	6-May	26 days (26 days)	32 days (32 days)	17-Jun	58 ± 7.6 (827 ± 109)	0.06%
	601110314 601110315	SERVICE	9.25	5-May	56,909[b]			6-May	21 days (21 days)	30 days (30 days)	15-Jun	47 ± 6.9 (655 ± 96)	0.08%
1996	601110506 601110507 601110508	OLGB	50.5	26-Apr	67,155	4	12	28-Apr	4 days (9 days)	22 days (25 days)	29-May	66 ± 8.1 (525 ± 69)	0.10%
	601110509 601110510	SERVICE	9.25	27-Apr	50,460			28-Apr	1 day (1 day)	3 days (4 days)	7-May	156 ± 12.5 (1,143 ± 94)	0.31%
1997	601110607 601110608 601110609 601110610	OLGB	50.5	22-Apr	105,203	6	15	9-May	25 days (25 days)	26 days (26 days)	19-May	32 ± 6 (273 ± 50)	0.03%
	601110604 601110605 601110606	SERVICE	9.25	23-Apr	91,111			25-Apr	23 days (17 days)	26 days (26 days)	20-May	56 ± 7 (663 ± 92)	0.06%
1998	601110703 601110704 601110705 601110706	OLGB	50.5	15-Apr	94,058	2	22	17-Apr	25 days (27 days)	34 days (34 days)	2-Jun	130 ± 11 (816 ± 74)	0.14%
	601110707 601110708	CLUB	-3	17-Apr	47,760	NA	NA	17-Apr	11 days (12 days)	15 days (15 days)	5-May	64 ± 8 (361 ± 48)	0.13%
1999	06-46-01 06-46-02 06-46-03	OLGB	50.5	17-Apr	76,221	12	22	18-Apr	13 days (13 days)	33 days (34 days)	22-May	45 (248)	0.06%
	06-46-04 06-46-05	OFC (SJR)	-3	18-Apr	50,957			18-Apr	2 days (2 days)	3 days (4 days)	30-Apr	158 (728)	0.31%
2000	06-45-56 06-45-57 06-45-58	OLGB	50.5	13-Apr	72,674	13	33	15-Apr	12 days (12 days)	20 days (20 days)	22-May	37 (210)	0.05%
	06-45-59 06-45-60	OFC (SJR)	-3	14-Apr	44,769			17-Apr	4 days (4 days)	8 days (8 days)	29-Apr	81 (422)	0.18%
2001	06-44-12 06-44-13 06-44-14	OLGB	50.5	22-Apr	68,885	7	9	26-Apr	6 days (6 days)	7 days (7 days)	3-May	107 (390)	0.16%
	06-44-43 06-44-44	OFC (SJR)	-3	26-Apr	46,443			27-Apr	3 days (3 days)	3 days (3 days)	9-May	399 (1,439)	0.86%
2002	06-44-67 06-44-68 06-44-06	OLGB	50.5	24-Apr	74,924	4	7	27-Apr	4 days (4 days)	5 days (5 days)	12-May	179 (859)	0.24%
	06-44-69 06-44-61	OFC (SJR)	-3	26-Apr	23,871			27-Apr	2 days (2 days)	5 days (5 days)	10-May	116 (556)	0.49%

a. California Department of Fish and Game, La Grange, CA.
b. 1995 CWT Summary Update indicates 83,549 fish released from the upper site, and 53,298 fish released from the lower site.
c. 2002 Recoveries of 2nd release group not included in analysis due to mmajority of fish passing Mossdale on day with no trawls

Table A3
Flow Variation During CWT Recovery at Lower Tuolumne RSTs and Mossdale Trawl

Release Year	Flow at Release (cfs) at:			Flow Variability During 70% Lower Tuolumne Recapture Period at:				Flow Variability During 70% Mossdale Recapture Period at:				Flow Variability During CPUE Expanded [d, e] 70% Mossdale Recapture Period at:			
	La Grange [a]	Modesto [b]	Vernalis [c]	La Grange [a]		Modesto [b,d]		Modesto [b,d]		Vernalis [c]		Modesto [b,d]		Vernalis [c]	
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1987	563	741	2,790	NA	NA	NA	NA	761	741 - 776	2,716	2,580 - 2,790	761	741 - 776	2,738	2,690 - 2,790
	563	741	2,790					750	741 - 762	2,757	2,720 - 2,790	750	741 - 762	2,757	2,720 - 2,790
1990	599	414	1,260	NA	NA	NA	NA	535	414 - 589	1,365	1,260 1,440	534	414 - 589	1,388	1,260 - 1,480
	573	556	1,350					347	145 - 589	1,307	1,080 - 1,480	331	134 - 589	1,294	1,080 - 1,480
1994	1,160	424	1,410	N/A	N/A	N/A	N/A	736	398 - 1,150	2,577	1,410 - 3,640	736	398 1,150	2,577	1,410 - 3,640
	1,260	862	1,730					736	398 - 1,150	2,577	1,730 - 3,640	767	398 - 1,150	2,694	1,730 - 3,640
1995	7,730	7,270	19,000	7,743	7,630 - 8,000	7,771	7,270 - 8020	8,097	7,270 - 8,610	22,730	19,000 - 23,500	8,097	7,270 - 8,610	22,730	19,000 - 23,500
	7,640	7,740	20,800	NA	NA	NA	NA	8,045	7,630 - 8,610	22,827	20,800 - 23,500	8,045	7,630 - 8,610	22,827	20,800 - 23,500
1996	2,580	2,740	6,690	2,616	2,570 - 2,700	2,816	2,740 - 2860	2,816	2,740 - 2,860	6,668	6,600 - 6,700	2,772	2,230 - 3,200	6,558	6,230 - 6,700
	2,610	2,810	6,700	NA	NA	NA	NA	2,835	2,810 - 2,860	6,690	6,680 - 6,700	2,835	2,810 - 2,860	6,690	6,680 - 6,700
1997	2,860	1,690	5,790	2,790	2,740 - 2,860	2,777	1,690 - 2970	2,093	550 - 2,970	5,865	4,410 - 6,350	2,093	550 - 2,970	5,865	4,410 - 6,350
	2,800	2,970	6,080	NA	NA	NA	NA	2,174	879 - 2,970	5,928	4,860 - 6,350	2,377	1,140 - 2,970	6,007	5,540 - 6,350
1998	6,400	7,100	24,900	6,523	6,400 - 6,650	7,083	7,050 - 7100	4,228	2,300 - 7,100	19,885	16,300 - 25,000	4,175	2,300 - 7,100	19,646	16,300 - 25,000
	6,650	7,100	24,900	NA	NA	NA	NA	5,354	4,450 - 7,100	22,200	19,300 - 25,000	5,354	4,450 - 7,100	22,200	19,300 - 25,000
1999	1,930	1,680	6,630	2,689	1,870 - 3,460	5,041	4,180 - 7,050	2,006	1,300 - 3,270	6,915	6,630 - 7,280	2,006	1,300 - 3,270	6,915	6,630 - 7,280
	1,970	1,780	6,780												
	1,960	1,750	6,930												
	1,970	1,780	6,780	NA	NA	NA	NA	2,340	1,300 - 3,270	7,017	6,730 - 7,340	2,340	1,300 - 3,270	7,017	6,730 - 7,340
	1,960	1,750	6,930												

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Table A3
Flow Variation During CWT Recovery at Lower Tuolumne RSTs and Mossdale Trawl

Release Year	Flow at Release (cfs) at:			Flow Variability During 70% Lower Tuolumne Recapture Period at:				Flow Variability During 70% Mossdale Recapture Period at:				Flow Variability During CPUE Expanded [d, e] 70% Mossdale Recapture Period at:			
	La Grange [a]	Modesto [b]	Vernalis [c]	La Grange [a]		Modesto [b,d]		Modesto [b,d]		Vernalis [c]		Modesto [b,d]		Vernalis [c]	
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
2000	3,780	1,600	3,120	2,310	1,040 - 3,830	3,790	2,340 - 4,830	2,711	1,100 - 4,430	5,908	3,120 - 7,070	2,711	1,100 - 4,430	5,908	3,120 - 7,070
	3,800	4,290	5,660												
	3,800	4,290	5,660												
	3,670	4,260	5,900	NA	NA	NA	NA	4,345	4,260 - 4,430	5,860	4,360 - 7,070	4,345	4,260 - 4,430	5,860	4,360 - 7,070
	3,830	4,060	4,360												
2001	623	858	4530	706	618 - 1,240	796	748 - 877	784	748 - 858	4,304	4,100 - 4,530	784	748 - 858	4,304	4,100 - 4,530
	684	775	4200	NA	NA	NA	NA	790	748 - 877	4,160	4,100 - 4,210	790	748 - 877	4,160	4,100 - 4,210
	618	748	4100												
2002	1310	978	3220	1,305	1,290 - 1,310	1,194	978 - 1,280	1,194	978 - 1,280	3,378	3,220 - 3,500	1,194	978 - 1,280	3,378	3,220 - 3,500
	1310	978	3220												
	1310	1210	3310												
	1310	1290	3610	NA	NA	NA	NA	1,285	1,280 - 1,290	3,555	3,500 - 3,610	1,285	1,280 - 1,290	3,555	3,500 - 3,610
	1290	1240	3410												

(shaded) indicates violation of assumption of <20% variability.

sources:
a. USGS gauge Tuolumne River below La Grange Dam, near La Grange, CA (11289650)
b. USGS gauge Tuolumne River at Modesto, CA (11290000)
c. USGS gauge San Joaquin River Basin near Vernalis, CA (11303500)
d. In 1994, flow variability during 70% and 90% Mossdale recapture period does not represent expanded CPUE.
e. In 1999, flows at Modesto were estimated by new USGS rating curve.

Table A4
Temperature Variation During CWT Recovery at Lower Tuolumne RSTs and Mossdale Trawl

Release Year	Temperature (°C) at Release: La Grange [a]	Temperature (°C) at Release: Modesto [b]	Temperature (°C) at Release: Vernalis [c]	Temperature Variability During 70% Lower Tuolumne Recapture Period at: La Grange [a] Mean	La Grange [a] Range	Modesto [b,e] Mean	Modesto [b,e] Range	Temperature Variability During 70% Mossdale Recapture Period at: Modesto [b,e] Mean	Modesto [b,e] Range	Vernalis [c] Mean	Vernalis [c] Range	Temperature Variability During CPUE Expanded [d] 70% Mossdale Recapture Period at: Modesto [b] Mean	Modesto [b] Range	Vernalis [c] Mean	Vernalis [c] Range
1987	11.5	18.00	17.50	NA	NA	NA	NA	16.6	15.0 - 18.0	17.1	16.0 - 18.0	16.9	16.0 - 18.0	16.4	15.0 - 17.5
	11.5	18.00	17.50					17.0	16.0 - 17.5	17.7	17.0 - 18.0	17.7	17.0 - 18.0	17.0	16.0 - 17.5
1990	10.1	19.6	20.0	NA	NA	NA	NA	19.0	18.4 - 19.6	22.3	20.5 - 24.3	19.3	18.4 - 20.3	23.3	20.5 - 25.6
	10.0	19.3	20.6					19.5	17.5 - 21.1	22.7	20.5 - 25.6	19.4	17.5 - 21.1	22.6	20.5 - 25.6
1994	10.50	17.75 [b]	17.75	N/A	N/A	N/A	N/A	15.9	13.5 - 19.5	16.7	15.0 - 19.8	15.9	13.5 - 19.5	16.7	15.0 - 19.8
	10.50	15.50 [b]	16.00					15.7	13.5 - 19.5	16.6	15.0 - 19.8	15.7	13.5 - 19.5	16.6	15.0 - 19.8
1995	10.00	12.15 [c]	18.00	10.6	10.50 - 10.8	10.8	10.30 - 11.3 [c]	12.2	11.0 - 13.0	17.9	15.8 - 20.3	11.1	10.3 - 11.6	17.9	15.8 - 20.3
	10.00	11.60 [c]	17.25					12.0	11.0 - 12.8	17.6	15.8 - 19.5	11.0	10.3 - 11.4	17.6	15.8 - 19.5
1996	11.25	13.45 [d]	17.25	11.2	11.00 - 11.3	13.3	13.00 - 13.5	13.3	13.1 - 13.6	16.8	16.0 - 17.3	13.4	12.9 - 13.8	17.2	16.0 - 18.0
	11.00	13.30 [d]	17.00					13.2	13.1 - 13.3	16.5	16.0 - 17.0	13.2	13.0 - 13.3	16.5	16.0 - 17.0
1997	9.75	13.50 [f]	18.25	9.9	9.80 - 10	12.6	12.20 - 13.8 [f]	13.7	12.1 - 18.6	17.5	15.0 - 20.8	13.7	12.0 - 18.5	17.4	15.0 - 20.8
	10.00	12.35 [f]	16.75					13.5	12.1 - 16.4	17.3	15.0 - 20.8	13.0	12.0 - 14.6	16.4	15.0 - 18.3
1998	10.25	10.95 [f]	13.25	10.3	10.30 - 10.3	11.0	10.90 - 11.2 [f]	12.0	11.0 - 13.1	17.4	13.3 - 19.8	12.0	10.9 - 13.0	17.3	13.3 - 19.8
	10.25	11.05 [f]	14.00	NA	NA	NA	NA	11.6	11.0 - 12.4	16.3	13.3 - 18.5	11.7	11.0 - 12.3	16.7	14.0 - 18.5
	10.25	11.15 [f]	14.75												
1999	10.8	13.3	16.7	10.3	9.5 - 11.5	13.6	10.5 - 15.5	13.5	11.7 - 14.8	16.2	14.0 - 18.0	13.5	11.7 - 14.8	16.2	14.0 - 18.0
	10.5	13.1	16.8												
	10.5	12.8	16.5												
	10.5	14.3	16.8	NA	NA	NA	NA	13.1	11.5 - 14.4	15.7	14.0 - 18.0	13.1	11.5 - 14.4	15.7	14.0 - 18.0
	10.5	14.0	16.5												

Table A4
Temperature Variation During CWT Recovery at Lower Tuolumne RSTs and Mossdale Trawl

Release Year	Temperature (°C) at Release: La Grange [a]	Modesto [b]	Vernalis [c]	Temperature Variability During 70% Lower Tuolumne Recapture Period at: La Grange [a] Mean	Range	Modesto [b,e] Mean	Range	Temperature Variability During 70% Mossdale Recapture Period at: Modesto [b,e] Mean	Range	Vernalis [c] Mean	Range	Temperature Variability During CPUE Expanded [d] 70% Mossdale Recapture Period at: Modesto [b] Mean	Range	Vernalis [c] Mean	Range
2000	11.0	15.80	17.4	11.1	10.5 - 12.0	14.1	11.2 - 19.6	13.6	11.9 - 15.4	16.0	14.3 - 17.3	13.6	11.9 - 15.4	16.0	14.3 - 17.3
	11.0	12.20	14.3												
	11.0	12.20	14.3												
	11.0	12.30	13.9	NA	NA	NA	NA	12.2	11.9 - 12.7	14.8	14.3 - 15.5	12.2	11.9 - 12.7	14.8	14.3 - 15.5
	11.0	14.20	16.8												
2001	11.34[g]	13.20	14.27	11.5	11.2 - 11.6	17.2	13.8 - 18.8	16.4	13.2 - 17.8	17.7	14.9 - 19.5	16.4	13.2 - 17.8	17.7	14.9 - 19.5
	11.38[g]	13.20	17.48	NA	NA	NA	NA	17.1	16.0 - 17.8	18.6	17.6 - 19.5	17.1	16.0 - 17.8	18.6	17.6 - 19.5
	11.57[g]	13.20	18.63												
2002	10.5	16.0	17.6	10.4	10.3 - 10.5	14.3	12.7 - 16.0	14.3	12.7 - 16.0	16.4	14.7 - 17.6	14.3	12.7 - 16.0	16.4	14.7 - 17.6
	10.5	16.0	17.6												
	10.5	15.1	17.4												
	10.5	12.9	14.7	NA	NA	NA	NA	13.0	12.9 - 13.0	14.5	14.3 - 14.7	13.0	12.9 - 13.0	14.5	14.3 - 14.7
	10.25	14.3	16.8												

indicates violation of assumption of <20% variability.

sources:
a. USGS gauge Tuolumne River below La Grange Dam, near La Grange, CA (11289650)
b. USGS gauge Tuolumne River at Modesto, CA (11290000)
c. TID thermograph Riverdale park (RM 12.3)
d. TID thermograph Charles Road (RM 24.9)
e. TID thermograph Shiloh Rd. (RM 3.4) used for 1987, 1999-2001
f. TID thermograph Hughson (RM 23.6)
g. USGS gauge San Joaquin River near Vernalis, CA (11303500)
h. In 1994, temperature variability during 70% and 90% Mossdale recapture period does not represent expanded CPUE.

Table A5
Daily recapture counts at Mossdale Trawl by Tuolumne River release group (1987, 1990, 1994-2002).

Date	1987		1990		1994		1995		1996		1997		1998		1999		2000		2001		2002	
Site	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower	upper	lower
15-Apr	-	-	-	-	-	-	-	-	0	0	0	0	-	-	0	0	0	0	-	-	0	0
16-Apr	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17-Apr	0	59	-	-	-	-	-	-	0	0	0	0	5	7	1	7	0	0	0	0	0	0
18-Apr	0	177	-	-	-	-	-	-	0	0	0	0	6	3	-	-	2	4	0	0	0	0
19-Apr	10	43	-	-	-	-	-	-	0	0	0	0	6	3	0	28	3	0	0	0	0	0
20-Apr	43	2	-	-	-	-	-	-	0	0	0	0	6	3	0	92	9	7	0	0	0	0
21-Apr	27	3	-	-	-	-	-	-	0	0	0	0	6	3	5	17	3	1	0	0	0	0
22-Apr	20	6	-	-	-	-	-	-	0	0	0	0	6	3	3	4	6	3	0	0	0	0
23-Apr	17	6	-	-	-	-	-	-	0	0	0	0	6	3	3	2	-	-	0	0	0	0
24-Apr	6	3	-	-	-	-	-	-	0	0	0	0	6	3	3	0	0	0	0	0	0	0
25-Apr	2	4	-	-	1	10	-	-	0	0	0	4	-	-	2	1	6	2	0	0	0	0
26-Apr	0	2	-	-	43	13	-	-	0	0	0	0	-	-	7	5	1	1	32	0	0	0
27-Apr	0	2	-	-	58	4	-	-	0	0	0	0	2	5	0	1	0	1	42	249	72	78
28-Apr	2	3	-	-	20	5	-	-	19	113	0	1	1	6	2	0	0	0	17	10	56	30
29-Apr	1	2	-	-	4	3	-	-	16	17	0	1	6	3	4	0	6	3	10	134	34	5
30-Apr	0	3	-	-	4	3	-	-	17	13	0	1	2	2	5	1	-	-	1	2	0	0
1-May	0	1	-	-	2	5	-	-	3	6	0	2	2	2	0	0	0	0	3	1	5	19
2-May	-	-	8	10	21	5	-	-	0	1	0	0	2	1	-	-	0	0	-	-	0	1
3-May	-	-	38	12	10	6	-	-	0	0	0	1	6	3	0	0	1	0	2	0	1	3
4-May	-	-	-	-	13	5	-	-	0	5	0	5	6	3	1	0	0	0	0	0	2	2
5-May	-	-	2	20	6	2	-	-	2	0	0	7	6	3	-	-	0	0	0	2	3	0
6-May	-	-	0	4	9	5	1	1	0	0	0	1	6	3	0	0	-	-	0	0	3	0
7-May	0	1	8	24	6	2	0	1	1	1	0	3	6	3	1	0	-	-	0	0	0	2
8-May	-	-	2	11	5	3	0	2	0	0	0	3	6	3	1	0	0	0	0	0	0	0
9-May	-	-	3	8	1	0	1	0	0	0	1	4	6	3	-	-	0	0	0	1	0	0
10-May	-	-	1	6	-	-	-	-	0	0	0	1	6	3	0	0	0	0	0	0	0	1
11-May	-	-	0	12	3	0	-	-	0	0	1	0	4	0	1	0	0	0	0	0	2	0
12-May	-	-	0	16	1	0	-	-	0	0	1	2	7	0	-	-	0	0	0	0	1	0
13-May	-	-	0	7	-	-	-	-	0	0	0	1	6	3	0	0	-	-	0	0	0	0
14-May	-	-	0	6	-	-	-	-	0	0	2	1	2	0	0	0	-	-	0	0	0	0
15-May	-	-	0	3	0	1	1	0	0	0	8	4	3	0	0	0	0	0	0	0	0	0
16-May	-	-	0	6	-	-	-	-	0	0	5	2	2	0	0	0	0	0	0	0	0	0
17-May	-	-	-	-	-	-	3	3	1	0	7	5	6	3	0	0	1	0	0	0	0	0
18-May	-	-	0	3	-	-	3	11	1	0	6	4	3	0	0	0	0	0	0	0	0	0
19-May	-	-	0	6	-	-	1	1	2	0	1	4	5	0	1	0	0	0	0	0	0	0
20-May	-	-	0	2	-	-	6	2	0	0	0	2	-	-	1	0	6	3	0	0	0	0
21-May	-	-	1	1	-	-	2	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0
22-May	-	-	0	3	-	-	4	3	0	0	0	0	2	0	3	0	1	0	0	0	0	0
23-May	-	-	0	8	-	-	6	2	0	0	0	0	0	0	-	-	0	0	0	0	0	0
24-May	-	-	0	2	-	-	2	2	0	0	-	-	-	-	0	0	0	0	0	0	0	0
25-May	-	-	0	2	-	-	3	2	0	0	-	-	-	-	0	0	0	0	0	0	-	-
26-May	-	-	-	-	-	-	5	3	-	-	-	-	2	0	-	-	0	0	0	0	-	-
27-May	-	-	-	-	-	-	-	-	-	-	0	0	6	3	0	0	-	-	0	0	-	-
28-May	-	-	-	-	-	-	-	-	1	0	0	0	0	0	0	0	-	-	0	0	0	0
29-May	-	-	0	1	-	-	-	-	1	0	0	0	0	0	0	0	-	-	0	0	0	0
30-May	-	-	-	-	-	-	4	0	0	0	0	0	1	0	-	-	0	0	0	0	0	0
31-May	-	-	-	-	-	-	2	0	0	0	0	0	-	-	-	-	-	-	0	0	0	0
1-Jun	-	-	-	-	-	-	0	2	0	0	-	-	0	0	0	0	0	0	0	0	-	-
2-Jun	-	-	-	-	-	-	-	-	0	0	0	0	2	0	-	-	0	0	-	-	-	-
3-Jun	-	-	-	-	-	-	5	1	0	0	0	0	-	-	0	0	-	-	-	-	0	0
4-Jun	-	-	-	-	-	-	2	5	0	0	0	0	0	0	0	0	-	-	0	0	0	0
5-Jun	-	-	-	-	-	-	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-Jun	-	-	-	-	-	-	1	0	0	0	0	0	0	0	-	-	0	0	0	0	0	0
7-Jun	-	-	-	-	-	-	-	-	0	0	-	-	-	-	0	0	-	-	0	0	0	0
8-Jun	-	-	-	-	-	-	-	-	0	0	-	-	0	0	0	0	0	0	0	0	-	-
9-Jun	-	-	-	-	-	-	-	-	0	0	0	0	0	0	-	-	0	0	-	-	-	-
10-Jun	-	-	-	-	-	-	-	-	0	0	-	-	-	-	0	0	-	-	-	-	0	0
11-Jun	-	-	-	-	-	-	0	1	0	0	0	0	0	0	0	0	-	-	0	0	-	-
12-Jun	-	-	-	-	-	-	0	1	0	0	0	0	0	0	-	-	0	0	0	0	0	0
13-Jun	-	-	-	-	-	-	0	0	0	0	0	0	0	0	-	-	0	0	0	0	-	-
14-Jun	-	-	-	-	-	-	-	-	0	0	-	-	-	-	0	0	0	0	0	0	0	0
15-Jun	-	-	-	-	-	-	1	1	-	-	-	-	0	0	0	0	0	0	0	0	-	-
16-Jun	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-	-	0	0	-	-	-	-
17-Jun	-	-	-	-	-	-	1	0	0	0	-	-	-	-			-	-	-	-	-	-

Note: " - " indicates no trawls confirmed to occur on this date

Table A6
Daily trawl effort (No. of trawls and minutes) at Mossdale for 1987, 1990, 1994-2002)

Date	1987		1990		1994		1995		1996		1997		1998		1999		2000		2001		2002	
Site	No.	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)	(n)	(min)
15-Apr	-	-	-	-	-	-	-	-	3	30	10	100	20	400	10	200	20	400	-	-	15	300
16-Apr	-	-	-	-	-	-	-	-	10	100	10	100	15	300	10	200	9	180	10	200	15	300
17-Apr	10	100	-	-	10	100	-	-	10	100	10	100	20	400	10	200	10	200	10	200	16	320
18-Apr	5	50	-	-	10	100	-	-	10	100	10	100	20	400	-	-	17	340	10	200	15	300
19-Apr	10	100	-	-	10	100	-	-	10	100	10	100	10	200	11	220	20	390	11	220	15	300
20-Apr	5	50	-	-	10	100	-	-	10	100	10	100	20	400	20	400	20	382	10	200	15	300
21-Apr	10	100	-	-	10	100	-	-	10	100	10	100	20	400	20	400	10	200	10	201	15	300
22-Apr	8	80	-	-	10	100	-	-	10	100	10	100	20	400	6	120	12	240	10	201	15	300
23-Apr	12	120	-	-	10	100	-	-	10	100	15	150	17	340	10	200	-	-	10	200	15	300
24-Apr	10	100	-	-	10	100	-	-	10	100	15	150	20	400	20	400	14	280	20	400	15	300
25-Apr	10	100	-	-	10	100	-	-	10	100	15	150	-	-	10	200	10	200	20	400	16	303
26-Apr	11	110	-	-	10	100	-	-	10	100	15	150	-	-	20	400	14	280	20	400	15	300
27-Apr	5	50	-	-	10	100	-	-	10	100	10	100	10	200	10	200	20	400	20	400	15	300
28-Apr	10	100	10	101	10	100	-	-	10	100	10	100	10	200	13	260	19	380	20	400	15	300
29-Apr	10	100	10	100	10	100	-	-	13	130	10	100	10	200	20	400	10	200	20	400	15	300
30-Apr	10	100	10	100	10	100	-	-	10	100	10	100	10	200	20	400	10	180	20	380	15	300
1-May	11	110	10	100	10	100	-	-	13	130	10	100	6	120	10	200	11	220	14	280	15	300
2-May	10	100	16	158	10	100	-	-	10	100	10	100	10	200	-	-	10	200	-	-	15	300
3-May	10	100	14	140	10	100	10	100	10	100	10	100	10	200	10	200	10	200	20	400	15	303
4-May	5	50	10	100	10	100	10	100	10	101	10	100	10	200	10	200	10	200	20	399	15	300
5-May	10	100	10	100	10	100	15	150	10	100	10	100	10	200	10	200	10	200	20	400	15	300
6-May	10	100	10	100	10	100	20	200	10	100	10	100	10	200	10	160	10	200	20	400	15	300
7-May	10	100	11	110	10	100	10	100	10	100	10	100	10	200	10	200	-	-	20	400	15	300
8-May	-	-	10	100	10	100	20	200	10	100	10	100	10	200	10	200	10	180	17	340	15	300
9-May	-	-	10	100	10	100	20	200	10	100	10	100	10	200	-	-	11	220	20	400	15	300
10-May	-	-	10	100	10	100	20	200	10	100	10	100	10	200	20	400	10	200	18	281	15	300
11-May	-	-	10	100	10	100	15	150	10	100	10	100	10	200	20	380	10	200	20	400	15	300
12-May	-	-	10	100	10	100	20	200	10	100	10	100	10	200	20	400	10	200	20	400	15	300
13-May	-	-	10	100	10	100	7	70	10	100	10	100	10	200	20	400	10	200	10	200	15	300
14-May	-	-	10	100	10	100	10	100	10	100	10	100	10	200	10	200	10	200	15	300	15	297
15-May	-	-	10	100	10	100	10	100	10	100	21	203	10	200	10	200	10	200	16	321	15	300
16-May	-	-	10	100	10	100	10	100	10	100	20	200	10	199	-	-	10	180	20	400	15	300
17-May	-	-	10	100	10	100	10	100	10	100	20	200	10	190	10	200	10	200	20	400	15	300
18-May	-	-	10	100	-	-	10	110	10	100	19	190	10	200	7	140	11	220	18	360	10	200
19-May	-	-	10	100	10	100	10	100	10	100	15	150	10	200	9	158	10	200	20	400	10	200
20-May	-	-	10	100	10	100	10	100	10	100	10	100	10	200	10	200	10	200	20	400	10	200
21-May	-	-	10	100	10	100	10	100	10	100	10	100	10	200	10	200	-	-	15	300	10	200
22-May	-	-	10	100	10	100	10	91	10	100	10	100	10	192	10	200	20	400	20	400	10	200
23-May	-	-	10	100	10	100	10	100	10	100	10	100	10	200	-	-	20	400	20	400	11	220
24-May	-	-	10	100	10	100	10	220	1	10	-	-	-	-	10	200	18	360	20	400	10	185
25-May	-	-	10	100	10	100	10	100	10	100	-	-	-	-	10	200	10	200	15	300	-	-
26-May	-	-	-	-	10	100	10	100	-	-	-	-	10	200	10	200	10	200	20	400	-	-
27-May	-	-	10	100	10	100	-	-	-	-	10	100	10	200	11	220	10	200	20	400	-	-
28-May	-	-	-	-	-	-	-	-	10	100	10	100	10	200	10	200	-	-	18	360	10	200
29-May	-	-	10	100	-	-	-	-	10	100	10	100	10	200	10	200	-	-	10	200	10	200
30-May	-	-	-	-	-	-	10	100	10	100	10	100	10	200	-	-	10	200	10	200	10	200
31-May	-	-	10	100	10	100	10	100	10	100	10	100	10	200	-	-	-	-	10	200	10	200
1-Jun	-	-	-	-	-	-	10	100	10	100	-	-	10	200	10	200	10	200	10	200	-	-
2-Jun	-	-	10	100	10	100	1	10	10	100	10	100	10	200	-	-	10	200	-	-	-	-
3-Jun	-	-	-	-	-	-	10	100	10	100	10	100	10	200	20	360	-	-	-	-	10	200
4-Jun	-	-	-	-	-	-	10	100	10	100	10	100	10	200	20	380	-	-	10	200	10	200
5-Jun	-	-	-	-	-	-	10	100	10	100	10	100	10	200	9	180	5	100	10	200	10	200
6-Jun	-	-	-	-	10	100	7	70	10	100	10	100	10	200	10	200	10	200	10	200	10	200
7-Jun	-	-	-	-	-	-	-	-	10	100	-	-	-	-	10	200	-	-	7	140	10	200
8-Jun	-	-	-	-	10	100	-	-	10	100	-	-	10	200	10	200	10	200	10	200	-	-
9-Jun	-	-	-	-	-	-	10	100	10	100	10	100	-	-	10	200	6	120	-	-	-	-
10-Jun	-	-	-	-	-	-	10	100	10	100	-	-	10	200	10	200	-	-	-	-	9	180
11-Jun	-	-	-	-	-	-	10	100	10	100	10	100	-	-	10	200	-	-	11	220	-	-
12-Jun	-	-	-	-	-	-	10	100	10	100	-	-	-	-	-	-	10	200	10	200	10	200
13-Jun	-	-	-	-	-	-	10	100	10	100	10	100	-	-	-	-	10	200	7	133	-	-
14-Jun	-	-	-	-	-	-	10	100	10	100	-	-	-	-	10	200	10	200	10	200	10	200
15-Jun	-	-	-	-	-	-	10	100	-	-	-	-	-	-	10	200	10	200	10	200	-	-
16-Jun	-	-	-	-	-	-	10	100	-	-	10	100	-	-	-	-	10	200	-	-	-	-
17-Jun	-	-	-	-	-	-	10	100	10	100	-	-	-	-	2	40	-	-	-	-	-	-

Notes " - " indicates no trawls confirmed to occur on this date

1. Trawl data from 1996-2004 downloaded from IEP online database 8 March 2005.
2. Trawl data for 1987, 1990, and 1995 data partially reconstructed from CWT recovery data provided by CDFG

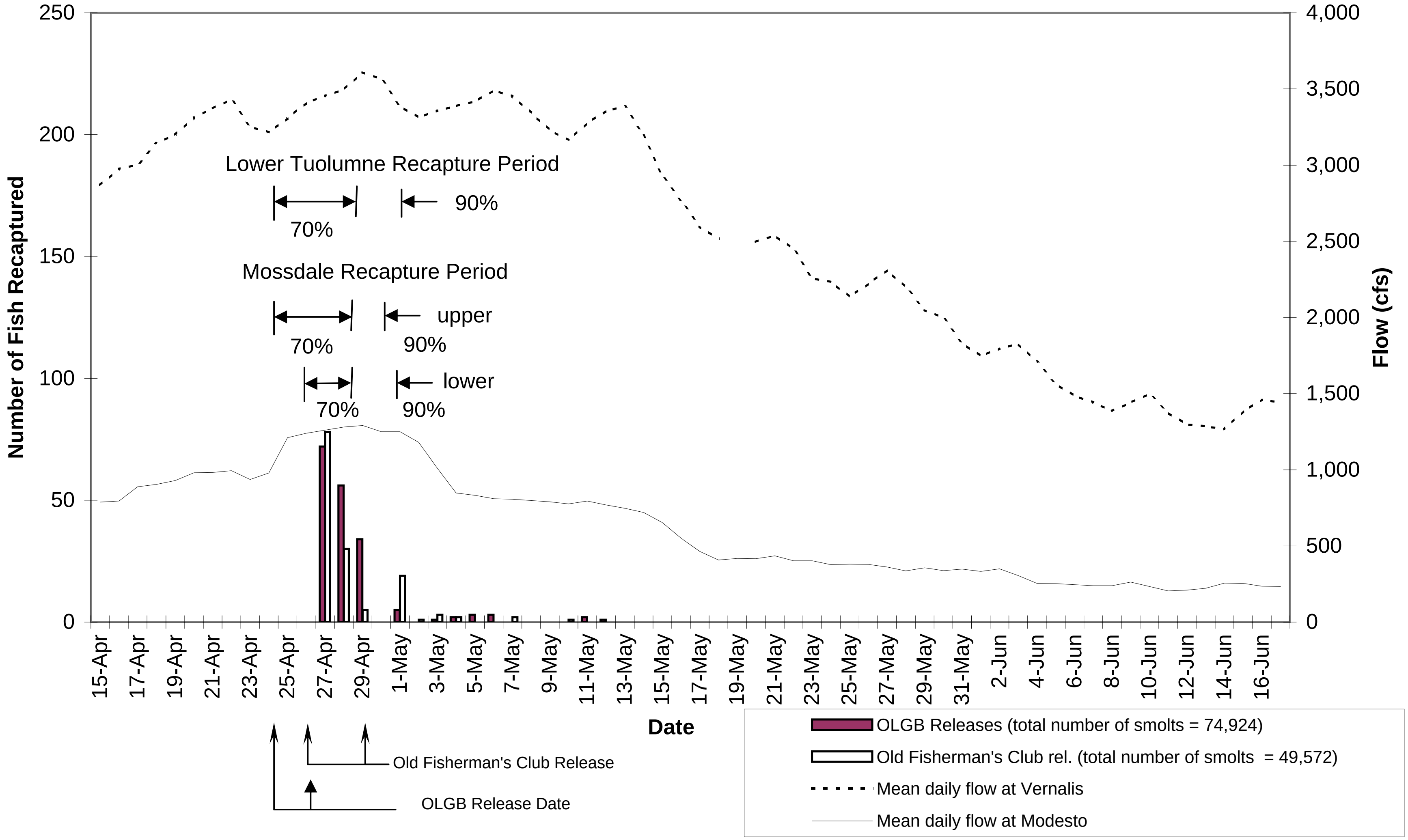

Figure A1. Recovery at Mossdale of CWT smolts released in the Tuolumne River vs. FLOW - 2002

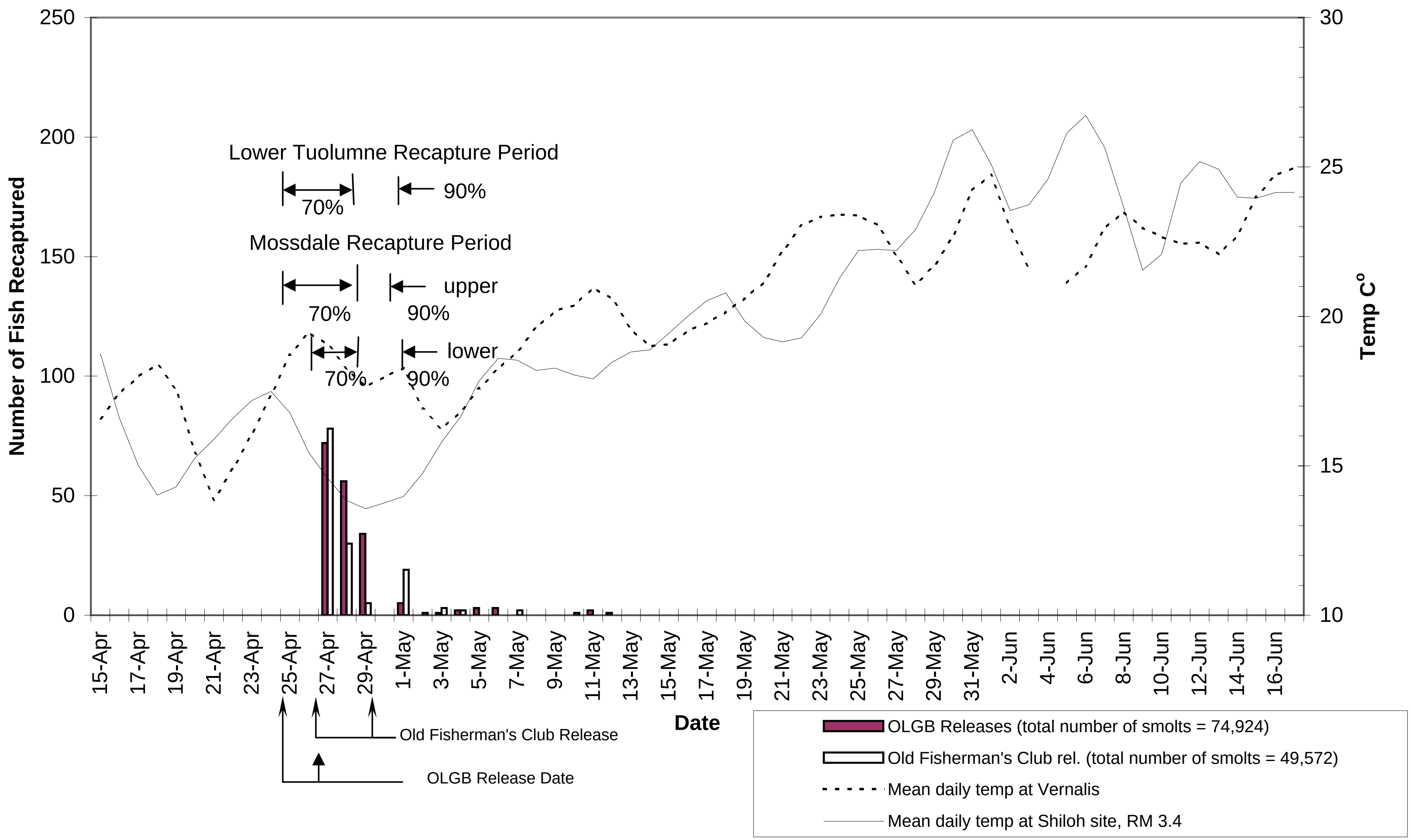

Figure A2. Recovery at Mossdale of CWT smolts released in the Tuolumne River vs. TEMPERATURE - 2002

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-8

Coded-wire Tag Summary Update

Prepared by

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and

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March 2005

EXECUTIVE SUMMARY

Releases of coded-wire-tagged (CWT) fall-run Chinook salmon originating from the San Joaquin Basin, primarily from the Merced River Hatchery, have been made in the San Joaquin River and tributaries since 1978. Beginning in 1986, CWT hatchery smolt releases have been made in mid-April to early-May of most years to study differential survival of smolts released at various river flows and locations.

This report, an update of FERC Reports 1996-13 and 2003-3, summarizes the available recovery data for the 2000-2002 basin release groups. The principal focus of this report is the Tuolumne River CWT smolt survival studies, which began in 1986 under the Don Pedro Project FERC fish study program. Relative survival indices for upper and lower Tuolumne release groups are calculated for juvenile and adult recovery locations from various sampling programs. CWT smolt releases in the Tuolumne River ended in 2002. Updated adult survival indices for expanded ocean harvest for 2000, 2001 and 2002 releases were 0.55, 0.24 and 1.67, respectively, based on 2004 ocean harvest data. Escapement survival indices for 2000 and 2001were 0.53 and 0.16, respectively; data based on three-year old salmon in the 2004 runs from the 2002 study are not yet available. These adult indices indicate moderate survival for the 2000 study, low survival for the 2001 study and high survival for the 2002 study.

The review of survival estimates from 1986-2002 Tuolumne study releases from up to 7 recovery sources per test found, in general, the survival indices are variable, but trend from relatively low survival with low flows (<700 cfs) to relatively high survival 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. Some recommendations for further data analyses are included.

CWT releases in the Merced, Stanislaus, and San Joaquin rivers that originated from the Merced River Hatchery are summarized in Table 1 for the 2000-2004 period.

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CODED-WIRE TAG SUMMARY UPDATE

1. INTRODUCTION

This report summarizes data on coded-wire tagged (CWT) hatchery salmon reared by the California Department of Fish and Game (CDFG) at the Merced River Hatchery (MRH) or other San Joaquin basin facilities. Specific focus here is on the results of large Tuolumne River smolt survival study releases. Included are updated release and recovery data for all tag codes used in the basin since 2000. CWT smolt releases ended in the Tuolumne River after 2002.

This report updates Federal Energy Regulatory Commission (FERC) Report19 96-13 (TID/MID 1997) which included data available through 1996 and FERC Report 2003-3 (TID/MID 2004) which included data available through 2003. Springtime CWT smolt releases of MRH salmon in the San Joaquin system began in 1986 (brood year 1985). Since 1998, some CWT salmon were also pan-jet marked and released in smaller groups, often over extended periods and at various locations.

Prior to 1999, CDFG conducted the tagging and releases of hatchery Chinook salmon. Starting in 1999, a private contractor has conducted most of the tagging operation at the Merced River Hatchery. For these studies, a CWT is inserted into the snout of each juvenile salmon. The wire tags are coded by group, usually in lots of about 25,000 tags. The code allows for later determination of the group release date and release location for recovered fish. The tagged fish also have the adipose fin removed to provide an external mark to enable identification of fish containing tags during various sampling efforts. Large CWT releases often include more than one tag code. For most years, an estimate is available of the tag loss, or shed, rate.

Tag recoveries are made from (1) sacrificed adipose-clipped juvenile salmon captured at several inland monitoring locations and (2) heads of adult tagged fish retained from port landings, hatcheries, and carcasses found in spawning run surveys. The tags are dissected from the specimens and decoded by CDFG or the U.S. Fish and Wildlife Service (USFWS). Analyses of the decoded data enable estimates of relative and absolute survival indices and the contribution of the tagged fish to the commercial/sport ocean catch and to spawning runs. The CWT smolt survival index studies were primarily intended to examine relative survival rates of hatchery smolts in specific river reaches at various flows within the San Joaquin River (SJR) system and Sacramento-San Joaquin delta.

The Tuolumne River evaluations since 1996 were conducted for the Tuolumne River Technical Advisory Committee (TRTAC) pursuant to the 1995 Don Pedro Project FERC Settlement Agreement. More data details and discussion of study assumptions and implementation are contained in Baker and Speed (1998), Neillands and Loudermilk (1998), the TRTAC peer review process of December 1998 (Centers for Water and Wildland Resources 1998), and FERC Report 2004-7 which is a detailed review of the results of large Tuolumne River CWT study releases focusing on Mossdale recovery data in the 1987-2002 period.

2. METHODS

2.1 Data Summary Format

Each CWT release group was catalogued by tag code(s) and recoveries were summarized by code and release group. Inland recoveries of juvenile salmon and ocean and inland adult salmon were made at various locations (Table 1). Data were grouped by year and location for the Merced, Tuolumne, Stanislaus, and the lower San Joaquin Rivers (SJR). Juvenile recovery locations include a trawl near Mossdale on the San Joaquin River, the state (SWP) and federal (CVP) fish salvage operations at the two largest delta water export facilities, the USFWS Chipps Island trawl, and the Jersey Point or Antioch trawl operations by Hanson Environmental, Inc. (1997-2004). In addition to these recovery sites, a pushnet was used one year (1987) in the SJR below the Tuolumne confluence and screw traps has been used at Shiloh Road or Grayson River Ranch in the Tuolumne River from 1995-2004 (Figure 1). Survival indices from pushnet and screw traps are presented, but not used in the analyses, as that sampling does not meet study criteria in the few years available. CWT recoveries at screw traps in the Stanislaus and Merced Rivers are not included in this report.

Adult recovery data are from the commercial and sport ocean harvest at various ports. Ocean harvest data were obtained from Pacific States Marine Fisheries Commission (2005) and includes preliminary 2004 data from CDFG, Oregon Department of Fish and Wildlife (ODFW) and other agencies. Inland recoveries of CWT spawners are from escapement surveys and hatchery return data from CDFG (1986-2003) and are limited to the San Joaquin tributaries and other northern CA hatcheries (2001-2002). Adult recoveries are presented by age group and inland recoveries listed by river. The inland adult recovery data for 2000-2002 is incomplete for those cohorts. The juvenile recovery data is from CDFG (Region 4) and USFWS (Bay-Delta Office, Stockton). CDFG has not provided recovery data for 2004 Mossdale recoveries.

2.2 Data Analysis

Salmon recovery data were analyzed by comparing recovery numbers of release groups for each recovery location. The release locations were chosen to compare the relative survival of salmon in various reaches of the river system. Upstream and downstream release locations in the San Joaquin tributaries were intended to identify relative survival differences between release sites under certain flow conditions. The San Joaquin River release locations were chosen to provide survival differences of salmon within reaches of that river and in migration routes through the delta.

A survival index of 1.0 indicates no difference in survival of the two groups. Survival index values substantially greater than one may indicate problems of two types: 1) that there is a significant difference between the two release groups, such as disease, stress, behavioral, or physiological factors, and/or 2) the likelihood of recovery from each group differed due to sampling effort, timing, migration rates, or other factors. Survival indices of less than 1.0 may have similar problems that are not readily evident and require careful review to see if study assumptions are met. For example, if fish of either group migrate at different rates or after flows have changed, then data comparability may be compromised. Low recovery numbers (e.g. less than 4 for either group) also lead to highly variable results. The ocean harvest data may represent the most reliable recovery data due to the number of tag recoveries and the extended recovery period, assuming that other study criteria are met. Sampling close to the lower release group can result in greater potential for differential capture probability and spurious data - this problem may occur at Mossdale in some years.

Relative survival index values were calculated for the Tuolumne River releases made in 1986, 1987, 1990, and 1994-2002 (Table 2). Expanded recoveries that account for sampling effort were used for SWP, CVP, and ocean harvest indices in the analysis. Actual recoveries were used for the Tuolumne River screw trap, and adult inland spawner indices. Mossdale trawl indices are shown for unadjusted and adjusted values. The survival index values were 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. Adult recoveries are (1) expanded estimates for fish recovered from the ocean harvest port surveys, and (2) actual carcasses found during basin spawning surveys or hatchery returns; both consist of 1+ to 5- year old salmon. Spawning recovery survival estimate for 2002 will be considered when data on three-year olds from the 2004 run is available. Indices were also averaged for Delta trawls, Delta pump salvage, and “adult” (ocean and spawning) sources.

The original analysis of survival indices was plotted against release flow at La Grange at the time of the upper releases. Because there has often been extended migration and recapture periods, the target release flow did not necessarily represent the flow conditions entirely experienced by the study fish. As a result of the TRTAC review, it was decided to also use an adjusted flow at La Grange (accounting for lag time to Mossdale) that was weighted by the daily recaptures at the Mossdale trawl as a better estimate of the flow conditions encountered by the CWT smolts. Another adjustment was made to the Mossdale trawl survival indices to account for varying daily capture effort (time that trawling was in operation) over the recovery period. Indices for recoveries made at pump salvage facilities, Chipps Island and Antioch/Jersey Point trawls, and ocean harvest are also based on expanded values that are weighted for sample effort. The TRTAC review of Mossdale recovery data determined that 1990, 1994, and 1997 Tuolumne studies should be considered invalid due to failure to meet key study assumptions. Fortunately, those studies were done at low and medium flows similar other study years.

3. RESULTS AND DISCUSSION

3.1 Updated Survival Index Results for Tuolumne River CWT Smolt Releases

2000, 2001 and 2002 Adult Survival Indices

Updated ocean harvest survival indices for 2000, 2001, and 2002 CWT smolt releases were 0.55, 0.24, and 1.67 based on preliminary 2004 expanded ocean harvest data (Table 2). Escapement survival indices for the 2000, 2001, and 2002 releases were 0.53, 0.16, and 0.17 respectively based on data through the 2003 run. The 2002 escapement data is limited to 2-year old salmon at present. Survival indices for adult recoveries from 2000-2002 smolt releases are incomplete at this time.

3.2 Survival Indices and Tuolumne Flow Analysis

Figure 2 includes all years and indices for all recovery sources that captured 4 or more salmon from either upper or lower release group plotted against unadjusted release flow at La Grange. Figure 3 excludes those years determined to be invalid (1990, 1994, 1997 – FERC Report 2002-4) and has a power trend line R^2 value of 0.3985, using all indices. Figure 4 has the same indices as Figure 3, except has adjusted Mossdale indices, plotted at the adjusted La Grange flows. Figure 4 has a power trend line R^2 value of 0.3977, using all indices. Table 3 includes the values used for Figures 3 and 4.

In general, the survival indices, when examined for all recovery locations, are quite variable, but trend toward higher survival (all indices >0.6) in the three years with high flood release flow conditions (>6,000 cfs, or >4,000 cfs as adjusted flow) – results at low flows (500-700 cfs) had all values of less than 0.7. 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:

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.

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 values were lower.

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.

3.3 Other Data in Table 1

Table 1 includes CWT recovery data from: (1) Merced River smolt releases made between 2000-2004, (2) Stanislaus River smolt releases made in 2000-2003, (3) Lower San Joaquin River/Delta smolt releases made in 2000-2004 which originated from the Merced Hatchery. Data for earlier years were in FERC Reports 1998-5 and 2003-3.

3.4 Summary and Recommendations

Detailed review by the TRTAC resulted in removal of three study years based on a review of Mossdale recovery and other data. That review also resulted in capture effort-adjusted survival indices for Mossdale and some adjustments in the applicable La Grange study flows. In general, when examined for all recovery locations (up to 7 per test), the survival indices are variable, but trend from relatively low survival with low flows (<700 cfs) to relatively high survival 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. In some cases, indices exceeded 1.0 or are based on relatively few recoveries (Table 2). Complete adult recovery data through the run of 2006 from releases in 2002 will conclude the data resulting from these studies.

Recommendations are:

- Recovery data from delta sampling sites other than Mossdale should be reviewed to examine the timing pattern of recoveries.
- Consider analyzing individual tag code recoveries to examine variation in the results forming the basis of the entire release group survival index.
- Absolute survival to adult, accounting for harvest, could be estimated for release groups. This could require inland adult recovery data that accounts for sampling effort for each tributary.
- Consider if adjustment for the difference in distance between release groups is warranted, since the downstream release locations have varied over 15.5 river miles.
- Consider use of multivariate methods to analyze the indices and determine confidence intervals. Some grouping of recovery data (e.g. combined salvage) or other data treatment could be considered.
- Link within-Tuolumne indices to other CWT data in the San Joaquin River and Delta to examine potential combined downstream survival in the inland reach down to Jersey Point in the central Delta.
- Continue comparison of Tuolumne results to those of other San Joaquin tributaries.

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Table 1. Tuolumne River CWT (2000-2002)

TUOLUMNE RIVER	JUVENILE SALMON CWT RELEASES TAG NO.	EFFECTIVE RELEASE	RELEASE SITE	DATE	SMOLTS/ YEARLING	JUVENILE RECOVERIES SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	ADULT OCEAN RECOVERIES ESTIMATED 1+ COMM.	SPORT	TOTAL	2+ COMM.	SPORT	TOTAL	3+ COMM.	SPORT	TOTAL	4+ COMM.	SPORT	TOTAL	1+ - 4+ TOTAL	ADULT INLAND TOTAL (HATCHERY AND SURVEY) 2	3	4	5	Age 2 to 5 TOTAL
BY99	06-45-56	23603	OLGB	13APR00	SMOLTS		17	13	1	6	5	0	0	0	55	14	69	0	3	3	0	0	0	72	8	26	4		38
	06-45-57	22096	OLGB	15APR00	SMOLTS		15	4	2	1	2	0	14	14	33	32	64	0	3	3	0	0	0	81	5	19	4		28
	06-45-58	26975	OLGB	15APR00	SMOLTS		8	10	0	5	3	0	7	7	28	20	48	9	4	13	0	0	0	68	6	23	2		31
	06-45-59	23071	OFC(SJR)	16APR00	SMOLTS		33	27	1	4	12	0	2	2	101	31	132	5	2	7	0	0	0	141	17	33	3		53
	06-45-60	21698	OFC(SJR)	14APR00	SMOLTS		49	20	1	5	10	0	4	4	70	24	94	3	5	8	0	0	0	106	18	33	9		60
	06-45-61	17936	RF/HUGH.	4/13-5/5	SMOLTS		7	10	2			0	12	12	24	7	31	2	4	6	0	0	0	49	8	15	1		24
	06-45-62	19198	RF/HUGH.	4/13-5/5	SMOLTS		9	6	0			3	0	3	13	11	24	0	0	0	0	0	0	27	7	13	1		21
	06-46-08	11803	GRAYSON	4/16-5/23	SMOLTS		8	1	0			0	3	3	7	3	10	0	0	0	0	0	0	13	1	8	0		9
TOTAL		72674	OLGB			241	40	27	3	12	10	0	21	21	116	66	181	9	10	19	0	0	0	221	19	68	10		97
TOTAL		44769	0FC(SJR)			------	82	47	2	9	22	0	6	6	171	55	226	8	7	15	0	0	0	247	35	66	12		113
BY00	06-44-12	24600	OLGB	22APR01	SMOLTS		38	0	0	2	2			0	7	0	7	0	0	0				7	6	1			7
	06-44-13	22758	OLGB	22APR01	SMOLTS		40	0	1	2	6			0	19	4	23	0	0	0				23	2	0			2
	06-44-14	21527	OLGB	22APR01	SMOLTS		32	0	0	4	10			0	12	3	15	0	0	0				15	1	3			4
	06-44-43	22051	OFC(SJR)	28APR01	SMOLTS		165	0	0	13	35	6	4	10	30	8	38	11	0	11				59	13	14			27
	06-44-44	24393	OFC(SJR)	26APR01	SMOLTS		262	2	1	12	25	0	12	12	40	5	44	5	5	10				66	15	12			27
TOTAL		68885	OLGB			109	110	0	1	8	18	0	0	0	38	7	45	0	0	0				45	9	4			13
TOTAL		46444	0FC(SJR)			------	427	2	1	25	60	6	16	22	70	13	82	16	5	21				125	28	26			54
BY01	06-44-06	24976	OLGB	24APR02	SMOLTS		65	2	1	1	3	0	0	0	19	6	26							26	1				
	06-44-67	24813	OLGB	24APR02	SMOLTS		63	2	0	7	5	0	0	0	16	0	16							16	0				
	06-44-68	25220	OLGB	24APR02	SMOLTS		51	2	1	0	3	0	0	0	21	0	21							21	0				
	06-44-61	25701	OFC(SJR)	26APR02	SMOLTS		116	1	0	6	1	0	0	0	4	10	14							14	1				
	06-44-69	23870	OFC(SJR)	29APR02	SMOLTS		25	2	1	3	2	0	0	0	4	7	11							11	3				
	06-44-62	15434	GRAYSON	4/3-5/30	SMOLTS			0	1	1	3	0	0	0	0	5	5							5	0				
TOTAL		75009	OLGB			1008	179	6	2	8	11	0	0	0	56	6	63							63	1				
TOTAL		49571	0FC(SJR)			------	141	3	1	9	3	0	0	0	8	17	25							25	4				

Table 1. Tuolumne River CWT (2000-2002)

TUOLUMNE RIVER		INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER							
	TAG NO.	Age 2								Age 3								Age 4								Age 5							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY99	06-45-56							8				1				22	3							4									
	06-45-57							5								19								4									
	06-45-58							6								20	3							2									
	06-45-59							7	10						1	16	16							2	1								
	06-45-60				1			5	12						2	20	11							7	2								
	06-45-61							7	1							15								1									
	06-45-62					1		6								12	1							1									
	06-46-08							1								7	1																
TOTAL								19	0						0	61	6							10	0								
TOTAL								12	22						3	36	27							9	3								
BY00	06-44-12							6								1																	
	06-44-13							2																									
	06-44-14							1								3																	
	06-44-43						2	5	6						4	5	5																
	06-44-44							5	10						3	5	4																
TOTAL							0	9	0						0	4	0																
TOTAL							2	10	16						7	10	9																
BY01	06-44-06							1																									
	06-44-67																																
	06-44-68																																
	06-44-61								1																								
	06-44-69							1	2																								
	06-44-62																																
TOTAL								1	0																								
TOTAL								1	3																								

Table 1. Merced River CWT (2000-2004)

MERCED RIVER		JUVENILE SALMON CWT RELEASES				JUVENILE RECOVERIES						ADULT OCEAN RECOVERIES ESTIMATED													ADULT INLAND TOTAL (HATCHERY AND SURVEY)				Age
	TAG NO.	EFFECTIVE RELEASE	RELEASE SITE	DATE	SMOLTS/ YEARLING	SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	1+ COMM.	SPORT	TOTAL	2+ COMM.	SPORT	TOTAL	3+ COMM.	SPORT	TOTAL	4+ COMM.	SPORT	TOTAL	1+ - 4+ TOTAL	2	3	4	5	2 to 5 TOTAL
BY 1999	06-45-39	25313	MRH	4/12-4/13	SMOLTS		9	5	0	5	2	0	2	2	18	0	18	3	0	3	0	0	0	23	6	15	0		21
	06-45-40	25507	MRH	4/12-4/13	SMOLTS		7	11	0	3	9	0	0	0	6	3	9	13	0	13	0	0	0	22	9	10	1		20
	06-45-41	25318	MRH	4/12-4/13	SMOLTS		14	8	1	4	2	0	0	0	8	0	8	2	0	2	0	0	0	10	9	15	2		26
	06-45-42	25395	MRH	4/12-4/13	SMOLTS		12	10	1	5	2	0	0	0	32	18	50	5	4	9	0	0	0	59	4	19	1		24
	06-45-43	24525	HATFIELD	4/13-4/14	SMOLTS		45	28	1	5	8	7	7	14	58	36	93	8	0	8	0	0	0	115	14	24	0		38
	06-45-44	24490	HATFIELD	4/13-4/14	SMOLTS		51	25	0	6	9	0	0	0	35	13	48	28	4	31	0	0	0	79	15	32	2		49
	06-45-45	24432	HATFIELD	4/13-4/14	SMOLTS		41	29	1	2	8	6	3	9	83	32	114	14	0	14	0	0	0	137	13	29	6		48
TOTAL	UPPER	101533	MRH				42	34	2	17	15	0	2	2	64	21	85	23	4	27				114	28	59	4		91
TOTAL	LOWER	73447	HATFIELD				137	82	2	13	25	13	10	23	176	81	255	50	4	53				331	42	85	8		135
BY 1999	06-45-49	25433	MRH	24APR00	SMOLTS		5	2	0	5	3	0	4	4	31	4	35	0	0	0	2	0	2	41	3	15	5		23
	06-45-50	27042	MRH	24APR00	SMOLTS		10	2	3	6	2	0	8	8	22	0	22	6	0	6	0	0	0	36	9	12	0		21
	06-45-51	24378	MRH	24APR00	SMOLTS		8	6	0	1	8	0	5	5	10	0	10	0	4	4	0	0	0	19	11	15	0		26
	06-45-52	25293	MRH	24APR00	SMOLTS		6	0	1	4	7	0	0	0	17	6	23	3	0	3	0	0	0	26	9	25	2		36
	06-45-53	25794	HATFIELD	27APR00	SMOLTS		24	12	0	5	13	6	0	6	35	7	42	11	4	15	0	0	0	63	17	23	4		44
	06-45-54	26189	HATFIELD	27APR00	SMOLTS		26	20	1	4	5	0	4	4	75	18	93	0	0	0	0	0	0	97	22	36	5		63
	06-45-55	25444	HATFIELD	27APR00	SMOLTS		23	16	2	6	10	0	4	4	30	6	36	0	0	0	0	0	0	40	11	27	5		43
TOTAL	UPPER	102146	MRH				29	10	4	16	20	0	17	17	80	10	90	9	4	13	2	0	2	122	32	67	7		106
TOTAL	LOWER	77427	HATFIELD				73	48	3	15	28	6	8	14	140	31	171	11	4	15	0	0	0	200	50	86	14		150
BY00	06-44-15	25107	MRH	21APR01	SMOLTS		59	0	0	3	3			0	13	0	13	11	0	11				24	5	7			12
	06-44-16	24270	MRH	21APR01	SMOLTS		39	1	0	3	10			0	21	8	29	2	0	2				31	13	7			20
	06-44-17	24537	MRH	21APR01	SMOLTS		48	1	0	1	1	0	9	9	16	0	16	0	2	2				27	7	8			15
	06-44-18	24229	MRH	21APR01	SMOLTS		49	0	0	0	7	0	4	4	8	3	12	0	5	5				21	8	6			14
	06-44-19	24974	HATFIELD	26APR01	SMOLTS		164	3	0	8	11	3	11	14	22	9	32	8	0	8				54	6	4			10
	06-44-20	24989	HATFIELD	26APR01	SMOLTS		154	3	2	6	17	4	8	12	31	9	40	0	0	0				52	6	9			15
	06-44-21	24916	HATFIELD	26APR01	SMOLTS		153	3	0	17	24			0	39	0	39	5	0	5				44	15	19			34
TOTAL	UPPER	98143	MRH				195	2	0	7	21	0	13	13	58	11	70	13	7	20				103	33	28			61
TOTAL	LOWER	74879	HATFIELD				471	9	2	31	52	7	19	26	92	18	111	13	0	13				150	27	32			59
BY00	06-44-22	25311	MRH	08MAY01	SMOLTS		39	0	0	2	10	0	0	0	0	0	0	0	0	0				0	0	2			2
	06-44-23	24685	MRH	08MAY01	SMOLTS		51	0	0	1	9	0	0	0	0	0	0	0	0	0				0	0	2			2
	06-44-24	26534	MRH	08MAY01	SMOLTS		36	0	0	1	12	0	0	0	0	0	0	0	0	0				0	1	3			4
	06-44-25	23641	MRH	08MAY01	SMOLTS		57	0	0	0	7	0	0	0	6	0	6	0	0	0				6	0	0			0
	06-44-26	23074	HATFIELD	11MAY01	SMOLTS		138	0	0	1	19	0	0	0	7	4	11	2	0	2				13	0	2			2
	06-44-27	23186	HATFIELD	13MAY01	SMOLTS		122	0	0	1	20	0	0	0	8	0	8	0	0	0				8	1	2			3
	06-44-28	23387	HATFIELD	13MAY01	SMOLTS		116	1	0	4	14	0	0	0	6	0	6	0	0	0				6	0	3			3
TOTAL	UPPER	100171	MRH				183	0	0	4	38	0	0	0	6	0	6	0	0	0				6	1	7			8
TOTAL	LOWER	69647	HATFIELD				376	1	0	6	53	0	0	0	21	4	25	2	0	2				27	1	7			8
BY01	06-44-63	23188	MRH	31MAR02	SMOLTS		2	1	1	1	1	0	0	0	0	0	0							0					
	06-44-64	23915	MRH	31MAR02	SMOLTS		0	0	0	0	0	0	0	0	0	0	0							0					
	06-44-65	23775	MRH	31MAR02	SMOLTS		0	0	0	0	0	0	0	0	0	0	0							0					
	06-44-66	23185	MRH	31MAR02	SMOLTS		2	0	0	0	0	0	0	0	0	0	0							0					
	06-44-51	24380	HATFIELD	4/3-4/5	SMOLTS		118	9	40	2	10	0	0	0	0	0	0							0	4				
	06-44-52	24228	HATFIELD	4/3-4/5	SMOLTS		140	6	41	1	1	0	0	0	11	4	15							15	1				
	06-45-48	24890	HATFIELD	4/3-4/5	SMOLTS		146	9	44	3	3	0	0	0	6	0	6							6	0				
TOTAL	UPPER	94063	MRH				4	1	1	1	1	0	0	0	0	0	0							0					
TOTAL	LOWER	73498	HATFIELD				404	24	125	6	14	0	0	0	17	4	21							21	5				
BY01	06-44-82	22522	MRH	21APR02	SMOLTS		4	0	0	0	0	0	0	0	0	0	0							0					
	06-44-83	23086	MRH	21APR02	SMOLTS		11	0	0	0	1	0	0	0	0	0	0							0					
	06-44-84	23140	MRH	21APR02	SMOLTS		10	0	0	0	0	0	0	0	4	0	4							4					
	06-44-85	22183	MRH	21APR02	SMOLTS		9	0	0	0	0	0	0	0	0	0	0							0					
	06-44-86	23349	HATFIELD	4/26-4/29	SMOLTS		44	1	1	2	2	0	0	0	4	0	4							4	0				
	06-44-87	23363	HATFIELD	4/26-4/29	SMOLTS		50	2	0	0	5	0	1	1	0	4	4							5	1				
	06-44-88	23639	HATFIELD	4/26-4/29	SMOLTS		50	1	0	1	2	0	0	0	0	3	3							3	2				
TOTAL	UPPER	90931	MRH				34	0	0	0	1	0	0	0	4	0	4							4					
TOTAL	LOWER	70351	HATFIELD				144	4	1	3	9	0	1	1	4	7	11							12	3				

Table 1. Merced River CWT (2000-2004)

MERCED RIVER	JUVENILE SALMON CWT RELEASES					JUVENILE RECOVERIES						ADULT OCEAN RECOVERIES ESTIMATED													ADULT INLAND TOTAL (HATCHERY AND SURVEY)				Age
		EFFECTIVE	RELEASE		SMOLTS/							1+			2+			3+			4+			1+ - 4+					2 to 5
	TAG NO.	RELEASE	SITE	DATE	YEARLING	SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	TOTAL	2	3	4	5	TOTAL
BY02	06-44-89	22677	MRH	13APR03	SMOLTS			1	2	1	3	0	0	0										0					
	06-44-90	22816	MRH	13APR03	SMOLTS			0	0	1	1	0	0	0										0					
	06-44-91	22946	MRH	13APR03	SMOLTS			1	0	0	2	0	3	3										3					
	06-44-92	21725	MRH	13APR03	SMOLTS			1	0	1	0	4	0	4										4					
	06-44-93	23274	HATFIELD	16APR03	SMOLTS			3	1	4	6	0	3	3										3					
	06-44-94	23872	HATFIELD	16APR03	SMOLTS			2	1	1	2	0	0	0										0					
	06-44-95	23833	HATFIELD	16APR03	SMOLTS			0	1	4	4	0	3	3										3					
TOTAL	UPPER	90164	MRH					3	2	3	6	4	3	7										7					
TOTAL	LOWER	70979	HATFIELD					5	3	9	12	0	6	6										6					
BY02	06-44-96	24232	MRH	25APR03	SMOLTS			0	0	0	0	0	0	0										0					
	06-44-97	23869	MRH	25APR03	SMOLTS			0	0	0	0	0	0	0										0					
	06-44-98	23757	MRH	25APR03	SMOLTS			0	0	0	1	0	0	0										0					
	06-44-99	23950	MRH	25APR03	SMOLTS			0	1	0	0	0	0	0										0					
	06-45-64	24545	HATFIELD	29APR03	SMOLTS			0	0	0	0	0	0	0										0					
	06-45-65	24483	HATFIELD	29APR93	SMOLTS			0	0	2	0	0	0	0										0					
	06-45-66	24358	HATFIELD	29APR03	SMOLTS			1	0	0	1	0	0	0										0					
TOTAL	UPPER	95808	MRH					0	1	0	1	0	0	0										0					
TOTAL	LOWER	73386	HATFIELD					1	0	2	1	0	0	0										0					
BY02	06-27-77	23590	MRH	04MAY03	SMOLTS			0	0	1	0	0	0	0										0					
	06-27-78	23862	MRH	04MAY03	SMOLTS			0	1	0	0	0	0	0										0					
	06-44-49	23512	MRH	04MAY03	SMOLTS			0	1	1	1	0	0	0										0					
	06-44-50	24330	MRH	04MAY03	SMOLTS			1	0	2	0	0	4	4										4					
	06-45-46	22603	HATFIELD	07MAY03	SMOLTS			0	0	1	0	0	2	2										2					
	06-45-47	22714	HATFIELD	07MAY03	SMOLTS			0	0	0	2	0	7	7										7					
	06-45-72	22649	HATFIELD	07MAY03	SMOLTS			0	0	2	0	0	3	3										3					
TOTAL	UPPER	95294	MRH					1	2	4	1	0	4	4										4					
TOTAL	LOWER	67966	HATFIELD					0	0	3	2	0	12	12										12					
BY03	06-45-92	23628	SHAFFER	19APR04	SMOLTS			0	0	0	0																		
	06-45-93	22440	SHAFFER	19APR04	SMOLTS			0	0	0	1																		
	06-45-94	23489	HATFIELD	20APR04	SMOLTS			0	0	1	0																		
	06-45-95	23037	HATFIELD	20APR04	SMOLTS			1	0	1	0																		
TOTAL	UPPER	46068	SHAFFER					0	0	0	1																		
TOTAL	LOWER	46526	HATFIELD					1	0	2	0																		
BY03	06-46-64	25501	SHAFFER	27ARP04	SMOLTS			0	0	0	0																		
	06-46-65	25489	SHAFFER	27APR04	SMOLTS			0	0	1	0																		
	06-46-66	24511	HATFIELD	28APR04	SMOLTS			0	1	2	0																		
	06-46-67	25307	HATFIELD	28APR04	SMOLTS			1	2	0	0																		
TOTAL	UPPER	50990	SHAFFER					0	0	1	0																		
TOTAL	LOWER	49818	HATFIELD					1	3	2	0																		
BY03	06-45-96	25028	MRFF	09MAY04	SMOLTS			0	2	0	0																		
	06-45-97	25358	MRFF	09MAY04	SMOLTS			0	0	0	0																		
	06-46-68	25340	MRFF	09MAY04	SMOLTS			1	1	0	0																		
	06-46-69	24417	MRFF	09MAY04	SMOLTS			0	0	0	0																		
	06-45-81	24274	HATFIELD	12-13MAY	SMOLTS			2	1	1	0																		
	06-45-98	24897	HATFIELD	12-13MAY	SMOLTS			0	0	0	0																		
	06-45-99	24769	HATFIELD	12-13MAY	SMOLTS			2	3	0	0																		
TOTAL	UPPER	100143	MRFF					1	3	0	0																		
TOTAL	LOWER	73940	HATFIELD					4	4	1	0																		

Table 1. Merced River CWT (2000-2004)

MERCED RIVER		INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER							
	TAG NO.	Age 2								Age 3								Age 4								Age 5							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY 1999	06-45-39								6				1				14																
	06-45-40								9	1							9								1								
	06-45-41								9					1			14								2								
	06-45-42								4								19								1								
	06-45-43								14			1		1			22																
	06-45-44								15			1					31								2								
	06-45-45	2							11			1					28							1	5								
TOTAL	UPPER								28	1	0	0	1	1			56							0	4								
TOTAL	LOWER								40	0	0	3	0	1			81							1	7								
BY 1999	06-45-49								3								15								5								
	06-45-50							1	8								12																
	06-45-51								11								15																
	06-45-52								9							1	24								2								
	06-45-53								17				1			3	19								4								
	06-45-54								22								36								5								
	06-45-55								11							1	26								5								
TOTAL	UPPER							1	31							1	66								7								
TOTAL	LOWER							0	50							4	81								14								
BY00	06-44-15								5								7																
	06-44-16			1					12							1	6																
	06-44-17								7								8																
	06-44-18								8								6																
	06-44-19								6								4																
	06-44-20								6								9																
	06-44-21								15								19																
TOTAL	UPPER								32							1	27																
TOTAL	LOWER								27							0	32																
BY00	06-44-22																2																
	06-44-23																2																
	06-44-24								1								3																
	06-44-25																																
	06-44-26																2																
	06-44-27								1								2																
	06-44-28																3																
TOTAL	UPPER								1								7																
TOTAL	LOWER								1								7																
BY01	06-44-63																																
	06-44-64																																
	06-44-65																																
	06-44-66																																
	06-44-51								4																								
	06-44-52								1																								
	06-45-48																																
TOTAL	UPPER																																
TOTAL	LOWER								5																								
BY01	06-44-82																																
	06-44-83																																
	06-44-84																																
	06-44-85																																
	06-44-86																																
	06-44-87								1																								
	06-44-88								2																								
TOTAL	UPPER																																
TOTAL	LOWER								3																								

Table 1. Merced River CWT (2000-2004)

MERCED RIVER		INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER							
	TAG NO.	Age 2								Age 3								Age 4								Age 5							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY02	06-44-89																																
	06-44-90																																
	06-44-91																																
	06-44-92																																
	06-44-93																																
	06-44-94																																
	06-44-95																																
TOTAL	UPPER																																
TOTAL	LOWER																																
BY02	06-44-96																																
	06-44-97																																
	06-44-98																																
	06-44-99																																
	06-45-64																																
	06-45-65																																
	06-45-66																																
TOTAL	UPPER																																
TOTAL	LOWER																																
BY02	06-27-77																																
	06-27-78																																
	06-44-49																																
	06-44-50																																
	06-45-46																																
	06-45-47																																
	06-45-72																																
TOTAL	UPPER																																
TOTAL	LOWER																																
BY03	06-45-92																																
	06-45-93																																
	06-45-94																																
	06-45-95																																
TOTAL	UPPER																																
TOTAL	LOWER																																
BY03	06-46-64																																
	06-46-65																																
	06-46-66																																
	06-46-67																																
TOTAL	UPPER																																
TOTAL	LOWER																																
BY03	06-45-96																																
	06-45-97																																
	06-46-68																																
	06-46-69																																
	06-45-81																																
	06-45-98																																
	06-45-99																																
TOTAL	UPPER																																
TOTAL	LOWER																																

Table 1. Stanislaus River CWT (2000-2003)

STANISLAUS RIVER	JUVENILE SALMON CWT RELEASES					JUVENILE RECOVERIES						ADULT OCEAN RECOVERIES ESTIMATED													ADULT INLAND TOTAL (HATCHERY AND SURVEY)				Age
		EFFECTIVE	RELEASE		SMOLTS/							1+			2+			3+			4+			1+ - 4+					2 to 5
	TAG NO.	RELEASE	SITE	DATE	YEARLING	SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	COMM.	SPORT	TOTAL	TOTAL	2	3	4	5	TOTAL
BY 99	06-44-07	25511	KNIGHTS F	19MAY00	SMOLTS		66	18	17	3	0	0	0	0	7	0	7	0	0	0	0	0	0	7		1			1
	06-44-08	25786	KNIGHTS F	18MAY00	SMOLTS		77	21	12	1	0	0	0	0	4	0	4	0	0	0	0	0	0	4		0			0
	06-44-09	26140	KNIGHTS F	18MAY00	SMOLTS		71	17	13	0	0	0	0	0	0	0	0	3	0	3	0	0	0	3		1			1
	06-44-10	25712	TWO RIVERS	20MAY00	SMOLTS		91	52	23	4	0	0	0	0	0	4	4	8	0	8	0	0	0	12		4			4
	06-44-11	24835	TWO RIVERS	20MAY00	SMOLTS		157	32	12	0	0	0	0	0	0	0	0	6	0	6	0	0	0	6		3			3
TOTAL	UPPER	77437					214	56	42	4	0	0	0	0	11	0	11	3	0	3	0	0	0	14		2			2
	LOWER	50547					248	84	35	4	0	0	0	0	0	4	4	14	0	14	0	0	0	18		7			7
BY00	0601110804	24273	KNIGHTS F	22MAY01	SMOLTS		51	0	2	0	0	0	0	0	11	0	11	0	0	0				11					
	0601110805	24225	KNIGHTS F	22MAY01	SMOLTS		69	0	2	0	0	0	0	0	0	0	0	0	0	0				0					
	0601110715	25634	TWO RIVERS	25MAY01	SMOLTS		32			0	0	0	0	0	0	0	0	0	0	0				0					
TOTAL	UPPER	48498					120	0	4	0	0	0	0	0	11	0	11	0	0	0				11					
	LOWER	25634					32			0	0	0	0	0	0	0	0	0	0	0				0					
BY01	06-44-46	23745	KNIGHTS F	01MAY02	SMOLTS		76	0	1	2	1	0	0	0	4	0	4							4					
	06-44-47	24236	KNIGHTS F	01MAY02	SMOLTS		82	1	0	2	5	0	4	4	4	10	14							18					
	06-44-48	24646	TWO RIVERS	04MAY02	SMOLTS		196	0	0	1	3	0	0	0	0	0	0							0	2				
TOTAL	UPPER	47981					158	1	1	4	6	0	4	4	8	10	18							22					
	LOWER	24646					196	0	0	1	3	0	0	0	0	0	0							0	2				
BY 02	06-45-67	25599	KNIGHTS F	25APR03	SMOLTS			0	0	0	1	0	0	0										0					
	06-45-68	26226	KNIGHTS F	25APR03	SMOLTS			0	0	1	0	0	0	0										0					
	06-45-69	26136	KNIGHTS F	25APR03	SMOLTS			0	0	0	1	0	11	11										11					
	06-45-70	26101	TWO RIVERS	27APR03	SMOLTS			0	0	0	1	0	0	0										0					
	06-45-71	26632	TWO RIVERS	28APR03	SMOLTS			0	0	0	3	0	0	0										0					
TOTAL	UPPER	77961						0	0	1	2	0	11	11										11					
	LOWER	52733						0	0	0	4	0	0	0										0					

Table 1. Stanislaus River CWT (2000-2003)

STANISLAUS RIVER		INLAND TOTAL BY RIVER Age 2								INLAND TOTAL BY RIVER Age 3								INLAND TOTAL BY RIVER Age 4								INLAND TOTAL BY RIVER Age 5							
	TAG NO.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY 99	06-44-07														1																		
	06-44-08																																
	06-44-09														1																		
	06-44-10														2	1	1																
	06-44-11															2	1																
TOTAL	UPPER																																
	LOWER																																
BY00	0601110804																																
	0601110805																																
	0601110715																																
TOTAL	UPPER																																
	LOWER																																
BY01	06-44-46																																
	06-44-47																																
	06-44-48							1	1																								
TOTAL	UPPER																																
	LOWER							1	1																								
BY 02	06-45-67																																
	06-45-68																																
	06-45-69																																
	06-45-70																																
	06-45-71																																
TOTAL	UPPER																																
	LOWER																																

Table 1. San Joaquin River CWT (2000-2004)

SAN JOAQUIN RIVER	JUVENILE SALMON CWT RELEASES					JUVENILE RECOVERIES						ADULT OCEAN RECOVERIES ESTIMATED													ADULT INLAND TOTAL (HATCHERY AND SURVEY)				Age
	TAG NO.	EFFECTIVE RELEASE	RELEASE SITE	DATE	SMOLTS/ YEARLING	SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	1+ COMM.	SPORT	TOTAL	2+ COMM.	SPORT	TOTAL	3+ COMM.	SPORT	TOTAL	4+ COMM.	SPORT	TOTAL	1+ - 4+ TOTAL	2	3	4	5	2 to 5 TOTAL
BY 99	06-45-63	24457	DFP	17APR00	SMOLTS		20	40	1	11	11	6	4	10	147	78	225	10	0	10	0	0	0	245	19	58	3		80
	06-04-01	23529	DFP	17APR00	SMOLTS		20	33	2	7	6	3	11	14	130	46	176	20	0	20	0	4	4	214	32	51	1		84
	06-04-02	24177	DFP	17APR00	SMOLTS		19	31	2	10	10	2	18	20	148	57	205	1	3	4	0	0	0	229	23	67	2		92
	06-44-01	23465	MOSSDALE	18APR00	SMOLTS		7	41	1	9	14	0	13	13	138	47	185	8	0	8	0	0	0	206	18	67	7		92
	06-44-02	22784	MOSSDALE	18APR00	SMOLTS		10	45	1	9	16	5	4	9	121	28	150	11	4	15	0	0	0	174	13	54	2		69
	06-44-05	23371	MOSSDALE	4/19-5/03	SMOLTS		21	32	1	7	9	4	4	8	87	52	140	7	0	7	0	0	0	155	19	52	6		77
	06-44-03	25527	JERSEY PT	20APR00	SMOLTS			0	0	24	50	12	44	56	399	142	542	39	10	48	0	0	0	646	68	124	5		197
	06-44-04	25824	JERSEY PT	20APR00	SMOLTS			0	0	41	47	10	14	24	455	142	597	73	11	85	0	0	0	706	84	123	5		212
TOTAL		72163	DFP				59	104	5	28	27	11	33	44	425	181	606	31	3	34	0	4	4	688	74	176	6		256
TOTAL		69620	MOSSDALE				38	118	3	25	39	9	21	30	346	127	475	26	4	30	0	0	0	535	50	173	15		238
TOTAL		51351	JERSEY PT				0	0	0	65	97	22	58	80	854	284	1139	112	21	133	0	0	0	1352	152	247	10		409
BY 99	0601060914	23698	DFP	28APR00	SMOLTS		27	15	1	7	8	0	4	4	29	10	39	3	0	3	0	0	0	46	13	21	3		37
	0601060915	26805	DFP	28APR00	SMOLTS		32	19	2	5	15	0	4	4	32	0	32	8	0	8	0	0	0	44	6	23	3		32
	0601110814	23889	DFP	28APR00	SMOLTS		35	12	1	10	8	0	0	0	61	9	70	0	0	0	0	0	0	70	1	16	0		17
	0601061001	25572	JERSEY PT	01MAY00	SMOLTS			1	0	48	76	0	14	14	223	63	286	44	12	56	0	0	0	356	43	60	5		108
	0601061002	24661	JERSEY PT	01MAY00	SMOLTS			1	0	30	76	11	22	33	140	42	182	13	0	13	0	0	0	228	25	37	3		65
TOTAL		74392	DFP				94	46	4	22	31	0	8	8	122	19	141	11	0	11	0	0	0	160	20	60	6		86
TOTAL		50233	JERSEY PT					2	0	78	152	11	36	47	363	105	468	57	12	69	0	0	0	584	68	97	8		173
BY 00	06-44-29	23354	DFP	30APR01	SMOLTS			0	1	14	28	0	4	4	57	12	69	19	3	22				95	15	19			34
	06-44-30	22837	DFP	30APR01	SMOLTS			0	2	22	30	3	24	26	99	20	119	10	0	10				155	31	18			49
	06-44-31	22491	DFP	30APR01	SMOLTS			0	4	17	18	0	4	4	78	14	92	14	0	14				110	23	16			39
	06-44-32	23000	MOSSDALE	01MAY01	SMOLTS			2	2	17	18	4	12	16	84	19	104	3	0	3				123	23	17			40
	06-44-33	22177	MOSSDALE	01MAY01	SMOLTS			0	1	14	15	0	0	0	87	19	107	0	0	0				107	26	29			55
	06-44-34	24443	JERSEY PT	04MAY01	SMOLTS					50	156	13	38	50	346	41	386	28	0	28				464	64	32			96
	06-44-35	24992	JERSEY PT	04MAY01	SMOLTS					61	173	27	45	72	335	101	437	34	9	44				553	78	42			120
TOTAL		68682	DFP					0	7	53	76	3	32	34	234	46	280	43	3	46				360	69	53			122
TOTAL		45177	MOSSDALE					2	3	31	33	4	12	16	171	38	211	3	0	3				230	49	46			95
TOTAL		49435	JERSEY PT							111	329	40	83	122	681	142	823	62	9	72				1017	142	74			216
BY 00	06-44-36	24025	DFP	07MAY01	SMOLTS			1	1	2	8	0	5	5	6	3	9	3	0	3				17	3	12			15
	06-44-37	24029	DFP	07MAY01	SMOLTS			0	0	5	11	4	4	9	17	11	29	9	0	9				47	3	6			9
	06-44-38	24177	DFP	07MAY01	SMOLTS			1	1	2	10	0	4	4	18	6	24	0	0	0				28	1	10			11
	06-44-39	23878	MOSSDALE	08MAY01	SMOLTS			0	1	4	8	0	11	11	3	5	8	6	0	6				25	3	2			5
	06-44-40	25308	MOSSDALE	08MAY01	SMOLTS			2	1	4	11	0	0	0	21	6	27	0	0	0				27	2	6			8
	06-44-41	25909	JERSEY PT	11MAY01	SMOLTS					17	43	0	18	18	171	22	194	28	3	31				243	30	17			47
	06-44-42	25465	JERSEY PT	11MAY01	SMOLTS					27	53	9	4	13	253	46	299	20	0	20				332	29	17			46
TOTAL		72231	DFP					2	2	9	29	4	13	18	41	20	62	12	0	12				92	7	28			35
TOTAL		49186	MOSSDALE					2	2	8	19	0	11	11	24	11	35	6	0	6				52	5	8			13
TOTAL		51374	JERSEY PT							44	96	9	22	31	424	68	493	48	3	51				575	59	34			93
BY01	06-44-71	23920	DFP	18APR02	SMOLTS			2	1	4	11	0	0	0	21	8	30							30	2				
	06-44-72	25176	DFP	18APR02	SMOLTS			7	5	9	20	0	12	12	53	19	72							84	2				
	06-44-73	23872	DFP	18APR02	SMOLTS			5	0	4	12	0	0	0	41	24	65							65	1				
	06-44-74	24747	DFP	18APR02	SMOLTS			7	2	4	20	0	0	0	48	12	61							61	1				
	06-44-57	25515	MOSSDALE	19APR02	SMOLTS			14	2	6	13	0	0	0	44	28	72							72	0				
	06-44-58	25272	MOSSDALE	19APR02	SMOLTS			7	6	7	29	0	0	0	55	15	70							70	0				
	06-44-59	24802	JERSEY PT	22APR02	SMOLTS					46	101	2	39	41	289	130	420							461	0				
	06-44-60	24128	JERSEY PT	22APR02	SMOLTS					37	89	0	40	40	277	77	354							394	0				
TOTAL		97715	DFP					21	8	21	63	0	12	12	163	63	228							240	6				
TOTAL		50787	MOSSDALE					21	8	13	42	0	0	0	99	43	142							142	0				
TOTAL		48930	JERSEY PT							83	190	2	79	81	566	207	774							855	0				

Table 1. San Joaquin River CWT (2000-2004)

SAN JOAQUIN RIVER	JUVENILE SALMON CWT RELEASES TAG NO.	EFFECTIVE RELEASE	RELEASE SITE	DATE	SMOLTS/ YEARLING	JUVENILE RECOVERIES SJR PUSH. /SCREWTRAP	MOSSDALE	SWP	CVP	CHIPPS	JERSEY Antioch	ADULT OCEAN RECOVERIES ESTIMATED 1+ COMM.	SPORT	TOTAL	2+ COMM.	SPORT	TOTAL	3+ COMM.	SPORT	TOTAL	4+ COMM.	SPORT	TOTAL	1+ - 4+ TOTAL	ADULT INLAND TOTAL (HATCHERY AND SURVEY) 2	3	4	5	Age 2 to 5 TOTAL
BY01	06-44-70	24680	DFP	25APR02	SMOLTS			1	3	3	6	0	0	0	16	3	18							18	1				
	06-44-75	24659	DFP	25APR02	SMOLTS			4	0	5	2	0	3	3	14	0	14							17	2				
	06-44-76	24783	DFP	25APR02	SMOLTS			4	2	3	4	0	0	0	5	2	8							8	1				
	06-44-77	24381	DFP	25APR02	SMOLTS			4	2	4	6	0	0	0	4	0	4							4	3				
	06-44-78	24519	MOSSDALE	26APR02	SMOLTS			8	1	2	3	0	2	2	21	0	21							23	5				
	06-44-79	24820	MOSSDALE	26APR02	SMOLTS			3	0	3	4	0	0	0	14	0	14							14	0				
	06-44-80	24032	JERSEY PT	30APR02	SMOLTS					18	43	0	14	14	178	90	268							282	12				
	06-44-81	22880	JERSEY PT	30APR02	SMOLTS					28	32	0	19	19	216	44	259							278	13				
TOTAL		98503	DFP					13	7	15	18	0	3	3	39	5	44							47	7				
TOTAL		49339	MOSSDALE					11	1	5	7	0	2	2	35	0	35							37	5				
TOTAL		46912	JERSEY PT							46	75	0	33	33	394	134	527							560	25				
BY02	06-02-82	24563	DFP	21APR03	SMOLTS			0	2	0	1	0	5	5										5					
	06-02-83	26036	DFP	21APR03	SMOLTS			0	1	2	4	0	0	0										0					
	06-27-42	24179	DFP	21APR03	SMOLTS			1	2	1	1	0	8	8										8					
	06-27-48	24706	MOSSDALE	22APR03	SMOLTS			0	0	2	2	0	0	0										0					
	06-27-43	25480	MOSSDALE	22APR03	SMOLTS			0	0	3	2	0	0	0										0					
	06-27-44	24649	JERSEY PT	25APR03	SMOLTS					57	71	0	93	93										93					
TOTAL		74778	DFP					1	5	3	6	0	13	13										13					
TOTAL		50186	MOSSDALE					0	0	5	4	0	0	0										0					
TOTAL		24649	JERSEY PT							57	71	0	93	93										93					
BY02	06-27-45	24815	DFP	28APR03	SMOLTS			0	1	0	0	0	0	0										0					
	06-27-46	25319	DFP	28APR03	SMOLTS			0	1	0	0	0	0	0										0					
	06-27-47	24758	DFP	28APR03	SMOLTS			0	0	0	0	0	0	0										0					
	06-27-49	24219	MOSSDALE	29APR03	SMOLTS			0	1	0	0	0	3	3										3					
	06-27-50	24505	MOSSDALE	29APR03	SMOLTS			0	0	1	0	0	0	0										0					
	06-27-51	25950	JERSEY PT	02MAY03	SMOLTS					39	36	0	115	115										115					
TOTAL		74892	DFP					0	2	0	0	0	0	0										0					
TOTAL		48724	MOSSDALE					0	1	1	0	0	3	3										3					
TOTAL		25950	JERSEY PT							39	36	0	115	115										115					
BY03	06-27-52	23440	DFP	22APR04	SMOLTS			1	2	0	1																		
	06-27-53	21714	DFP	22APR04	SMOLTS			0	3	1	1																		
	06-27-54	23328	DFP	22APR04	SMOLTS			0	2	1	0																		
	06-27-55	23783	DFP	22APR04	SMOLTS			1	0	1	0																		
	06-46-70	25319	MOSSDALE	23APR04	SMOLTS			0	0	0	1																		
	06-45-82	23586	MOSSDALE	23APR04	SMOLTS			0	2	1	0																		
	06-45-83	24803	MOSSDALE	23APR04	SMOLTS			1	0	2	0																		
	06-45-80	22911	JERSEY PT	26APR04	SMOLTS			0	1	25	22																		
TOTAL		92265	DFP					2	7	3	2																		
TOTAL		73708	MOSSDALE					1	2	3	1																		
TOTAL		22911	JERSEY PT					0	1	25	22																		

Table 1. San Joaquin River CWT (2000-2004)

SAN JOAQUIN RIVER	TAG NO.	INLAND TOTAL BY RIVER Age 2							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY 99	06-45-63			1			1	6	11
	06-04-01			2			1	9	20
	06-04-02						1	4	18
	06-44-01			1		1		4	12
	06-44-02	1		1			1	3	7
	06-44-05							5	14
	06-44-03			7	3	12	1		45
	06-44-04			11	4	14		5	50
TOTAL		0		3	0	0	3	19	49
TOTAL		1		2	0	1	1	12	33
TOTAL		0		18	7	26	1	5	95
BY 99	0601060914							4	9
	0601060915						1	2	3
	0601110814			1					
	0601061001			8	3	3	2	3	24
	0601061002			3	1	4			17
TOTAL		0	0	1	0	0	1	6	12
TOTAL		0	0	11	4	7	2	3	41
BY 00	06-44-29			1			2	1	11
	06-44-30			2			5	10	14
	06-44-31			1	1		4	3	14
	06-44-32						5	6	12
	06-44-33			2			2	2	20
	06-44-34			8	1	6		2	47
	06-44-35	1		6	5	6	4	4	52
TOTAL		0	0	4	1	0	11	14	39
TOTAL		0	0	2	0	0	7	8	32
TOTAL		1	0	14	6	12	4	6	99
BY 00	06-44-36								3
	06-44-37						1	0	2
	06-44-38								1
	06-44-39							1	2
	06-44-40						1	0	1
	06-44-41	1		1	1	5	1	0	21
	06-44-42	1		1	2	5	1	2	17
TOTAL							1	0	6
TOTAL							1	1	3
TOTAL		2	0	2	3	10	2	2	38
BY01	06-44-71						1		1
	06-44-72							1	1
	06-44-73								1
	06-44-74								1
	06-44-57								
	06-44-58								
	06-44-59								
	06-44-60								
TOTAL							1	1	4
TOTAL							0	0	0
TOTAL							0	0	0

SAN JOAQUIN RIVER	TAG NO.	INLAND TOTAL BY RIVER Age 3							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY 99	06-45-63			1		1	10	26	20
	06-04-01	1			1		6	23	20
	06-04-02			1			5	25	36
	06-44-01					1	9	20	37
	06-44-02			2			3	11	38
	06-44-05	1				2	8	11	30
	06-44-03	2		16	6	11	7	8	74
	06-44-04	2		15	10	14	3	7	72
TOTAL		1	0	2	1	1	21	74	76
TOTAL		1	0	2	0	3	20	42	105
TOTAL		4	0	31	16	25	10	15	146
BY 99	0601060914			2		1	3	8	7
	0601060915					1	4	11	7
	0601110814						4	5	7
	0601061001			1	5	5	2	7	40
	0601061002	1	1	5	2	2	2	5	19
TOTAL		0	0	2	0	2	11	24	21
TOTAL		1	1	6	7	7	4	12	59
BY 00	06-44-29						10	3	6
	06-44-30						9	4	5
	06-44-31						8	5	3
	06-44-32						6	3	8
	06-44-33						12	5	12
	06-44-34						5	1	26
	06-44-35						6	3	33
TOTAL							27	12	14
TOTAL							18	8	20
TOTAL							11	4	59
BY 00	06-44-36						3	1	8
	06-44-37						3	2	1
	06-44-38						3	3	4
	06-44-39								2
	06-44-40						3	1	2
	06-44-41						4	1	12
	06-44-42						2	1	14
TOTAL							9	6	13
TOTAL							3	1	4
TOTAL							6	2	26
BY01	06-44-71								
	06-44-72								
	06-44-73								
	06-44-74								
	06-44-57								
	06-44-58								
	06-44-59								
	06-44-60								
TOTAL									
TOTAL									
TOTAL									

SAN JOAQUIN RIVER	TAG NO.	INLAND TOTAL BY RIVER Age 4								INLAND TOTAL BY RIVER Age 5							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY 99	06-45-63						1	2									
	06-04-01						1										
	06-04-02						1	1									
	06-44-01						4		3								
	06-44-02							1	1								
	06-44-05						2	2	2								
	06-44-03						1	1	3								
	06-44-04						1		4								
TOTAL							3	3									
TOTAL							6	3	6								
TOTAL							2	1	7								
BY 99	0601060914						1	1	1								
	0601060915						1	2									
	0601110814																
	0601061001						1	2	2								
	0601061002						1		2								
TOTAL							2	3	1								
TOTAL							2	2	4								
BY 00	06-44-29																
	06-44-30																
	06-44-31																
	06-44-32																
	06-44-33																
	06-44-34																
	06-44-35																
TOTAL																	
TOTAL																	
TOTAL																	
BY 00	06-44-36																
	06-44-37																
	06-44-38																
	06-44-39																
	06-44-40																
	06-44-41																
	06-44-42																
TOTAL																	
TOTAL																	
TOTAL																	
BY01	06-44-71																
	06-44-72																
	06-44-73																
	06-44-74																
	06-44-57																
	06-44-58																
	06-44-59																
	06-44-60																
TOTAL																	
TOTAL																	
TOTAL																	

Table 1. San Joaquin River CWT (2000-2004)

SAN JOAQUIN RIVER		INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER								INLAND TOTAL BY RIVER							
	TAG NO.	Age 2								Age 3								Age 4								Age 5							
		SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.	SAC.	BATT.	FEATH.	AMER.	MOK.	STAN.	TUOL.	MER.
BY01	06-44-70							1																									
	06-44-75						1	1																									
	06-44-76							1																									
	06-44-77						3																										
	06-44-78						3		2																								
	06-44-79																																
	06-44-80								12																								
	06-44-81						1		12																								
TOTAL							4	3	0																								
TOTAL							3	0	2																								
TOTAL							1	0	24																								
BY02	06-02-82																																
	06-02-83																																
	06-27-42																																
	06-27-48																																
	06-27-43																																
	06-27-44																																
TOTAL																																	
TOTAL																																	
TOTAL																																	
BY02	06-27-45																																
	06-27-46																																
	06-27-47																																
	06-27-49																																
	06-27-50																																
	06-27-51																																
TOTAL																																	
TOTAL																																	
TOTAL																																	
BY03	06-27-52																																
	06-27-53																																
	06-27-54																																
	06-27-55																																
	06-46-70																																
	06-45-82																																
	06-45-83																																
	06-45-80																																
TOTAL																																	
TOTAL																																	
TOTAL																																	

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Tuolumne River RELEASE YEAR	TAG NO.	EFFECT. RELEASE	AVG. FL (mm)	RIVER WT	RELEASE SITE	DATE	SMOLT RECOVERIES PUSHNET/ RS TRAP	MOSS-DALE	SWP PUMPS	EXPAND. SWP	CVP PUMPS	EXPAND. CVP	JERSEY PT. (ANTIOCH)	JERSEY(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	OCEAN CATCH EXPD.	SPAWN
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	0
	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	0
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
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

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Tuolumne River RELEASE YEAR	TAG NO.	EFFECT. RELEASE	AVG. FL (mm)	RIVER WT	RELEASE SITE	DATE	SMOLT RECOVERIES PUSHNET/ RS TRAP	MOSS-DALE	SWP PUMPS	EXPAND. SWP	CVP PUMPS	EXPAND. CVP	JERSEY PT. (ANTIOCH)	JERSEY(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	OCEAN CATCH EXPD.	SPAWN
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.		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	84	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	29	88	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	31	93	43
TOTAL	UPPER	76221	86		OLGB	RM diff.	202	45	184	1220	161	1419	15	0.04	7	0.06	80	263	97
TOTAL	LOWER	50957	85		OFC(SJR)	= 53.5		164	172	985	135	1349	26	0.11	20	0.24	61	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	35	106	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	79	247	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	17	58	27
w/ HORB	06-44-44	24393			OFC(SJR)	26APR01		262	2	12	1	12	25	0.19	12	0.23	18	66	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	35	124	54
2002	06-44-06	24976			OLGB	24APR02		65	2	12	1	12	3	0.020	1	0.020	7	26	1
	06-44-67	24813			OLGB	24APR02		63	2	12	0	0	5	0.037	7	0.141	4	16	0
LG FLOW:	06-44-68	25220			OLGB	24APR02		51	2	18	1	12	3	0.023	0	--	6	21	0
1300 cfs	06-44-61	25701			OFC(SJR)	26APR02		116	1	6	0	0	1	0.007	6	0.111	4	14	1
w/ HORB	06-44-69	23870			OFC(SJR)	29APR02		25	2	15	1	12	2	0.015	3	0.063	3	11	3
TOTAL	UPPER	75009	86	54	OLGB	RM diff.	1008	179	6	42	2	24	11	0.026	8	0.053	17	63	1
TOTAL	LOWER	49571	86	62	OFC(SJR)	= 53.5		141	3	21	1	12	3	0.011	9	0.087	7	25	4

Notes:
- 1990 groups had different origin, rearing conditions, and sizes
- 1994 lower release occurred prior to pulse
- 1996 recoveries at Shiloh and Mossdale are considered to be invalid; also a high tag loss rate
- 1997 fish sizes were small; also a high tag loss rate
- River mile differences range from 38 to 53.5 miles
- 2002 Mossdale survival indices were calculated using tagcode 06-44-61 only, for the lower release group.

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

Tuolumne River		SMOLT SURVIVAL INDEX (Upper / Lower; corrected for release group number)												
RELEASE YEAR	TAG NO.	PUSHNET/ RS TRAP	MOSS- DALE	SWP PUMPS	SWP EXPD.	CVP PUMPS	CVP EXPD.	JERSEY PT. (ANTIOCH)	JP(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	OCEAN CATCH EXPD.	SPAWN
1986	06-46-54													
LG FLOW:	06-46-55													
6600 cfs	06-46-56													
w/o HORB	06-46-57													
TOTAL	UPPER	NA	NA	0.88	0.93	0.82	1.00	NA		1.77	1.48	1.01	0.99	1.18
TOTAL	LOWER													
1987	06-46-60													
	06-46-61													
LG FLOW:	06-46-62													
560 cfs	06-46-63													
w/o HORB	06-45-01													
	06-45-02													
TOTAL	UPPER	0.35	0.42	0.11	0.11	0.68	0.67	NA		0.31	0.28	0.33	0.29	0.29
TOTAL	LOWER													
1990	H601110201													
	H601110202													
LG FLOW:	H601110114													
600 cfs	H601110115													
w/o HORB	H601110203													
	H601110204													
	H601110205													
TOTAL	UPPER	NA	0.31	2.35	1.58	0.87	1.16	NA		3.34	4.00	1.25	0.79	NO
TOTAL	LOWER													RECOVS.
1994	0601110302													
LG FLOW:	0601110303													
1200 cfs	0601110304													
w/ HORB	0601110305													
	0601110306													
TOTAL	UPPER	NA	1.73	1.80	2.19	0.24	0.20	NA		0.90	0.89	0.99	0.99	0.94
TOTAL	LOWER													
1995	H61110311													
LG FLOW:	H61110312													
7700 cfs	H61110313													
w/o HORB	H61110314													
	H61110315													
TOTAL	UPPER	0.64	0.80	0.97	1.35	0.75	0.75	NA		1.12	1.14	0.99	1.02	0.70
TOTAL	LOWER													
1996	H61110506													
LG FLOW:	H61110507													
2600 cfs	H61110508													
w/o HORB	H61110509													
	H61110510													
TOTAL	UPPER	1.25	0.31	1.50	1.57	0.80	0.73	NA		0.56	0.57	0.64	0.65	0.75
TOTAL	LOWER													
1997	H61110607													
	H61110608													
LG FLOW:	H61110609													
2800 cfs	H61110610													
w/ HORB	H61110604													
	H61110605													
	H61110606													
TOTAL	UPPER	0.06	0.44	0.43	0.58	1.46	1.50	0.12	0.10	0.19	0.21	0.26	0.25	0.23
TOTAL	LOWER													

Table 2. Recovery data and survival indices for Tuolumne River CWT smolt survival releases.

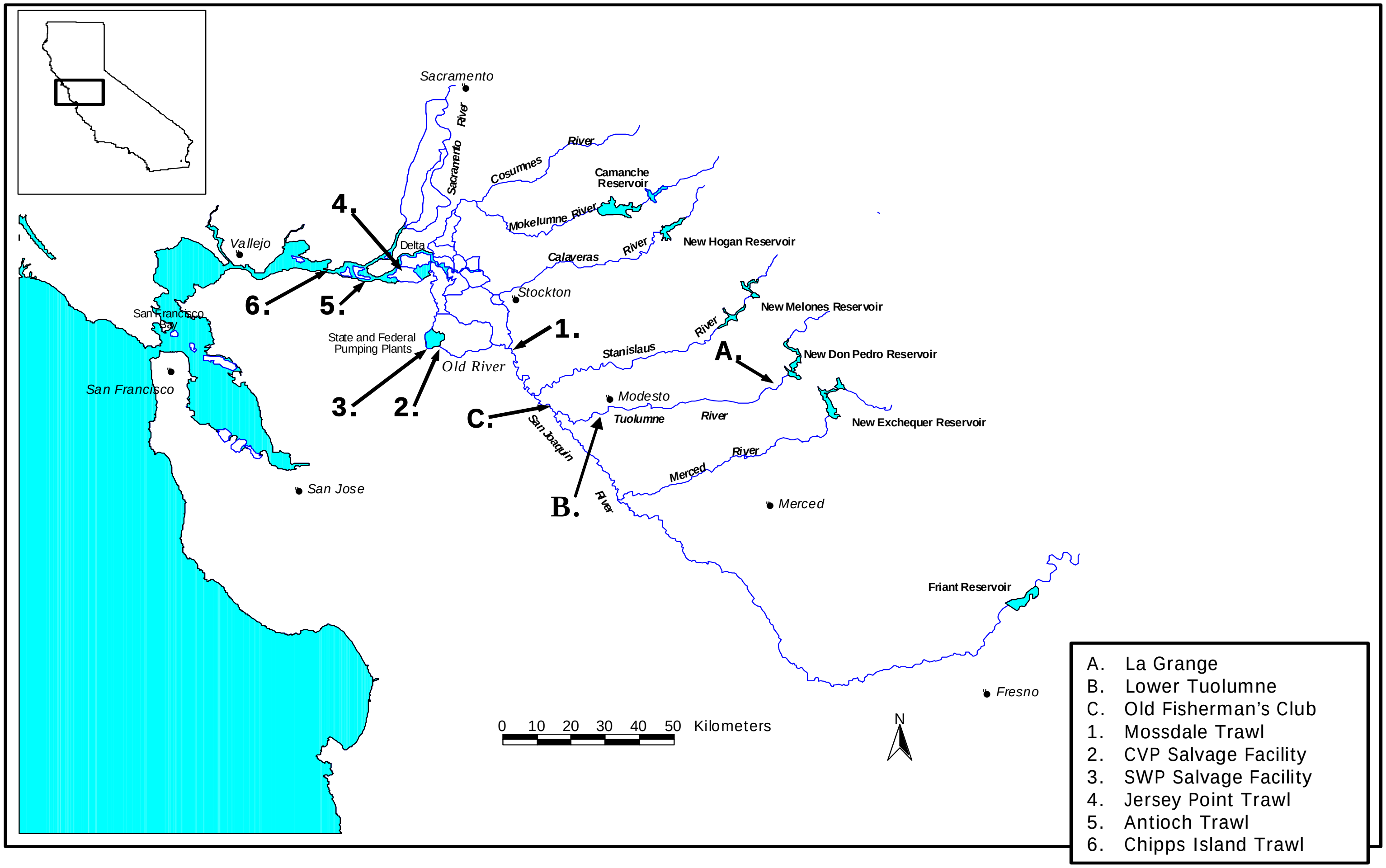
Tuolumne River RELEASE YEAR	TAG NO.	SMOLT SURVIVAL INDEX (Upper / Lower; corrected for release group number) PUSHNET/ RS TRAP	MOSS-DALE	SWP PUMPS	SWP EXPD.	CVP PUMPS	CVP EXPD.	JERSEY PT. (ANTIOCH)	JP(ANT) SURV.	CHIPPS IS.	CHIPPS SURV.	OCEAN CATCH	OCEAN CATCH EXPD.	SPAWN
1998	61110703													
	61110704													
LG FLOW:	61110705													
6400 cfs	61110706													
w/o HORB	61110707													
	61110708													
TOTAL	UPPER		1.03			1.16	1.13	1.07	0.71	0.72	0.63	2.23	1.90	1.65
TOTAL	LOWER													
1999	06-46-01													
	06-46-02													
LG FLOW:	06-46-03													
2000 cfs	06-46-04													
w/o HORB	06-46-05													
TOTAL	UPPER		0.18	0.72	0.83	0.80	0.70	0.39	0.39	0.23	0.24	0.88	0.95	0.70
TOTAL	LOWER													
2000	06-45-56													
	06-45-57													
LG FLOW:	06-45-58													
3800 cfs	06-45-59													
w/ HORB	06-45-60													
TOTAL	UPPER		0.30	0.35	0.41	0.92	0.92	0.28	0.29	0.82	0.84	0.54	0.55	0.53
TOTAL	LOWER													
2001	06-44-12													
	06-44-13													
LG FLOW:	06-44-14													
620 cfs	06-44-43													
w/ HORB	06-44-44													
TOTAL	UPPER		0.17			0.67	0.67	0.20	0.20	0.22	0.21	0.21	0.24	0.16
TOTAL	LOWER													
2002	06-44-06													
	06-44-67													
LG FLOW:	06-44-68													
1300 cfs	06-44-61													
w/ HORB	06-44-69													
TOTAL	UPPER		0.53	1.32	1.32	1.32	1.32	2.42	2.36	0.59	0.61	1.60	1.67	0.17
TOTAL	LOWER													

Table 3. Tuolumne River Smolt Survival Indices

Tuolumne Smolt Survival Index -- min. of 4 recoveries in one release group and excluding 1990, 1994, and 1997

2002 Mossdale using 1st lower group only

RELEASE YEAR	LG FLOW (cfs)	ADJUSTED LG FLOW	Trawl MOSS-DALE	Adjusted MOSS-DALE	"pump" SWP EXPD.	"pump" CVP EXPD.	Trawl JERSEY PT. ANTIOCH	Trawl CHIPPS	"adult" OCEAN CATCH	"adult" SPAWN	Averages: Trawl average	Adj. Trawl	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	1.09
1987	560	563	0.42	0.35	0.11	0.67		0.28	0.29	0.29	0.35	0.32	0.39	0.29
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	0.86
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	0.70
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	1.78
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	0.83
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	0.54
2001	640	634	0.17	0.27			0.20	0.21	0.24	0.16	0.19	0.23		0.20
2002	1,300	1,300	0.53	0.53	1.32		2.36	0.61	1.67		1.17	1.17	1.32	1.67



Tuolumne River CWT Release Locations and Smolt Recovery Sites

Figure 1. Tuolumne River CWT release locations and smolt recovery sites

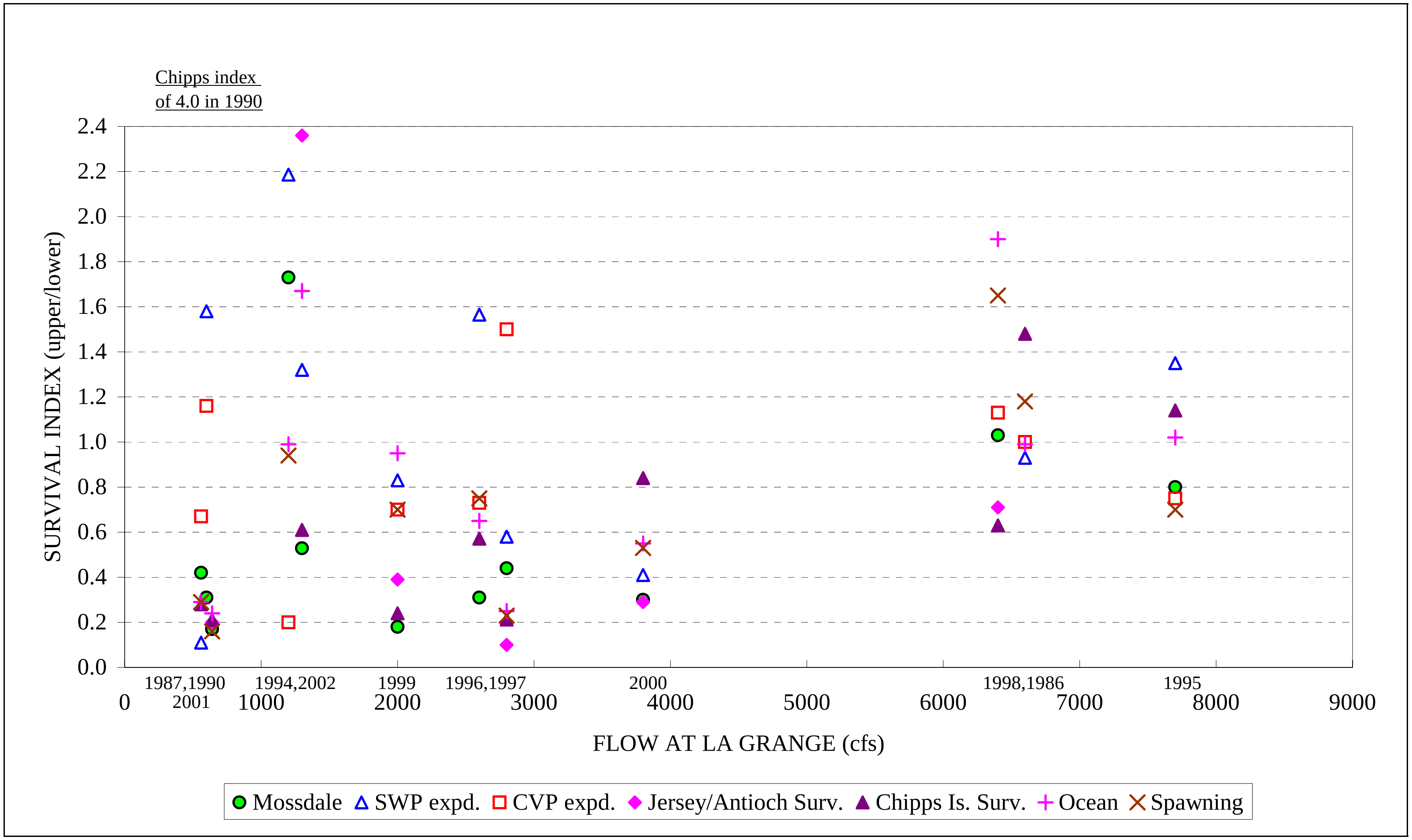


Figure 2. Survival indices (min. 4 recoveries from either release group) of all Tuolumne CWT smolt studies plotted at initial flow.

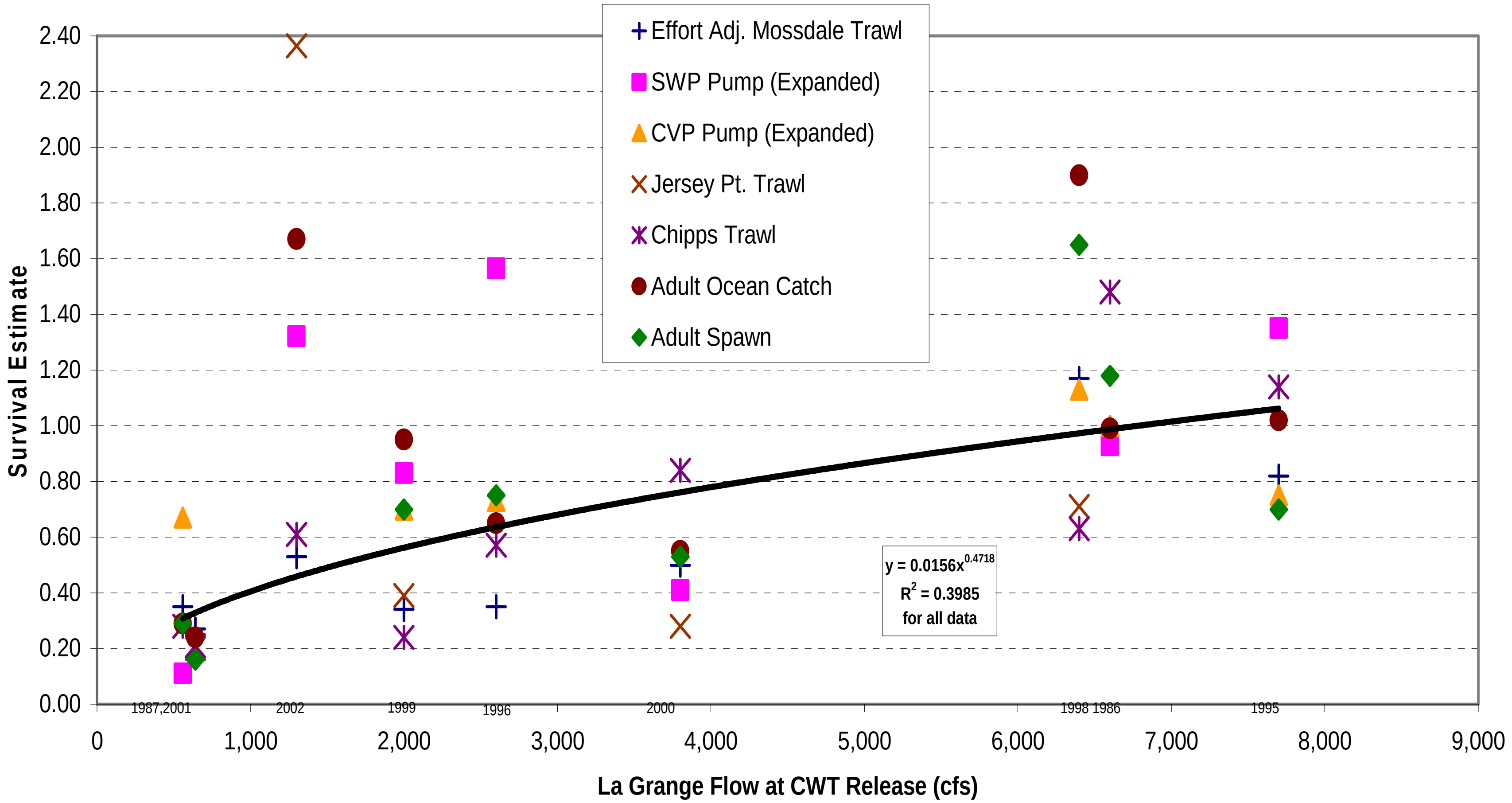


Figure 3. Survival indices (min. 4 recoveries from either release group; using adjusted Mossdale values) of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at initial flow.

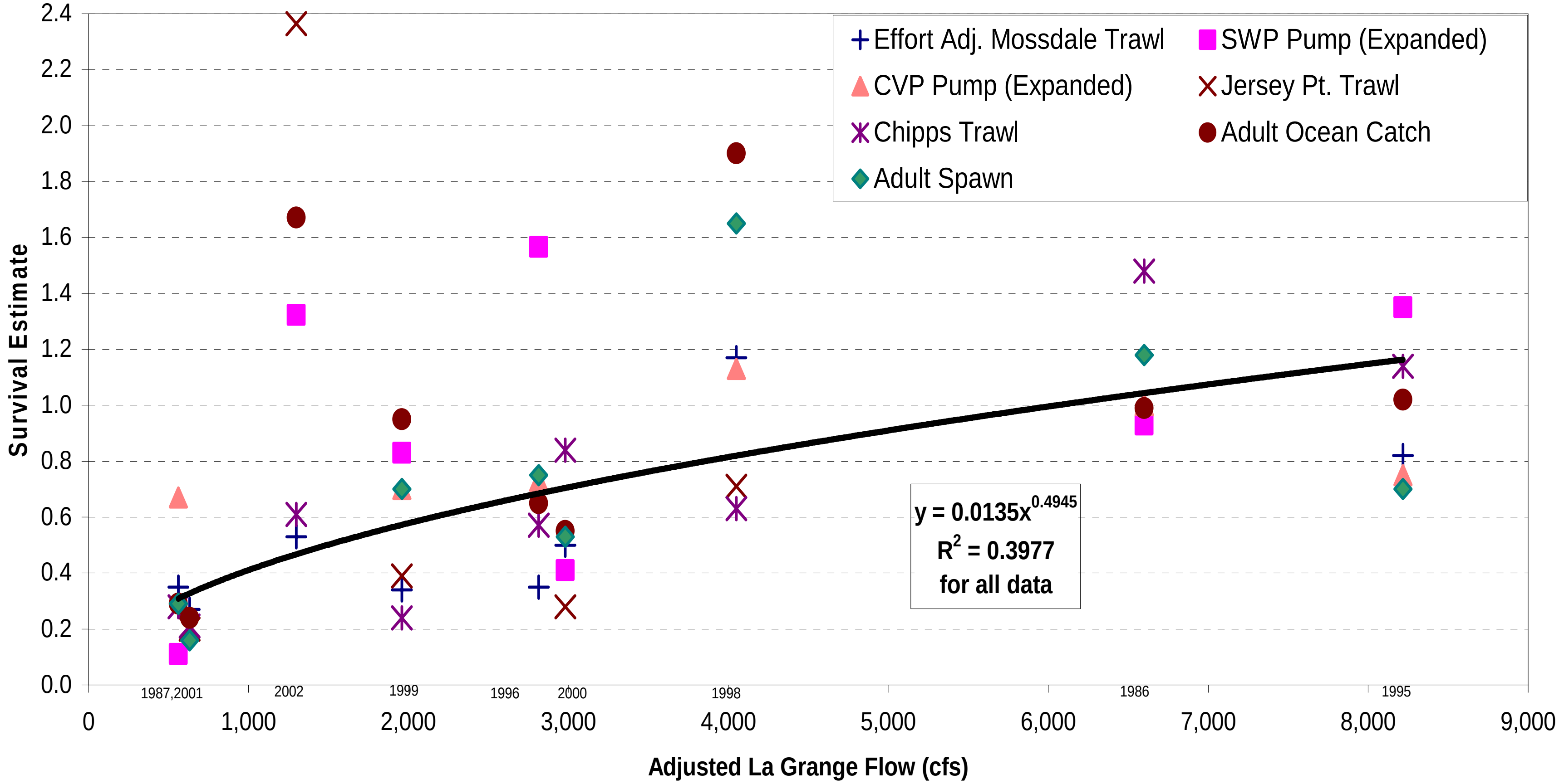


Figure 4. Survival indices (min. 4 recoveries from either release group; using adjusted Mossdale values) of validated Tuolumne CWT smolt studies (excluding 1990, 1994, 1997) plotted at adjusted flow.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-9

Aquatic Invertebrate Monitoring Report (2003-2004)

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1 INTRODUCTION

The diet of many resident and anadromous fish populations in river ecosystems is largely comprised of aquatic macroinvertebrates. Aquatic macroinvertebrate 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 (FERC License No. 2299). 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 1990 FERC Report (TID/MID 1991). Summer Flow Invertebrate Studies for the years 1989–1993 are presented in the FERC Report 1996-4 (TID/MID 1997). In 1996, the FERC ordered an increase in the summer flow schedule in the Tuolumne River in accordance with the 1995 FERC Settlement Agreement (FSA) (TID/MID 1996). The Districts have voluntarily continued to collect summer invertebrate samples in most years since then. An analysis was presented in FERC Report 2002-8 (TID/MID 2003) based on aquatic invertebrate samples collected in the years 1994, 1996, 1997, 2001–2002 by Stillwater Sciences and EA Engineering on behalf of the Districts. No invertebrate samples were collected in the years 1995, 1998, and 1999 due to high flow conditions.

The macroinvertebrate community in most freshwater systems is dominated by larval aquatic insects and the presence of these organisms is often used to indicate ecosystem "health" in rivers (Plafkin et al. 1989, Barbour et al. 1999). A rapid bioassessment protocol (RBP) based upon invertebrate composition indices has been adopted by the California Department of Fish and Game as the California Stream Rapid Bioassessment Protocol (CBSP) (CDFG 1999). Revisions to the CBSP have been continuing and are primarily based on adopting standards established for the Pacific Northwest by Aquatic Biology Associates, Inc. This report provides a summary of CBSP monitoring for the lower Tuolumne River conducted in 2003–2004 by Stillwater Sciences on behalf of the Turlock and Modesto Irrigation Districts (Districts) using the current (CDFG 2003) standard level of taxonomic effort as documented by the California Aquatic Bioassessment Laboratory Network (CAMLnet).

2 METHODS

Invertebrate collection methods used in this study were based on standard field and laboratory protocols (Merritt and Cummins 1996, CDFG 1999, CDFG 2003). Sample site characterization along with collection methods and modifications are presented below.

2.1 Study Sites

Benthic invertebrate Hess samples have been collected on a long-term basis at Riffle 4A at river mile (RM) 48.8, approximately 3.5 miles downstream of La Grange Dam (Figure 1). As a result, Riffle 4A has been maintained as a reference site for invertebrate sampling over all sample years. Beginning in the 2001, additional upstream and downstream sampling sites were added and the sampling methods modified to include Kick Net sampling in addition to Hess sampling. The sampling locations were revised in

2002 with the relocation of the Riffle 21 site to Riffle 33 and the addition of a site at Riffle 72. Beginning in 2003, the Riffle 33 site was relocated to Riffle 31. The sampling sites used in 2003–2004 are shown in Figure 1.

Sample sites used for invertebrate collection, dates, location (RM), method, and numbers of samples analyzed are listed in Table 1. All sampling sites were located in riffle habitats dominated by cobble and gravel substrate. Samples were collected in mid-summer (late July to August) in order to provide a consistent assessment of the invertebrate community from year-to-year, and avoid short-term invertebrate community shifts due to variable emergence timing of many insects.

Table 1. The location, method, and number of samples analyzed by year for Tuolumne River benthic invertebrates in 2003 and 2004.

Location	**River Mile**	**2003** **July 30-July 31**	**2004** **July 21-July 22**
Riffle A4	51.6	Kick Net (1-composite)	Kick Net (1-composite)
Riffle 4A	48.8	Hess (3 of 3 collected) Kick Net (1-composite)	Hess (3 of 3 collected) Kick Net (2-composites separated by 250 ft)
Riffle 23C	42.3	Hess (3 of 3 collected) Kick Net (1-composite)	Hess (3 of 3 collected) Kick Net (1-composite)
Riffle 31	38.1	Kick Net (1-composite)	Kick Net (1-composite)
Riffle 57	31.5	Kick Net (1-composite)	Kick Net (1-composite)
Riffle 72	25.4	Kick Net (1-composite)	Kick Net (1-composite)

The Riffle 23C sample site was moved upstream by 450 ft because of gravel deposition near the head of the riffle to better represent local hydraulic and substrate characteristics found in prior surveys. At Riffle 4A, long-term gravel attrition at the riffle head had resulted in coarser substrate and deeper water. For this reason, a second Kick-net sample was collected 250 ft downstream of the location of the Hess samples used in past surveys to determine whether the two sites were comparable.

2.2 Sample Collection and Preservation

2.2.1 Hess Samples

A 0.10 m^2 Hess sampler (Hess 1941, Jacobi 1978) was used to collect invertebrates at Riffle 4A and Riffle 23C. Samples were collected along transects within the upper portion each riffle, including the upper 200-ft section of Riffle 4A. This same 200-ft section was used in all previous samples years at Riffle 4A and represents an area undisturbed from other fieldwork. Three samples are collected along each transect and spaced so that one was collected in the approximate center of the channel, and one on each side of the channel, approximately midway between the center and the edge of the water. In 2003, six samples from two transects were collected at Riffle 4A and three samples along one transect at Riffle 23C. In 2004, three samples along one transect each were collected at both sites.

Distance measurements of sample collection locations along the transects and transect placement within the riffle area were recorded relative to a designated reference datum at each riffle. Water depths and mean water column velocities were also measured at the upstream edge of each sample collection area using a flow meter (Marsh-McBirney Flowmate 2000) and topset wading rod.

2.2.2 Kick-net Samples

In addition to Hess samples, benthic invertebrates were collected using a D-frame Kick-net (Frost et al. 1971) at selected riffles along the river from RM 51.6–25.4. (Table 1). At Riffles 4A and 23C, Kick-net samples were collected in the vicinity of their respective Hess sample locations.

Kick-net sampling consisted of collecting composite samples in general accordance with the Non-point Source Sampling Design as described in the CSBP (CDFG 1999). A total of one composite sample was collected at each riffle area. The samples were collected by randomly selecting a transect within the upper third of the riffle area. Invertebrates were collected at three stations along the transect representing the stream center and side margins.

2.2.3 Sample Preservation

Samples were initially preserved in the field in 95% ethanol, and the bottle labeled with the location, date, sampling technique, and replicate number. Upon returning from the field all samples were stored at ambient temperatures until sample processing.

2.3 Sample Processing

2.3.1 Sub-sampling

During sample processing, samples were decanted, picked and sorted based on protocols outlined in the CBSP (CDFG 1999). Excessively large samples or samples with large numbers of individuals in them are sub-sampled to save processing time. The sample is quantitatively reduced, the invertebrates from a known portion of the sample are then counted, and these counts are extrapolated back to the entire sample. Sample contents were spread onto a gridded tray, grids were randomly selected, and invertebrates were picked from the grid contents (Caton 1991, Carter and Resh 2001).

In general, 30 grids were used for dense samples. For samples with lower numbers of individuals, a coarser grid randomization was used rather than counting all 30 grids. In cases where sample density is very low, a smaller 8-inch tray divided in quarters and eighths is used for sub-sampling. In all cases, sorting continued until a 300-individual sample had been picked. Any individuals from the last grid in excess of 300 were retained to supplement potentially discarded or misidentified invertebrates during identification.

2.3.2 Invertebrate Identification

Sample picking, sorting and identification was performed by Aquatic Biology Associates, Inc. (Corvallis, OR) using the current standard level of taxonomic effort adopted by the CSBP and outlined by CAMLnet (CDFG 2003). Revisions to the level of taxonomic effort may impact the ability to make direct comparisons of results from shown in this report to those from previous years, although many of the metrics calculations used would be largely unaffected unless the specific taxon in question were very abundant in the sample.

2.3.3 Quality Assurance

Quality Assurance (QA) guidelines outlined in the CSBP (CDFG 1999) include Sample Handling and Custody, Sub-sampling, Taxonomic Identification and Enumeration, Organism Recovery, and Taxonomic Validation. All archived samples were found to be well preserved with ethanol in jars labeled with river name, sample date and time, location, and sample ID number. Sample tally sheets recorded counts of organisms, grid information, and notes on discarded organisms due to mis-identification or fragmentation. Sample remnants were inspected to ensure they contained fewer than 10% of the total organisms sampled (*e.g.*, 30 for a 300 count sample).

2.4 Data Analysis

A large number of indices have been developed in the CSBP (CDFG 1999, CDFG 2003). Because some of these metrics require sample identification to genus or species levels, not all metrics are comparable to previous samples or between individual taxonomists without strict adherence to the most current version of the CSBP. Additional information on various metrics may be found in Plafkin et al. (1989) and Barbour et al. (1999). The functional feeding group concept is discussed by Cummins (1973), and genus-level functional feeding group designations for aquatic insects are provided by Merritt and Cummins (1996). We note below the adjustments made to the RBP metrics used in this report.

Shannon's diversity index. Based on information theory, Shannon's diversity index (Shannon and Weaver 1949), represents the amount of "information" gained by commonly or rarely encountered organisms in a sample. In other words, it is also the uncertainty in predicting what family an organism chosen at random from a sample will belong to. The proportion (p_i) of species (i) relative to the total number of species (n) is calculated, and then multiplied by the natural logarithm of this proportion (ln p_i). The resulting product is summed across species, and multiplied by -1:

$$H = -\sum_{i=1}^{n} p_i \ln(p_i)$$

EPT Index. The EPT index used in this report represents the proportion of individuals identified to the family level that belong to three orders of aquatic insects: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The index was based upon a comparison by Lenat (1988), which found that the numbers of families within the three orders of aquatic insects could be used as an indicator of water and sediment quality.

EPT Taxa. This represents the number of taxa within the three orders of mayflies, stoneflies, and caddisflies.

% Insects. Widening the EPT Index to all insects represented in a sample is often warranted because insects offer high quality food for rearing fish and are indicators of faster moving (lotic) and higher quality waters (Plafkin et al. 1989). As an index, % Insects can be used to show community shifts away from more sessile organisms (*i.e.,* mollusks) that represent lower food value to rearing fish.

% Chironomids. Because of their pollution tolerance, chironomids (midges) are often used to indicate poor water quality conditions. Chironomid larvae occur in almost any aquatic system and many species are very tolerant to pollution (*e.g.,* bloodworms).

EPT/Chironomid ratio. This metric uses the ratio of these indicator groups as a measure of community balance. Communities with a good biotic condition would be expected to have a substantial representation of EPT taxa. Samples with disproportionate numbers of generally tolerant chironomids relative to the more sensitive insect groups may indicate environmental stress (Ferrington 1987).

Tolerance Value. The Tolerance Value is based upon the Hilsenhoff Biotic Index (HBI) (Hilsenhoff, 1988) and provides a means of assessing water quality at sites where macroinvertebrate samples have been collected and the number of individuals in each taxon has been identified. In this method, individual taxa are assigned pollution-tolerance values based on the taxon’s tolerance to organic pollution and only those taxa with assigned tolerance values are included in the analysis. An HBI score at the high end of the scale (0–10) indicates that the invertebrate community is dominated by pollution-tolerant organisms and indicates that the site has been subjected to organic pollution. In contrast, a low score indicates that organisms intolerant of organic pollution dominate the invertebrate community and implies that water quality at the site is good.

% Tolerant/Intolerant Organisms. Percent tolerant or intolerant taxa gives an indication of the balance in the community. Intolerant organisms (*e.g.,* EPT organisms and others) are usually not found in the presence of even moderate reductions in dissolved oxygen.

Percent Gatherers/Scrapers/Predators/Shredders. Etc. The percentage composition of various functional feeding groups is used to characterize community response to hydraulics (lentic vs. lotic) and source of organic matter at the base of the food web (Cummins 1973; Merritt and Cummins 1996). In general, collector/gatherers (*e.g.*, beetles and larval flies) generally decompose fine particulate organic matter (FPOM) including detrital remains of vascular plants and algae. Scrapers generally feed on periphyton (attached algae). Predators feed on other invertebrates, whereas shredders feed on vascular macrophyte tissue and coarse particulate organic material (CPOM), including wood.

Dominant Taxon. Similar to diversity indices, % dominant taxon is used to indicate the presence of an overly represented organism in the total sample. A sample dominated by a single taxon is normally an indication that an outside stress has altered the system and created conditions that favor the proliferation of one group of invertebrates (*e.g.,* pollution-tolerant chironomids, etc.). Although this index is most useful when compared to undisturbed references sites, it is also a useful indicator of changes of habitat conditions (*e.g.,* water quality) through time.

3 RESULTS

3.1 Environmental Conditions

Annual hydrographs in the lower Tuolumne River below La Grange Dam (USGS 11289650) are included graphically as Appendix A. The 30-day average flow preceding invertebrate sampling was approximately 240 cfs in 2003 and approximately 114 cfs in 2004. Tables 2 and 3 show depth and velocity as measured during sample collection in 2003 and 2004, respectively.

Temperature conditions in the lower Tuolumne River (Appendix B) were measured using thermographs at the following locations: Riffle 3B (RM 49.0), Ruddy Gravel (RM 36.7), and Hughson Wastewater Treatment Plant (RM 23.6). The 30-day minimum temperature (C) preceding invertebrate sampling was approximately 12.8 at Riffle 3B and 22.5 at Hughson in 2003 and 14.7 at Riffle 3B and 25.1 at Hughson in 2004. The 30-day maximum temperature (C) preceding invertebrate sampling was approximately 16.0 at Riffle 3B and 27.9 at Hughson in 2003 and 18.4 at Riffle 3B and 27.9 at Hughson in 2004. Tables 2 and 3 show water temperatures as measured during sample collection in 2003 and 2004.

3.2 Hess Sampling Results at Riffle 4A

Table 2 presents EPT Index, EPT/Chironomid Ratio, Percent Chironomids, Percent Insects, Percent Dominant Taxon, and Density [No./m^2] along with sampling conditions (flow, temperature, depth, velocity) at Riffle 4A. In terms of total numbers of invertebrates, Figure 2 shows that the mean density of invertebrates at Riffle 4A generally varied between 20,000 and 40,000 m^{-2}, depending upon year and sampling method employed. Appendix C (Table C1) presents family level sample identification results and mean sample densities found in 2003 and 2004.

3.3 Longitudinal Variation of RBP Indices in the lower Tuolumne River

In addition to the density estimates and RBP indices shown in Table 2, Figures 3–5 show longitudinal variation in by Riffle in 2003 and 2004 (Riffles A4, 4A, 23C, 57, 72). Table 2 present the sampling conditions (flow, temperature, depth, velocity), with annual flow and temperature records presented in Appendices A and B, respectively. Appendix C (Table C2) presents sample identification to the family level.

EPT species exhibited an increase in mid-river sampling sites (Riffles 23C and 31) relative to upstream sites (Figures 4 & 5). Although the proportions of Baetids, Leptohyphids, and Hydropsychids remain relatively consistent to one another and generally show a decline with distance downstream (Appendix C), the replicate R4A kick samples show very different community composition. That is, kick-samples collected at the long-term monitoring site at Riffle 4A had lower EPT abundance than the sample collected 200 ft downstream in shallower water (Tables 1 and 2).

4 DISCUSSION

RBP indices use presence/absence and abundance of taxa with different stress tolerance levels to monitor changes in the environment (Jackson and Resh 1988). Biological impairment may be caused by several major factors such as organic enrichment, habitat degradation, or toxicological effects. It may be manifested in several ways including: (1) absence of pollution-sensitive taxa, especially the EPT group, such as Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies); (2) excessive dominance of pollution-tolerant taxa such as Chironomidae (midges) and Oligochaeta (worms); (3) low overall taxa numbers, or (4) other perceptible differences in community structure relative to a reference condition. For the years 2003 and 2004, invertebrate sampling in the lower Tuolumne River focused on relative differences in these metrics in response to longitudinal gradients in riffle habitats.

For the riffles sampled in 2003 and 2004, pollution-tolerant invertebrate species comprise a larger proportion of the samples with distance downstream (Table 2, Figures 4 and 5, Appendix C), with chironomid species present in all samples. Instream temperatures generally rise above 20^{o}C at downstream locations from midsummer until mid-October. Although diversity normally decreases with disturbance or ecological stress (*e.g.*, water, temperature, fine sediment, pollution events, etc.), this pattern is not borne out by the sampling conducted in 2003–2004. Lastly, invertebrate abundance decreases with distance downstream.

5 CONCLUSIONS AND RECOMMENDATIONS

- For samples collected at Riffle 4A, community composition has shifted away from pollution-tolerant organisms and towards those with higher food value for fish since 1995 (TID/MID 2003). This trend is indicative of improved instream conditions for resident fish species in the lower Tuolumne River as a result of the higher flow schedules under the 1996 FERC Order.

- Based examination of long-term sample data collected at Riffle 4A, invertebrate abundance in the 1994 samples appeared to be anomalously low. We recommend preliminary steps in identification and enumeration of the remaining 7 samples from this effort to determine if the prior results are due to actual field conditions, sample preservation or other problems.

- In any future surveys, we recommend considering discontinuing routine Hess sampling at Riffle 23C and expanding the sampling at R4A to 6 replicates. The location of future sample collection at Riffle 4A should be changed permanently to the site 200 ft downstream of the location used in past surveys. Based upon the results of the 2004 surveys, the low water velocities and greater water depths at the historical location suggest this site no longer represents comparable riffle habitat conditions.

- RBP metrics at lower Tuolumne River sites occupied since 2001–2002 continue to exhibit a pattern of decreasing habitat quality from upstream (high) to downstream (low), likely due to increases in higher average temperatures and increases in fine sediments with increasing distance from La Grange dam. We recommend continuation of Kick-samples as well as a more comprehensive evaluation (i.e., 1988–present for Riffle 4A, and 2001–present for multi-site sampling) based upon the most recent update of the CSBP. Because, varying levels of taxonomic effort have been applied to the collected samples, comparisons of community indices from different years requires collapsing the data sets to the least precise taxonomic information resulting in a loss of the more precise information. For this reason, a multi-year assessment would require re-identification of previously sorted samples collected in 1996, 1997, and 2001 to extend taxonomic information to the genus level for all samples collected since 1994.

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Table 2. CSBP metrics for Hess and Kick samples in 2003 by River Mile.

	Riffle A4 RM 51.6 Kick Net Mean	Riffle 4A RM 48.8 Hess Sampler Mean	Riffle 4A RM 48.8 Kick Net Mean	Riffle 23C RM 42.3 Hess Sampler Mean	Riffle 23C RM 42.3 Kick Net Mean	Riffle 31 RM 37.9 Kick Net Mean	Riffle 57 RM 31.5 Kick Net Mean	Riffle 72 RM 25.4 Kick Net Mean
Taxonomic Richness	25	43	33	40	21	21	30	22
EPT Taxa	7	9	8	10	9	7	10	7
Ephemeroptera Taxa	3	4	3	5	5	5	6	3
Plecoptera Taxa	1	0	0	0	0	0	0	0
Trichoptera Taxa	3	5	5	5	4	2	4	4
EPT Index	41	39	39	51	85	77	52	17
Sensitive EPT Index	2	4	4	1	1	5	2	2
Shannon Diversity	2.4	2.4	2.5	2.4	1.9	1.9	2.3	2.4
Tolerance Value	6	5	5	5	5	4	4	5
Percent Intolerant Organisms	3	2	0	1	1	5	2	1
Percent Tolerant Organisms	24	3	4	2	1	1	1	1
Percent Hydropsychidae	4	0	0	28	36	48	26	6
Percent Baetidae	31	1	2	18	35	22	23	4
Percent Dominant Taxon	31	30	26	28	36	48	26	30
Percent Collector-Gatherers	62	68	59	28	48	29	33	30
Percent Collector-Filterers	19	9	13	30	37	51	29	14
Percent Scrapers	2	1	2	7	5	9	12	9
Percent Predators	2	2	2	23	5	3	10	9
Percent Shredders	2	0	0	0	0	0	0	0
Percent Others	14	20	24	12	4	9	16	39
EPT/Chironomid Ratio	1.8	0.8	0.9	8.2	91.2	15.0	7.2	0.7
Percent Chironomid	22	49	43	8	1	5	7	24
Percent Insects	73	90	83	65	90	85	70	48
Abundance (total in sample)	3554	2355	7548	1177	1611	943	1110	335
Density (No./m2)	18692	23547	39702	11767	8474	4961	5839	1762
Water Depth (ft)	1.75	1.45	1.40	1.27	1.30	1.25	1.80	2.00
Water Velocity (fps)	2.80	1.11	1.10	2.67	2.60	3.40	2.50	3.10
Water Temperature (C)	11.8	13.2	13.2	16.9	16.9	19.0	23.8	25.4

Table 3. CSBP metrics for Hess and Kick samples in 2004 by River Mile.

	Riffle A4 RM 51.6 Kick Net Mean	Riffle 4A RM 48.8 Hess Sampler Mean	Riffle 4A RM 48.8 Kick Net Mean	Riffle 4A RM 48.8 Kick Net (rep) Mean	Riffle 23C RM 42.3 Hess Sampler Mean	Riffle 23C RM 42.3 Kick Net Mean	Riffle 31 RM 38.1 Kick Net Mean	Riffle 57 RM 31.5 Kick Net Mean	Riffle72 RM 25.4 Kick Net Mean
Taxonomic Richness	28	34	23	31	29	20	25	27	26
EPT Taxa	8	9	9	11	10	7	10	11	8
Ephemeroptera Taxa	4	4	4	5	5	5	7	7	4
Plecoptera Taxa	1	0	0	0	2	0	0	0	0
Trichoptera Taxa	3	5	5	6	3	2	3	4	4
EPT Index	33	68	77	71	79	82	77	68	24
Sensitive EPT Index	3	0	1	1	1	1	4	12	7
Shannon Diversity	2.2	1.9	1.6	2.3	1.8	1.7	1.9	2.5	2
Tolerance Value	6	5	5	5	4	4	4	4	5
Percent Intolerant Organisms	3	4	1	1	1	1	4	12	7
Percent Tolerant Organisms	15	1	1	2	0	0	1	1	2
Percent Hydropsychidae	2	1	1	15	48	56	51	29	8
Percent Baetidae	26	1	1	25	14	11	8	21	1
Percent Dominant Taxon	31	52	53	25	48	56	51	29	40
Percent Collector-Gatherers	42	66	62	60	31	23	26	43	57
Percent Collector-Filterers	41	7	9	20	49	57	51	29	12
Percent Scrapers	4	1	1	5	4	7	12	13	10
Percent Predators	1	3	1	4	11	9	6	6	2
Percent Shredders	0	0	0	0	0	0	0	0	0
Percent Others	12	23	27	11	5	4	6	9	19
EPT/Chironomid Ratio	1.6	3.2	5.9	6.8	26.9	51.4	107.8	16.1	1.5
Percent Chironomid	21	21	13	10	3	2	1	4	16
Percent Insects	85	90	90	84	84	85	85	76	41
Abundance (total in sample)	3519	2893	3468	6432	1912	2749	2232	813	659
Density (No./m2)	18508	28933	18242	33832	19120	14460	11740	4276	3466
Water Depth (ft)	1.25	1.00	1.00	1.10	0.68	0.70	1.30	1.20	1.80
Water Velocity (fps)	2.30	0.59	0.60	2.00	3.06	3.10	3.10	3.00	2.40
Water Temperature (C)	12.1	16.1	16.1	16.1	22.2	22.2	25.9	27.7	29.1

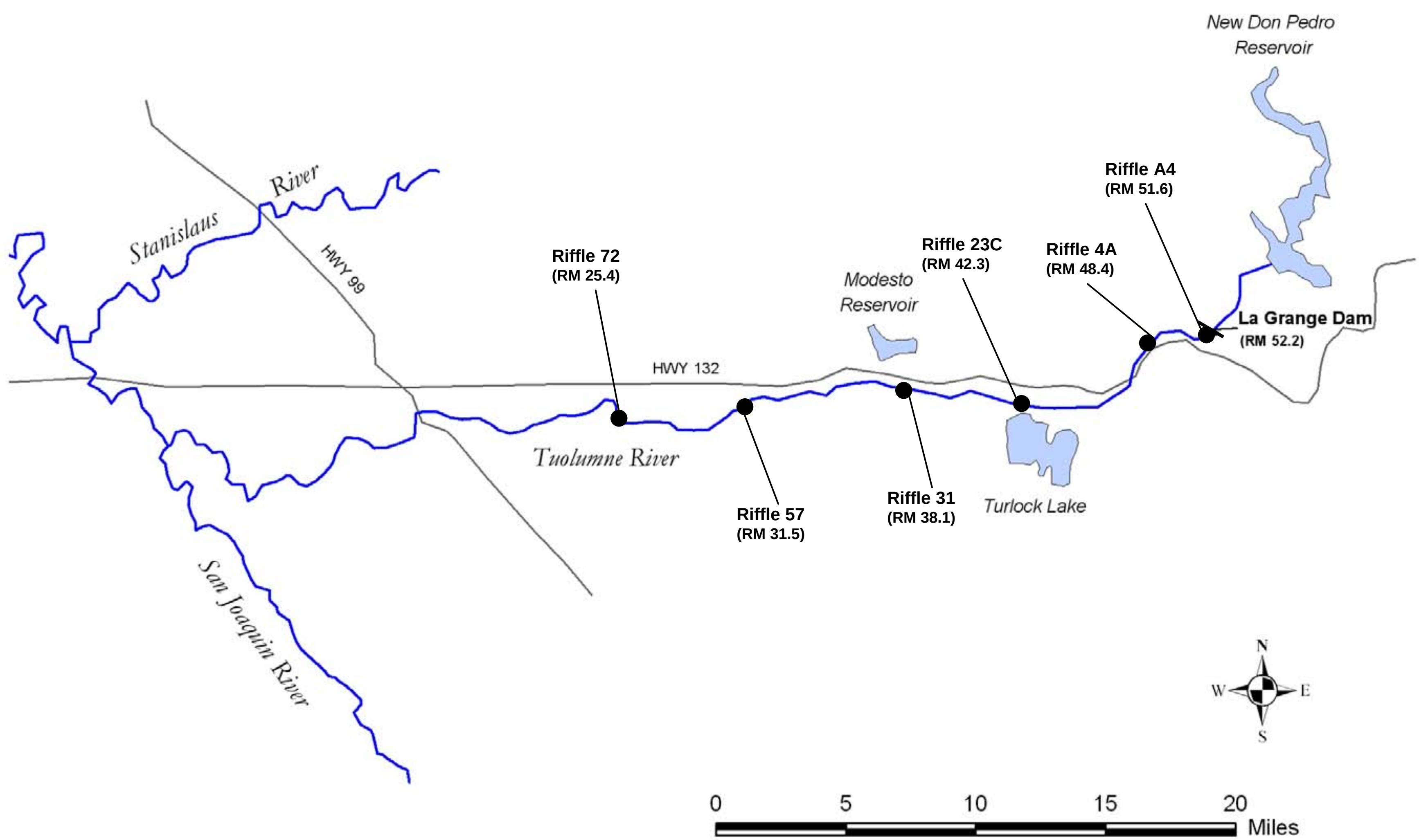


Figure 1. Locations of invertebrate sampling sites on the lower Tuolumne River, 2003-2004.

Stillwater Sciences

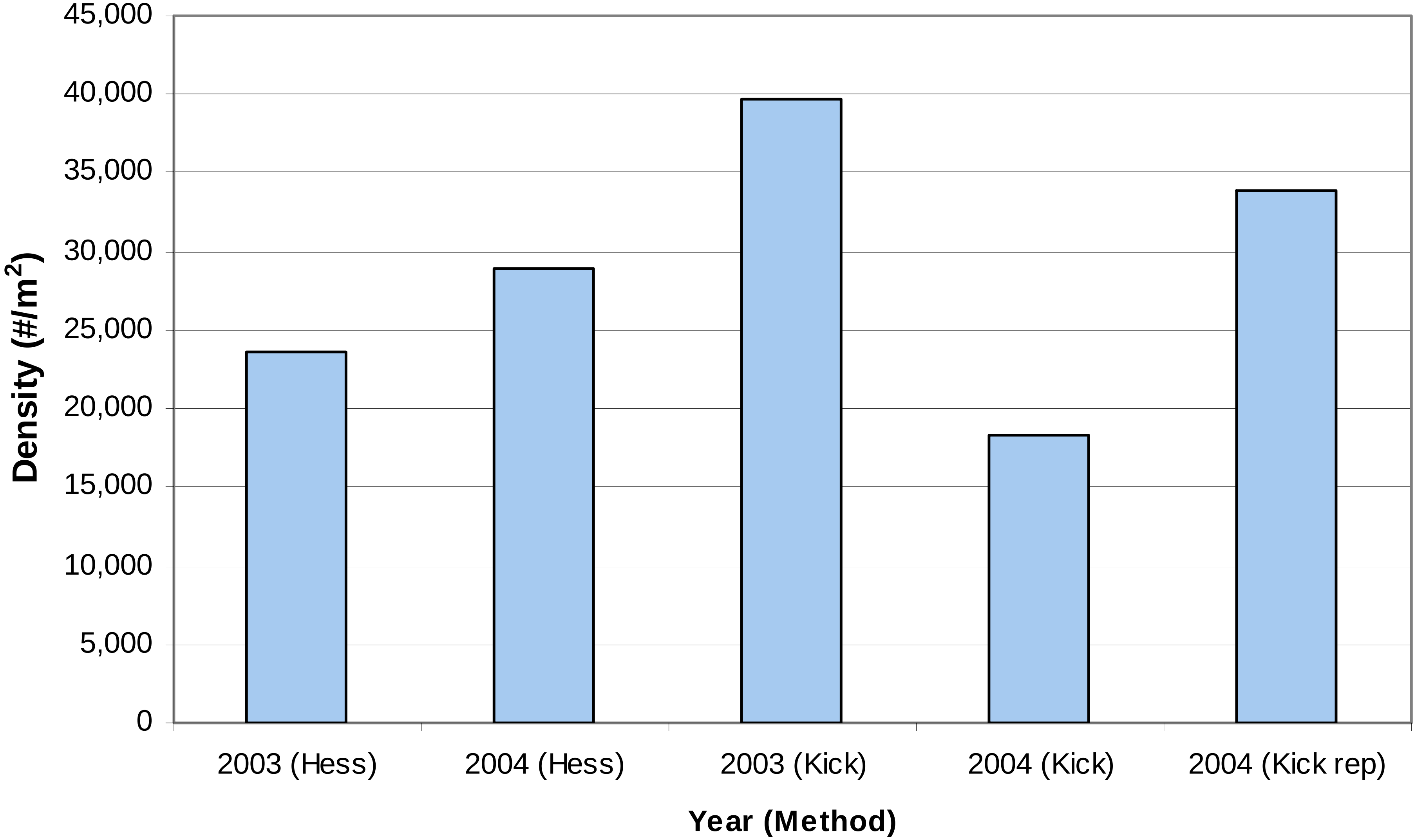


Figure 2. Invertebrate density from hess and kick samples at Riffle 4A in the lower Tuolumne River, 2003-2004.

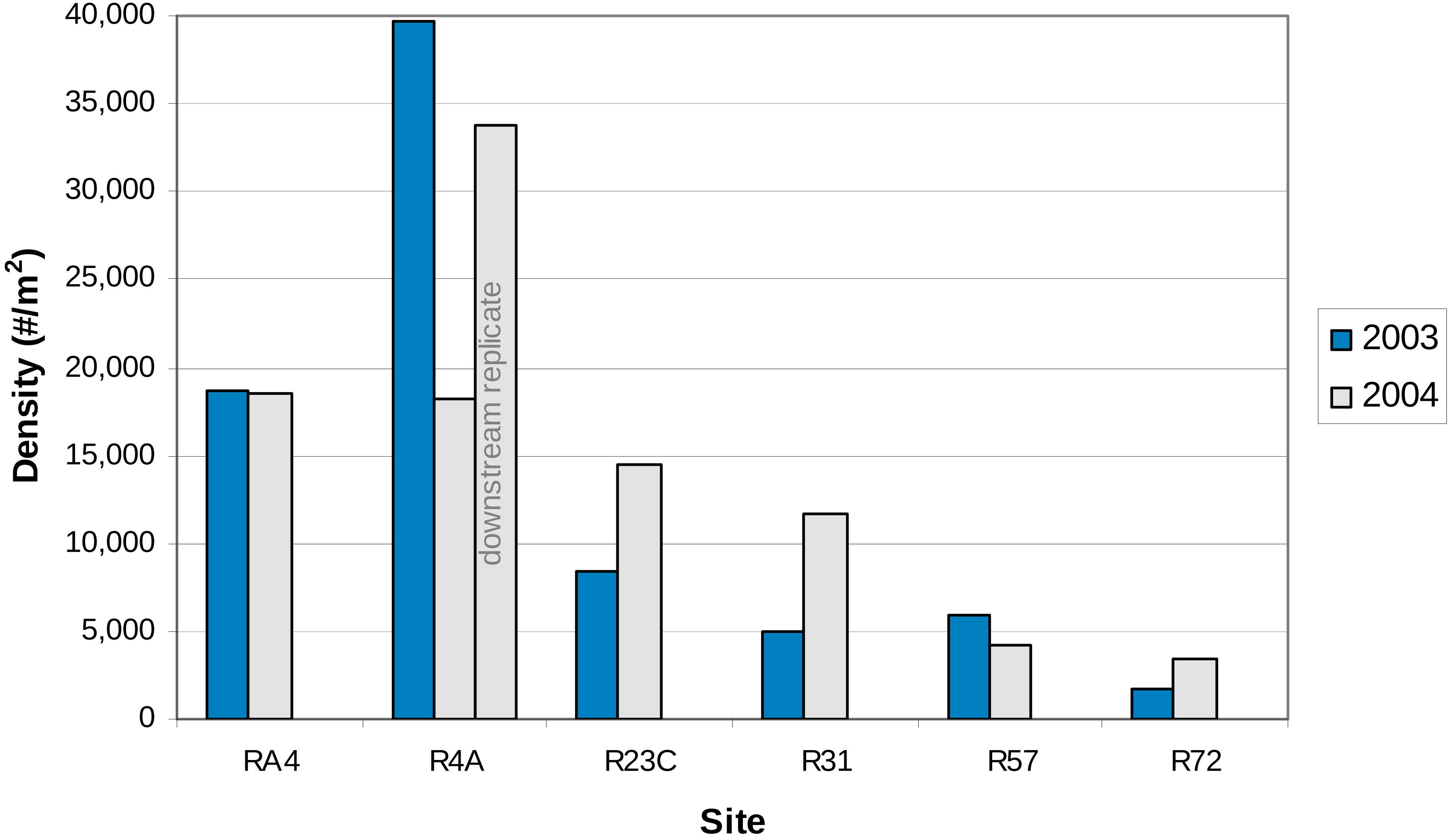


Figure 3. Invertebrate density from kick samples in the lower Tuolumne River, 2003-2004.

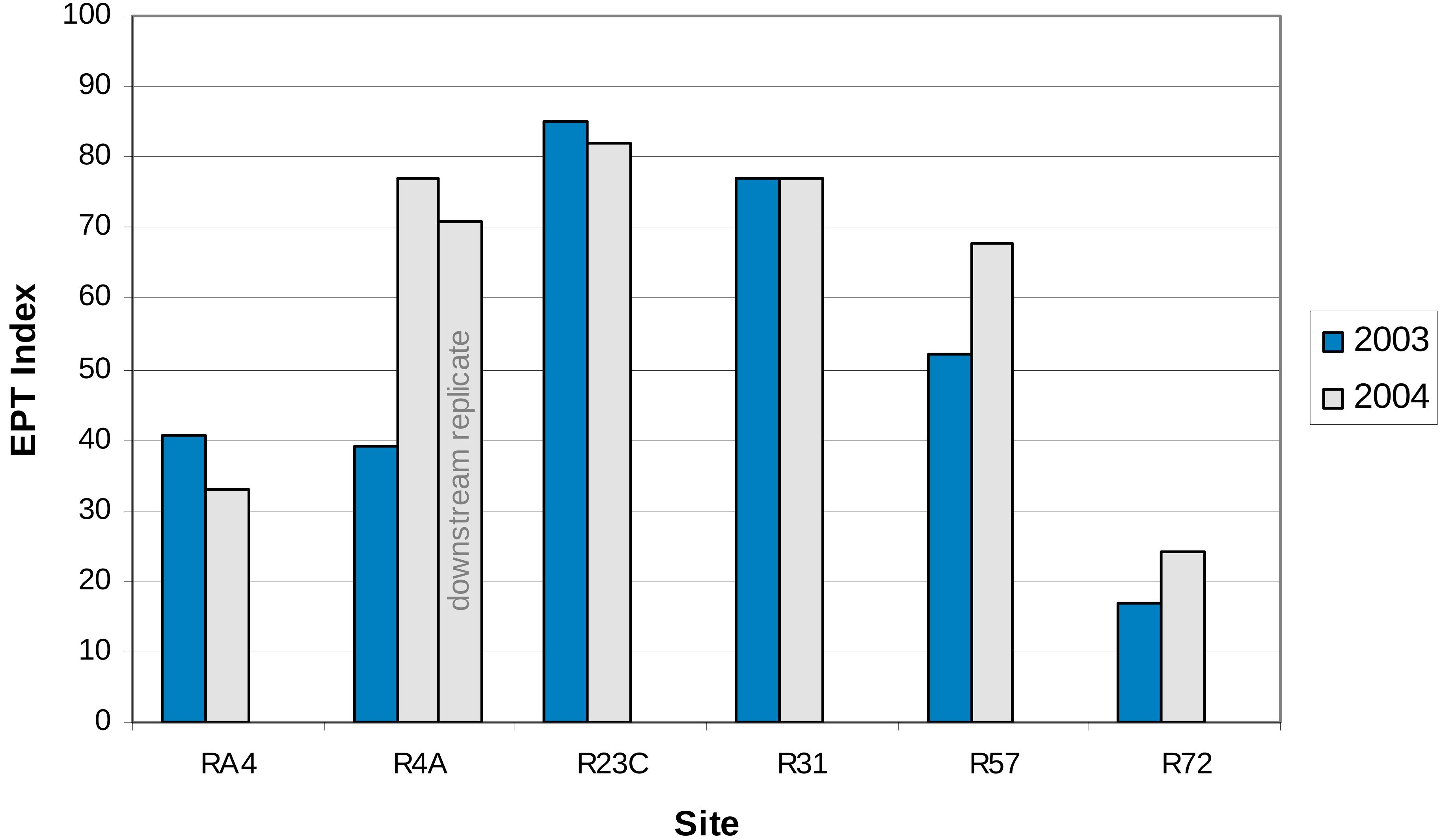


Figure 4. EPT Index from kick samples in the lower Tuolumne River, 2003-2004.

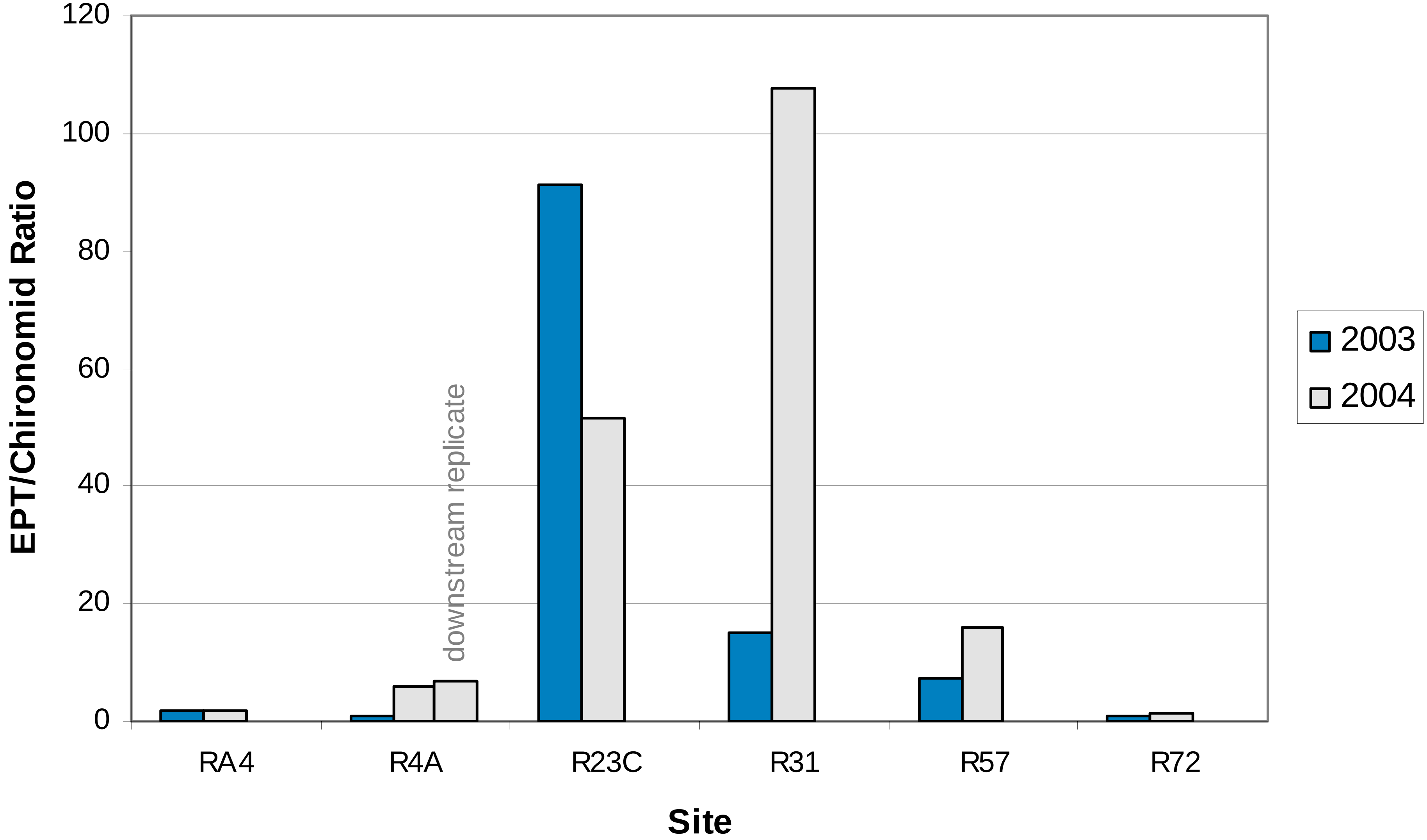
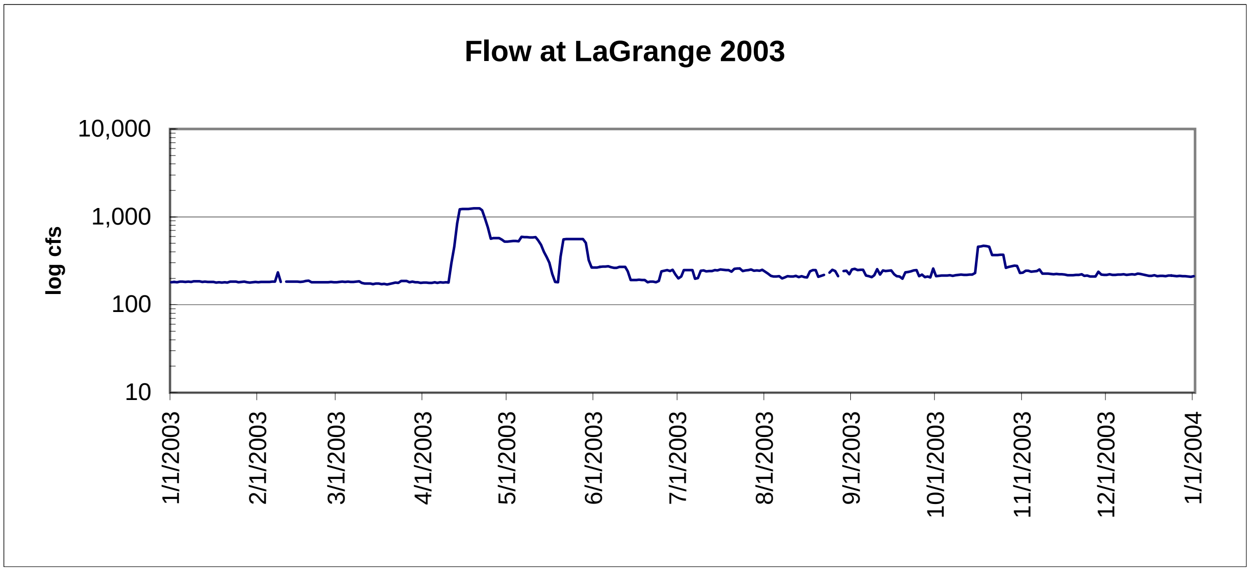
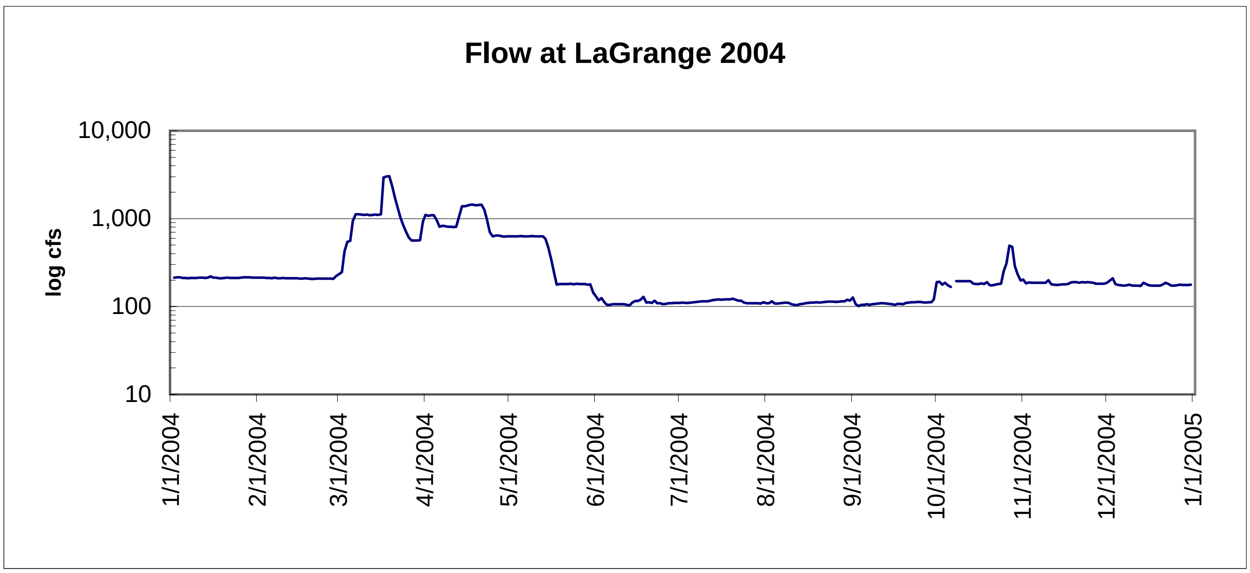
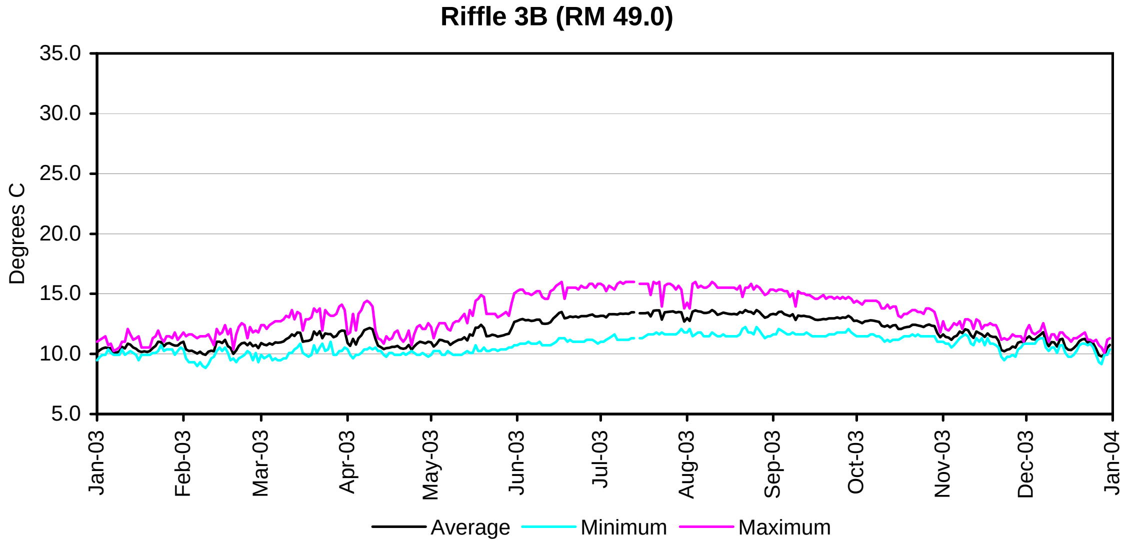
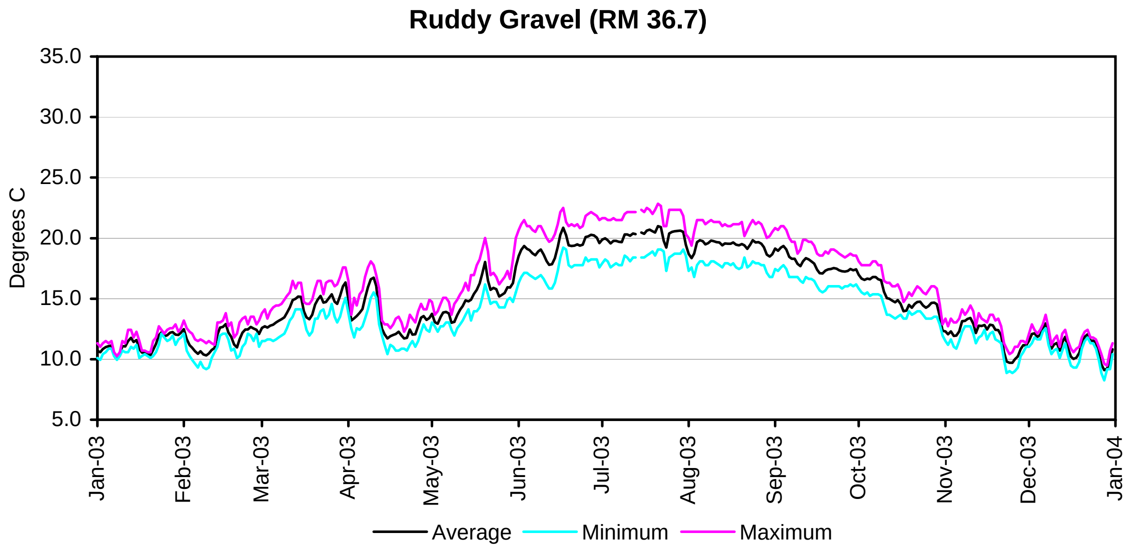


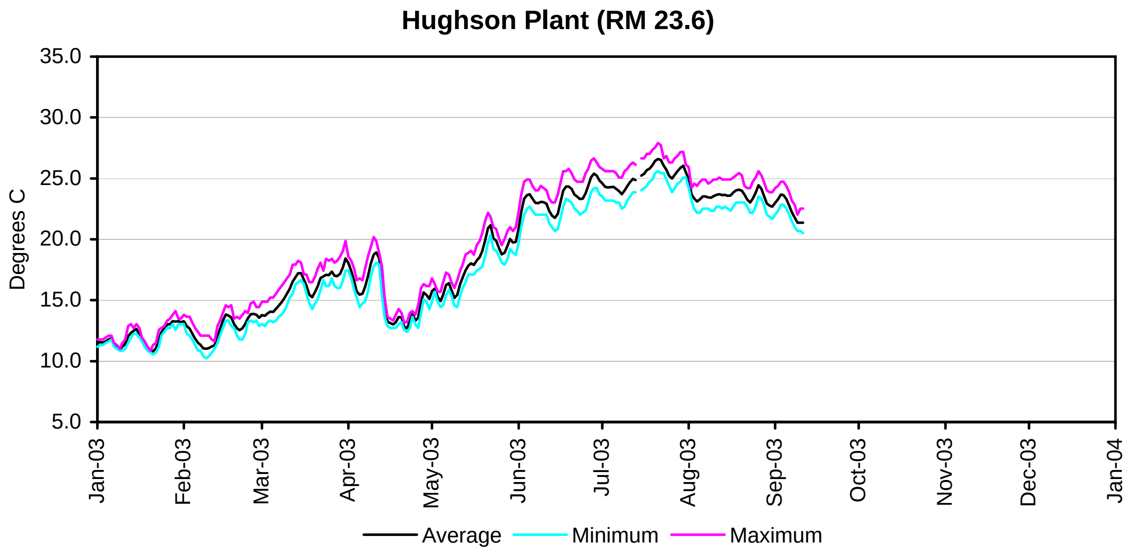
Figure 5. EPT/Chironomid Ratio from kick samples in the lower Tuolumne River, 2003-2004.

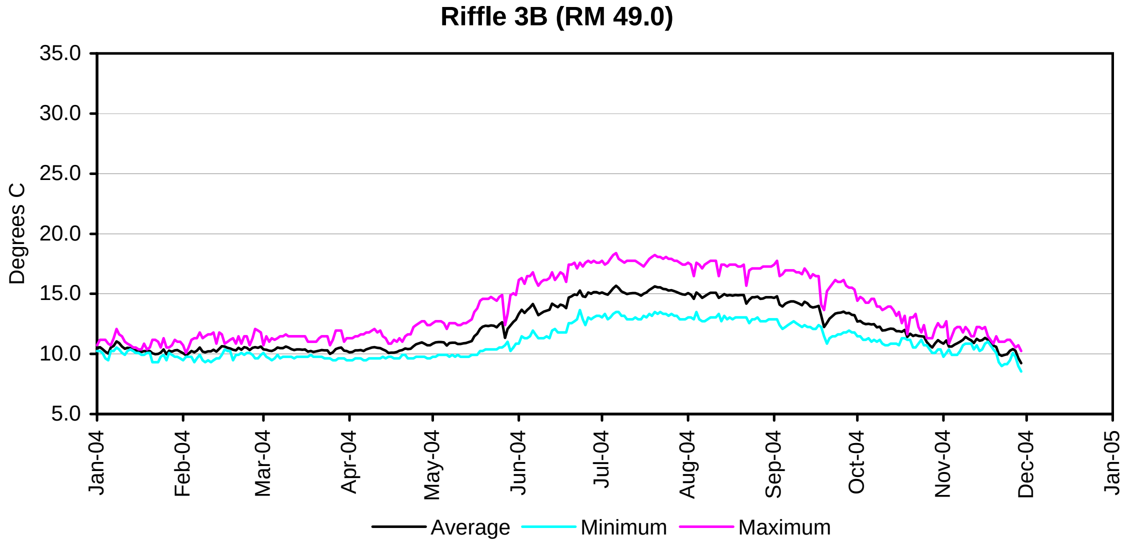

Flow at LaGrange 2003
log cfs
10,000
1,000
100
10
1/1/2003
2/1/2003
3/1/2003
4/1/2003
5/1/2003
6/1/2003
7/1/2003
8/1/2003
9/1/2003
10/1/2003
11/1/2003
12/1/2003
1/1/2004

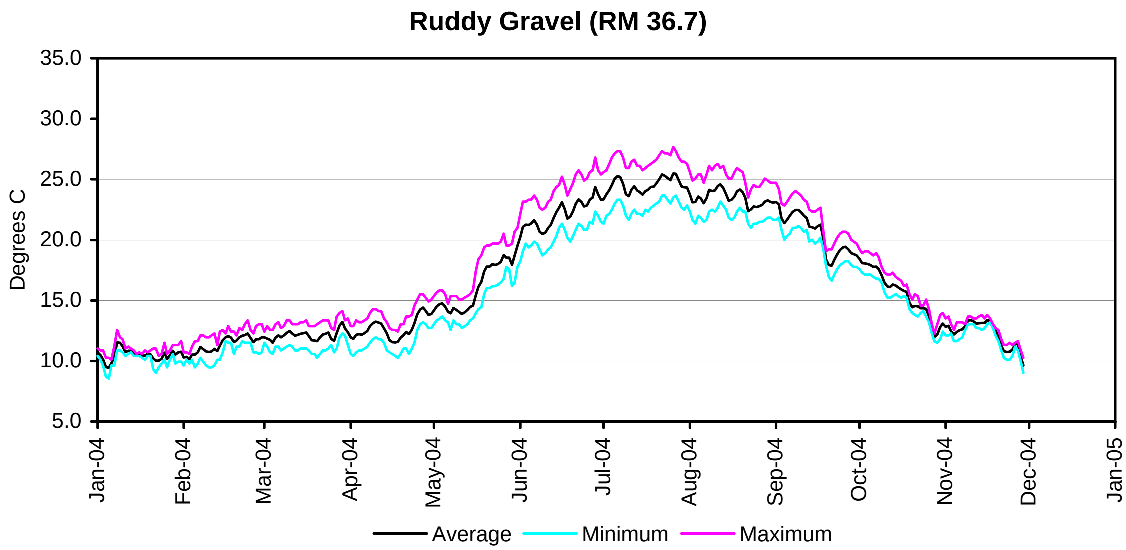

Flow at LaGrange 2004
log cfs
10,000
1,000
100
10
1/1/2004
2/1/2004
3/1/2004
4/1/2004
5/1/2004
6/1/2004
7/1/2004
8/1/2004
9/1/2004
10/1/2004
11/1/2004
12/1/2004
1/1/2005

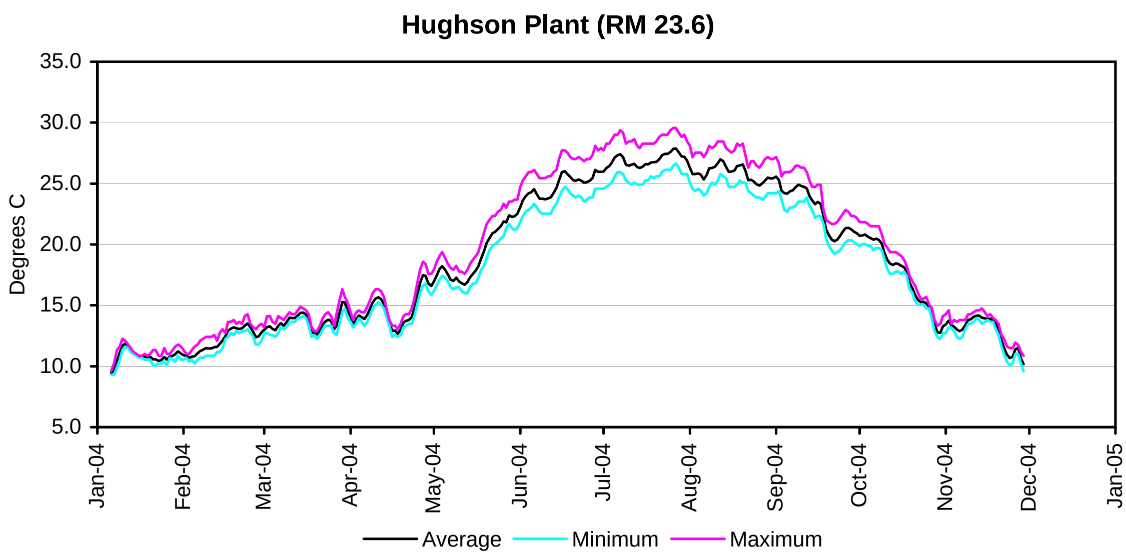

Riffle 3B (RM 49.0)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Average
Minimum
Maximum


Ruddy Gravel (RM 36.7)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Average
Minimum
Maximum


Hughson Plant (RM 23.6)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03
Jan-04
Average
Minimum
Maximum


Riffle 3B (RM 49.0)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Average
Minimum
Maximum


Ruddy Gravel (RM 36.7)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Average
Minimum
Maximum


Hughson Plant (RM 23.6)
Degrees C
35.0
30.0
25.0
20.0
15.0
10.0
5.0
Jan-04
Feb-04
Mar-04
Apr-04
May-04
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Average
Minimum
Maximum

APPENDIX C

Table C1. Hess sample identifications and average density, lower Tuolumne River 2003-2004.

			Density of Hess Samples (No./m2) and Standard Error (SE)							
			Riffle 4A 2003		Riffle 4A 2004		Riffle 23C 2003		Riffle 23C 2004	
PHYLUM **Class** Order **Family** *Genus species*	TV[1]	FFG[2]	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ARTHROPODA										
Hexapoda/Insecta										
Coleoptera (Larvae)										
Elmidae										
Ordobrevia nubifera	4	g					60	5	147	6
Hydrophilidae	5	p								
Diptera										
Blephariceridae	0	g					13	1	147	1
Ceratopogonidae	6	p								
Bexxia Palpomyia sp.	6	p								
Chironomidae										
Chironomidae-pupae	6	o	133	3	107	3	40	0		
Chironominae (subfamily)										
Chironomini (tribe)	6	c								
Dicrotendipes	8	c	307	9	107	7				
Glyptotendipes	10	c								
Parachironomus	10	p								
Polypedilum	6	o	93	7	27	3	7	1	80	0
Cryptochironomus	8	p	27	3						
Phaenospectra	7	g	40	2						
Limnochironomus	10	c								
Tanytarsini (tribe)	6	c								
Rheotanytarsus	6	f					20	1		
Micropsectra	7	c								
Stempellina	2	c			27	3				
Stempellinella	4	o			27	3				
Cladotanytarsus	7	c	3760	148	293	3	13	1		
Paratanytarsus	6	o	947	14	907	17				
Tanytarsus	6	f	1987	54	1893	49	27	1		
Orthocladiinae (subfamily)	5	c								
Orthocladius complex	6	c	3187	16	907	47	120	6	53	5
Cardiocladius	5	p					13	1		
Cricotopus	7	c	40	2	80	5	27	1	27	3
Eukiefferiella	8	o	27	3			133	10		
Synorthocladius	2	c	293	10	907	10	27	3		
Nanocladius	3	c	13	1	27	3				
Thienemanniella	6	c	173	5	213	7	307	16	187	4
Corynoneura	7	c	27	3	213	5	7	1	53	1
Tvetenia Vitracies Gr.	5	c	53	5	53	5	40	2	93	4
Rheocricotopus	6	o							27	3
Diamesinae (subfamily)										
Diamesini (tribe)										
Potthastia Gaedii Gr.	2	c	67	7	213	7	13	1		
Potthastia Longimana Gr.	2	c	93	1	27	3				
Tanypodinae (subfamily)	7	p								
Pentaneurini (tribe)										

PHYLUM / Class / Order / **Family** / *Genus species*	TV[1]	FFG[2]	Density of Hess Samples (No./m2) and Standard Error (SE) Riffle 4A 2003 Mean	SE	Riffle 4A 2004 Mean	SE	Riffle 23C 2003 Mean	SE	Riffle 23C 2004 Mean	SE
Thienemannimyia	6	p	67	5	133	5	33	2	40	2
Empididae										
Chelifera Metachela sp	6	p	173	7						
Clinocera sp.	6	p								
Hemerodromia sp	6	p	13	1					13	1
Neoplasta sp.	6	p								
Wiedemannia	6	p	27	3						
Psychodidae										
Simuliidae										
Simulium sp.	6	f					40	2	67	4
Tipulidae										
Antocha sp.	3	c	27	3			13	1		
Brachycera (sub-order)	10	o								
Ephemeroptera										
Baetidae										
Acentrella sp.	4	c								
Acentrella insignificans	4	c	133	10	187	10	1013	37	467	9
Baetis sp.	5	c								
Baetis tricaudatus	6	c	27	4	27	3	1407	69	2400	89
Camelobaetidius sp.	4	c								
Centroptilum Procloeon sp.	2	c								
Fallceon quilleri	4	c								
Paracloeodes minutus	4	c								
Ephemerellidae										
Ephemerella sp.	1	c								
Serratella micheneri	1	c					13	1	67	1
Heptageniidae										
Heptagenia										
Heptagenia / Nixe sp.	4	g	27	4	27	3	20	2	360	11
Leucrocuta Nixe sp.	3	g								
Leptohyphidae										
Tricorythodes sp.	4	c								
Tricorythodes minutes	4	c	7507	237	14933	65	380	21	2813	110
Plecoptera										
Nemouridae										
Malenka sp.	2	s								
Zapada sp.	2	s							13	1
Perlodidae										
Isoperla sp.	2	p							27	3
Trichoptera										
Glossosomatidae										
Glossosoma sp.	1	g	27	4						
Protoptila sp.	1	g			27	3	33	3	13	1
Hydropsychidae										
Hydropsyche sp.	4	f	40	2	187	15	3747	162	8853	141
Hydroptilidae										
Hydroptila sp.	6	o	867	17	4160	70	100	8	27	3
Leucotrichia pictipes	6	g								

PHYLUM / Class / Order / **Family** / *Genus species*	TV[1]	FFG[2]	Riffle 4A 2003 Mean	Riffle 4A 2003 SE	Riffle 4A 2004 Mean	Riffle 4A 2004 SE	Riffle 23C 2003 Mean	Riffle 23C 2003 SE	Riffle 23C 2004 Mean	Riffle 23C 2004 SE
Oxythira sp.	3	o	947	32	27	3				
Ochrotrichia sp.	4	o								
Lepidostomatidae										
Lepidostoma sp.	1	s								
Leptoceridae										
Nectopsyche	3	o								
Mystacides sp.	4	o	27	4	27	3				
Mystacides alafimbriata	4	o								
Oecetis sp.	8	p								
Philopotamidae	3	f								
Chimarra	4	f					13	1		
Polycentropodidae										
Polycentropus sp.	6	p					20	2		
Rhyacophilidae										
Rhyacophila sp.	0	p								
Odonata										
Coenagrionidae										
Argia sp.	7	p							27	3
unknown small larva	9	p								
Gomphidae										
Progomphus	4	p								
Libellulidae	9	p								
Hemiptera										
Naucoridae										
Ambrysus sp.	5	p								
Gerridae										
Lepidoptera										
Pyralidae										
Petrophila sp.	5	g	80		213	7	527	13	147	13
Subphylum Chelicerata										
Arachnoidea										
Acari	5	o	1560	48	1333	25	880	20	773	10
Halacaridae	5	p								
Hydrachnida										
Hygrobatidae										
Atractides sp.	8	p								
Hygrobates sp.	8	p								
Lebertiidae										
Lebertia sp.	8	p								
Oribatida	5	p								
Sperchontidae										
Sperchon sp.	8	p								
Torrenticolidae										
Torrenticola sp.	5	p								
Subphylum Crustacea										
Brachiopoda										
Cladocera										
Chydoridae	8	c								

Density of Hess Samples (No./m2) and Standard Error (SE)

PHYLUM / Class / Order / Family / *Genus species*	TV[1]	FFG[2]	Riffle 4A 2003 Mean	Riffle 4A 2003 SE	Riffle 4A 2004 Mean	Riffle 4A 2004 SE	Riffle 23C 2003 Mean	Riffle 23C 2003 SE	Riffle 23C 2004 Mean	Riffle 23C 2004 SE
Copepoda										
Cyclopoida	8	c								
Harpacticoida	8	c								
Poecilostomatoida		p								
Malacostraca										
Amphipoda										
Crangonyctidae										
Crangonyx sp	4	c	13	1			40	2		
Stygobromus sp.	4	c					13	1	27	3
Hyalellidae										
Hyalella sp	8	c	13	1						
Isopoda										
Asellidae										
Caecidotea sp.	8	c	267	14	240	5	7	1		
Ostracoda										
Cyprididae	8	c								
MOLLUSCA										
Gastropoda										
Ancylidae										
Ferrissia sp.	6	g								
Hydrobiidae	8	g								
Lymnaeidae										
Pseudosuccinea columella	6	g								
Physidae										
Physa . Physella sp.	8	g								
Planorbidae	6	g	13	1	80	5	120	4		
Gyraulus sp.	8	g								
Menetus sp.	7	g								
Planorbella sp.	6	g								
Bivalvia										
Pelecypoda										
Corbiculidae										
Corbicula fluminea	10	f					113	1	40	2
Sphaeriidae										
Pisidium sp.	8	f	40	4			7	1		
NEMATODA	5	p	80		133	7	93	5		
PLATYHELMINTHES										
Turbellaria										
Tricladia	4	p	40	2	533	23	2140	22	2093	65
Planariidae	4	p								
ANNELIDA										
Hirudinea										
Rhyncobdellida										
Glossiphoniidae										
Helobdella sp.	6	p	13	2						
Oligochaeta	5	c	253	9	640	9	127	2	40	2
Haplotaxida										

Density of Hess Samples (No./m2) and Standard Error (SE)

APPENDIX C

PHYLUM / Class / Order / Family / *Genus species*	TV[1]	FFG[2]	Density of Hess Samples (No./m2) and Standard Error (SE)							
			Riffle 4A 2003		Riffle 4A 2004		Riffle 23C 2003		Riffle 23C 2004	
			Mean	SE	Mean	SE	Mean	SE	Mean	SE
Megadrili	5	c								
Microdrili	5	c								
NEMERTEA										
Enopla										
Tertastemmatidae										
Prostoma sp.	8	p								
TARDIGRADA										

TV[1] Tolerance Value from CAMLNet
FFG[2] Functional Feeding Group from CAMLNet

Table C2. Kick sample identifications and estimated density, lower Tuolumne River 2003-2004.

PHYLUM / Class / Order / Family / *Genus species*	TV[1]	FFG[2]	Density of Kick Samples (No./m2) in 2003 and 2004												
			Riffle A4		Riffle 4A			Riffle 23C		Riffle 31		Riffle 57		Riffle 72	
			2003	2004	2003	2004	2004 (rep)	2003	2004	2003	2004	2003	2004	2003	2004
ARTHROPODA															
Hexapoda/Insecta															
Coleoptera (Larvae)															
Elmidae															
Ordobrevia nubifera	4	g								162	379	284	39	5	
Hydrophilidae	5	p											8		
Diptera															
Blephariceridae	0	g									21				
Ceratopogonidae	6	p												5	
Bexxia Palpomyia sp.	6	p													
Chironomidae															
Chironomidae-pupae	6	o	281	126	821	126	126	32		36		74		95	158
Chironominae (subfamily)															
Chironomini (tribe)	6	c													
Dicrotendipes	8	c			1073	63									5
Glyptotendipes	10	c													5
Parachironomus	10	p													5
Polypedilum	6	o			126		63		57				47		
Cryptochironomus	8	p				32									
Phaenospectra	7	g			126	32									
Limnochironomus	10	c													
Tanytarsini (tribe)	6	c													
Rheotanytarsus	6	f	807	1540			126			99		147	8	126	126
Micropsectra	7	c	35												
Stempellina	2	c													
Stempellinella	4	o			316										
Cladotanytarsus	7	c			6628	158	63								
Paratanytarsus	6	o			1326	379	252								
Tanytarsus	6	f		25	4860	1420	568								
Orthocladiinae (subfamily)	5	c													
Orthocladius complex	6	c	421	101	1073	63	505	16	29	36	21	21		5	21
Cardiocladius	5	p										11			
Cricotopus	7	c	105	51	316		126	16		36	21	95		79	68
Eukiefferiella	8	o	1578	1414			252			9			8		
Synorthocladius	2	c		25	126	95	126			9				11	
Nanocladius	3	c													
Thienemanniella	6	c	351	202	126				86	27	42	74	118	116	163
Corynoneura	7	c							57						
Tvetenia Vitracies Gr.	5	c	421	328	126		1326	16							
Rheocricotopus	6	o													
Diamesinae (subfamily)															
Diamesini (tribe)															
Potthastia Gaedii Gr.	2	c													
Potthastia Longimana Gr.	2	c	105	25											
Tanypodinae (subfamily)	7	p													
Pentaneurini (tribe)															
Thienemannimyia	6	p			126										11
Empididae															
Chelifera Metachela sp	6	p	70		189			47							
Clinocera sp.	6	p													
Hemerodromia sp	6	p			63				29			11			
Neoplasta sp.	6	p													
Wiedemannia	6	p													
Psychodidae															
Simuliidae															
Simulium sp.	6	f	1964	5707		63	694		143			53	8		
Tipulidae															
Antocha sp.	3	c		25	63		63								
Brachycera (sub-order)	10	o									21				
Ephemeroptera															

PHYLUM / Class / Order / **Family** / *Genus species*	TV[1]	FFG[2]	Density of Kick Samples (No./m2) in 2003 and 2004												
			Riffle A4		Riffle 4A			Riffle 23C		Riffle 31		Riffle 57		Riffle 72	
			2003	2004	2003	2004	2004 (rep)	2003	2004	2003	2004	2003	2004	2003	2004
Baetidae															
Acentrella sp.	4	c													
Acentrella insignificans	4	c			568	63	252	1231	287	198	631	1189	560		
Baetis sp.	5	c													
Baetis tricaudatus	6	c	5751	4848	126	32	8332	1752	1320	884	189	105	181		
Camelobaetidius sp.	4	c									84	32	95	5	11
Centroptilum Procloeon sp.	2	c													
Fallceon quilleri	4	c									21		47	68	37
Paracloeodes minutus	4	c													
Ephemerellidae															
Ephemerella sp.	1	c													
Serratella micheneri	1	c	140	126			63	32	115	18	442	105	300		21
Heptageniidae															
Heptagenia															
Heptagenia / Nixe sp.	4	g	140	51		95	63	110	689	45	484	32	181		
Leucrocuta Nixe sp.	3	g													
Leptohyphidae															
Tricorythodes sp.	4	c		25	10289										
Tricorythodes minutes	4	c				9752	8079	947	1176	63	1241	32	110	47	252
Plecoptera															
Nemouridae															
Malenka sp.	2	s	281												
Zapada sp.	2	s													
Perlodidae															
Isoperla sp.	2	p		25											
Trichoptera															
Glossosomatidae															
Glossosoma sp.	1	g	35	404		32	63	16							
Protoptila sp.	1	g			63		126			207	21	11	213	5	205
Hydropsychidae															
Hydropsyche sp.	4	f	736	354	126	95	5113	3077	8148	2381	5933	1494	1223	110	268
Hydroptilidae															
Hydroptila sp.	6	o	491	303	2462	3819	1767	16				11		42	16
Leucotrichia pictipes	6	g													
Oxythira sp.	3	o			1515	63		16							
Ochrotrichia sp.	4	o													
Lepidostomatidae															
Lepidostoma sp.	1	s					63								
Leptoceridae															
Nectopsyche	3	o					63					11	8	26	16
Mystacides sp.	4	o			252	126									
Mystacides alafimbriata	4	o													
Oecetis sp.	8	p													
Philopotamidae	3	f													
Chimarra	4	f													
Polycentropodidae															
Polycentropus sp.	6	p							57		21		8		
Rhyacophilidae															
Rhyacophila sp.	0	p													
Odonata															
Coenagrionidae															
Argia sp.	7	p							29						
unknown small larva	9	p													
Gomphidae															
Progomphus	4	p													
Libellulidae	9	p										11			
Hemiptera															
Naucoridae															
Ambrysus sp.	5	p													
Gerridae															
Lepidoptera															
Pyralidae															

PHYLUM / Class / Order / Family / *Genus species*	TV[1]	FFG[2]	Riffle A4 2003	Riffle A4 2004	Riffle 4A 2003	Riffle 4A 2004	Riffle 4A 2004 (rep)	Riffle 23C 2003	Riffle 23C 2004	Riffle 31 2003	Riffle 31 2004	Riffle 57 2003	Riffle 57 2004	Riffle 72 2003	Riffle 72 2004
			Density of Kick Samples (No./m2) in 2003 and 2004												
Petrophila sp.	5	g			63			300	57		358	305	95	105	47
Subphylum Chelicerata															
Arachnoidea															
Acari	5	o	316	354	2714	442	1199	268	488	388	673	842	331	521	463
Halacaridae	5	p													
Hydrachnida															
Hygrobatidae															
Atractides sp.	8	p													
Hygrobates sp.	8	p													
Lebertiidae															
Lebertia sp.	8	p													
Oribatida	5	p													
Sperchontidae															
Sperchon sp.	8	p													
Torrenticolidae															
Torrenticola sp.	5	p													
Subphylum Crustacea															
Brachiopoda															
Cladocera															
Chydoridae	8	c													
Copepoda															
Cyclopoida	8	c													
Harpacticoida	8	c													
Poecilostomatoida		p													
Malacostraca															
Amphipoda															
Crangonyctidae															
Crangonyx sp	4	c		51							42	11			
Stygobromus sp.	4	c						16							
Hyalellidae															
Hyalella sp	8	c			63							42			
Isopoda															
Asellidae															
Caecidotea sp.	8	c	2806	1263	505	95	126								
Ostracoda															
Cyprididae	8	c													
MOLLUSCA															
Gastropoda															
Ancylidae															
Ferrissia sp.	6	g		25						9	21	11	8		37
Hydrobiidae	8	g							29		42				
Lymnaeidae															
Pseudosuccinea columella	6	g													
Physidae															
Physa . Physella sp.	8	g	70	101								11	8	16	37
Planorbidae	6	g	70	152	505		1389	32	230	9	42	42	16	32	32
Gyraulus sp.	8	g													
Menetus sp.	7	g													
Planorbella sp.	6	g													
Bivalvia															
Pelecypoda															
Corbiculidae															
Corbicula fluminea	10	f						79		27	42		8	5	26
Sphaeriidae															
Pisidium sp.	8	f			126		189					11	8		
NEMATODA	5	p	175				63								5
PLATYHELMINTHES															
Turbellaria															
Tricladia	4	p	70	152	568	221	1326	395	1176	162	673	568	229	147	53
Planariidae	4	p													
ANNELIDA															
Hirudinea															

PHYLUM / Class / Order / Family / *Genus species*	TV[1]	FFG[2]	Density of Kick Samples (No./m2) in 2003 and 2004												
			Riffle A4		Riffle 4A			Riffle 23C		Riffle 31		Riffle 57		Riffle 72	
			2003	2004	2003	2004	2004 (rep)	2003	2004	2003	2004	2003	2004	2003	2004
Rhyncobdellida															
Glossiphoniidae															
Helobdella sp.	6	p													
Oligochaeta	5	c	1473	707	2272	978	1262	63	258	153	274	200	410	189	1378
Haplotaxida															
Megadrili	5	c													
Microdrili	5	c													
NEMERTEA															
Enopla															
Tertastemmatidae															
Prostoma sp.	8	p													
TARDIGRADA															

TV[1] Tolerance Value from CAMLNet
FFG[2] Functional Feeding Group from CAMLNet

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-10

2004 Water Quality Report

Prepared by

Noah Hume and Shawn White

Stillwater Ecosystem, Watershed, & Riverine Sciences
Berkeley, CA

March 2005

Stillwater Sciences

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TECHNICAL MEMORANDUM

DATE: July 1, 2004

TO: Tim Ford

FROM: Noah Hume and Shawn White

SUBJECT: Lower Tuolumne River water quality monitoring results May/June 2004

INTRODUCTION

In the lower Tuolumne River, temperature conditions for over-summering salmonids relate directly to ambient air temperatures and instream flows (Aceituno 1990; USFWS 1995) and formed part of the basis of the present day flow allocation (FERC 1996). Dissolved oxygen (DO) and other water quality (WQ) data are limited for much of the lower Tuolumne River above the Dry Creek confluence in Modesto (Kratzner et. al. 2004; Kratzner and Shelton 1998). The TRTAC participants have discussed the need to obtain additional DO and other WQ data within the uppermost portions of the river that support over-summering salmonids. A study request made by the NOAA Fisheries in April 2004 included specific DO and WQ sampling. In their letter NOAA requests: 1) continued water temperature monitoring, 2) dissolved oxygen monitoring at a minimum of 15-day intervals, and 3) water quality sampling for potential contaminants.

In response to the first data request related to ongoing temperature monitoring, continuous data collection using in-situ thermographs has been carried out by the Districts since 1987, reported as daily min, max and averages (TID/MID 1992, 1998, 2002, 2003). Hourly data collected since 1998 was distributed in a series of Excel files (TID/MID 2004a). In addition, the Districts reported that the water temperature responses to the adaptive summer flow schedule based on Modesto air temperatures in the summer of 2003 met the objectives of increased downstream cool water habitat within the available water allocation (TID/MID 2004b).

In response to the second and third data requests related to dissolved oxygen and other water quality conditions during the summer flow period, the Districts have conducted data collection to provide this information to the TRTAC participants. This memorandum summarizes the approach, methods and results to date of water quality conditions sampled between RM 52 and RM 36 of the lower Tuolumne River.

APPROACH

The results of this monitoring study is intended to provide an initial record of water quality encountered by over-summering Chinook salmon (*Oncorhynchus tshawytscha*) and trout (*O. mykiss*). To provide representative data, synoptic (*i.e.,* multiple locations at or near the same time) water quality surveys were conducted downstream of La Grange Dam (RM 52) at multiple sites (Table 1 and Figure 1). These data were supplemented by spot checks of water quality parameters (Table 2) across the river cross section and vertically. In addition to these surveys, a single round of upstream and downstream water chemistry sampling was conducted to include nutrients, and a screening analysis for common pesticides and herbicides (Table 2). Due to the considerable cost of conducting each survey, the Districts do not choose to conduct the surveys every two weeks. The initial surveys were conducted before and after the transition from the spring flow schedule to a lower summer flow period in early June, 2004. Additional surveys during hot weather conditions and/or in late summer will be discussed after review of the results to date.

METHODS

Wherever possible, standard methods were used during the course of these surveys (APHA 1998, USEPA 1999, Wagner et. al. 2000). Two calibrated water quality meters (Sondes) were placed in pool tails at RM 51 and RM 43 (Table 1) on the morning of Friday May 28th and retrieved Saturday June 5th 2004. Survey sites (Table 1 and Figure 1) were located by river mile and by hand-held GPS unit. In situ spot checks of physical water quality parameters (Table 2) were performed at additional locations shown in Table 1 along the channel margins and at various depths as site access permitted. Water chemistry sampling for the constituents in Table 2 was performed by the Districts on Monday, June 7, 2004 at the conclusion of the second synoptic survey, with samples collected in approved containers and stored according to recommended preservation and hold times until analysis.

RESULTS AND DISCUSSION

Stillwater Sciences and TID staff participated in two field efforts on 5/28-5/29 and 6/4-6/5, with water chemistry samples collected by TID at RM 43 on 6/7. Flows at La Grange (USGS 11289650) ranged from near 180 cfs on 5/28 to near 100 cfs on 6/7 with air temperatures at Modesto ranging between 60–70 ^{o}F at night to near 90^{o}F during the day. Due to changes in the USGS rating curve at the La Grange gage after the surveys were completed, the flow levels were apparently not as low as first indicated. The revised values are used in this report.

Diel Studies. Attachment A provides a record of the continuous water quality data recorded at RM 51 (upstream) and RM 43 (downstream) over a seven day period (5/28-6/4). Figures 2 and 3 show the hourly variations of temperature and dissolved oxygen at the upstream and downstream locations.

Although instream temperatures are more accurately assessed using the Districts thermographs deployed throughout the river, recorded temperatures in the first few days ranged from 10.7–13.5 ^{o}C upstream and 13–17 ^{o}C at the downstream location. Variations in temperature reached minimum and maximum values just after dawn (5–6 am) and early evening (6 pm) with average values near mid-afternoon (2 pm to 3 pm). The decrease in flow combined with increased air temperatures after 6/1 served to increase the water temperature at the downstream location to a range of 15.6–20 ^{o}C) at the downstream location (Figure 2). These conditions were associated with only minor changes in upstream water temperatures due to the short travel time of the water from Don Pedro Dam (Figure 2).

Although the slightly larger diel variation in DO at the downstream site suggests that aquatic vegetation may exert an influence, DO was at or near saturation throughout the sampling period, ranging from 9.5–11 mg/L upstream and 9.2–11.3 mg/L at the downstream location (Figure 3).

Variations in DO reached minimum and maximum values before dawn (5 am) and late afternoon (5 pm) with average values near mid-afternoon (1 pm to 3 pm).

Spot checks. In addition to recording diel variations in water quality at Riffles A7 and 21, spot checks of water quality were conducted at ten sites (Table 1) from RM 51.8 to RM 36.7. Within each site, samples were taken at several locations characterized by meso-habitat (e.g., backwater, pool, run, riffle), sample depth (e.g., surface, mid-depth, and bottom) and cross section (e.g., mid-channel, edge). Vertical profile data was recorded in pool habitats and above the Sonde locations at the time of recovery.

Attachment B provides a record of all sample data recorded, which were analyzed by using linear fitting and analysis of variance. For temperature, DO and conductivity, date and site effects are much larger than within site effects by meso-habitat, sample depth or cross section location. Water temperatures generally varied with distance downstream (i.e. downstream > upstream), by meso-habitat (i.e., backwater > riffle > run > pool), as well as by cross section (i.e. backwater > margin > mid-channel). A slight decrease in temperature was apparent with depth; the relatively shallow water (approx. 4-8 ft) appeared to be well mixed at the observed flows.

Dissolved oxygen decreases slightly, but significantly in the downstream direction, with DO remaining at or near saturation in all locations. There were apparent differences in DO by meso-habitat conditions (e.g., Riffle > Run > Pool > Backwater), with mid-riffle locations having the highest levels, perhaps due to the greatest amount of turbulence. In exploratory analyses, no significant variations in DO were found with depth or meso-habitat with the combination of distance downstream and date accounting for 18% of the variability in DO. However, after separating out the site and date effects from DO levels in individual locations, the variation by cross section (i.e. mid-channel > margin).was found highly significant ($p < 0.0001$), whereas variations with depth or meso-habitat were at best marginally significant ($p=0.07$ and $p=0.13$, respectively).

pH increased only slightly in the downstream direction. However, specific conductivity increased significantly by distance (i.e., downstream > upstream) and by cross section (i.e., edge > mid-channel). The combination of distance downstream and date accounts for 77% of the variability in conductivity. Although conversion of the conductivity values to dissolved solids would require a correlation between laboratory and instrument testing, the increases in conductivity in the downstream direction are on the order of 10–30 mg/L, suggesting that groundwater may have an influence on salinity, temperature and other water quality conditions in the lower Tuolumne River.

Water Chemistry. Samples for nutrients, herbicides, pesticides and algae (Table 2) were collected below Riffle A7 (RM 50.8) and above Riffle 21 (RM 43) by TID staff at 1 pm and 2 pm, respectively on 6/7/04. Contaminant samples were sent to Environmental Micro Analysis, Inc., Woodland CA, whereas the nutrient samples were sent to A & L Western Agricultural Laboratories, Inc., Modesto CA.

Table 3 shows the physical and water quality conditions at the time of sampling along with values of the analytes tested. 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 in Table 3 as non-detect (ND) would exceed the Table 2 MRLs. With the possible exception of legacy contamination from historic gold mining debris (Churchill 1999), contaminants responsible for lower water quality are generally associated with agricultural activities that primarily occur downstream of the Dry Creek confluence in Modesto (Kratzner and Shelton 1998). To provide some basis of comparison, a 2000–2001 water resources investigation report by USGS (Kratzner et. al 2004) reported relatively low summertime nutrients levels downstream of the study area at Shiloh Rd. (RM 3.5). Because average reported ammonia, nitrate and organic nitrogen concentrations were 0.03, 1.59 and 0.23 mg-N/L, respectively, it is likely that actual concentrations are well below the reported MRLs in Table 2. Historical grab sample data available for pesticides from the USGS (http://waterdata.usgs.gov/nwis/qw) are also generally consistent with the results found in this sampling event.

CONCLUSIONS AND RECOMMENDATIONS

Like many other rivers of the Sierra Nevada, the Tuolumne River is regarded as producing surface water of excellent quality. Minimum DO levels during pre-dawn hours found in these surveys were near 8 mg/L at the downstream location; above the applicable standards (i.e. DO > 85% saturation or 7.0 mg/L at all times). Water chemistry sampling resulted in non-detects for nutrients and contaminants. Comparisons with independent studies of water quality conditions in downstream locations below Modesto suggest that the lower Tuolumne River approaches natural background levels for nutrients. The combinations of non-detect values for nutrients and relatively high nighttime DO levels (8–10 mg/L) suggest that water quality conditions are suitable for all aquatic beneficial uses. Although it is unlikely that chemical water quality conditions will be substantially degraded under hotter conditions during mid- to late-summer, it is unknown to what degree the increase in algal and macrophyte biomass later in the summer will increase the nighttime oxygen demand in the river. For this reason, the Districts may elect to perform one or more additional diel surveys and paired water chemistry sampling event for nutrients to confirm the results of these initial surveys, pending further discussion by the TRTAC participants.

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Table 1. Water quality sampling locations on the lower Tuolumne River

Location	River mile	Sampling Type: Diel	Sampling Type: Spot Check	Sampling Type: Chem.	Site Description
La Grange Gage	51.8		X		Pool habitat below gage house access road.
SRP 1 (pool above RA7)	51	X	X		Pool habitat upstream of Riffle A7.
Riffle A7	50.8		X	X	Riffle habitat off of OLGB access road.
Riffle 5B (New Basso Br.)	47.9		X		Riffle, pool and backwater habitat.
Riffle 13B (Zanker)	45.5		X		Riffle, pool and backwater habitat.
Riffle 21 (TRR/BobCat Flat)	43	X	X	X	Pool habitat with dense aquatic vegetation.
Riffle 24B (TLSRA)	41.6		X		Riffle habitat below TLSRA Campground.
Roberts Ferry Bridge	39.4		X		Riffle and pool habitat.
Riffle 36A/35B (Santa Fe Aggr.)	36.7		X		Riffle, pool and backwater habitat above Santa Fe Aggregates. bridge

Table 2. Water quality analytical methods

Parameter Type	Parameter	Reporting Limit	Method
Physical Water Quality Parameters	Temperature	0.1 C	EPA 170.1
	Dissolved Oxygen (DO)	0.0 mg/L	SM 4500-O
	Conductivity (Total Dissolved Solids)	1.0 umhos/cm	SM 2510-B
	pH	0.1 s.u.	SM 4500-H
	Turbidity	0.1 NTU	SM 2130 B
Nutrients	Nitrate-Nitrite (NO_3 + NO_2 as N)	2 mg/L	SM-4500-NO3-F
	Ammonia (NH_3 as N)	0.3 mg/L	SM 4500-NH3-B
	Kjeldahl Nitrogen (TKN as N)	0.3 mg/L	SM 4500-NH3-B
	Total Phosphorous (TP as P)	0.1 mg/L	SM 4500-P-F
	Orthophosphate (PO_4 as P)	0.01 mg/L	SM 4500-P-F
Biological	Algae (chlorophyll-*a*)	0.5 ug/L	SM 10200-H
Organophosphorus Pesticides	Azinphos-methyl (Guthion)	0.5 ug/L	EPA 8141A
	Bolstar (Sulprofos)	0.5 ug/L	
	Bensulide	0.5 ug/L	
	Carbofenthion (Trithion)	2 ug/L	
	Chlorfenvinphos (Supona)	0.5 ug/L	
	Chlorpyrifos (Dursban)	0.3 ug/L	
	Chlorpyrifos-methyl	0.3 ug/L	
	Ciodrin (Crotophos)	0.5 ug/L	
	Coumaphos (Co-Ral)	1.5 ug/L	
	DEF	0.5 ug/L	
	Demeton (Systox) O/S Analogues	0.5 ug/L	
	Diazinon	0.5 ug/L	
	Dibrom (Naled)	0.5 ug/L	
	Dicrotophos (Didrin)	0.5 ug/L	
	Dimethoate (Cygon)	0.5 ug/L	
	Disulfoton (Disyston)	0.3 ug/L	
	EPN	1.0 ug/L	
	Ethion	0.5 ug/L	
	Ethoprop (Modap)	0.5 ug/L	
	Fenamiphos (Nemacur)	0.5 ug/L	
	Fenitrothion (Sumithion)	0.5 ug/L	
	Fenthion (Baytex)	0.5 ug/L	
	Fonofos (Dyfonate)	0.5 ug/L	
	Imidan (Phosmet)	0.5 ug/L	
	Isofenphos (Oftanol)	0.5 ug/L	
	Malathion	0.5 ug/L	
	Methidathion (Supracide)	0.5 ug/L	
	Methyl Parathion	0.5 ug/L	
	Mevinphos (Phosdrin)	0.5 ug/L	
	Parathion	0.5 ug/L	
	Phorate (Thimet)	0.5 ug/L	
	Phosalone (Zolone)	1.5 ug/L	
	Phosphamidon (Dimecron)	1.0 ug/L	
	Primiphos-methyl	0.5 ug/L	
	Profenofos (Curacron)	1.0 ug/L	
	Propetamiphos (Safrotin)	0.5 ug/L	
	Ronnel (Fenchlorfos)	0.5 ug/L	
	Tetrachlorvinphos (Gardona)	0.5 ug/L	
	Thionazin (Zinophos)	0.5 ug/L	
Chlorinated Herbicides	2, 4 - D	0.25 ug/L	EPA 8161A
	2, 4 -DB	0.25 ug/L	
	2, 4, 5 - T	0.13 ug?l	
	2, 4, 5 -TP	0.13 ug/L	
	Dicamba	0.13 ug?L	
	Dichloroprop	0.13 ug/L	
	Dinoseb	0.13 ug/L	

Table 3. Water chemistry results of 6/7/04 sampling on the lower Tuolumne River

Parameter	Method	Riffle A7 (RM 50.8)	Riffle 21 (RM 43)
Sampling Conditions			
Time		12:55	14:05
Depth		1.4 ft	2.0 ft
Flow at La Grange		106 cfs	106 cfs
Air Temp at Modesto		75°F (24.4°C)	78°F (25.6°C)
Barometric Pressure		753 mm Hg	753 m Hg
Physical Water Quality			
Temperature	EPA 170.1	12.96	19.92
Dissolved Oxygen (DO)	SM 4500-O	10.41	10.10
Conductivity (Total Dissolved Solids)	SM 2510-B	32	41
pH	SM 4500-H	7.01	7.74
Turbidity	SM 2130 B	0.33	0.77
Nutrients			
Nitrate-Nitrite ($NO_3 + NO_2$ as N)	EPA 300.0	ND	ND
Ammonia (NH_3 as N)	EPA 350.2		
Kjeldahl Nitrogen (TKN as N)	EPA 351.3		
Total Phosphorous (TP as P)	EPA 365.3		
Orthophosphate (PO_4 as P)	EPA 365.2		
Algae (Chlorophyll-*a*)	SM 10200-H	ND	ND
Organophosphorus Pesticides	EPA 8141A	ND	ND
Chlorinated Herbicides	EPA 8161A	ND	ND

Note: See Table 2 for the method reporting limits associated with non-detect (ND) results.

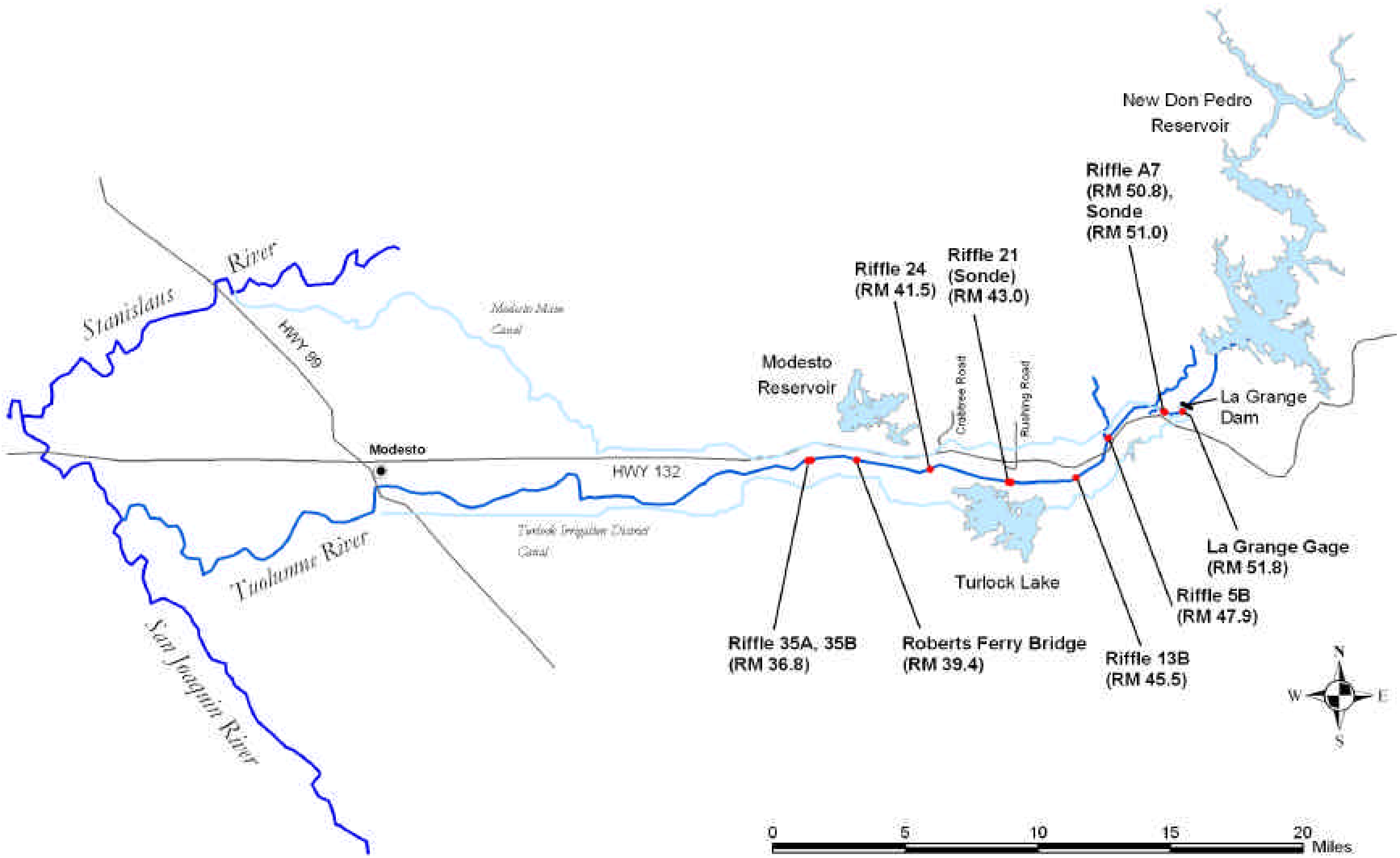

Figure 1. 2004 Water quality sampling locations on the lower Tuolumne River

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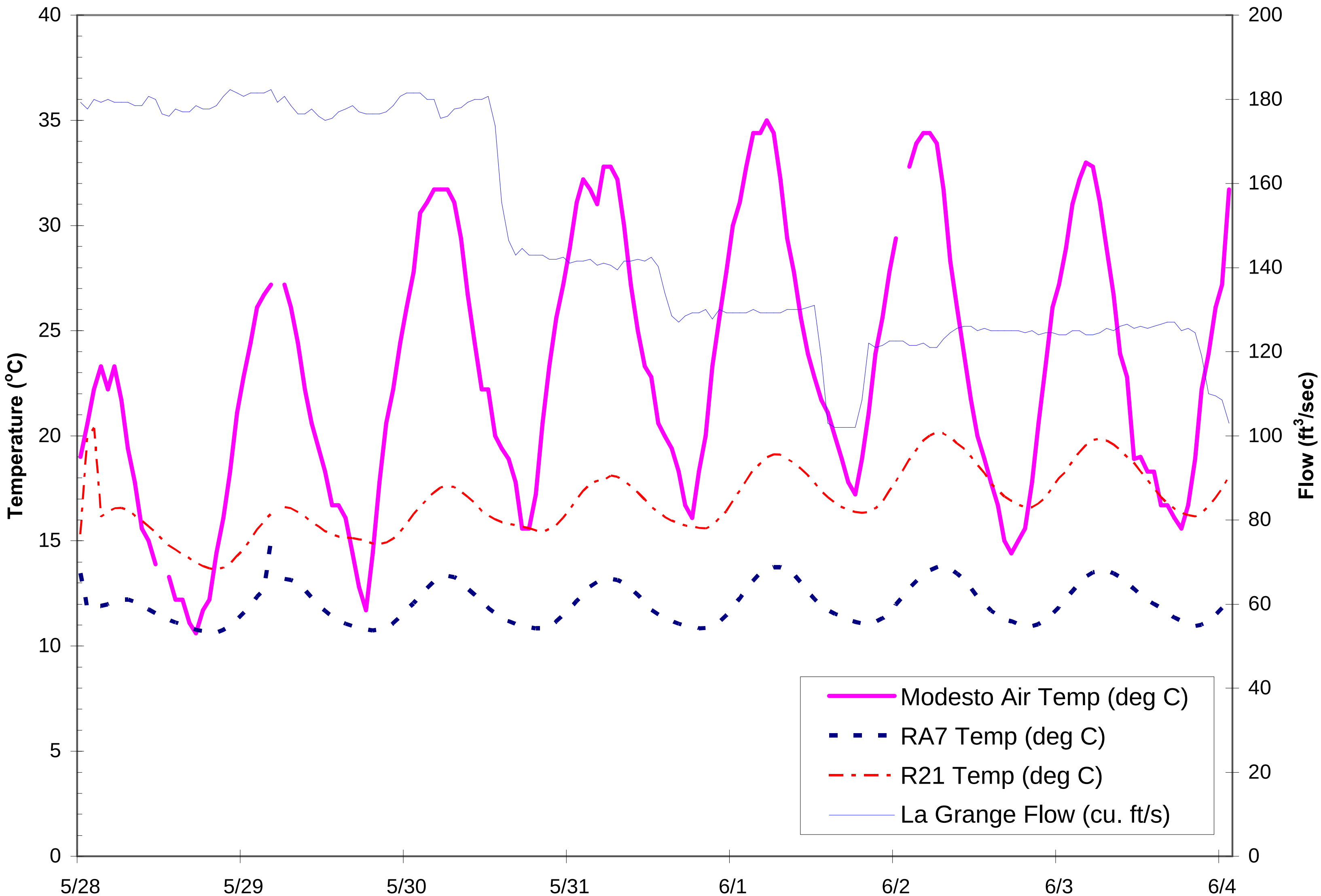

Figure 2. Air and water temperature variations from 5/28 to 6/7/2004 on the lower Tuolumne River

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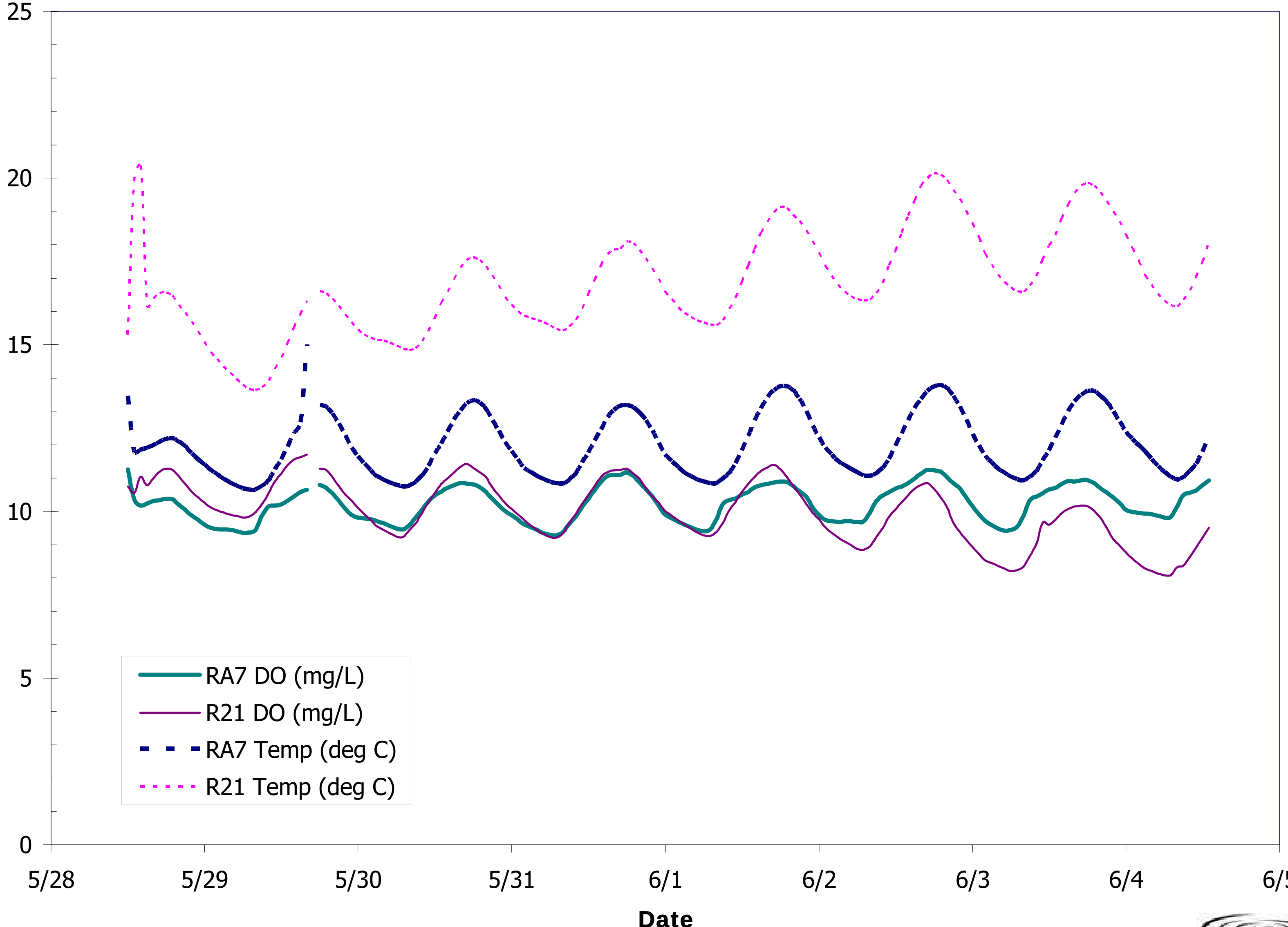

Figure 3. Air and water temperature variations from 5/28 to 6/7/2004 on the lower Tuolumne River

Stillwater Sciences

Attachment A: Continuous water quality data record from RM 51 and RM 43 on the lower Tuolumne River May/June 2004

	Modesto Airport Conditions						La Grange	Riffle A7 Conditions					Riffle 21 Conditions					
Date/Time	Modesto Air Temp (deg C)	Modesto Air Temp (deg F)	Humidity	Press (in H2O)	Bar. at Modesto (mm Hg)	Weather	La Grange Flow (cu. ft/s)	RA7 Temp (deg C)	RA7 DO (%)	RA7 DO (mg/L)	RA7 Cond (uS/cm)	RA7 pH	R21 Temp (deg C)	R21 DO (%)	R21 DO (mg/L)	R21 Cond (uS/cm)	R21 pH	Turbidity (NTU)
5/28/04 12:00	19	66.2	68%	29.98	759.5	Overcast	179.3	13.5	107.9	11.26	19.0	6.6	15.3	107.2	10.75	57.4	6.9	1.2
5/28/04 13:00	20.6	69.08	63%	29.95	758.7	Overcast	177.8	11.8	95.7	10.37	32.0	6.8	19.9	115.9	10.56	66.3	7.0	1.2
5/28/04 14:00	22.2	71.96	57%	29.95	758.7	Partly Cloudy	180.0	11.9	94.1	10.18	32.0	6.8	20.4	122.3	11.03	67.0	7.0	1.2
5/28/04 15:00	23.3	73.94	53%	29.92	758.0	Scattered Clouds	179.3	11.9	94.7	10.23	32.0	6.8	16.2	109.7	10.79	64.2	7.5	0.4
5/28/04 16:00	22.2	71.96	55%	29.92	758.0	Overcast	180.0	12.0	95.7	10.31	32.0	6.9	16.4	112.3	11.00	64.0	7.6	0.3
5/28/04 17:00	23.3	73.94	48%	29.92	758.0	Partly Cloudy	179.3	12.1	96.2	10.34	32.0	6.9	16.6	114.8	11.20	64.0	7.7	0.3
5/28/04 18:00	21.7	71.06	44%	29.92	758.0	Scattered Clouds	179.3	12.2	96.7	10.38	32.0	6.9	16.6	115.7	11.28	64.0	7.8	0.4
5/28/04 19:00	19.4	66.92	45%	29.92	758.0	Scattered Clouds	179.3	12.2	96.6	10.36	32.0	6.9	16.5	115.1	11.25	64.0	7.8	0.3
5/28/04 20:00	17.8	64.04	50%	29.92	758.0	Clear	178.5	12.1	94.8	10.20	32.0	6.9	16.2	112.5	11.06	63.5	7.6	0.3
5/28/04 21:00	15.6	60.08	57%	29.92	758.0	Clear	178.5	12.0	93.2	10.05	32.0	6.9	16.0	109.7	10.83	63.0	7.5	0.3
5/28/04 22:00	15	59	60%	29.95	758.7	Clear	180.8	11.7	91.2	9.88	32.9	6.8	15.7	106.7	10.60	62.7	7.4	0.7
5/28/04 23:00	13.9	57.02	69%	29.95	758.7	Clear	180.0	11.6	89.6	9.75	33.0	6.8	15.4	104.4	10.43	62.0	7.3	0.5
5/29/04 0:00							176.5	11.4	87.9	9.60	33.0	6.8	15.1	102.0	10.27	61.2	7.2	0.5
5/29/04 1:00	13.3	55.94	75%	29.95	758.7	Clear	176.0	11.2	86.8	9.52	33.0	6.7	14.8	99.9	10.12	60.5	7.1	0.6
5/29/04 2:00	12.2	53.96	80%	29.95	758.7	Clear	177.8	11.1	86.1	9.48	33.0	6.7	14.6	98.6	10.03	60.0	7.1	0.5
5/29/04 3:00	12.2	53.96	80%	29.92	758.0	Clear	177.0	11.0	85.7	9.45	33.0	6.7	14.4	97.5	9.96	59.8	7.1	0.5
5/29/04 4:00	11.1	51.98	83%	29.92	758.0	Clear	177.0	10.9	85.4	9.45	33.0	6.7	14.2	96.4	9.90	59.0	7.0	0.6
5/29/04 5:00	10.6	51.08	86%	29.95	758.7	Clear	178.5	10.8	84.9	9.41	33.0	6.7	14.0	95.7	9.87	59.0	7.0	0.6
5/29/04 6:00	11.7	53.06	80%	29.95	758.7	Clear	177.8	10.7	84.3	9.36	33.0	6.7	13.8	94.9	9.82	58.4	7.0	0.6
5/29/04 7:00	12.2	53.96	83%	29.98	759.5	Clear	177.8	10.7	84.2	9.37	33.0	6.7	13.7	94.8	9.84	58.0	7.0	0.3
5/29/04 8:00	14.4	57.92	75%	29.98	759.5	Clear	178.5	10.7	85.0	9.45	32.5	6.7	13.6	96.1	9.98	58.0	7.0	0.2
5/29/04 9:00	16.1	60.98	67%	30.01	760.3	Clear	180.8	10.8	89.2	9.89	32.0	6.7	13.7	98.7	10.23	58.0	7.1	0.6
5/29/04 10:00	18.3	64.94	58%	30.01	760.3	Clear	182.3	10.9	91.9	10.14	32.0	6.7	13.9	102.3	10.56	58.0	7.1	0.1
5/29/04 11:00	21.1	69.98	53%	30.01	760.3	Clear	181.5	11.3	92.8	10.17	32.0	6.8	14.3	106.4	10.90	58.9	7.3	0.1
5/29/04 12:00	22.8	73.04	48%	30.01	760.3	Clear	180.8	11.6	93.8	10.21	32.0	6.8	14.6	109.6	11.14	59.3	7.3	0.1
5/29/04 13:00	24.4	75.92	37%	29.98	759.5	Clear	181.5	11.9	95.7	10.33	32.0	6.8	15.1	113.2	11.39	60.0	7.5	0.0
5/29/04 14:00	26.1	78.98	31%	29.98	759.5	Clear	181.5	12.3	97.8	10.46	32.0	6.9	15.5	115.9	11.56	61.0	7.6	0.1
5/29/04 15:00	26.7	80.06	29%	29.98	759.5	Clear	181.5	12.7	99.7	10.59	32.0	6.9	15.9	117.6	11.62	61.8	7.7	0.1
5/29/04 16:00	27.2	80.96	25%	29.95	758.7	Clear	182.3	15.0	105.1	10.64	21.3	6.5	16.3	119.4	11.71	62.4	7.9	0.1
5/29/04 17:00							179.3											
5/29/04 18:00	27.2	80.96	25%	29.92	758.0	Clear	180.8	13.2	102.9	10.80	32.0	7.0	16.6	115.8	11.29	63.5	7.8	0.6
5/29/04 19:00	26.1	78.98	29%	29.92	758.0	Clear	178.5	13.1	102.0	10.71	32.0	7.0	16.6	115.2	11.24	62.9	7.7	0.2
5/29/04 20:00	24.4	75.92	33%	29.95	758.7	Clear	176.5	12.9	99.9	10.54	32.0	7.0	16.4	112.7	11.03	62.0	7.6	0.2
5/29/04 21:00	22.2	71.96	40%	29.95	758.7	Clear	176.5	12.6	97.3	10.33	32.5	6.9	16.2	109.4	10.76	62.0	7.4	0.2
5/29/04 22:00	20.6	69.08	42%	29.98	759.5	Clear	177.8	12.3	94.2	10.09	33.0	6.9	15.9	106.2	10.50	61.3	7.3	0.4
5/29/04 23:00	19.4	66.92	42%	29.98	759.5	Clear	176.0	11.9	91.7	9.90	33.0	6.8	15.7	104.0	10.33	61.0	7.2	0.5
5/30/04 0:00	18.3	64.94	48%	29.98	759.5	Clear	175.0	11.7	90.5	9.82	33.0	6.8	15.5	101.3	10.11	60.3	7.1	0.4
5/30/04 1:00	16.7	62.06	58%	29.98	759.5	Clear	175.5	11.4	89.7	9.79	33.0	6.7	15.3	99.0	9.92	60.0	7.0	0.7
5/30/04 2:00	16.7	62.06	58%	29.95	758.7	Clear	177.0	11.2	89.0	9.76	33.0	6.7	15.2	97.0	9.74	60.0	7.0	0.5
5/30/04 3:00	16.1	60.98	62%	29.95	758.7	Clear	177.8	11.1	88.1	9.71	33.0	6.7	15.2	95.1	9.55	59.0	6.9	0.4
5/30/04 4:00	14.4	57.92	75%	29.98	759.5	Clear	178.5	10.9	87.4	9.65	33.0	6.7	15.1	93.9	9.44	59.0	6.9	0.5
5/30/04 5:00	12.8	55.04	80%	29.98	759.5	Clear	177.0	10.9	86.5	9.57	33.0	6.7	15.1	92.8	9.34	59.0	6.9	0.6
5/30/04 6:00	11.7	53.06	89%	29.98	759.5	Clear	176.5	10.8	85.6	9.49	33.0	6.7	15.0	91.6	9.24	59.0	6.9	0.5
5/30/04 7:00	14.4	57.92	78%	30.01	760.3	Clear	176.5	10.8	85.3	9.46	33.0	6.7	14.9	91.3	9.23	59.0	6.8	0.4
5/30/04 8:00	17.8	64.04	60%	30.01	760.3	Clear	176.5	10.8	86.5	9.59	33.0	6.7	14.8	93.2	9.43	58.3	6.9	0.3
5/30/04 9:00	20.6	69.08	51%	30.01	760.3	Clear	177.0	10.9	88.9	9.83	33.0	6.7	14.9	95.5	9.65	58.8	6.9	1.5
5/30/04 10:00	22.2	71.96	46%	30.01	760.3	Clear	178.5	11.1	91.4	10.06	33.0	6.7	15.1	99.0	9.96	59.0	7.0	0.2
5/30/04 11:00	24.4	75.92	40%	30.01	760.3	Clear	180.8	11.4	94.1	10.30	32.7	6.8	15.4	102.8	10.28	59.3	7.1	0.2
5/30/04 12:00	26.1	78.98	36%	30.01	760.3	Clear	181.5	11.7	96.6	10.48	32.0	6.8	15.8	106.5	10.55	60.1	7.2	0.2
5/30/04 13:00	27.8	82.04	30%	30.01	760.3	Clear	181.5	12.0	98.4	10.59	32.0	6.8	16.3	110.3	10.83	60.9	7.4	0.2
5/30/04 14:00	30.6	87.08	22%	29.98	759.5	Clear	181.5	12.4	100.2	10.71	32.0	6.9	16.6	112.8	10.99	61.6	7.5	0.2
5/30/04 15:00	31.1	87.98	24%	29.95	758.7	Clear	180.0	12.7	101.8	10.79	32.0	6.9	17.0	115.5	11.17	62.3	7.6	0.2
5/30/04 16:00	31.7	89.06	22%	29.95	758.7	Clear	180.0	13.0	103.0	10.84	32.0	6.9	17.3	118.0	11.33	63.0	7.8	0.2
5/30/04 17:00	31.7	89.06	22%	29.92	758.0	Clear	175.5	13.2	103.5	10.84	32.0	7.0	17.5	119.6	11.43	63.5	7.9	0.2
5/30/04 18:00	31.7	89.06	22%	29.92	758.0	Clear	176.0	13.3	103.4	10.82	32.0	7.0	17.6	118.5	11.31	64.0	7.9	0.2
5/30/04 19:00	31.1	87.98	22%	29.92	758.0	Clear	177.8	13.3	102.5	10.74	32.0	7.0	17.5	117.1	11.19	63.6	7.8	0.2

	Modesto Airport Conditions						La Grange	Riffle A7 Conditions					Riffle 21 Conditions					
Date/Time	Modesto Air Temp (deg C)	Modesto Air Temp (deg F)	Humidity	Press (in H2O)	Bar. at Modesto (mm Hg)	Weather	La Grange Flow (cu. ft/s)	RA7 Temp (deg C)	RA7 DO (%)	RA7 DO (mg/L)	RA7 Cond (uS/cm)	RA7 pH	R21 Temp (deg C)	R21 DO (%)	R21 DO (mg/L)	R21 Cond (uS/cm)	R21 pH	Turbidity (NTU)
5/30/04 20:00	29.4	84.92	26%	29.92	758.0	Clear	178.0	13.1	100.6	10.58	32.3	7.0	17.4	114.9	11.03	63.0	7.6	0.2
5/30/04 21:00	26.7	80.06	34%	29.92	758.0	Clear	179.3	12.7	97.9	10.38	33.0	6.9	17.1	111.2	10.72	63.0	7.4	0.2
5/30/04 22:00	24.4	75.92	37%	29.92	758.0	Clear	180.0	12.4	95.5	10.19	33.0	6.9	16.8	108.0	10.48	62.0	7.3	0.4
5/30/04 23:00	22.2	71.96	46%	29.95	758.7	Clear	180.0	12.1	93.1	10.01	33.0	6.8	16.4	104.9	10.26	61.6	7.2	0.6
5/31/04 0:00	22.2	71.96	46%	29.95	758.7	Clear	180.8	11.8	91.4	9.89	33.0	6.8	16.2	102.7	10.09	61.0	7.1	1.0
5/31/04 1:00	20	68	59%	29.95	758.7	Clear	173.8	11.6	89.6	9.75	33.0	6.8	16.0	100.5	9.91	60.8	7.0	0.7
5/31/04 2:00	19.4	66.92	61%	29.92	758.0	Clear	155.5	11.3	87.8	9.61	33.0	6.7	15.9	98.5	9.74	60.0	7.0	41.6
5/31/04 3:00	18.9	66.02	59%	29.92	758.0	Clear	146.5	11.2	86.7	9.52	33.0	6.7	15.8	96.6	9.58	60.0	6.9	1.0
5/31/04 4:00	17.8	64.04	67%	29.92	758.0	Clear	143.0	11.1	85.7	9.44	33.0	6.7	15.7	94.9	9.42	60.0	6.9	0.6
5/31/04 5:00	15.6	60.08	75%	29.92	758.0	Clear	144.5	11.0	84.7	9.34	33.0	6.7	15.7	93.8	9.32	60.0	6.9	0.7
5/31/04 6:00	15.6	60.08	78%	29.92	758.0	Clear	143.0	10.9	84.1	9.30	33.0	6.7	15.6	92.7	9.23	59.3	6.9	0.8
5/31/04 7:00	17.2	62.96	67%	29.92	758.0	Clear	143.0	10.8	83.9	9.28	33.0	6.7	15.5	92.5	9.22	59.0	6.9	0.6
5/31/04 8:00	20.6	69.08	53%	29.92	758.0	Clear	143.0	10.8	84.7	9.38	33.0	6.7	15.4	93.6	9.35	59.0	6.9	0.4
5/31/04 9:00	23.3	73.94	43%	29.92	758.0	Clear	142.0	10.9	87.1	9.62	33.0	6.7	15.6	96.9	9.65	59.7	6.9	0.3
5/31/04 10:00	25.6	78.08	39%	29.92	758.0	Clear	142.0	11.1	89.6	9.84	33.0	6.7	15.7	99.9	9.92	60.1	7.0	0.3
5/31/04 11:00	27.2	80.96	36%	29.92	758.0	Clear	142.5	11.5	92.9	10.13	33.0	6.7	16.1	103.7	10.22	61.3	7.1	0.2
5/31/04 12:00	28.9	84.02	34%	29.89	757.2	Clear	141.0	11.8	95.8	10.38	33.0	6.8	16.5	107.6	10.50	62.3	7.2	0.3
5/31/04 13:00	31.1	87.98	32%	29.86	756.5	Scattered Clouds	141.5	12.1	99.0	10.64	32.9	6.8	17.0	111.3	10.77	63.7	7.4	0.2
5/31/04 14:00	32.2	89.96	29%	29.86	756.5	Clear	141.5	12.5	102.1	10.89	32.2	6.8	17.4	115.2	11.04	64.6	7.6	0.3
5/31/04 15:00	31.7	89.06	29%	29.83	755.7	Scattered Clouds	142.0	12.8	104.6	11.07	32.0	6.9	17.7	117.4	11.18	65.3	7.7	0.3
5/31/04 16:00	31	87.8	29%	29.83	755.7	Scattered Clouds	140.5	13.0	105.4	11.10	32.0	6.9	17.9	118.2	11.23	65.9	7.8	0.2
5/31/04 17:00	32.8	91.04	23%	29.8	754.9	Clear	141.0	13.2	105.8	11.10	32.0	6.9	17.9	118.5	11.24	66.0	7.8	0.5
5/31/04 18:00	32.8	91.04	24%	29.77	754.2	Clear	140.5	13.2	106.5	11.17	32.0	6.9	18.1	119.4	11.28	66.0	7.9	0.2
5/31/04 19:00	32.2	89.96	27%	29.77	754.2	Clear	139.5	13.1	105.3	11.07	32.2	7.0	18.1	117.8	11.14	65.9	7.8	0.2
5/31/04 20:00	30	86	30%	29.77	754.2	Clear	141.5	13.0	103.0	10.86	33.0	6.9	17.9	115.6	10.98	65.2	7.7	0.2
5/31/04 21:00	27.2	80.96	34%	29.77	754.2	Clear	141.5	12.7	100.6	10.67	33.0	6.9	17.6	112.1	10.70	64.8	7.5	0.4
5/31/04 22:00	25	77	40%	29.8	754.9	Clear	142.0	12.4	97.9	10.45	33.0	6.9	17.3	108.9	10.46	64.0	7.3	0.9
5/31/04 23:00	23.3	73.94	41%	29.8	754.9	Clear	141.5	12.1	94.5	10.17	33.0	6.8	17.0	106.2	10.26	63.5	7.2	0.5
6/1/04 0:00	22.8	73.04	37%	29.8	754.9	Clear	142.5	11.7	91.4	9.91	33.1	6.7	16.6	102.9	10.03	62.8	7.1	1.3
6/1/04 1:00	20.6	69.08	47%	29.8	754.9	Clear	140.3	11.5	89.8	9.79	33.2	6.7	16.4	100.8	9.87	62.0	7.0	1.0
6/1/04 2:00	20	68	42%	29.8	754.9	Clear	134.0	11.3	88.6	9.69	33.0	6.7	16.1	98.8	9.72	61.8	7.0	0.8
6/1/04 3:00	19.4	66.92	49%	29.77	754.2	Clear	128.5	11.2	87.4	9.60	33.0	6.7	16.0	97.2	9.61	61.0	6.9	0.7
6/1/04 4:00	18.3	64.94	52%	29.77	754.2	Clear	127.0	11.1	86.5	9.53	33.0	6.6	15.8	95.7	9.48	61.0	6.9	0.6
6/1/04 5:00	16.7	62.06	62%	29.77	754.2	Clear	128.5	11.0	85.6	9.45	33.1	6.6	15.7	94.4	9.37	61.0	6.9	0.7
6/1/04 6:00	16.1	60.98	64%	29.77	754.2	Clear	129.3	10.9	85.1	9.41	33.7	6.6	15.7	93.4	9.29	60.3	6.9	0.7
6/1/04 7:00	18.3	64.94	54%	29.8	754.9	Clear	129.3	10.8	85.5	9.47	33.6	6.6	15.6	93.1	9.27	60.0	6.9	0.5
6/1/04 8:00	20	68	50%	29.8	754.9	Clear	130.0	10.9	88.2	9.76	33.0	6.6	15.6	94.2	9.38	60.0	6.9	0.4
6/1/04 9:00	23.3	73.94	40%	29.8	754.9	Clear	127.8	11.0	92.7	10.23	33.0	6.7	15.7	97.3	9.65	60.8	6.9	0.3
6/1/04 10:00	25.6	78.08	39%	29.8	754.9	Clear	130.0	11.2	94.1	10.34	33.0	6.7	16.1	101.8	10.03	61.4	7.0	0.3
6/1/04 11:00	27.8	82.04	39%	29.8	754.9	Clear	129.3	11.5	95.2	10.39	33.0	6.7	16.4	105.2	10.29	62.2	7.1	0.3
6/1/04 12:00	30	86	36%	29.8	754.9	Clear	129.3	11.8	97.0	10.50	33.0	6.8	16.9	109.3	10.59	63.2	7.3	0.3
6/1/04 13:00	31.1	87.98	35%	29.8	754.9	Clear	129.3	12.3	98.8	10.59	33.0	6.8	17.4	113.1	10.84	64.3	7.5	0.3
6/1/04 14:00	32.8	91.04	29%	29.77	754.2	Clear	129.3	12.7	101.2	10.73	33.0	6.8	17.9	116.3	11.04	65.5	7.6	0.3
6/1/04 15:00	34.4	93.92	28%	29.77	754.2	Clear	130.0	13.1	102.6	10.78	33.0	6.9	18.4	119.5	11.22	66.5	7.8	0.2
6/1/04 16:00	34.4	93.92	25%	29.74	753.4	Clear	129.3	13.4	103.8	10.83	33.0	6.9	18.7	121.3	11.33	67.5	7.9	0.4
6/1/04 17:00	35	95	25%	29.71	752.7	Clear	129.3	13.6	104.6	10.87	32.9	7.0	19.0	122.8	11.39	68.0	8.1	0.2
6/1/04 18:00	34.4	93.92	24%	29.71	752.7	Clear	129.3	13.8	105.2	10.90	32.9	7.0	19.1	121.8	11.27	68.0	8.1	0.2
6/1/04 19:00	32.2	89.96	24%	29.71	752.7	Clear	129.3	13.8	105.1	10.89	33.0	7.0	19.1	119.3	11.04	68.0	7.9	0.3
6/1/04 20:00	29.4	84.92	28%	29.71	752.7	Clear	130.0	13.6	103.5	10.76	33.0	7.0	18.9	116.0	10.78	68.0	7.7	0.3
6/1/04 21:00	27.8	82.04	28%	29.74	753.4	Clear	130.0	13.4	101.6	10.61	33.0	7.0	18.7	112.7	10.52	67.4	7.5	0.8
6/1/04 22:00	25.6	78.08	35%	29.74	753.4	Scattered Clouds	130.0	13.0	99.1	10.44	33.0	6.9	18.4	108.9	10.22	67.0	7.3	0.5
6/1/04 23:00	23.9	75.02	40%	29.77	754.2	Partly Cloudy	130.5	12.6	95.1	10.12	33.0	6.8	18.1	105.5	9.96	66.2	7.2	1.0
6/2/04 0:00	22.8	73.04	42%	29.77	754.2	Cl	131.0	12.2	92.3	9.89	33.0	6.8	17.8	102.6	9.76	65.4	7.1	1.1
6/2/04 1:00	21.7	71.06	47%	29.77	754.2	Clear	118.5	11.9	90.2	9.74	33.0	6.7	17.4	99.2	9.52	64.8	7.0	0.8
6/2/04 2:00	21.1	69.98	49%	29.74	753.4	Clear	103.0	11.7	89.4	9.70	33.0	6.7	17.1	97.0	9.35	64.0	7.0	0.9
6/2/04 3:00	20	68	55%	29.74	753.4	Clear	102.0	11.5	88.9	9.69	33.0	6.7	16.8	94.9	9.22	63.2	7.0	0.9
6/2/04 4:00	18.9	66.02	63%	29.74	753.4	Clear	102.0	11.4	88.8	9.71	33.0	6.7	16.6	93.5	9.11	62.7	6.9	1.2

	Modesto Airport Conditions						La Grange	Riffle A7 Conditions					Riffle 21 Conditions					
Date/Time	Modesto Air Temp (deg C)	Modesto Air Temp (deg F)	Humidity	Press (in H2O)	Bar. at Modesto (mm Hg)	Weather	La Grange Flow (cu. ft/s)	RA7 Temp (deg C)	RA7 DO (%)	RA7 DO (mg/L)	RA7 Cond (uS/cm)	RA7 pH	R21 Temp (deg C)	R21 DO (%)	R21 DO (mg/L)	R21 Cond (uS/cm)	R21 pH	Turbidity (NTU)
6/2/04 5:00	17.8	64.04	65%	29.77	754.2	Clear	102.0	11.3	88.6	9.71	33.0	6.7	16.5	92.0	8.99	62.0	6.9	1.0
6/2/04 6:00	17.2	62.96	65%	29.77	754.2	Clear	102.0	11.2	88.2	9.69	33.0	6.7	16.4	90.7	8.88	62.0	6.9	0.9
6/2/04 7:00	18.9	66.02	56%	29.77	754.2	Clear	108.5	11.1	88.2	9.71	33.0	6.6	16.3	90.3	8.85	62.0	6.9	0.9
6/2/04 8:00	21.1	69.98	49%	29.77	754.2	Clear	122.0	11.1	90.6	9.97	33.0	6.7	16.4	91.4	8.95	62.0	6.9	0.5
6/2/04 9:00	23.9	75.02	41%	29.8	754.9	Clear	121.0	11.1	93.8	10.31	33.0	6.7	16.6	94.6	9.23	62.3	7.0	0.5
6/2/04 10:00	25.6	78.08	39%	29.8	754.9	Clear	121.5	11.3	95.7	10.48	33.0	6.7	16.9	98.2	9.52	63.2	7.0	0.4
6/2/04 11:00	27.8	82.04	37%	29.77	754.2	Clear	122.5	11.6	97.2	10.58	33.0	6.7	17.4	102.7	9.85	64.5	7.2	0.4
6/2/04 12:00	29.4	84.92	36%	29.77	754.2	Clear	122.5	12.0	99.1	10.68	33.0	6.8	17.8	105.9	10.06	65.7	7.3	0.8
6/2/04 13:00							122.5	12.3	100.6	10.75	33.0	6.8	18.4	109.5	10.29	67.3	7.5	0.4
6/2/04 14:00	32.8	91.04	28%	29.74	753.4	Clear	121.5	12.7	102.4	10.85	33.0	6.9	18.9	112.8	10.49	68.7	7.7	0.4
6/2/04 15:00	33.9	93.02	29%	29.74	753.4	Clear	121.5	13.1	104.5	10.99	32.9	6.9	19.3	116.0	10.69	70.0	7.9	0.4
6/2/04 16:00	34.4	93.92	24%	29.71	752.7	Clear	122.0	13.4	106.5	11.13	33.0	7.0	19.8	118.2	10.79	71.0	8.1	0.4
6/2/04 17:00	34.4	93.92	23%	29.71	752.7	Clear	121.0	13.6	108.1	11.24	33.0	7.0	20.0	119.4	10.85	71.3	8.3	0.4
6/2/04 18:00	33.9	93.02	27%	29.71	752.7	Clear	121.0	13.7	108.4	11.24	33.0	7.0	20.1	117.8	10.68	71.3	8.2	0.5
6/2/04 19:00	31.7	89.06	22%	29.71	752.7	Clear	123.0	13.8	108.2	11.20	33.0	7.0	20.1	114.8	10.41	71.0	8.0	0.7
6/2/04 20:00	28.3	82.94	21%	29.74	753.4	Clear	124.5	13.7	106.4	11.03	33.0	7.0	19.9	111.2	10.12	70.5	7.8	0.5
6/2/04 21:00	26.1	78.98	24%	29.74	753.4	Clear	125.5	13.5	104.1	10.85	33.0	6.9	19.6	105.6	9.67	69.7	7.5	0.9
6/2/04 22:00	23.9	75.02	29%	29.77	754.2	Clear	126.0	13.2	101.9	10.70	33.0	6.9	19.4	101.9	9.39	69.0	7.4	1.1
6/2/04 23:00	21.7	71.06	38%	29.77	754.2	Partly Cloudy	126.0	12.8	98.5	10.43	33.0	6.9	19.0	98.7	9.15	68.3	7.2	1.1
6/3/04 0:00	20	68	47%	29.8	754.9	Clear	125.0	12.3	94.9	10.15	33.0	6.8	18.6	95.5	8.93	67.7	7.1	1.1
6/3/04 1:00	18.9	66.02	52%	29.8	754.9	Clear	125.5	12.0	92.0	9.92	33.8	6.7	18.2	92.6	8.72	66.7	7.1	1.2
6/3/04 2:00	17.8	64.04	58%	29.8	754.9	Clear	125.0	11.7	89.5	9.72	34.0	6.7	17.7	89.7	8.53	65.6	7.0	1.3
6/3/04 3:00	16.7	62.06	62%	29.83	755.7	Clear	125.0	11.5	87.9	9.58	34.0	6.7	17.4	88.2	8.45	65.0	7.0	0.9
6/3/04 4:00	15	59	72%	29.83	755.7	Clear	125.0	11.3	86.6	9.49	34.0	6.7	17.1	86.7	8.36	64.2	6.9	0.9
6/3/04 5:00	14.4	57.92	75%	29.83	755.7	Clear	125.0	11.2	85.7	9.42	34.0	6.6	16.9	85.5	8.29	63.6	6.9	3.3
6/3/04 6:00	15	59	72%	29.83	755.7	Clear	125.0	11.0	85.7	9.44	34.0	6.6	16.7	84.5	8.21	63.0	6.9	1.3
6/3/04 7:00	15.6	60.08	72%	29.86	756.5	Clear	124.5	11.0	86.4	9.53	34.0	6.6	16.6	84.5	8.23	62.8	6.9	1.9
6/3/04 8:00	17.8	64.04	65%	29.86	756.5	Clear	125.0	10.9	89.4	9.88	33.0	6.7	16.6	85.7	8.35	62.0	6.9	1.5
6/3/04 9:00	20.6	69.08	54%	29.89	757.2	Clear	124.0	11.0	93.8	10.33	33.0	6.7	16.8	89.2	8.67	62.9	7.0	0.5
6/3/04 10:00	23.3	73.94	46%	29.89	757.2	Clear	124.5	11.2	95.2	10.45	33.0	6.7	17.1	93.4	9.02	63.0	7.1	0.6
6/3/04 11:00	26.1	78.98	39%	29.89	757.2	Clear	124.5	11.5	96.9	10.55	33.0	6.8	17.6	101.2	9.66	64.1	7.2	2.2
6/3/04 12:00	27.2	80.96	35%	29.92	758.0	Clear	124.0	11.8	98.5	10.65	33.0	6.8	18.0	101.3	9.59	65.0	7.3	0.8
6/3/04 13:00	28.9	84.02	31%	29.92	758.0	Clear	124.0	12.2	99.9	10.71	33.0	6.9	18.3	103.7	9.75	65.7	7.4	0.5
6/3/04 14:00	31	87.8	25%	29.92	758.0	Scattered Clouds	125.0	12.6	101.8	10.83	33.0	6.9	18.8	106.7	9.94	66.8	7.6	0.5
6/3/04 15:00	32.2	89.96	25%	29.89	757.2	Clear	125.0	13.0	103.6	10.91	33.0	7.0	19.2	109.1	10.08	67.6	7.7	0.5
6/3/04 16:00	33	91.4	24%	29.89	757.2	Overcast	124.0	13.3	104.1	10.90	33.0	7.0	19.6	110.7	10.15	68.4	7.9	0.4
6/3/04 17:00	32.8	91.04	23%	29.89	757.2	Clear	124.0	13.5	104.9	10.93	33.0	7.0	19.8	111.4	10.17	69.0	8.1	0.4
6/3/04 18:00	31.1	87.98	24%	29.89	757.2	Clear	124.5	13.6	105.2	10.93	33.0	7.1	19.9	111.2	10.14	69.1	8.1	0.5
6/3/04 19:00	28.9	84.02	26%	29.89	757.2	Clear	125.5	13.6	104.4	10.85	33.0	7.1	19.8	109.7	10.02	69.1	8.1	0.5
6/3/04 20:00	26.7	80.06	29%	29.92	758.0	Clear	125.0	13.5	102.6	10.70	33.0	7.0	19.6	106.9	9.80	69.0	7.9	0.4
6/3/04 21:00	23.9	75.02	34%	29.92	758.0	Clear	126.0	13.3	100.9	10.57	33.0	7.0	19.3	103.0	9.50	68.7	7.6	0.5
6/3/04 22:00	22.8	73.04	34%	29.95	758.7	Clear	126.5	13.0	98.9	10.42	33.0	6.9	19.0	98.8	9.16	67.9	7.4	0.5
6/3/04 23:00	18.9	66.02	45%	29.95	758.7	Partly Cloudy	125.5	12.7	96.7	10.26	33.0	6.9	18.7	96.1	8.97	67.3	7.3	0.7
6/4/04 0:00	19	66.2	46%	29.95	758.7	Mostly Cloudy	126.0	12.4	94.1	10.05	33.0	6.8	18.3	93.2	8.77	66.4	7.2	0.7
6/4/04 1:00	18.3	64.94	43%	29.95	758.7	Scattered Clouds	125.5	12.2	93.0	9.98	33.0	6.8	17.9	90.5	8.58	65.5	7.1	0.8
6/4/04 2:00	18.3	64.94	45%	29.95	758.7	Scattered Clouds	126.0	12.0	92.3	9.95	33.0	6.8	17.5	88.1	8.43	64.9	7.1	0.9
6/4/04 3:00	16.7	62.06	53%	29.95	758.7	Scattered Clouds	126.5	11.8	91.7	9.93	33.0	6.7	17.1	85.9	8.29	63.9	7.0	0.9
6/4/04 4:00	16.7	62.06	53%	29.95	758.7	Scattered Clouds	127.0	11.6	91.2	9.92	33.0	6.7	16.8	84.6	8.20	63.2	7.0	0.9
6/4/04 5:00	16.1	60.98	58%	29.95	758.7	Scattered Clouds	127.0	11.4	90.3	9.87	33.0	6.7	16.5	83.4	8.14	62.8	6.9	1.0
6/4/04 6:00	15.6	60.08	62%	29.95	758.7	Scattered Clouds	125.0	11.2	89.4	9.81	33.0	6.7	16.3	82.5	8.08	62.0	6.9	1.0
6/4/04 7:00	16.7	62.06	60%	29.98	759.5	Scattered Clouds	125.5	11.0	89.2	9.82	33.0	6.7	16.2	82.3	8.08	62.0	6.9	0.9
6/4/04 8:00	18.9	66.02	59%	29.98	759.5	Scattered Clouds	124.5	11.0	91.9	10.14	33.0	6.7	16.1	84.6	8.32	65.1	6.9	0.8
6/4/04 9:00	22.2	71.96	48%	29.98	759.5	Clear	119.0	11.0	95.2	10.49	33.0	6.7	16.3	85.5	8.37	66.5	6.9	0.8
6/4/04 10:00	23.9	75.02	40%	29.98	759.5	Clear	110.0	11.2	96.2	10.56	33.0	6.8	16.6	88.7	8.64	67.2	7.0	0.6
6/4/04 11:00	26.1	78.98	36%	29.98	759.5	Clear	109.5	11.4	97.4	10.63	33.0	6.8	17.0	92.5	8.93	67.6	7.1	0.5
6/4/04 12:00	27.2	80.96	34%	29.98	759.5	Clear	108.5	11.8	99.6	10.78	33.0	6.9	17.5	96.4	9.22	68.8	7.1	0.7
6/4/04 13:00	31.7	89.06	31%	29.98	759.5	Clear	103.0	12.2	101.9	10.92	33.0	6.9	18.1	100.6	9.51	70.4	7.2	0.4

Attachment B: Physical water quality data from spot checks by meso-habitat and distance downstream from La Grange Dam May/June 2004

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
05/28/04	12:53	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	1.50	11.44	10.59	97.1	29		6.95	600XL-SW	backwater on RL bank
05/28/04	12:48	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	12.00	11.33	10.66	97.5	29		7.11	600XL-SW	pool with bedrock
05/28/04	12:51	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	1.50	11.36	10.62	97.1	29		7.03	600XL-SW	surface of pool
05/28/04	12:15	overcast	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.00	12.84	10.36	97.9	31		7.10	600XL-TID	backwater on RL bank
05/28/04	12:07	overcast	757		Riffle A7	50.8	10S 0724340 4171517	6.00	11.77	10.44	96.3	31		7.00	600XL-TID	pool tail above riffle
05/28/04	12:10	overcast	757		Riffle A7	50.8	10S 0724340 4171517	0.50	11.90	10.32	96.0	31		6.95	600XL-TID	pool surface above riffle
05/28/04	11:06	overcast	757		Riffle A7	50.8	10S 0724340 4171517	1.50	11.60	10.29	94.6	29		6.64	600XL-SW	mid riffle depression to RL of island (~20 ft into river from RL)
05/28/04	11:08	overcast	757		Riffle A7	50.8	10S 0724340 4171517	2.00	11.64	10.09	92.9	31		6.90	600XL-TID	mid riffle to RR of island
05/28/04	12:05	overcast	757		Riffle A7	50.8	10S 0724340 4171517	3.00	11.74	10.75	99.0	31		7.00	600XL-TID	riffle head
05/28/04	12:00	overcast	757		Riffle A7	50.8	10S 0724340 4171517	3.00	11.75	10.31	95.1	31		6.93	600XL-TID	riffle tail
05/28/04	11:02	overcast	757		Riffle A7	50.8	10S 0724340 4171517	0.50	11.75	10.93	101.2	31		6.85	600XL-TID	mid riffle RL edge
05/28/04	15:21	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	1.06	15.34	9.21	92.0	32		7.14	600XL-SW	backwater along edge of RB
05/28/04	15:14	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	2.20	14.00	11.00	107.0	31		7.10	600XL-SW	pool tail at end of run
05/28/04	15:27	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	4.40	14.18	10.58	103.0	31		7.13	600XL-SW	pool head on RB below backwater
05/28/04	15:17	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	0.60	10.05	10.75	104.0	31		7.03	600XL-SW	riffle head below pool
05/28/04	15:24	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	1.30	14.07	10.72	104.0	31		7.03	600XL-SW	riffle tail
05/28/04	16:11	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	3.20	15.66	10.47	105.3	40		7.06	600XL-SW	backwater bottom
05/28/04	16:12	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	0.50	15.70	10.46	105.2	41		7.06	600XL-SW	backwater surface
05/28/04	16:16	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.90	14.93	10.55	104.4	33		7.02	600XL-SW	head of pool below riffle
05/28/04	16:04	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	3.80	16.66	10.50	107.8	35		7.20	600XL-SW	backwater on RR
05/28/04	15:59	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.80	14.93	10.72	106.2	33		7.05	600XL-SW	riffle (75 feet downstream of pump that park next to)
05/28/04	16:09	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	2.00	14.88	10.56	104.4	33		7.03	600XL-SW	riffle tail (300 feet below pump)
05/28/04	14:02	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	2.00	16.50	10.34	105.9	39		7.09	600XL-SW	shallow pool
05/28/04	14:07	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	4.00	16.55	10.28	105.4	39		7.16	600XL-SW	located at sonde in shallow pool
05/28/04	14:10	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	4.00	16.51	10.32	105.7	39		7.15	600XL-SW	shallow pool

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
05/28/04	17:08	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	0.50	17.82	9.72	102.0	45		7.41	600XL-SW	backwater on RL (in shade)
05/28/04	17:03	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	2.30	18.05	10.54	111.5	43		7.34	600XL-SW	pool head 50 yards below campground
05/28/04	17:15	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	1.30	17.99	10.37	109.4	42		7.44	600XL-SW	riffle head
05/28/04	17:11	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	2.80	18.01	10.25	108.0	43		7.36	600XL-SW	riffle tail
05/28/04	17:14	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	0.80	18.04	10.35	109.0	42		7.43	600XL-SW	riffle opposite west campground
05/29/04	15:06	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.00	12.97	10.78	102.1	29		7.16	600XL-TID	surface of pool above sonde
05/29/04	15:07	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	4.50	12.82	10.78	101.9	29		7.16	600XL-TID	pool profile above sonde
05/29/04	15:08	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	2.50	12.91	10.72	101.6	29		7.14	600XL-TID	pool profile above sonde
05/29/04	15:10	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	7.50	12.84	10.76	101.7	29		7.11	600XL-TID	pool profile above sonde
05/29/04	16:33	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	0.50	17.08	10.87	112.7	38		7.32	600XL-TID	surface
05/29/04	16:34	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	1.50	17.09	10.84	112.4	38		7.39	600XL-TID	mid profile
05/28/04	12:53	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	1.50	11.44	10.59	97.1	29		6.95	600XL-SW	backwater on RL bank
05/28/04	12:48	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	12.00	11.33	10.66	97.5	29		7.11	600XL-SW	pool with bedrock
05/28/04	12:51	overcast	757		La Grange Gage	51.8	10S 0725712 4171722	1.50	11.36	10.62	97.1	29		7.03	600XL-SW	surface of pool
05/28/04	12:15	overcast	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.00	12.84	10.36	97.9	31		7.10	600XL-TID	backwater on RL bank
05/28/04	12:07	overcast	757		Riffle A7	50.8	10S 0724340 4171517	6.00	11.77	10.44	96.3	31		7.00	600XL-TID	pool tail above riffle
05/28/04	12:10	overcast	757		Riffle A7	50.8	10S 0724340 4171517	0.50	11.90	10.32	96.0	31		6.95	600XL-TID	pool surface above riffle
05/28/04	11:06	overcast	757		Riffle A7	50.8	10S 0724340 4171517	1.50	11.60	10.29	94.6	29		6.64	600XL-SW	mid riffle depression to RL of island (~20 ft into river from RL)
05/28/04	11:08	overcast	757		Riffle A7	50.8	10S 0724340 4171517	2.00	11.64	10.09	92.9	31		6.90	600XL-TID	mid riffle to RR of island
05/28/04	12:05	overcast	757		Riffle A7	50.8	10S 0724340 4171517	3.00	11.74	10.75	99.0	31		7.00	600XL-TID	riffle head
05/28/04	12:00	overcast	757		Riffle A7	50.8	10S 0724340 4171517	3.00	11.75	10.31	95.1	31		6.93	600XL-TID	riffle tail
05/28/04	11:02	overcast	757		Riffle A7	50.8	10S 0724340 4171517	0.50	11.75	10.93	101.2	31		6.85	600XL-TID	mid riffle RL edge
05/28/04	15:21	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	1.06	15.34	9.21	92.0	32		7.14	600XL-SW	backwater along edge of RB
05/28/04	15:14	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	2.20	14.00	11.00	107.0	31		7.10	600XL-SW	pool tail at end of run
05/28/04	15:27	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	4.40	14.18	10.58	103.0	31		7.13	600XL-SW	pool head on RB below backwater
05/28/04	15:17	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	0.60	10.05	10.75	104.0	31		7.03	600XL-SW	riffle head below pool

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
05/28/04	15:24	sunny	757	27.0	Riffle 5B (New Basso Br.)	47.9	10S 0721197 4169903	1.30	14.07	10.72	104.0	31		7.03	600XL-SW	riffle tail
05/28/04	16:11	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	3.20	15.66	10.47	105.3	40		7.06	600XL-SW	backwater bottom
05/28/04	16:12	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	0.50	15.70	10.46	105.2	41		7.06	600XL-SW	backwater surface
05/28/04	16:16	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.90	14.93	10.55	104.4	33		7.02	600XL-SW	head of pool below riffle
05/28/04	16:04	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	3.80	16.66	10.50	107.8	35		7.20	600XL-SW	backwater on RR
05/28/04	15:59	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.80	14.93	10.72	106.2	33		7.05	600XL-SW	riffle (75 feet downstream of pump that park next to)
05/28/04	16:09	sunny	757	24.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	2.00	14.88	10.56	104.4	33		7.03	600XL-SW	riffle tail (300 feet below pump)
05/28/04	14:02	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	2.00	16.50	10.34	105.9	39		7.09	600XL-SW	shallow pool
05/28/04	14:07	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	4.00	16.55	10.28	105.4	39		7.16	600XL-SW	located at sonde in shallow pool
05/28/04	14:10	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	4.00	16.51	10.32	105.7	39		7.15	600XL-SW	shallow pool
05/28/04	17:08	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	0.50	17.82	9.72	102.0	45		7.41	600XL-SW	backwater on RL (in shade)
05/28/04	17:03	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	2.30	18.05	10.54	111.5	43		7.34	600XL-SW	pool head 50 yards below campground
05/28/04	17:15	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	1.30	17.99	10.37	109.4	42		7.44	600XL-SW	riffle head
05/28/04	17:11	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	2.80	18.01	10.25	108.0	43		7.36	600XL-SW	riffle tail
05/28/04	17:14	sunny	757	24.0	Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	0.80	18.04	10.35	109.0	42		7.43	600XL-SW	riffle opposite west campground
05/29/04	15:06	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.00	12.97	10.78	102.1	29		7.16	600XL-TID	surface of pool above sonde
05/29/04	15:07	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	4.50	12.82	10.78	101.9	29		7.16	600XL-TID	pool profile above sonde
05/29/04	15:08	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	2.50	12.91	10.72	101.6	29		7.14	600XL-TID	pool profile above sonde
05/29/04	15:10	sunny	757	26.0	SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	7.50	12.84	10.76	101.7	29		7.11	600XL-TID	pool profile above sonde
05/29/04	16:33	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	0.50	17.08	10.87	112.7	38		7.32	600XL-TID	surface
05/29/04	16:34	overcast	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715179 4167681	1.50	17.09	10.84	112.4	38		7.39	600XL-TID	mid profile
06/04/04		sunny	757		Riffle A7	50.8	10S 0724340 4171517							7.00	600XL-TID	pH after recalibration
06/04/04		sunny	757		Riffle A7	50.8	10S 0724340 4171517							7.00	600XL-SW	pH after recalibration
06/04/04	12:51	sunny	757		Riffle A7	50.8	10S 0724340 4171517		13.38	10.82	105.4	32	25	7.63	600XL-TID	final parallel calibration check
06/04/04	12:51	sunny	757		Riffle A7	50.8	10S 0724340 4171517		13.31	10.83	106.6	30	23	6.61	600XL-SW	final parallel calibration check
06/04/04	13:01:5	sunny	757		Riffle A7	50.8	10S 0724340 4171517		13.51	11.07	106.8	32	25	6.98	600XL-TID	final parallel calibration check

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
06/04/04	13:01:4	sunny	757		Riffle A7	50.8	10S 0724340 4171517		13.37	10.91	104.9	30	23	6.64	600XL-SW	final parallel calibration check
06/04/04	15:02	sunny	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715023 4167522	0.50	19.69	10.56	115.5	37	34	7.23	600XL-SW	surface of shallow pool
06/04/04	15:03	sunny	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715023 4167522	1.85	19.70	10.51	114.9	37	34	7.27	600XL-SW	middle of shallow pool
06/04/04	15:04	sunny	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715023 4167522	3.35	19.71	10.17	114.6	37	34	7.33	600XL-SW	bottom of shallow pool
06/04/04	17:11	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		0.50	20.35	10.39	115.1	37	34	7.68	600XL-SW	surface of deeper pool. Profile collected at site of sampler which was moved ~55 ft d/s toward RR from original deployed position and placed in a bed of aquatic vegetation
06/04/04	17:13	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		2.33	20.31	10.34	114.4	38	35	7.68	600XL-SW	middle of deeper pool. Profile collected at site of sampler which was moved ~55 ft d/s toward RR from original deployed position and placed in a bed of aquatic vegetation
06/04/04	17:13	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		3.83	20.18	10.03	111.3	44	40	7.59	600XL-SW	bottom of deeper pool. Profile collected at site of sampler which was moved ~55 ft d/s toward RR from original deployed position and placed in a bed of aquatic vegetation
06/04/04	17:35	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0			18.48	5.98	63.9	50	44	6.65	600XL-TID	post retrieval parallel readings. Collected on channel edge dense with aquatic vegetation on RL. GPS was 11 ft accuracy
06/04/04	17:34	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0			18.42	5.66	60.5	47	41	6.83	600XL-SW	post retrieval parallel readings. Collected on channel edge dense with aquatic vegetation on RL. GPS was 11 ft accuracy
06/04/04	17:35	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0			18.12	5.81	62.1	86	75	6.68	6920-SW	post retrieval parallel readings. Collected on channel edge dense with aquatic vegetation on RL. GPS was 11 ft accuracy
06/05/04	10:10	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724	0.50	11.11	9.86	89.7	31	23	6.40	600XL-SW	surface #1. pool profile in center of river toward RR, just before last break in shelf.
06/05/04	10:11	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724	0.50	11.17	9.84	89.6	31	23	6.41	600XL-SW	surface #2. pool profile in center of river toward RR, just before last break in shelf.
06/05/04	10:13	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724	5.45	11.11	9.83	89.4	31	23	6.44	600XL-SW	middle. pool profile in center of river toward RR, just before last break in shelf.
06/05/04	10:14	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724	10.95	11.11	9.78	89.0	32	23	6.45	600XL-SW	bottom. pool profile in center of river toward RR, just before last break in shelf.
06/05/04	10:28	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724		11.60	9.94	91.4	32	23	6.50	600XL-SW	post sample profile collection
06/05/04	10:28	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724		11.59	9.95	91.5	32	24	6.88	600XL-TID	post sample profile collection
06/05/04	10:23	sunny	757	25.1	La Grange Gage	51.8	10S 0725712 4171724	5.00	13.69	9.65	92.1	33	26	6.50	600XL-SW	collected in backwater (1.5 ft deep) area very shallow on RL just d/s of pool sample site.
06/05/04	9:22		757		La Grange Gage	51.8	10S 0725712 4171724		11.18	10.15	92.5	32	23	7.00	600XL-TID	Unit 1- pre- in situ calibration
06/05/04	10:04		757		La Grange Gage	51.8	10S 0725712 4171724		11.41	10.08	92.3	32	23	6.96	600XL-TID	Unit 1- post- in situ calibration
06/05/04	9:21		757		La Grange Gage	51.8	10S 0725712 4171724		11.05	10.03	89.3	30	22	6.63	600XL-SW	Unit 2- pre- in situ calibration
06/05/04	10:04		757		La Grange Gage	51.8	10S 0725712 4171724		11.49	9.80	89.9	32	24	6.63	600XL-SW	Unit 2- post- in situ calibration
06/05/04	11:01	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	0.50	11.89	10.42	96.8	32	24	6.71	600XL-SW	profile collected at sample site where datalogger was originally depolyed, 8.97' was deepest point btw RL bank and diel profile.
06/05/04	11:02	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	3.30	11.74	10.23	94.6	32	24	6.71	600XL-SW	profile collected at sample site where datalogger was originally depolyed, 8.97' was deepest point btw RL bank and diel profile.
06/05/04	11:03	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	7.30	11.67	10.19	93.9	32	24	6.72	600XL-SW	profile collected at sample site where datalogger was originally depolyed, 8.97' was deepest point btw RL bank and diel profile.
06/05/04	11:14	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	0.50	11.97	10.35	96.3	32	24	6.73	600XL-SW	pool tail surface
06/05/04	11:15	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.73	11.73	10.25	94.6	32	24	6.76	600XL-SW	pool tail mid profile

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
06/05/04	11:16	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	3.73	11.67	10.19	94.0	32	24	6.77	600XL-SW	pool tail bottom
06/05/04	11:37	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	0.67	15.36	10.00	99.6	32	26	6.73	600XL-SW	backwater on RL at rifflehead. Note: backwater sites had small fish/tadpoles and some type of biofilm
06/05/04	11:24	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.91	11.89	10.05	93.1	32	24	6.61	600XL-SW	mid riffle elevation dip u/s of island
06/05/04	11:28	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	2.90		10.06	93.2	32	24	6.53	600XL-SW	mid riffle RR of island
06/05/04	11:32	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	2.58	12.00	10.05	93.3	32	24	6.56	600XL-SW	mid riffle RR d/s of island
06/05/04	11:17	sunny, clear, breezy	757		SRP 1 (pool above RA7)	51.0	10S 0724519 4171481	1.19	11.71	10.13	93.4	32	24	6.70	600XL-SW	rifflehead
06/05/04	12:13	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	1.49	16.59	10.25	105.4	35	29	6.99	600XL-SW	center backwater pool u/s of boulder in center
06/05/04	12:08	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	0.95	21.43	7.36	83.8	48	45	6.81	600XL-SW	backwater RR stagnant pool
06/05/04	12:18	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	1.85	15.75	10.26	103.5	35	29	6.85	600XL-SW	mid riffle
06/05/04	12:06	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	1.53	15.55	10.45	104.8	35	28	6.79	600XL-SW	rifflehead
06/05/04	12:33	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	1.39	15.94	10.25	103.9	35	29	6.87	600XL-SW	riffle head repeat
06/05/04	12:29	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	2.34	15.91	10.16	102.7	35	29	6.88	600XL-SW	riffle tail u/s of deep tailend reading
06/05/04	12:38	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430		16.23	10.77	109.8	35	29	7.32	600XL-TID	post sample parallel reading: set in turbulent water
06/05/04	12:37	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430		16.17	10.30	104.8	35	29	6.94	600XL-SW	post sample parallel reading: set in turbulent water
06/05/04	12:41	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430		16.49	10.65	109.0	35	29	7.36	600XL-TID	post sample parallel reading: set in still water
06/05/04	12:41	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430		16.46	10.20	104.3	35	29	7.02	600XL-SW	post sample parallel reading: set in still water
06/05/04	12:22	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	0.50	15.96	10.17	103.1	35	29	6.92	600XL-SW	RR at large boulders. Riffle tail RR at end of backwater.
06/05/04	12:24	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	2.82	16.01	10.15	102.9	35	29	6.93	600XL-SW	RR at large boulders. Riffle tail mid depth
06/05/04	12:25	sunny	757		Riffle 5B (New Basso Br.)	47.9	10S 0706328 4168430	6.82	16.00	10.16	103.0	35	29	6.97	600XL-SW	RR at large boulders. riffle tail bottom.
06/05/04	13:22	sunny, breezy, cirrus clouds blowing in	757	31.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	2.76	19.09	9.58	103.4	39	34	7.00	600XL-SW	backwater center of first pool on RR (biofilm)
06/05/04	13:25	sunny, breezy, cirrus clouds blowing in	757	31.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	2.83	17.53	9.67	101.1	37	32	6.85	600XL-SW	mid riffle main flow.
06/05/04	13:19	sunny, breezy, cirrus clouds blowing in	757	31.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.57	17.27	9.84	102.4	36	31	6.91	600XL-SW	rifflehead end of ~200ft run
06/05/04	13:28	sunny, breezy, cirrus clouds blowing in	757	31.0	Riffle 13B (Zanker)	45.5	10S 0718851 4167324	1.52	17.41	9.67	100.9	36	31	6.90	600XL-SW	riffle tail at start of straight section with small pool on RR.
06/05/04	14:06	sunny	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715023 4167522	0.50	19.76	10.07	10.3	41	37	7.85	600XL-SW	surface of shallow pool. original sonde location (u/s)
06/05/04	14:07	sunny	757		Riffle 21 (TRR/BobCat-orig.)	43.0	10S 0715023 4167522	3.24	19.78	9.96	109.2	42	37	7.84	600XL-SW	bottom of shallow pool. original sonde location (u/s)
06/05/04	14:24	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		0.50	19.99	11.06	121.7	42	38	7.68	600XL-SW	surface of deeper pool. Final sonde location (d/s).

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
06/05/04	14:25	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		4.02	19.97	10.99	120.8	42	38	7.67	600XL-SW	middle of deeper pool. Final sonde location (d/s).
06/05/04	14:26	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		8.02	19.95	10.95	120.3	42	38	7.67	600XL-SW	bottom of deeper pool. Final sonde location (d/s).
06/05/04	14:30	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		0.50	20.00	10.91	120.0	42	38	7.61	600XL-SW	surface of deeper pool. Final sonde location (d/s).
06/05/04	14:32	sunny	757		Riffle 21 (TRR/BobCat-final)	43.0		3.81	19.93	10.78	118.5	45	41	7.58	600XL-SW	bottom of deeper pool. Final sonde location (d/s).
06/05/04	15:23	sunny	757		Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	0.72	20.89	9.93	111.1	49	45	7.56	600XL-SW	backwater RL under overhanging willows
06/05/04	15:15	sunny	757		Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	2.28	21.18	10.95	123.3	47	44	7.58	600XL-SW	mid riffle main flow.
06/05/04	15:19	sunny	757		Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	1.55	21.21	10.92	123.0	47	44	7.54	600XL-SW	mid riffle top of long run.
06/05/04	15:11	sunny	757		Riffle 24B (TLSRA)	41.6	10S 0713142 4167530	1.10	21.10	11.14	125.4	47	43	7.62	600XL-SW	rifflehead.
06/05/04	15:46	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	3.93	21.38	10.59	119.8	63	59	7.43	600XL-SW	pool tail
06/05/04	15:50	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	3.75	21.43	10.45	118.2	63	59	7.28	600XL-SW	pool tail #2
06/05/04	16:07	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	4.35	21.53	9.59	108.8	63	59	7.26	600XL-SW	pool tail #3 bottom
06/05/04	16:06	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	0.50	21.67	9.55	108.6	63	59	7.23	600XL-SW	pool tail #3 surface
06/05/04	16:00	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	3.61	21.54	10.03	113.7	87	87	7.12	600XL-SW	backwater
06/05/04	15:53	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	0.84	21.52	10.37	117.4	63	59	7.21	600XL-SW	mid riffle
06/05/04	15:56	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	2.35	21.51	10.36	112.3	63	59	7.19	600XL-SW	riffle tail
06/05/04	15:48	sunny	757		Roberts Ferry Bridge	39.4	10S 070261 416785	0.73	21.44	10.47	118.5	63	59	7.28	600XL-SW	rifflehead (shade)
06/05/04	17:19	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	0.50	23.33	9.58	112.4	66	64	7.91	600XL-SW	pool head surface
06/05/04	17:20	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	3.50	23.33	9.60	112.6	66	64	7.92	600XL-SW	pool head middle
06/05/04	17:21	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	6.50	23.32	9.57	112.3	67	64	7.92	600XL-SW	pool head bottom
06/05/04	17:28	sunny, breeze ~3-8 mph)	757		Riffle 35B (Santa Fe Aggr.)	36.8	10S 0706328 4168430	2.74	23.23	9.62	112.8	67	64	7.89	600XL-SW	pool tail
06/05/04	17:10	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	1.30	23.23	9.71	113.7	67	64	7.90	600XL-SW	mid riffle
06/05/04	17:07	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	10.85	23.23	9.76	114.3	67	64	7.96	600XL-SW	rifflehead
06/05/04	17:07	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	0.85	23.28	9.75	114.3	67	65	8.18	600XL-TID	rifflehead (TID unit)
06/05/04	17:15	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	0.50	23.29	9.62	112.9	66	64	7.92	600XL-SW	riffle tail surface
06/05/04	17:17	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.8	10S 0706328 4168430	4.18	23.26	9.64	113.1	67	64	7.92	600XL-SW	riffle tail bottom
06/05/04	17:39	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7		3.05	23.32	9.58	112.4	67	64	7.95	600XL-SW	pool tail #2

Date	Time	Weather	Bar. P (mm Hg)	Air Temp C	location	RM	GPS	depth	H2O Temp C	DO mg/L	DO %	Sp Cond (umhos/cm 25C)	Sp Cond (umhos/cm)	pH	unit used	Notes
06/05/04	17:44	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7		1.35	24.29	8.21	98.2	81	80	7.79	600XL-SW	Backwater RL on d/s end of island
06/05/04	17:35	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7		1.31	23.34	9.57	111.7	67	65	7.92	600XL-SW	riffle tail
06/05/04	17:32	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7		2.09	23.34	9.62	112.9	67	64	7.89	600XL-SW	mid riffle RL edge
06/05/04	17:48	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7			22.75	8.79	102.1	104	99	8.11	6920-SWS	post sampling parallel readings
06/05/04	17:48	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7			23.32	9.68	113.9	69	67	7.84	6600-TID	post sampling parallel readings
06/05/04	17:48	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7			23.32	9.37	110.0	68	66	8.00	600XL-TID	post sampling parallel readings
06/05/04	17:48	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7			23.30	9.17	107.5	67	65	7.87	600XL-SW	post sampling parallel readings
06/05/04	17:30	sunny, breeze ~3-8 mph)	757		Riffle 36A (Santa Fe Aggr.)	36.7		0.93	23.33	9.62	112.8	67	64	7.88	600XL-SW	riffle head RL

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Turlock Irrigation District	)	
	)	
and	)	Project No. 2299
	)	
Modesto Irrigation District	)	

2004 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2004-11

2004 Rainbow Trout Summary Report

[REPORT TO BE SUBMITTED SEPARATELY]

Prepared by

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Turlock and Modesto Irrigation Districts

and

Steve Kirihara
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March 2005