March 30, 2015

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
Mail Code: DHAC, PJ-12.3
888 First Street, NE
Washington, DC 20426

RE: Turlock and Modesto Irrigation Districts
Project No. 2299 – Article 58 Annual Report for 2014

Please find the enclosed 2014 Lower Tuolumne River annual report submitted to the Commission pursuant to Article 58 of the license for Project No. 2299 (76 FERC ¶ 61,117) and ordering paragraph (B) of the April 3, 2008 Order on Ten-Year Summary Report Under Article 58 (123 FERC ¶ 62,012). The report provides annual updates of Project operations and ongoing Chinook salmon monitoring activities required under Article 58. If you have any questions, please contact Steve Boyd at (209) 883-8364.

Respectfully submitted,

MODESTO IRRIGATION DISTRICT

Greg Dias
Project Manager

TURLOCK IRRIGATION DISTRICT

Steve Boyd
Assistant General Manager

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

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- FERC PROJECT NO. 2299 –

2014 ANNUAL SUMMARY REPORT

Turlock and Modesto Irrigation Districts

Background and Introduction

This is the seventh annual report to the Federal Energy Regulatory Commission (FERC) pursuant to the "Order on Ten-Year Summary Report Under Article 58" issued on April 3, 2008 (2008 Order). The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) ("Districts") have reported on operations and monitoring of the Don Pedro Project (Project) since 1972. A listing of the Article 39 and Article 58 technical reports filed from 1992 to the present is included in Section 9 at the end of this report.

An eight volume report pursuant to Article 39 of the License was filed in 1992 (20-Year Report) and included 28 technical reports. The 1996 Annual Report was filed in 1997 pursuant to the July 31, 1996 Order and consisted of seven volumes that included information for 1992-96 as well as other material not contained in the 20-Year Report. A Ten-Year Summary Report was filed in March 2005 as required by the 1996 Order and the Districts continued to file annual reports in 2005-2011.

The 2008 Order required, in part, (1) continued annual reporting by April 1 of San Joaquin River tributary salmon escapement numbers. Other directives of the 2008 Order pertaining to implementation and reporting of certain rainbow trout/steelhead (*Oncorhynchus mykiss*) monitoring elements have been completed in compliance with the Order and appear in previous Lower Tuolumne River Annual Report submittals.

This report covers the 2014 calendar year and contains:

(1) Fishery monitoring
(2) Other monitoring and studies
(3) Downstream issues
(4) Hydrology, flow schedules, and river operations
(5) Status of habitat restoration
(6) Coordination and regulatory information
(7) Technical reports on fishery/habitat monitoring and flow operations

The current FERC license for the Project on the Tuolumne River expires on April 30, 2016. On February 10, 2011, the Districts filed their notice of intent (NOI) to apply for a new license for the Project. The Don Pedro relicensing process is being reported separately under docket P-2299-075 and additional information may be found at the Project relicensing website: http://www.donpedro-relicensing.com/default.htm

1 - Fishery Monitoring

1.1 Fall-run Salmon Counts and Estimates

The commercial and sport ocean harvest season for fall-run Chinook salmon (*O. tshawytscha*) operated under traditional limits in California for the fourth consecutive year following the partial ban enforced in 2010. The Central Valley fall Chinook runs in 2014 were lower than 2013 and catch totals were near projection estimates (PFMC 2015a). Exhibits 1 and 2 contain graphs of run estimates/counts for the current year and are summarized below.

1.1.1 San Joaquin Tributary Chinook Salmon Run Estimates

The San Joaquin River tributaries presently report fall run Chinook salmon escapement, with incidental numbers of Chinook salmon observed with other run timing outside of the September to mid-January period. The 2008 Order specified that the annual Article 58 report include a comparison the Stanislaus, Tuolumne, and Merced River Chinook salmon escapement (run) numbers. The California Department of Fish and Wildlife (CDFW) conducts their fall-run surveys on the tributaries each year and the Districts depend on them to provide such information in a timely manner. The CDFW estimates, previously obtained indirectly through an online CDFW "GrandTab" compilation, were not available as of March 17, 2014. The annual CDFW Tuolumne River fall spawning survey report for 2014 (Report 2014-1) along with preliminary carcass count data was also not available in time for this submittal. Summary details for these surveys, dating back to 1973 can be found in Report 2014-2, while specific details for any given year are in the annual survey reports as available. Results from the 2014 surveys are currently not available. A comparison of the Tuolumne River escapement to the Stanislaus River escapement can be made based on results of counting weir results from both rivers.

The counting weir operation was initiated at RM 24.5 on the Tuolumne River in 2009, with counting operations typically scheduled to begin in September of each year. The Tuolumne weir operation was supported by the Districts and CCSF and implemented by FISHBIO consultants, whom also operated a counting weir on the Stanislaus River. Weir operation in 2014 for both the Tuolumne and Stanislaus rivers was initiated in mid-September. The 2014 fall run weir count for the Tuolumne was 638 adult Chinook salmon, while a total of 5,507 salmon were counted at the Stanislaus weir (both counts through December 31, 2014). These counts represent a decrease from the 2013 count of 3,738 salmon in the Tuolumne River and an increase from the 2013 count of 5,457 salmon in the Stanislaus River.

CalFish, a cooperative program involving state and federal agencies is providing an updated system for accessing information on salmon escapement throughout California. The CalFish system is a query based, interactive website using the StreamNet database design. The system is currently operational, but does not contain data for the current year. It is expected that this new system will become fully updated and may ultimately replace the GrandTab reporting system. The CalFish website can be found at www.calfish.org.

The most recent CDFW spawning survey report is for the 2010 escapement. Consequently, Report 2014-2 only contains an abbreviated update for 2014, along with existing summary data from prior years. Report 2014-6 has a detailed review of the Tuolumne River counting weir operation in 2014.

1.1.2 Sacramento and Central Valley Fall-run Chinook Salmon Estimates

Overall numbers of fall-run salmon for the entire Central Valley (including hatcheries) and detailed numbers of fall-run escapements by tributary were not able to be developed in 2014 due to the unavailability of data from CDFW "Grand Tab" estimates. However, the Pacific Fishery Management Council (PFMC) also provides estimates for the Central Valley. The PFMC reports a total of 254,802 fall Chinook (hatchery and natural) for the Central Valley in 2014 (PFMC 2015a), which is lower than the total of 445,958 reported for 2013.

The 2014 estimate of adult fall-run in the Sacramento basin was 211,688, lower than the revised 2013 total of 404,666 and greater than the PFMC upper management target of 180,000 combined hatchery and natural adults for the Sacramento River system (PFMC 2015a). The 2014 estimate was lower, however, than the PFMC escapement projection of 314,700 (PFMC 2015a).

The 2014 total number of estimated 2-year olds in the Sacramento basin was 25,359 (PFMC 2015b). The PFMC uses this estimate in their Sacramento Index (SI) as a predictor of population abundance for fishery management purposes. The SI forecast for the Sacramento basin in 2015 is 651,985 adults and is based on a prediction formula using a logarithmic regression first used for 2014 prediction. This forecast results in no projected restrictions during the 2015 salmon fishing season. Exhibits 1 and 2 contain graphs of historical harvest and abundance through 2014.

1.2 Seine Sampling

Report 2014-3 reviews the routine monitoring conducted in eleven beach seine surveys during January-June 2014 at eight Tuolumne River sites from RM 50.5-3.4 and two San Joaquin River locations. A total of 3,664 natural Chinook salmon were caught in the Tuolumne River and none in the San Joaquin River. This was slightly more than double the salmon catch of 1,763 during the 2013 sampling period and the highest catch since 2003. Salmon were captured at Tuolumne River locations downstream to RM 24.9 (Charles Road). There were no salmon captures in the lower section of the Tuolumne River and no captures in the two San Joaquin River locations upstream and downstream of the Tuolumne River confluence.

Density of fry (≤ 50 mm) peaked on February 11 and the density of juveniles peaked on March 25, similar in timing to other years of the 2007–2014 period. Fork length (FL) ranged from 29–87 mm. Fry were captured through the June 4 survey. A comparative review with other years is included in Report 2014-3. The seine report classifies "juvenile" salmon as >50 mm.

A total of 10 *O. mykiss* (29–52 mm FL) were caught in the Tuolumne River downstream to RM 50.5 from March 25–June 4. In addition to salmon, a total of 12 fish species were recorded in the Tuolumne River and 5 species in the San Joaquin River during the 2014 season.

1.3 Rotary Screw Trapping

Report 2014-4 reviews the 2014 rotary screw trap monitoring conducted near Waterford (RM 29.8) and near Grayson (RM 5.2) and includes a comparison with other years. In 2014, the Waterford trap was operated from January 2 thru May 16, while the Grayson trap was operated from January 27 thru May2, due to issues with water depth, low velocity, and hyacinth loading. Total juvenile salmon catches were 12,358 at the Waterford trap and 8 at the Grayson trap.

The estimated total passage of salmon in 2014 was based on a revised linear model as reported in Robichaud and English (2013). The estimated total passage of salmon at Waterford in 2014 was 137,013 fish, an increase from the estimate of 41,060 from the previous year. The Waterford estimate was comprised of 89,411 fry (<50 mm), 23,137 parr (50-69 mm), and 24,465 smolts (≥ 70 mm). The estimated passage of all lifestages increased from the previous year estimate of 21,951 fry, 2,011 parr, and 17,098 smolts.

The estimated total passage of salmon at Grayson in 2014 was 211 fish, a decrease from the estimate of 642 from the previous year. The Grayson estimate was comprised of 19 fry (<50 mm), 73 parr (50-69 mm), and 119 smolts (≥ 70 mm). The estimated passage of fry and smolts increased while the estimated passage of smolts decreased from the previous year estimate of 6 fry, 7 parr, and 629 smolts.

Due to the issues associated with sampling at Grayson this past season, a survival estimate was not calculated for 2014. Typically, this index is developed from the ratio of estimated total passage at Grayson relative to the estimated total passage at Waterford and does not account for any salmon produced from spawning downstream of the Waterford trap site.

There were no captures of *O. mykiss* at the either the Waterford trap site or the Grayson trap site in 2014. There were 21 other fish species captured in the traps in 2014.

1.4 Reference Count Snorkeling

Report 2014-5 reviews the snorkel survey that was conducted on July 29-31 within the RM 31.5-50.7 (Waterford to La Grange) reach of the Tuolumne River. The survey was conducted at a flow of approximately 104 cfs with water temperature ranging from 13.6°C (56.5 °F) to 29.2°C (84.6 °F). A total of six juvenile Chinook salmon and 53 *O. mykiss* were recorded during the survey.

Chinook salmon were observed at Riffle A7 (RM 50.7) and *O. mykiss* downstream to Riffle 13B (RM 45.5). Other native fish species observed were Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), and riffle sculpin (*Cottus gulosus*). Non-native species observed included bluegill sunfish (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), green sunfish (*L. cyanellus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), and spotted bass (*M. punctulatus*). Report 2014-5 also contains a comparison with other years, dating back to 1982.

1.5 Counting Weir

The year 2014 represents the sixth consecutive year in which the counting weir was operational on the Tuolumne River. A similar weir has been in operation on the Stanislaus River since 2003. Report 2014-6 provides detailed results and sampling conditions for the Tuolumne River weir during the 2014-2015 Fall/Winter monitoring season, which totaled 638 adult Chinook salmon counted for the lower Tuolumne River at RM 24.5 from September 29, 2014 through December 31, 2014. The 2014 Tuolumne River passage was the lowest recorded since the initial count of 264 salmon during the 2009 period. As discussed in previous annual spawning survey reports (e.g., report 2010-1), the weir count does not include fish spawning downstream of RM 24.5. There was no *O. mykiss* passage at the Tuolumne River weir in 2014.

2 - Other TRTAC Monitoring and Studies

2.1 Temperature

Daily average thermograph data and daily max-min air temperatures are graphed in Part 2 of Attachment A. Complete thermograph data for the Tuolumne and San Joaquin Rivers are posted at the TRTAC website, http://tuolumnerivertac.com/data.htm.

3 – Downstream Issues

Important factors influencing salmonid populations occur downstream of the Tuolumne River from the San Joaquin River to the Pacific Ocean where they spend most of their life. Some of these are reviewed in this section. Exhibits 3 and 4 have information on the size and numbers of salmon captured in sampling efforts from lower tributary stations, the San Joaquin River, and the Delta export facilities. Those include rotary screw trap, trawl, and export salvage sampling programs within the January-June season that spans the juvenile salmon (fry to smolt) rearing and migration period. Juvenile density decreased in 2014 compared with 2013 for the Mossdale trawl catch and in the export salvage.

3.1 Ocean Conditions

Central Valley Chinook salmon spend the majority of their lives in the eastern Pacific Ocean and the influence of ocean conditions on their growth and survival is widely recognized (Williams 2006). Temperature, upwelling, and general productivity of the Northern California Current vary considerably from year to year and the understanding of that environment has increased in recent years. The Northwest Fisheries Science Center (NWFSC) reported conditions in 2014 as being relatively poor, with summer PDO (Pacific Decadal Oscillation) conditions strongly positive (warm), El Niño reported as 'neutral', and sea surface temperatures warmer than usual. Biological indicators indicated a high abundance of large, lipid-rich zooplankton but a low abundance of winter fish larvae that develop into salmon prey in the spring. The 2014 conditions were reported to likely lead to below average returns of adult coho salmon in 2015 and Chinook salmon in 2016. Details pertaining to the NWFSC forecasts are available at NWFSC website (http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm). The effects of ocean conditions may not be evident for years until salmon cohorts (year classes) return to spawn.

3.2 Delta Issues

3.2.1. Salmon salvage and losses at Delta water export facilities

Exhibit 4 contains 2014 State Water Project (SWP) and Federal Central Valley Project (CVP) delta water export facility salmon salvage and loss information. Natural/unmarked salmon salvage for January-June at the facilities was lower in 2014 with combined facility estimates of 544 salmon salvaged compared with 4,534 in 2013. The number of salmon losses at the facilities was also lower in 2014 (total estimate of 401) compared with 2013 (total estimate of 8,649). The overall average export rate for this period much lower in 2014 compared with 2013. The reported numbers do not include associated indirect losses within the Delta. Additionally, the salvage loss estimates for fry (mostly in Jan-Mar) may be inherently low due to reduced screening efficiency. It is not known how many of these salmon were from the San Joaquin basin, but salmon within the same size range and timing are recorded in catches from tributary and mainstem (Mossdale) sampling programs (Exhibit 3).

No salmon fry (<50 mm) were reported at the facilities from January-July. There was a predominant salvage of larger juveniles/smolts (75-90 mm) from mid-April through mid-May. Weekly density (combined salvage and loss/1,000 AF of export) was highest during April and May at the CVP, with the SWP recording loss only in mid-May.

3.2.2 Spring smolt conditions and evaluation

The Delta Operations for Salmonids and Sturgeon (DOSS) Technical Working Group is the primary agency organization for providing information on conditions in the Delta pertaining to Chinook salmon. The DOSS group provides recommendations to the Water Operations Management Team (WOMT) and the National Marine Fisheries Service (NMFS) for real-time management of the CVP and SWP. The DOSS also provides annual reports and oversees the implementation of the acoustic tag experiments involving San Joaquin River fish, among other tasks. A detailed description of DOSS along with meeting notes and a listing of annual reports can be found at: http://www.swr.noaa.gov/ocap/doss.htm.

The DOSS (2014) annual report includes information on the 6-year steelhead tagging study designed to provide information on increasing survival of salmonids as they migrate through the Delta to the ocean. Based on the findings, DOSS will make recommendations to NMFS, Reclamation, CDFW, DWR, and FWS on future actions to be undertaken in the San Joaquin Basin as part of an adaptive management approach aimed at analyzing distinct combinations of outflow and export as a measure of how salmonid survival through the Delta is influenced by inflow from the San Joaquin River.

The 2014 tagging study represents the fourth year of the 6-Year Acoustic Tag Experiment as required by the 2009 NMFS Biological Opinion (NMFS 2009). The 2014 tagging study included three release groups, ranging from 478 to 480 acoustically tagged steelhead smolts from the Mokelumne River Hatchery during March–May, which generally coincided with the Tuolumne River spring pulse flow release (See Section 4 for specific pulse flow volumes for the Tuolumne River). The releases are typically made into the San Joaquin River at Durham Ferry, downstream of both the Tuolumne and Stanislaus rivers and upstream of Old River. The study does not impose additional pulse flow volumes on the tributaries as was the case in previous years under the now-expired San Joaquin River Agreement (SJRA). Data analysis for this study is currently ongoing. A review of the 2014 study did not result in any proposed changes to the study, however ongoing discussions with an independent review group regarding loss calculations and uncertainty continued. Results from the 2014 study will be shown with and without a predator-fish filter developed in 2011 (DOSS 2014).

3.2.3 Other Delta and San Joaquin Basin issues

Due to continued drought conditions the SWP and CVP projects were operated under a series of drought contingency plans and associated orders issued by the SWRCB during WY 2014 (DOSS 2014). The export facilities were operated to supply water needed to meet essential human health and safety needs while coordinating with fish agencies to minimize adverse effects to listed fish species. The SWRCB has compiled a comprehensive chronological summary of the drought actions and associated documentation during WY 2014, available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp.shtml

A trial implementation of the "OMR Index Demonstration Project" was approved by NMFS in WY 2014[1]. As part of the project, OMR compliance is measured using the OMR index (an estimate of OMR flow based on an equation that includes Vernalis flow and exports) rather than the tidally-averaged daily OMR based on USGS gauge data. The project is part of the Old and Middle River flow management objective to reduce vulnerability of emigrating juvenile winter run, yearling spring run, and CV steelhead within the lower Sacramento and San Joaquin rivers and at the export facilities in the south Delta. The action is in effect from January 1 through June 15.

There was increasing concern with the spread of water hyacinth (*Eichhornia crassipes*) throughout the Delta and San Joaquin River system in 2014 and the potential for impact to migrating salmon. The California Department of Boating and Waterways (CDBW) is tasked with identifying and controlling the spread of water hyacinth. The CDFW developed the Water Hyacinth Control Program (WHCP) in consultation with NMFS and FWS. The 2015 WHCP is available at: http://www.dbw.ca.gov/PressRoom/2014/140310WaterHyacinth.aspx

4 – Hydrology, Flow Schedules, and River Operations

The 2014 calendar year included part of the 2014 and 2015 water years (WY) from October 1st through September 30th. The preliminary WY2014 Tuolumne River computed natural runoff was 31% of the long-term average (http://cdec.water.ca.gov/cgi-progs/reports/FLOWOUT.201409). The final 2014 San Joaquin Basin 60-20-20 Water Supply Index was calculated at 1,351,134 corresponds to releases associated with "Critical Water Year and Below" in the Article 37 classification, which run from April 15th through April 14th. The daily average computed natural flow, actual La Grange flow, and fish flow schedules of WYs 2014 and 2015 are graphed in Part 1 of Attachment A; actual flows at other SJR basin locations, Delta exports, Don Pedro Reservoir storage, and snow and precipitation data are also included.

Calendar year 2014 included Article 37 minimum flow and pulse flow requirements spanning the 2013 and 2014 FFYs. Part 3 of Attachment A contains the primary flow schedule correspondence. The final volume used in the April 2014 scheduling process was 94,000 AF

[1] NMFS 2/27/14 letter approving the OMR Index Demonstration Project is available at: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/nmfs_response_to_reclamation_s_omr_index_demonstration_project_-_february_27__2014.pdf

representing a decrease from the requirement of 108,482 AF scheduled in the previous year due to below average runoff conditions. The spring (outmigration) pulse flow volume of 11,091 AF during April 15-25 (as shown in the April 8, 2014 email), was scheduled with a base flow of 150 cfs to provide a pulse flow peaks of 1,022 cfs (April 17) and 575 cfs (April 23) along with associated ramping flows. No fall (attraction) pulse flow volume was scheduled.

There were no flood management releases pursuant to ACOE criteria required in 2014 as the Don Pedro Reservoir water surface elevation did not encroach the designated flood control storage space as shown in the graph in Part 1 of Attachment A.

5 – TRTAC Habitat Restoration Activities

As directed under the 1995 FSA, the TRTAC developed ten top priority habitat restoration projects aimed at improving both geomorphic and biological components of the lower Tuolumne River corridor. TID had acted as the Project Manager on behalf of the TRTAC for implementation of grant funding of these projects. No TRTAC habitat restoration activities have been undertaken since 2007.

The table below lists these projects under three categories (Channel and Riparian Restoration, Predator Isolation, and Sediment Management).

TRTAC Habitat Restoration Projects	Current Status
Channel and Riparian Restoration Projects	
Gravel Mining Reach Phase I (7-11 Segment)	Completed in 2003.
Gravel Mining Reach Phase II (MJ Ruddy Segment)	Design work completed. Implementation funding withheld.
Gravel Mining Reach Phase III (Warner-Deardorff Segment)	Design work completed. Implementation funding withheld.
Gravel Mining Reach Phase IV (Reed Segment)	Cost estimate developed, but no funding source was ever identified.
Predator Isolation Projects	
Special Run-Pool (SRP) 9	Completed in 2001.
Special Run-Pool (SRP) 10	Phase I hydraulic modeling and design completed in 2006. No Phase II funding for acquisition and construction has been identified.
Sediment Management Projects	
Riffle Cleaning (Fine sediment)	Survival to emergence study and pool sand volume assessment completed. Funding and permitting of Riffle Cleaning to be determined.
Gasburg Creek basin (Fine sediment)	Completed in 2007.
Gravel augmentation near La Grange (Coarse sediment)	Coarse Sediment Management Plan and Design Manual completed in 2006. Implementation funding withheld.
River Mile 43 (Coarse sediment)	Completed in 2005.

Four of the ten identified TRTAC projects have been completed. Three other projects followed a rigorous and competitive review/selection process, with substantial CALFED grant funding being approved. However, as reviewed in previous annual reports, funding for these projects was later withheld. Considerable FSA and the federal AFRP funds were expended for extensive related pre-project efforts, including proposal development and refinement, completion of the Habitat Restoration Plan, the Floodway Restoration Design Manual, and the Coarse Sediment Management Plan. Two of the projects were partially implemented, and the remaining project (Gravel Mining Reach Phase IV) had a cost estimate developed and was pending completion of the prior channel restoration projects.

A restoration project at Bobcat Flat (RM 43) initiated in two phases by the Friends of the Tuolumne (now Tuolumne River Conservancy) in 2005 was completed in September 2011, with post-project monitoring by FWS occurring in 2012–2014.

6 – Tuolumne River Technical Advisory Committee (TRTAC)

Four quarterly TRTAC meetings were held in 2014: March, June, September, and December. NOAA fisheries attended the March 2014 meeting via phone. No other fishery agencies attended any of the other meetings in 2014. Attachment B contains the 2014 TRTAC meeting agendas, summaries, handouts, and other materials. The website (http://tuolumnerivertac.com/) was used for posting various TRTAC related items (documents, reports, correspondence, meeting materials, etc.) and other fishery/habitat information.

7 - References

Delta Operations for Salmonids and Sturgeon (DOSS) 2014. Annual Report of Activities, October 1, 2013, to September 30, 2014. Technical Working Group. October 2014.

FERC (Federal Energy Regulatory Commission). 2008. Order on ten-year summary report under article 58. April 3. 123 FERC ¶62,012.

National Marine Fisheries Service (NMFS) 2009. Final Biological Opinion and Conference Opinion of the Proposed Long-term Operations of the Central Valley Project and State Water Project. U.S. Department of Commerce National Marine Fisheries Service. 4 June 2009.

Pacific Fishery Management Council (PFMC) 2015a. Review of 2014 Ocean Salmon Fisheries. Portland, OR. February 2015.
http://www.pcouncil.org/wp-content/uploads/salsafe2014_FullDocument.pdf

PFMC 2015b. Preseason Report 1: Stock Abundance Analysis and Environmental Assessment Part I for 2015 Ocean Salmon Fishery Regulations. Portland, OR. February 2015. Available at: http://www.pcouncil.org/wp-content/uploads/Preseason_Report_I_2015_FINAL.pdf

Robichaud, D. and K. English. 2013. Analysis of Tuolumne River Rotary Screw Trap Data to examine the relationship between river flow and survival rates for Chinook smolts migrating between Waterford and Grayson (2006-12). LGL Limited, British Columbia, Canada. Draft Report submitted to Turlock and Modesto Irrigation Districts.

Williams, John G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science. Vol. 4, Issue 3 (December 2006), Article 2. http://repositories.cdlib.org/jmie/sfews/vol4/iss3/art2

8 - General List of Acronyms and Abbreviations

ACOE	Army Corps of Engineers
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
C	degrees Celsius
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
CDFW	California Department of Fish and Wildlife
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
DPS	distinct population segment
DOSS	Delta Operations for Salmonids and Sturgeon
DWR	Department of Water Resources
ESA	Endangered Species Act
ESU	evolutionarily significant unit
F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
FL	fork length
FOT	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
MID	Modesto Irrigation District

NHI	Natural Heritage Institute
NMFS	National Marine Fisheries Service
NOAA Fisheries	also National Marine Fisheries Service
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
NWS	National Weather Service
OMR	Old and Middle Rivers
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
SI	Sacramento Index
SJR	San Joaquin River
SJRA	San Joaquin River Agreement
SJRGA	San Joaquin River Group Authority
SRP	Special Run/Pool (mined area of river, usually with #, e.g. SRP 9)
SWP	State Water Project
TID	Turlock Irrigation District
TRE	Tuolumne River Expeditions
TRT	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
WOMT	Water Operations Management Team
WT	water temperature
WY	Water Year
YOY	Young of Year

9 - List of 1992-2014 Technical Reports by Topic

Salmon Population Models

1992 Appdx. 1: Population Model Documentation
1992 Appdx. 26: Export Mortality Fraction Submodel
1992 Appdx. 2: Stock Recruitment Analysis of the Population Dynamics of San Joaquin River System Chinook salmon
Report 1996-5: Stock-Recruitment Analysis Report

Salmon Spawning Surveys

1992 Appdx. 3: Tuolumne River Salmon Spawning Surveys 1971-88
Report 1996-1: Spawning Survey Summary Report
- 96-1.1 1986 Spawning Survey Report
- 96-1.2 1987 Spawning Survey Report
- 96-1.3 1988 Spawning Survey Report
- 96-1.4 1989 Spawning Survey Report
- 96-1.5 1990 Spawning Survey Report
- 96-1.6 1991 Spawning Survey Report
- 96-1.7 1992 Spawning Survey Report
- 96-1.8 1993 Spawning Survey Report
- 96-1.9 1994 Spawning Survey Report
- 96-1.10 1995 Spawning Survey Report
- 96-1.11 1996 Spawning Survey Report
- 96-1.12 Population Estimation Methods

1997-1: 1997 Spawning Survey Report and Summary Update
1998-1: Spawning Survey Summary Update
1999-1: 1998 Spawning Survey Report
2000-1: 1999 and 2000 Spawning Survey Reports
2000-2: Spawning Survey Summary Update
2001-1: 2001 Spawning Survey Report
2001-2: Spawning Survey Summary Update
2002-1: 2002 Spawning Survey Report
2002-2: Spawning Survey Summary Update
2003-1: Spawning Survey Summary Update
2004-1: 2003 and 2004 Spawning Survey Reports
2004-2: Spawning Survey Summary Update
2006-1: 2005 and 2006 Spawning Survey Reports
2006-2: Spawning Survey Summary Update
2007-1: 2007 Spawning Survey Report
2007-2: Spawning Survey Summary Update
2008-2: Spawning Survey Summary Update
2009-1: 2008 and 2009 Spawning Survey Reports
2009-2: Spawning Survey Summary Update
2009-8: 2009 Counting Weir Report
2010-1: 2010 Spawning Survey Report
2010-2: Spawning Survey Summary Update

2010-8: 2010 Counting Weir Report
2011-2: Spawning Survey Summary Update
2011-8: 2011 Tuolumne River Weir Report
2012-2: Spawning Survey Summary Update
2012-6: 2012 Tuolumne River Weir Report
2013-2: Spawning Survey Summary Update
2013-6: 2013 Tuolumne River Weir Report
2014-2: Spawning Survey Summary Update
2014-6: 2014 Tuolumne River Weir Report

Seine, Snorkel, Fyke Reports and Various Juvenile Salmon Studies

1992 Appdx. 10: 1987 Juvenile Chinook salmon Mark-Recapture Study
1992 Appdx. 12: Data Reports: Seining of Juvenile Chinook salmon in the Tuolumne, San Joaquin, and Stanislaus Rivers, 1986-89
1992 Appdx. 13: Report on Sampling of Chinook Salmon Fry and Smolts by Fyke Net and Seine in the Lower Tuolumne River, 1973-86
1992 Appdx. 20: Juvenile Salmon Pilot Temperature Observation Experiments
Report 1996-2: Juvenile Salmon Summary Report
96-2.1 1986 Snorkel Survey Report
96-2.2 1988-89 Pulse Flow Reports
96-2.3 1990 Juvenile Salmon Report
96-2.4 1991 Juvenile Salmon Report
96-2.5 1992 Juvenile Salmon Report
96-2.6 1993 Juvenile Salmon Report
96-2.7 1994 Juvenile Salmon Report
96-2.8 1995 Juvenile Salmon Report
96-2.9 1996 Juvenile Salmon Report
96-9 Aquatic Invertebrate Report
1997-2: 1997 Juvenile Salmon Report and Summary Update
1998-2: 1998 Juvenile Salmon Report and Summary Update
1999-4: 1999 Juvenile Salmon Report and Summary Update
2000-3: 2000 Seine/Snorkel Report and Summary Update
2001-3: 2001 Seine/Snorkel Report and Summary Update
2002-3: 2002 Seine/Snorkel Report and Summary Update
2003-2: 2003 Seine/Snorkel Report and Summary Update
2004-3: 2004 Seine/Snorkel Report and Summary Update
2005-3: 2005 Seine/Snorkel Report and Summary Update
2006-3: 2006 Seine/Snorkel Report and Summary Update
2007-3: 2007 Seine/Snorkel Report and Summary Update
2008-3: 2008 Seine Report and Summary Update
2008-5: 2008 Snorkel Report and Summary Update
2009-3: 2009 Seine Report and Summary Update
2009-5: 2009 Snorkel Report and Summary Update
2010-3: 2010 Seine Report and Summary Update
2010-5: 2010 Snorkel Report and Summary Update
2011-3: 2011 Seine Report and Summary Update

2011-5: 2011 Snorkel Report and Summary Update
2012-3: 2012 Seine Report and Summary Update
2012-5: 2012 Snorkel Report and Summary Update
2013-3: 2013 Seine Report and Summary Update
2013-5: 2013 Snorkel Report and Summary Update
2014-3: 2014 Seine Report and Summary Update
2014-5: 2014 Snorkel Report and Summary Update

Screw Trap Monitoring
1996-12: Screw Trap Monitoring Report: 1995-96
1997-3: 1997 Screw Trap and Smolt Monitoring Report
1998-3: 1998 Tuolumne River Outmigrant Trapping Report
1999-5: 1999 Tuolumne River Upper Rotary Screw Trap Report
2000-4: 2000 Tuolumne River Smolt Survival and Upper Screw Traps Report
2000-5: 1999-2000 Grayson Screw Trap Report
2001-4: 2001 Grayson Screw Trap Report
2004-4: 1998, 2002, and 2003 Grayson Screw Trap Reports
2004-5: 2004 Grayson Screw Trap Report
2005-4: 2005 Grayson Screw Trap Report
2005-5: Rotary Screw Trap Summary Update
2006-4: 2006 Rotary Screw Trap Report
2006-5: Rotary Screw Trap Summary Update
2007-4: 2007 Rotary Screw Trap Report
2008-4: 2008 Rotary Screw Trap Report
2009-4: 2009 Rotary Screw Trap Report
2010-4: 2010 Rotary Screw Trap Report
2011-4: 2011 Rotary Screw Trap Report
2012-4: 2012 Rotary Screw Trap Report
2013-4: 2013 Rotary Screw Trap Report
2014-4: 2014 Rotary Screw Trap Report

Fluctuation Assessments
1992 Appdx. 14: Fluctuation Flow Study Report
1992 Appdx. 15: Fluctuation Flow Study Plan: Draft
Report 2000-6: Tuolumne River Chinook Salmon Fry and Juvenile Stranding Report
2005 Ten-Year Summary Report Appdx. E: Stranding Survey Data (1996-2002)

Predation Evaluations
1992 Appdx. 22: Lower Tuolumne River Predation Study Report
1992 Appdx. 23: Effects of Turbidity on Bass Predation Efficiency
2006-9: Lower Tuolumne River Predation Assessment Final Report

Smolt Monitoring and Survival Evaluations
1992 Appdx. 21: Possible Effects of High Water Temperature on Migrating Salmon Smolts in the San Joaquin River
1996-13: Coded-wire Tag Summary Report
1998-4: 1998 Smolt Survival Peer Review Report

1998-5: CWT Summary Update
1999-7: Coded-wire Tag Summary Update
2000-4: 2000 Tuolumne River Smolt Survival and Upper Screw Traps Report
2000-8: Coded-wire Tag Summary Update
2001-5: Large CWT Smolt Survival Analysis
2001-6: Coded-wire Tag Summary Update
2002-4: Large CWT Smolt Survival Analysis
2002-5: Coded-wire Tag Summary Update
2003-3: Coded-wire Tag Summary Update
2004-7: Large CWT Smolt Survival Analysis Update
2004-8: Coded-wire Tag Summary Update
2005-6: Coded-wire Tag Summary Update
2006-6: Coded-wire Tag Summary Update
2007-5: Coded-wire Tag Summary Update

Fish Community Assessments

1992 Appdx. 24: Effects of Introduced Species of Fish in the San Joaquin River System
1992 Appdx. 27: Summer Flow Study Report 1988-90
Report 1996-3: Summer Flow Fish Study Annual Reports: 1991-94
96-3.1 1991 Report
96-3.2 1992 Report
96-3.3 1993 Report
96-3.4 1994 Report
2001-8: Distribution and Abundance of Fishes Publication
2002-9: Publication on the Effects of Flow on Fish Communities
2007-7: 2007 Rainbow Trout Data Summary Report
2008-6: 2008 July *Oncorhynchus mykiss* Population Estimate Report
2010 Tuolumne River *Oncorhynchus mykiss* Monitoring Report (submitted January 15)
Attachment 5: March and July 2009 Population Estimates of *Oncorhynchus mykiss* Report
2011 Tuolumne River *Oncorhynchus mykiss* Monitoring Summary Report (submitted January 15)
2010-6: 2010 *Oncorhynchus mykiss* Population Estimate Report
2010-7: 2010 *Oncorhynchus mykiss* Acoustic Tracking Report
2011-6: 2011 *Oncorhynchus mykiss* Population Estimate Report
2011-7: 2011 *Oncorhynchus mykiss* Acoustic Tracking Report

Invertebrate Reports

1992 Appdx. 16: Aquatic Invertebrate Studies Report
1992 Appdx. 28: Summer Flow Invertebrate Study
Report 1996-4: Summer Flow Aquatic Invertebrate Annual Reports: 1989-93
96-4.1 1989 Report
96-4.2 1990 Report
96-4.3 1991 Report
96-4.4 1992 Report
96-4.5 1993 Report
1996-9: Aquatic Invertebrate Report

2002-8: Aquatic Invertebrate Report
2004-9: Aquatic Invertebrate Monitoring Report (2003-2004)
2008-7: Aquatic Invertebrate Monitoring (2005, 2007, 2008) and Summary Update
2009-7: 2009 Aquatic Invertebrate Monitoring and Summary Update

Delta Salmon Salvage
1999-6: 1993-99 Delta Salmon Salvage Report

Gravel, Incubation, and Redd Distribution Studies
1992 Appdx. 6: Spawning Gravel Availability and Superimposition Report (incl. map)
1992 Appdx. 7: Salmon Redd Excavation Report
1992 Appdx. 8: Spawning Gravel Studies Report
1992 Appdx. 9: Spawning Gravel Cleaning Methodologies
1992 Appdx. 11: An Evaluation of the Effect of Gravel Ripping on Redd Distribution
1996-6: Redd Superimposition Report
1996-7: Redd Excavation Report
1996-8: Gravel Studies Report: 1987-89
1996-10: Gravel Cleaning Report: 1991-93
2000-7: Tuolumne River Substrate Permeability Assessment and Monitoring Program Report
2006-7: Survival to Emergence Study Report
2008-9: Monitoring of Winter 2008 Runoff Impacts from Peaslee Creek

Water Temperature and Water Quality
1992 Appdx. 17: Preliminary Tuolumne River Water Temperature Report
1992 Appdx. 18: Instream Temperature Model Documentation: Description and Calibration
1992 Appdx. 19: Modeled Effects of La Grange Releases on Instream Temperatures in the Lower Tuolumne River
1996-11: Intragravel Temperature Report: 1991
1997-5: 1987-97 Water Temperature Monitoring Data Report
2002-7: 1998-2002 Temperature and Conductivity Data Report
2004-10: 2004 Water Quality Report
2007-6: Flow, Delta Export, Weather, and Water Quality Data Report: 2003-2007

IFIM Assessment
1992 Appdx. 4: Instream Flow Data Processing, Tuolumne River
1992 Appdx. 5: Analysis of 1981 Lower Tuolumne River IFIM Data
1995 USFWS Report on the Relationship between Instream Flow and Physical Habitat Availability (submitted by Districts to FERC in May 2004)

Flow and Delta Exports
1997-4: Streamflow and Delta Water Export Data Report
2002-6: 1998-2002 Streamflow and Delta Water Export Data Report
2003-4: Review of 2003 Summer Flow Operation
2007-6: Flow, Delta Export, Weather, and Water Quality Data Report: 2003-2007
2008-8: Review of 2008 Summer Flow Operation
2009-6: Review of 2009 Summer Flow Operation

Restoration, Project Monitoring, and Mapping

1996-14: Tuolumne River GIS Database Report and Map
1999-8: A Summary of the Habitat Restoration Plan for the Lower Tuolumne River Corridor
1999-9: Habitat Restoration Plan for the Lower Tuolumne River Corridor
1999-10: 1998 Restoration Project Monitoring Report
1999-11: 1999 Restoration Project Monitoring Report
2001-7: Adaptive Management Forum Report
2004-12: Coarse Sediment Management Plan
2004-13: Tuolumne River Floodway Restoration (Design Manual)
2005 Ten-Year Summary Report Appdx. D: Salmonid Habitat Maps
2005 Ten-Year Summary Report Appdx. F: GIS Mapping Products
2005-7: Bobcat Flat/River Mile 43: Phase 1 Project Completion Report
2006-8: Special Run Pool 9 and 7/11 Reach: Post-Project Monitoring Synthesis Report
2006-10: Tuolumne River La Grange Gravel Addition, Phase II Annual Report
2006-11: Tuolumne River La Grange Gravel Addition, Phase II Geomorphic Monitoring Report

General Monitoring Information

1992 Fisheries Studies Report
2002-10: 2001-2002 Annual CDFG Sportfish Restoration Report
2005 Ten-Year Summary Report

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Exhibits

1. Spawning run estimates
   1.1. San Joaquin River tributary estimates
   1.2. Other Central Valley Fall-run estimates
2. Salmon harvest and Sacramento abundance data
   2.1. California Chinook ocean harvest
   2.2. Sacramento River Fall-run Estimates
   2.3. Abundance Index and Harvest Rates
3. January-June 2014 Basin salmon rearing/outmigration data
   3.1. Tributary screw trap catches and San Joaquin River (Mossdale) trawl catch
   3.2. Average size in catch and delta salvage
   3.3. Mossdale catch individual size and mark
4. January-June 2014 delta salmon salvage data, water exports, and basin flows
   4.1. Table of weekly salvage and flow/export data
   4.2. Graphs of estimated salvage/loss numbers and density (relative abundance)
   4.3. Weekly average flow and exports
   4.4. Size and hatchery origin of delta salvage
   4.5. Daily San Joaquin Basin flows and rainfall

Exhibit 1 – Spawning run estimates

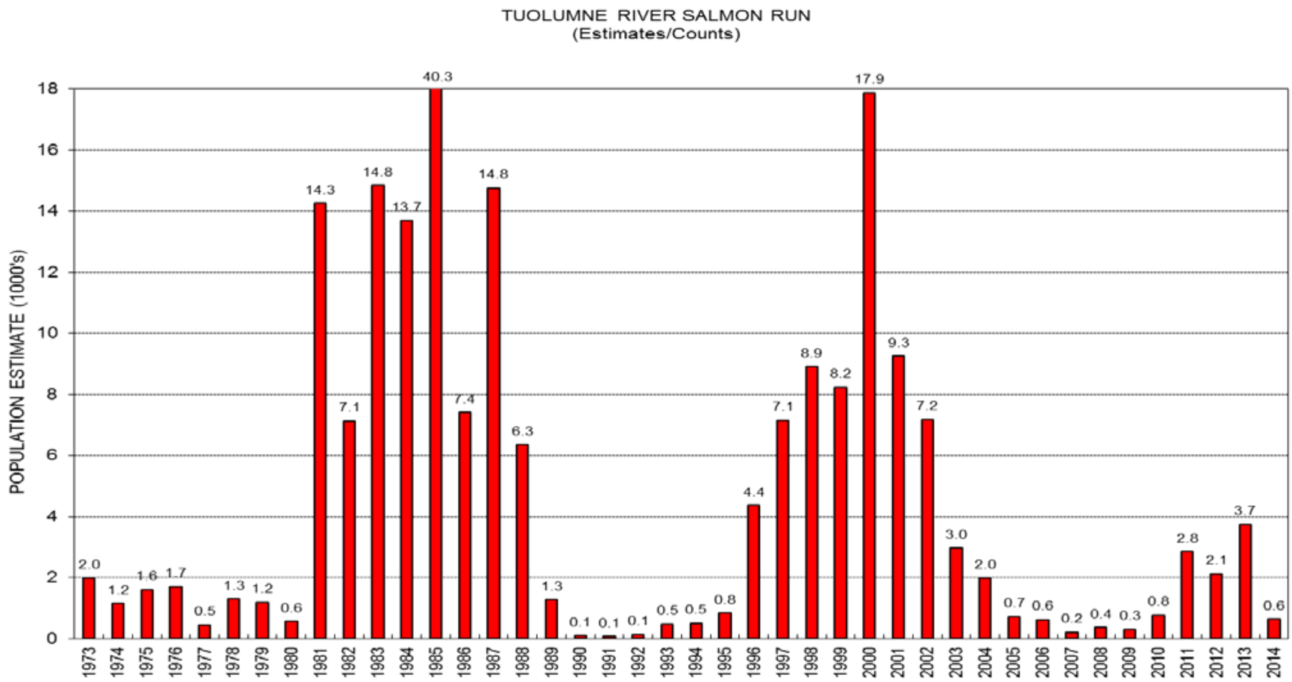


Exhibit 1A Years 2009-2014 are based on counting weir results. All previous years from CDFW surveys. Survey periods may vary over the years for both methods.

San Joaquin River Tributaries Fall-run Salmon Estimates – Hatcheries are on Merced and Mokelumne (Mokelumne is an Eastside Delta tributary)

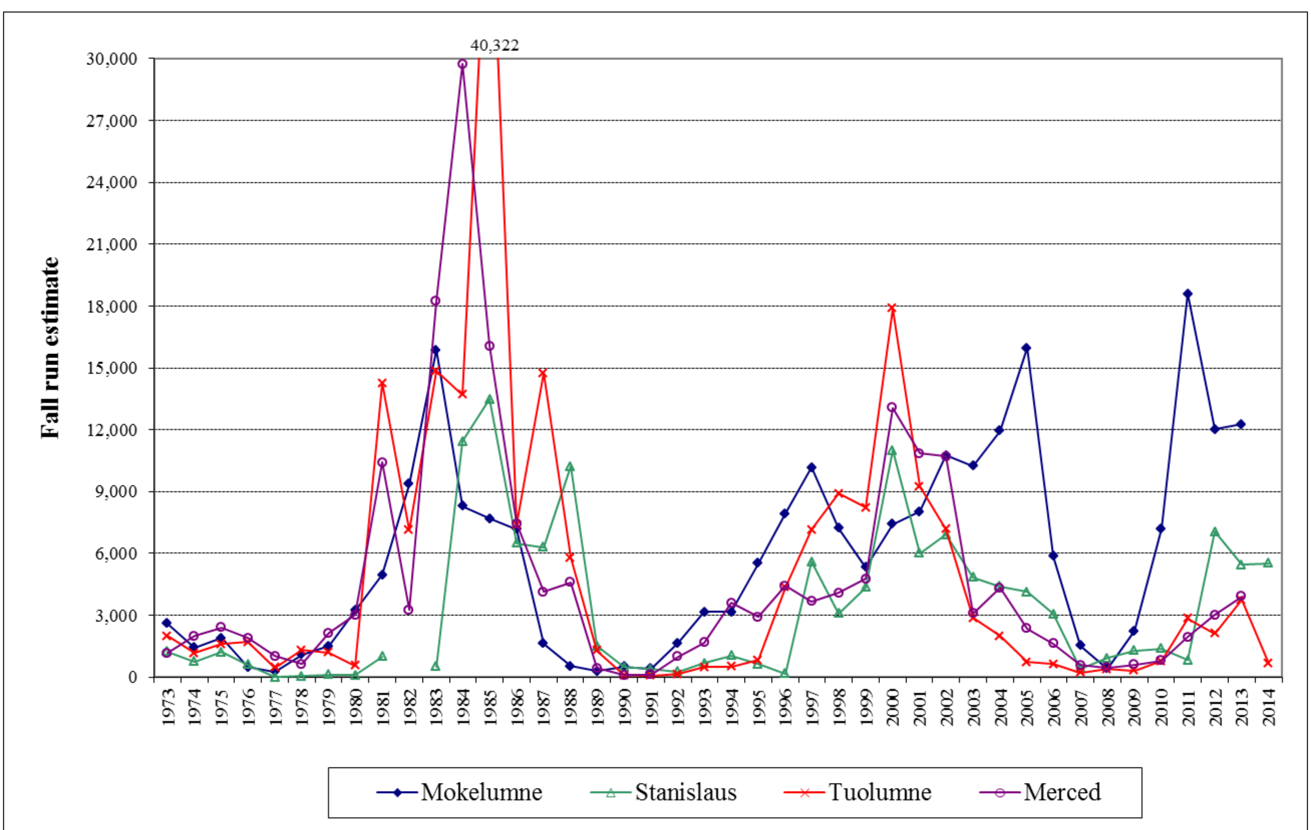


Exhibit 1B [2014 data for Mokelumne and Merced Rivers not available as of March 2015.]

Some Fall-run salmon rivers in Sacramento Basin
(Yuba River does not have a hatchery)

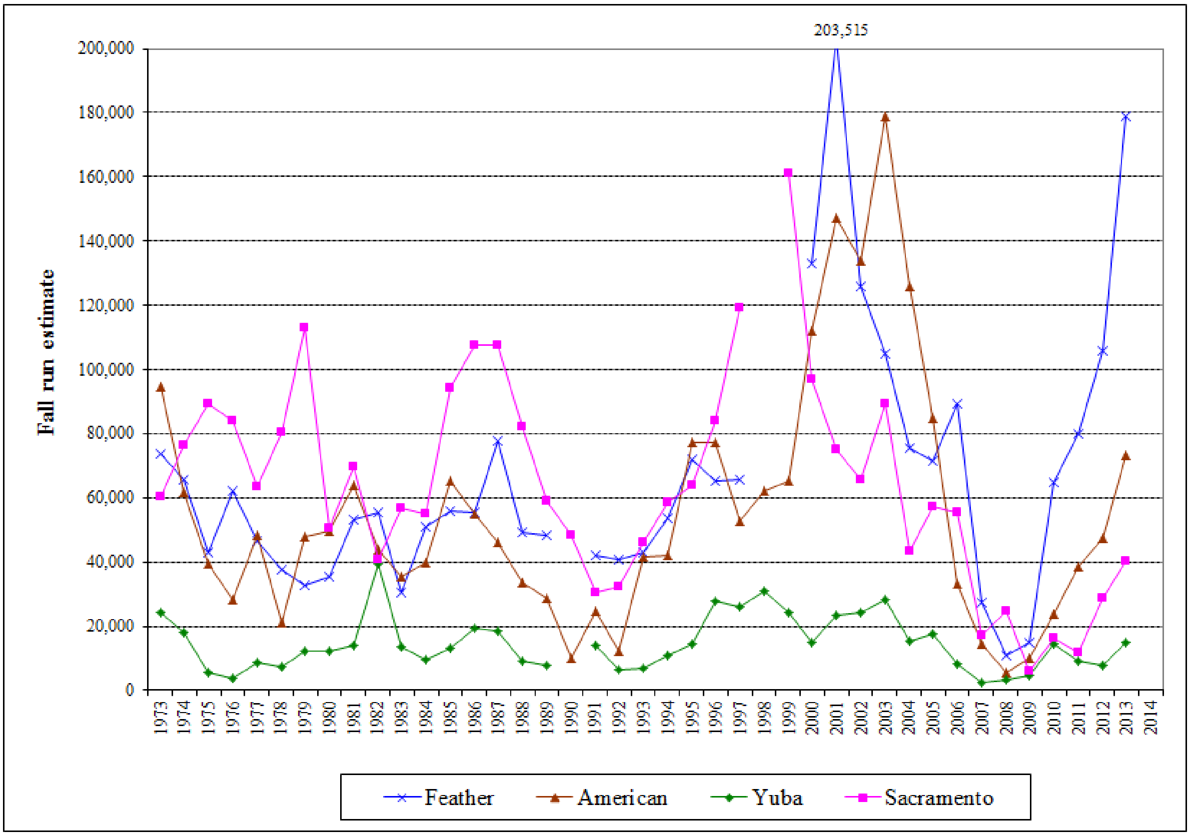


Exhibit 1C [2014 data not available as of March 2015]

Combined Natural Spawning and Hatchery Fall-run Total Since 1973

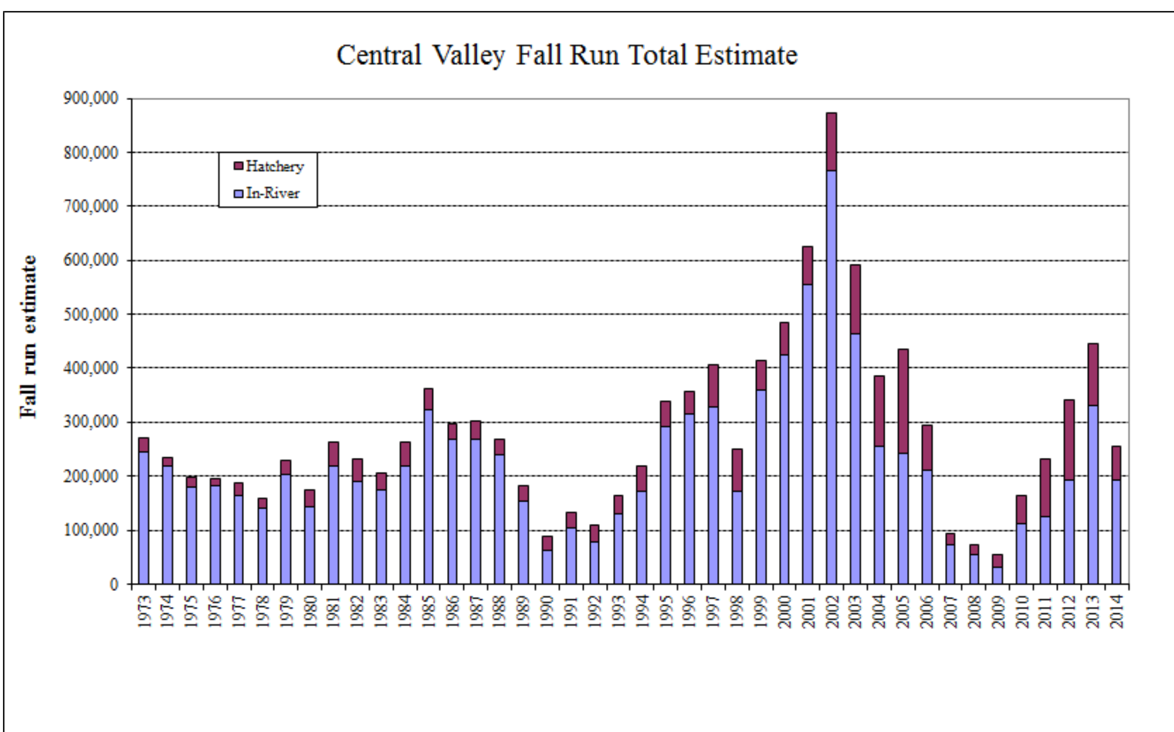


Exhibit 1D [2014 data from PFMC (2015a)]

Exhibit 2 – Salmon harvest and Sacramento abundance data

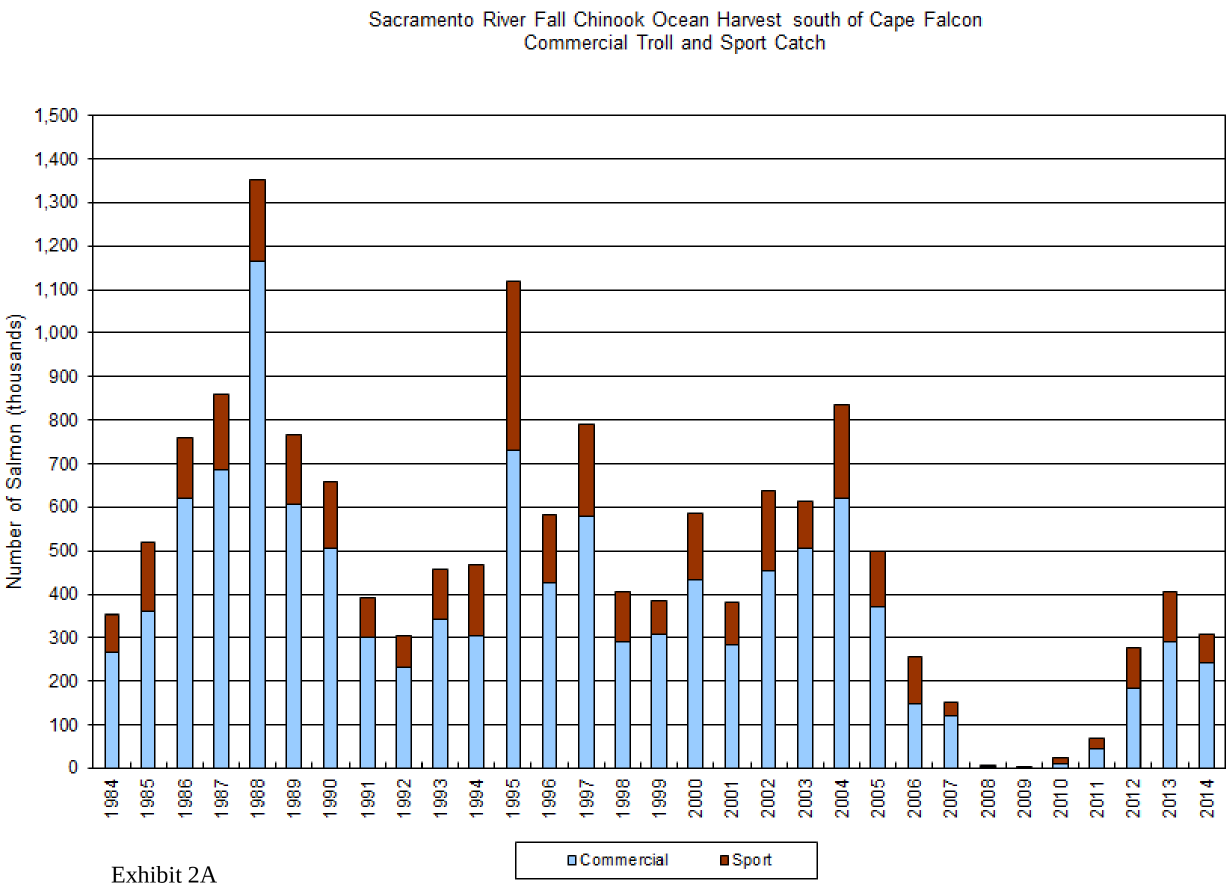


Exhibit 2A

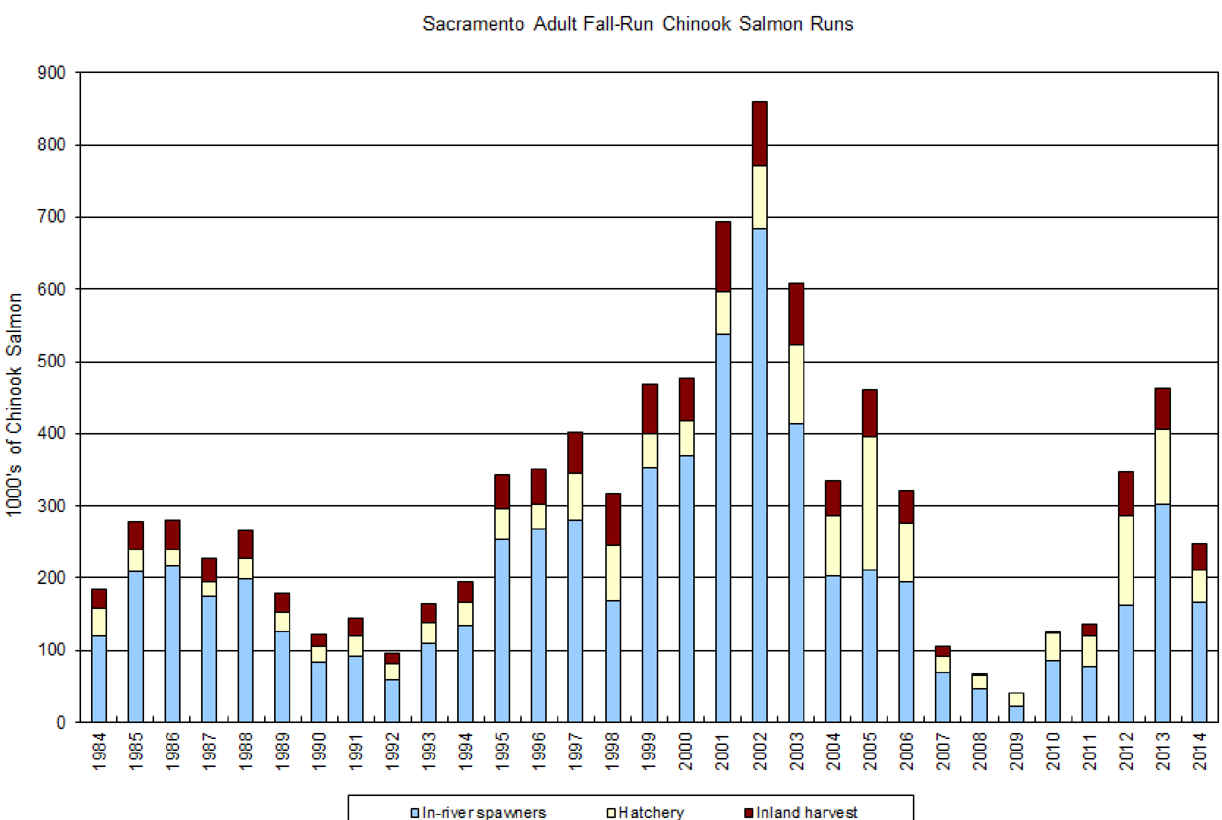


Exhibit 2B

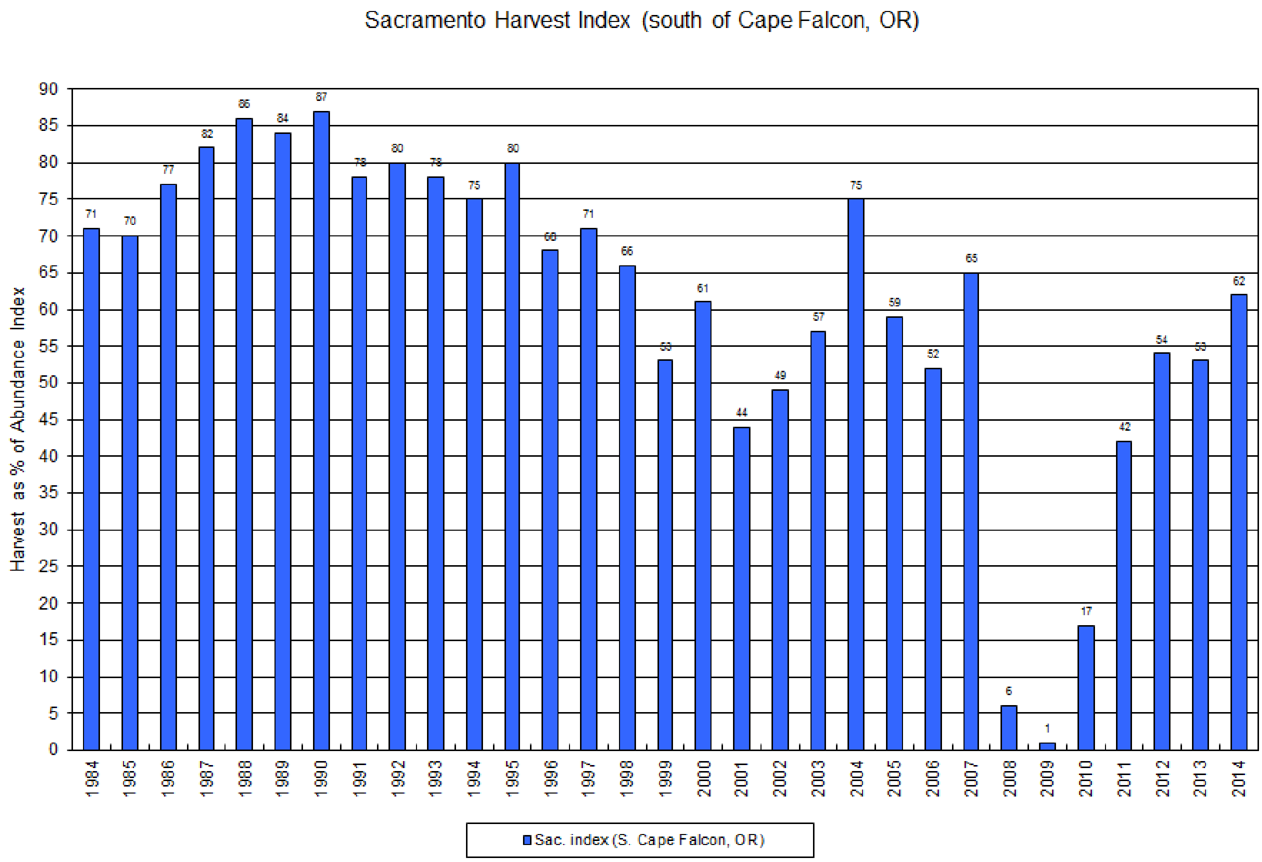


Exhibit 2C

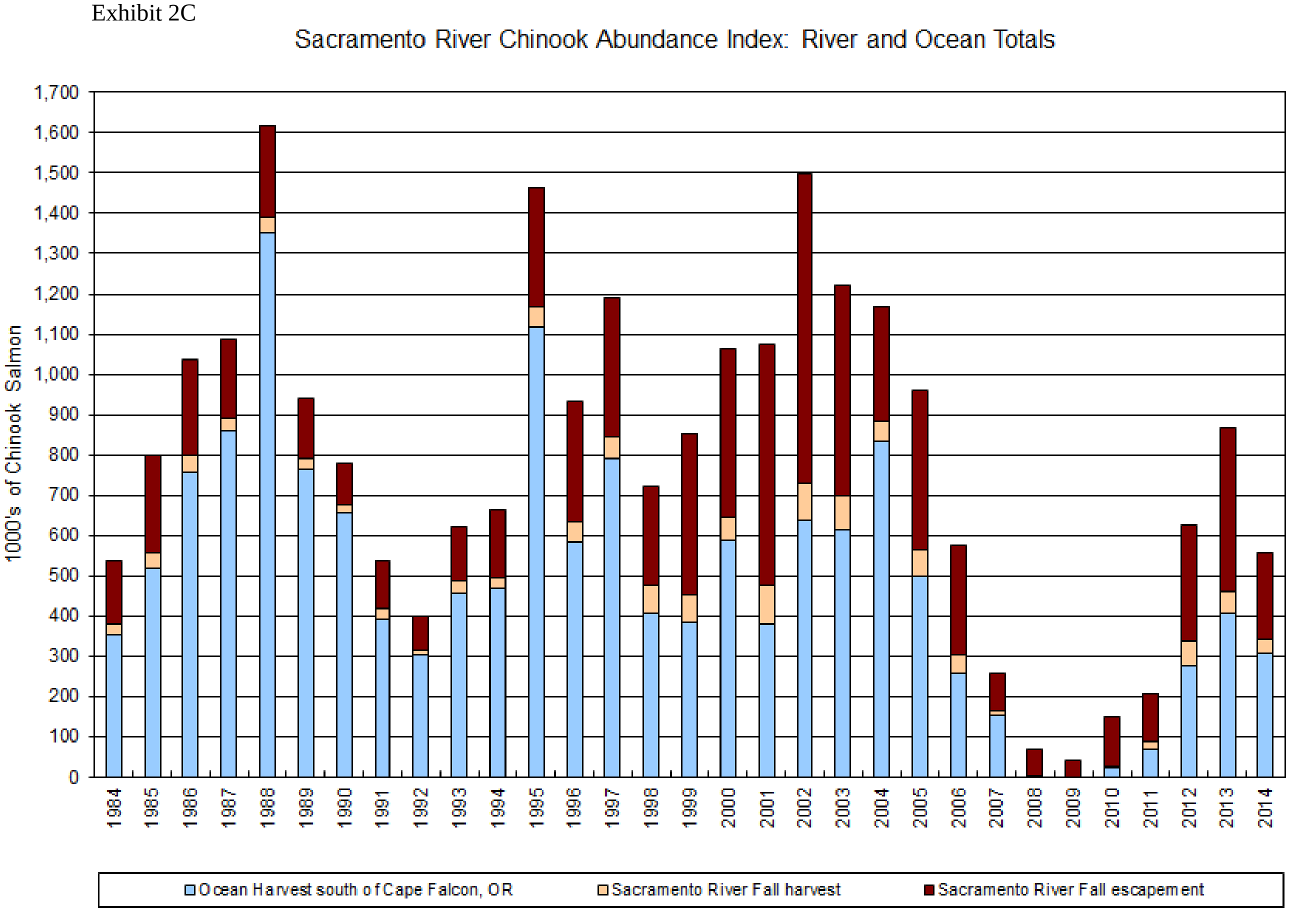


Exhibit 2D

Exhibit 3 – January-June 2013 Basin salmon rearing/outmigration data

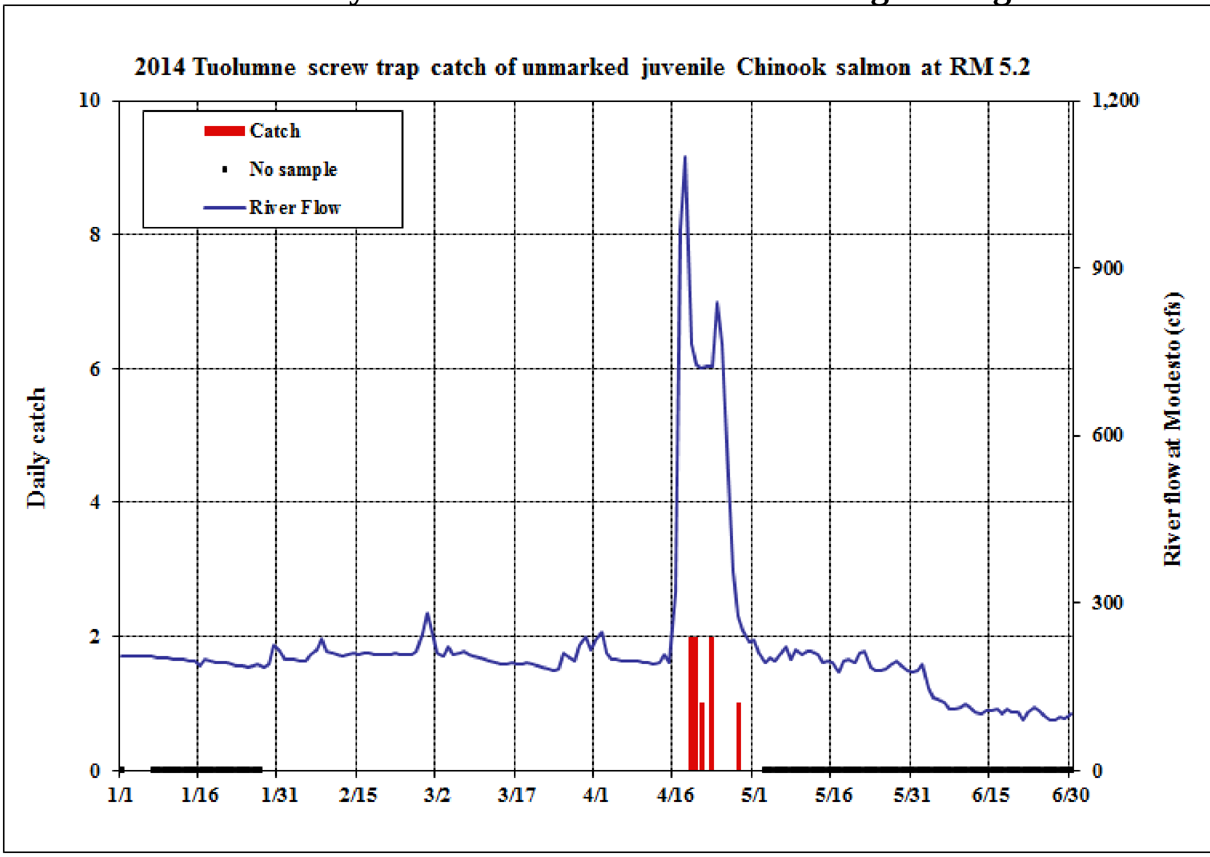


Exhibit 3A

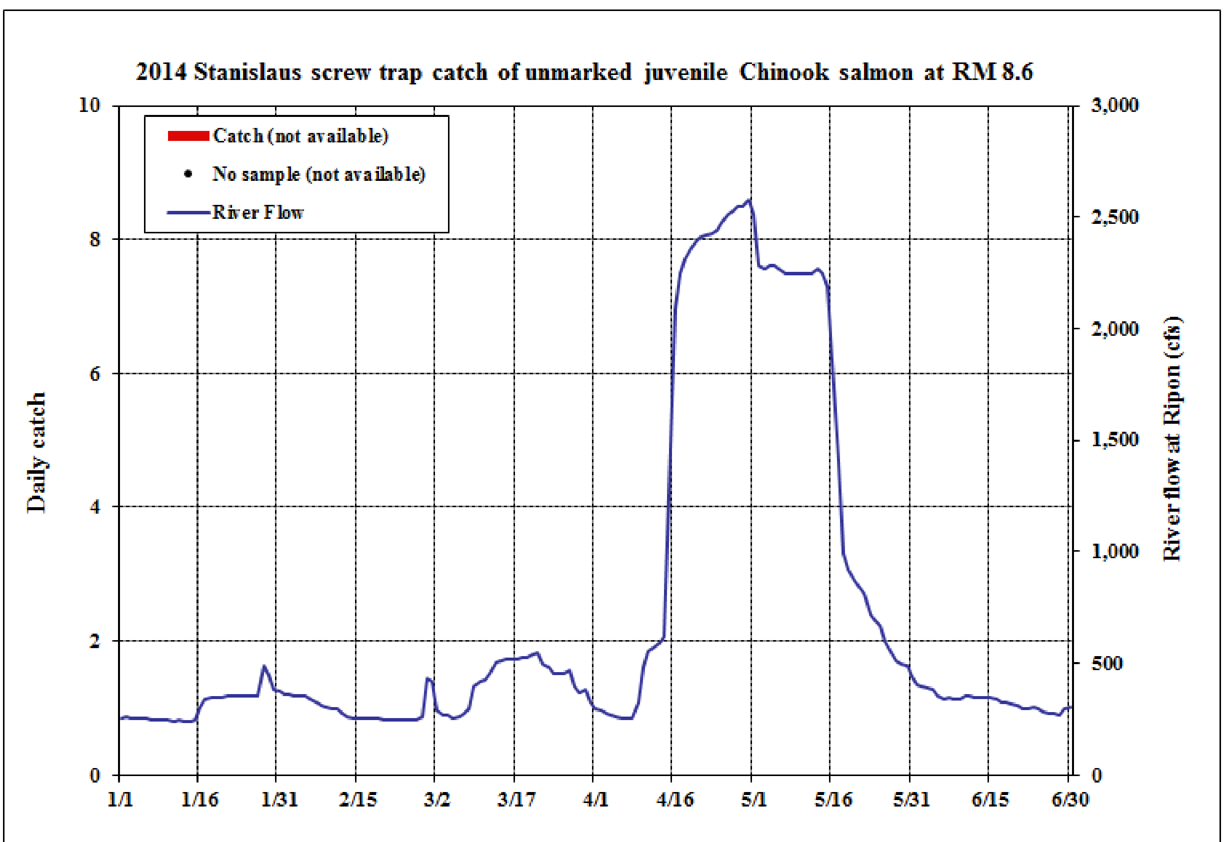


Exhibit 3B

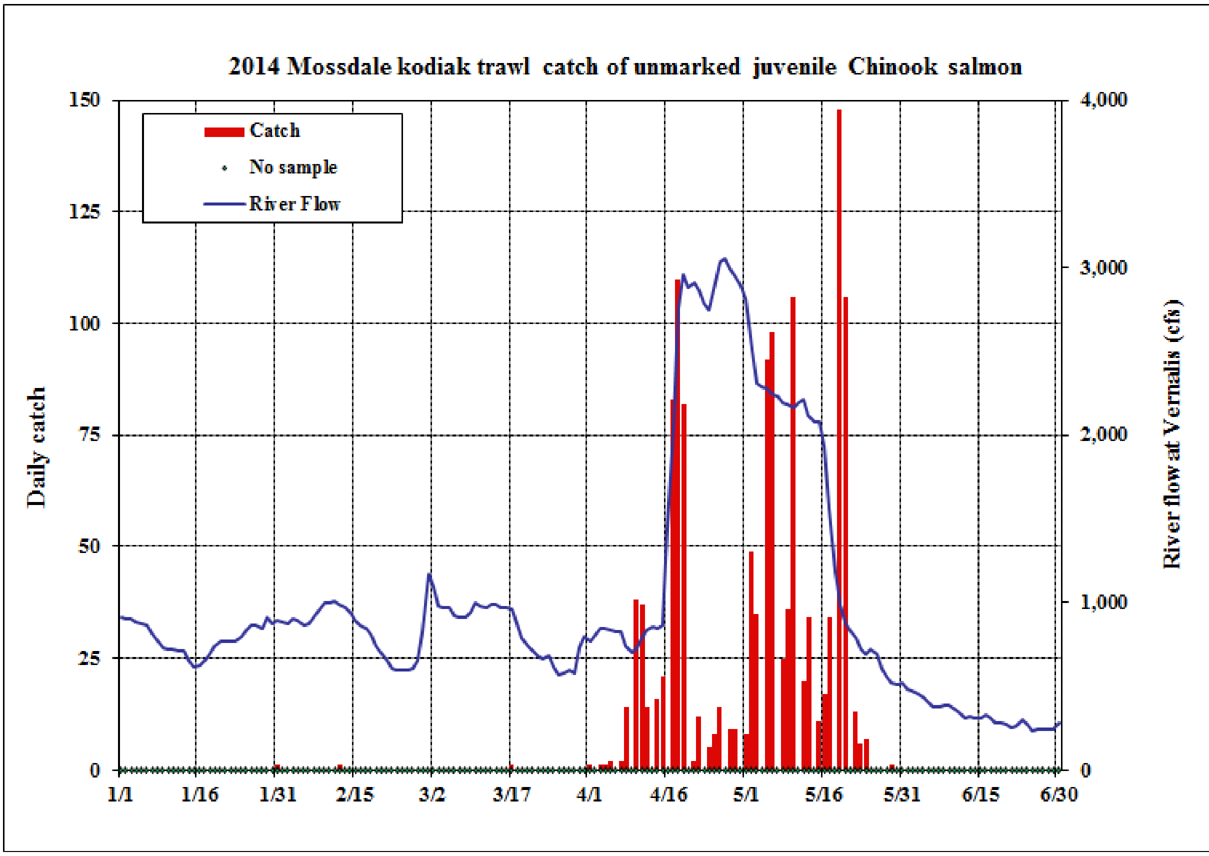

2014 Mossdale kodiak trawl catch of unmarked juvenile Chinook salmon
Catch
No sample
River Flow
Daily catch
River flow at Vernalis (cfs)
150
125
100
75
50
25
0
4,000
3,000
2,000
1,000
0
1/1
1/16
1/31
2/15
3/2
3/17
4/1
4/16
5/1
5/16
5/31
6/15
6/30

Exhibit 3C

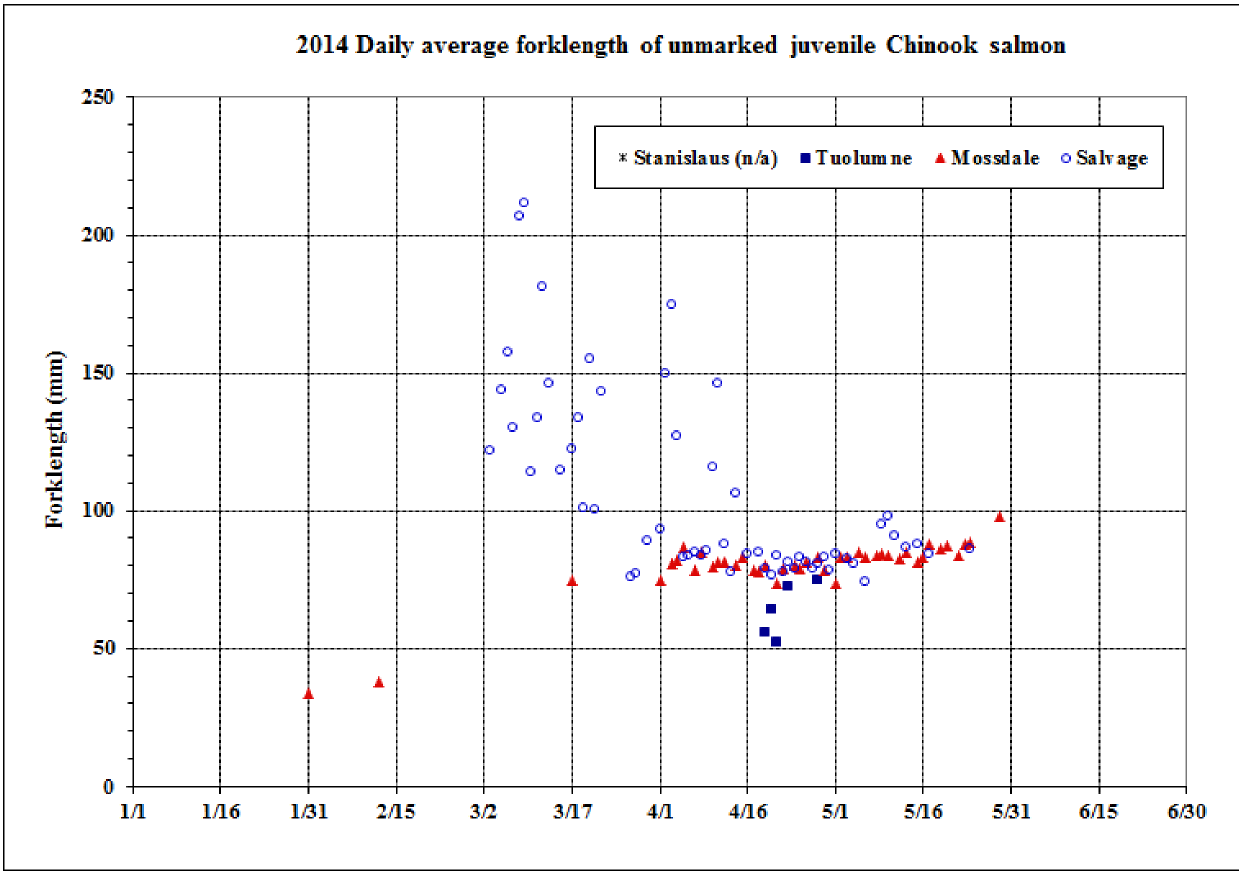


Exhibit 3D

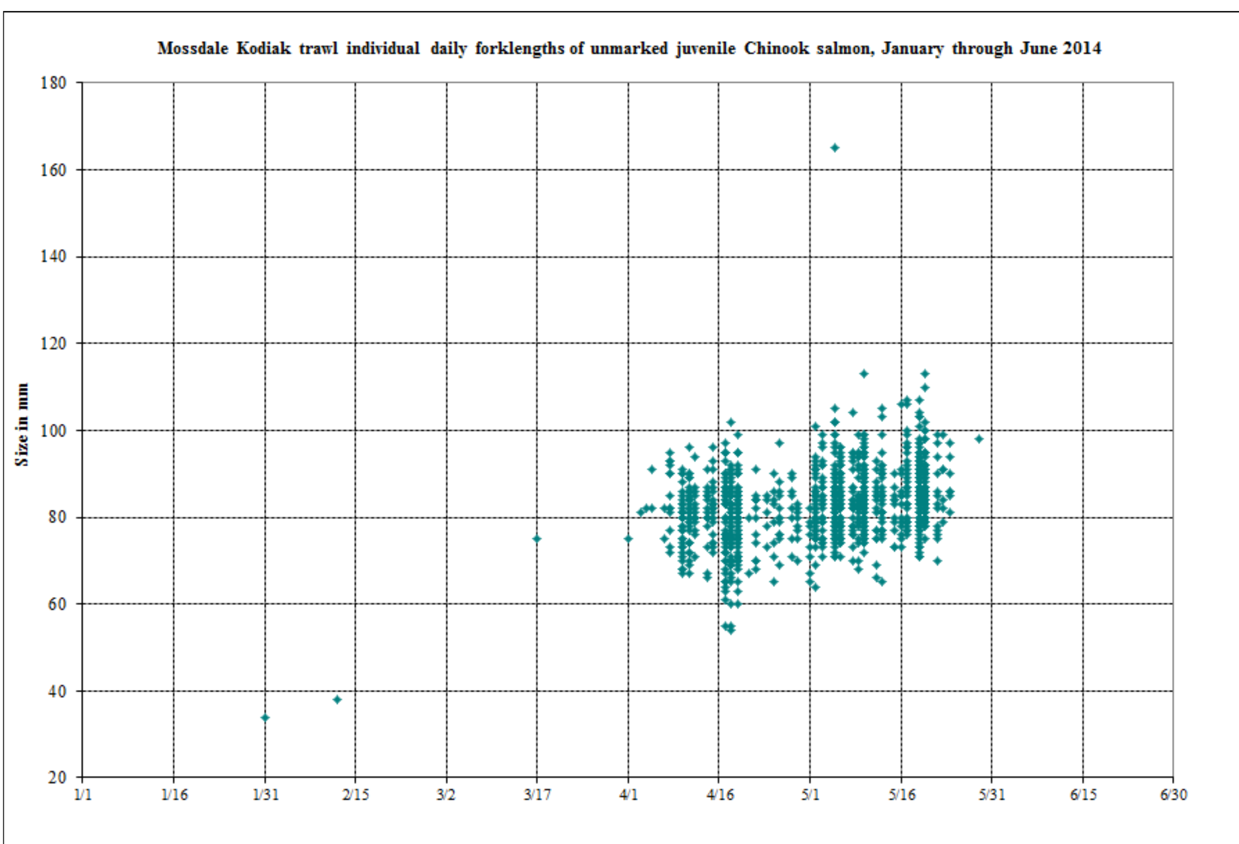


Exhibit 3E

Exhibit 4 – January-June 2014 Delta salmon salvage data, water exports and basin flows

STATE WATER PROJECT							SWP	SWP	CVP&SWP
week ending							Expanded	Combined	average
date	Total chinook salvage			Combined	Ave. cfs	Acre ft.	salvage /	salvage & loss	export rate
	Observed	Exp.Salvage	Est. Loss	salvage & loss	Export	Export	1,000 ac.ft.	per 1,000 ac.ft.	(cfs)
01/07/14	0	0	0	0	1,281	17,788	0.0	0.0	2,081
01/14/14	0	0	0	0	748	10,379	0.0	0.0	1,546
01/21/14	0	0	0	0	1,399	19,423	0.0	0.0	1,410
01/28/14	0	0	0	0	1,074	14,908	0.0	0.0	1,286
02/04/14	0	0	0	0	280	3,883	0.0	0.0	533
02/11/14	0	0	0	0	517	7,180	0.0	0.0	1,119
02/18/14	0	0	0	0	3,097	42,991	0.0	0.0	5,646
02/25/14	0	0	0	0	904	12,546	0.0	0.0	2,430
03/04/14	0	0	0	0	1,484	20,603	0.0	0.0	2,803
03/11/14	0	0	0	0	3,221	44,715	0.0	0.0	6,446
03/18/14	0	0	0	0	2,913	40,433	0.0	0.0	6,110
03/25/14	0	0	0	0	1,034	14,357	0.0	0.0	2,684
04/01/14	0	0	0	0	707	9,818	0.0	0.0	1,826
04/08/14	0	0	0	0	1,239	17,205	0.0	0.0	5,453
04/15/14	0	0	0	0	369	5,120	0.0	0.0	3,965
04/22/14	0	0	0	0	427	5,933	0.0	0.0	2,360
04/29/14	0	0	0	0	298	4,141	0.0	0.0	2,797
05/06/14	0	0	0	0	507	7,036	0.0	0.0	2,180
05/13/14	2	4	16	20	220	3,054	1.3	6.5	1,219
05/20/14	0	0	0	0	181	2,518	0.0	0.0	1,083
05/27/14	0	0	0	0	210	2,913	0.0	0.0	1,019
06/03/14	0	0	0	0	190	2,631	0.0	0.0	1,005
06/10/14	0	0	0	0	487	6,754	0.0	0.0	932
06/17/14	0	0	0	0	652	9,048	0.0	0.0	652
06/24/14	0	0	0	0	627	8,699	0.0	0.0	628
07/01/14	0	0	0	0	559	7,757	0.0	0.0	950
Total & avg	**2**	**4**	**16**	**20**	**947**	**341,835**	**0.1**	**6.5**	**2,314**
CENTRAL VALLEY PROJECT							CVP	CVP	
week ending							Expanded	Combined	Vernalis
date	Total chinook salvage			Combined	Ave. cfs	Acre ft.	salvage/	salvage & loss	flow
	Observed	Expanded	Est. Loss	salvage & loss	Export	Export	1,000 ac.ft.	per 1,000 ac.ft.	(cfs)
01/07/14	0	0	0	0	799	11,095	0.0	0.0	880
01/14/14	0	0	0	0	798	11,075	0.0	0.0	718
01/21/14	0	0	0	0	10	143	0.0	0.0	694
01/28/14	0	0	0	0	212	2,943	0.0	0.0	821
02/04/14	0	0	0	0	253	3,512	0.0	0.0	888
02/11/14	0	0	0	0	602	8,352	0.0	0.0	944
02/18/14	0	0	0	0	2,549	35,387	0.0	0.0	900
02/25/14	0	0	0	0	1,526	21,182	0.0	0.0	641
03/04/14	0	0	0	0	1,319	18,309	0.0	0.0	898
03/11/14	0	0	0	0	3,225	44,766	0.0	0.0	947
03/18/14	2	8	5	13	3,197	44,374	0.2	0.3	958
03/25/14	3	12	8	20	1,650	22,904	0.5	0.9	696
04/01/14	1	4	3	7	1,119	15,527	0.3	0.5	661
04/08/14	0	0	0	0	4,214	58,493	0.0	0.0	818
04/15/14	4	12	7	19	3,596	49,918	0.2	0.4	803
04/22/14	38	104	77	181	1,932	26,822	3.9	6.7	2,554
04/29/14	97	277	191	468	2,499	34,685	8.0	13.5	2,924
05/06/14	34	91	67	158	1,673	23,225	3.9	6.8	2,476
05/13/14	4	8	7	15	999	13,863	0.6	1.0	2,183
05/20/14	10	20	16	36	901	12,513	1.6	2.9	1,528
05/27/14	2	4	3	7	809	11,234	0.4	0.6	720
06/03/14	0	0	0	0	816	11,321	0.0	0.0	500
06/10/14	0	0	0	0	445	6,183	0.0	0.0	390
06/17/14	0	0	0	0	0	1	0.0	0.0	318
06/24/14	0	0	0	0	2	22	0.0	0.0	275
07/01/14	0	0	0	0	391	5,427	0.0	0.0	249
Total & avg	**195**	**540**	**385**	**925**	**1,367**	**493,275**	**0.8**	**33.7**	**1,015**

Exhibit 4A

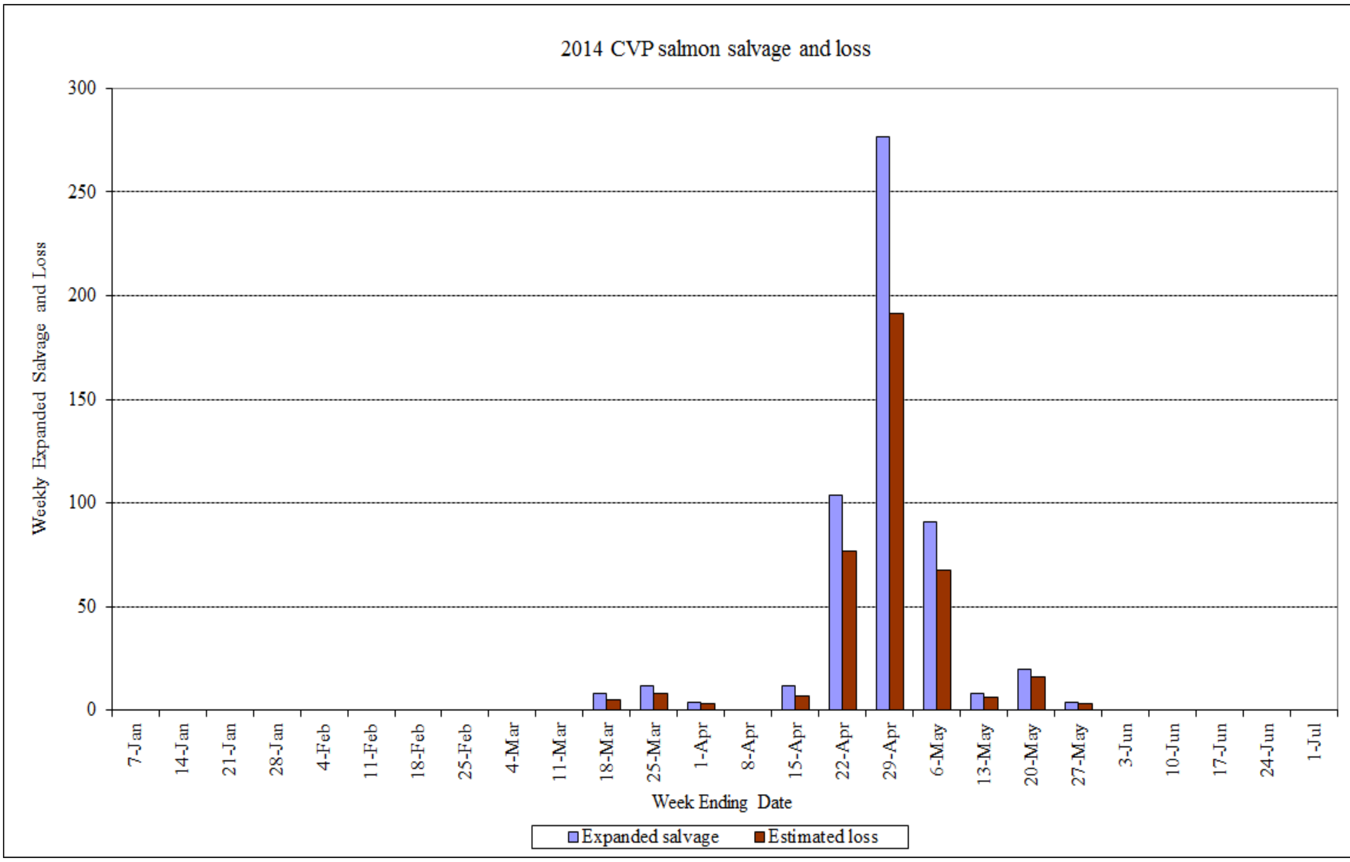


Exhibit 4B

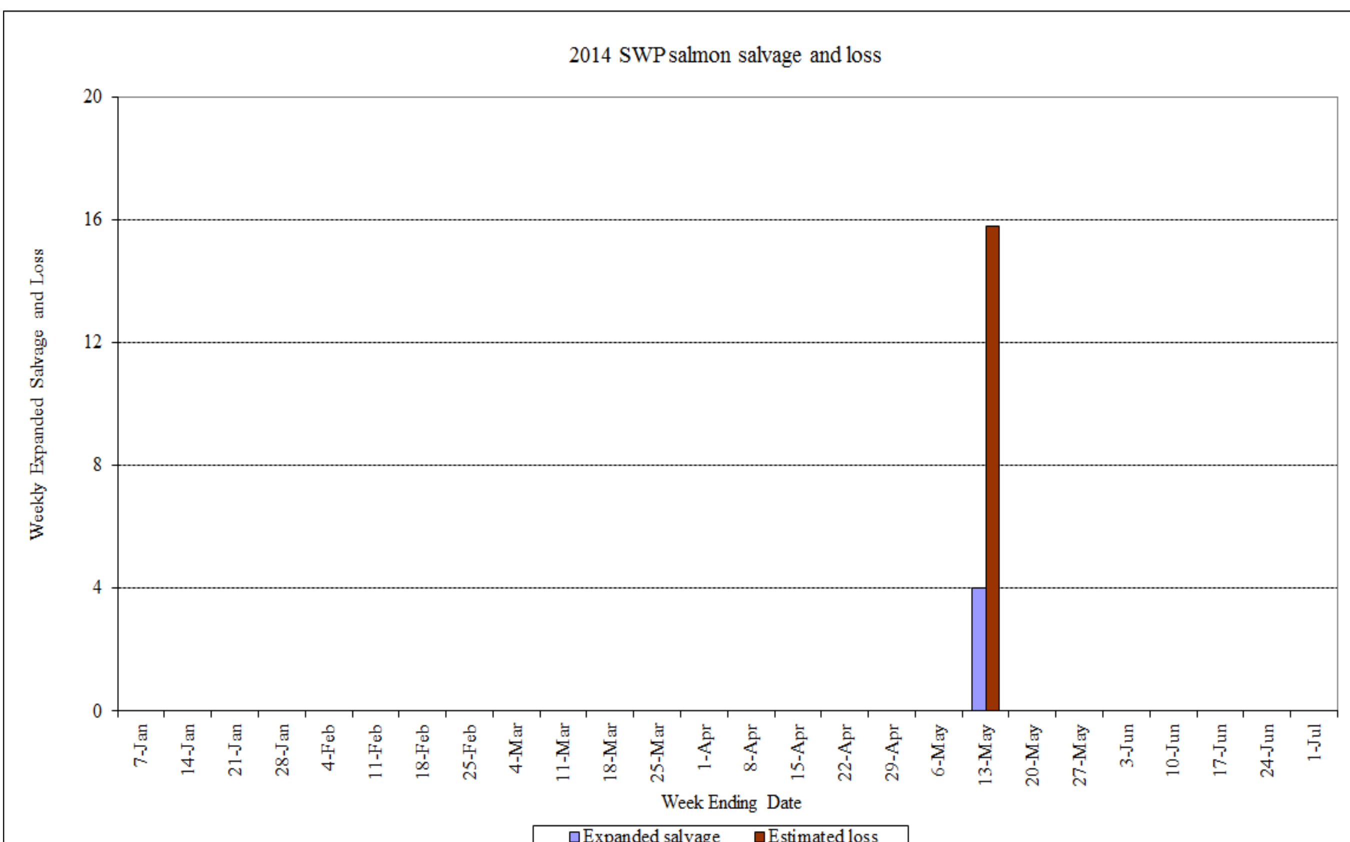


Exhibit 4C

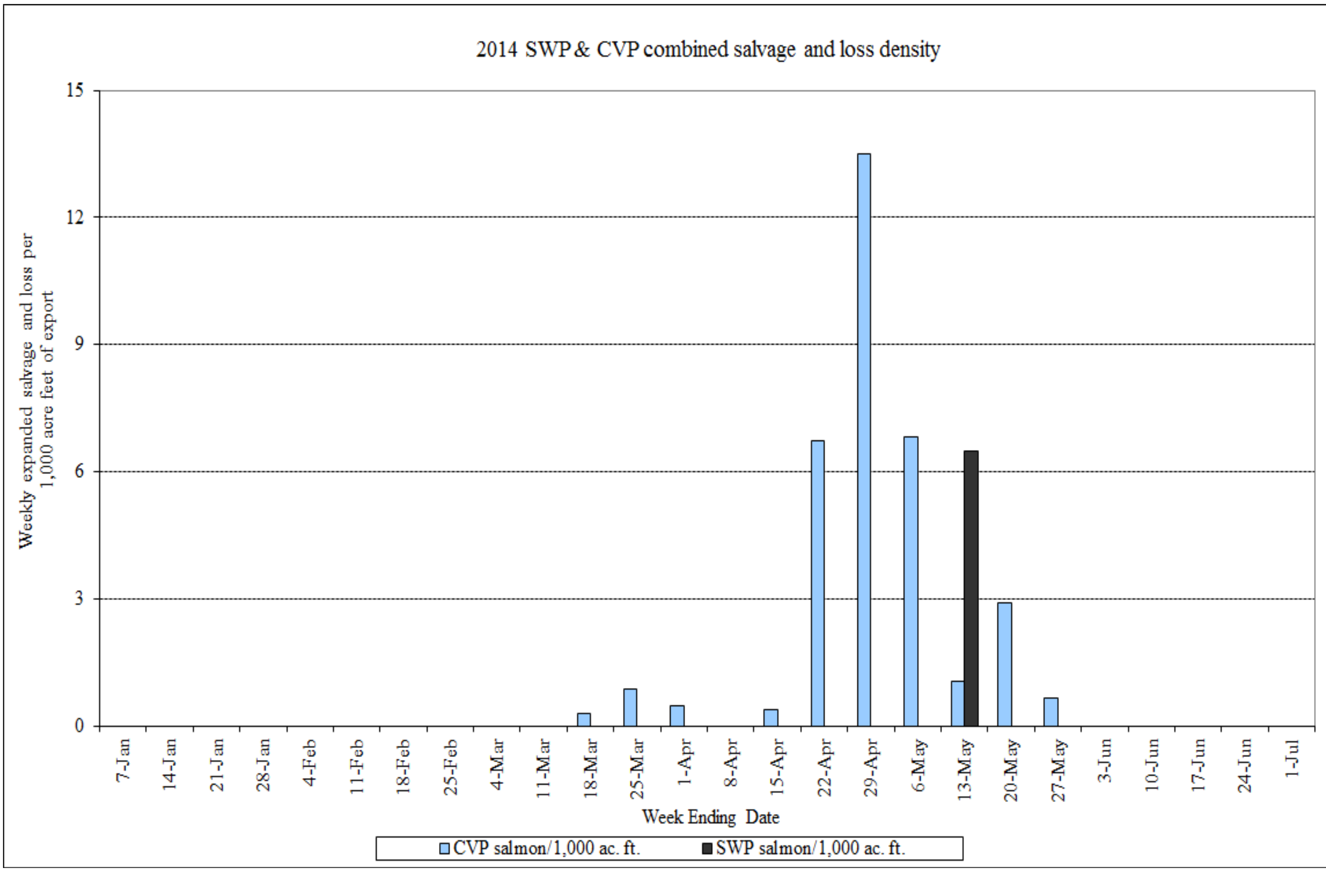


Exhibit 4D

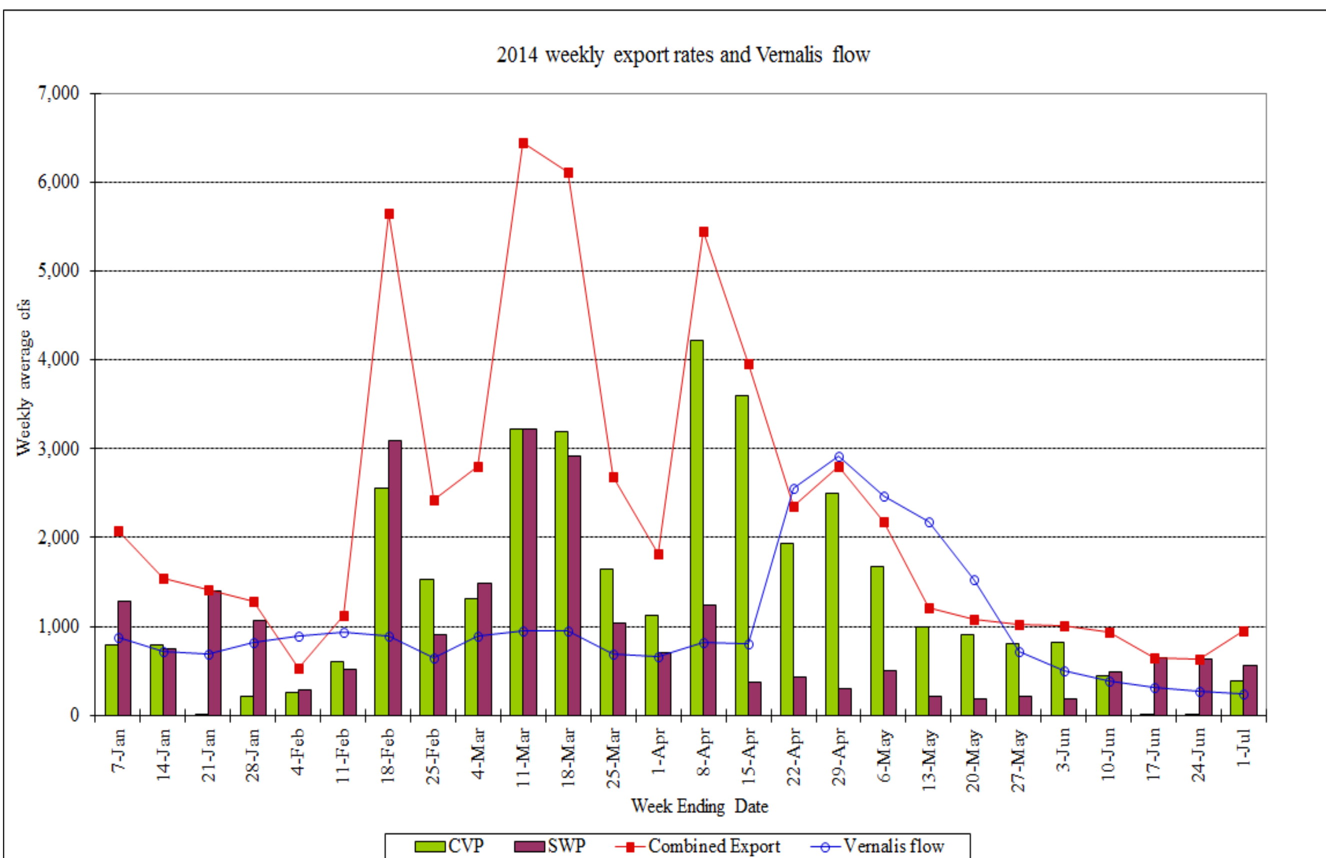
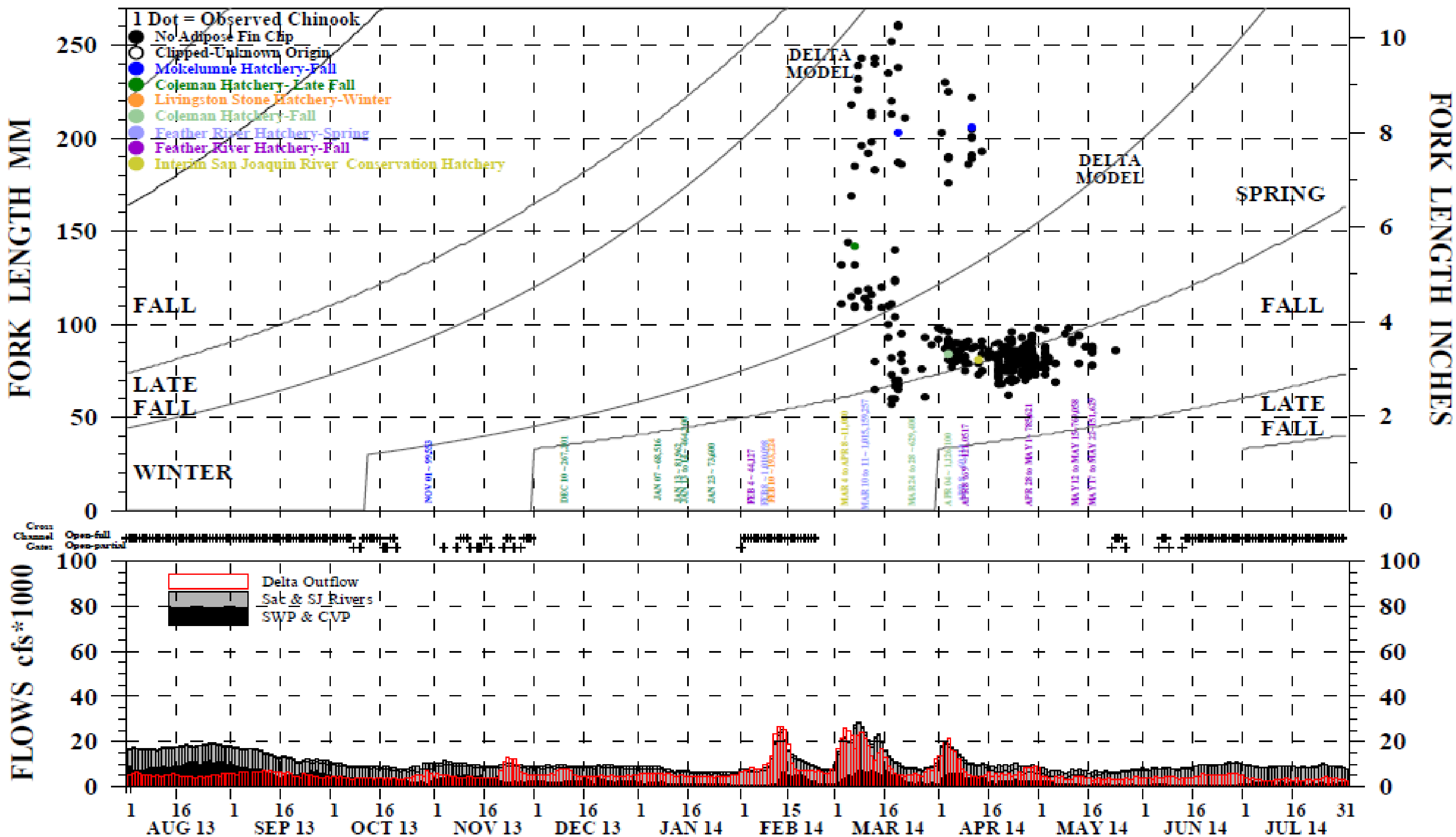


Exhibit 4E

OBSERVED CHINOOK SALVAGE AT THE SWP & CVP

DELTA FISH FACILITIES 8/1/2013 THROUGH 7/31/2014



Note: Chinook not measured for length and Chinook outside of the length-at-date criteria (Delta Model) are not reported.

Exhibit 4F

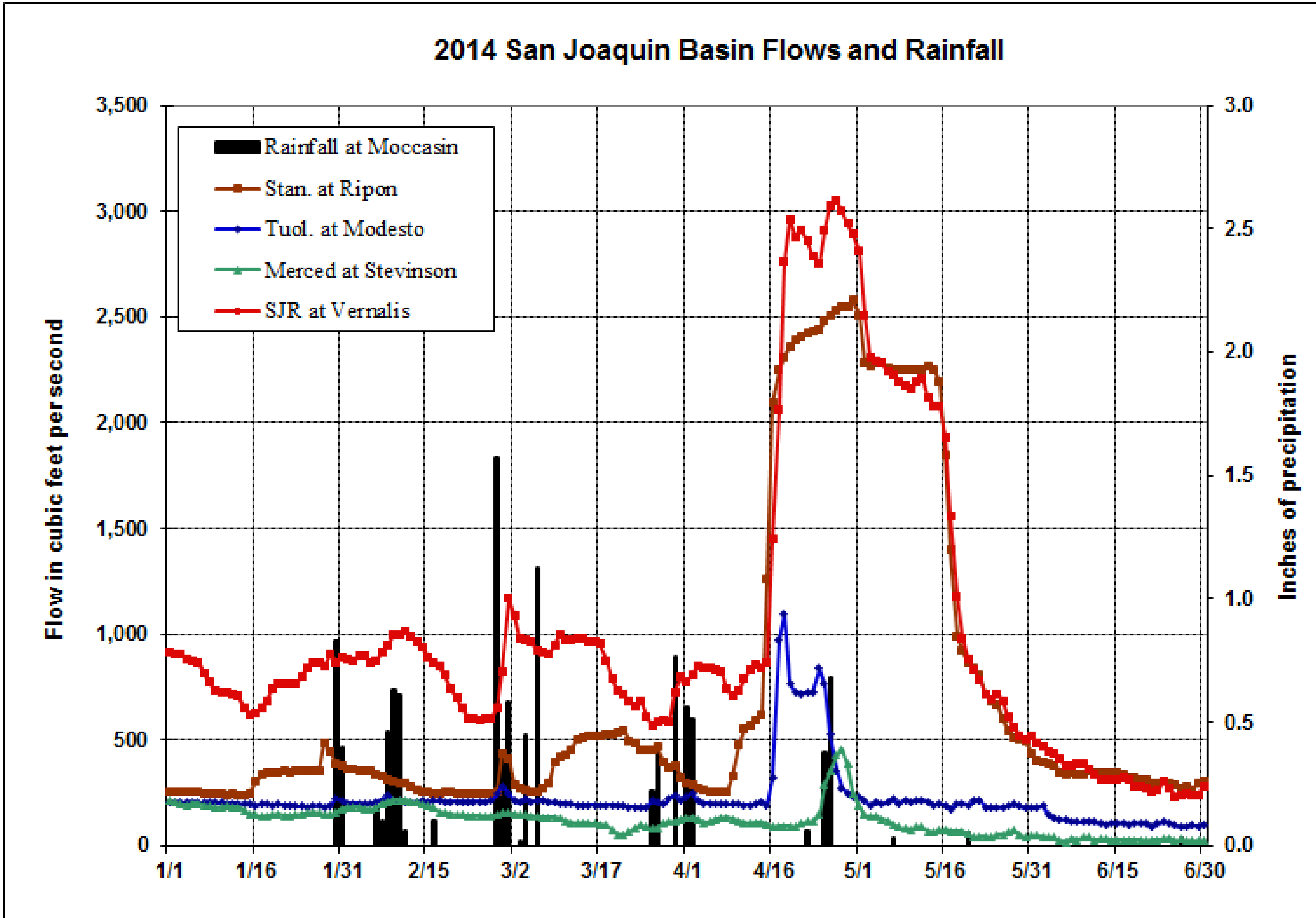

2014 San Joaquin Basin Flows and Rainfall
Rainfall at Moccasin
Stan. at Ripon
Tuol. at Modesto
Merced at Stevinson
SJR at Vernalis
Flow in cubic feet per second
Inches of precipitation
3,500
3,000
2,500
2,000
1,500
1,000
500
0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/1
1/16
1/31
2/15
3/2
3/17
4/1
4/16
5/1
5/16
5/31
6/15
6/30

Exhibit 4G

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Attachment -A-

Water, Flows, Temperature, and Flow Schedule Correspondence

1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data
   - 1.1. 2014/2015 Water Years (Oct-Sep) daily average computed natural flow, actual flow, and FERC flow schedule at La Grange
   - 1.2. 2014/2015 Water Years actual flow: Tuolumne at Modesto, Stanislaus at Ripon, Merced nr Stevinson, and San Joaquin at Fremont Ford and at Vernalis. San Joaquin at Vernalis and combined CVP and SWP exports, San Joaquin at Vernalis minus combined CVP and SWP exports.
   - 1.3. Required flow volume forecasts and final amount
   - 1.4. 2014/2015 Water Years Don Pedro Reservoir storage
   - 1.5. 2014/2015 Precipitation Years (Sep-Aug) watershed precipitation index and snow sensor water content index as percent of average.
2. Graphs of water temperature and air temperature
   - 2.1. Water Year 2014 daily water temperature for Tuolumne and San Joaquin Rivers
   - 2.2. Modesto air temperature for Water Year 2014
   - 2.3. Modesto air temperature for Water Year 2015
3. Flow schedule correspondence for 2014
   - 3.1. April 8, 2014 – 2014-2015 Minimum Flow Requirement

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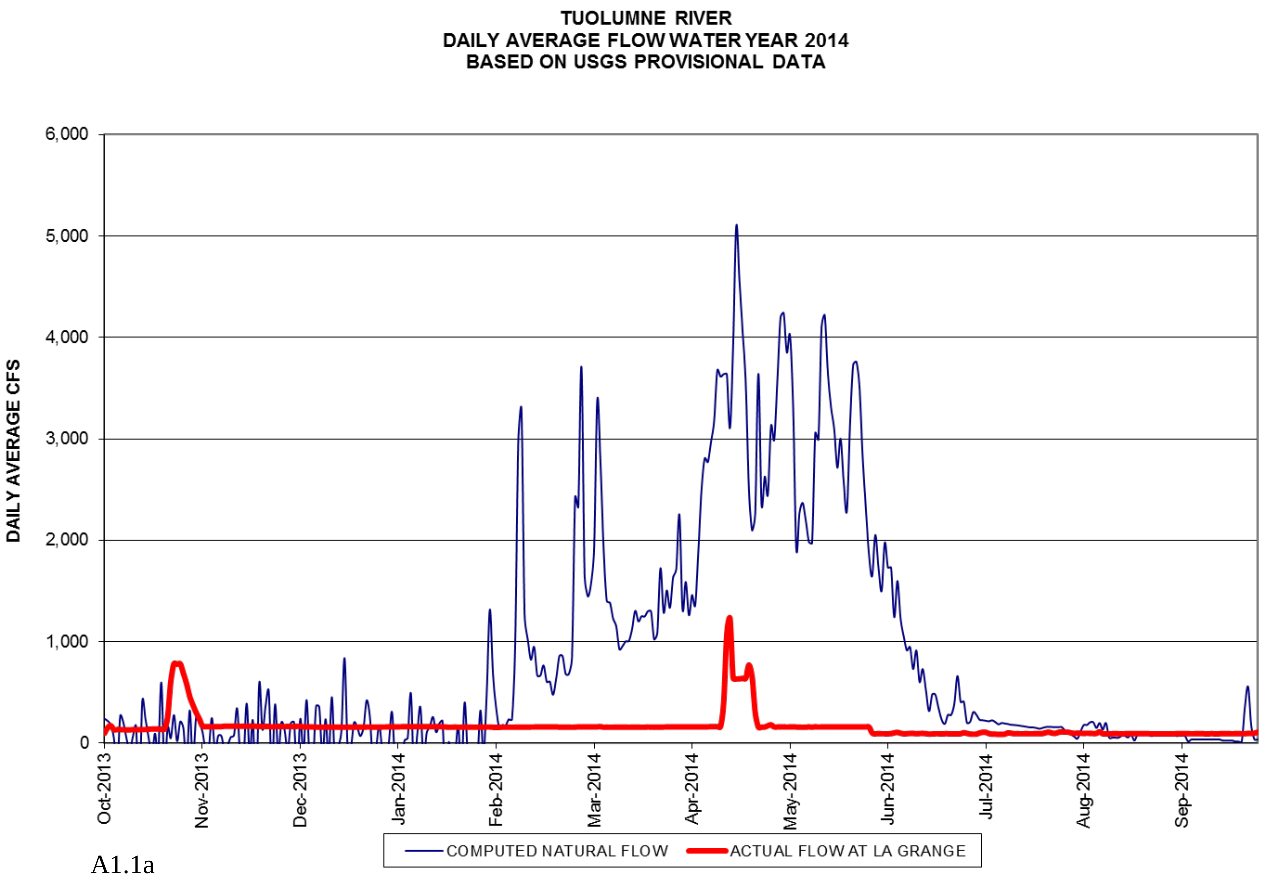
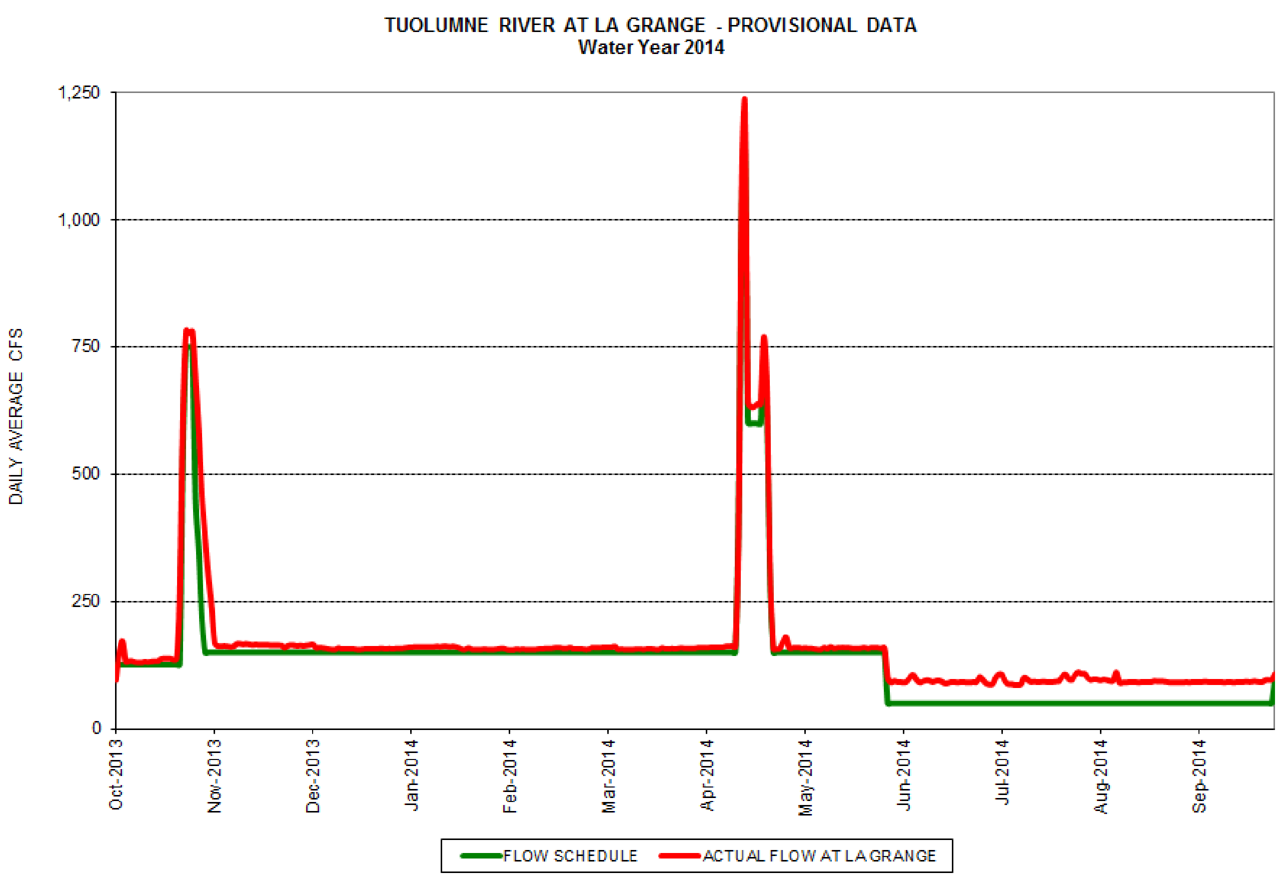
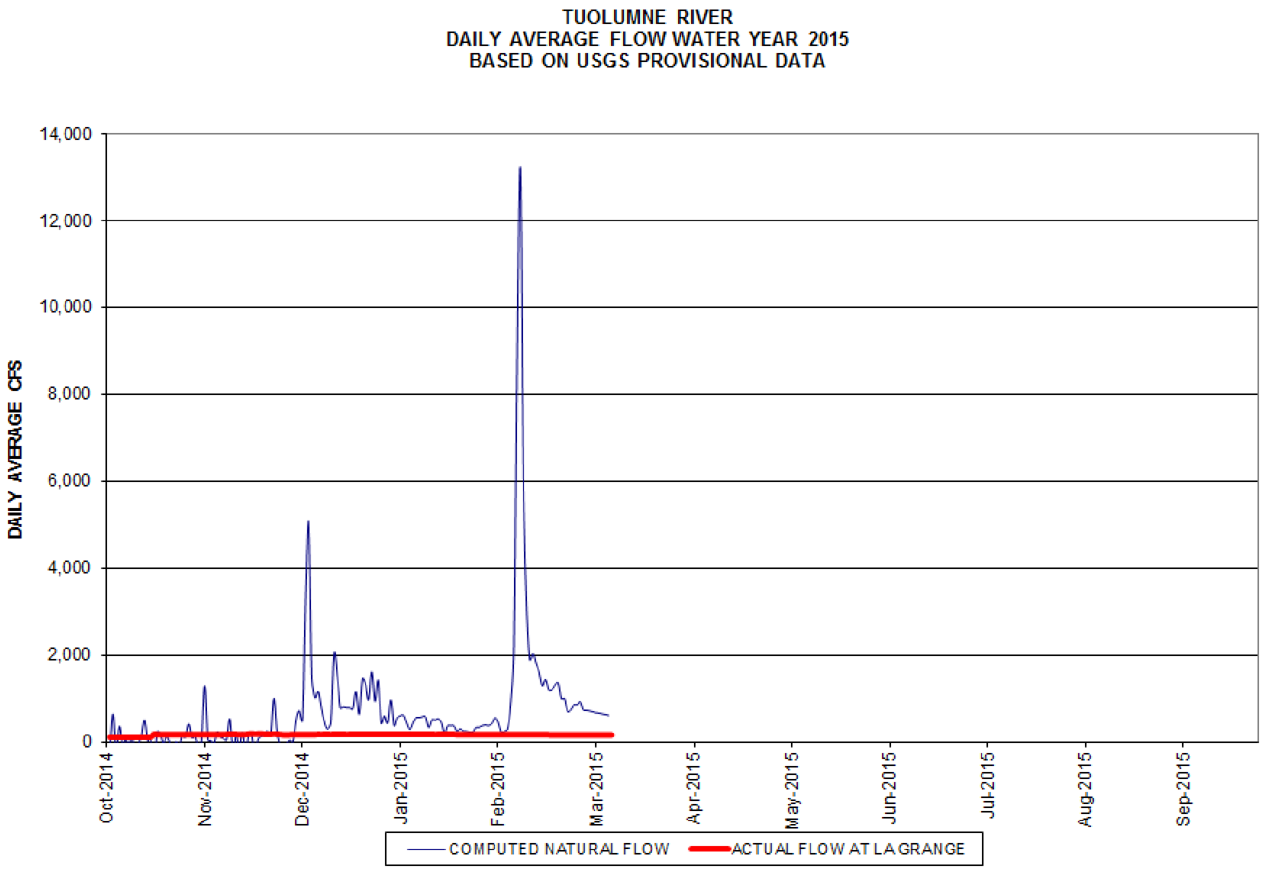
1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data



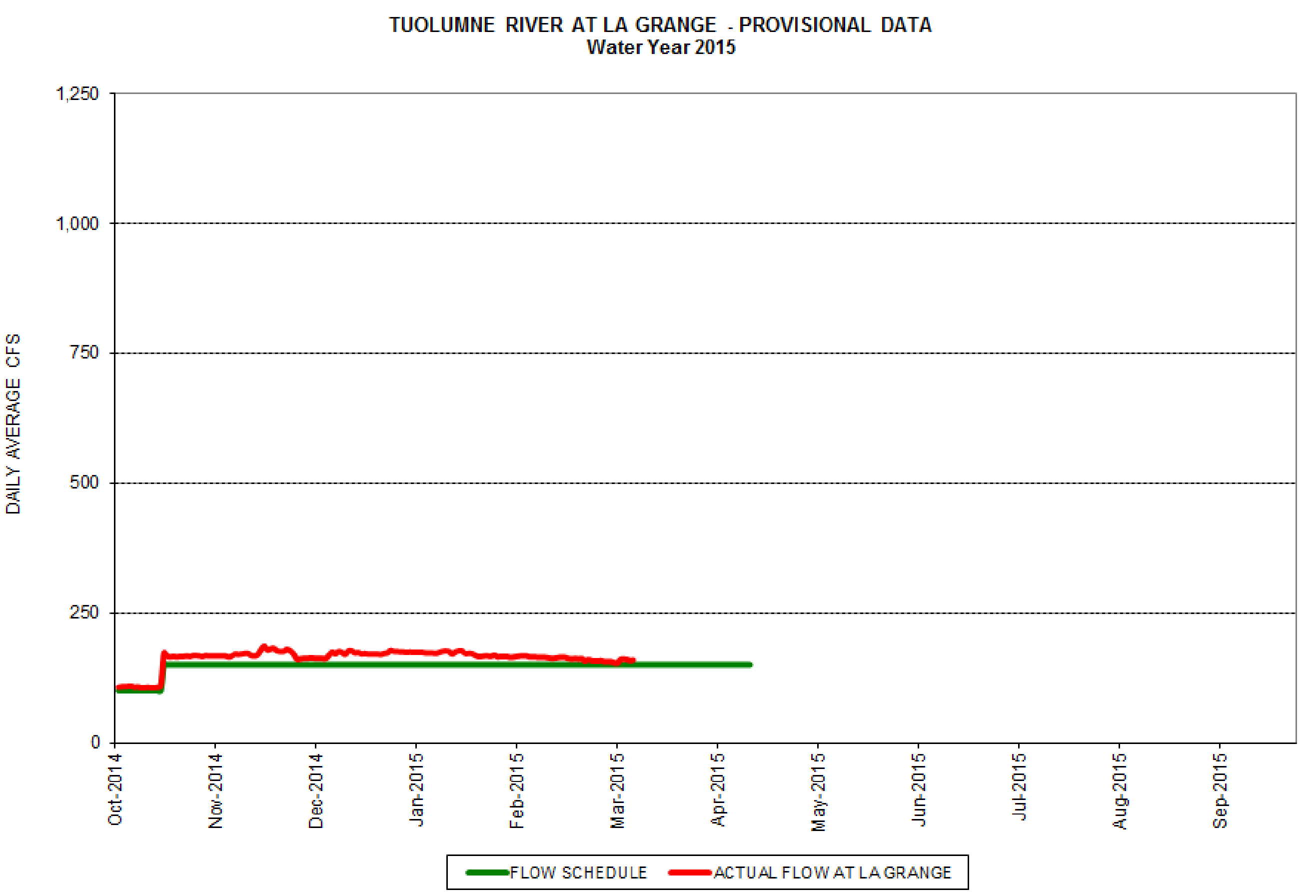
A1.1a



A1.1b

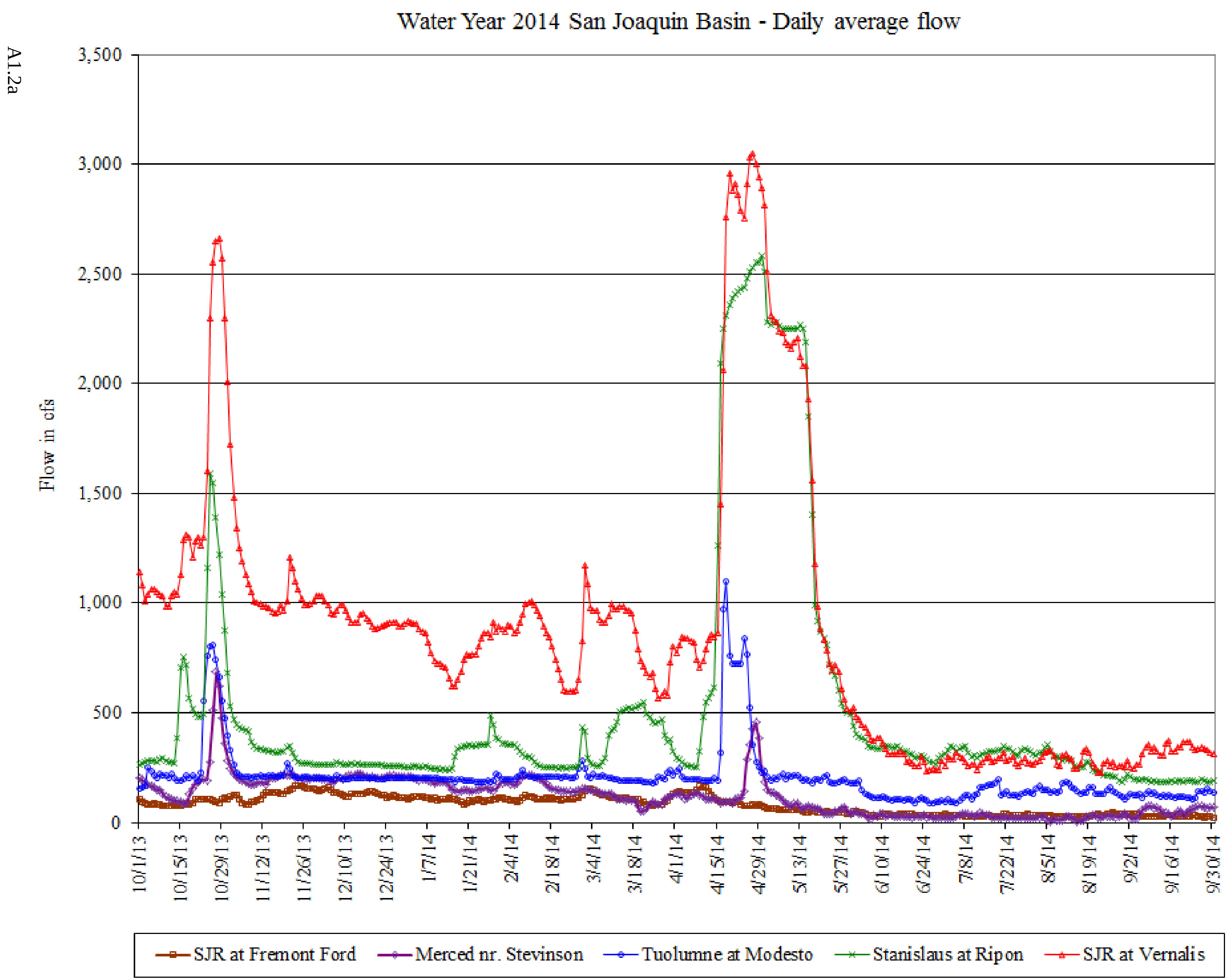

TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2015
BASED ON USGS PROVISIONAL DATA
DAILY AVERAGE CFS
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Oct-2014
Nov-2014
Dec-2014
Jan-2015
Feb-2015
Mar-2015
Apr-2015
May-2015
Jun-2015
Jul-2015
Aug-2015
Sep-2015
COMPUTED NATURAL FLOW
ACTUAL FLOW AT LA GRANGE

A1.1c


TUOLUMNE RIVER AT LA GRANGE - PROVISIONAL DATA
Water Year 2015
DAILY AVERAGE CFS
1,250
1,000
750
500
250
0
Oct-2014
Nov-2014
Dec-2014
Jan-2015
Feb-2015
Mar-2015
Apr-2015
May-2015
Jun-2015
Jul-2015
Aug-2015
Sep-2015
FLOW SCHEDULE
ACTUAL FLOW AT LA GRANGE

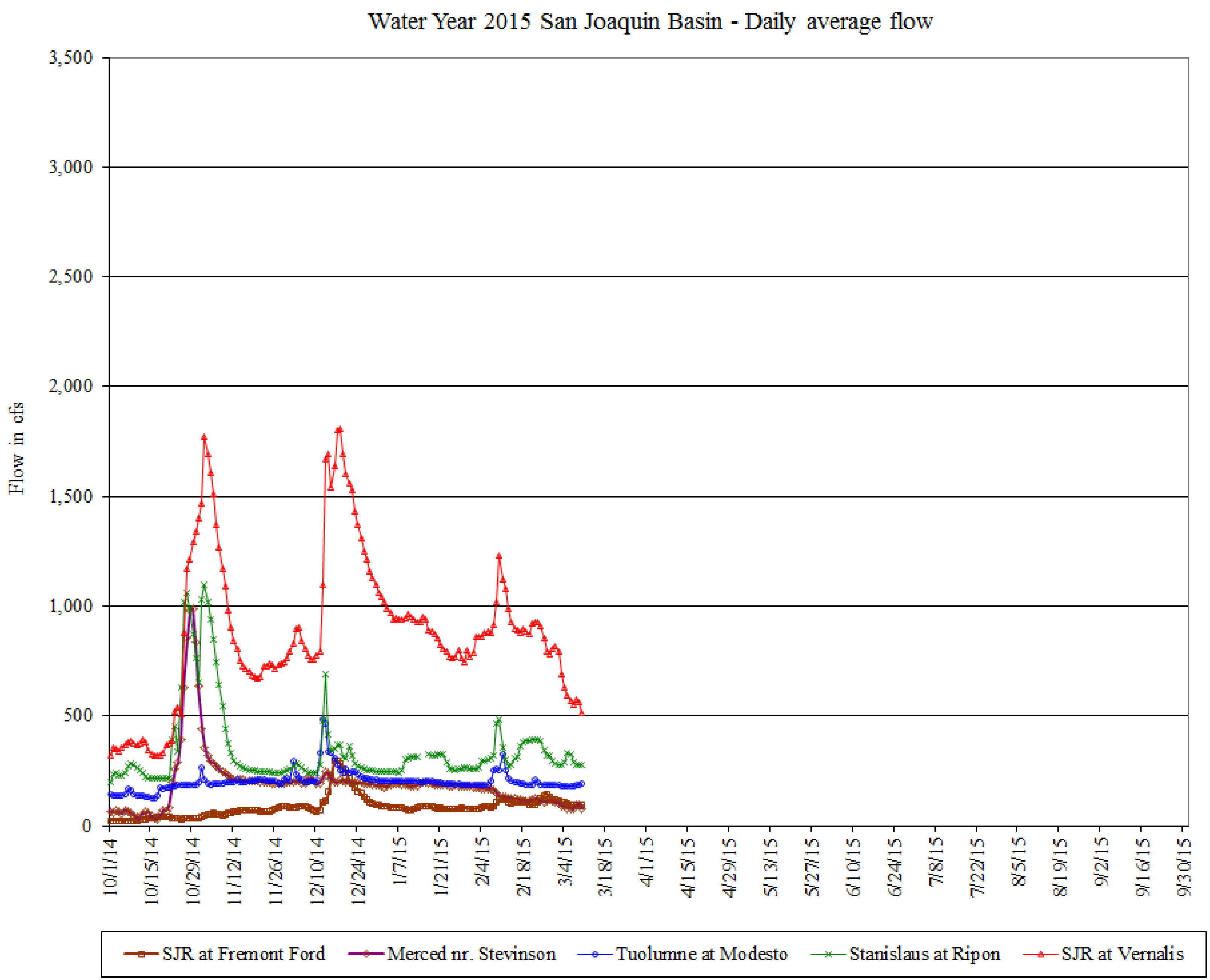
A1.1d

A1.2a

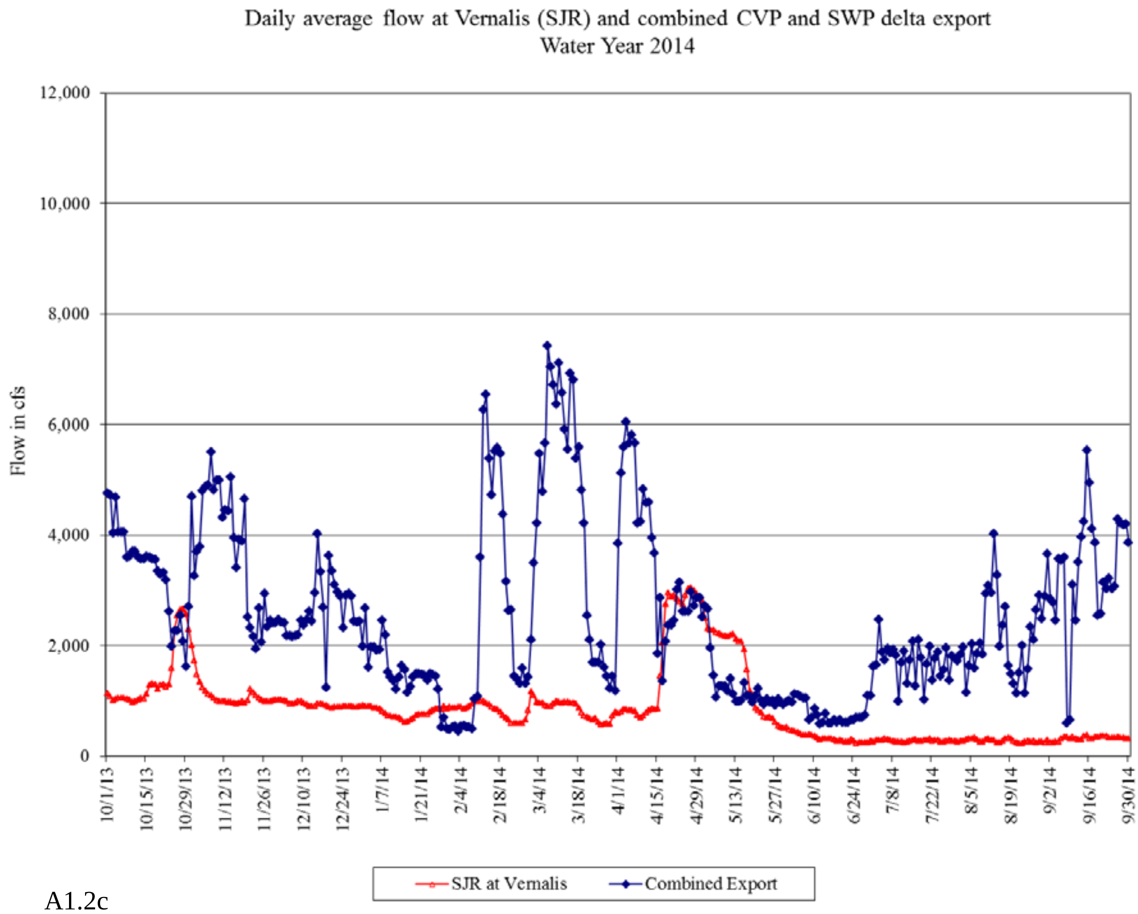


Water Year 2014 San Joaquin Basin - Daily average flow
Flow in cfs
3,500
3,000
2,500
2,000
1,500
1,000
500
0
10/1/13
10/15/13
10/29/13
11/12/13
11/26/13
12/10/13
12/24/13
1/7/14
1/21/14
2/4/14
2/18/14
3/4/14
3/18/14
4/1/14
4/15/14
4/29/14
5/13/14
5/27/14
6/10/14
6/24/14
7/8/14
7/22/14
8/5/14
8/19/14
9/2/14
9/16/14
9/30/14
SJR at Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis

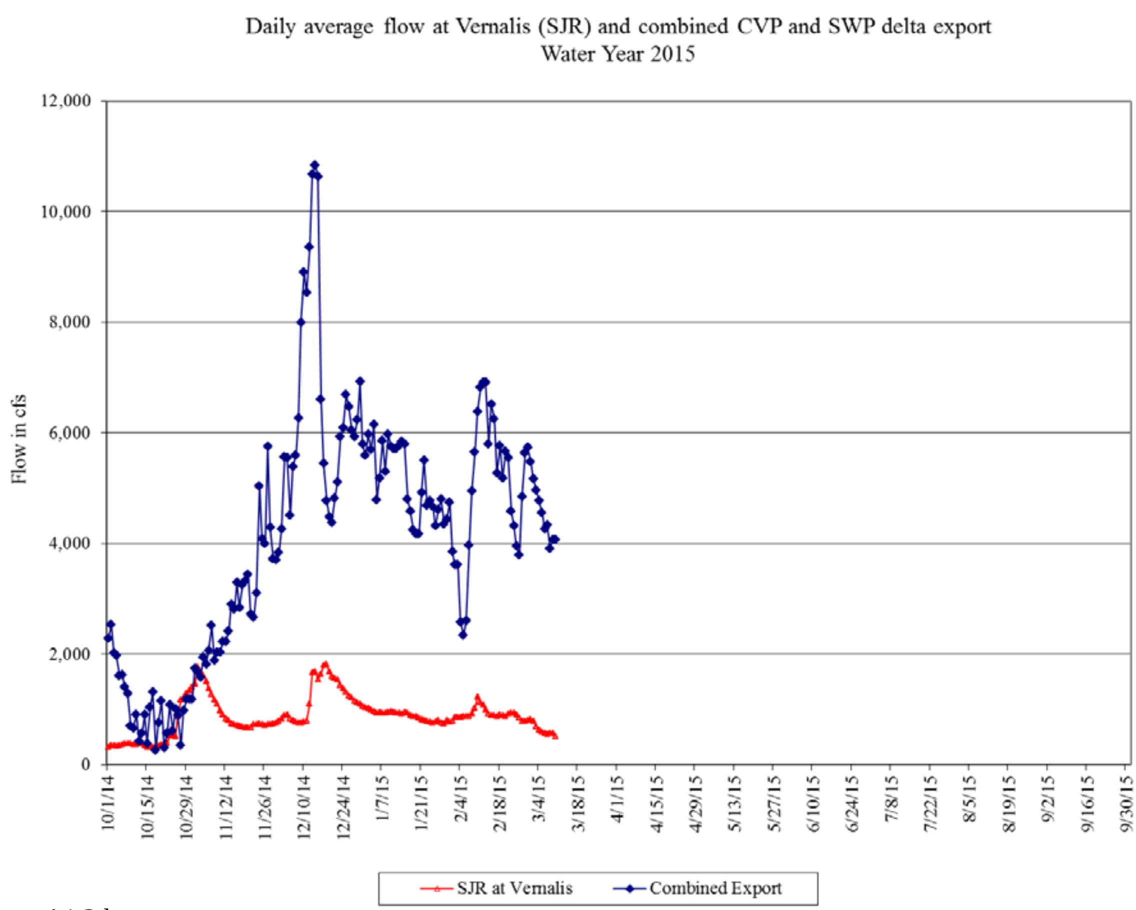
A1.2b



Water Year 2015 San Joaquin Basin - Daily average flow
Flow in cfs
3,500
3,000
2,500
2,000
1,500
1,000
500
0
10/1/14
10/15/14
10/29/14
11/12/14
11/26/14
12/10/14
12/24/14
1/7/15
1/21/15
2/4/15
2/18/15
3/4/15
3/18/15
4/1/15
4/15/15
4/29/15
5/13/15
5/27/15
6/10/15
6/24/15
7/8/15
7/22/15
8/5/15
8/19/15
9/2/15
9/16/15
9/30/15
SJR at Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis

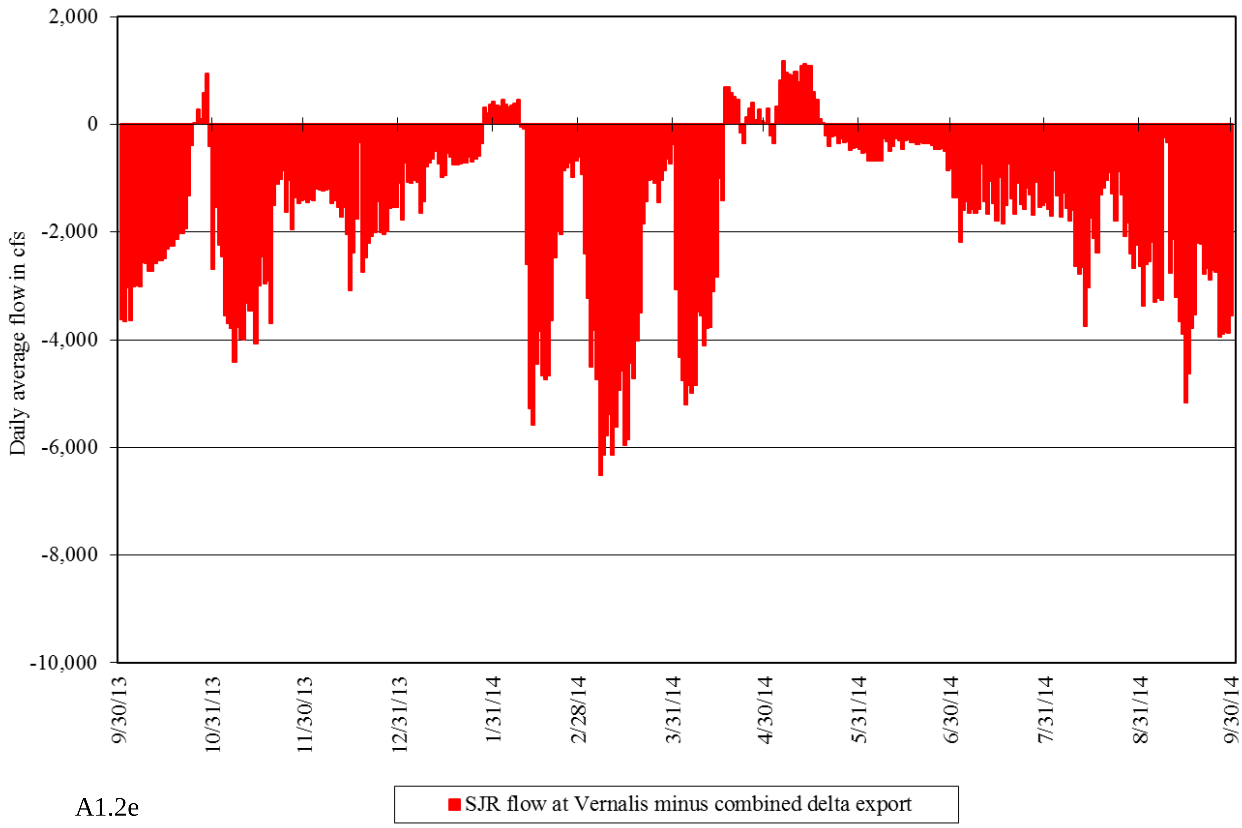

Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2014
Flow in cfs
12,000
10,000
8,000
6,000
4,000
2,000
0
10/1/13
10/15/13
10/29/13
11/12/13
11/26/13
12/10/13
12/24/13
1/7/14
1/21/14
2/4/14
2/18/14
3/4/14
3/18/14
4/1/14
4/15/14
4/29/14
5/13/14
5/27/14
6/10/14
6/24/14
7/8/14
7/22/14
8/5/14
8/19/14
9/2/14
9/16/14
9/30/14
SJR at Vernalis
Combined Export

A1.2c


Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2015
Flow in cfs
12,000
10,000
8,000
6,000
4,000
2,000
0
10/1/14
10/15/14
10/29/14
11/12/14
11/26/14
12/10/14
12/24/14
1/7/15
1/21/15
2/4/15
2/18/15
3/4/15
3/18/15
4/1/15
4/15/15
4/29/15
5/13/15
5/27/15
6/10/15
6/24/15
7/8/15
7/22/15
8/5/15
8/19/15
9/2/15
9/16/15
9/30/15
SJR at Vernalis
Combined Export

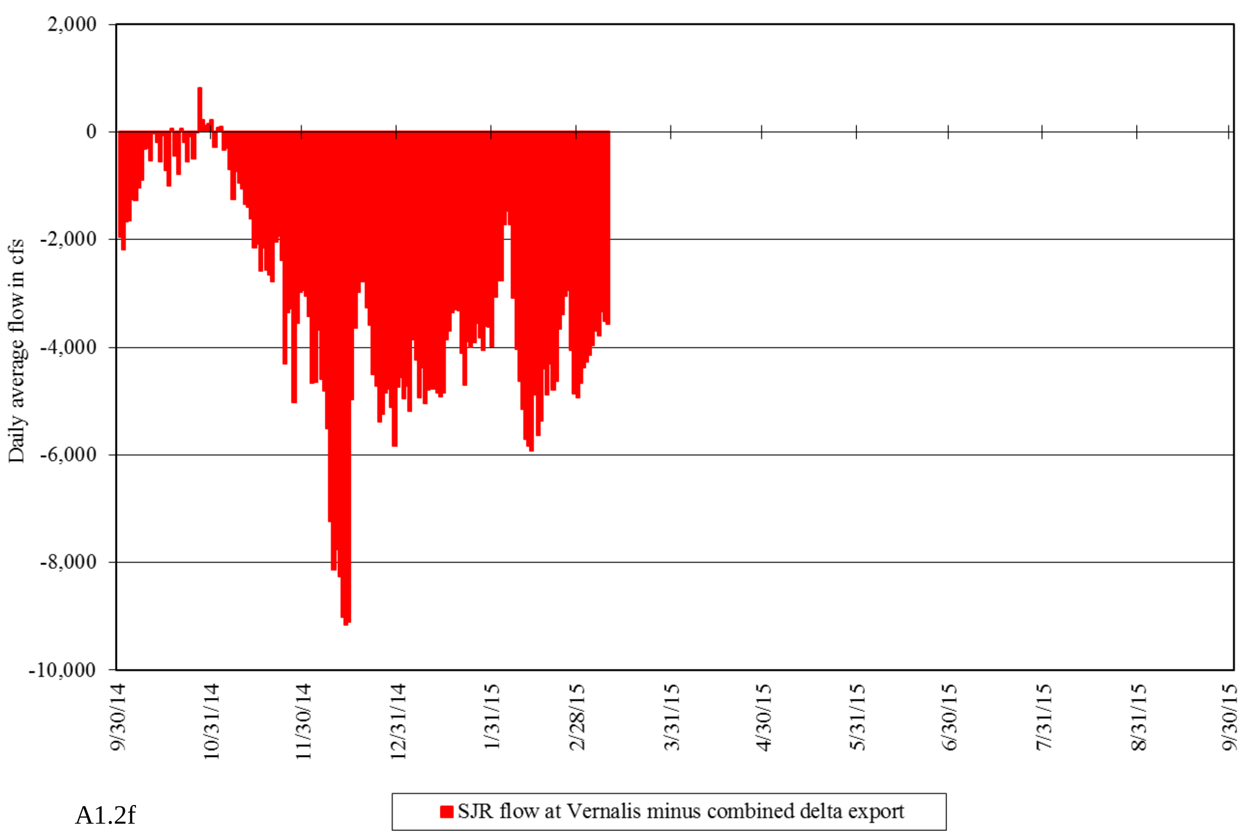
A1.2d

Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2014

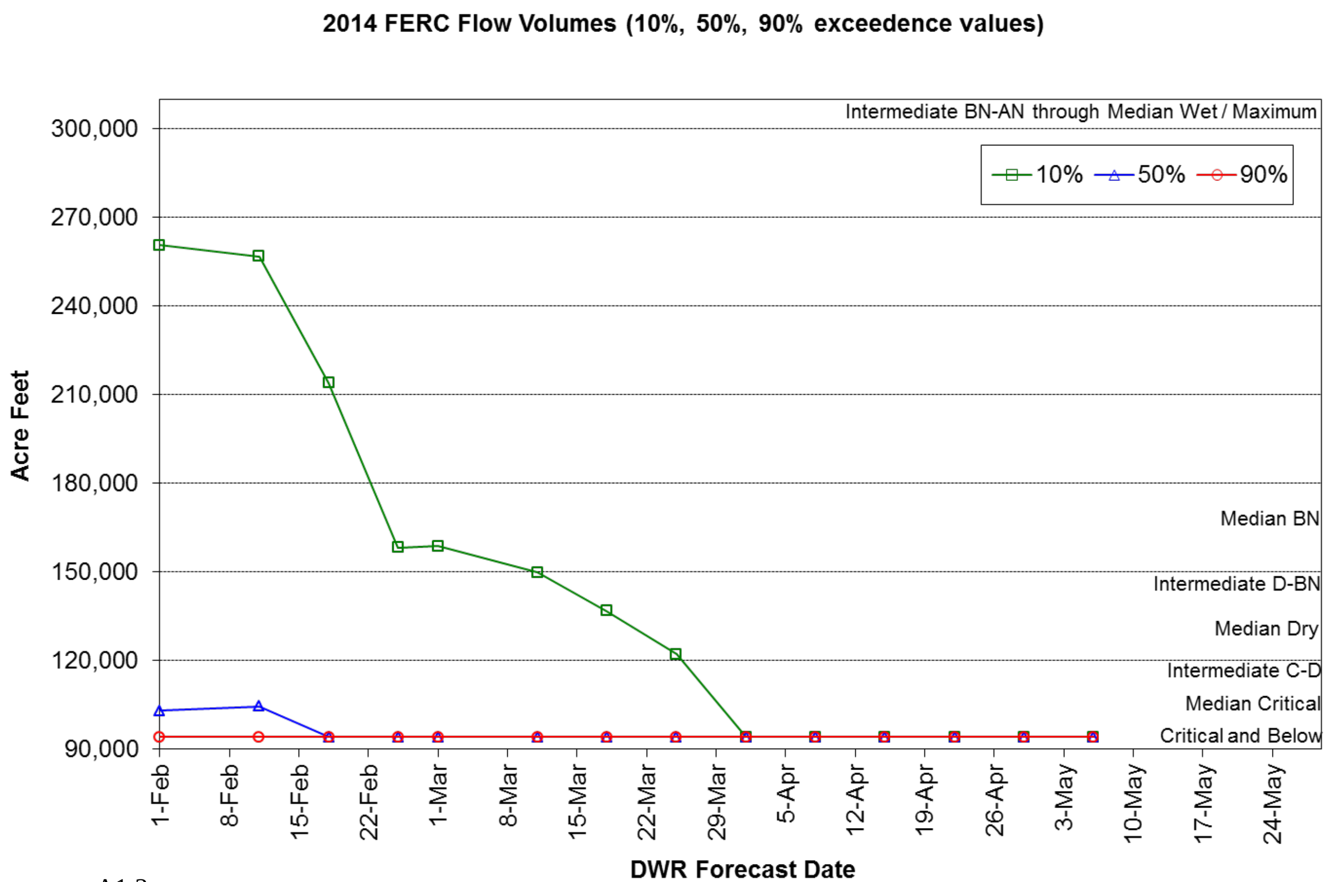


A1.2e

Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2015

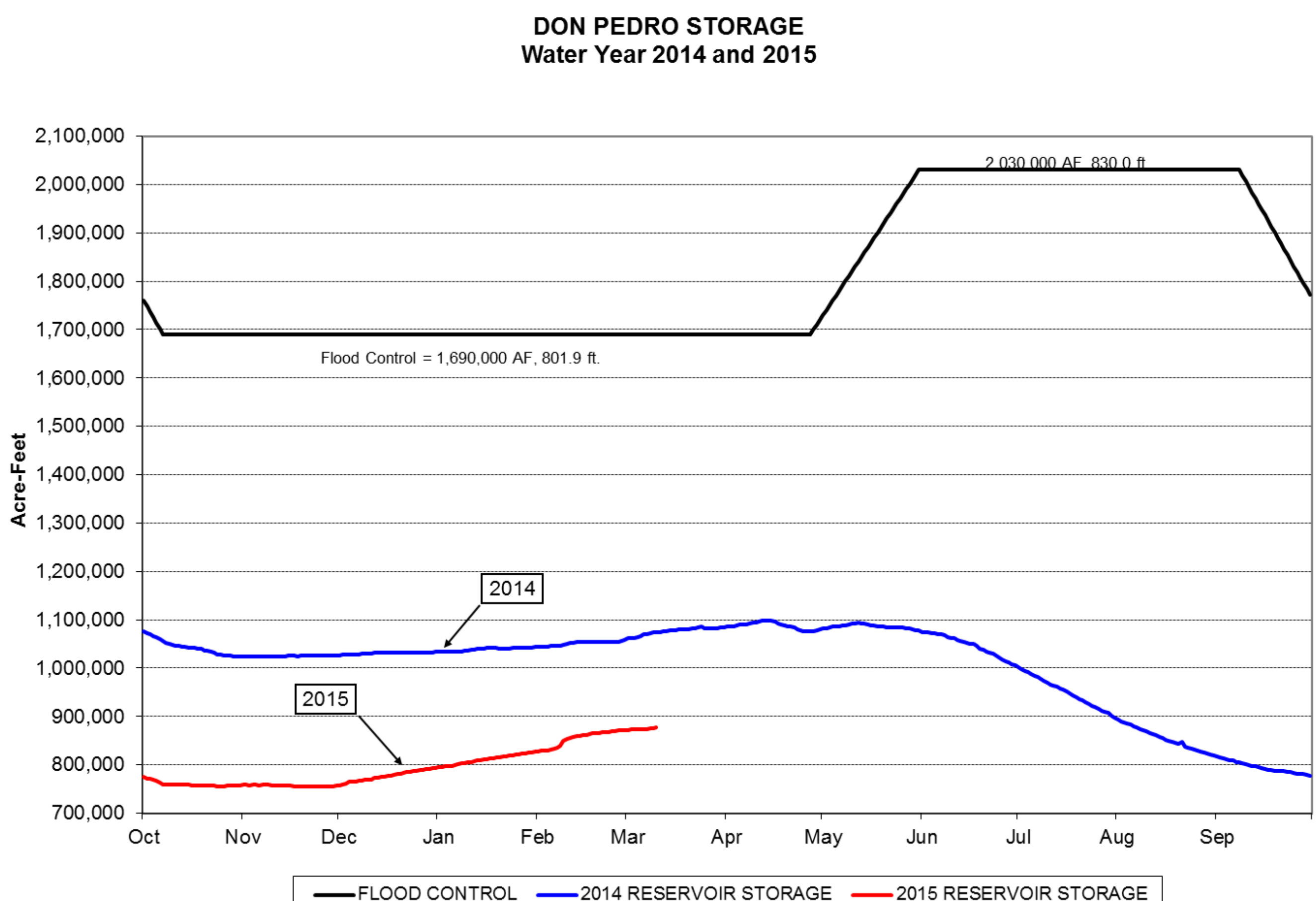


A1.2f



2014 FERC Flow Volumes (10%, 50%, 90% exceedence values)
Intermediate BN-AN through Median Wet / Maximum
10%
50%
90%
300,000
270,000
240,000
210,000
180,000
150,000
120,000
90,000
Acre Feet
Median BN
Intermediate D-BN
Median Dry
Intermediate C-D
Median Critical
Critical and Below
1-Feb
8-Feb
15-Feb
22-Feb
1-Mar
8-Mar
15-Mar
22-Mar
29-Mar
5-Apr
12-Apr
19-Apr
26-Apr
3-May
10-May
17-May
24-May
DWR Forecast Date

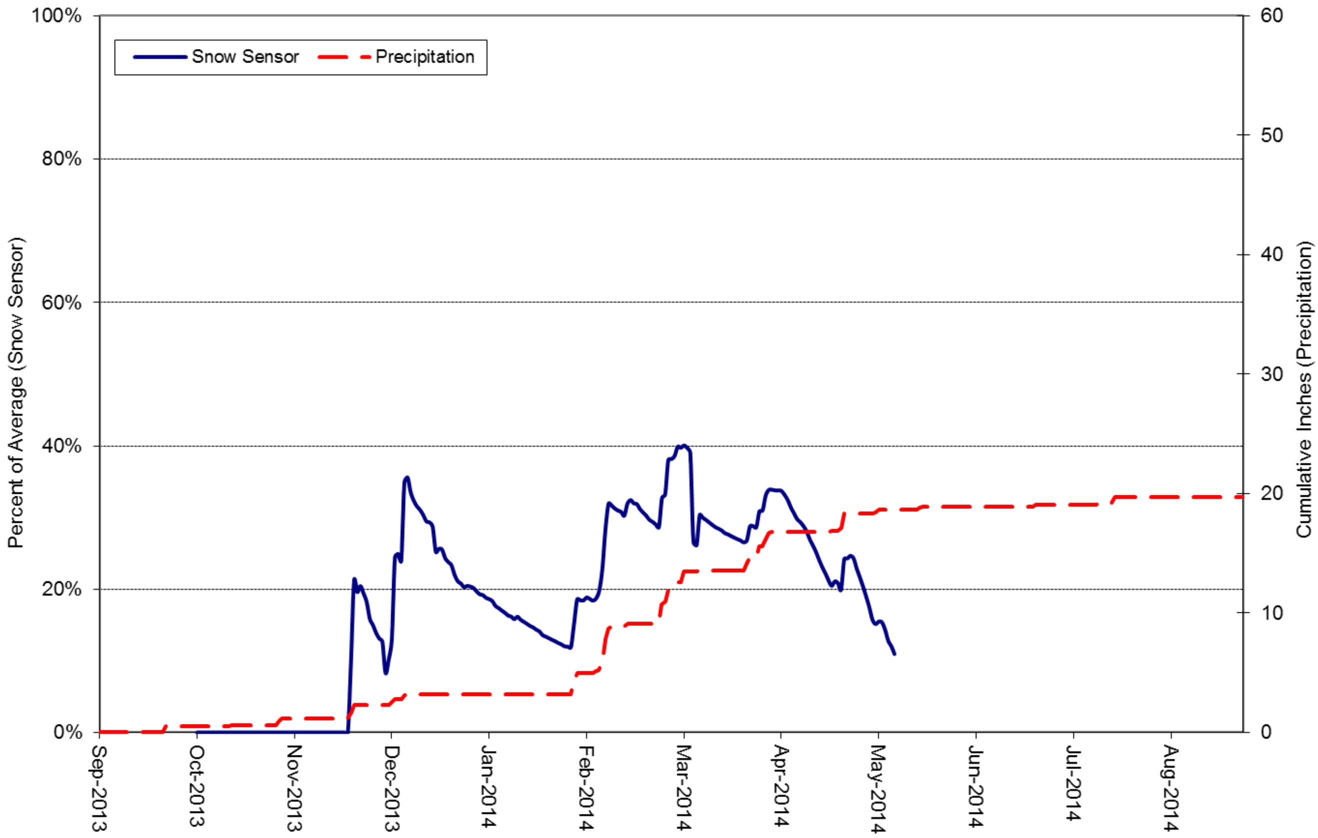
A1.3



DON PEDRO STORAGE
Water Year 2014 and 2015
2,100,000
2,000,000
1,900,000
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
Acre-Feet
2,030,000 AF, 830.0 ft.
Flood Control = 1,690,000 AF, 801.9 ft.
2014
2015
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
FLOOD CONTROL
2014 RESERVOIR STORAGE
2015 RESERVOIR STORAGE

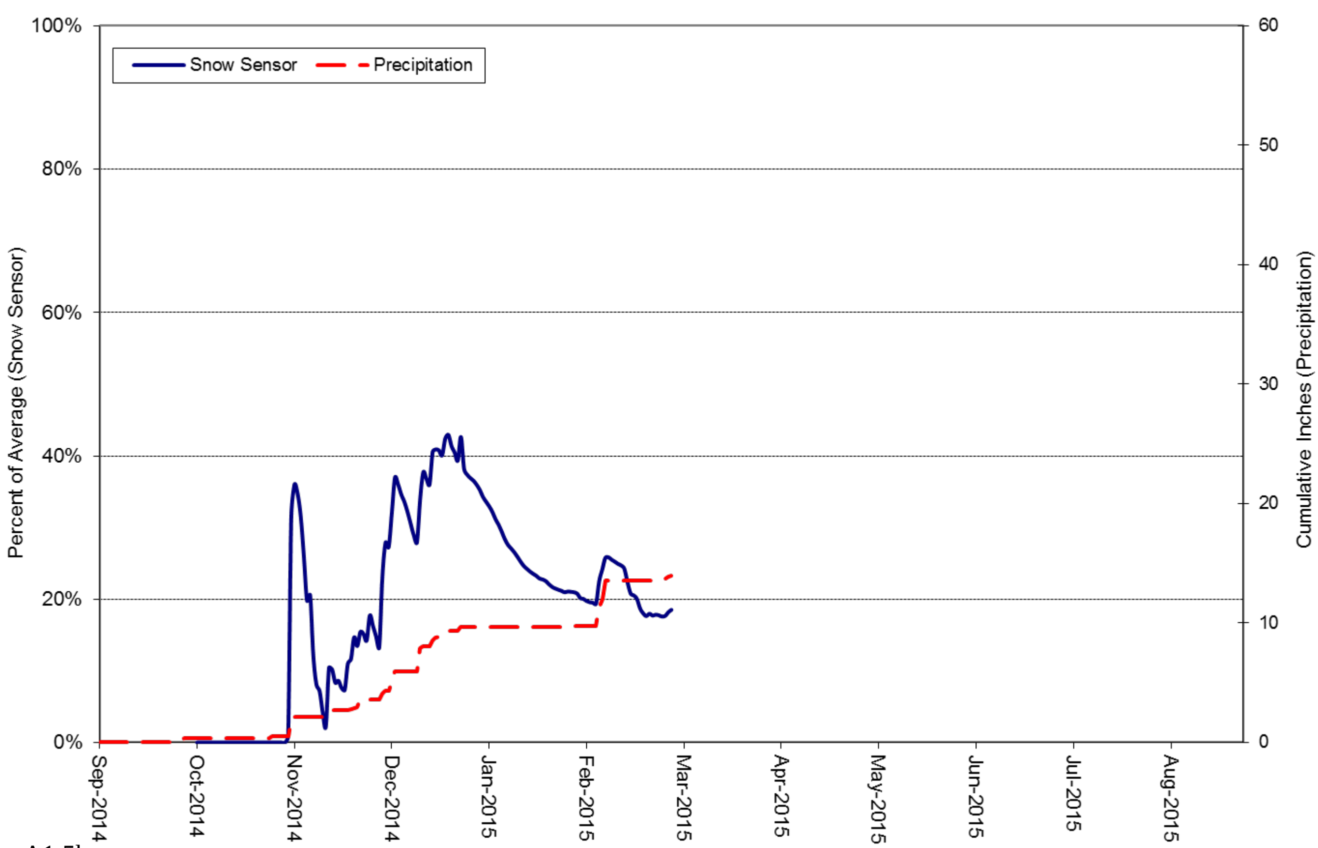
A1.4

Watershed Precipitation and Snow Sensor - Precipitation Year 2014



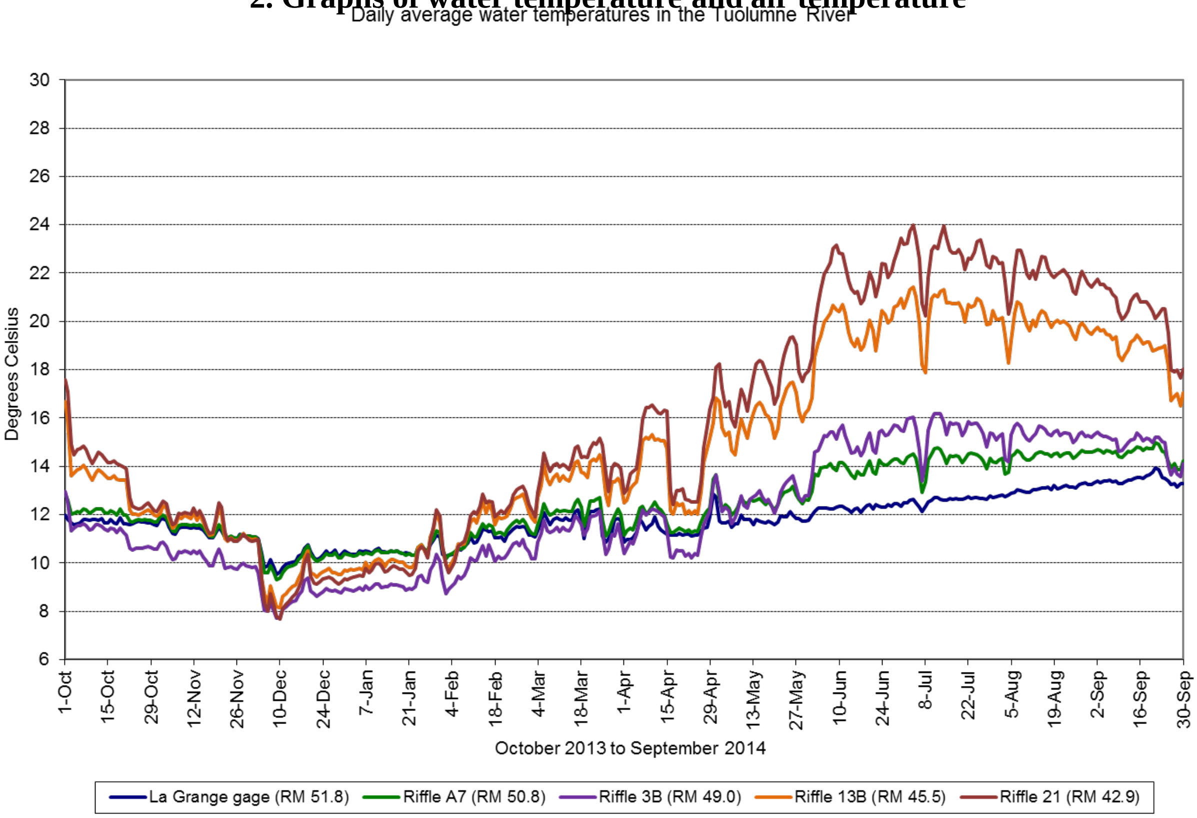
A1.5a

Watershed Precipitation and Snow Sensor - Precipitation Year 2015

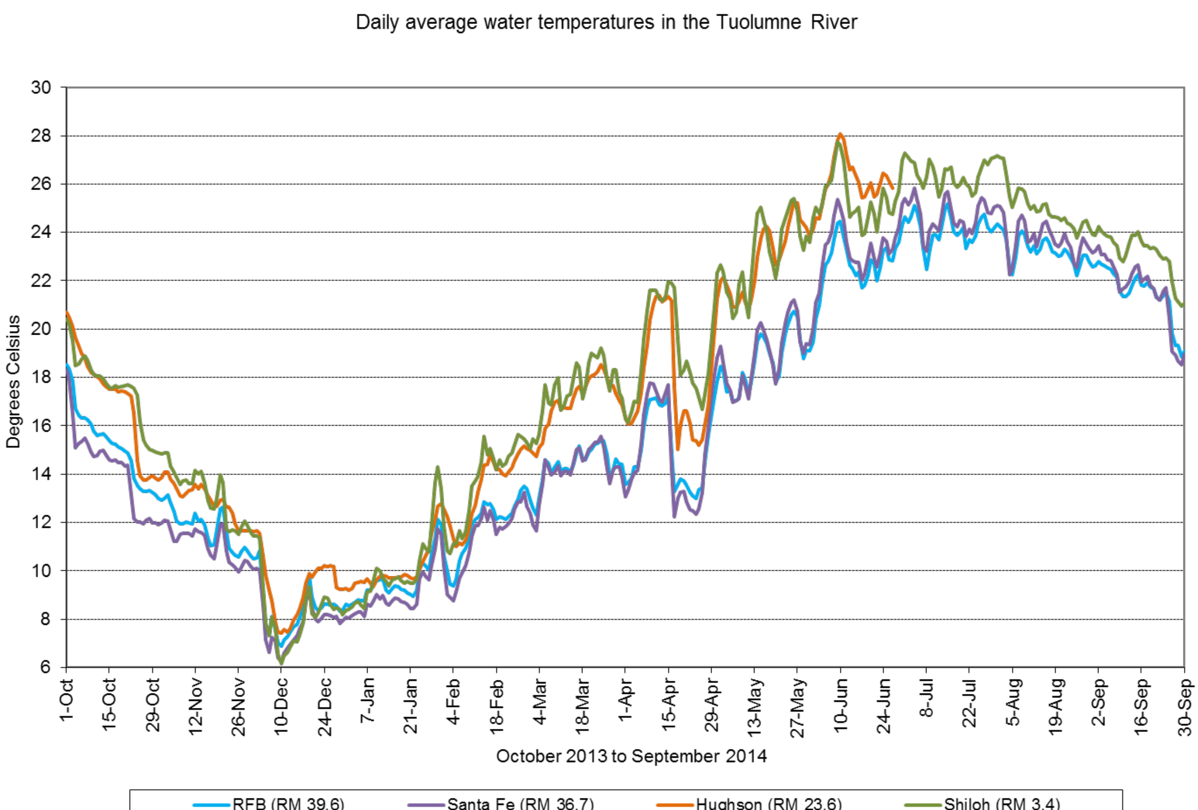


A1.5b

2. Graphs of water temperature and air temperature

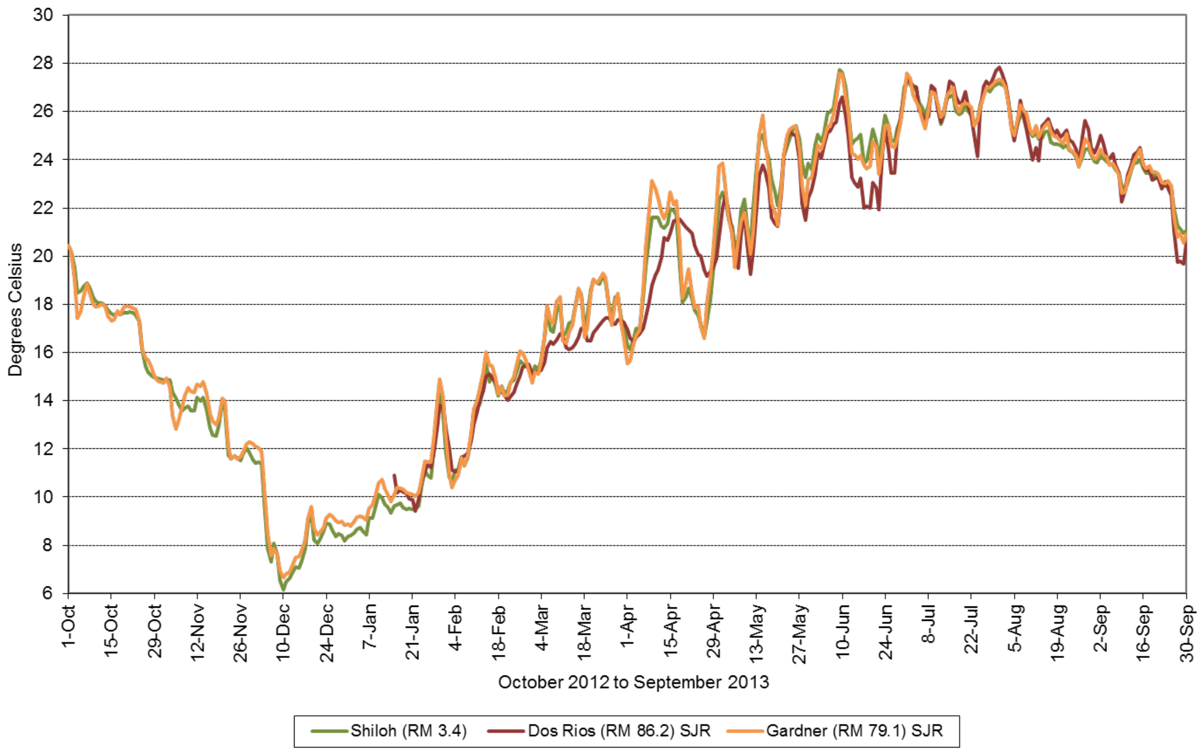


A2.1a

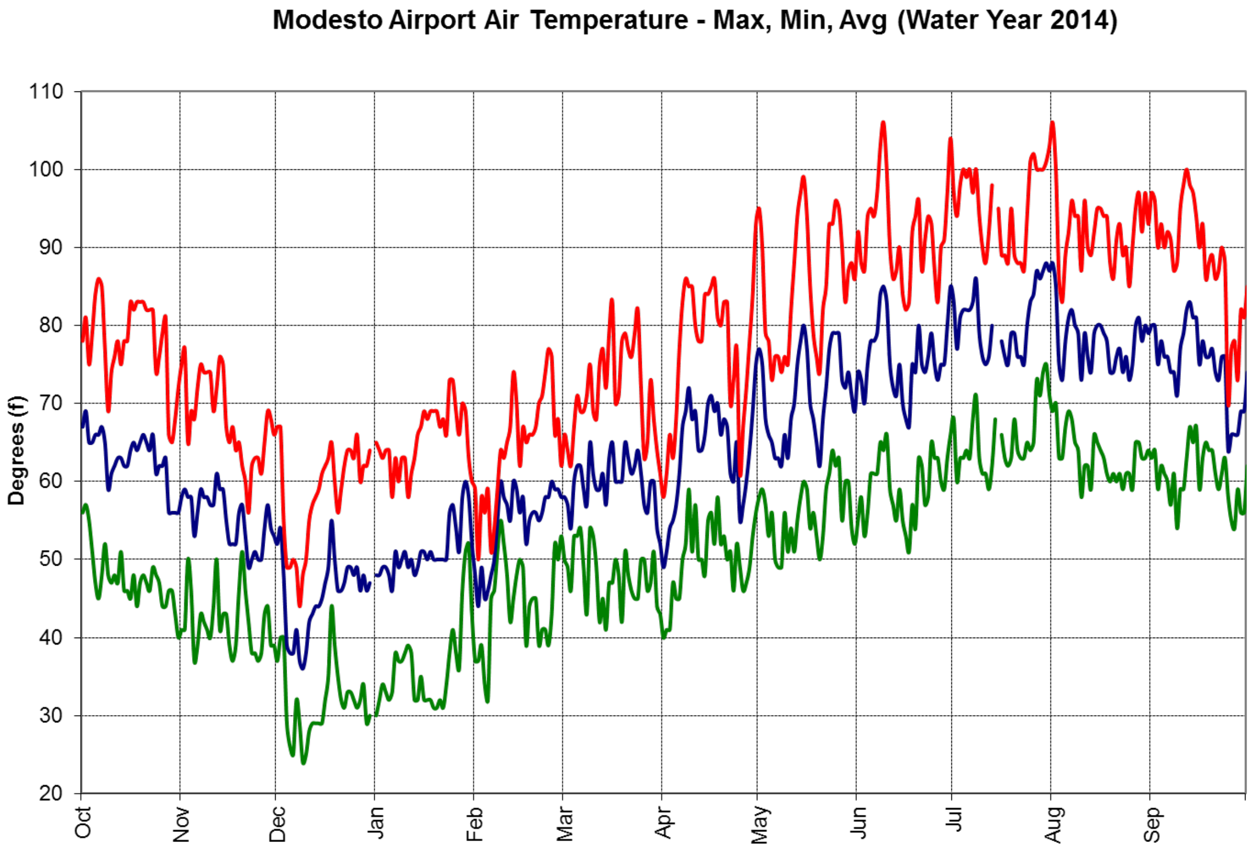


A2.1b

Daily average water temperatures in San Joaquin River and Tuolumne River at Shiloh Road

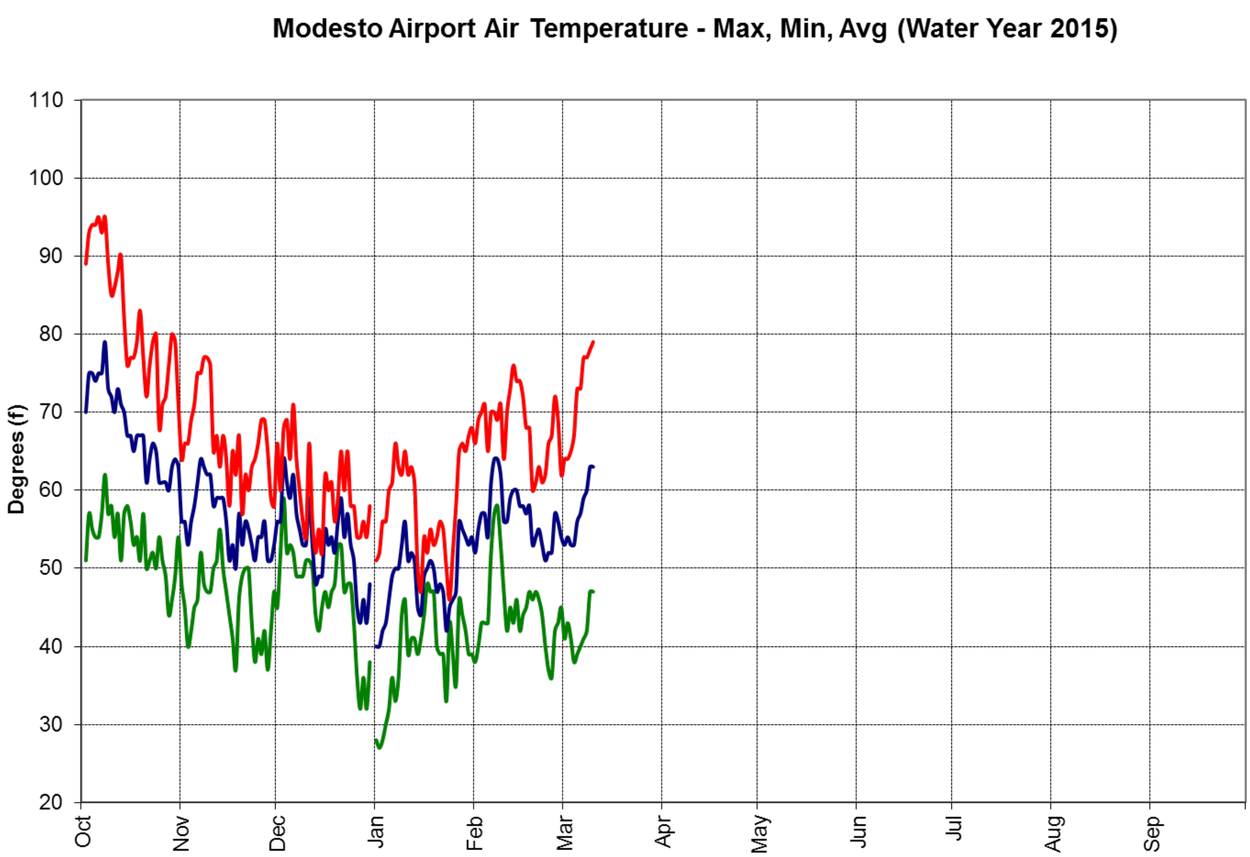


A2.1c



Modesto Airport Air Temperature - Max, Min, Avg (Water Year 2014)
Degrees (f)
110
100
90
80
70
60
50
40
30
20
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

A2.2



Modesto Airport Air Temperature - Max, Min, Avg (Water Year 2015)
Degrees (f)
110
100
90
80
70
60
50
40
30
20
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

A2.3

A3. Flow schedule correspondence for 2014

From: Wes Monier <fwmonier@tid.org>
Sent: Friday, April 11, 2014 6:13 PM
To: 'afg@mrgb.org'; 'Agengr6@aol.com'; 'bparis@olaughlinparis.com'; Casey J. Hashimoto; 'donn.w.furman@sfgov.org'; David R. Jigour; 'Frederick.Holzmer@hdrinc.com'; 'GREGD@mid.org'; Jason A. Carkeet; 'jasonguignard@fishbio.com'; 'joyw@mid.org'; 'lindaF@mid.org'; Noah Hume; Steve E. Boyd; 'towater@olaughlinparis.com'; Wayne Swaney; 'WSears@sfwater.org'; 'andreafuller@fishbio.com'; 'Devine, John (John.Devine@hdrinc.com)'; 'Arthur Godwin <afg@mrgb.org> (afg@mrgb.org)'; 'Carrie Loschke'; 'Jenna.Borovansky@hdrinc.com'; 'Carin.loy@hdrinc.com'; 'rogerv@mid.org'; Brian L. LaFollette; 'John Davids'; Patrick E. Maloney

Subject: RE: 2014-2015 Minimum Flow Requirement

Attachments: Flow Schedule2.xlsx

I called Zac at FWS regarding the 2014 pulse flow late this afternoon. He stated that he and Tim H. of CFWS concurred with the flow schedule that is shown in the attached spreadsheet on tab “DispatchOrders” that I had sent them last week. I asked if I could get an email or letter for the paper trail. Zac stated that Tim H. was working on this and I should get it by Monday, however Zac did say that he would give Tim a call to follow up. If I have not heard anything by noon on Monday, Zac asked that I give him a call and he would send me something.

As it stands now, this schedule will be implemented. Please let me know if you have any questions.

Thanks
Wes

Attachment -B-

2014 Tuolumne River
Technical Advisory Committee Materials:

- List of 2014 TRTAC Activities/Materials

- March Meeting
- June Meeting
- September Meeting
- December Meeting

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
Fax: (209) 656-2191
Email: pemaloney@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

March 13, 2014 at 9:30 AM

Turlock Irrigation District, Room 152

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from Dec 2013 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Fall run information – weir; river surveys
   - Ongoing monitoring – seine, screw trap, weir
   - 2013 Annual Report to FERC

4. FLOW OPERATIONS:
   - Current watershed conditions, runoff and flow volume forecasts
   - Spring flow schedule(s)

5. AGENCY/NGO UPDATES
   - USFWS Bobcat Flat habitat utilization surveys

6. ADDITIONAL ITEMS

7. NEXT MEETING DATES – JUNE 12, SEPTEMBER 11, DECEMBER 11

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
Fax: (209) 656-2191
Email: pemaloney@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

13 March 2014 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. INTRODUCTION AND ANNOUNCEMENTS

- Participants made self introductions.

2. ADMINISTRATIVE ITEMS:

- Review/Revise agenda – No changes.
- Approve notes from December meeting – No changes were identified. Notes for the last meeting are posted to the TRTAC website: http://tuolumnerivertac.com/
- Items since last meeting – A handout list posted at http://tuolumnerivertac.com/ was reviewed.
- No annual monitoring report documents were posted, but will be included in the 2013 Annual Summary Report on April 1st.

3. MONITORING/REPORTS: (*Handouts were reviewed*)

- Fall run information – As of today's date, 3763 Chinook have migrated upstream past the counting weir, as compared to 2215 at this same time last year. Vandalism of the weir electrical box occurred about February 7th, which in turn caused a data gap of about 13 days. Video review of the time period in question is pending. No O. mykiss passages were recorded this season. The annual weir report is nearly complete.
- Ongoing monitoring – seine crews report difficulty seining at some of the seine sites located lower river due to the presence of water hyacinth. However, in general seining has gone well. Rotary screw trap monitoring included a component of trap efficiency. Chinook fry from Merced River Fish Hatchery were utilized for the efficiency evaluations. The annual seine and rotary screw trap reports are nearly complete.

4. FLOW OPERATIONS:

- Current watershed conditions as of March 1, 2014: the Tuolumne River watershed is at 46% of normal unimpaired runoff. This water year is considered a critical water year type. Base flows will remain at 150 cfs through May 31, dropping to 100 cfs, 50 cfs above the 50 cfs minimum flow requirement.
- The spring pulse flow schedule allows for 11,091 acre feet based on the 90% exceedance. The shape and timing of the pulse flow will be decided by Zachary Jackson (USFWS) and Tim Heyne (CDFW).

5. AGENCY/NGO UPDATES

- USFWS Bobcat Flat Habitat Utilization Surveys: TID has assisted USFWS in collecting site specific hydraulic information and salmonid habitat use at recent gravel habilitation projects and nearby control sites near Bobcat Flat.
- No announcements from TRT or TRC.

6. ADDITIONAL ITEMS

- None

7. NEXT MEETING DATES – JUNE 12, SEPTEMBER 11, DECEMBER 11

TRTAC Meeting Attendees

	Name	Organization
1.	Patrick Maloney	TID
2.	Jason Guignard	FISHBIO
3.	Noah Hume	Stillwater
4.	Monica Gutierrez (by phone)	NOAA

2014 TRTAC Materials/Postings to Website

2013Dec13-2014Mar13 Postings to TRTAC website http://tuolumnerivertac.com/

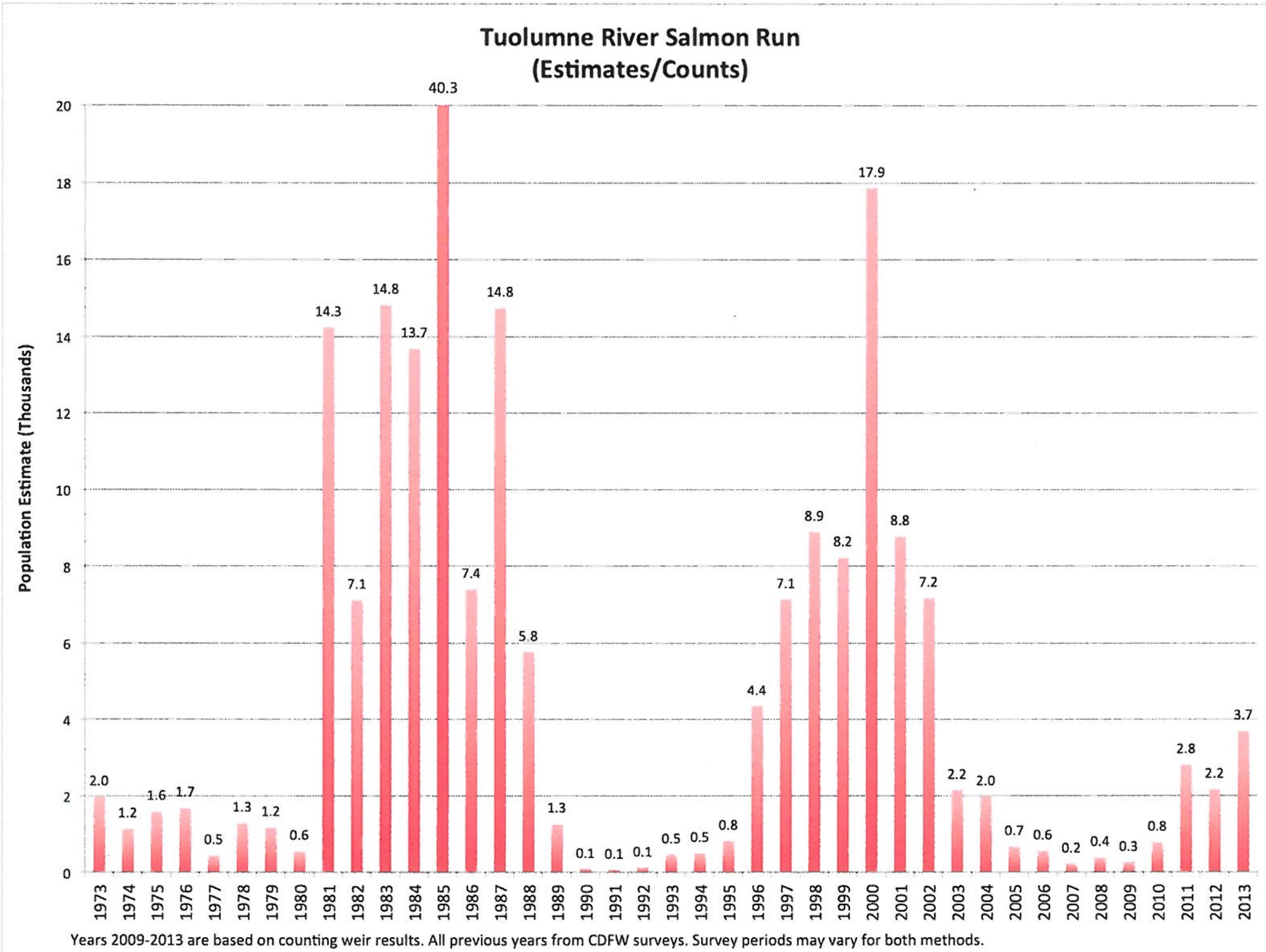
- Meetings
  - December 2013 TRTAC meeting summary and handouts
  - March 2014 TRTAC meeting agenda

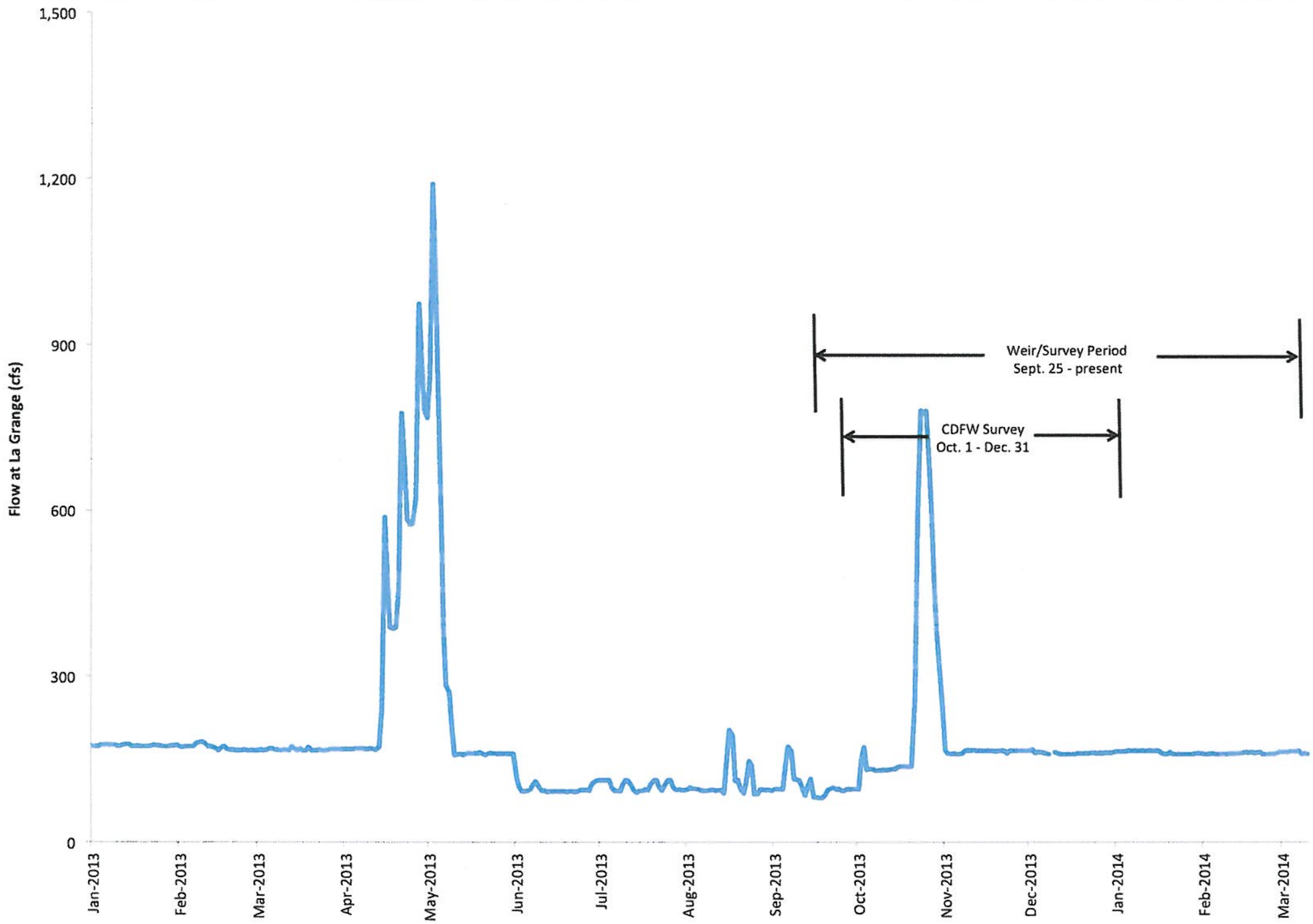
- Correspondence
  - January 6, 2014. ILP Updated Study Report of Turlock Irrigation District and Modesto Irrigation District under P-2299 Don Pedro Project. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14174952
  - January 27, 2014. ILP Updated Study Report Meeting Summary of Turlock Irrigation District and Modesto Irrigation District under P-2299 Don Pedro Project. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14180873
  - February 14, 2014. Request of Turlock Irrigation District and Modesto Irrigation District for extension of time to conduct FERC-approved Predation Study under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14187175
  - February 20, 2014. Comments by the National Park Service on the Updated Study Reports for the Don Pedro Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14188370
  - February 24, 2014. Conservation Groups' Comments on Draft License Application and Updated Study Report, under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14189142
  - February 26, 2014. Comments of State Water Resources Control Board (CA) on Updated Study Report for New Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14189985
  - February 26, 2014. ILP Comments of NOAA Fisheries Service West Coast Region on Updated Study Report, and Requests for Study Modifications under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14189986
  - February 26, 2014. USFWS Comments on USR and DLA Ltr under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14190046
  - February 26, 2014. USFWS ENCLOSURES under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14190073
  - February 27, 2014. USFWS Filing of Updated Study Report/Draft License Application Comment Letter Enclosure 5 and its Enclosures, Don Pedro Hydroelectric Project, FERC Project #P-2299 on the Tuolumne River; Tuolumne and Stanislaus Counties, CA. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14190271
    February 28, 2014. Comments of California Department of Fish and Wildlife on Draft License Application for Don Pedro Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14190517
  - March 3, 2014. ILP Comments or Study Request of State Water Resources Control Board (CA) under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14191024

- March 3, 2014. ILP Comments of NOAA's Fisheries Service, West Coast Region, on Draft License Application under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14191079
- March 3, 2014. ILP Comments on the Don Pedro Hydroelectric Project Draft License Application BLM - CALIFORNIA under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14191060
- March 4, 2014. Comments on Draft License Application re Turlock Irrigation District's Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14191331
- March 5, 2014. Letter order granting Turlock Irrigation District's 2/14/14 request for a one year extension of time to conduct Predation Study re the Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14191550
- March 10, 2014. California State Water Resources Control Board submits comments on the updated study report for the New Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14193228
- March 11, 2014. State Water Resources Control Board submits comments re the draft license application for the Don Pedro Hydro Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14193615

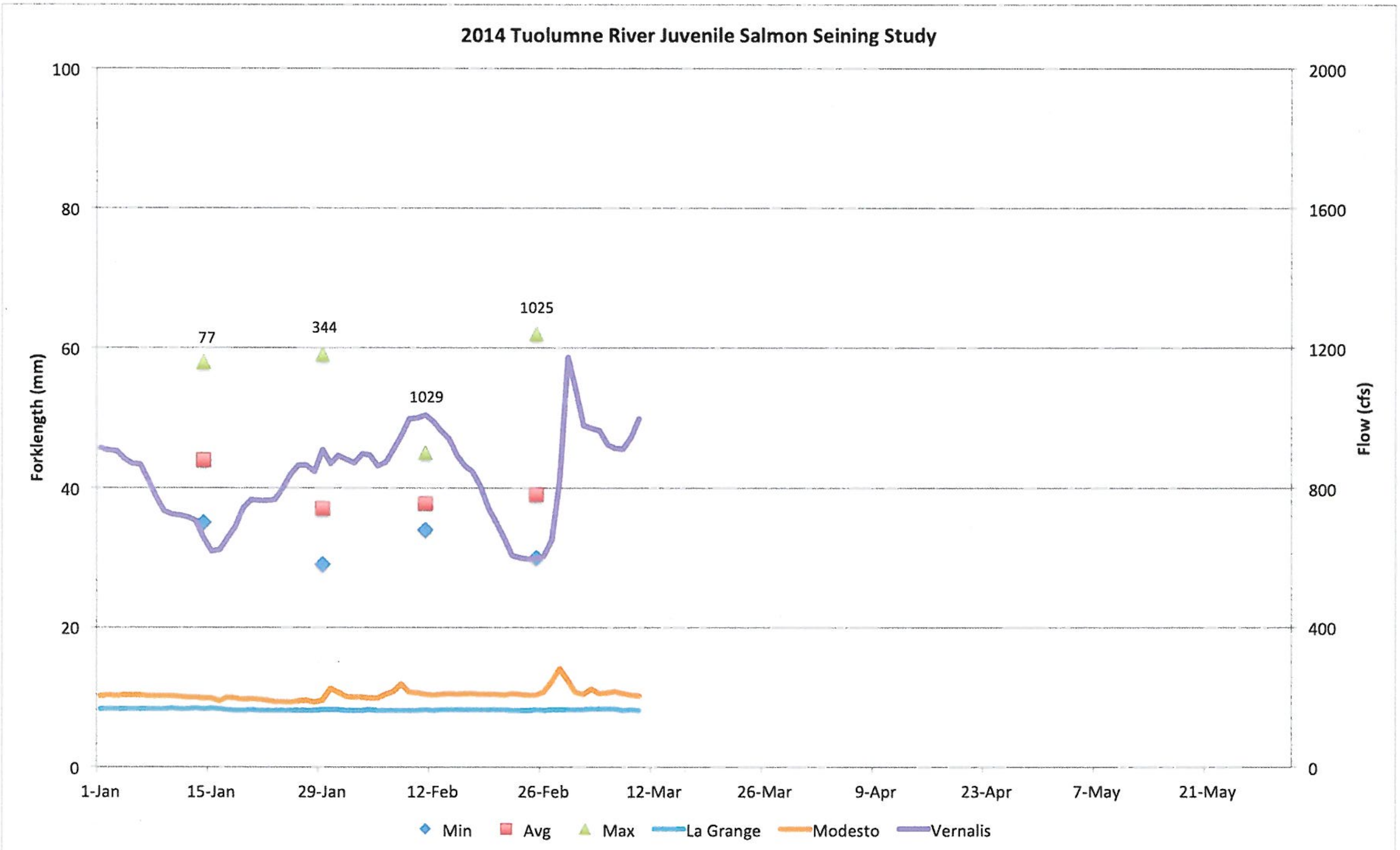
- Documents
  - No Documents
  - No postings

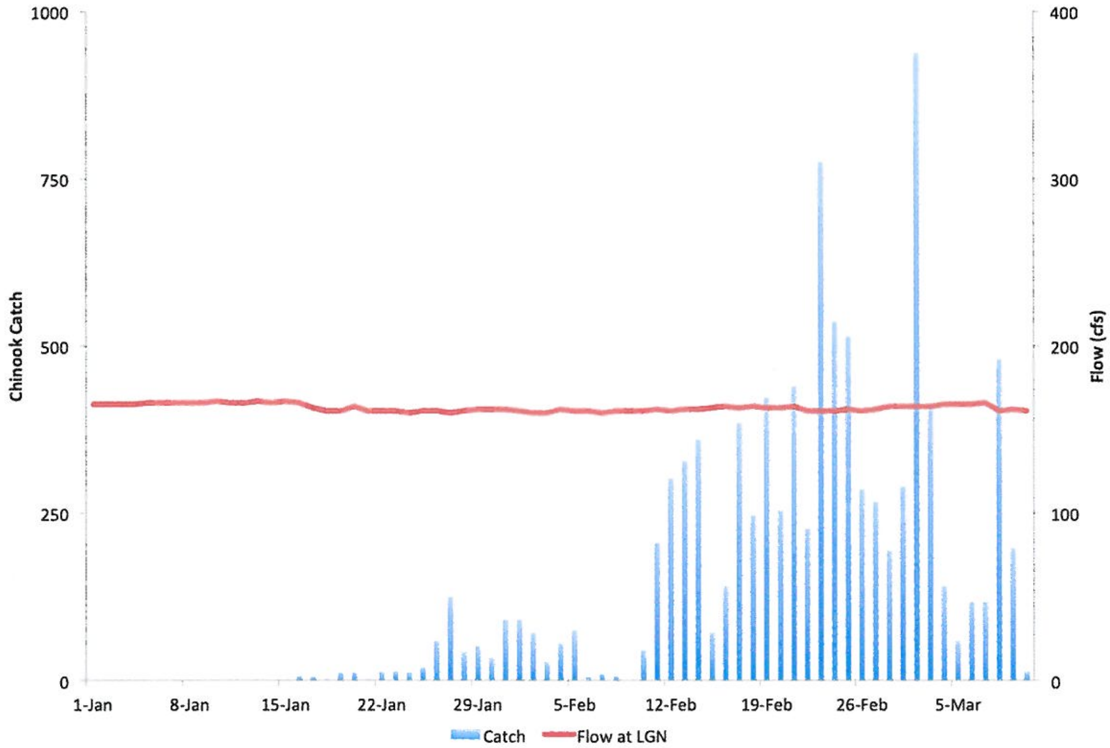
- Data/Monitoring
  - No postings


Tuolumne River Salmon Run
(Estimates/Counts)
Population Estimate (Thousands)
0
2
4
6
8
10
12
14
16
18
20
2.0
1.2
1.6
1.7
0.5
1.3
1.2
0.6
14.3
7.1
14.8
13.7
40.3
7.4
14.8
5.8
1.3
0.1
0.1
0.1
0.5
0.5
0.8
4.4
7.1
8.9
8.2
17.9
8.8
7.2
2.2
2.0
0.7
0.6
0.2
0.4
0.3
0.8
2.8
2.2
3.7
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Years 2009-2013 are based on counting weir results. All previous years from CDFW surveys. Survey periods may vary for both methods.

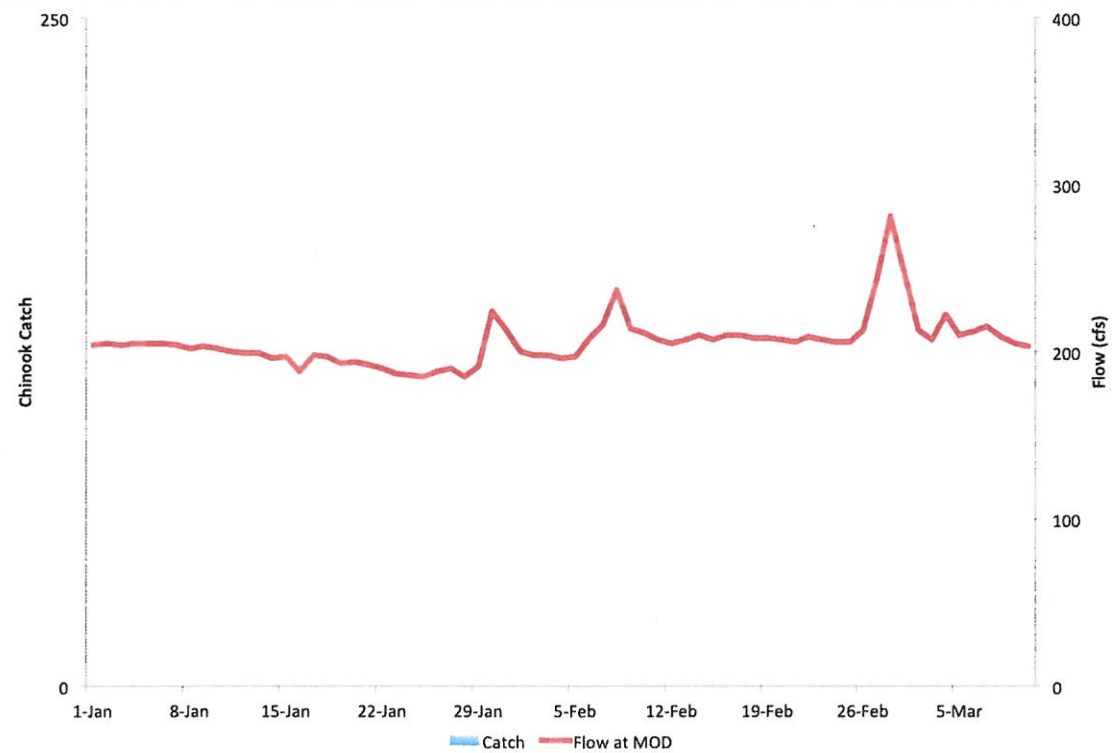


Tuolumne River spawning surveys 2013. Counting weir (FISHBIO), no 2013 data available from CDFW surveys (www.calfish.org)


2014 Tuolumne River Juvenile Salmon Seining Study
Forklength (mm)
Flow (cfs)
100
80
60
40
20
0
2000
1600
1200
800
400
0
77
344
1029
1025
1-Jan
15-Jan
29-Jan
12-Feb
26-Feb
12-Mar
26-Mar
9-Apr
23-Apr
7-May
21-May
Min
Avg
Max
La Grange
Modesto
Vernalis



Juvenile Chinook catch at Waterford and Tuolumne River flow at La Grange, 2014. Total catch through March 10, 2014 = 9,609.



Juvenile Chinook catch at Grayson and Tuolumne River flow at Modesto, 2014. Total catch through March 10, 2014 = 0.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2013 LOWER TUOLUMNE RIVER ANNUAL REPORT

2013 Annual Summary Report

Exhibits: Spawning runs, harvest data, rearing/outmigration data, Delta salvage and exports

Attachment A: Water Conditions, Flows, Temperature, and Flow Schedule Correspondence

Attachment B: 2013 Tuolumne River Technical Advisory Committee Materials

Report 2013-1: 2013 Spawning Survey Report

Report 2013-2: Spawning Survey Summary Update

Report 2013-3: 2013 Seine Report and Summary Update

Report 2013-4: 2013 Rotary Screw Trap Report

Report 2013-5: 2013 Snorkel Report and Summary Update

Report 2013-6: 2013 Tuolumne River Weir Report

Mar 2014 SNOW COURSE READINGS

TUOLUMNE BASIN SNOW COURSE SURVEY DATA

Snow Course	Number	Elevation	Ave. W. C. on 01APR	Date	Depth	W. C.	Density	% of 01APR	% of 01Mar
DANA MEADOWS	157	9,800	31.1	22-Feb	38.5	10.5	27%	34%	42%
RAFFERTY MEADOWS	158	9,400							
BOND PASS	159	9,300	44.9	26-Feb	41.5	12.0	29%	27%	35%
NEW GRACE MEADOW	368	8,900	48.0	26-Feb	48.5	14.5	30%	30%	38%
TUOLUMNE MEADOWS	161	8,600	22.7	23-Feb	19.5	6.0	31%	26%	28%
HORSE MEADOW	162	8,400	46.7	26-Feb	44.5	13.5	30%	29%	37%
WILMER LAKE	163	8,000	43.2	26-Feb	46.5	15.0	32%	35%	42%
SACHSE SPRINGS	165	7,900	38.1	3-Mar	41.3	13.4	32%	35%	42%
HUCKLEBERRY LAKE	166	7,800	41.9	26-Feb	36.0	11.5	32%	27%	35%
SPOTTED FAWN	164	7,800	45.6	3-Mar	54.8	16.3	30%	36%	44%
PARADISE MEADOW	167	7,650	39.9	25-Feb	36.0	13.0	36%	33%	41%
KERRICK CORRAL	348	7,000	23.5	24-Feb	22.0	8.0	36%	34%	35%
UPPER KIBBIE RIDGE	168	6,700	18.6	3-Mar	6.9	2.4	35%	13%	13%
VERNON LAKE	169	6,700	22.4	24-Feb	13.1	5.0	38%	22%	25%
LOWER KIBBIE RIDGE	173	6,700	26.0	3-Mar	9.7	2.9	30%	11%	12%
BELL MEADOW	172	6,500	15.5	24-Feb	2.0	0.5	25%	3%	3%
BEEHIVE MEADOW	171	6,500	23.5	24-Feb	9.5	3.0	32%	13%	13%
Average	17 TOT.	7,862			29.4	9.2	31.6%	26%	30.4%

MERCED BASIN SNOW COURSE SURVEY DATA

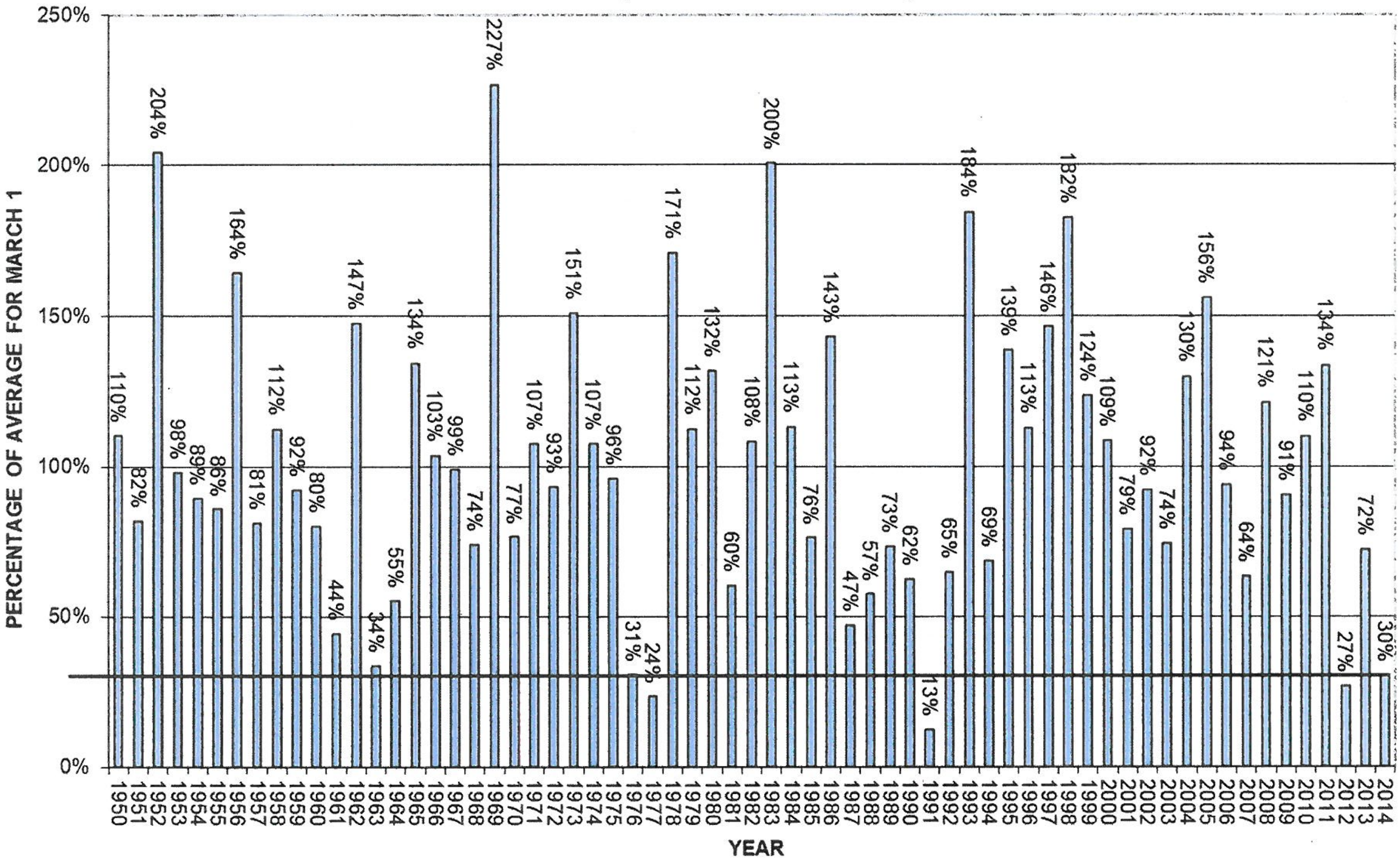
Snow Course	Number	Elevation	Ave. W. C. on 01APR	Date	Depth	W. C.	Density	% of 01APR Ave.	
SNOW FLAT	176	8,700	44.5	24-Feb	40.5	13.0	32%	29%	38%
OSTRANDER LAKE	177	8,200	32.6	25-Feb	22.0	7.0	32%	21%	25%
LAKE TENAYA	178	8,150	33.6	24-Feb	26.5	9.0	34%	27%	32%
GIN FLAT	179	7,000	32.0	3-Mar	16.0	7.0	44%	22%	24%
PEREGOY MEADOWS	180	7,000	29.3	26-Feb	12.0	4.0	33%	14%	16%
Average	5 TOT.	7,810			23.4	8.0	35.0%	23%	27%

STANISLAUS BASIN SNOW COURSE SURVEY DATA

Snow Course	Number	Elevation	Ave. W. C. on 01APR	Date	Depth	W. C.	Density	% of 01APR Ave.	
DEADMAN CREEK	345	9,250	35.1	24-Feb	38.7	13.5	35%	38%	53%
CLARK FORK MEADOW	344	8,900	39.8	24-Feb	49.5	17.0	34%	43%	56%
GIANELLI MEADOW	427	8,400	52.9	2-Mar	74.7	21.5	29%	41%	55%
LOWER RELIEF VALLEY	138	8,100	39.6	24-Feb	31.0	11.5	37%	29%	35%
SODA CREEK FLAT	139	7,800	22.0	24-Feb	16.5	6.5	39%	30%	35%
STANISLAUS MEADOW	384	7,750	51.0	25-Feb	49.5	18.6	38%	36%	49%
EAGLE MEADOW	140	7,500	24.2	24-Feb	14.5	6.5	45%	27%	31%
HERRING CREEK	142	7,300	28.0	24-Feb	17.5	7.5	43%	27%	31%
RELIEF DAM	143	7,250	19.9	24-Feb	14.5	6.0	41%	30%	34%
BLOODS CREEK	416	7,200	34.6	27-Feb	45.5	13.5	30%	39%	49%
CORRAL MEADOW	430	6,650	19.7						
HELLS KITCHEN	373	6,550	21.8	27-Feb	8.0	2.5	31%	11%	13%
NIAGARA FLAT	145	6,500	19.6	24-Feb	8.0	3.5	44%	18%	19%
BLACK SPRINGS	386	6,500	22.0	27-Feb	8.5	2.5	29%	11%	12%
Average	13 TOT.	7,546			29.0	10.0	36.5%	29%	36%

Tuolumne Snow Courses

March, 2014 Snow Course Readings



DWR March 1 Forecast

March 1, 2014 FORECAST
OF UNIMPAIRED RUNOFF
(in thousands of acre-feet)

April-July Forecast

	April thru July	Percent of Average	80% Probability Range
NORTH COAST			
Trinity River at Lewiston Lake	185	28%	70 - 440
Scott River near Fort Jones	29	17%	
SACRAMENTO RIVER			
Sacramento River above Shasta Lake	105	35%	
McCloud River above Shasta Lake	210	54%	
Pit River above Shasta Lake	580	55%	
Total inflow to Shasta Lake	930	51%	660 - 1690
Sacramento River above Bend Bridge	1180	47%	860 - 2290
Feather River at Oroville	510	29%	330 - 1260
Yuba River at Smartsville	360	36%	170 - 780
American River below Folsom Lake	490	40%	210 - 1160
SAN JOAQUIN RIVER			
Cosumnes River at Michigan Bar	40	31%	10 - 130
Mokelumne River inflow to Pardee	220	48%	115 - 450
Stanislaus River below Goodwin Res.	320	46%	150 - 690
Tuolumne River below La Grange	560	46%	320 - 1140
Merced River below Merced Falls	210	33%	110 - 550
San Joaquin River inflow to Millerton Lk	440	35%	260 - 1010
TULARE LAKE			
Kings River below Pine Flat Res.	460	37%	310 - 950
Kaweah River below Terminus Res.	80	28%	50 - 220
Tule River below Lake Success	8	13%	2 - 57
Kern River inflow to Lake Isabella	120	26%	70 - 350
NORTH LAHONTAN			
Truckee River,Tahoe to Farad accretions	65	25%	
Lake Tahoe Rise, in feet	0.5	36%	
West Carson River at Woodfords	25	47%	
East Carson River near Gardnerville	90	48%	
West Walker River below Little Walker	75	48%	
East Walker River near Bridgeport	21	33%	

DWR March 1 Forecast

March 1, 2014 FORECAST
OF UNIMPAIRED RUNOFF
(in thousands of acre-feet)

Water-Year (WY) Forecast and Monthly Distribution

	Oct thru Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Water Year	80% Probability Range	WY % Avg
Trinity, Lewiston	38	49	65	80	70	28	7	3	0	340	180 - 690	25
Inflow to Shasta	697	284	340	310	260	190	170	160	159	2570	2105 - 3870	43
Sacramento, Bend	922	419	470	390	335	245	210	180	179	3350	2800 - 5240	38
Feather, Oroville	308	258	270	210	140	90	70	62	52	1460	1170 - 2675	32
Yuba, Smartville	91	188	210	170	135	40	15	8	8	865	555 - 1550	37
American, Folsom	48	237	158	220	200	60	10	1	1	935	560 - 1825	35
Cosumnes, Mich.Bar	7	20	23	23	12	4	1	0	0	90	40 - 195	23
Mokelumne, Pardee	9	33	42	80	110	26	4	1	0	305	170 - 580	41
Stanislaus, Gdw.	25	36	60	120	140	50	10	3	1	445	255 - 850	38
Tuolumne, LaGrange	20	52	105	175	250	115	20	6	2	745	460 - 1450	38
Merced, McClure	10	13	35	75	95	32	8	2	0	270	150 - 700	27
San Joaquin, Mil.	45	23	55	120	200	90	30	12	5	580	360 - 1220	32
Kings, Pine Flat	39	20	55	120	210	105	25	9	7	590	410 - 1160	34
Kaweah, Terminus	8	6	18	28	36	13	3	2	1	115	70 - 300	25
Tule, Success	3	2	7	4	3	1	0	0	0	20	9 - 80	14
Kern, Isabella	37	11	25	35	45	25	15	10	7	210	145 - 530	29

60-20-20 Index

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	
13	290,397	597,042	267,194	518,953	1,673,586	323,159	476,812	207,327	318,805	1,326,103	1,706,346	108,516	Critical
14	320,000	560,000	210,000	440,000	1,530,000	120,570	177,238	57,878	123,151	478,837	1,355,037	94,000	Critical
Feb 1 Forecast													
Dry	90,000	270,000	105,000	260,000	725,000	61,000	88,000	32,000	77,000	258,000	827,869	94,000	Critical
Average	280,000	560,000	260,000	520,000	1,620,000	121,000	173,000	77,000	152,000	523,000	1,417,869	94,000	Critical
Wet	700,000	1,250,000	740,000	1,220,000	3,910,000	236,000	378,000	237,000	307,000	1,158,000	2,918,869	229,471	Below Normal
Feb 11 Update													
Dry	130,000	320,000	110,000	250,000	810,000	61,000	88,000	32,000	77,000	258,000	878,869	94,000	Critical
Average	330,000	610,000	260,000	500,000	1,700,000	121,000	173,000	77,000	152,000	523,000	1,465,869	94,000	Critical
Wet	750,000	1,280,000	680,000	1,180,000	3,890,000	236,000	378,000	237,000	307,000	1,158,000	2,906,869	225,577	Below Normal
Feb 18 Update													
Dry	120,000	310,000	100,000	230,000	760,000	61,000	88,000	32,000	77,000	258,000	848,869	94,000	Critical
Average	300,000	580,000	230,000	440,000	1,550,000	121,000	173,000	77,000	152,000	523,000	1,375,869	94,000	Critical
Wet	710,000	1,230,000	630,000	1,100,000	3,670,000	236,000	378,000	237,000	307,000	1,158,000	2,774,869	182,746	Below Normal
Feb 25 Update													
Dry	90,000	270,000	85,000	170,000	615,000	61,000	88,000	32,000	77,000	258,000	761,869	94,000	Critical
Average	260,000	510,000	190,000	350,000	1,310,000	121,000	173,000	77,000	152,000	523,000	1,231,869	94,000	Critical
Wet	650,000	1,110,000	550,000	950,000	3,260,000	236,000	378,000	237,000	307,000	1,158,000	2,528,869	151,421	Below Normal
Mar 1 Forecast													
Dry	150,000	320,000	110,000	260,000	840,000	101,000	132,000	38,000	83,000	354,000	916,069	94,000	Critical
Average	320,000	560,000	210,000	440,000	1,530,000	121,000	177,000	58,000	123,000	479,000	1,355,069	94,000	Critical
Wet	690,000	1,140,000	550,000	1,010,000	3,390,000	156,000	302,000	148,000	193,000	799,000	2,535,069	151,861	Below Normal

TABLE 5

MINIMUM TUOLUMNE RIVER FLOW REQUIREMENT BASED ON 1996 SETTLEMENT AGREEMENT
INDEX CUTOFFS BASED ON SAN JOAQUIN 602020 INDEX UPDATED THROUGH WATER YEAR 2013

Dry San Joaquin Index =916,069 Average San Joaquin Index =1,355,069

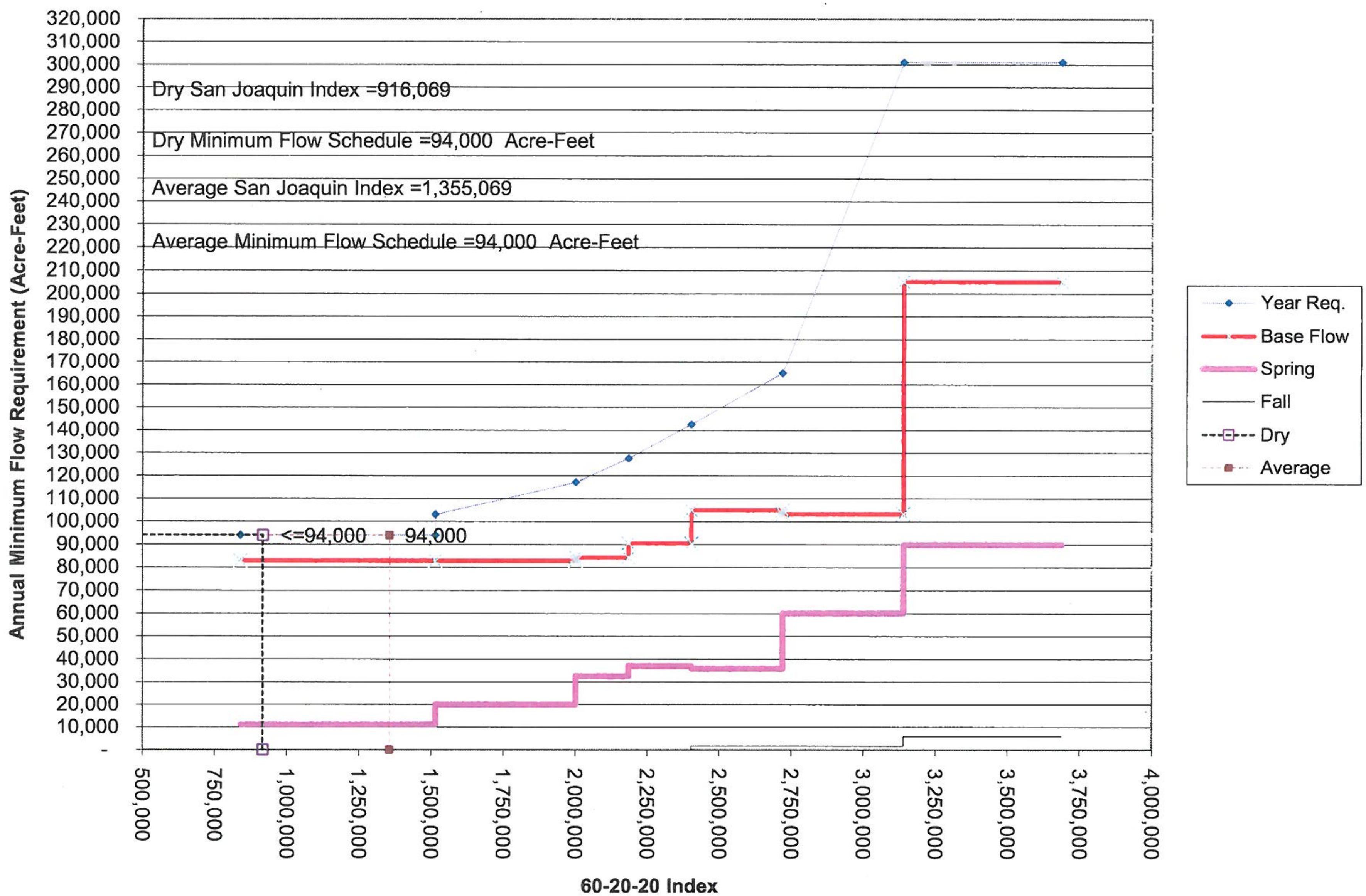
BASE FLOW (Table a)
C.F.S.

	INDEX CUTOFF	31 JAN	28 FEB	31 MAR	30 APR	31 MAY	30 JUN	31 JUL	31 AUG	30 SEP	31 OCT	30 NOV	31 DEC	
1 CRITICAL WATER YEAR AND BELOW	0	150	150	150	150	150	50	50	50	50	126	150	150	82,909
2 MEDIAN CRITICAL WATER YEAR	1,515	150	150	150	150	150	50	50	50	50	126	150	150	82,909
3 INTERMEDIATE C-D WATER YEAR	2,002	150	150	150	150	150	50	50	50	50	150	150	150	84,397
4 MEDIAN DRY	2,185	150	150	150	150	150	75	75	75	75	150	150	150	90,446
5 INTERMEDIATE D-BN	2,403	180	180	180	180	180	75	75	75	75	180	180	180	104,906
6 MEDIAN BELOW NORMAL	2,720	175	175	175	175	175	75	75	75	75	187	175	175	103,240
7 INTERMEDIATE BN-AN	3,139	300	300	300	300	300	250	250	250	250	300	300	300	205,091
8 MEDIAN ABOVE NORMAL	3,689	300	300	300	300	300	250	250	250	250	300	300	300	205,091
9 INTERMEDIATE AN-W	4,028	300	300	300	300	300	250	250	250	250	300	300	300	205,091
10 MEDIAN WET/ MAXIMUM	4,754	300	300	300	300	300	250	250	250	250	300	300	300	205,091

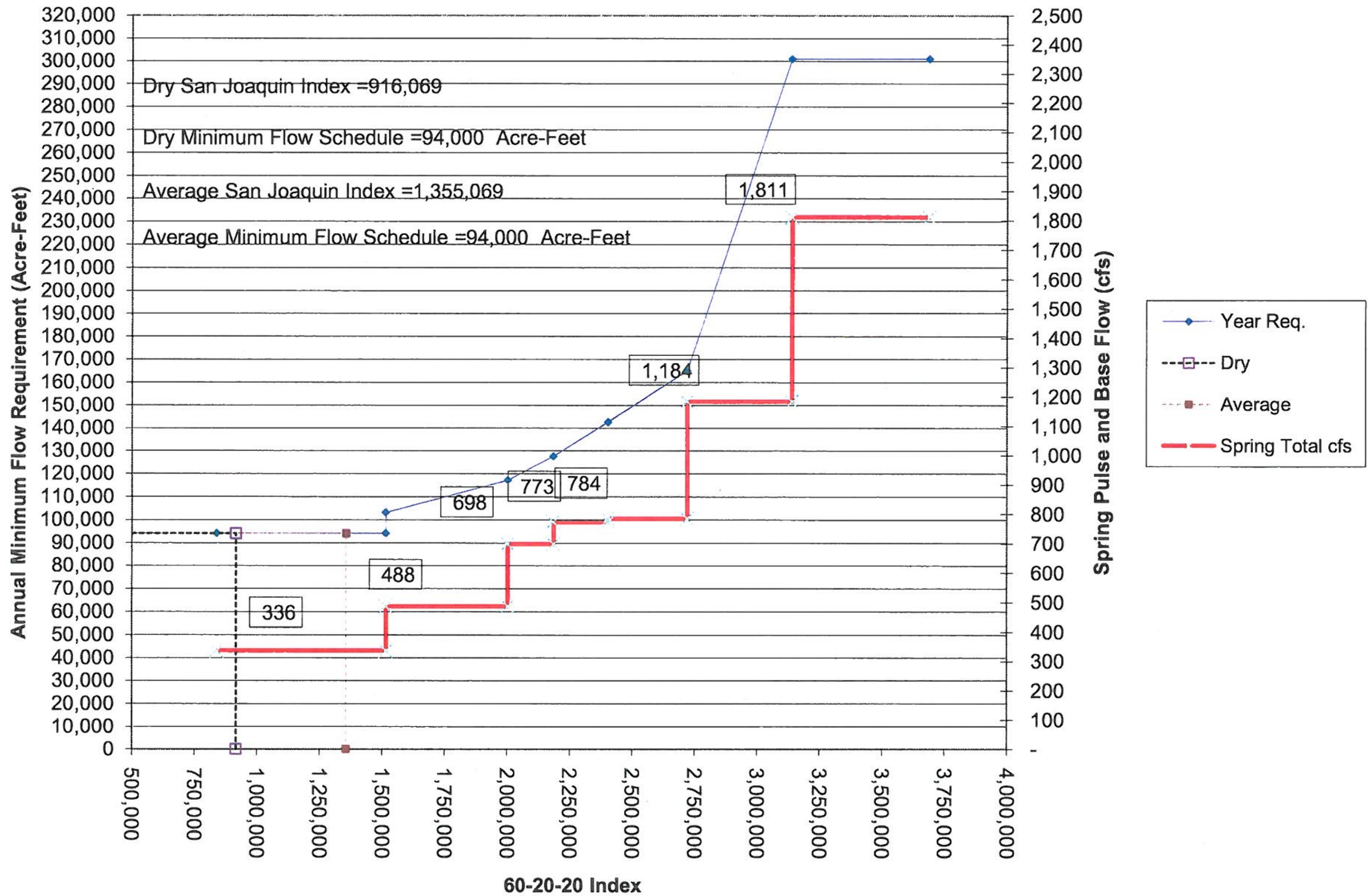
PULSE FLOWS (Table b)
A.F.

		31 JAN	28 FEB	31 MAR	30 APR	31 MAY	30 JUN	31 JUL	31 AUG	30 SEP	31 OCT	30 NOV	31 DEC
1 CRITICAL WATER YEAR AND BELOW	0				11,091								
2 MEDIAN CRITICAL WATER YEAR	1,515				20,091								
3 INTERMEDIATE C-D WATER YEAR	2,002				32,619								
4 MEDIAN DRY	2,185				37,060								
5 INTERMEDIATE D-BN	2,403				35,920						1,676		
6 MEDIAN BELOW NORMAL	2,720				60,027						1,736		
7 INTERMEDIATE BN-AN	3,139				89,882						5,950		
8 MEDIAN ABOVE NORMAL	3,689				89,882						5,950		
9 INTERMEDIATE AN-W	4,028				89,882						5,950		
10 MEDIAN WET/ MAXIMUM	4,754				89,882						5,950		

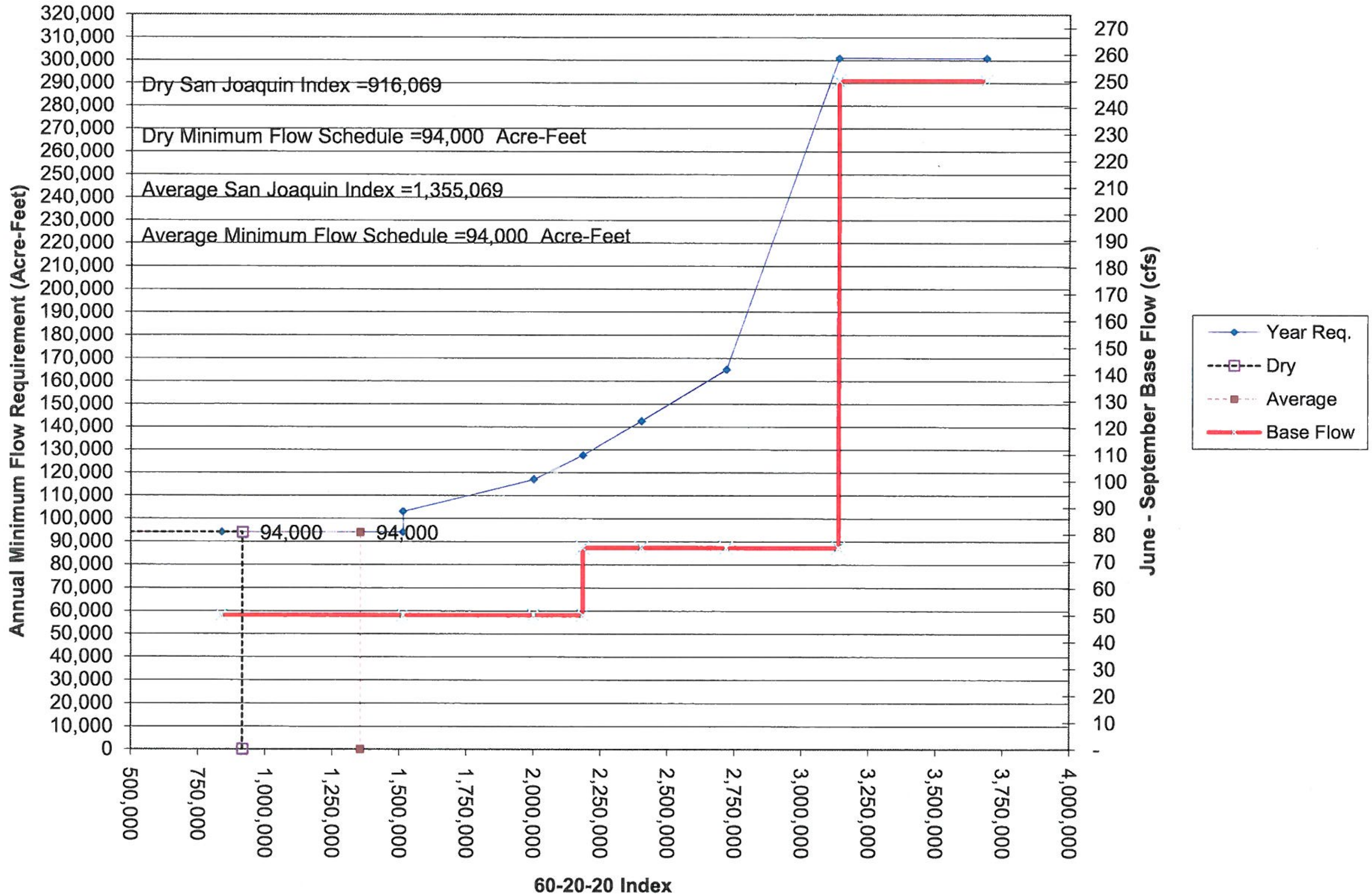
TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 1)
Annual Flow Requirement



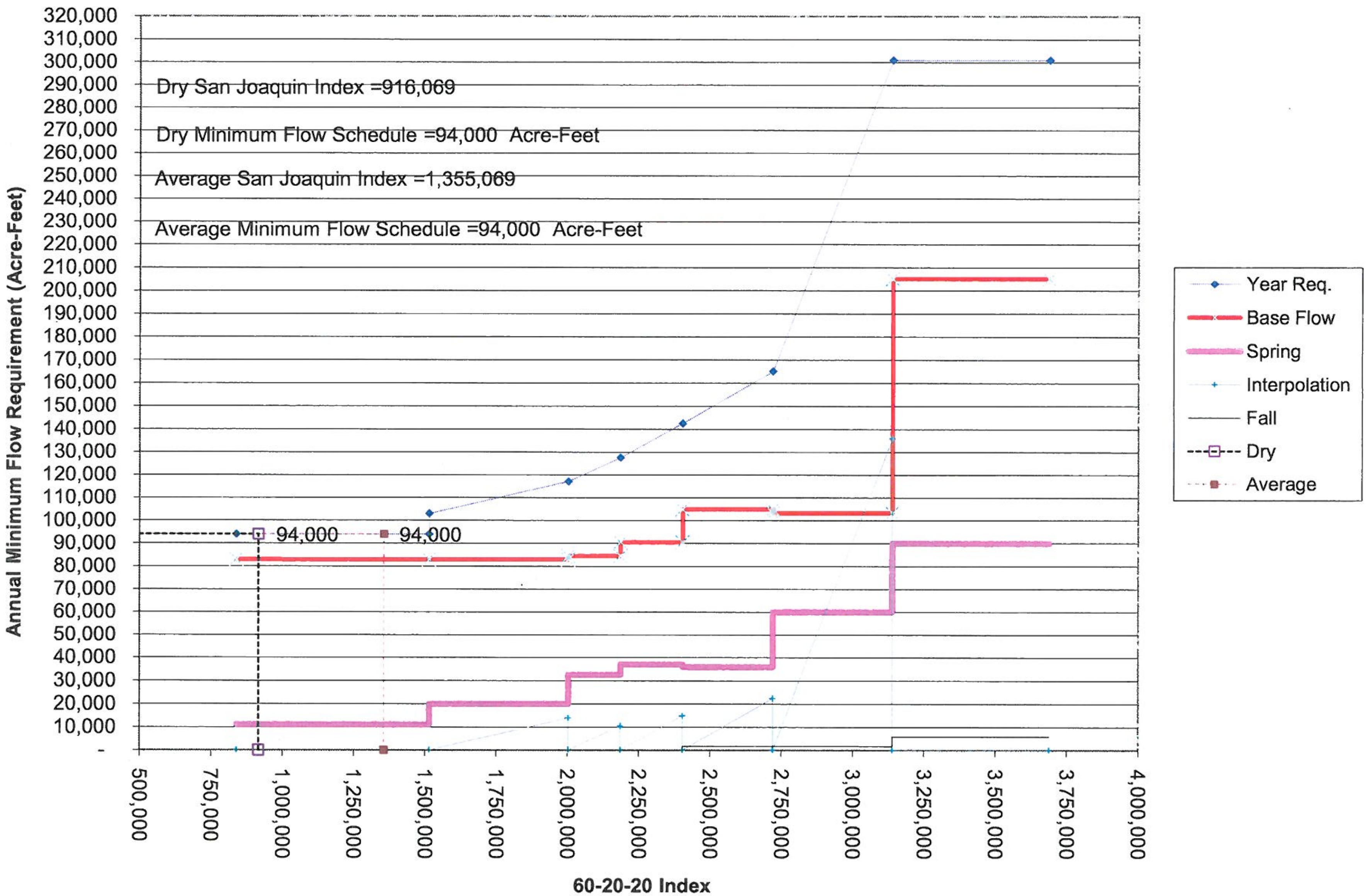
TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 2)
(Spring Pulse Flow Plus Base Flow)



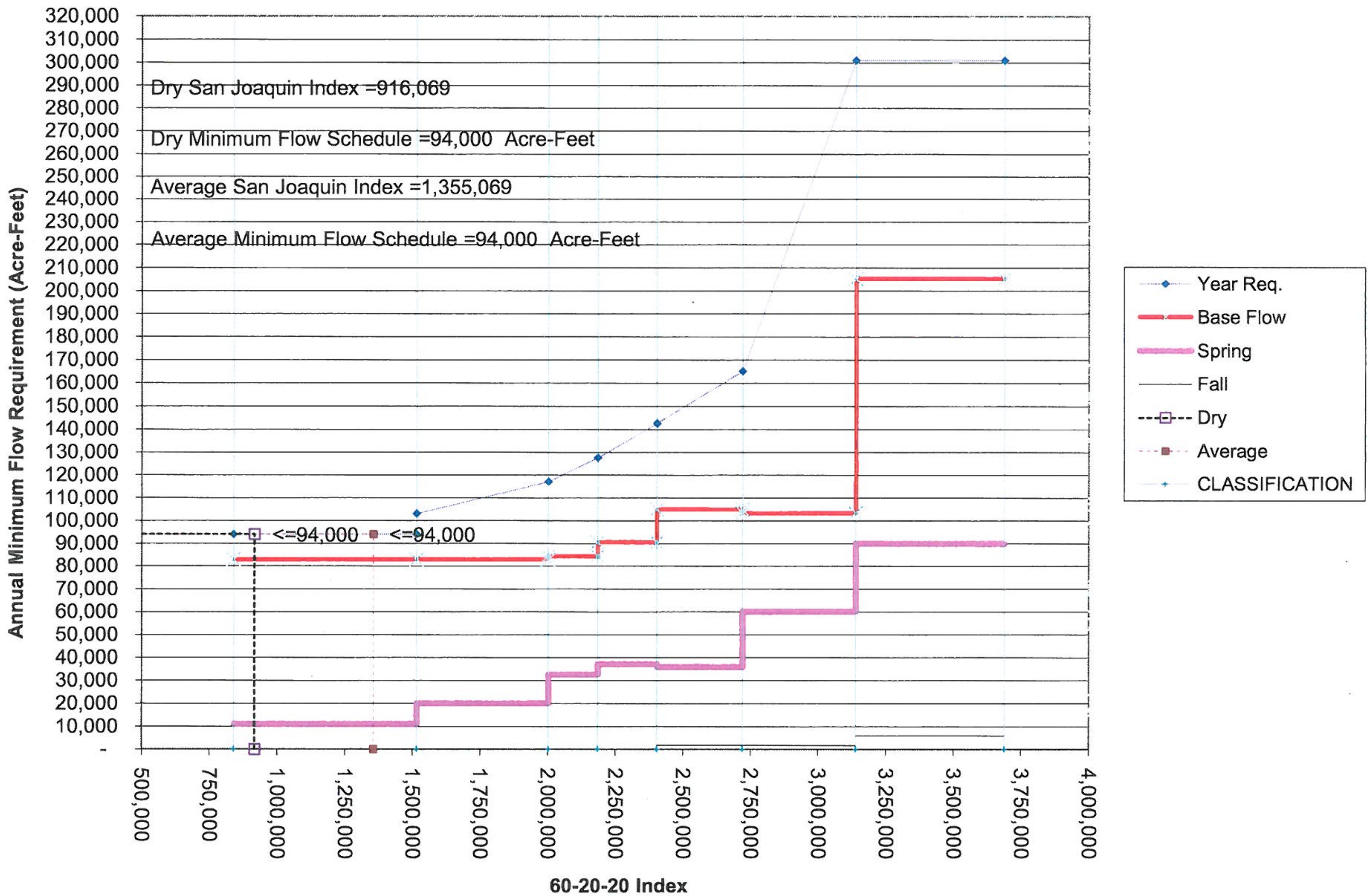
TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 3)
(Summer Base Flow)



TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 4)
Interpolation Volume



TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 5)
Classification



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TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
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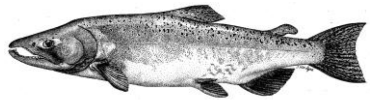

TECHNICAL ADVISORY COMMITTEE MEETING

June 12, 2014 at 9:30 AM

Turlock Irrigation District, Room 152

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from March 2014 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Review spring monitoring (Sein, RST's)
   - Review 2013 weir operations
   - Planned summer 2014 Relicensing studies (Swim tube study)
   - Other summer 2014 Monitoring (Reference count snorkeling, water temperature)

4. FLOW OPERATIONS:
   - Review spring pulse flows
   - Review summer flow schedule and fluxuation methodology

5. AGENCY/NGO UPDATES

6. ADDITIONAL ITEMS

7. NEXT MEETING DATES – SEPTEMBER 11, DECEMBER 11, 2014

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
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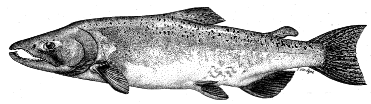

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
Fax: (209) 656-2191
Email: pemaloney@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

12 June 2014 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. **INTRODUCTION AND ANNOUNCEMENTS**
   - Participants made self introductions.

2. **ADMINISTRATIVE ITEMS:**
   - Review/Revise agenda – No changes.
   - Approve notes from March 2014 meeting – Water hyacinth issues discussed but not recorded in March – will discuss today. No feedback from Monica Gutierrez (NOAA) regarding O. mykiss passage (document supplied to Monica by Fishbio). Notes for the last meeting are posted to the TRTAC website: http://tuolumnerivertac.com/
   - Items since last meeting – A handout list posted at http://tuolumnerivertac.com/ was reviewed.

3. **MONITORING/REPORTS:** (*Handouts were reviewed*)
   - Seine: The number of smolts captured in 2014 was twice that of 2013 (number of female spawners was higher than normal). No smolts were captured below Charles Road. Water hyacinth issues persisted during spring pulse causing several seine sites to be unfishable.
   - Rotary Screw Traps: Highest catch on record was recorded at Waterford.
   - Weir: The number of female spawners was higher than normal.
   - Swim Tunnel Study (Project #2): SWS holds permit – SWS requested that all details of permit, including notification 2 weeks prior to initiation, be strictly adhered to. Jason and Andrea of Fishbio to contact Noah of SWS to address permit details. Permit amendments on hold – waiting on Annie Mangie's comments to revised study plan. Noah and Wayne of SWS requested updates from Fishbio on permit and study progress. Night seining might be an option, as per observations made by Patrick Maloney. Additional population information may be gained and communicated to Fishbio as Wayne and Patrick conduct the Annual Reference Count Snorkel Survey – Wayne and Patrick to report to Jason Guignard daily in order to advise where 100-200mm fish were observed.
   - Predation Study: TID and consulting firms are in the process of coordinating with the agencies – possibly to begin in 2015.

4. **FLOW OPERATIONS:**
   - Spring Pulse: Flows caused water hyacinth issues with the RST, seining and weir. However, RST and seine #'s were good except for the days hyacinth overtook the areas.
   - Summer Flow Schedule: Reviewed method used to calculate summer flows. Flows will range between 95-110cfs depending on predicted air temperature in Modesto. On October 1, the base flow will go to 100cfs. On October 17 the base flow will go to 150cfs.
   - Fall Pulse: No fall pulse planned.

5. **AGENCY/NGO UPDATES**
   - Mountain lions observed near the State Park (TLSRA), lions were seen feeding during daylight hours, (.31 miles from a full campground). Sighting reported to CDFW Warden Chris Cahill.

6. **ADDITIONAL ITEMS**
   - None

7. **NEXT MEETING DATE** – SEPTEMBER 11, 2014

TRTAC Meeting Attendees

	Name	Organization
1.	Patrick Maloney	TID
2.	Jason Guignard	FISHBIO
3.	Wayne Swaney	Stillwater
4.	John Davids	MID

2014 TRTAC Materials/Postings to Website

2014Mar13 – 2014June 11 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2014 TRTAC meeting summary and handouts
  - June 2014 TRTAC meeting agenda

- Correspondence
  - March 21, 2014. NOAA Fisheries', West Coast Region, Additional Response to Proposal for Traditional Licensing Process for the La Grange Hydroelectric Project, Federal Energy Regulatory Commission Project No. P-14581, Tuolumne River, California. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14196593
  - March 27, 2014. USFWS Comments on the Technical Memorandum for the Lower Tuolumne River Instream Flow Study - Pacific lamprey, Sacramento Splittail, and Non-native Predatory Fish Habitat Assessment: Final 1-D PHABSIM Habitat Suitability Criteria for FERC #2299 project. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14198366
  - March 28, 2014. ILP Districts Response to Relicensing Participants' comments on Don Pedro Updated Study Report of Turlock Irrigation District and Modesto Irrigation District under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14198975
  - April 3, 2014. Memorandum of Commission staff MOU Meeting with California State Water Resources Control Board staff on Coordination of Pre-application Activities under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14201039
  - April 18, 2014. Submittal on behalf of Turlock Irrigation District and Modesto Irrigation District of the final meeting notes and responses to Relicensing Participant comments on the W&AR-10 Modeling Workshop No. 2 held on November 5, 2013 under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14206767
  - April 28, 2014. Comments of California Department of Fish and Wildlife on second year predation study plan and request for extension under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14209581
  - April 28, 2014. Application For Relicense of Turlock Irrigation District and Modesto Irrigation District's Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14209655
  - April 28, 2014. Application For Relicense of Turlock Irrigation District and Modesto Irrigation District's Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14209656
  - April 28, 2014. Application For Relicense of Turlock Irrigation District and Modesto Irrigation District's Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14209657
  - April 29, 2014. Letter to Turlock Irrigation District et al regarding the Determination on Requests for Study Modifications for the Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14210546

- April 29, 2014. Turlock Irrigation District and Modesto Irrigation District's CD containing Exhibit G maps and Form 587 re the final license application for the relicensing for the Don Pedro Hydroelectric Project under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14212481
- April 29, 2014. Turlock Irrigation District and Modesto Irrigation District submits final license application for the relicensing of the Don Pedro Hydroelectric Project under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14212390
- May 9, 2014. Letter acknowledging Turlock Irrigation District's et al 4/28/14 filing of its license application for the Don Pedro Hydro Project under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14214755
  May 9, 2014. Notice of Application Tendered for Filing with the Commission & Establishing Procedural Schedule for Licensing & Deadline for Submission of Final Amendments re Turlock Irrigation District et al under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14214756
- May 12, 2014. California State Water resources Control Board submits comments re the Project under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14215578
- May 13, 2014. Confirmation of mailing, in accordance with May 9, 2014 FERC directive, a copy of the Districts' FLA for the Don Pedro Project (under P-2299-082) to the Bureau of Land Management's Branch of Adjudication and Records in Sacramento, California.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14215695
- May 16, 2014. Turlock Irrigation District and Modesto Irrigation District submittal of affidavits of publication of the Public Notice for the filing of the Don Pedro Project Final License Application under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14217124
- June 2, 2014. Notice of Environmental Site Review re Turlock Irrigation District and Modesto Irrigation District's Don Pedro Hydroelectric Project under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14221734

- Documents
  - March 31, 2014. 2013 Lower Tuolumne River annual report submitted to the Commission pursuant to Article 58 of the license for Project No. 2299 and ordering paragraph (B) of the April 3, 2008 Order on Ten-Year Summary Report Under Article 58 under P-2299.
    http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14199238

- Data/Monitoring
  - No postings

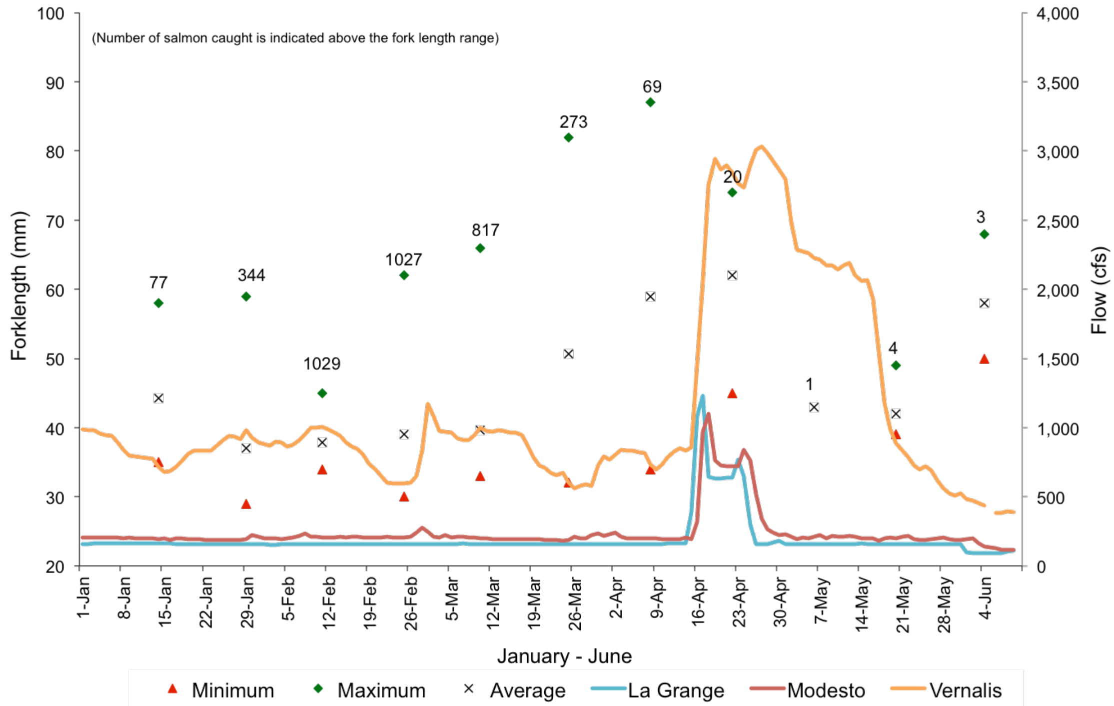

Figure 1. Number of Chinook salmon captured, length and flow data recorded during the 2014 Tuolumne River seine surveys.

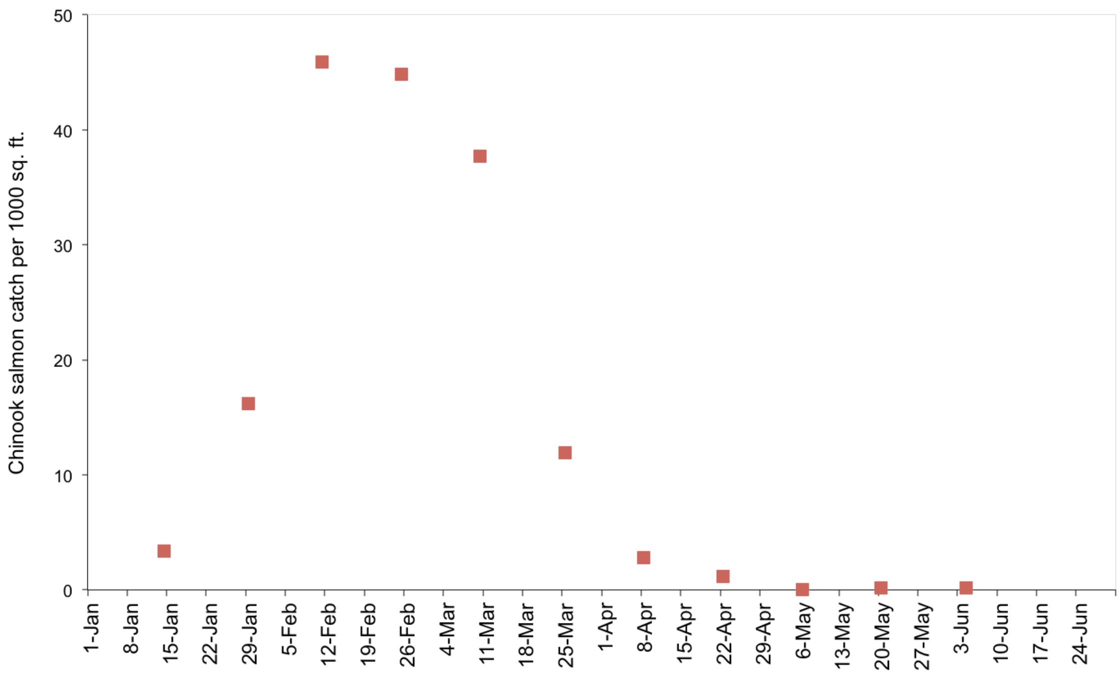

Figure 2. 2014 Tuolumne river-wide density of Chinook salmon (fry and juvenile combined).

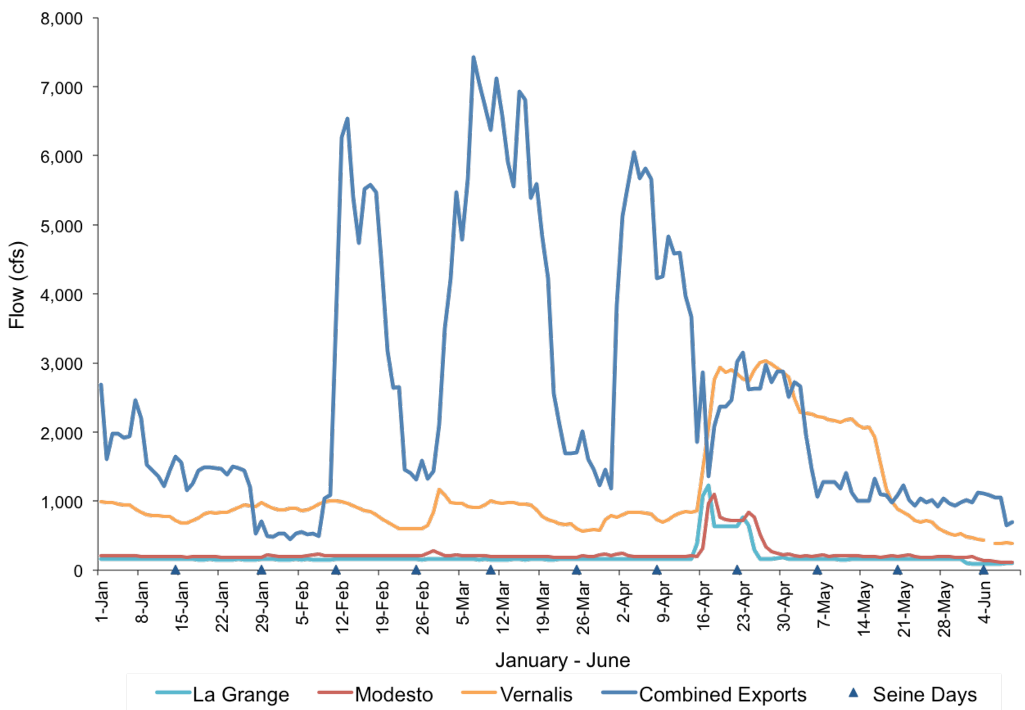

Figure 3. River flows and Delta exports during 2014 Tuolumne River seine surveys.

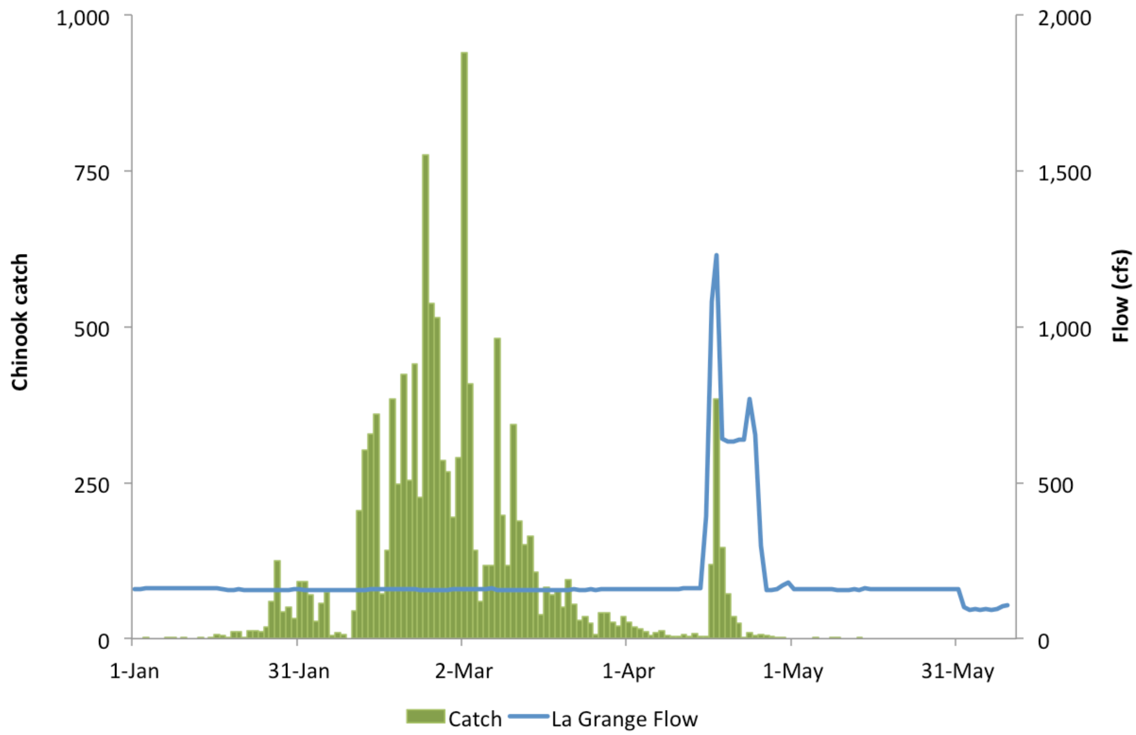

Figure 4. 2014 daily Chinook salmon catch at Waterford and Tuolumne River flow recorded at La Grange. Total catch = 3,664 Chinook salmon.

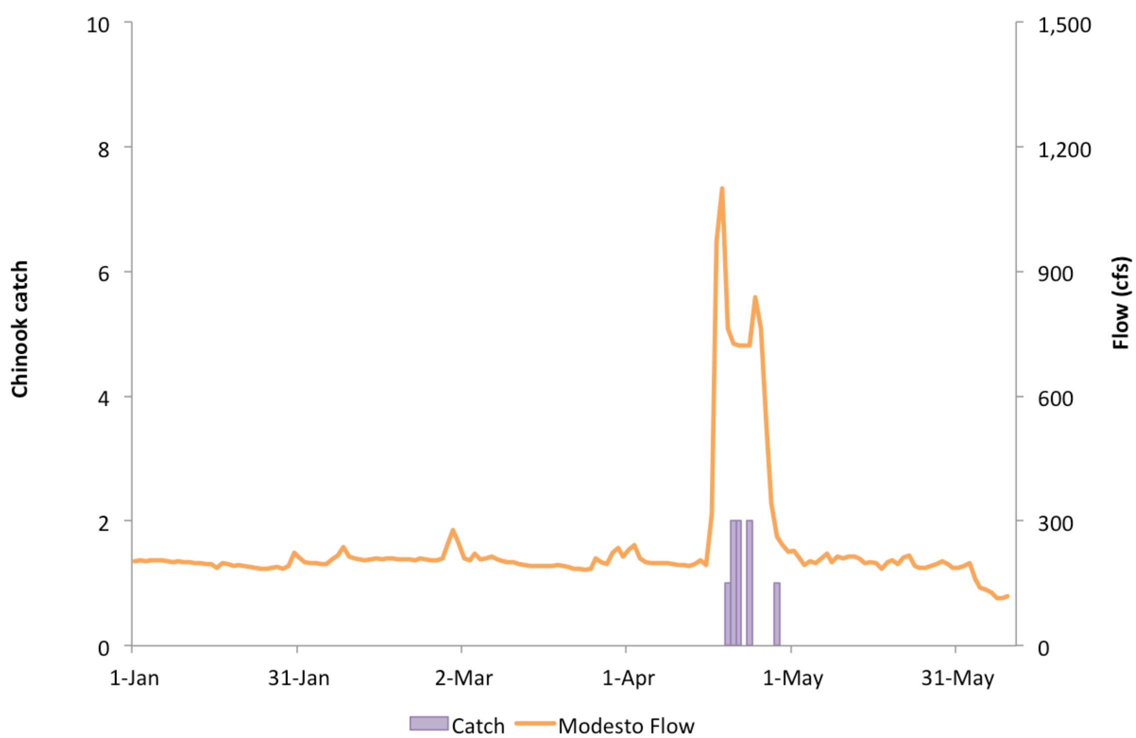

Figure 5. 2014 daily Chinook salmon catch at Grayson and Tuolumne River flow recorded at Modesto. Total catch = 8 Chinook salmon.

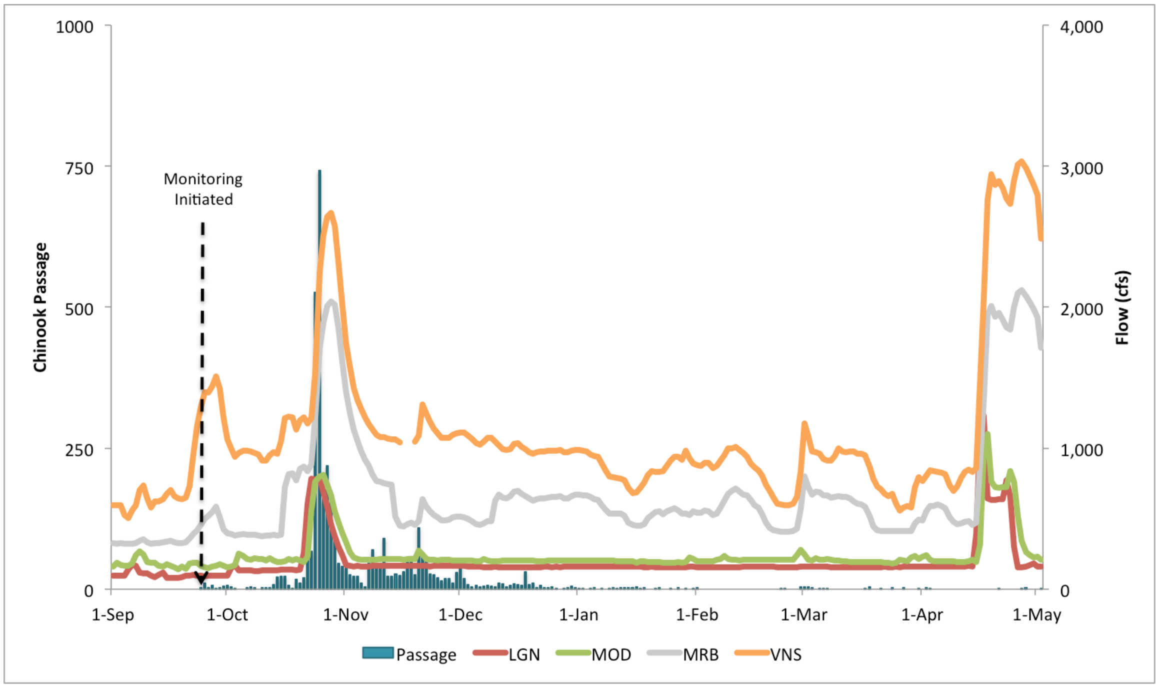

Figure 6. Daily upstream Chinook passage at the Tuolumne River Weir in relation to daily average flows (cfs) recorded in the Tuolumne River at La Grange (LGN) and Modesto (MOD), and in the San Joaquin River at Maze Rd (MRB) and Vernalis (VNS) in 2013/14. Season total of Chinook detections = 3,737. No *O. mykiss* detected in 2013/14.

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TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
Fax: (209) 656-2191
Email: pemaloney@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

September 11, 2014 at 9:30 AM

Turlock Irrigation District, Room 152

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from June 2014 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Routine snorkel and temperature
   - In-progress FERC relicensing studies
   - Fall monitoring 2014
   - Planned Annual FERC Report progress

4. FLOW OPERATIONS:
   - Review status of final basin index; annual fish flow volume
   - Fall flow schedule

5. AGENCY/NGO UPDATES

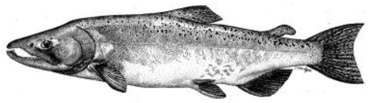
6. ADDITIONAL ITEMS

7. NEXT MEETING DATE – DECEMBER 11

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE



333 East Canal Drive
Turlock, CA 95381-0949
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Email: pemaloney@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

11 September 2014 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. **INTRODUCTION AND ANNOUNCEMENTS**
   - Participants made self-introductions.

2. **ADMINISTRATIVE ITEMS:**
   - <u>Review/Revise agenda</u> – No changes.
   - <u>Approve notes from June meeting</u> – No changes were identified. Notes for the last meeting are posted to the TRTAC website: http://tuolumnerivertac.com/
   - <u>Items since last meeting</u> – A handout list posted at http://tuolumnerivertac.com/ was reviewed.

3. **MONITORING/REPORTS:** (*Handouts were reviewed*)
   - Ongoing summer monitoring – Routine snorkel and temperature monitoring were conducted this summer.
   - In progress relicensing studies – W&AR-7 Predation Study – Additional survey activity planned for 2015. W&AR-11 Otolith Study – Draft laboratory results have been received. Analysis for report proceeding. W&AR-14 Temperature Criteria – Swim tunnel study data collection completed in July 2014. Draft report in preparation.
   - Fall Monitoring 2014 – The counting weir will be installed October 1st.
   - Redd surveys will continue this spawning season.
   - Planned Annual FERC Report progress – compilation of studies in progress.
   - La Grange Dam Licensing Plans – A meeting to discuss the Proposed Study Plan will be held on October 6, 2014 from 10 am to 4 pm at MID. In their Proposed Study Plan document submittal of September 5, 2014, the Districts included three studies:
     - Cultural Resources Study
     - Recreation Access and Safety Assessment
     - Fall-Run Chinook Salmon Migration Barrier Study

4. **FLOW OPERATIONS:**
   - Current watershed conditions as of September 11, 2014: the Tuolumne River Watershed is at 31% of normal unimpaired runoff for WY 2014. This water year is considered a critical water year type.
   - Base flows will remain at 50cfs through October 1, rising to 100cfs on October 1st, and rising again to 150cfs on October 16. Base flows will remain at 150cfs through

April 14, 2015.

- No fall pulse is scheduled.

5. **AGENCY/NGO UPDATES**

- None

6. **ADDITIONAL ITEMS**

- None

7. **NEXT MEETING DATE** – DECEMBER 11, 2014.

TRTAC Meeting Attendees

	Name	**Organization**
1.	Patrick Maloney	TID
2.	Jason Guignard	FISHBIO
3.	Noah Hume	Stillwater

2014 TRTAC Materials/Postings to Website

2014June 12 – 2014September 11, Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2014 TRTAC meeting agenda, handouts, materials list and notes
  - June 2014 TRTAC meeting agenda, handouts, materials list and notes
  - September 2014 TRTAC meeting agenda

- Correspondence
  - June 23, 2014. CDFW - Supplemental Information / California Department of Fish and Wildlife comments addressing Turlock Irrigation District proposed plans to dewater the diversion tunnel and complete maintenance under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14228148
  - June 30, 2014. CDFW - Correspondence from California Department of Fish and Wildlife to Turlock Irrigation District re the Don Pedro Hydroelectric Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14230033
  - July 30, 2014. City and County of San Francisco City and County of San Francisco - Letter to State Water Resources Control Board from City and County of San Francisco under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14238771
  - July 18, 2014. Turlock Irrigation District and Modesto Irrigation District MODESTO AND TURLOCK IRR. DISTS Turlock Irrigation District and Modesto Irrigation District - Turlock Irrigation District and Modesto Irrigation District's W&AR-12 O.mykiss Habitat Assessment Update on Second Year of LWD collection for the Don Pedro Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14235371
  - July 18, 2014. MODESTO AND TURLOCK IRR. DISTS Turlock Irrigation District and Modesto Irrigation District Turlock Irrigation District and Modesto Irrigation District - Turlock Irrigation District and Modesto Irrigation District submittal of Final Meeting Notes and Responses to Relicensing Participants' Comments on Don Pedro Project W&AR-21 Floodplain Hydraulic Assessment Consultation Workshop No. 1 under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14235374
  - July 18, 2014. Turlock Irrigation District and Modesto Irrigation District Turlock Irrigation District and Modesto Irrigation District - Turlock Irrigation District and Modesto Irrigation District submittal of Final Meeting Notes w/Attachments A & B-Response to RP Comments on W&AR-21 Floodplain Hydraulic Assessment Study Consultation Workshop No. 1 under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14235498
  - July 22, 2014. Individual - Proof of Publication re Notice of Environmental Site Review re Modesto Irrigation & Turlock Irrigation Districts, Don Pedro Hydroelectric Projects under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14236346
  - July 30, 2014. City and County of San Francisco City and County of San Francisco - Letter to State Water Resources Control Board from City and County of San Francisco under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14238771

- August 19, 2014. BLM – CALIFORNIA - ILP Comments on draft historic management plan. BLM - CALIFORNIA under P-2299.
  http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14244043

- Documents - No postings

- Data/Monitoring - No postings

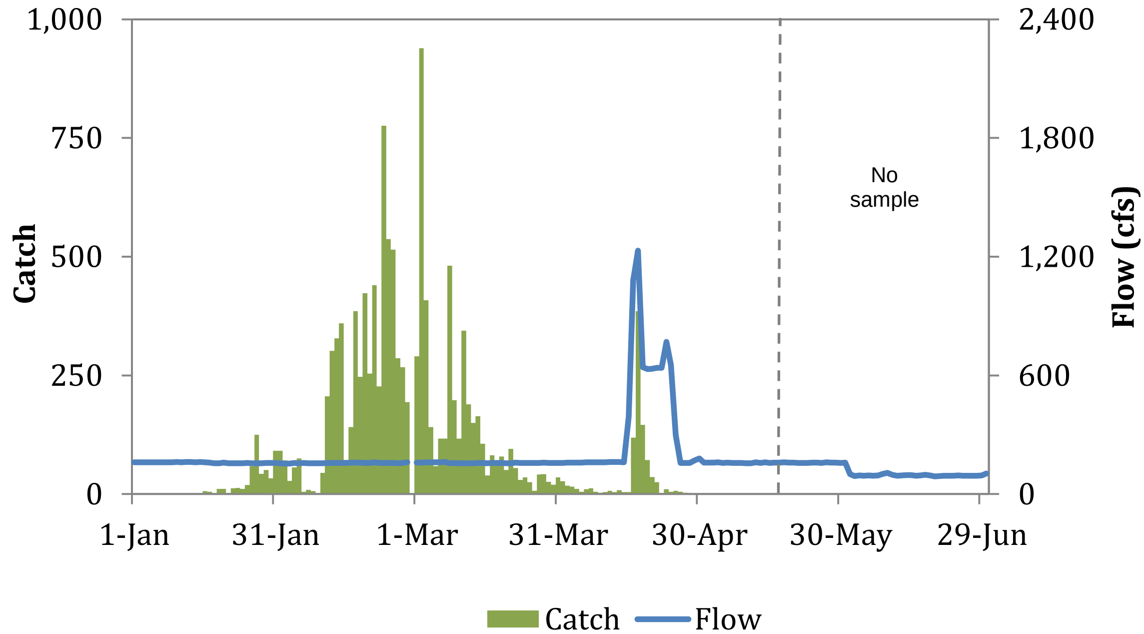


Figure 1. Waterford Chinook catch and Tuolumne River flow at La Grange, 2014.

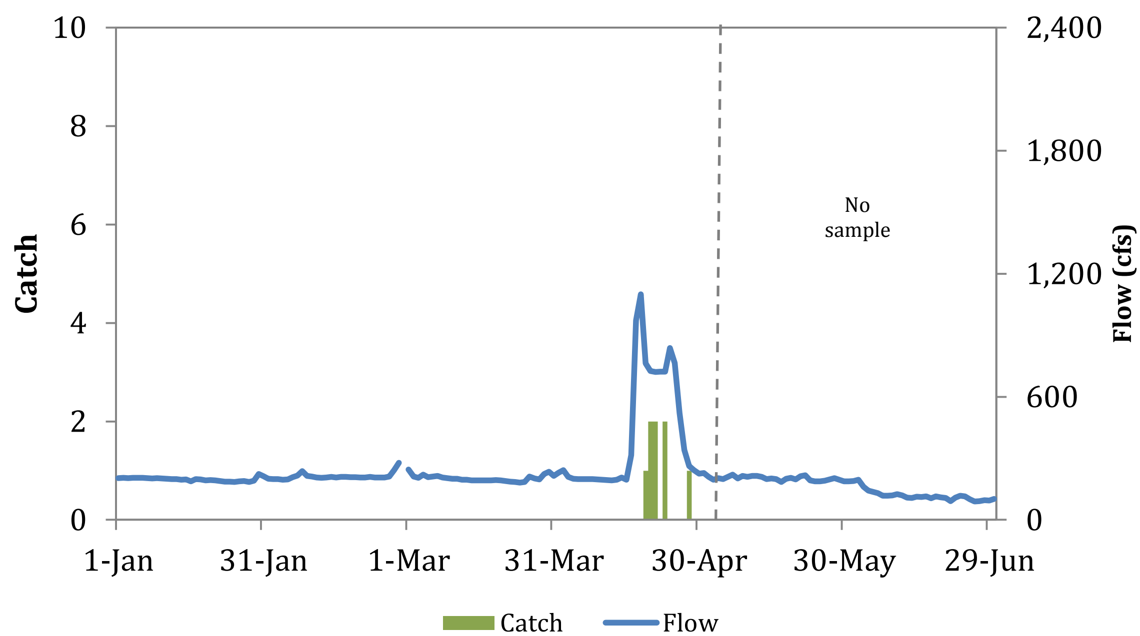


Figure 2. Grayson Chinook catch and Tuolumne River flow at Modesto, 2014.

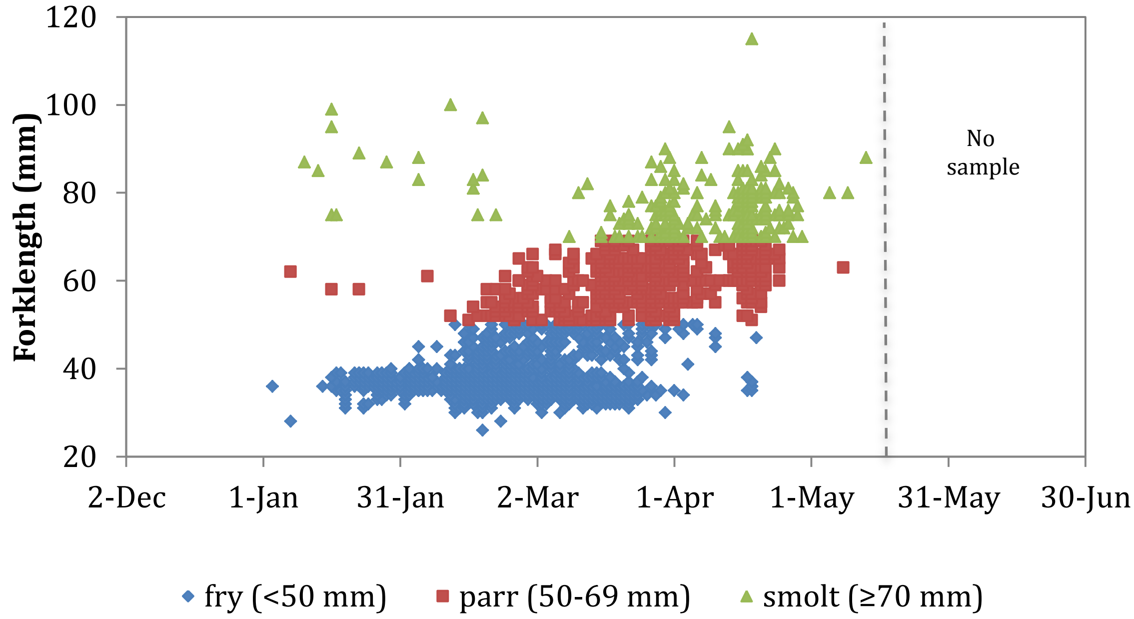


Figure 3. Chinook forklength by lifestage at Waterford, 2014.

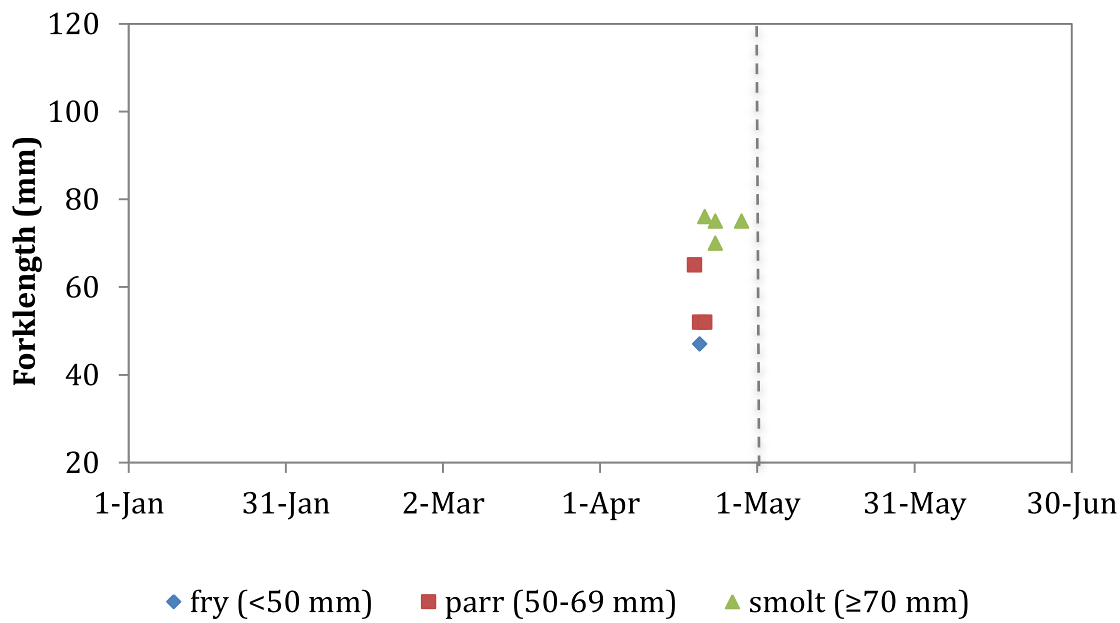


Figure 4. Chinook forklength by lifestage at Grayson, 2014.

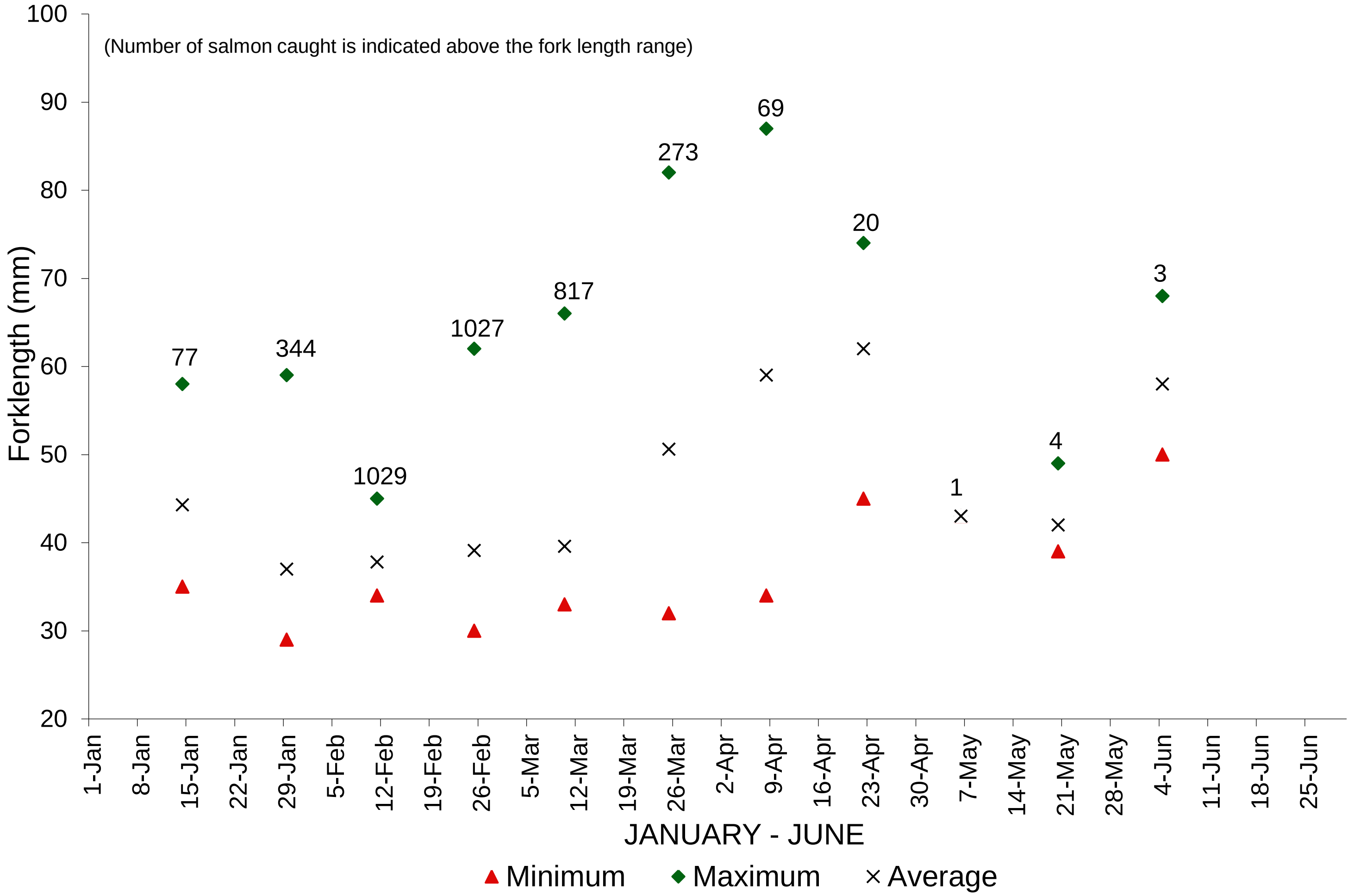


Figure 5. Number and minimum, maximum, and average forklength of Chinook captured during 2014 Tuolumne River seine surveys.

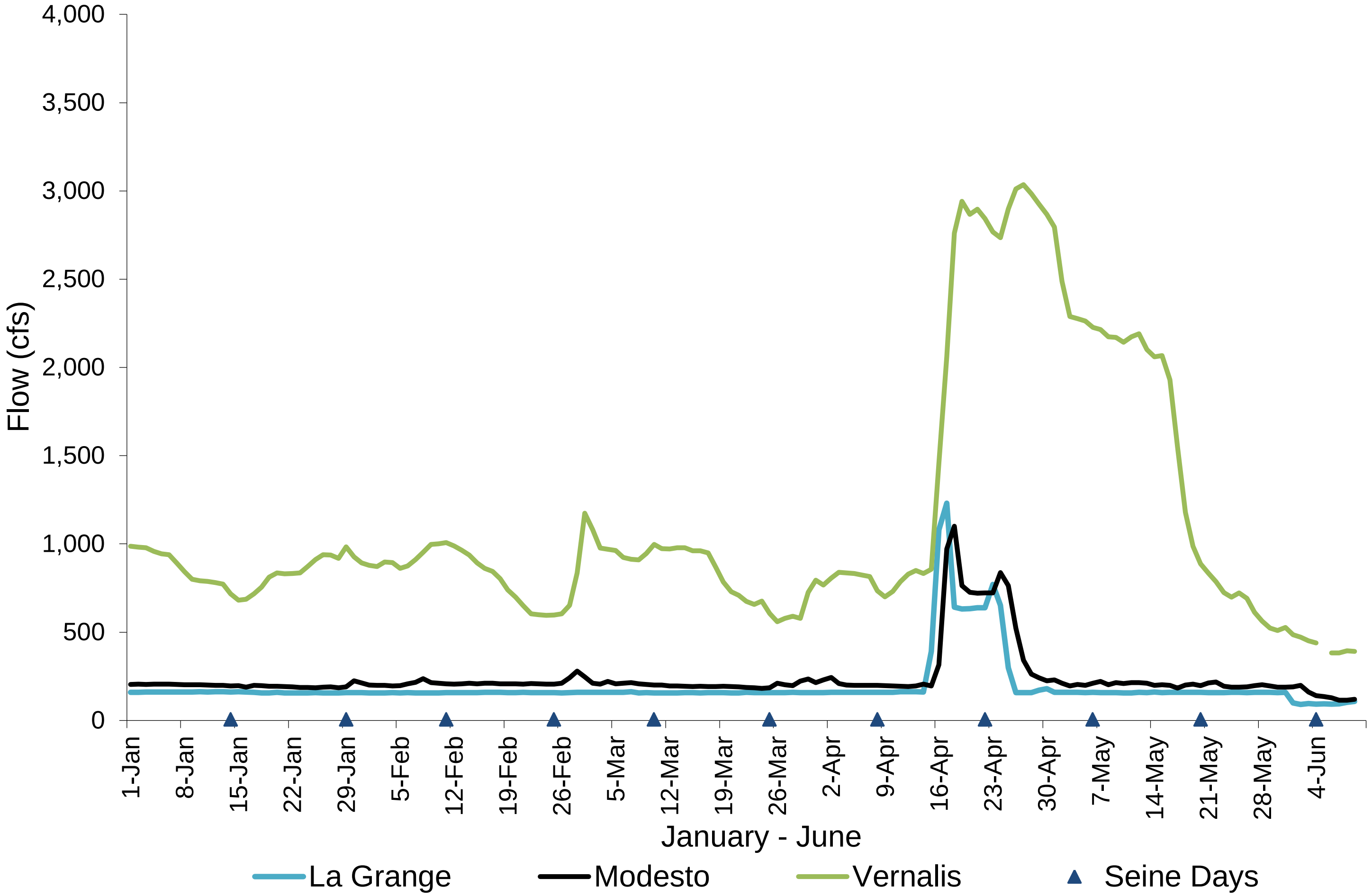
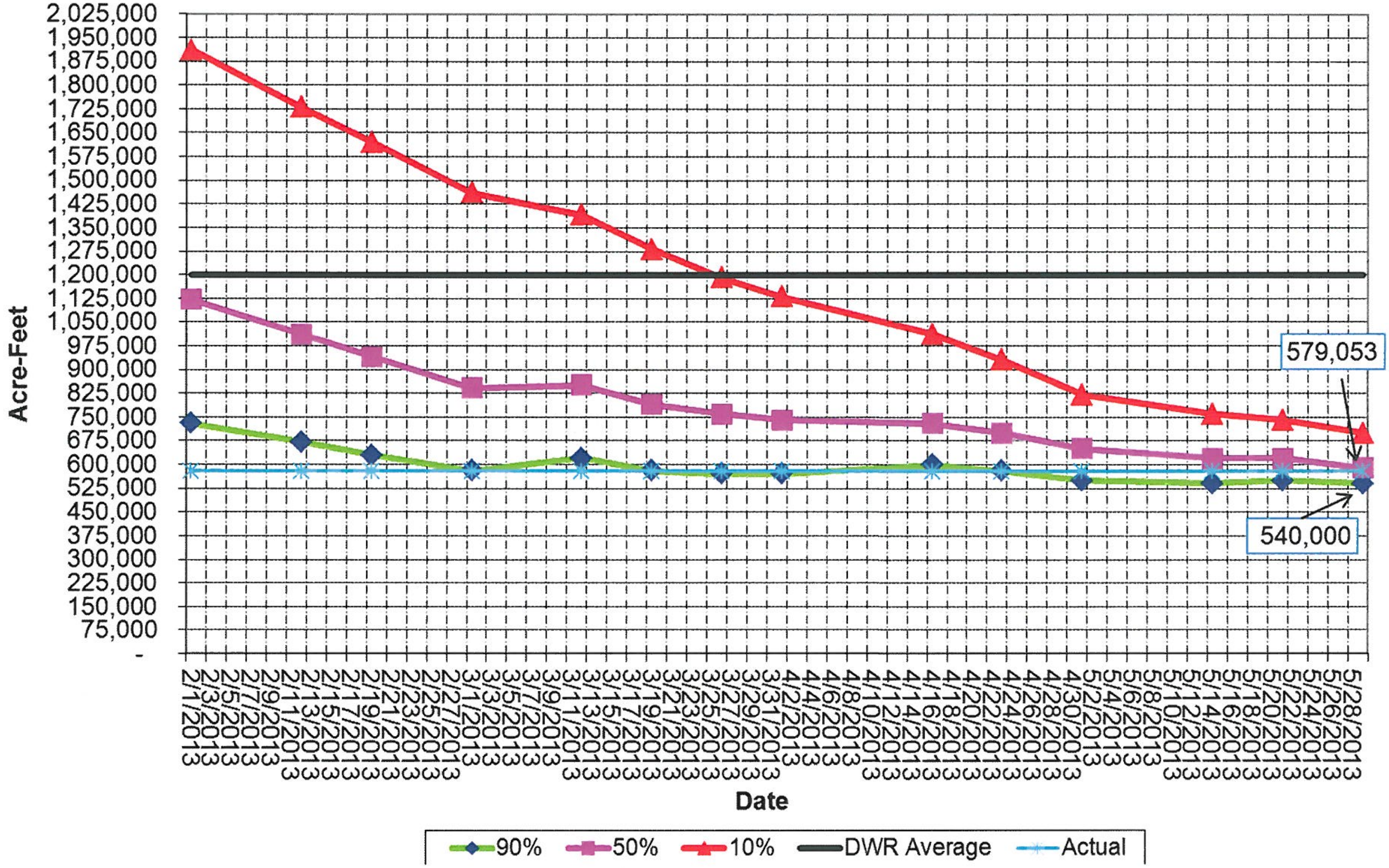


Figure 6. Tuolumne River flow at La Grange and Modesto and San Joaquin River flow at Vernalis during 2014 Tuolumne River seine surveys.

DWR Tuolumne River Forecast (2013 April-July)

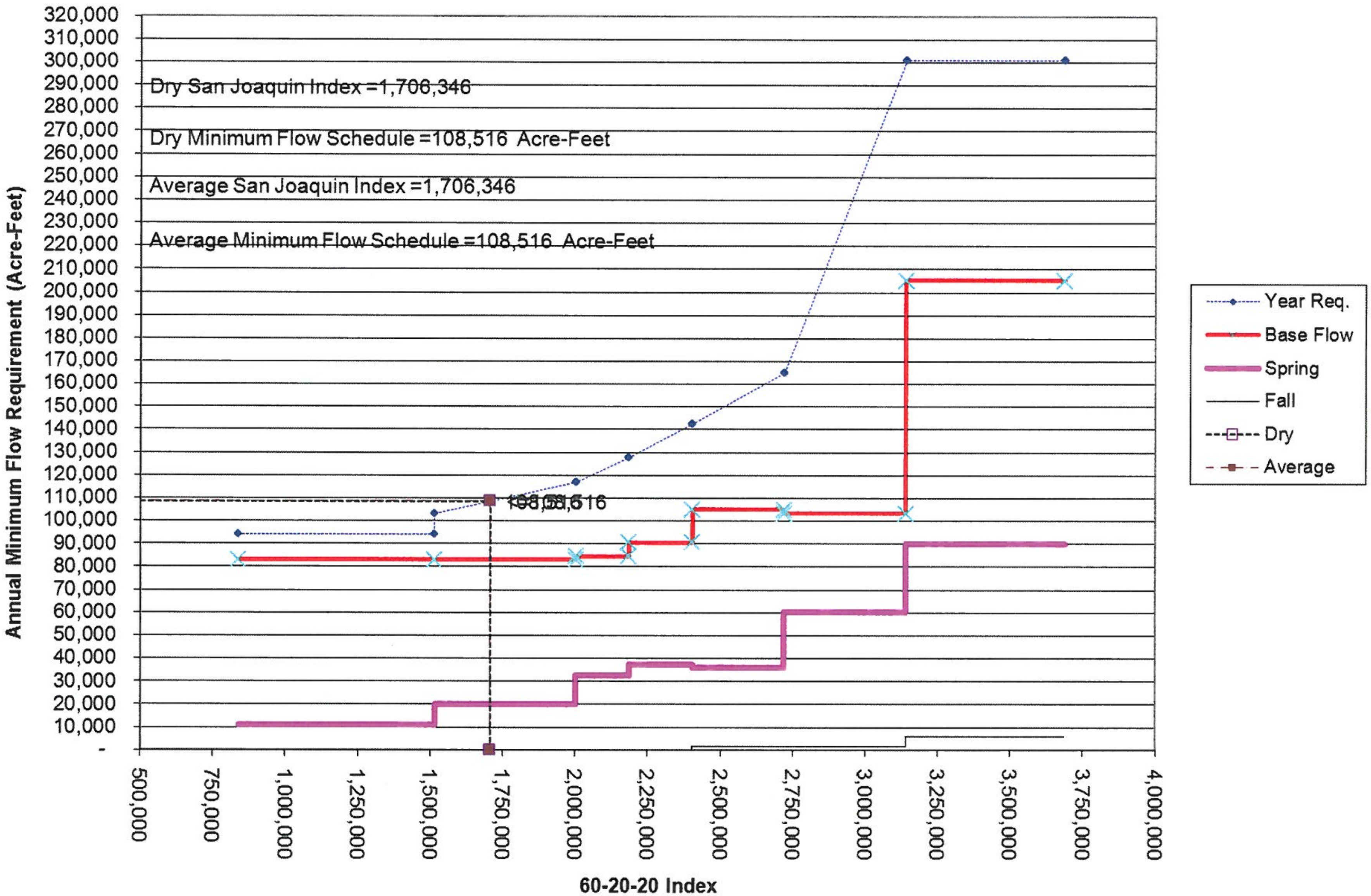


SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION (Final for 2014)

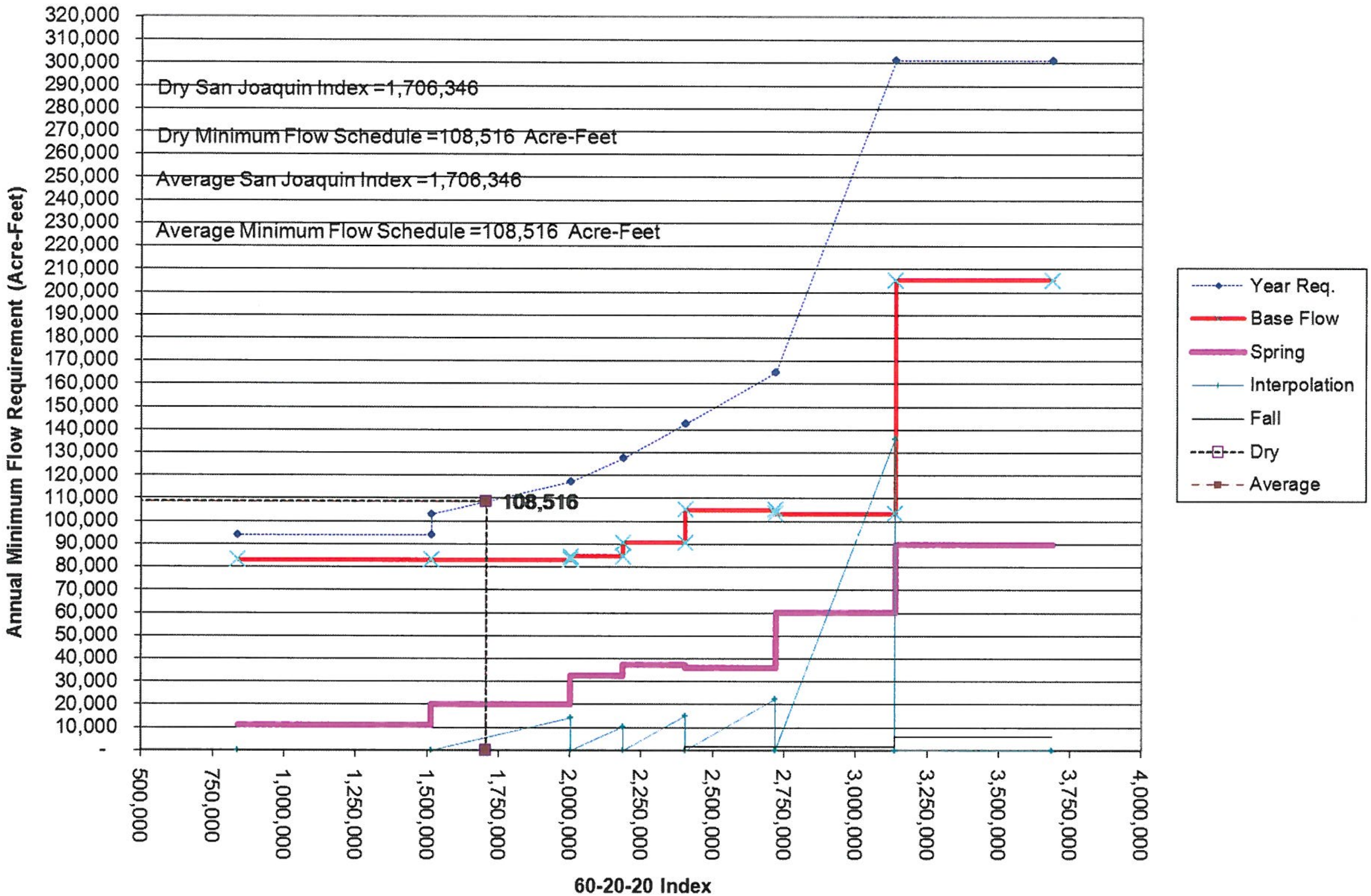
602020 INDEX

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)
12	394,507	609,424	300,876	558,917	1,863,724	216,256	254,324	117,856	244,726	833,162	2,184,867	127,506	Dry
13	290 397	597,042	267,194	518,953	1,673,586	323,159	476,812	207,327	318,805	1,326,103	1,706,346	108,516	Critical
Feb 1 Forecast													
Dry	400,000	730,000	370,000	770,000	2,270,000	295,000	415,000	165,000	240,000	1,115,000	2,021,973	118,169	Critical
Average	630,000	1,120,000	550,000	1,130,000	3,430,000	430,000	625,000	285,000	400,000	1,740,000	2,842,973	204,844	Below Normal
Wet	1,090,000	1,910,000	1,060,000	1,950,000	6,010,000	615,000	765,000	405,000	600,000	2,385,000	4,519,973	300,923	Wet
Feb 12 Update													
Dry	360,000	670,000	340,000	700,000	2,070,000	295,000	415,000	165,000	240,000	1,115,000	1,901,973	114,143	Critical
Average	570,000	1,010,000	500,000	1,030,000	3,110,000	430,000	625,000	285,000	400,000	1,740,000	2,650,973	160,089	Below Normal
Wet	1,000,000	1,730,000	950,000	1,760,000	5,440,000	615,000	765,000	405,000	600,000	2,385,000	4,177,973	300,923	Wet
Feb 19 Update													
Dry	340,000	630,000	310,000	640,000	1,920,000	295,000	415,000	165,000	240,000	1,115,000	1,811,973	111,554	Critical
Average	530,000	940,000	460,000	950,000	2,880,000	430,000	625,000	285,000	400,000	1,740,000	2,512,973	150,293	Below Normal
Wet	950,000	1,620,000	870,000	1,620,000	5,060,000	615,000	765,000	405,000	600,000	2,385,000	3,949,973	300,923	Wet
Mar 1 Forecast													
Dry	320,000	580,000	220,000	540,000	1,660,000	290,000	445,000	185,000	270,000	1,190,000	1,670,973	107,498	Critical
Average	490,000	840,000	360,000	820,000	2,510,000	330,000	495,000	215,000	330,000	1,370,000	2,216,973	129,711	Dry
Wet	880,000	1,460,000	710,000	1,410,000	4,460,000	420,000	615,000	285,000	440,000	1,760,000	3,464,973	300,923	Above Normal
Mar 12 Update													
Dry	360,000	620,000	230,000	560,000	1,770,000	290,000	445,000	185,000	270,000	1,190,000	1,736,973	109,397	Critical
Average	510,000	850,000	360,000	810,000	2,530,000	330,000	495,000	215,000	330,000	1,370,000	2,228,973	130,535	Dry
Wet	850,000	1,390,000	670,000	1,310,000	4,220,000	420,000	615,000	285,000	440,000	1,760,000	3,320,973	300,923	Above Normal
Mar 19 Update													
Dry	340,000	580,000	200,000	490,000	1,610,000	290,000	445,000	185,000	270,000	1,190,000	1,640,973	106,635	Critical
Average	480,000	790,000	320,000	720,000	2,310,000	330,000	495,000	215,000	330,000	1,370,000	2,096,973	122,468	Critical
Wet	790,000	1,280,000	610,000	1,160,000	3,840,000	420,000	615,000	285,000	440,000	1,760,000	3,092,973	285,964	Below Normal
Mar 26 Update													
Dry	340,000	570,000	200,000	440,000	1,550,000	290,000	445,000	185,000	270,000	1,190,000	1,604,973	105,600	Critical
Average	470,000	760,000	310,000	650,000	2,190,000	330,000	495,000	215,000	330,000	1,370,000	2,024,973	118,341	Critical
Wet	750,000	1,190,000	570,000	1,040,000	3,550,000	420,000	615,000	285,000	440,000	1,760,000	2,918,973	229,504	Below Normal
Apr 1 Forecast													
Dry	300,000	570,000	210,000	420,000	1,500,000	325,000	475,000	205,000	320,000	1,325,000	1,601,973	105,514	Critical
Average	420,000	740,000	310,000	610,000	2,080,000	325,000	475,000	205,000	320,000	1,325,000	1,949,973	115,524	Critical
Wet	670,000	1,130,000	550,000	950,000	3,300,000	325,000	475,000	205,000	320,000	1,325,000	2,681,973	162,290	Below Normal
Apr 16 Update													
Dry	300,000	600,000	220,000	410,000	1,530,000	325,000	475,000	205,000	320,000	1,325,000	1,619,973	106,031	Critical
Average	410,000	730,000	300,000	580,000	2,020,000	325,000	475,000	205,000	320,000	1,325,000	1,913,973	114,488	Critical
Wet	590,000	1,010,000	480,000	840,000	2,920,000	325,000	475,000	205,000	320,000	1,325,000	2,453,973	146,104	Dry
Apr 23 Update													
Dry	290,000	580,000	210,000	380,000	1,460,000	325,000	475,000	205,000	320,000	1,325,000	1,577,973	104,823	Critical
Average	390,000	700,000	280,000	540,000	1,910,000	325,000	475,000	205,000	320,000	1,325,000	1,847,973	112,590	Critical
Wet	530,000	930,000	420,000	760,000	2,640,000	325,000	475,000	205,000	320,000	1,325,000	2,285,973	134,450	Dry
May 1 Forecast													
Dry	270,000	550,000	200,000	340,000	1,360,000	323,000	477,000	207,000	319,000	1,326,000	1,518,173	103,103	Critical
Average	360,000	650,000	260,000	490,000	1,760,000	259,000	407,000	206,000	331,000	1,203,000	1,733,573	109,299	Critical
Wet	480,000	820,000	370,000	640,000	2,310,000	305,013	559,603	228,774	378,500	1,471,890	2,117,351	123,636	Dry
May 14 Update													
Dry	270,000	540,000	230,000	430,000	1,470,000	323,000	477,000	207,000	319,000	1,326,000	1,584,173	105,002	Critical
Average	340,000	620,000	270,000	500,000	1,730,000	259,000	407,000	206,000	331,000	1,203,000	1,715,573	108,781	Critical
Wet	420,000	760,000	350,000	620,000	2,150,000	305,013	559,603	228,774	378,500	1,471,890	2,021,351	118,134	Critical
May 21 Update													
Dry	270,000	550,000	240,000	450,000	1,510,000	323,000	477,000	207,000	319,000	1,326,000	1,608,173	105,692	Critical
Average	330,000	620,000	270,000	510,000	1,730,000	259,000	407,000	206,000	331,000	1,203,000	1,715,573	108,781	Critical
Wet	400,000	740,000	330,000	610,000	2,080,000	305,013	559,603	228,774	378,500	1,471,890	1,979,351	116,369	Critical
May 29 Update													
Dry	270,000	540,000	240,000	460,000	1,510,000	323,000	477,000	207,000	319,000	1,326,000	1,608,173	105,692	Critical
Average	300,000	590,000	260,000	510,000	1,660,000	259,000	407,000	206,000	331,000	1,203,000	1,673,573	107,573	Critical
Wet	350,000	700,000	310,000	580,000	1,940,000	305,013	559,603	228,774	378,500	1,471,890	1,895,351	113,952	Critical
Jan 00 Update													
Dry	0	0	0	0	0	323,000	477,000	207,000	319,000	1,326,000	702,173	94,000	Critical
Average	0	0	0	0	0	259,000	407,000	206,000	331,000	1,203,000	677,573	94,000	Critical
Wet	0	0	0	0	0	305,013	559,603	228,774	378,500	1,471,890	731,351	94,000	Critical
Jan 00 Update													
Dry	0	0	0	0	0	323,000	477,000	207,000	319,000	1,326,000	702,173	94,000	Critical
Average	0	0	0	0	0	259,000	407,000	206,000	331,000	1,203,000	677,573	94,000	Critical
Wet	0	0	0	0	0	305,013	559,603	228,774	378,500	1,471,890	731,351	94,000	Critical
Manual Cal Don By TID (DWR estimate adjusted for rainfall)													
Dry	355,051	571,854	300,980	566,927	1,794,812	323,159	476,812	207,327	318,805	1,326,103	1,779,081	110,608	Critical
Average	403,613	650,070	342,146	[illegible]	2,040,297	323,159	476,812	207,327	318,805	1,326,103	1,926,372	114,845	Critical
Wet	562,245	905,567	479,620	897,764	2,842,196	323,159	476,812	207,327	318,805	1,326,103	2,407,512	142,806	Dry

TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 1)
Annual Flow Requirement



TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT (Figure 4)
Interpolation Volume



Tuolumne River Flow Schedule

Based On Final Hydrologic Conditions, DWR 60-20-20 Index for 2013

Schedule For 2013-2014 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW[2]			INTERPOLATION FLOW			Other Adjusted Flow			TOTAL FERC FLOW	
					ACCUM			ACCUM			ACCUM			ACCUM		ACCUM[1]
From:	To:	DAYS	CFS	AF	A.F.	CFS	AF	A.F.	CFS	AF	A.F.	CFS	AF	A.F.	CFS	A.F.
15-Apr-2013	15-Apr-2013	1	150	298	298	400	793	793	0	0	0	0	0	0	550	1,091
16-Apr-2013	16-Apr-2013	1	150	298	595	200	397	1,190	0	0	0	0	0	0	350	1,785
17-Apr-2013	17-Apr-2013	1	150	298	893	200	397	1,587	0	0	0	0	0	0	350	2,479
18-Apr-2013	18-Apr-2013	1	150	298	1,190	200	397	1,983	0	0	0	0	0	0	350	3,174
19-Apr-2013	19-Apr-2013	1	150	298	1,488	200	397	2,380	0	0	0	0	0	0	350	3,868
20-Apr-2013	20-Apr-2013	1	150	298	1,785	200	397	2,777	0	0	0	0	0	0	350	4,562
21-Apr-2013	21-Apr-2013	1	150	298	2,083	600	1,190	3,967	0	0	0	0	0	0	750	6,050
22-Apr-2013	22-Apr-2013	1	150	298	2,380	400	793	4,760	0	0	0	0	0	0	550	7,140
23-Apr-2013	23-Apr-2013	1	150	298	2,678	400	793	5,554	0	0	0	0	0	0	550	8,231
24-Apr-2013	24-Apr-2013	1	150	298	2,975	400	793	6,347	0	0	0	0	0	0	550	9,322
25-Apr-2013	25-Apr-2013	1	150	298	3,273	400	793	7,140	0	0	0	0	0	0	550	10,413
26-Apr-2013	26-Apr-2013	1	150	298	3,570	400	793	7,934	0	0	0	0	0	0	550	11,504
27-Apr-2013	27-Apr-2013	1	150	298	3,868	800	1,587	9,521	0	0	0	0	0	0	950	13,388
28-Apr-2013	28-Apr-2013	1	150	298	4,165	600	1,190	10,711	0	0	0	0	0	0	750	14,876
29-Apr-2013	29-Apr-2013	1	150	298	4,463	600	1,190	11,901	0	0	0	0	0	0	750	16,364
30-Apr-2013	30-Apr-2013	1	150	298	4,760	600	1,190	13,091	0	0	0	0	0	0	750	17,851
01-May-2013	01-May-2013	1	150	298	5,058	600	1,190	14,281	0	0	0	0	0	0	750	19,339
02-May-2013	02-May-2013	1	150	298	5,355	1,000	1,983	16,264	0	0	0	0	0	0	1,150	21,620
03-May-2013	03-May-2013	1	150	298	5,653	800	1,587	17,851	0	0	0	0	0	0	950	23,504
04-May-2013	04-May-2013	1	150	298	5,950	550	1,091	18,942	0	0	0	0	0	0	700	24,893
05-May-2013	05-May-2013	1	150	298	6,248	279	553	19,496	0	0	0	0	0	0	429	25,743
06-May-2013	06-May-2013	1	150	298	6,545	200	397	19,892	0	0	0	0	0	0	350	26,438
07-May-2013	07-May-2013	1	150	298	6,843	100	198	20,091	0	0	0	0	0	0	250	26,934
08-May-2013	08-May-2013	1	150	298	7,140	0	0	20,091	0	0	0	0	0	0	150	27,231
09-May-2013	09-May-2013	1	150	298	7,438	0	0	20,091	0	0	0	0	0	0	150	27,529
10-May-2013	10-May-2013	1	150	298	7,736	0	0	20,091	0	0	0	0	0	0	150	27,826
11-May-2013	11-May-2013	1	150	298	8,033	0	0	20,091	0	0	0	0	0	0	150	28,124
12-May-2013	12-May-2013	1	150	298	8,331	0	0	20,091	0	0	0	0	0	0	150	28,421
13-May-2013	13-May-2013	1	150	298	8,628	0	0	20,091	0	0	0	0	0	0	150	28,719
14-May-2013	14-May-2013	1	150	298	8,926	0	0	20,091	0	0	0	0	0	0	150	29,016
15-May-2013	15-May-2013	1	150	298	9,223	0	0	20,091	0	0	0	0	0	0	150	29,314
16-May-2013	16-May-2013	1	150	298	9,521	0	0	20,091	0	0	0	0	0	0	150	29,611
17-May-2013	17-May-2013	1	150	298	9,818	0	0	20,091	0	0	0	0	0	0	150	29,909
18-May-2013	18-May-2013	1	150	298	10,116	0	0	20,091	0	0	0	0	0	0	150	30,206
19-May-2013	19-May-2013	1	150	298	10,413	0	0	20,091	0	0	0	0	0	0	150	30,504
20-May-2013	20-May-2013	1	150	298	10,711	0	0	20,091	0	0	0	0	0	0	150	30,801
21-May-2013	21-May-2013	1	150	298	11,008	0	0	20,091	0	0	0	0	0	0	150	31,099
22-May-2013	22-May-2013	1	150	298	11,306	0	0	20,091	0	0	0	0	0	0	150	31,396
23-May-2013	23-May-2013	1	150	298	11,603	0	0	20,091	0	0	0	0	0	0	150	31,694
24-May-2013	24-May-2013	1	150	298	11,901	0	0	20,091	0	0	0	0	0	0	150	31,991
25-May-2013	25-May-2013	1	150	298	12,198	0	0	20,091	0	0	0	0	0	0	150	32,289
26-May-2013	26-May-2013	1	150	298	12,496	0	0	20,091	0	0	0	0	0	0	150	32,586
27-May-2013	27-May-2013	1	150	298	12,793	0	0	20,091	0	0	0	0	0	0	150	32,884
28-May-2013	28-May-2013	1	150	298	13,091	0	0	20,091	0	0	0	0	0	0	150	33,181
29-May-2013	29-May-2013	1	150	298	13,388	0	0	20,091	0	0	0	0	0	0	150	33,479
30-May-2013	30-May-2013	1	150	298	13,686	0	0	20,091	0	0	0	0	0	0	150	33,777
31-May-2013	31-May-2013	1	150	298	13,983	0	0	20,091	0	0	0	0	0	0	150	34,074
01-Jun-2013	01-Jun-2013	1	50	99	14,083	0	0	20,091	0	0	0	0	0	0	50	34,173
02-Jun-2013	02-Jun-2013	1	50	99	14,182	0	0	20,091	0	0	0	0	0	0	50	34,272
03-Jun-2013	03-Jun-2013	1	50	99	14,281	0	0	20,091	0	0	0	0	0	0	50	34,372
04-Jun-2013	04-Jun-2013	1	50	99	14,380	0	0	20,091	0	0	0	0	0	0	50	34,471
05-Jun-2013	05-Jun-2013	1	50	99	14,479	0	0	20,091	0	0	0	0	0	0	50	34,570
06-Jun-2013	06-Jun-2013	1	50	99	14,579	0	0	20,091	0	0	0	0	0	0	50	34,669
07-Jun-2013	30-Jun-2013	24	50	2,380	16,959	0	0	20,091	0	0	0	0	0	0	50	37,049
01-Jul-2013	31-Jul-2013	31	50	3,074	20,033	0	0	20,091	0	0	0	0	0	0	50	40,124
01-Aug-2013	31-Aug-2013	31	50	3,074	23,107	0	0	20,091	0	0	0	0	0	0	50	43,198
01-Sep-2013	30-Sep-2013	30	50	2,975	26,083	0	0	20,091	0	0	0	0	0	0	50	46,173
01-Oct-2013	24-Oct-2013	24	126	5,989	32,071	0	0	20,091	0	0	0	0	0	0	126	52,162
25-Oct-2013	25-Oct-2013	1	126	250	32,321	0	0	20,091	400	793	793	0	0	0	526	53,205
26-Oct-2013	26-Oct-2013	1	126	250	32,571	0	0	20,091	800	1,587	2380	0	0	0	926	55,041
27-Oct-2013	27-Oct-2013	1	126	250	32,820	0	0	20,091	600	1,190	3570	0	0	0	726	56,481
28-Oct-2013	28-Oct-2013	1	126	250	33,070	0	0	20,091	400	793	4364	0	0	0	526	57,524
29-Oct-2013	29-Oct-2013	1	126	250	33,319	0	0	20,091	300	595	4959	0	0	0	426	58,368
30-Oct-2013	30-Oct-2013	1	126	250	33,569	0	0	20,091	200	397	5355	0	0	0	326	59,015
31-Oct-2013	31-Oct-2013	1	126	250	33,818	0	0	20,091	65	129	5,484	0	0	0	191	59,393
01-Nov-2013	30-Nov-2013	30	150	8,926	42,744	0	0	20,091	0	0	5,484	0	0	0	150	68,319
01-Dec-2013	31-Dec-2013	31	150	9,223	51,967	0	0	20,091	0	0	5,484	0	0	0	150	77,542
01-Jan-2014	31-Jan-2014	31	150	9,223	61,190	0	0	20,091	0	0	5,484	0	0	0	150	86,765
01-Feb-2014	28-Feb-2014	28	150	8,331	69,521	0	0	20,091	0	0	5,484	0	0	0	150	95,096
01-Mar-2014	31-Mar-2014	31	150	9,223	78,744	0	0	20,091	0	0	5,484	0	0	0	150	104,319
01-Apr-2014	14-Apr-2014	14	150	4,165	82,909	0	0	20,091	0	0	5,484	0	0	0	150	108,484
No. of days		365	(April 10 through April 14)													

1 cfs day = 1.983471 acre-feet (af)

1. Total accumulation amount pertains to 2013-2014 Fish Year Only

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

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
U. S. FISH & WILDLIFE SERVICE

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8278
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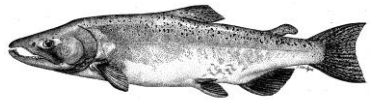
Email: pemaloney@tid.org



TECHNICAL ADVISORY COMMITTEE MEETING

11 December 2014 at 9:30 AM

Turlock Irrigation District, Room 152

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from Sep 2014 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Fall run information – status of weir and red surveys
   - Other technical reports for 2014 annual FERC report
   - Discuss winter monitoring and other studies

4. FLOW OPERATIONS:
   - Review status of flow schedule/watershed conditions

5. AGENCY/NGO UPDATES

6. ADDITIONAL ITEMS

7. NEXT MEETING DATE: MARCH 12, 2015

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

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TECHNICAL ADVISORY COMMITTEE MEETING

10 December 2014 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. INTRODUCTION AND ANNOUNCEMENTS

- Participants made self-introductions.

2. ADMINISTRATIVE ITEMS:

- Review/Revise agenda – No changes.
- Approve notes from September 2014 meeting – No changes were identified. Notes for the last meeting are posted to the TRTAC website: http://tuolumnerivertac.com/
- Items since last meeting – The handout list posted at http://tuolumnerivertac.com/ was not reviewed. Due to foul weather, participants attended by phone only and had no access to the list.
- A discussion was held regarding the water hyacinth problem. TID, Fishbio and HDR will continue to monitor to problem and will meet separately from the TRTAC in order to compile their observations. The compilation of observations will be provided to California Department of Boating and Waterways so that they are better equipped to manage the problem on the Tuolumne River. Spraying is scheduled to resume in May 2015.
- Acoustic tagging data from salmon tagged in the delta is being compiled by CDFW. This data may help to inform our present understanding of adult migration. Gretchen Murphy of CDFW La Grange may be able to provide this data in the future.

3. MONITORING/REPORTS: (*Handouts were reviewed*)

- Preliminary run estimates from the Tuolumne River weir were reviewed. As of December 7th, 573 Chinook salmon had migrated upstream past the Tuolumne River weir. The Stanislaus river weir count was 5146 for the same date.
- Preliminary carcass survey data from the Merced, Tuolumne and Stanislaus Rivers were reviewed. Preliminary data also indicate that the Merced and Tuolumne Rivers are having poorer runs than the Stanislaus River (see December 2014 meeting handouts for details - posted to the TRTAC website: http://tuolumnerivertac.com/).
- Fall Monitoring 2014 – The counting weir remains operational.
- Redd surveys will continue this spawning season through April in order to capture O. mykiss spawning data.
- Planned Annual FERC Report progress – compilation of studies in progress.

4. **FLOW OPERATIONS:**
    - Current watershed conditions as of December 10, 2014: This water year is considered a critical water year type.
    - Base flows will remain at 150cfs through April 14, 2015.

5. **AGENCY/NGO UPDATES**
    - None

6. **ADDITIONAL ITEMS**
    - None

7. **NEXT MEETING DATE** – MARCH 12, 2015.

TRTAC Meeting Attendees

	Name	Organization
1.	Patrick Maloney	TID
2.	Jason Guignard (by phone)	FISHBIO
3.	Wayne Swaney (by phone)	Stillwater

2014 TRTAC Materials/Postings to Website

2014September 12 – 2014December 10, Postings to TRTAC website
http://tuolumnerivertac.com/

- Meetings
  - March 2014 TRTAC meeting agenda, handouts, materials list and notes
  - June 2014 TRTAC meeting agenda, handouts, materials list and notes
  - September 2014 TRTAC meeting agenda, handouts, materials list and notes
  - December 2014 TRTAC meeting agenda, handouts

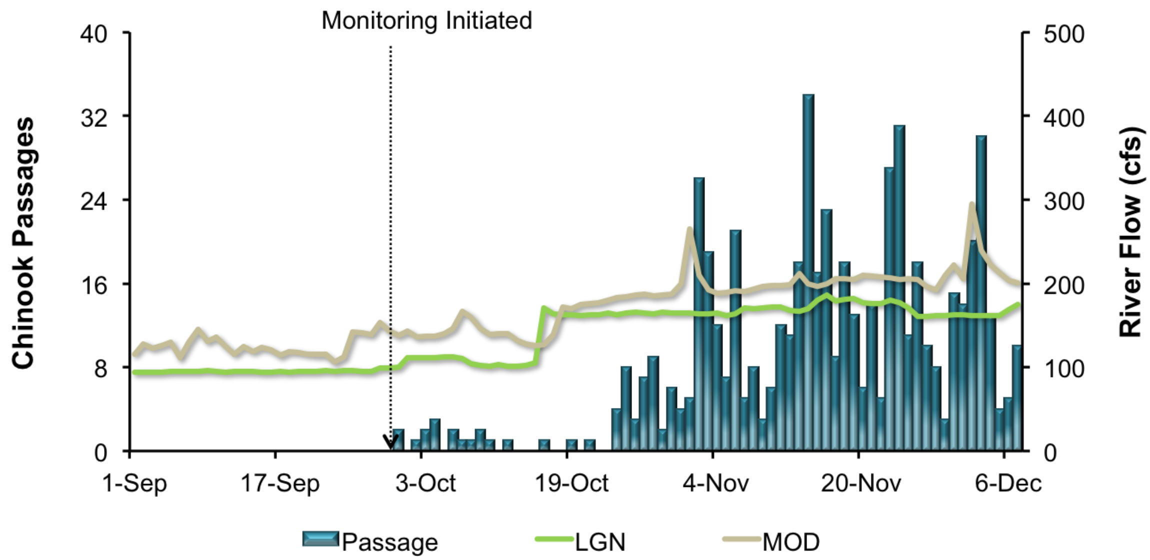
- Correspondence
  - September 6, 2014. NMFS - NMFS of Final Recovery Plan for Listed Central Valley Salmonids to all Administrative Records of FERC's Hydroelectric Projects in California's Central Valley and for Consideration as a Comprehensive Plan under Docket ZZ09-5, et. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14257901
  - October 21, 2014. San Francisco Regional Office - Letter acknowledging Turlock Irrigation District's 10/3/13 and 4/15/14 letters transmitting the draft High Flow Operation Plan et al for the Don Pedro Project under P-2299. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14263882
  - November 18, 2014. CDFW - Request to remove name and contact information of statewide California Department of Fish and Wildlife coordinator under P-67-000, et. al.. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14271697
  - December 4, 2014. NOAA - Comments of NOAA's National Marine Fisheries Service, West Coast Region, on the Proposed Study Plan for the La Grange Hydroelectric Project, P-14581. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14276796

Sub Docket: 082

  - October 6, 2014. NOAA - NMFS of Final Recovery Plan for Listed Central Valley Salmonids to all Administrative Records of FERC's Hydroelectric Projects in California?s Central Valley and for Consideration as a Comprehensive Plan under Docket ZZ09-5, et. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14257901
  - October 9, 2014. American Rivers American Whitewater California Trout Tuolumne River Trust California Sportfishing Protection Alliance Central Sierra Environmental Resource Center Friends of the River Golden West Women Flyfishers Trout Unlimited Merced Fly Fishing Club - Conservation Groups' Letter regarding potential impacts to the City and County of San Francisco of Increased Flow Requirements in the Lower Tuolumne River, P-2299-082. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14258994
  - December 4, 2014. NOAA - Comments of NOAA's National Marine Fisheries Service, West Coast Region, on the Proposed Study Plan for the La Grange Hydroelectric Project, P-14581. http://elibrary.ferc.gov/idmws/file_list.asp?document_id=14276796

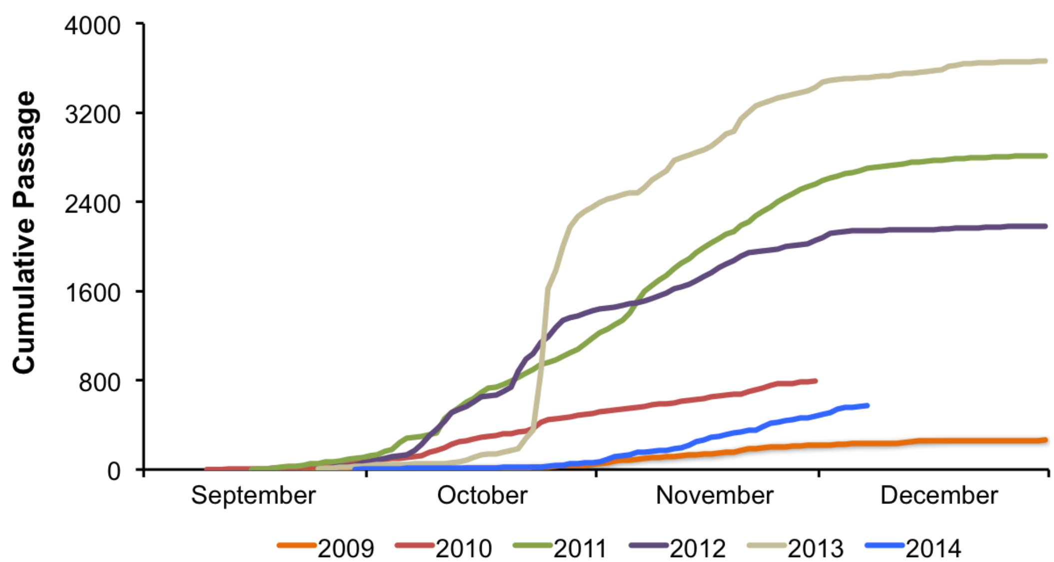
  - Documents - No postings
  - Data/Monitoring - No postings

Preliminary Results



2014 Lower Tuolumne River Chinook Passage.
Total passage = 573 through December 7, 2014.

Preliminary Results



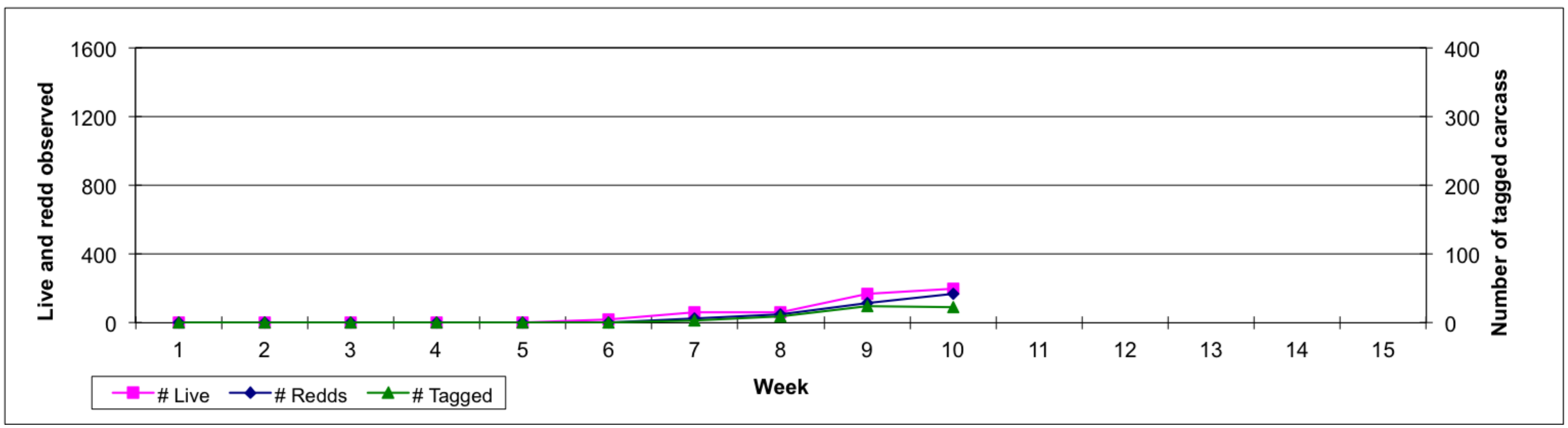
2009-2014 Lower Tuolumne River Chinook Passage.

Source: FISHBIO preliminary data.

Preliminary Data

Lower Merced River

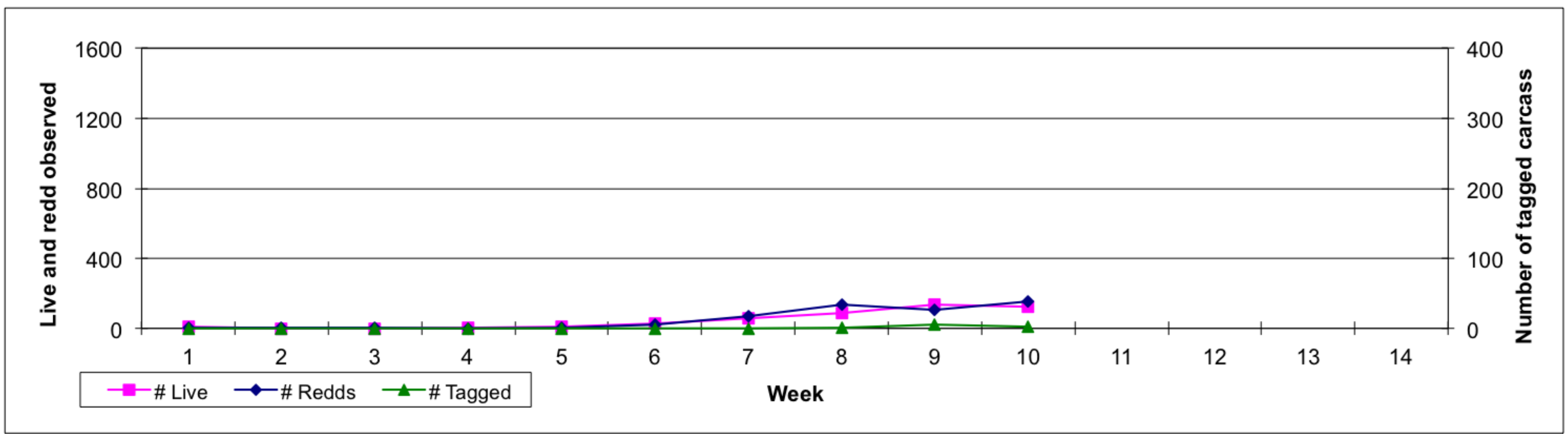
Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)	# Females spawned @ MRFF
1	9/29/14	0	0	0	0	0	0	0	115	
2	10/6/14	0	0	0	0	0	0	0	105	
3	10/13/14	2	0	0	0	0	0	0	105	
4	10/20/14	0	0	0	0	0	0	0	330	
5	10/27/14	0	0	0	0	0	0	0	887	
6	11/3/14	21	4	0	0	0	0	0	220	8
7	11/10/14	63	24	0	4	0	4	0	150	18
8	11/17/14	62	51	8	9	1	9	1	N/A	16
9	11/24/14	171	113	19	24	5	24	3	210	44
10	12/1/14	198	171	25	22	6	22	5	220	26
11	12/8/14									
12	12/15/14									
13	12/22/14									
14	12/29/14									
15	1/5/15									



Preliminary Data

Lower Tuolumne River

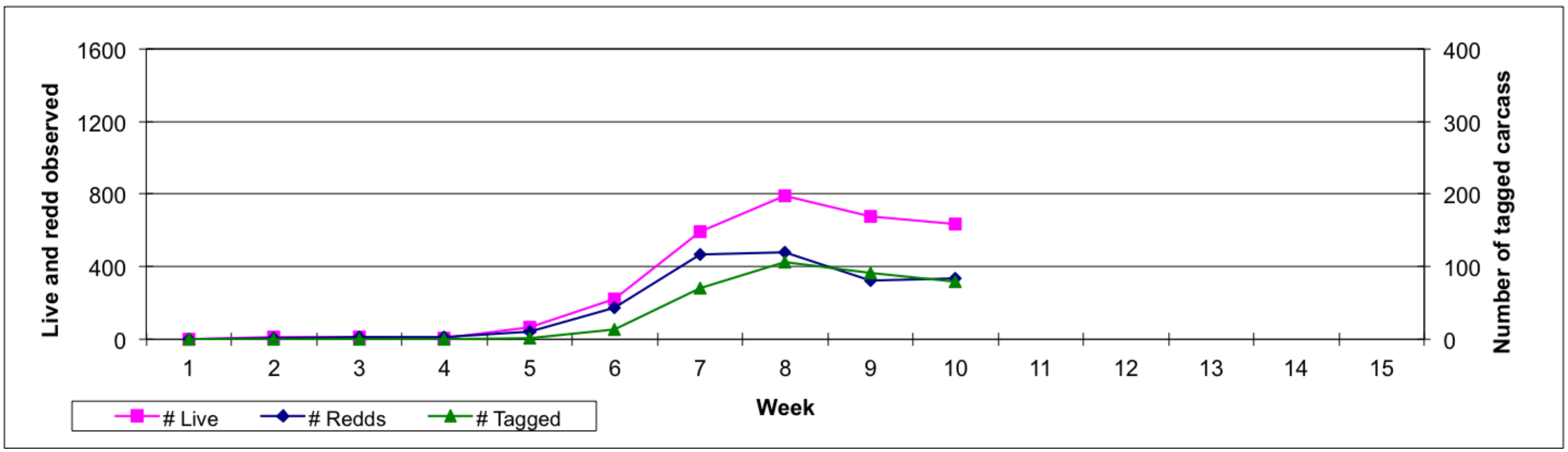
Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)
1	9/29/14	9	4	0	0	0	0	0	110
2	10/6/14	0	6	0	0	0	0	0	110
3	10/13/14	0	3	0	0	0	0	0	100
4	10/20/14	4	0	0	0	0	0	0	163
5	10/27/14	12	4	0	0	0	0	0	165
6	11/3/14	26	19	2	0	0	0	0	165
7	11/10/14	58	71	5	0	0	0	0	170
8	11/17/14	88	136	8	1	0	1	0	180
9	11/24/14	133	106	3	5	2	5	1	180
10	12/1/14	125	153	12	3	0	3	2	160
11	12/8/14								
12	12/15/14								
13	12/22/14								
14	12/29/14								
15	1/5/15								



Preliminary Data

Lower Stanislaus River

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)
1	9/29/14	0	0	0	0	0	0	0	164
2	10/6/14	13	8	0	0	0	0	0	228
3	10/13/14	11	15	1	0	0	0	0	220
4	10/20/14	8	14	0	0	0	0	0	336
5	10/27/14	69	43	0	1	0	1	0	937
6	11/3/14	223	176	1	14	2	14	0	875
7	11/10/14	592	470	40	71	10	71	3	260
8	11/17/14	788	479	80	107	21	107	19	215
9	11/24/14	674	326	101	91	14	91	34	202
10	12/1/14	635	334	150	79	13	79	19	205
11	12/8/14								
12	12/15/14								
13	12/22/14								
14	12/29/14								



Source: CDFW preliminary data.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

DRAFT COVER

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

2014 Annual Summary Report

Exhibits: Spawning runs, harvest data, rearing/outmigration data, Delta salvage and exports

Attachment A: Water Conditions, Flows, Temperature, and Flow Schedule Correspondence

Attachment B: 2014 Tuolumne River Technical Advisory Committee Materials

Report 2014-1: 2014 Spawning Survey Report

Report 2014-2: Spawning Survey Summary Update

Report 2014-3: 2012 Seine Report and Summary Update

Report 2014-4: 2012 Rotary Screw Trap Report

Report 2014-5: 2012 Snorkel Report and Summary Update

Report 2014-6: 2012 Counting Weir Report

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-1

2014 Spawning Survey Report

Prepared by

California Department of Fish and Wildlife
Tuolumne River Restoration Center
La Grange Field Office

March 2015

No report available at this time from CDFW

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-2

Spawning Survey Summary Update

Prepared by

Stillwater Sciences
Berkeley, CA

March 2015

SPAWNING SURVEY SUMMARY UPDATE

1. INTRODUCTION

The California Department of Fish and Wildlife (CDFW, formerly California Department of Fish and Game) has conducted fall-run Chinook salmon spawning surveys on the Tuolumne River since 1971 as part of the fish study program for the Don Pedro Project FERC license. TID/MID 1992 reviewed the 1971-1988 period and TID/MID 1997 summarized the 1989-1996 period. Due to the unavailability of 2014 data from CDFW at this time, this report provides only a minimal update for 2014 (Selected text [shown in *italics*] in Sections 2.1, 2.2, and 2.3 along with Figure 2 and Tables 1, 2, and 4) as part of the summary for the 1971-2014 period. The most recent CDFW draft report was for the 2010 spawning survey provided in 2013 (See Report 2013-1).

2. SUMMARY UPDATE

2.1 Survey Reach

The reach surveyed by CDFW in 2010 extended downstream into Section 5 (Figure 1) from near Fox Grove (RM 26.4) to Santa Fe Bridge (RM 21.5). *It is presumed that the same survey reach was used in 2014.* If this is the case, then our records indicate this would be the *fourth* year in a row that Section 5 has been included in the CDFW survey. It is thought that previous surveys extending into Section 5 ended about 1989. The survey was extended downstream in 2010 to examine spawning activity above and below the Tuolumne River counting weir (RM 24.5) which began operation in 2009.

2.2 Population Estimates, Sex Composition, and Potential Eggs

Tuolumne River carcass numbers, mark/recapture survey results, and population estimates since 1971 are shown in Table 1. *Run estimates for years 1971 through 2014 are shown in Figure 2. Run estimates through 2008 were based on CDFW mark/recapture data, while estimates beginning in 2009 are based on weir counts. The 2014 run estimate of 638 is based on weir counts from the period September 28, 2014 through December 31, 2014.*

The Tuolumne salmon run estimates for *1971-2014* have ranged from less than 100 salmon in 1990 and 1991 to 40,300 fish in 1985. Detailed and specific data on previous year's surveys can be found in past annual reports submitted to FERC. Estimates for the San Joaquin basin tributaries since 1940 are in Table 2. All estimates in this summary update report for *2009–2014* Tuolumne River fall Chinook salmon are based on calculations utilizing the weir count numbers and may differ from numbers contained in CDFW annual reports.

The percentage of females in the 1971-2010 runs has ranged from 25% in 1983 to 67% in 1978 (Figure 3). The years with less than 40% females usually had runs containing a large percentage of 2-year-old males. In 2009 there were about 57% females in the run and in 2010 there were about 34% based on all measured carcasses.

Beginning in 1981, the potential egg deposition for each year has been estimated using the number and average size of females. This is based on a formula from CDFW Los Banos trap data collected in 1988 using a female size to egg number relationship. These potential egg deposition estimates have ranged from 145,000 in 1991 to 128.6 million in 1985 (Figure 4, Table 3). The estimated 2009 potential egg number was about 1.03 million based on approximately 170 females with an average fork length of 76.8 cm. In 2010 the estimated potential egg number was about 1.47 million based on approximately 258 females with an average fork length of 74.6 cm.

2.3 Live and redd counts

Table 1 shows the maximum weekly counts of live salmon and redds from the CDFW surveys. Table 4 indicates the earliest date of the peak live count during the 1971–2014 period as being October 31, 1996 and the latest date of the peak live count being November 27, 1972. The 2014 run had a peak live count of 133 salmon during the week of November 24 and a peak redd count of 153 during the week of December 1.

2.4 Length Frequency Distribution and Age Class Composition

Fork length measurements have been recorded for carcasses since 1981. Males are typically 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 5). Estimation of age-class composition based on visual examination of the length frequency distribution of fresh measured carcasses was made for the 1981-2010 surveys (Table 6). These initial estimates are made for comparative purposes and may be modified when age analysis of scale/otolith samples and lengths of known age hatchery fish is utilized. The estimated female maximum fork lengths for ages two, three, and four were typically about 65, 83, 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.

Runs are mainly dominated by either 2 or 3-year-old salmon as shown in Figure 6. The 1998, 1999, and 2004 runs were estimated to have fairly equal numbers of two and three-year-old salmon. The 2009 and 2010 runs were dominated by 3-year-old salmon. Four-year-olds were estimated to be the most abundant age class only in 2001, but were estimated to be more than 10% of the 1986, 1989, 1990, and 1997-2009 runs. 2001 and 2007 had the highest estimated percentage of four-year-old salmon in the 1981-2010 study period. Five-year-olds are estimated to have comprised from 0-8% of the runs.

2.5 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 $r^2 = .82$ for the 1981-2009 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 $r^2 = .78$ (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.

2.6 Estimated Cohort Returns

The number of returns from a given cohort (spawning run) to the Tuolumne River was estimated using the age class composition values previously described. This enables cohort return estimates from the 1979 run, which first returned as 2-year olds in 1981; up to the 2007 run with 3-year olds returning in 2010 (the 2007 cohort was almost complete with 4-year olds still to return in the 2011 run). Runs since 1987 have had higher percentage contributions of known hatchery origin fish but no attempt was made here to separately consider their influence on the cohort returns.

The cohort return for a given year was determined by adding the estimated age 2 through age 5 returning fish from the subsequent runs. For example, the 1979 spawning run cohort returned as 2-year olds in 1981, 3-year olds in 1982, 4-year olds in 1983, and 5-year olds in 1984. Table 7 contains the age-class percentage estimates for each run, the corresponding number estimates that were added to result in the estimated cohort returns, and the estimated age composition of the cohorts. Figure 8 depicts the estimated runs with their estimated cohort returns, showing a wide range of variability.

2.7 Coded wire tagged hatchery salmon

The 2009 run contained 4 coded wire tag (CWT) salmon that originated from the Mokelumne River Hatchery and were released at several bay area locations. The 2010 run contained 27 possible CWT's out of 86 measured salmon but the tags have not been read yet. The 2011 run had a total of 239 possible CWT fish, but no additional data information on these are available at this time. A high percentage of hatchery origin salmon might indicate that a high degree of straying is occurring from these releases.

3. REFERENCES

CDFW (California Department of Fish and Wildlife) [1971-2010]. San Joaquin River Chinook salmon Enhancement Project. Annual Reports and preliminary data, Region 4, Fresno.

TID/MID (Turlock Irrigation District and Modesto Irrigation District). 1992. Tuolumne River Salmon Spawning Surveys 1971-1988. 1991 Federal Energy Regulatory Commission Article 39 Report, Appendix 3.

TID/MID 1997. Tuolumne River Salmon Spawning Summary, Supplement to 1992 FERC Report Appendix 3. 1996 Federal Energy Regulatory Commission Report 1996-1.

TID/MID 2011. Spawning Survey Summary Update. Report 2010-2. 2010 Lower Tuolumne River Annual Report. March 2011.

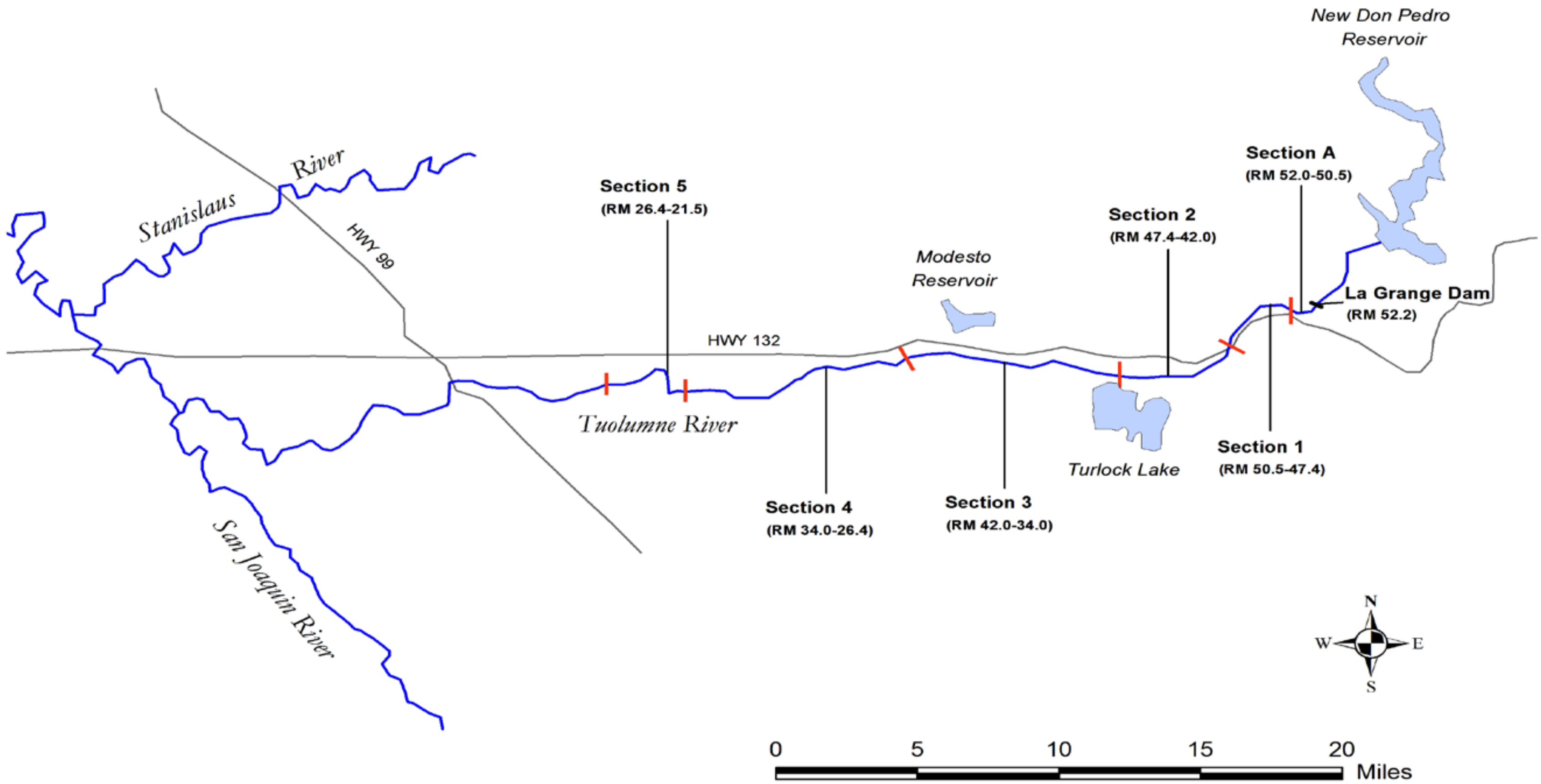


Figure 1. Map of the Tuolumne River salmon spawning survey reaches in 2010.

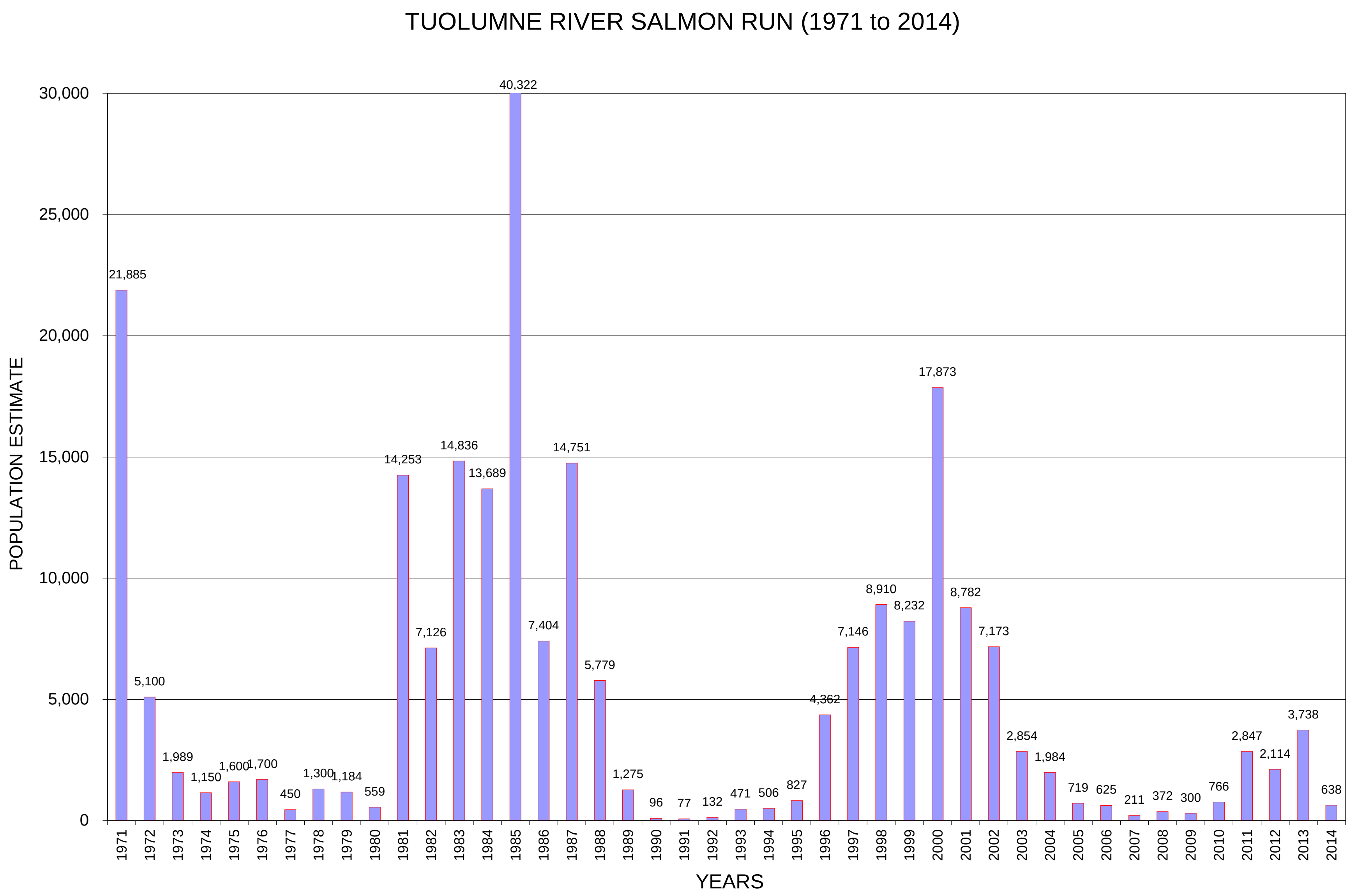


Figure 2. Tuolumne River Salmon Run Population Estimates, 1971-2014 (Years 2009-2014 based on weir counts).

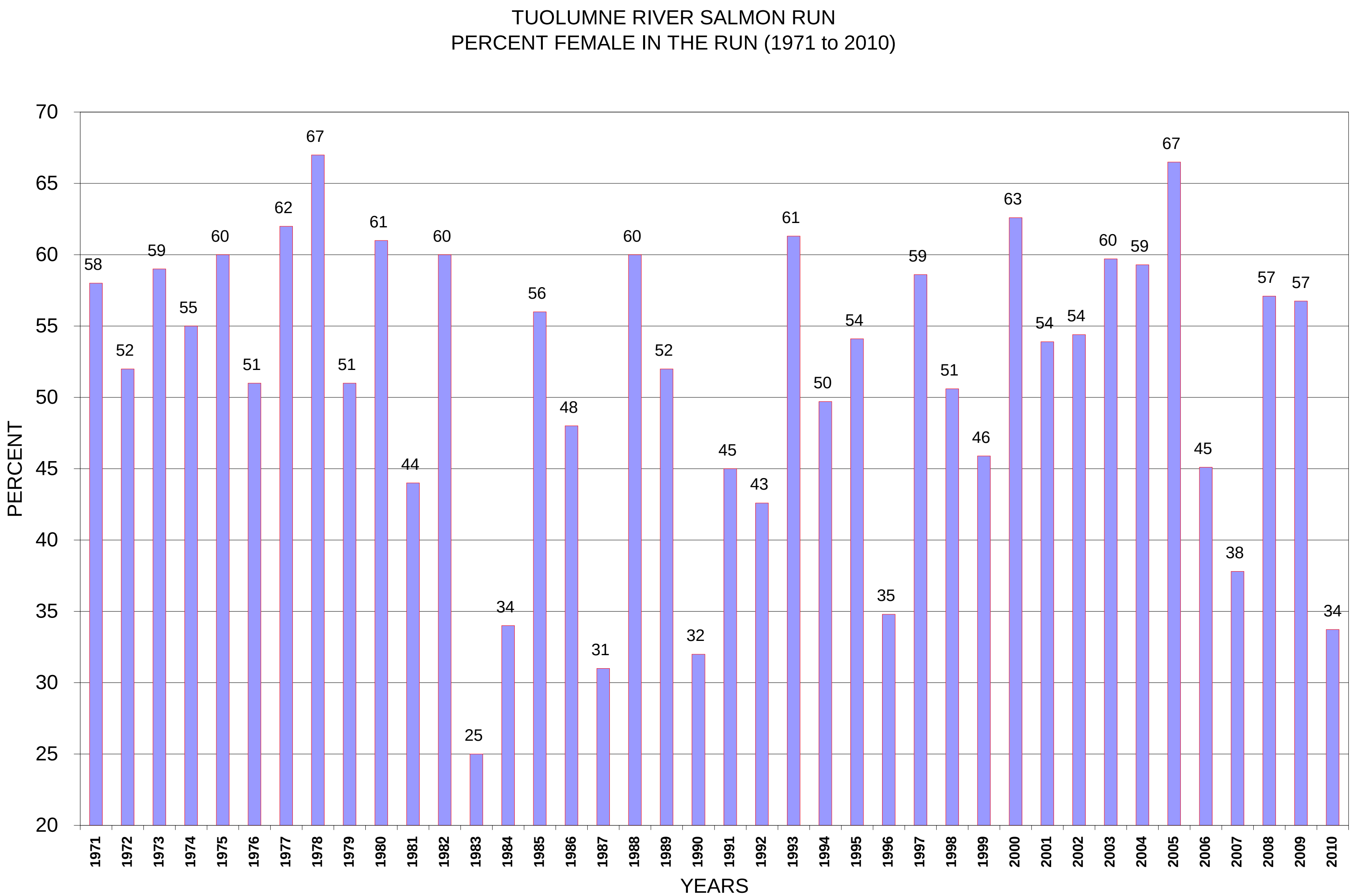


Figure 3. Percent Female salmon in the Tuolumne River runs, 1971-2010.

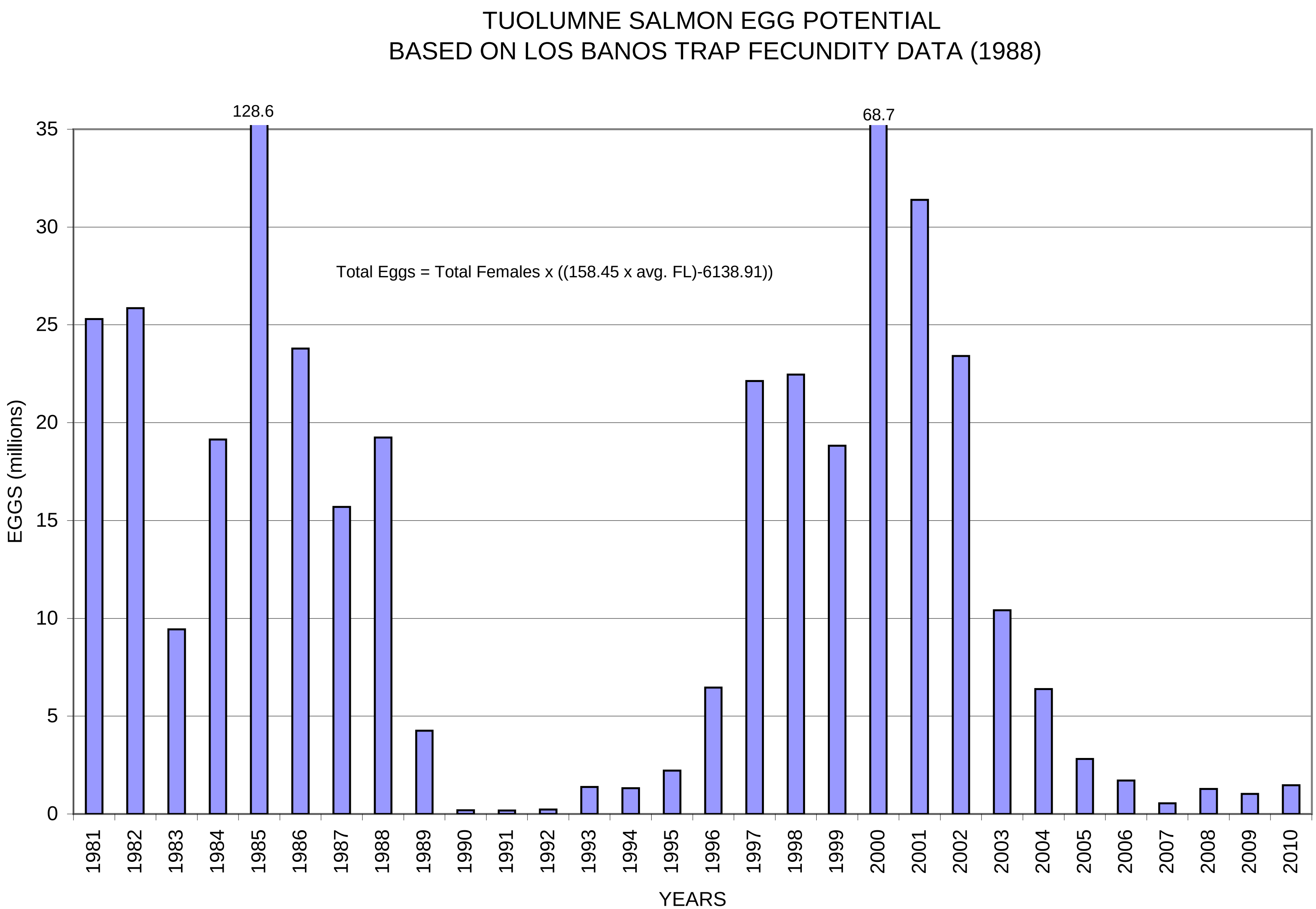


Figure 4. Potential egg deposition for Tuolumne River Chinook salmon, 1981-2010.

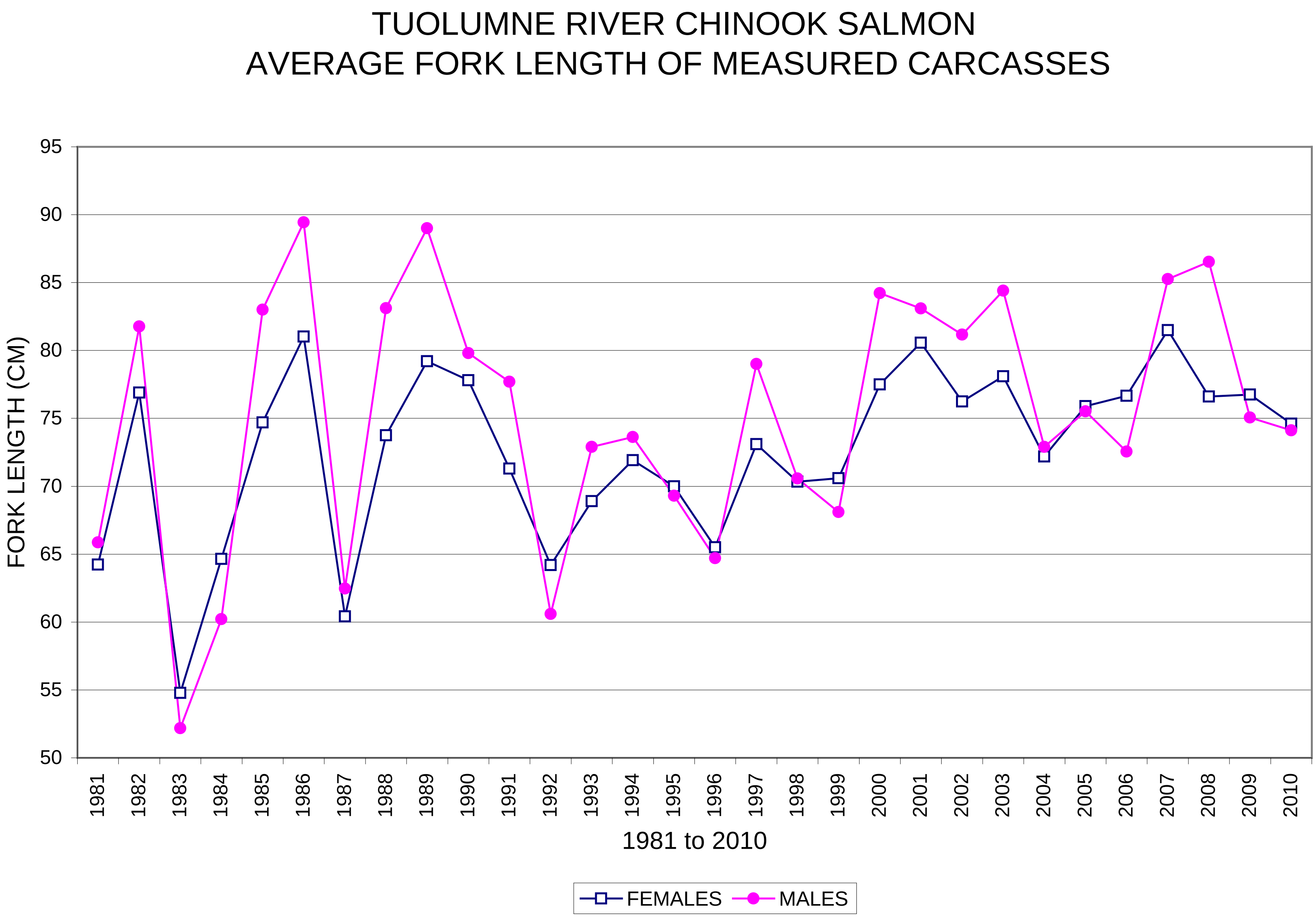
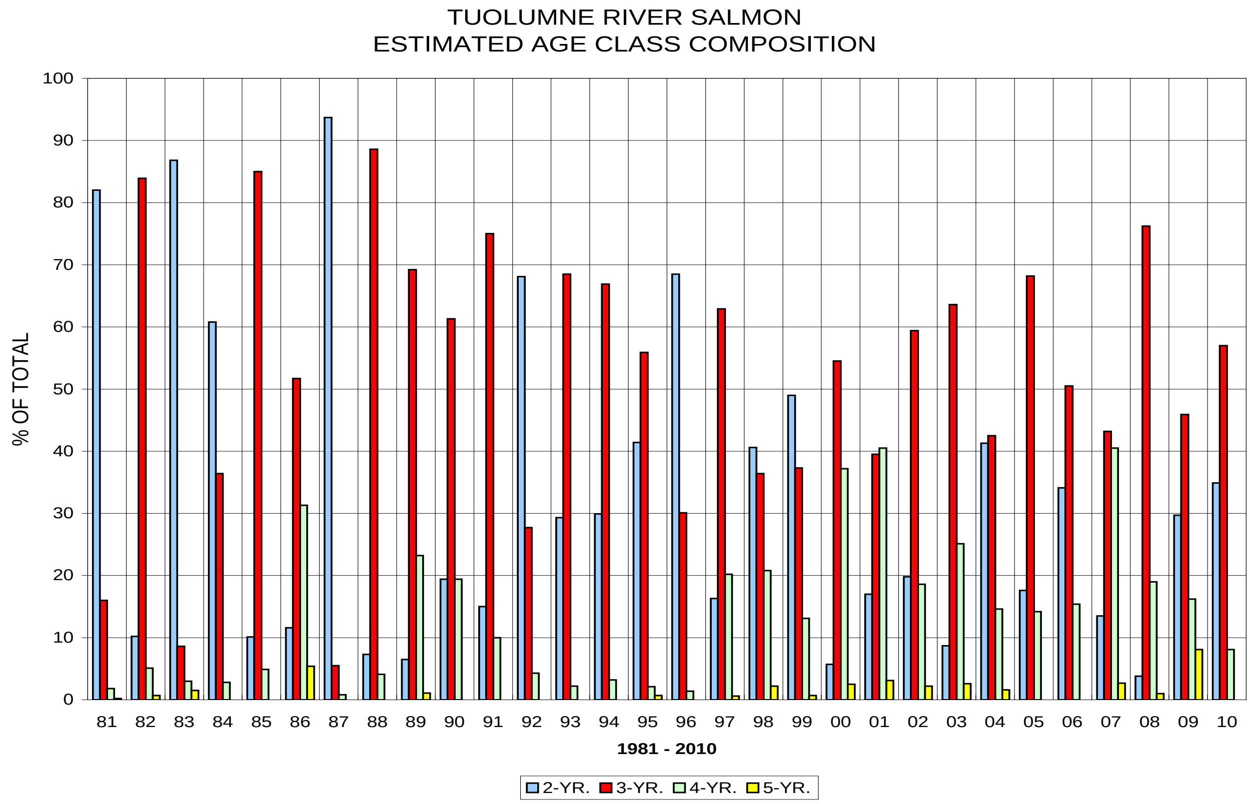


Figure 5. Average fork length of Tuolumne River salmon based on all measured carcasses, 1981-2010.



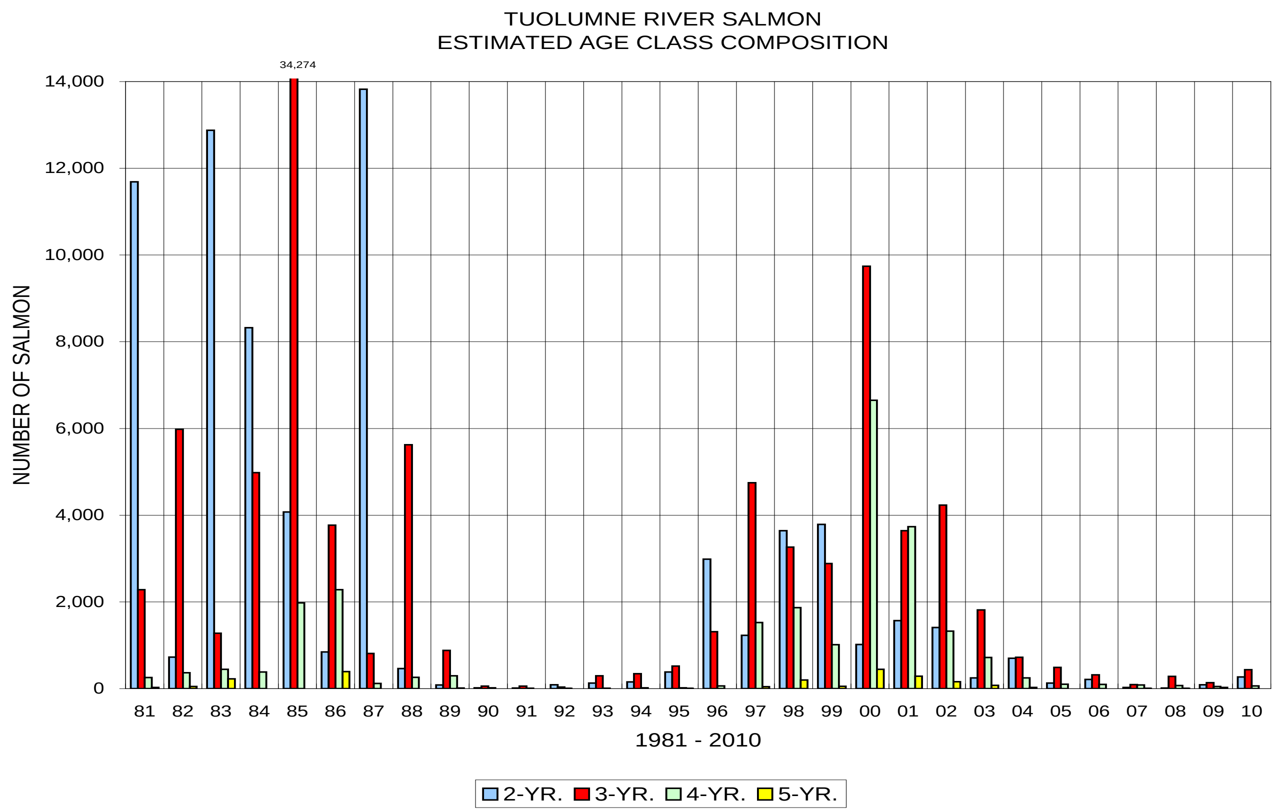
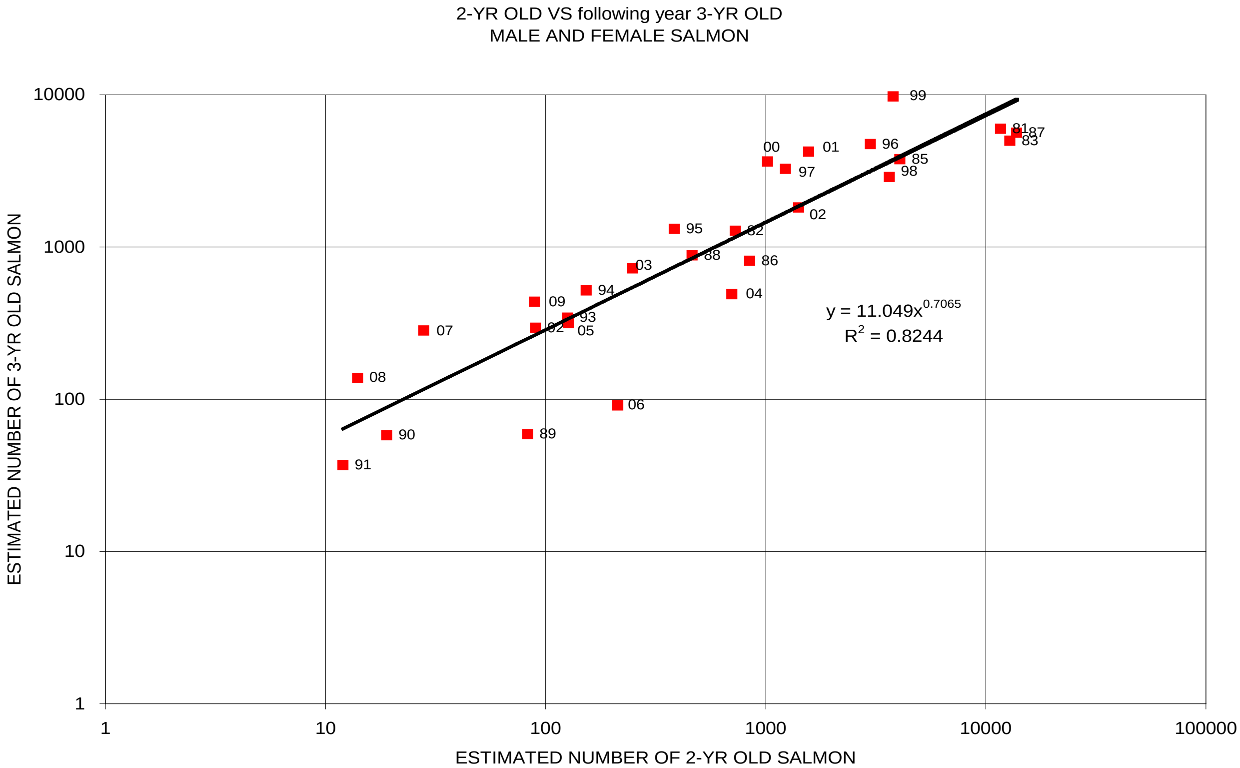


Figure 6. Estimated percent and number by age class for Tuolumne River salmon, 1981-2010.



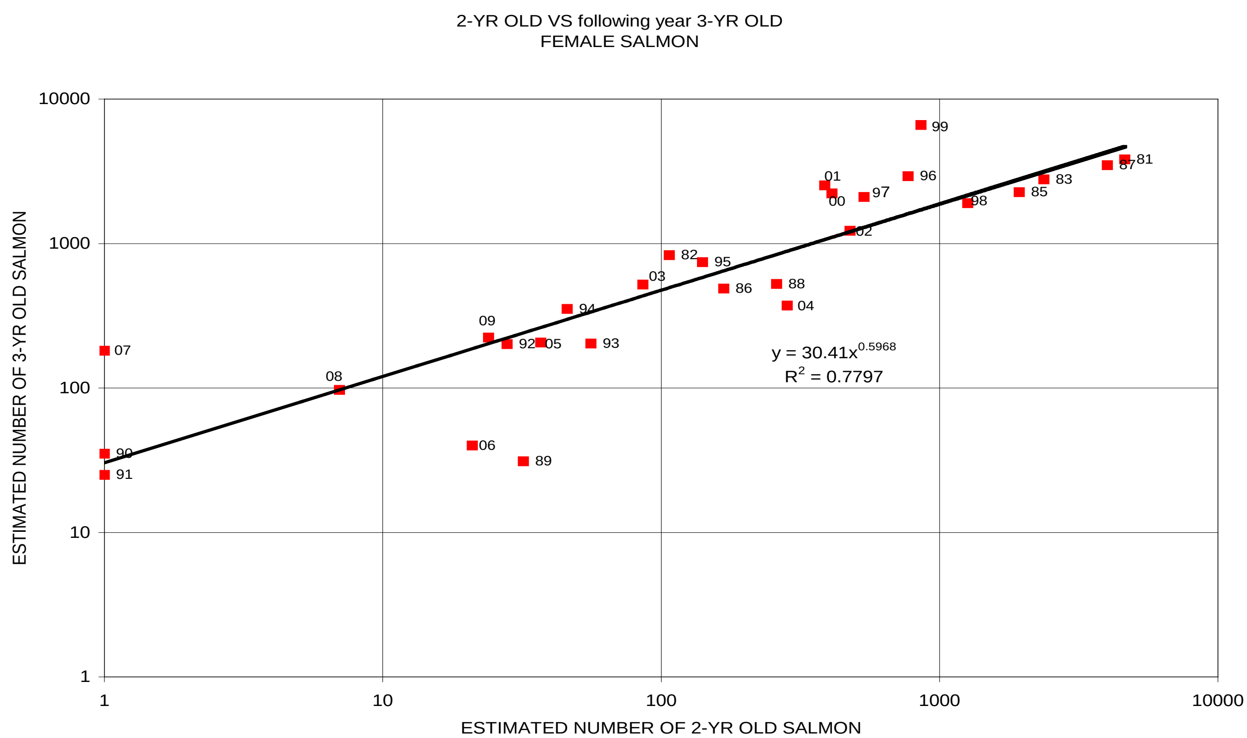


Figure 7. Estimated 2-yr-old salmon versus the following year 3-yr-old (1981-2009 Tuolumne River runs) excluding 1984 outlier, run years are for the 2-yr-olds.

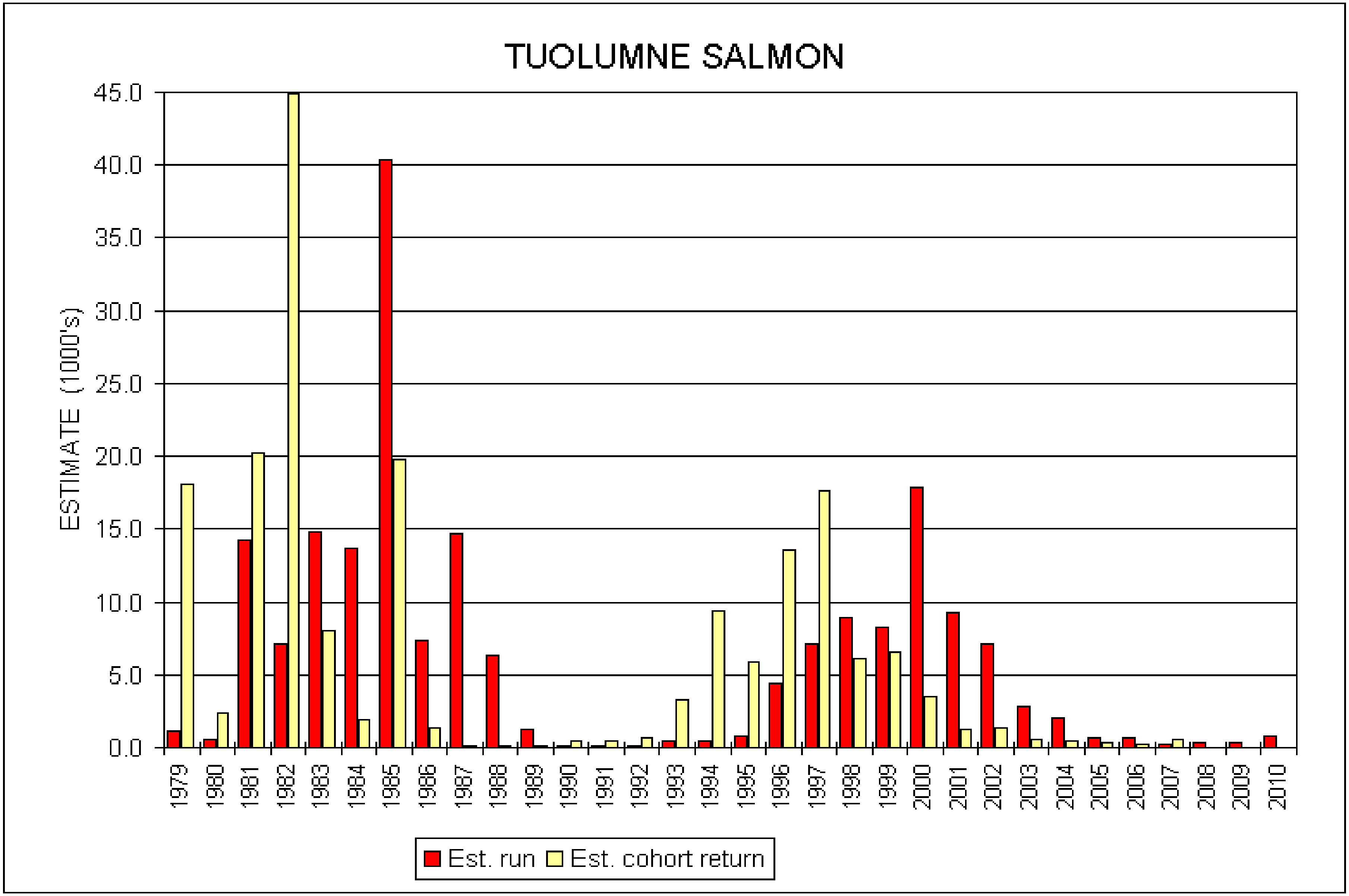


Figure 8. Estimated Tuolumne run numbers and spawner cohort returns, 1979-2010.

TABLE 1. TUOLUMNE RIVER SPAWNING SALMON SURVEY COUNTS AND ESTIMATES, 1971-2014.

YEAR	TOTAL CARCASSES	% FEMALE	TAGGED CARCASSES NUMBER TAGGED	TAGGED CARCASSES NUMBER RECOVERED[3]	TAGGED CARCASSES % RECOVERED		(WEEKLY) MAXIMUM LIVE COUNT	(WEEKLY) MAXIMUM REDD COUNT[1]	ESTIMATED RUN[2]
1971	2,283	58.0			10.4	e	2,128	1,598	21,885
1972	537	52.0			10.5	e	349	423	5,100
1973	351	59.0	270	35	13.0				1,989
1974	90	55.0	84	7	8.3				1,150
1975	130	60.0	125	8	6.4		154	212	1,600
1976	336	51.0	330	61	18.5		241	312	1,700
1977	45	62.0							450
1978	116	67.0	35	2	9.0	e	81	119	1,300
1979	305	51.0	75	22	29.3		153	204	1,184
1980	248	61.0	74	30	40.5		112	117	559
1981	5,819	44.0	664	334	50.3		1,646	1,650	14,253
1982	2,135	60.0	293	123	42.0		530	1,111	7,126
1983	1,280	25.0	270	25	9.3		263	465	14,836
1984	3,841	34.0	693	201	29.0		1,084	1,143	13,689
1985	11,651	56.0	895	273	30.5		2,986	3,034	40,322
1986	2,463	48.0	456	172	37.7		1,123	1,250	7,288
1987	5,280	31.0	1,069	461	43.1		2,155	850	14,751
1988	3,011	60.0	2,171	1,316	60.6		1,066	1,936	6,349
1989	625	52.0	491	318	64.8		291	461	1,274
1990	37	32.0	30	14	46.7		44	42	96
1991	30	45.0	12	7	58.3		24	51	77
1992	55	42.6	47	26	55.3		49	38	132
1993	187	61.3	169	96	56.8		94	215	431
1994	215	49.7	185	110	59.5		226	264	513
1995	461	54.1	415	175	42.2		270	174	928
1996	1,301	34.9	1,186	369	31.1		636	216	4,362
1997	1,520	58.6	1,056	253	24.0		1,258	716	7,548
1998	2,712	50.6	2,170	679	31.3		1,058	448	8,967
1999	3,980	45.9	2,375	1,398	58.9		1,403	404	7,730
2000	6,884	62.6	2,162	870	40.2		3,269	2,104	17,873
2001	5,400	53.9	1,170	717	61.3		1,865	1,251	9,222
2002	4,702	54.4	1,283	826	64.4		1,366	478	7,125
2003	1,489	59.7	585	328	56.1		463	349	2,961
2004	1,224	59.3	529	344	65.0		718	455	1,700
2005	312	66.5	176	58	33.0		129	124	719
2006	152	45.1	91	21	23.1		114	115	625
2007	87	37.8	37	15	40.5		92	107	211
2008	161	57.1	105	46	43.8		200	165	372
2009	40	56.8	23	18	78.3		69	62	300
2010	151	33.7	85	37	43.5		142	105	766
2011	n/a	n/a	n/a	n/a	n/a		170	95	2,847
2012	n/a	n/a	n/a	n/a	n/a		601	317	2,120
2013	n/a	n/a	n/a	n/a	n/a		841	541	3,738
2014	n/a	n/a	n/a	n/a	n/a		133	153	638

(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.
(2) Population estimate is based on weir counts beginning in 2009.
(3) Multiple recapture method implemented beginning in 2008.
e - estimated

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

Year	Stan.	Tuol.	Merced (river)	Merced (hatchery)	Merced (total)	Trib. Total	SJR abv. MR	Basin Total
1939							5.00	
1940	3.00	122.00	1.00		1.00	126.00		126.00
1941	1.00	27.00	1.00		1.00	29.00	9.00	38.00
1942		44.00				44.00		44.00
1943							35.00	
1944		130.00				130.00	5.00	135.00
1945							56.00	
1946		61.00				61.00	30.00	91.00
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	
1951	4.00	3.00				7.00		7.00
1952	10.00	10.00				20.00		20.00
1953	35.00	45.00	0.50		0.50	80.50		80.50
1954	22.00	40.00	4.00		4.00	66.00		66.00
1955	7.00	20.00				27.00		27.00
1956	5.00	6.00	0.00		0.00	11.00		11.00
1957	4.00	8.00	0.40		0.40	12.40		12.40
1958	6.00	32.00	0.50		0.50	38.50		38.50
1959	4.00	46.00	0.40		0.40	50.40		50.40
1960	8.00	45.00	0.40		0.40	53.40		53.40
1961	2.00	0.50	0.05		0.05	2.55		2.55
1962	0.30	0.20	0.06		0.06	0.56		0.56
1963	0.20	0.10	0.02		0.02	0.32		0.32
1964	4.00	2.10	0.04		0.04	6.14		6.14
1965	2.00	3.20	0.09		0.09	5.29		5.29
1966	3.00	5.10	0.04		0.04	8.14		8.14
1967	11.89	6.80	0.60		0.60	19.29		19.29
1968	6.39	8.60	0.60		0.60	15.59		15.59
1969	12.33	32.20	0.60		0.60	45.13		45.13
1970	9.30	18.40	4.70	0.10	4.80	32.50		32.50
1971	13.62	21.89	3.45	0.10	3.55	39.06		39.06
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
1977	0.00	0.45	0.35	0.20	0.55	1.00		1.00
1978	0.05	1.30	0.53	0.10	0.63	1.98		1.98
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
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
1988	10.21	6.35	4.14	0.46	4.59	21.15	2.30	23.45
1989	1.51	1.28	0.35	0.08	0.43	3.21	0.33	3.54
1990	0.48	0.10	0.04	0.05	0.08	0.66	0.28	0.94
1991	0.39	0.08	0.08	0.04	0.12	0.59	0.18	0.77
1992	0.26	0.13	0.62	0.37	0.99	1.37	0.00	1.37
1993	0.68	0.47	1.27	0.41	1.68	2.83		2.83
1994	1.03	0.51	2.65	0.94	3.59	5.13		5.13
1995	0.62	0.83	2.32	0.60	2.92	4.37		4.37
1996	0.17	4.36	3.29	1.14	4.43	8.96		8.96
1997	5.59	7.15	2.71	0.95	3.66	16.39		16.39
1998	3.09	8.91	3.29	0.80	4.09	16.09		16.09
1999	4.35	8.23	3.13	1.64	4.77	17.35		17.35
2000	11.00	17.87	11.00	1.95	12.95	41.82		41.82
2001	6.00	9.25	9.20	1.66	10.86	26.11		26.11
2002	6.90	7.17	8.87	1.80	10.67	24.74		24.74
2003	4.85	2.96	2.53	0.50	3.03	10.84		10.84
2004	4.41	1.98	3.27	1.05	4.32	10.71		10.71
2005	4.12	0.72	1.92	0.42	2.34	7.18		7.18
2006	3.07	0.63	1.47	0.15	1.62	5.31		5.31
2007	0.41	0.21	0.50	0.08	0.57	1.19		1.19
2008	0.92	0.37	0.40	0.08	0.47	1.77		1.77
2009	1.25	0.30	0.36	0.25	0.60	2.15		2.15
2010	1.38	0.77	0.65	0.15	0.80	2.94		2.94
2011	0.81	2.84	n/a	n/a	n/a	n/a	n/a	n/a
2012	7.04	2.12	n/a	n/a	n/a	n/a	n/a	n/a
2013	5.46	3.74	n/a	n/a	n/a	n/a	n/a	n/a
2014	5.44	0.64	n/a	n/a	n/a	n/a	n/a	n/a

Tuolumne and Stanislaus estimates (2009-2014) were based on weir count data.

TABLE 3. Number and % of females in the Tuolumne River salmon runs, 1971-2010.

Year	Estimated Run	# of Females	% females	Ave. FL females (cm)	(Y) Eggs per 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	7,404	3,554	48	81.0	6696	23.80
1987	14,751	4,573	31	60.4	3431	15.69
1988	5,779	3,467	60	73.8	5548	19.24
1989	1,275	663	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	471	289	61	68.8	4762	1.38
1994	506	251	50	71.9	5254	1.32
1995	827	447	54	70.0	4953	2.22
1996	4,362	1,518	35	65.6	4255	6.46
1997	7,146	4,188	59	72.1	5285	22.13
1998	8,910	4,508	51	70.2	4983	22.46
1999	8,232	3,778	46	70.2	4983	18.83
2000	17,873	11,188	63	77.5	6141	68.71
2001	8,782	4,733	54	80.6	6632	31.39
2002	7,173	3,902	54	76.6	5998	23.41
2003	2,854	1,704	60	77.3	6109	10.41
2004	1,984	1,177	59	73.0	5428	6.39
2005	719	478	67	75.9	5887	2.81
2006	625	282	45	76.9	6046	1.70
2007	211	80	38	81.5	6775	0.54
2008	372	212	57	76.6	5998	1.27
2009(1)	300	170	57	76.8	6024	1.03
2010(1)	766	258	34	74.6	5681	1.47

(1) Run estimate was from the weir count data

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

Table 4. Tuolumne River salmon survey periods and peak live counts.

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. (%)
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	
1982	08-Nov	29-Nov	15-Nov	545	7.1	7.7%
1983	07-Nov	01-Dec	15-Nov	263	14.8	1.8%
1984	01-Nov	30-Nov	01-Nov	1,084	13.7	7.9%
1985	29-Oct	20-Dec	12-Nov	2,986	40.3	7.4%
1986	27-Oct	05-Dec	03-Nov	1,123	7.3	15.4%
1987	28-Oct	16-Dec	17-Nov	2,155	14.8	14.6%
1988	25-Oct	29-Dec	14-Nov	1,066	6.3	16.8%
1989	24-Oct	29-Dec	09-Nov	291	1.3	22.8%
1990	23-Oct	26-Dec	19-Nov	44	0.1	45.8%
1991	22-Oct	02-Jan	25-Nov	24	0.1	31.2%
1992	05-Nov	21-Dec	19-Nov	49	0.1	37.1%
1993	14-Oct	18-Dec	06-Nov	94	0.4	21.8%
1994	03-Nov	05-Jan	21-Nov	226	0.5	44.1%
1995	27-Oct	30-Dec	03-Nov	270	0.9	29.1%
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%
1998	07-Oct	22-Dec	02-Nov	1,058	9.0	11.8%
1999	04-Oct	28-Dec	01-Nov	1,403	7.7	18.2%
2000	02-Oct	05-Jan	06-Nov	3,269	17.9	18.3%
2001	04-Oct	05-Jan	05-Nov	1,865	9.2	20.2%
2002	01-Oct	02-Jan	04-Nov	1,366	7.1	19.2%
2003	30-Sep	30-Dec	18-Nov	463	3.0	15.6%
2004	04-Oct	06-Jan	08-Nov	718	1.9	37.8%
2005	03-Oct	22-Dec	14-Nov	129	0.7	17.9%
2006	05-Oct	28-Dec	13-Nov	114	0.6	18.2%
2007	02-Oct	28-Dec	19-Nov	92	0.2	43.6%
2008	06-Oct	08-Jan	04-Nov	200	0.4	53.8%
2009	5-Oct	13-Jan	23-Nov	69	0.3	23.0%
2010	4-Oct	30-Nov	1-Nov	142	0.8	18.5%
2011	3-Oct	9-Jan	21-Nov	170	2.8	6.0%
2012	1-Oct	31-Dec	5-Nov	601	2.1	28.3%
2013	30-Sep	6-Jan	4-Nov	841	3.7	22.5%
2014	29-Sep	5-Jan	24-Nov	133	0.7	19.9%
Years 2009-2014 estimate based on weir count						
For period 1971-2010:						
Minimum	30-Sep	29-Nov	31-Oct	---	---	---
Maximum	29-Nov	23-Jan	27-Nov	---	---	---
Median	26-Oct	29-Dec	12-Nov	---	---	---

TABLE 5. TUOLUMNE RIVER CHINOOK SALMON FORK LENGTHS (cm) OF CARCASSES MEASURED DURING SPAWNING SURVEYS, 1981-2010.

FEMALES	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NUMBER	289	153	92	286	524	251	349	222	193	11	9	20	56	78	79
MIN.	47	56	41	43	47	53	45	49	52	73	68	43	49.5	50	51
MAX.	86	97	85	77	90	99	93	90	99	89	74	88	87.5	88.5	87
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	68.9	71.9	70.0
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	6.6	8.3	9.0
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	44.0	69.2	81.4
MALES	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
NUMBER	372	121	302	560	407	267	785	149	174	20	11	27	36	79	66
MIN.	37	29	34	30	54	35	39	50	46.5	44	52	46	47.5	52	49
MAX.	107	113	103	92	102	112	100	104	110.5	105	98	98	96	100.5	106
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	72.9	73.6	69.3
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	12.6	12.6	13.6
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	159.5	157.9	184.7

FEMALES	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NUMBER	150	232	378	382	594	844	658	278	245	117	42	14	60	21	29
MIN.	48	51	46	43	53	48	50	54	51	46	56	73	60	54	60
MAX.	89	95	93	93	105	105	104	98	98	93	92	91	86	90	83
AVG.	65.5	73.1	70.3	70.6	77.5	80.6	76.2	78.1	72.2	75.9	76.7	81.5	76.6	76.8	74.6
STD. DEV.	8.9	6.5	10.7	9.3	6.1	9.1	8.7	7.6	10.5	7.1	7.2	5.3	5.1	9.8	6.2
VARIANCE	79.3	41.8	113.6	86.6	37.0	83.7	76.5	57.5	110.3	50.2	51.4	28.0	26.0	95.8	38.5
MALES	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
NUMBER	279	164	358	476	305	672	589	184	186	59	49	23	45	16	57
MIN.	41	45	46	43	46	47	31	30	43	46	56	59	59	52	30
MAX.	101	100	105	105	110	115	111	108	108	101	95	105	104	110	98
AVG.	64.7	79.0	70.6	68.1	84.2	83.1	81.2	84.4	72.9	75.5	72.6	85.3	86.5	75.1	74.1
STD. DEV.	11.3	11.7	15.1	12.4	10.5	15.6	14.5	13.7	14.2	14.3	10.8	14.1	9.2	18.5	13.6
VARIANCE	127.9	138.0	226.9	153.0	109.1	243.4	211.3	187.5	201.8	204.2	117.5	199.1	83.8	341.0	186.0

TABLE 6. ESTIMATED AGE CLASS COMPOSITION FROM LENGTH FREQUENCY DISTRIBUTIONS OF TUOLUMNE RIVER SALMON BASED ON FRESH MEASURED CARCASSES (1981-2010)

		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%	

TABLE 6. ESTIMATED AGE CLASS COMPOSITION FROM LENGTH FREQUENCY DISTRIBUTIONS
OF TUOLUMNE RIVER SALMON BASED ON FRESH MEASURED CARCASSES (1981-2010)

			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
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)												
2005	FEMALE	65	5.1%	7.7%	82	51.7%	77.8%	94	9.7%	14.5%		
	MALE	70	12.5%	37.3%	90	16.5%	49.2%	102	4.5%	13.6%		
	TOTAL		17.6%			68.2%			14.2%		0.0%	
(1)												
2006	FEMALE	65	3.3%	7.1%	82	33.0%	71.4%	94	9.9%	21.4%		
	MALE	70	30.8%	57.1%	90	17.6%	32.7%	102	5.5%	10.2%		
	TOTAL		34.1%			50.5%			15.4%		0.0%	
(1)												
2007	FEMALE	65	0.0%	0.0%	82	18.9%	50.0%	94	18.9%	50.0%		
	MALE	70	13.5%	21.7%	90	24.3%	39.1%	102	21.6%	34.8%	2.7%	4.3%
	TOTAL		13.5%			43.2%			40.5%		2.7%	
(1)												
2008	FEMALE	65	1.9%	3.3%	82	48.6%	85.0%	94	6.7%	11.7%		
	MALE	70	1.9%	4.4%	90	27.6%	64.4%	102	12.4%	28.9%	1.0%	2.2%
	TOTAL		3.8%			76.2%			19.0%		1.0%	
(1)												
2009	FEMALE	65	8.1%	14.3%	82	32.4%	57.1%	94	16.2%	28.6%		
	MALE	70	21.6%	50.0%	90	13.5%	31.3%	102	0.0%	0.0%	8.1%	18.8%
	TOTAL		29.7%			45.9%			16.2%		8.1%	
(1)												
2010	FEMALE	65	3.5%	10.3%	82	29.1%	86.2%	94	1.2%	3.4%		
	MALE	70	31.4%	47.4%	90	27.9%	42.1%	102	7.0%	10.5%		
	TOTAL		34.9%			57.0%			8.1%		0.0%	

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

TABLE 7. ESTIMATED TUOLUMNE SALMON RUN NUMBERS AND AGE COMPOSITION WITH ESTIMATED COHORT RETURNS AND COHORT AGE COMPOSITION

	Estimated	Age-class composition for salmon run								Cohort	Cohort Composition			
	Run	2-yr	3-yr	4-yr	5-yr	2-yr	3-yr	4-yr	5-yr	Total	2-yr	3-yr	4-yr	5-yr
Year	(x 1000)	(x 1000)	(x 1000)	(x 1000)	(x 1000)	(%)	(%)	(%)	(%)	(x 1000)	(%)	(%)	(%)	(%)
1978	1.30													
1979	1.18									18.11	64.5%	33.0%	2.5%	0.0%
1980	0.56									2.39	30.5%	53.5%	16.1%	0.0%
1981	14.25	11.69	2.28	0.26	0.03	82.0	16.0	1.8	0.2	20.24	63.6%	24.6%	9.8%	2.0%
1982	7.13	0.73	5.98	0.36	0.05	10.2	83.9	5.1	0.7	44.91	18.5%	76.3%	5.2%	0.0%
1983	14.84	12.88	1.28	0.45	0.22	86.8	8.6	3.0	1.5	8.02	50.8%	47.7%	1.5%	0.0%
1984	13.69	8.32	4.98	0.38	0.00	60.8	36.4	2.8	0.0	1.94	44.2%	41.7%	13.4%	0.7%
1985	40.32	4.07	34.27	1.98	0.00	10.1	85.0	4.9	0.0	19.74	70.0%	28.5%	1.5%	0.0%
1986	7.40	0.86	3.83	2.32	0.40	11.6	51.7	31.3	5.4	1.36	34.0%	64.7%	1.4%	0.0%
1987	14.75	13.82	0.81	0.12	0.00	93.7	5.5	0.8	0.0	0.15	55.5%	39.4%	5.2%	0.0%
1988	6.35	0.46	5.63	0.26	0.00	7.3	88.6	4.1	0.0	0.08	22.7%	70.4%	6.9%	0.0%
1989	1.28	0.08	0.88	0.30	0.01	6.5	69.2	23.2	1.1	0.06	19.8%	62.5%	17.7%	0.0%
1990	0.10	0.02	0.06	0.02	0.00	19.4	61.3	19.4	0.0	0.43	20.7%	74.3%	3.7%	1.3%
1991	0.08	0.01	0.06	0.01	0.00	15.0	75.0	10.0	0.0	0.49	27.9%	68.5%	3.5%	0.0%
1992	0.13	0.09	0.04	0.01	0.00	68.1	27.7	4.3	0.0	0.72	21.1%	64.4%	8.5%	6.0%
1993	0.47	0.14	0.32	0.01	0.00	29.3	68.5	2.2	0.0	3.29	10.4%	39.8%	43.8%	5.9%
1994	0.51	0.15	0.34	0.02	0.00	29.9	66.9	3.2	0.0	9.39	31.8%	47.8%	19.7%	0.6%
1995	0.83	0.34	0.46	0.02	0.01	41.4	55.9	2.1	0.7	5.93	19.6%	54.7%	18.2%	7.5%
1996	4.36	2.99	1.31	0.06	0.00	68.5	30.1	1.4	0.0	13.62	26.6%	22.5%	48.8%	2.1%
1997	7.15	1.16	4.49	1.44	0.04	16.3	62.9	20.2	0.6	17.68	22.8%	55.1%	21.2%	0.9%
1998	8.91	3.62	3.24	1.85	0.20	40.6	36.4	20.8	2.2	6.08	16.8%	60.1%	21.9%	1.2%
1999	8.23	4.03	3.07	1.08	0.06	49.0	37.3	13.1	0.7	6.58	23.9%	64.7%	10.9%	0.5%
2000	17.87	1.02	9.74	6.65	0.45	5.7	54.5	37.2	2.5	3.53	40.3%	51.5%	8.2%	0.0%
2001	9.25	1.57	3.65	3.75	0.29	17.0	39.5	40.5	3.1	1.19	20.8%	70.6%	8.6%	0.0%
2002	7.17	1.42	4.26	1.33	0.16	19.8	59.4	18.6	2.2	1.41	58.0%	34.7%	6.8%	0.4%
2003	2.85	0.25	1.82	0.72	0.07	8.7	63.6	25.1	2.6	0.53	23.9%	59.3%	16.1%	0.7%
2004	1.98	0.82	0.84	0.29	0.03	41.3	42.5	14.6	1.6	0.40	53.4%	22.8%	17.7%	6.1%
2005	0.72	0.13	0.49	0.10	0.00	17.7	68.2	14.2	0.0	0.36	7.9%	78.6%	13.5%	
2006	0.63	0.21	0.32	0.10	0.00	34.1	50.5	15.4	0.0	0.21	6.6%	64.4%	29.0%	
2007	0.21	0.03	0.09	0.09	0.01	13.5	43.2	40.5	2.7	0.53	16.9%	83.1%		
2008	0.37	0.01	0.28	0.07	0.00	3.8	76.2	19.0	1.0					
2009	0.30	0.09	0.14	0.05	0.02	29.7	45.9	16.2	8.1					
2010	0.77	0.27	0.44	0.06	0.00	34.9	57.0	8.1	0.0					

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-3

2014 Seine Report and Summary Update

Prepared by

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2014 Seine Report and Summary Update

Tuolumne River

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

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1. INTRODUCTION

1.1 STUDY AREA

The Tuolumne River is the largest of three major tributaries (Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River. The Tuolumne River originates in Yosemite National Park, in the central Sierra Nevada Mountains, and flows west between the Merced River to the south and the Stanislaus River to the north (Figure 1). The San Joaquin River itself flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta within California's Central Valley. 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 the confluence with the San Joaquin River to La Grange Dam at river mile (RM) 52.2. The La Grange Dam site has been the upstream limit to anadromous fish migration since at least 1871.

1.2 PURPOSE AND HISTORY OF STUDY

FISHBIO conducted seine surveys in the Tuolumne and San Joaquin Rivers in 2014 for the Turlock and Modesto Irrigation Districts (TID/MID). Sampling was conducted in both rivers pursuant to the Don Pedro Project river-wide monitoring program. This was the 29th annual TID/MID seining study. The primary objective was to document juvenile Chinook salmon (*Oncorhynchus tshawytscha*) size, abundance, and distribution in the Tuolumne and San Joaquin rivers. The majority of the juvenile salmon captured in this study were the progeny of the 2013 fall-run Chinook salmon spawning population. Based on counts from the Tuolumne River weir, fall-run Chinook salmon escapement was estimated to be 3,664 fish (September through December 2013; Becker et al. 2014). A review of seining data collected since 1986 can be found in Section 4 of this report.

2. METHODS

2.1 SITE DESCRIPTIONS

The study area encompassed the lower Tuolumne River corridor, from La Grange Dam (RM 52.2) to its confluence with the San Joaquin River (at RM 0 on the Tuolumne River and RM 83.8 on the San Joaquin River), and the San Joaquin River from Laird Park (RM 90.2) to Gardner Cove (RM 79.4; Figure 1). Ten sites were sampled during each sampling event; eight were located on the Tuolumne River and two on the San Joaquin River.

For the purpose of this study, the Tuolumne River was stratified into three reaches. The upper reach (RM 52 to 34) is a higher gradient reach that includes the majority of salmonid spawning habitat in the river. Three sites were sampled in this reach – Old La Grange Bridge (RM 50.5), Riffle 5 (RM 48.0), and Tuolumne River Resort (TRR) (RM 42.4). The middle reach (RM 34 to 17) is a transitional area of the river where the predominant substrate changes from gravel to sand. This reach contains many of the in-channel areas that were historically mined for sand and/or gravel. Three sites were sampled in this reach – Hickman Bridge (RM 31.6), Charles Road (RM 24.9), and Legion Park (RM 17.2). The lower reach (RM 17 to 0) is a low gradient reach, located downstream of the Dry Creek confluence, with a predominately sandy substrate. Two sites were sampled in this reach – Service Road (RM 7.4) and Shiloh Bridge (RM 3.4).

The San Joaquin River reach (RM 79.4 to 90.2) is a low gradient reach with a substrate composed primarily of sand, that extends both upstream and downstream of the Tuolumne River confluence. Two sites were sampled in this reach – Laird Park (RM 90.2) and Gardner Cove (RM 79.4).

2.2 JUVENILE SALMON SAMPLING

The 2014 seining survey occurred between 14 January and 4 June. Sampling was conducted at two-week intervals resulting in a total of 11 sampling events. The same general areas at each site were surveyed during each sampling event to facilitate comparison between events.

2.2.1 Sampling

At each site, three downstream seine hauls were conducted parallel to the shoreline. Sampling was conducted using a 1/8-inch mesh nylon seine net measuring 4-ft high by 20-ft long. All fish captured in the seine were identified to species and enumerated. Additional data were collected on random sub-samples of fish to assess size and growth rate. At each site, up to 50 Chinook salmon and rainbow trout/steelhead (*Oncorhynchus mykiss),* and 20 individuals of each non-salmonid species were anesthetized with Alka-Seltzer® (1916 mg Sodium Bicarbonate/4 liters of water), measured (FL, in mm), weighed (in grams), and then allowed to recover in aerated containers prior to release. The smolting appearance of all measured Chinook salmon and *O. mykiss* was rated based on a seven category scale, where 1 = yolk-sac fry, 2 = fry, 3 = parr, 4 = silvery parr, 5 = smolt, 6 = mature adult, and IAD = immature adult (Interagency Ecological Program, unpublished).

2.2.2 Environmental Conditions Data Collection

The area sampled at each site during each event was estimated based on the average length and width of each seine haul. In addition, maximum depth was determined with a stadia rod to the nearest 0.5-ft at each area sampled. Instantaneous water temperature (°C) and dissolved oxygen (mg/L) were measured with a YSI ProODO (YSI Incorporated, Yellow Springs, OH). Conductivity (µS) was measured using an ExStik® II EC500 Electrical Conductivity Meter (Extech Instruments Corporation, Waltham, MA). Instantaneous turbidity (NTU) was measured by collecting a water sample and later testing it at the field station using a LaMotte turbidity meter (Model 2020e, LaMotte Company, Chestertown, MD). Time of day, weather conditions, and substrate type were also recorded at each site.

Flow data from the gauges closest to the sampling sites was obtained from the United States Geological Survey (USGS) and the California Data Exchange Center (CDEC), as downloaded from http://waterdata.usgs.gov and http://cdec.water.ca.gov, respectively. Flow gauges upstream of Vernalis, at Patterson Bridge (RM 98.5) and Maze Road (RM 77.3) represent best estimates of flow levels at the sampling locations of Laird Park (RM 90.2) and Gardner Cove (RM 79.4), respectively.

2.3 DATA ANALYSIS

Seine catch data were examined at three different spatial scales: river-wide; river reach (upper, middle, lower); and site. Salmon catch data were divided into two size classes for analysis: "fry" were defined as fish with a fork length ≤ 50 mm; and "juveniles" were defined as fish with a fork length > 50 mm. For each of the three spatial scales, density indices were computed for fry and juveniles by multiplying the number of salmon caught by 1,000 and dividing it by the area sampled. These indices of population density (i.e., relative abundance) were used for comparisons. The size ranges of salmon fry and juveniles were also examined by river section. A growth rate was indirectly estimated by dividing the amount of increase in maximum FL in the catch, over an extended period of time, by the number of days during the period.

A stochastic Ricker stock-recruitment model was used to evaluate the relationship between abundance of parental stock S (defined as the estimated number of female Chinook salmon in year t; detail is provided below), and recruitment R (alternatively defined as either peak or average index density of fry per 1000 ft^2) in year t+1. The Ricker model (Quinn and Deriso, 1999) has been applied extensively to investigate stock-recruitment relationships for anadromous species. It is more appropriate than other stock-recruitment models (e.g., Beverton-Holt) as it is not subject to constraints imposed by limited spawning habitats (i.e., redd superimposition at high spawner densities). The Ricker model is fit through the origin (no spawners = no recruits), and has the form

$$R = \alpha S e^{-\beta S + \varepsilon}$$

where α is a productivity parameter that is proportional to the fecundity of S, β is a density dependent parameter, and ε is a normally distributed error term. The Ricker model parameters α and β were estimated using non-linear least squares regression. $S_{\max}$, defined as the population/abundance of parental stock expected to generate maximum recruitment, was calculated using a linearized form of the Ricker stock-recruitment equation (PFMC 2005) expressed as

$$ln(R/S) = \alpha + \beta S + \varepsilon$$

and,

$$\hat{S}_{max} = 1/-\widehat{\beta}.$$

For a comparative review, results from 2014 sampling events were compared to findings from Tuolumne and San Joaquin River seine surveys conducted in other years. Historical estimates of female Chinook salmon abundance were obtained from California Department of Fish and Wildlife (formerly, Department of Fish and Game; CDFG/DFW) annual spawning and carcass surveys (years 1985 to 2008; TID/MID 2008) and from the Tuolumne Weir (years 2009 to 2013; FISHBIO 2010-2013). Chinook salmon density data (fry per 1000 ft^2) were obtained from TID/MID and FISHBIO seine surveys conducted from years 1986 to 2014. Due to the likelihood of fry outside of this timeframe not being progeny of fall-run Chinook salmon, only fry captured between 15 January and 15 March were used in the Ricker stock-recruitment analysis (Modified Fisher Race Table, unpublished).

3. RESULTS AND DISCUSSION

3.1 SEINE CATCH

During the 2014 survey, a total of 3,664 Chinook salmon and ten *O. mykiss* were caught in the Tuolumne River. No Chinook salmon or *O. mykiss* were caught in the San Joaquin River (Tables 1 and 2). As a result, all subsequent discussion of 2014 Chinook salmon catch data is in reference to the Tuolumne River.

3.1.1 Density of Fry and Juvenile Salmon

As salmon emerge from the gravel in the upper reaches of the Tuolumne River, they disperse downstream over time. Areas where fry emerge and begin rearing are often not conducive to sampling by seine net (i.e., vegetative or rocky cover). As a result, peak densities of fry catch are dependent on factors that influence fry distribution (i.e., time since emergence, location of emergence, migration rates), and factors that influence probability of capture (i.e., habitat type, and fry size, age and behavior).

The temporal peak in salmon fry density occurred between 11 February and 25 February (Figure 2). Fry densities were lowest just below the dam, at Old La Grange Bridge (potentially due to low probability of capture). Fry densities increased through the upper reach between Riffle 5 and Hickman Bridge and decreased again in the middle reach from Hickman Bridge through Charles Road (Figure 2). No fry or juveniles were observed downstream of the Charles Road site, in the lower reach of the Tuolumne River (i.e., Legion Park, Service Road and Shiloh Bridge) during the 2014 survey. Juvenile salmon densities increased spatially in the upper reach but did not show a clear temporal pattern; however, juvenile densities in the middle reach showed a gradual increase over time (corresponding with a decrease in fry catch over time in that reach) until a peak on 8 April at Hickman Bridge (Figure 2; Table 3). The survey results indicate a spatial peak in both fry and juveniles at Hickman Bridge (Figure 2).

Examining the data at the river reach scale shows that fry density in the Tuolumne River peaked in the upper reach on 11 February (67.6 fry/1,000 ft^2), and in the middle reach on 25 February (82.5 fry/1,000 ft^2; Figure 3). The density of juveniles peaked in both the upper and middle reaches on 25 Mar (2.5 juveniles/1,000 ft^2 and 9.4 juveniles/1,000 ft^2, respectively).

In 2014, across the entire river (all sites combined), the highest density of salmon fry (45.9 /1,000 ft^2) was observed on 11 February, and this observation was also the overall (fry and juvenile combined), river-wide maximum density observed during 2014. The highest observed density of juvenile salmon was 5.1 /1,000 ft^2, observed on 25 March (Table 3).

3.1.2 Size and Smoltification

Observed size of Chinook salmon ranged from 29 mm to 87 mm (FL). The average FL of both size classes increased throughout the survey period (Figures 4 and 5). Length frequency distributions for each sampling event are displayed in Figures 6 and 7. Size of Chinook salmon increased from late January to late April at most of the sampling locations. There was considerable temporal overlap in occurrence of fry and juveniles: fry were observed as late as 4 June, while salmon estimated to be large enough to undergo smoltification (> 70 mm FL) were first observed on 25 March.

3.1.3 Tuolumne River Stock-Recruitment Relationship

3.1.3.1 Peak Density of Chinook Fry

For the stock-recruitment relationship, with *R* defined as peak index density of fry per 1000 ft^2, the parameter estimates of α and β were 6.18 x 10^{-5} and -3.6300, respectively. The stock-recruitment (S-R) data and the estimated Ricker curve are shown in Figure 8. The spawner abundance expected to generate the maximum recruitment of fry (peak density) was 11,775 adult female Chinook.

3.1.3.2 Average Density of Chinook Fry

For the stock-recruitment relationship, with *R* alternatively defined as average index density of fry per 1000 ft^2, the parameter estimates of α and β were 7.254 x 10^{-5} and -4.234, respectively. The S-R data and the best-fit line are shown in Figure 9. The spawner abundance expected to generate the maximum recruitment of fry (average density) was 10,090 adult female Chinook.

3.1.3.3 Maximum Spawning Abundance

Due to the uncertainty (unknown magnitude of error) associated with past abundance estimates of female Chinook, *S*, a few caveats of these analyses should be considered. Prior to 2009, estimates of Chinook salmon spawner abundance in the Tuolumne River were obtained through carcass mark-recapture models, and the estimates may have been flawed due to either the use of inappropriate models, or the failure to meet certain assumptions of those models. The reliability of the spawner abundance data has improved over the past few years due to the availability of direct counts of migrating adults using a VAKI RiverWatcher infrared camera and video-monitoring system. In addition, this stock-recruitment relationship analysis assumes that the abundance indices (peak or average) of Chinook salmon fry density are consistently proportional to (and therefore representative of) the true number of Chinook salmon fry.

Both relationships appear to be well represented with the stochastic Ricker model equation (Figure 8 and 9). The estimates of S_{max}, the spawner abundance expected to generate the maximum recruitment, were similar; 10,090 adult female Chinook (based on the index of average fry density) versus 11,775 adult female Chinook (based on the index of peak fry density). Decadal fluctuations in escapement to the Tuolumne River have been observed since escapement surveys were first conducted in 1952. More recently, observed escapement rebounded from a low of 80 female spawners in 2007 to a high of 1,864 female spawners in 2013 (Table 9).

3.1.4 Species Richness

Twelve fish species, in addition to Chinook salmon, were captured in this survey. Four of these species were common to both the Tuolumne and San Joaquin rivers. The Tuolumne River showed higher species diversity with 11 species caught overall, excluding Chinook, while five non-focal species were captured in the San Joaquin River (Table 5). Of the native species observed, *O. mykiss*, Sacramento pikeminnow, Sacramento sucker, hardhead, and prickly sculpin were captured only in the Tuolumne River. No native species were captured in the San Joaquin River. A total of ten *O. mykiss* (29 mm to 52 mm FL) were caught in the upper reach (at Old La Grange Bridge) of the Tuolumne River between 25 March and 4 June (Table 7). No *O. mykiss* were captured in the middle or lower reaches of the Tuolumne River or in the San Joaquin River.

3.2 ENVIRONMENTAL CONDITIONS

Discharge in the Tuolumne River, downstream of La Grange Dam, was approximately 160 cfs at the beginning of the study period. Between 14 April and 24 April a pulse flow occurred that consisted of two short pulses designed by the U.S. Fish and Wildlife Service (USFWS) to mimic the natural run-off pattern in the Tuolumne River prior to impoundment (Figure 10). Peaks in flow during the spring pulse period ranged from 1,230 cubic feet per second (cfs) on 16 April to 770 cfs on 22 April. Following the pulse period, flows decreased to approximately 160 cfs through the end of May and then to approximately 100 cfs by early June.

Discharge in the San Joaquin River at Vernalis (RM 72.5) ranged from 382 cfs to 3,035 cfs from January through June (Figure 2). Discharge upstream of Vernalis, at Patterson Bridge (RM 98.5) and Maze Road (RM 77.3), ranged from 158 cfs to 635 cfs, and from 65 cfs to 2,122 cfs, respectively (Figure 10).

Instantaneous water temperatures generally increased over the study period. In both rivers, downstream reaches were consistently warmer than upstream reaches (Figure 11). The minimum recorded temperature in the Tuolumne River was 8.5 °C (48.0 °F) at Old La Grange Bridge, on 14 January. The maximum overall temperature recorded was 28.0 °C (82.4 °F) in the lower reach at Legion, on 4 June (Figure 11). Instantaneous water temperatures in the San Joaquin River exhibited a similar trend, with the lowest temperature at Gardner Cove on 14 January (10.9 °C; 51.6 °F) and the highest temperature at Laird Park on 4 June (26.6 °C; 79.9 °F; Figure 11).

Dissolved oxygen concentrations ranged from 8.3 mg/L to 12.8 mg/L in the Tuolumne River, and from 6.0 mg/L to 13.4 mg/L in the San Joaquin River (Figure 12).

Conductivity ranged from 28 µS to 221 µS in the Tuolumne River, and from 64.4 µS to 1,905 µS in the San Joaquin River (Figure 13). Under base flow conditions, conductivity in the Tuolumne River generally increased with distance downstream of La Grange Dam (Table 1). Conductivity was similar across sites during the pulse flow period (Figure 10). Overall, conductivity in the San Joaquin River was much higher than in the Tuolumne River, with the highest conductivity observed at the downstream sampling site (Figure 13).

Turbidity in the Tuolumne River ranged from 0.1 NTU to 10.3 NTU. Turbidity in the San Joaquin River was generally higher than in the Tuolumne River, and ranged from 2.8 NTU to 32.3 NTU (Figure 14). Turbidity also generally increased with distance downstream of La Grange Dam (Table 1).

4. COMPARATIVE REVIEW

4.1 SEINE SURVEYS: 1986-2014

Annual TID/MID Tuolumne River seining surveys began in 1986. Since that time, the number, location, and sampling frequency of sites have varied (Table 8). The number of salmon captured in the Tuolumne River during a single year has ranged from as low as 120 (1991), to as high as 14,825 (1987). The total number of salmon captured in 2014 was 3,664, which ranks 7th highest among the years documented (Table 2). In order to maintain continuity with previous reports, the inter-annual comparison of density and fork length in this report, primarily focused on the past six years (2008-2014). During this recent time period sampling locations and timing of biweekly sampling have been relatively consistent.

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 in the San Joaquin River has ranged from 0 (in several years) to 854 (in 1986), with average densities consistently lower than those found in the Tuolumne River (Table 4). No salmon were captured in the San Joaquin River during the 2014 survey.

4.1.1 Tuolumne River Salmon Density

In 2014, the average river-wide density of Chinook salmon was 15.1 salmon/1,000 ft^2 (Figure 20, Table 3). This is the highest recorded average density in the recent 2009 to 2014 period, and is more than double the average density recorded in 2013 (7.1 salmon/1,000 ft^2). Further, this density index is the highest average density recorded in the last ten years, and higher than the average yearly river-wide density calculated for the entire 1986 to 2014 period (Figure 20). In 2014, the river-wide density of salmon fry and juveniles peaked on 11 February and 25 March, respectively. The peak fry density in 2014 was 1.5 times the peak density in 2013, and the highest since 2003 (Figure 18). Peak density of juveniles in 2014 was the highest since 2009 (Figure 19, Table 3).

4.1.1.1 Density by Site

In 2014, the highest salmon fry densities were observed at the upper reach site of Riffle 5 and the middle reach sites of TRR and Hickman. The highest juvenile densities were primarily observed in the middle reach at all three sites (TRR, Hickman and Charles Road). Higher juveniles densities were observed in the upper reach at Riffle 5 in January. The early timing of these juvenile observations indicates it is likely that these fish were the progeny of spawning activity outside of the typical spawning period for fall-run Chinook salmon. No fry or juveniles were observed downstream of the Charles Road site. During the 2009 to 2014 period, fry and juveniles were only found below Charles Road in 2011 and 2012. In most years, fry and juvenile densities are highest at the TRR and Hickman sites, indicating the importance of that reach as a rearing area in the Tuolumne River.

4.1.1.2 Density by River Reach

In the upper reach of the Tuolumne River, fry density generally peaks between early February and early March, before steadily declining as fish grow into the juvenile size class or move downstream (Figure 19). Subsequently, there is a corresponding increase in juvenile density in the upper reach; typically beginning in late February, and peaking in early April to late May (Figure 19, Table 3). In 2014, the density of fry in the upper reach peaked on 11 February, and declined to low levels by late-April. Juvenile salmon density peaked a couple of weeks early on 25 March in the upper reach compared to other years (Table 3).

Fry and juvenile timing in the middle reach is generally similar to timing in the upper reach (Figure 22). In 2014, fry density peaked a couple weeks later on 25 February and juvenile density peaked on 25 March (Table 3).

In the lower reach, density of fry and juvenile salmon has been relatively low in most years since 1986. Although the locations in this reach were sampled inconsistently during the 1980s and 90s; since 1999, two sites have been consistently sampled in the lower reach. During the 2009 to 2014 period, fry were only observed in 2011, and the highest densities were recorded in early February (Figure 23). In the same period, juveniles were observed in two years, and the highest peak densities occurred in early February (2011) and in mid-April (2012; Figure 23). In 2014, no salmon (fry or juvenile) were caught in the lower reach. Since 2009, there have been no Chinook captured in four of the six years. The lack of Chinook salmon fry and juveniles captured in the lower reach may be an indication of low capture probabilities, poor salmon survival in the lower reach of river, active migration out of the river (i.e., no longer rearing in river margin habitat where sampling is conducted), or some combination of these factors.

4.1.2 San Joaquin River Salmon Density

Densities of salmon caught in the San Joaquin River at Laird Park and Gardner Cove (or nearby sites) were reviewed to compare relative abundance of salmon upstream and downstream of the Tuolumne River confluence. Due to low capture rates, the abundance indices were calculated for both fry and juveniles combined. The average salmon abundance at Laird Park (upstream of the Tuolumne confluence) was extremely low for all years during the entire 1986 to 2014 period (Figure 25, Table 4). The total number of salmon caught annually at Laird Park ranged from 0 to 51, totaling 152 during the 28-year period. No salmon were caught at Laird Park in 2014. The average abundance at Gardner Cove (downstream of the Tuolumne River confluence) was highest in 1986 and 1999, and moderately high in 1995, 1998, 2001, and 2006. A total of 1,097 salmon were caught at this location during the entire 1986 to 2014 period, of which nearly half (n=509) were caught in 1999 (Table 4). No salmon were caught at Gardner Cove in 2014.

4.1.3 Size and Growth

Similar to other years, minimum FL of Chinook salmon captured in the Tuolumne River in 2014 was less than 46 mm FL until mid-March (Figure 15). The increase in average FL during the January to March period was similar in timing and magnitude to the pattern observed in the 2009 to 2014 period (Figure 16). In all years since 2009, higher variability in FL has been observed beginning in April, due to decreasing capture rates and the migration of smolts out of the study area. Maximum FL in 2014 was highly variable throughout the entire sampling period (Figure 17).

4.1.4 Species Richness

The number of fish species (i.e., species richness), excluding Chinook salmon, captured during the 1986 to 2014 period, has ranged from 5 to 19 species in the Tuolumne River (Table 10). Species richness was lowest in 2012, as only five other species were captured. In all other years since 1986, the number of species captured has ranged from 11 to 19.

Species richness in the San Joaquin River has decreased since 2006. Species richness observed in the San Joaquin River prior to 2006 averaged 16 species (range: 12-21). Since 2006, the average number of species captured has dropped to 8 species (range: 5-12; Table 10). Native species, including Sacramento blackfish, Sacramento splittail, Pacific lamprey, hitch; and tule perch, and non-native species, including brown bullhead, goldfish, golden shiner, striped bass, threadfin shad, and white catfish, have historically been captured in seine surveys, however, none of these species have been observed since 2008.

5. FIGURES

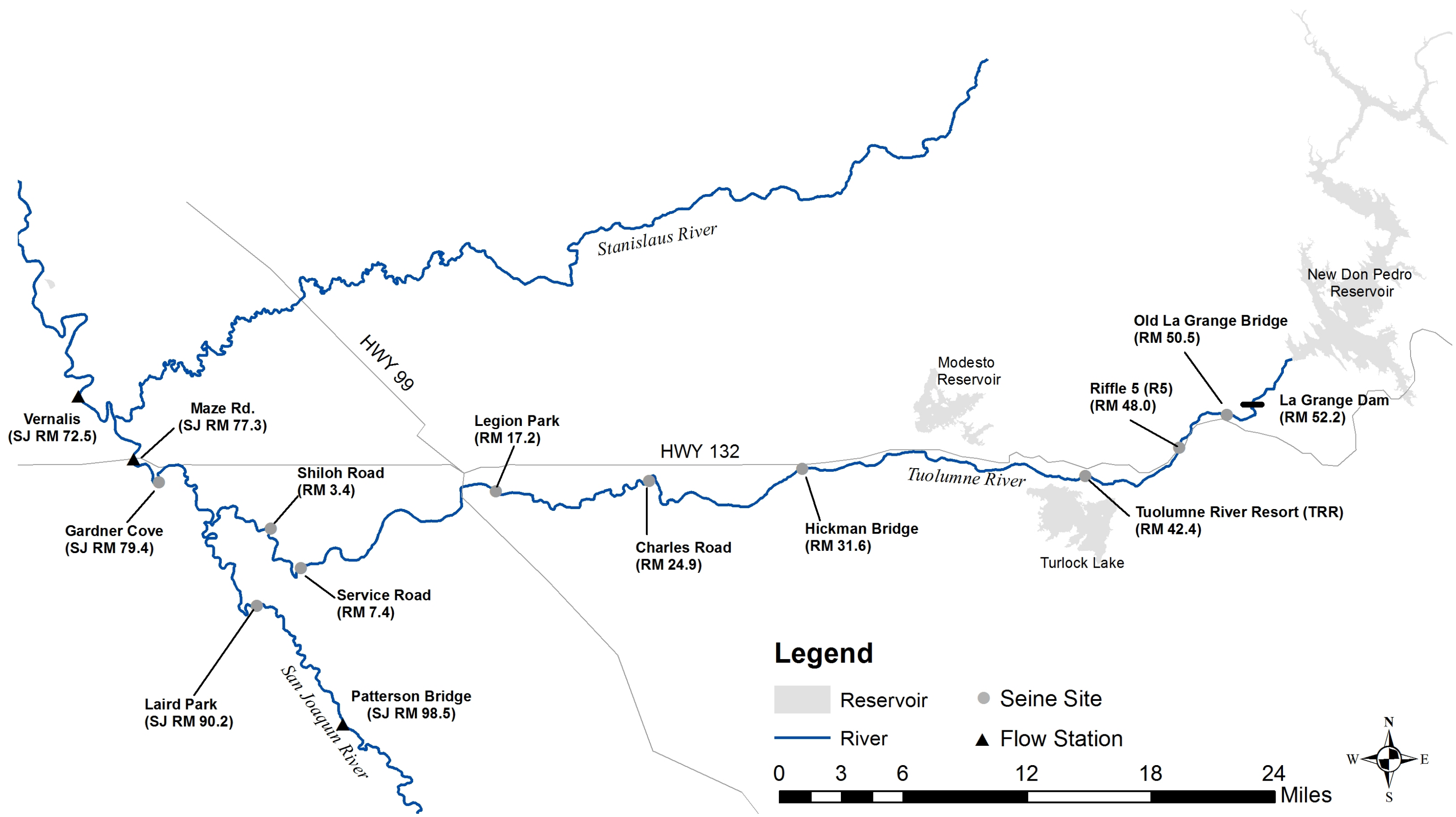
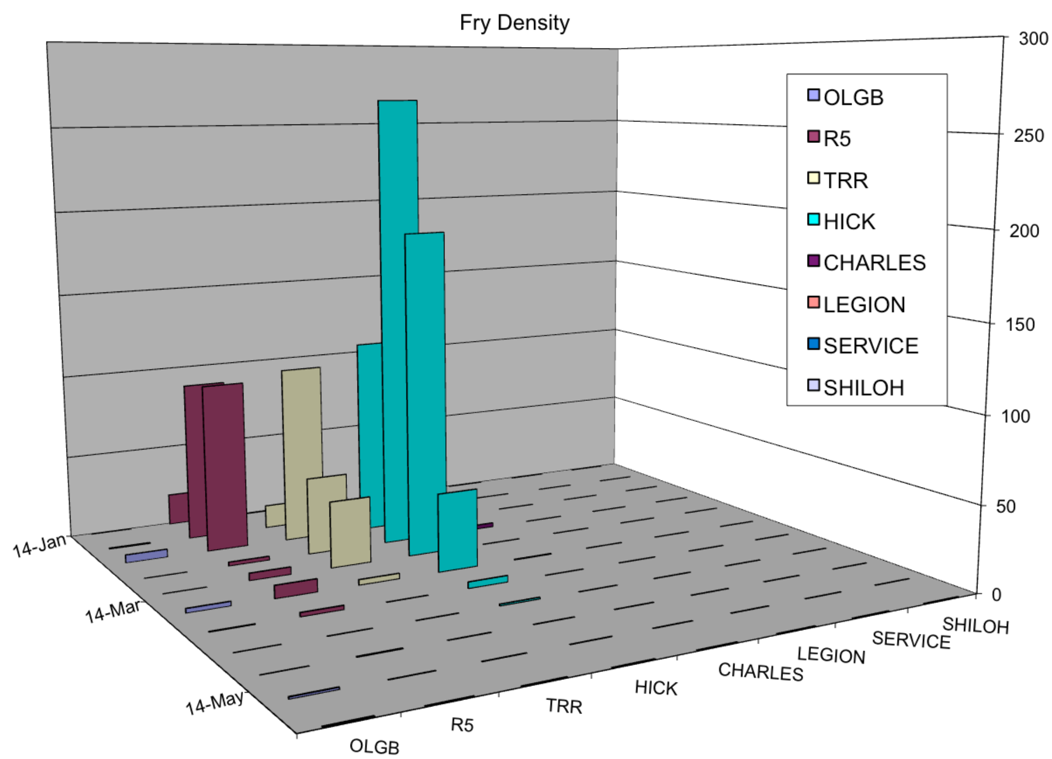


Figure 1. Locations of seine sampling sites on the lower Tuolumne and San Joaquin Rivers, 2014. Abbreviations used in figures below are as follows: OLGB = Old La Grange Bridge, R5 = Riffle 5, TRR = Tuolumne River Resort, HICK = Hickman Bridge, CROAD = Charles Road, LEGION = Legion Park, SERVICE = Service Road, SHILOH = Shiloh Bridge, LAIRD = Laird Park, and GARD = Gardner Cove.



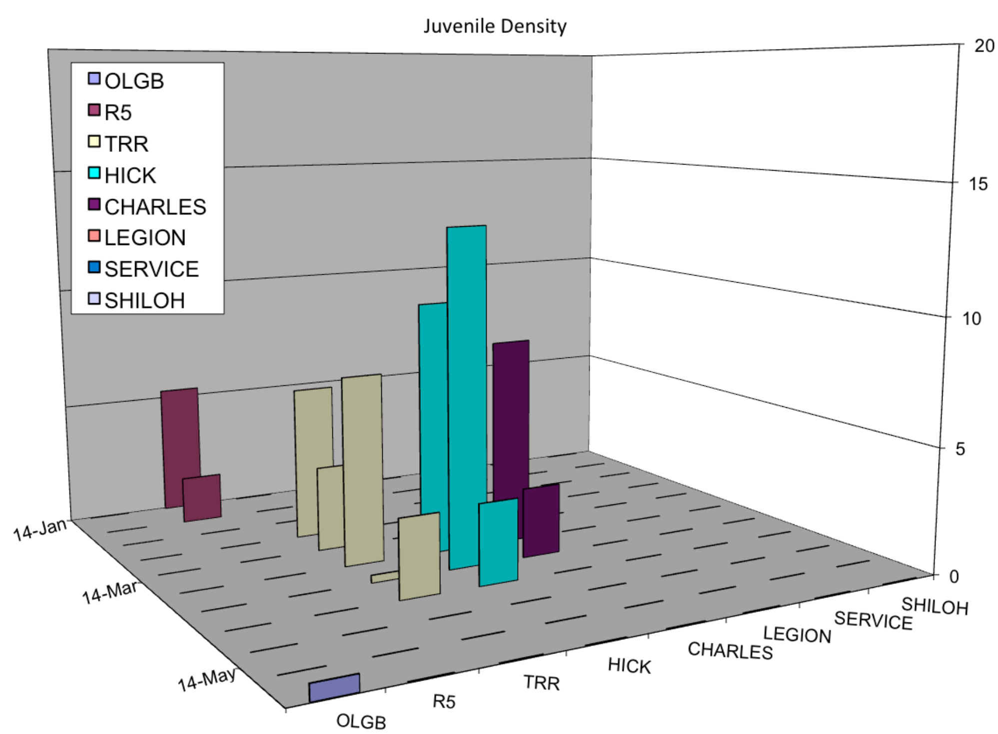


Figure 2. Tuolumne River density of fry (upper panel) and juvenile Chinook (lower panel; fish per 1000 ft^2) by location in 2014 (Upper reach = OLGB, R5, TRR; middle reach = HICK, Charles, Legion; lower reach = Service and Shiloh). See Figure 1 for site codes.

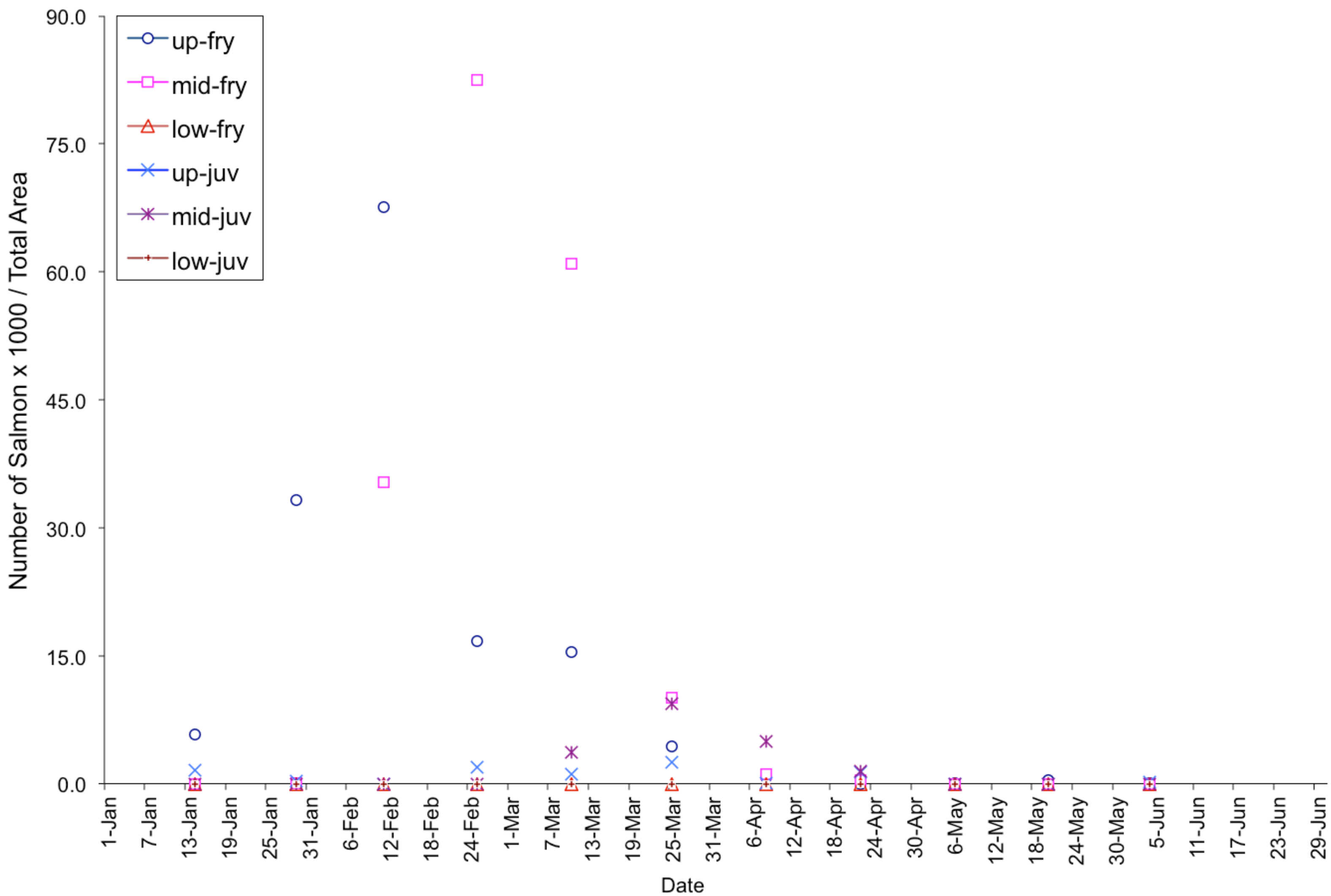


Figure 3. Tuolumne River fry and juvenile Chinook density by reach (upper, middle and lower) in 2014. Note: break in Y-axis scale indicated by double lines.

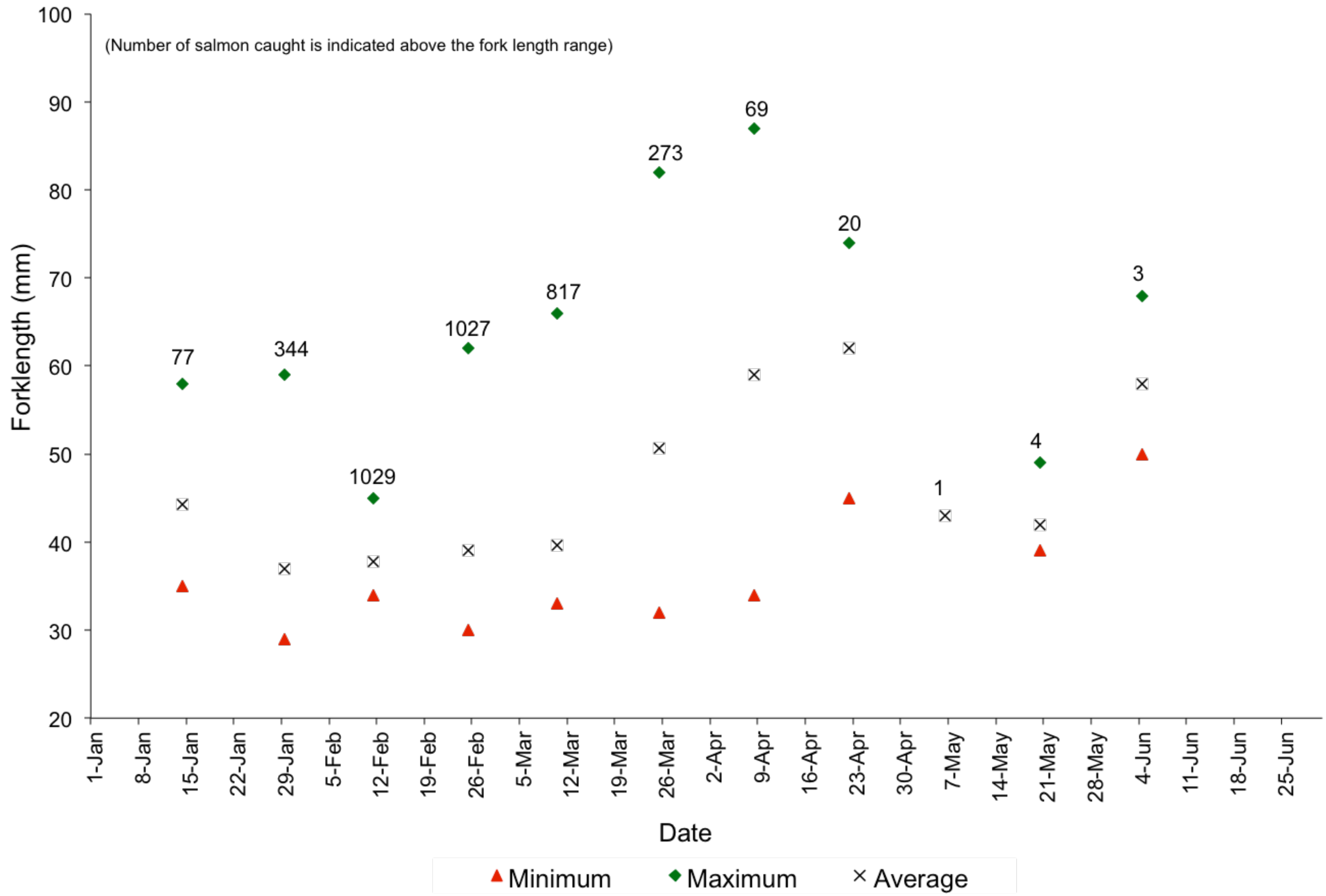


Figure 4. Ranges of fork lengths of Chinook salmon captured in the Tuolumne River in 2014.

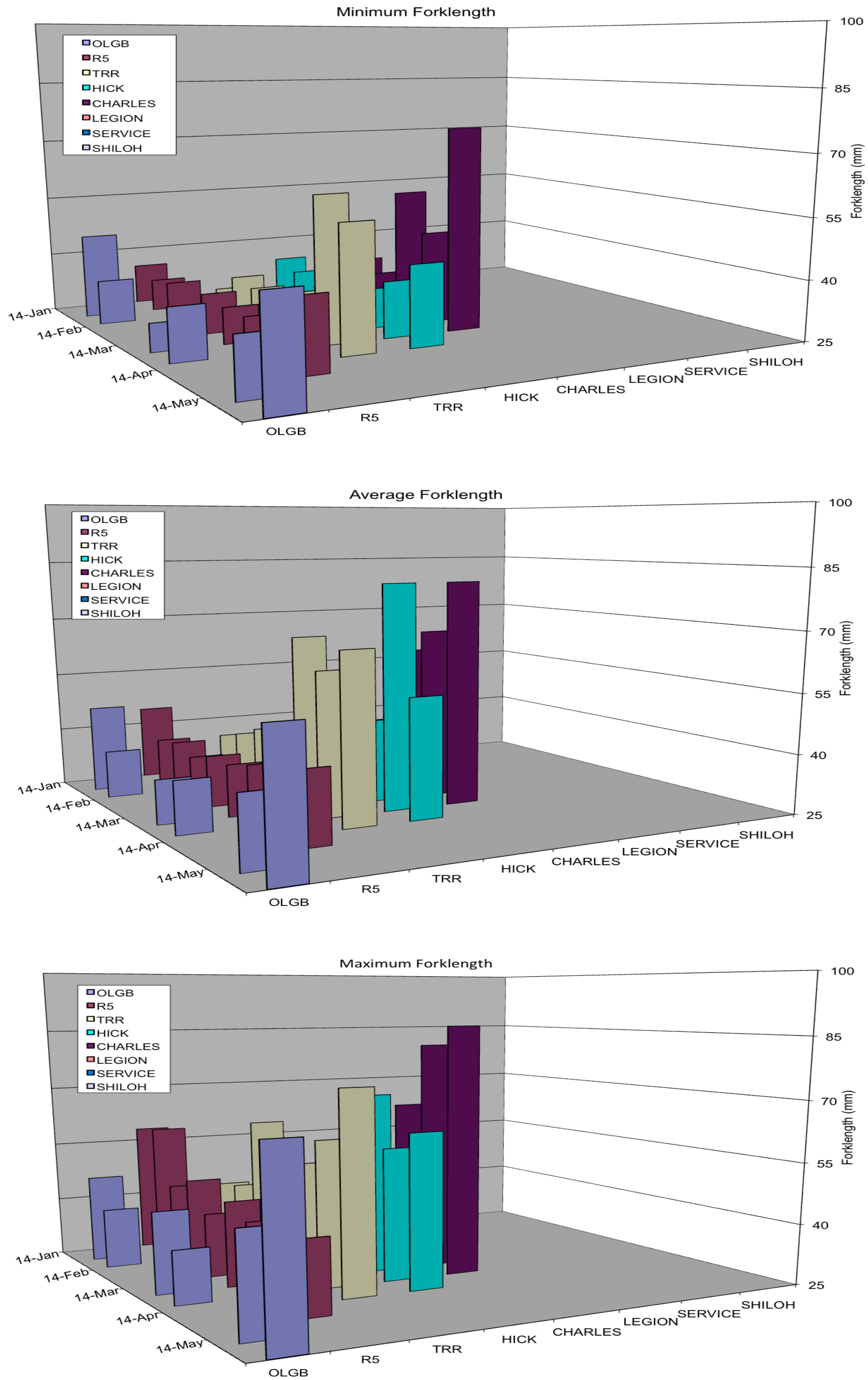


Figure 5. Minimum, average and maximum fork length of Chinook salmon by location and sampling event in 2014. See Figure 1 for site codes.

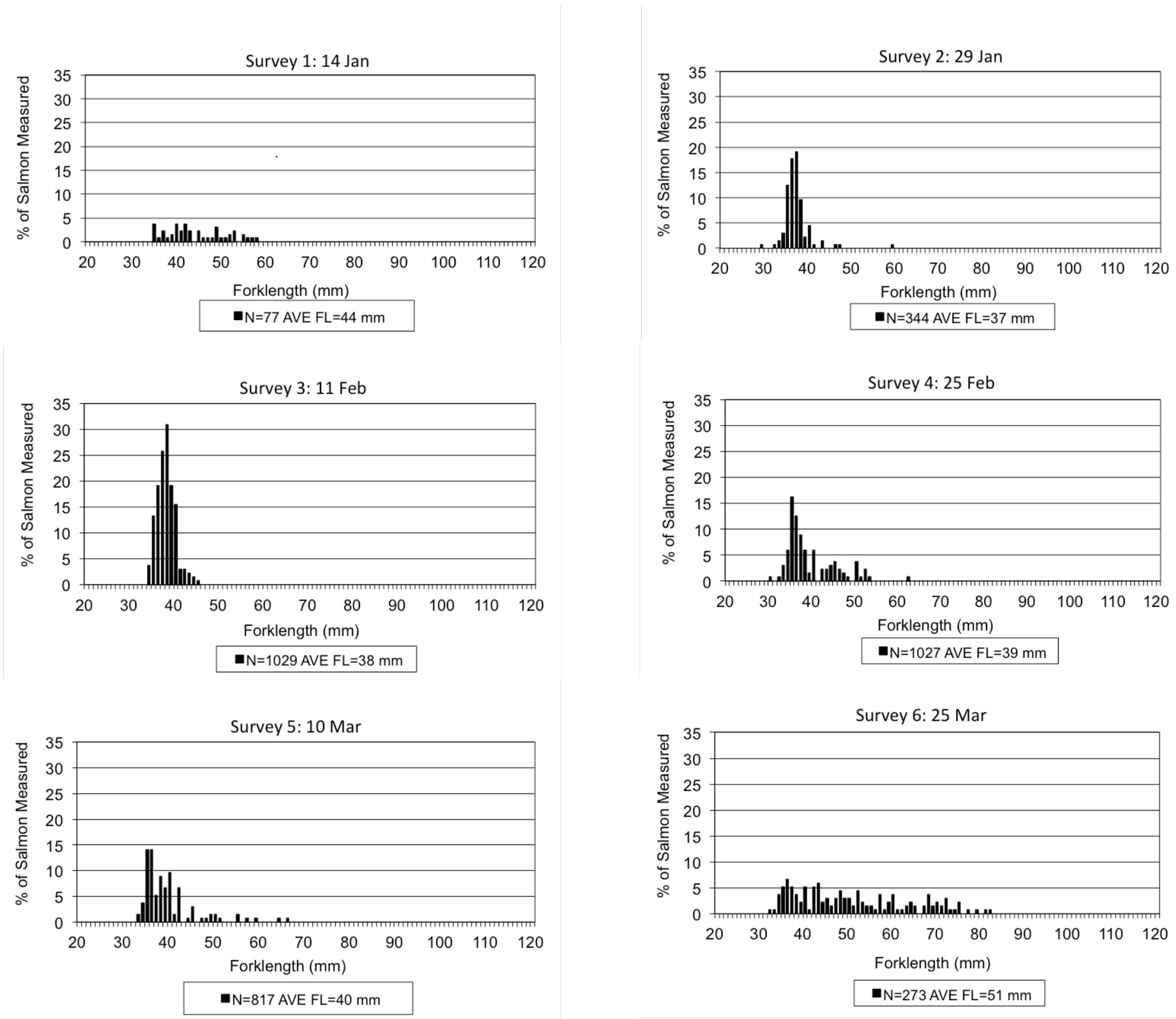


Figure 6. Length-frequency distribution of Chinook salmon captured in the Tuolumne River by sampling event in 2014.

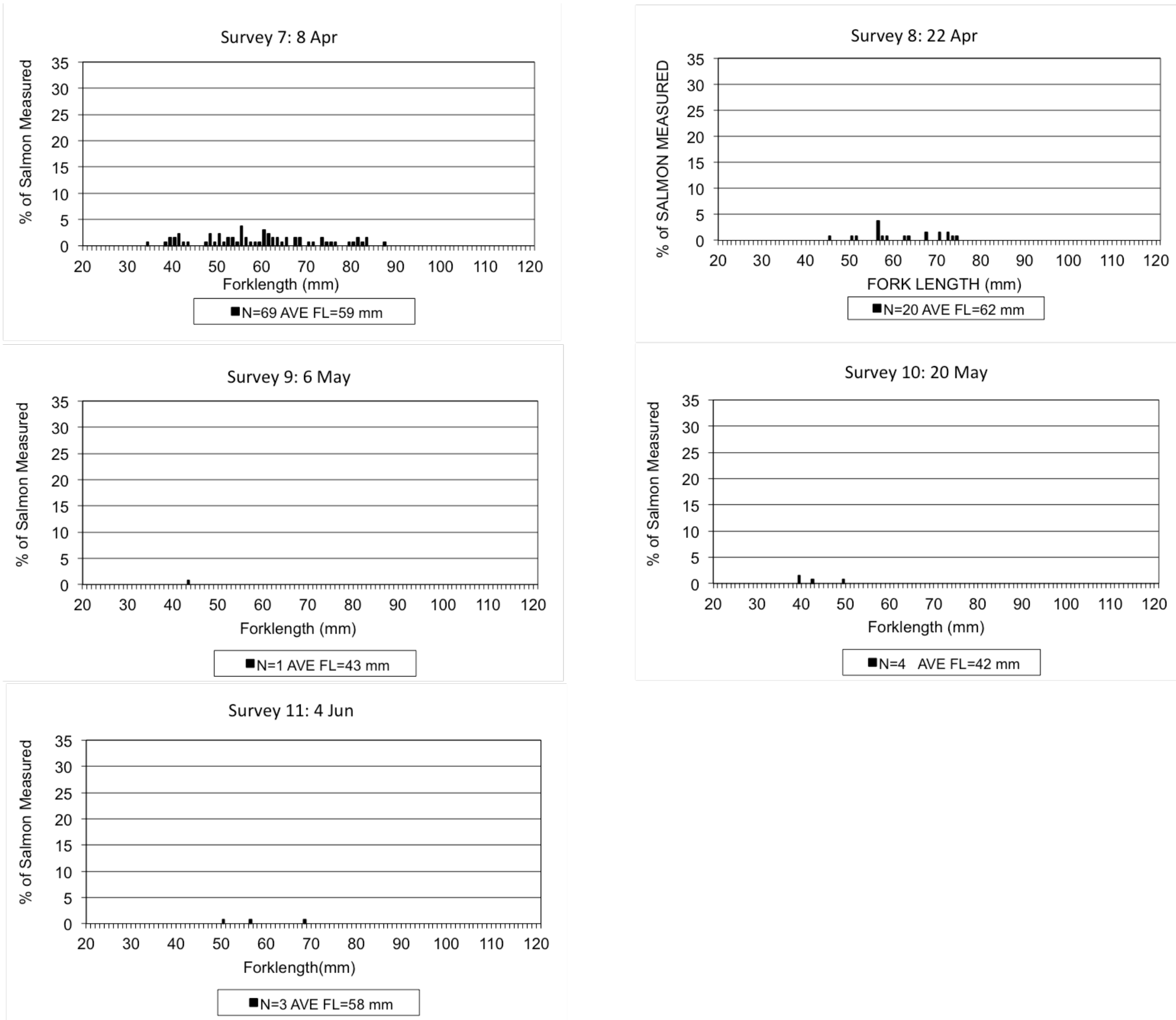


Figure 7. Length-frequency distribution of Chinook salmon captured in the Tuolumne River by sampling event in 2014 (continued from Figure 6).

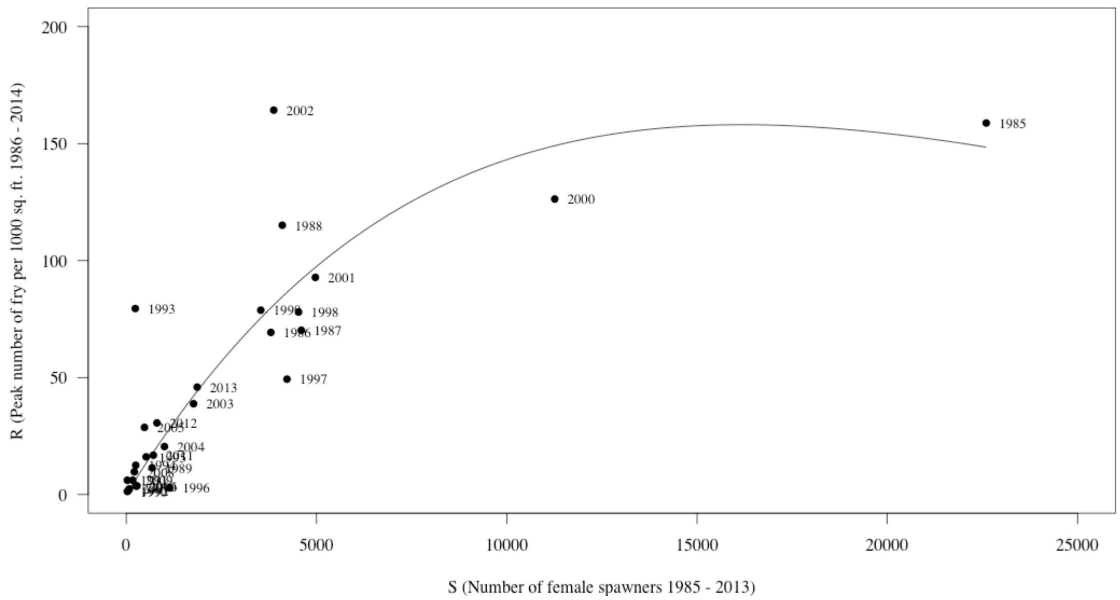


Figure 8. Tuolumne River peak Chinook salmon fry density in year *t+1* as a function of female spawner abundance in year *t*.

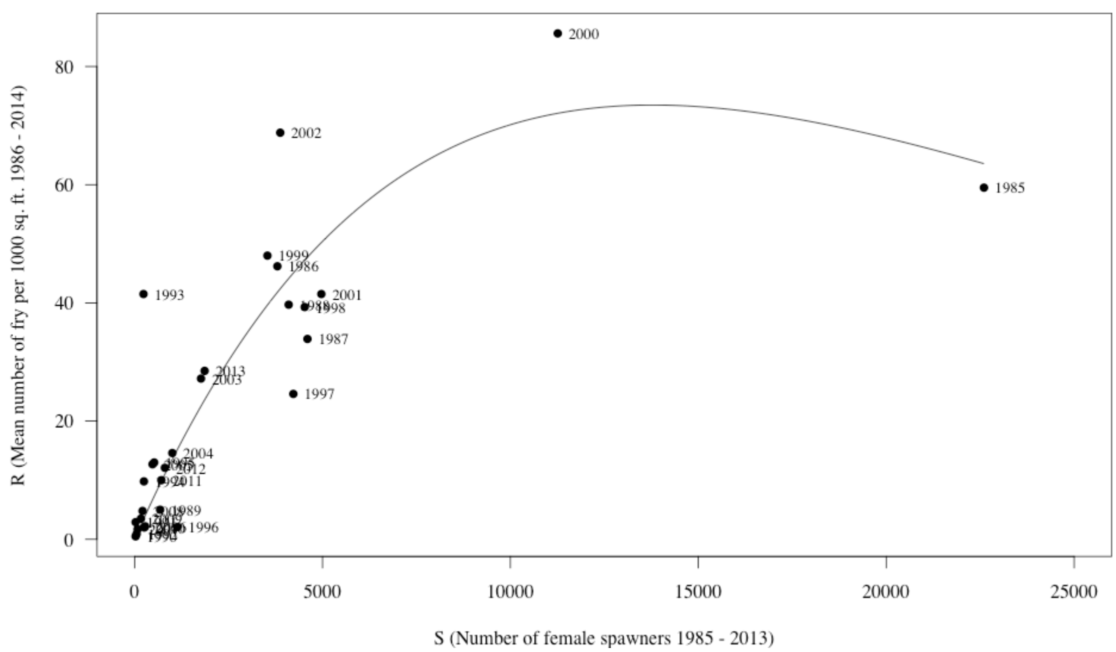


Figure 9. Tuolumne River average Chinook salmon fry density in year *t+1* as a function of female spawner abundance in year *t*.

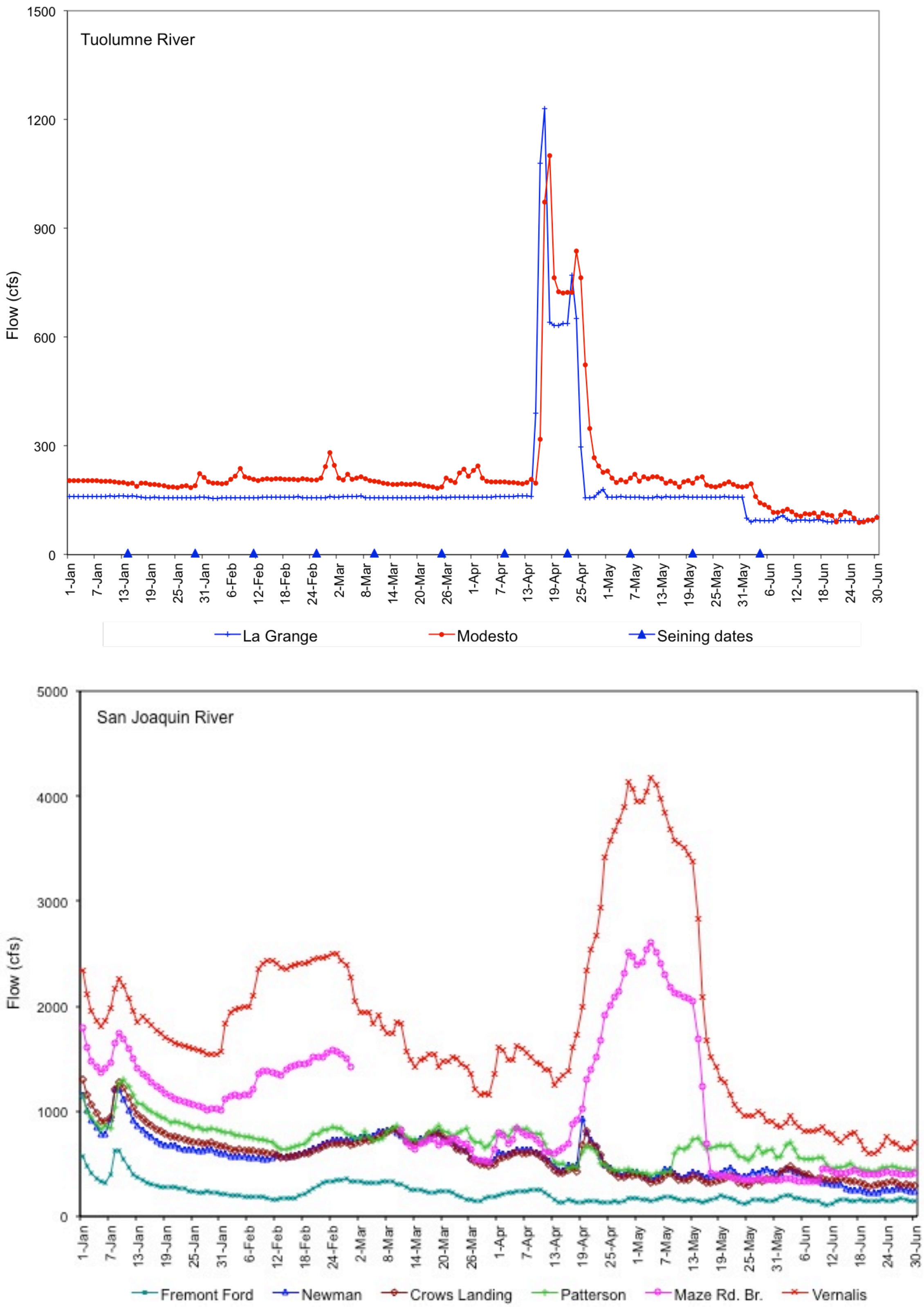


Figure 10. Daily mean flows in the Tuolumne (upper panel) and San Joaquin (lower panel) Rivers in 2014.

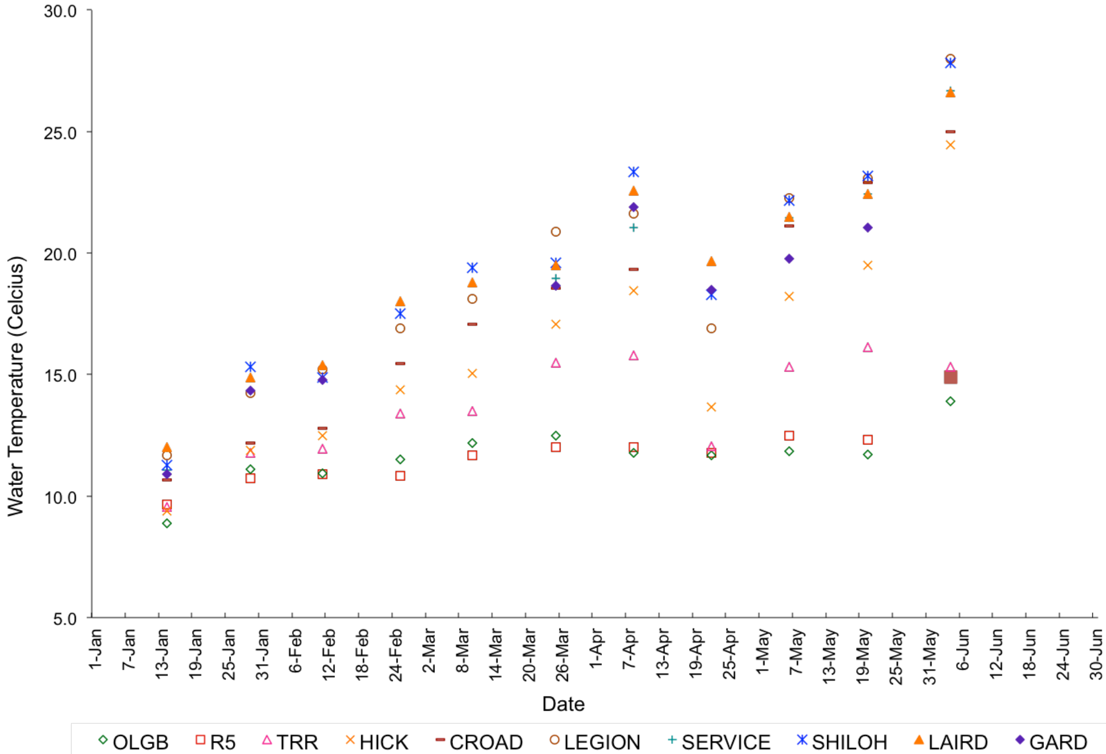


Figure 11. Instantaneous water temperatures in the Tuolumne and San Joaquin Rivers during sampling events in 2014. See Figure 1 for site codes.

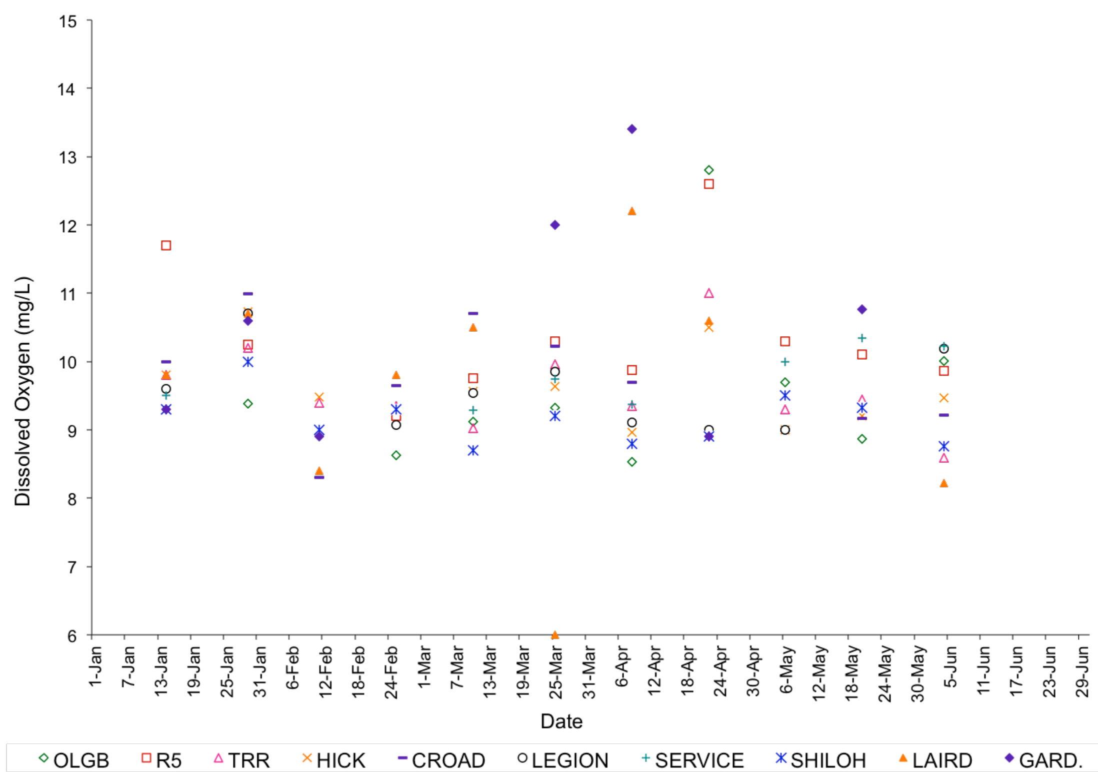


Figure 12. Instantaneous dissolved oxygen in the Tuolumne and San Joaquin Rivers during sampling events in 2014. See Figure 1 for site codes.

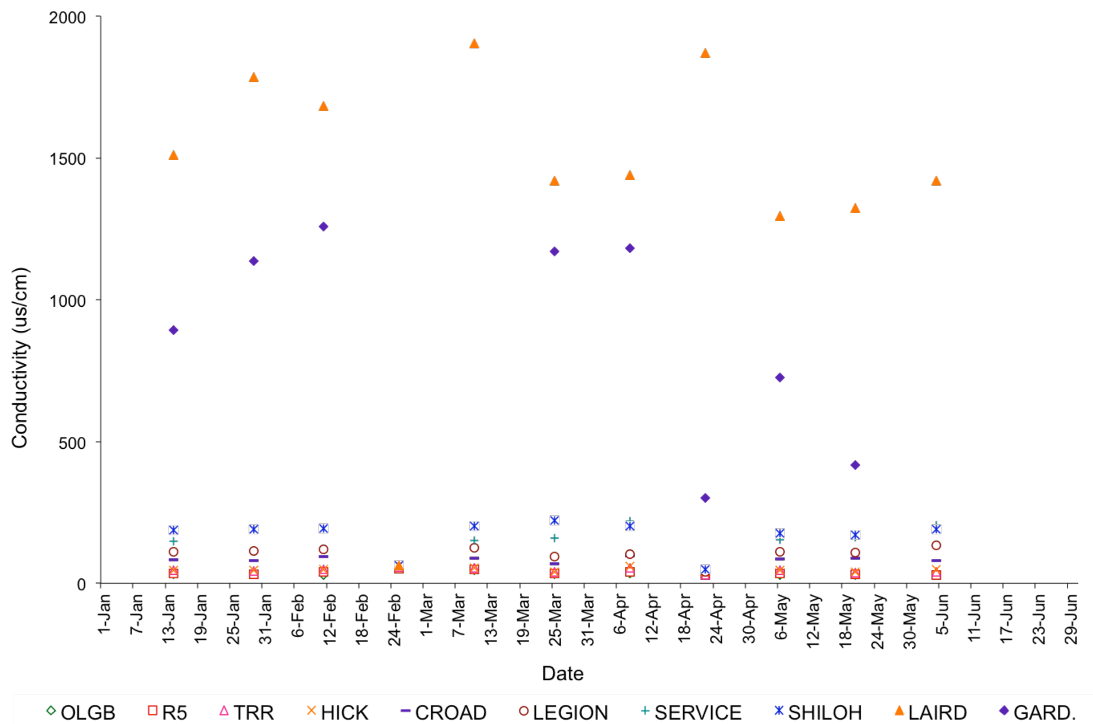


Figure 13. Instantaneous conductivity in the Tuolumne and San Joaquin Rivers during sampling events in 2014. See Figure 1 for site codes.

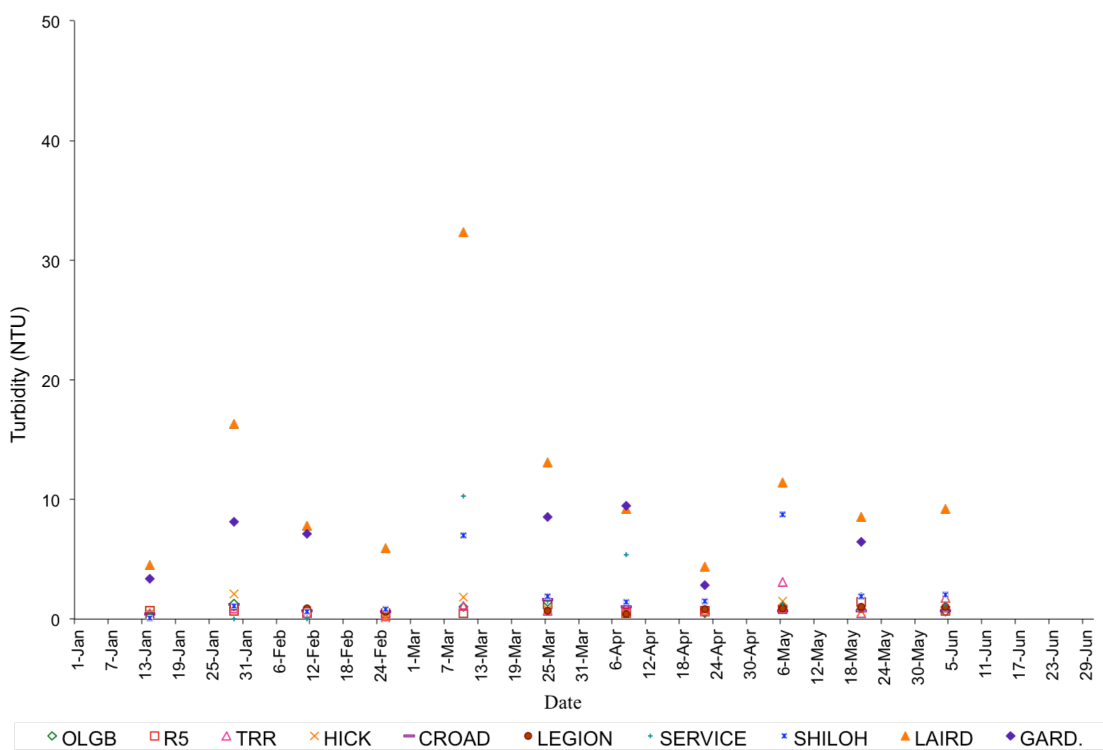


Figure 14. Instantaneous turbidity in the Tuolumne and San Joaquin Rivers during sampling events in 2014. See Figure 1 for site codes.

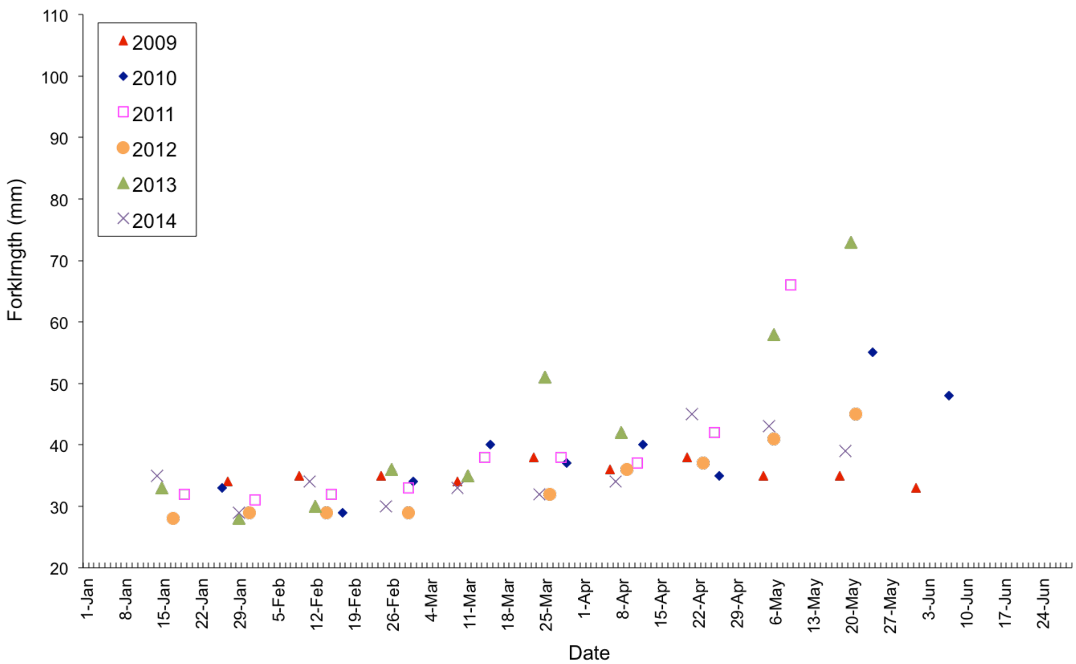


Figure 15. Minimum forklengths of Tuolumne River fry and juvenile Chinook salmon, 2009-2014.

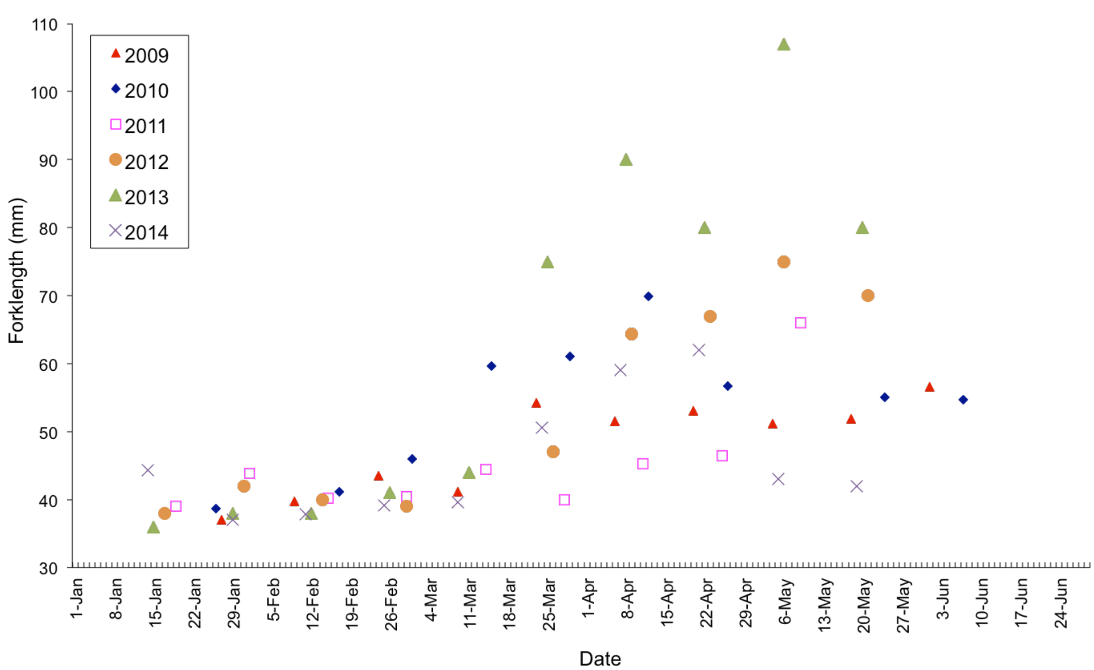


Figure 16. Average forklengths of Tuolumne River fry and juvenile Chinook salmon, 2009-2014.

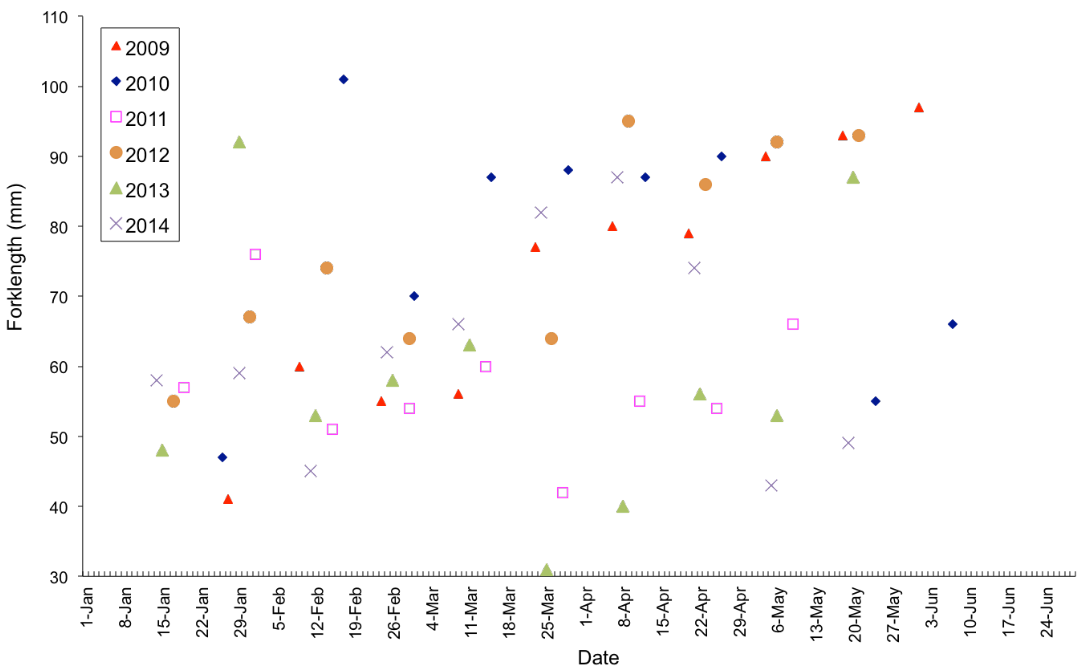


Figure 17. Maximum forklengths of Tuolumne River fry and juvenile Chinook salmon, 2009-2014.

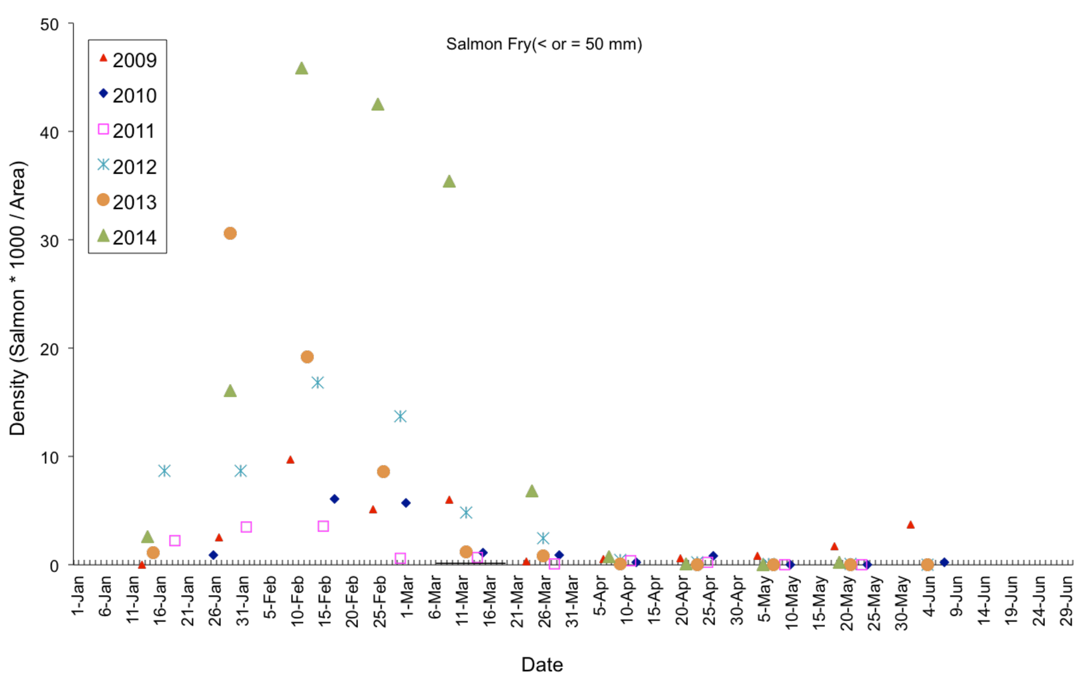


Figure 18. Density indices of Tuolumne River Chinook salmon fry, 2009-2014.

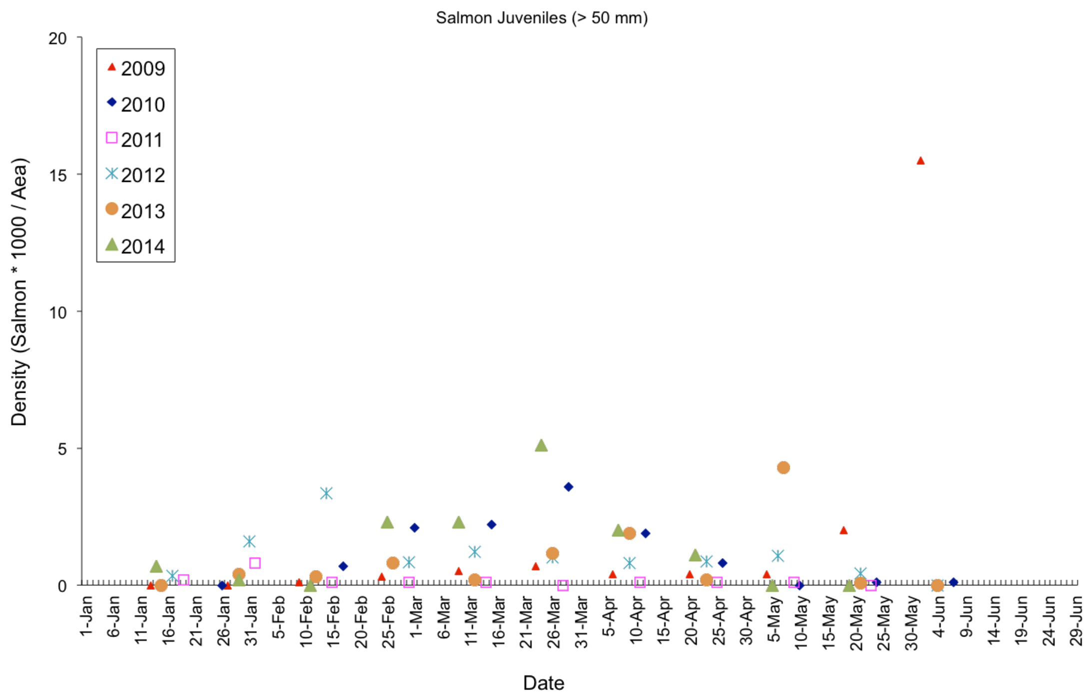


Figure 19. Density indices of Tuolumne River Chinook salmon juveniles, 2009-2014.

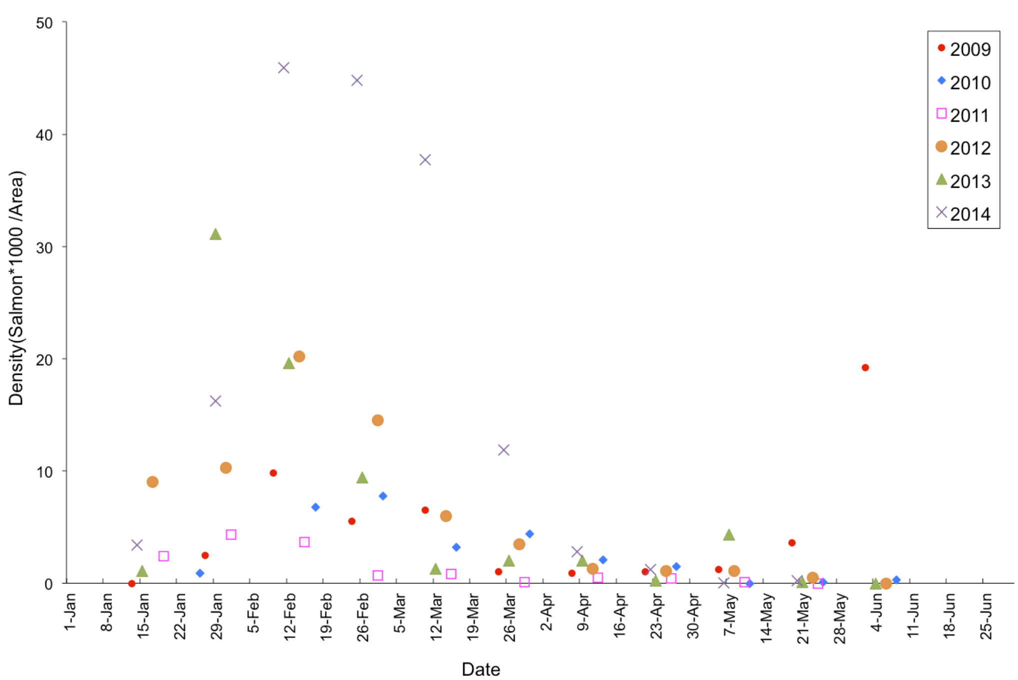
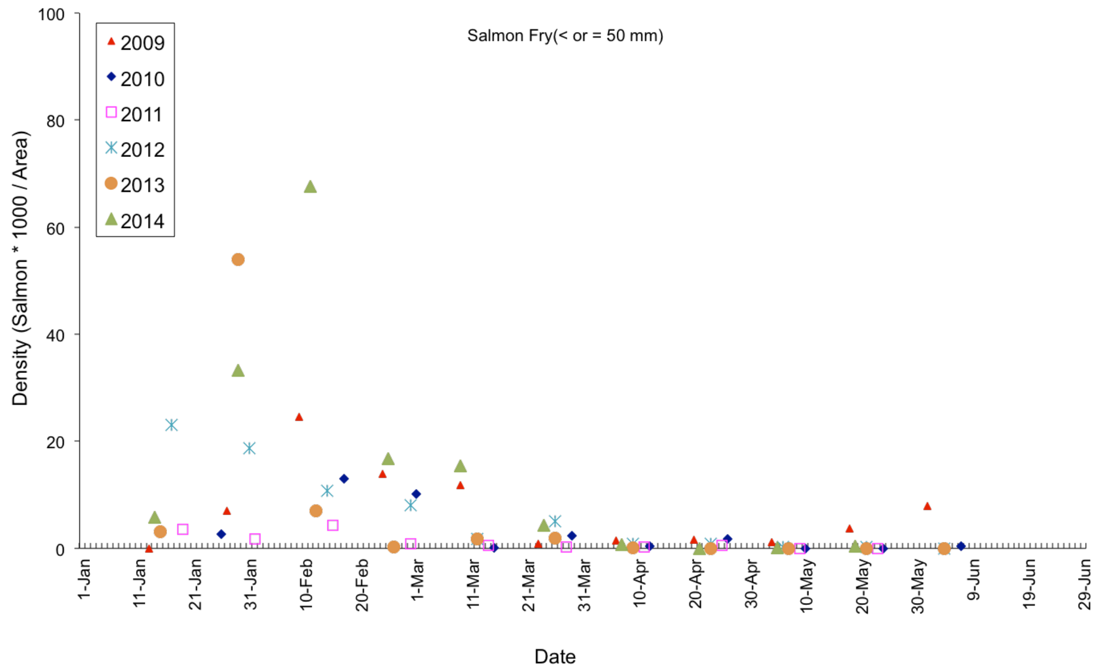


Figure 20. Density indices of fry and juvenile Chinook salmon combined, 2009-2014.



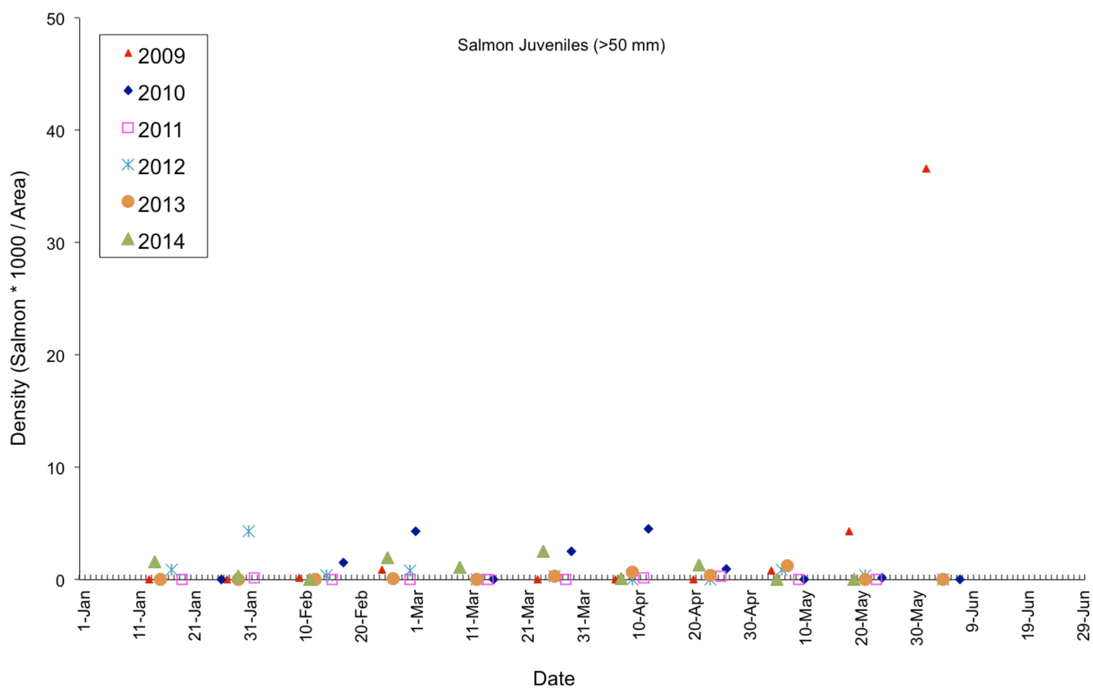


Figure 21. Upper reach density indices for Chinook salmon fry (upper panel) and juveniles (lower panel), 2009-2014. Note: the scale of the fry density graph is double the scale of the juvenile density graph.

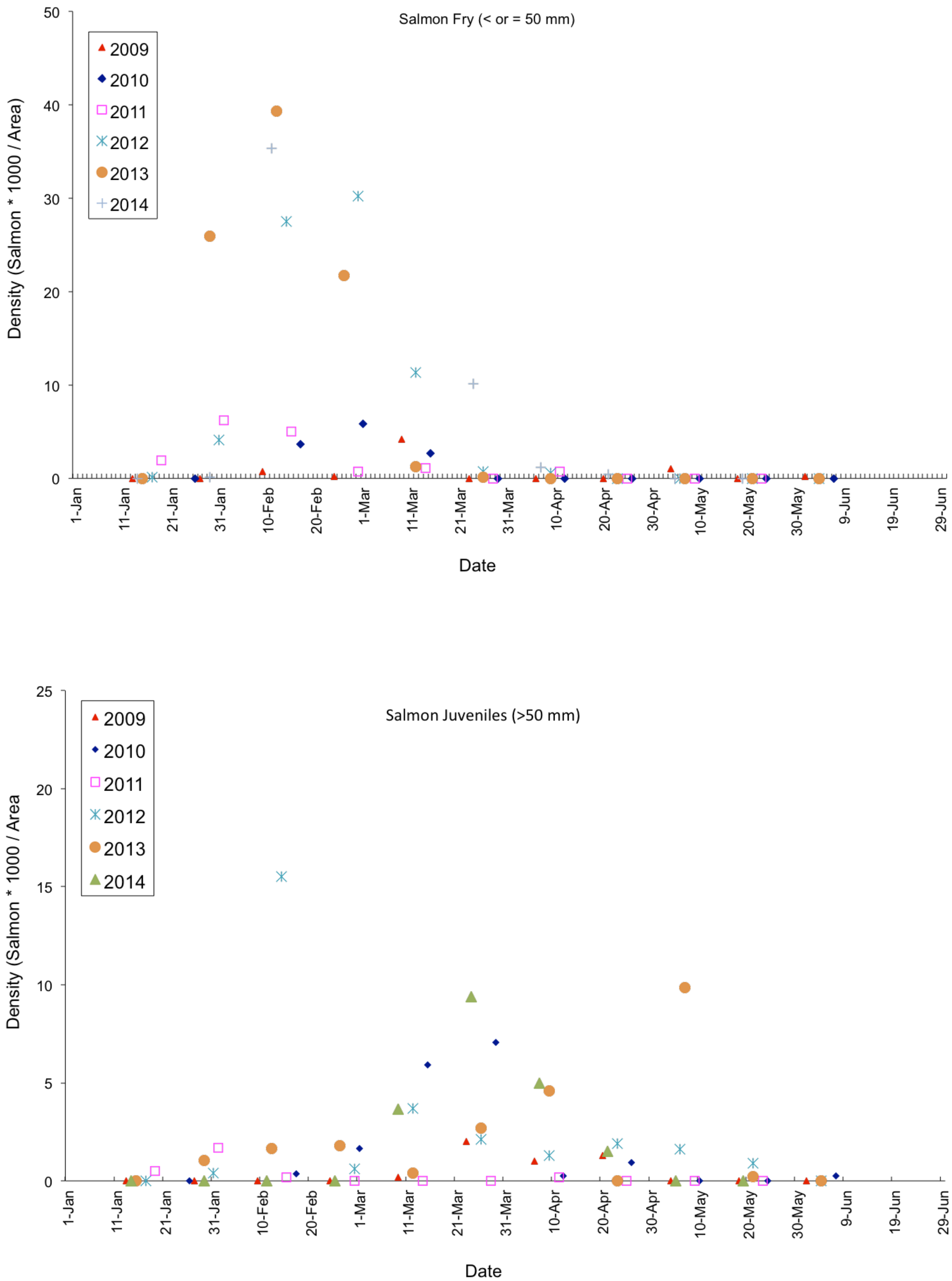
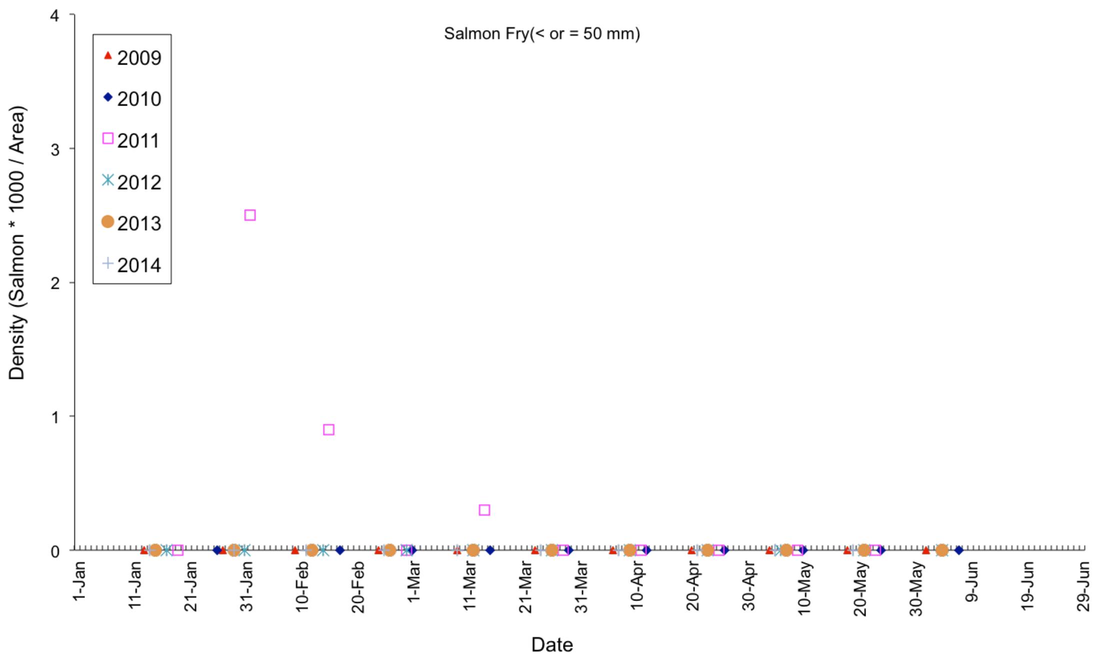


Figure 22. Middle reach density indices for Chinook salmon fry (upper panel) and juveniles (lower panel), 2009-2014. Note: the scale of the fry density graph is double the scale of the juvenile density graph.



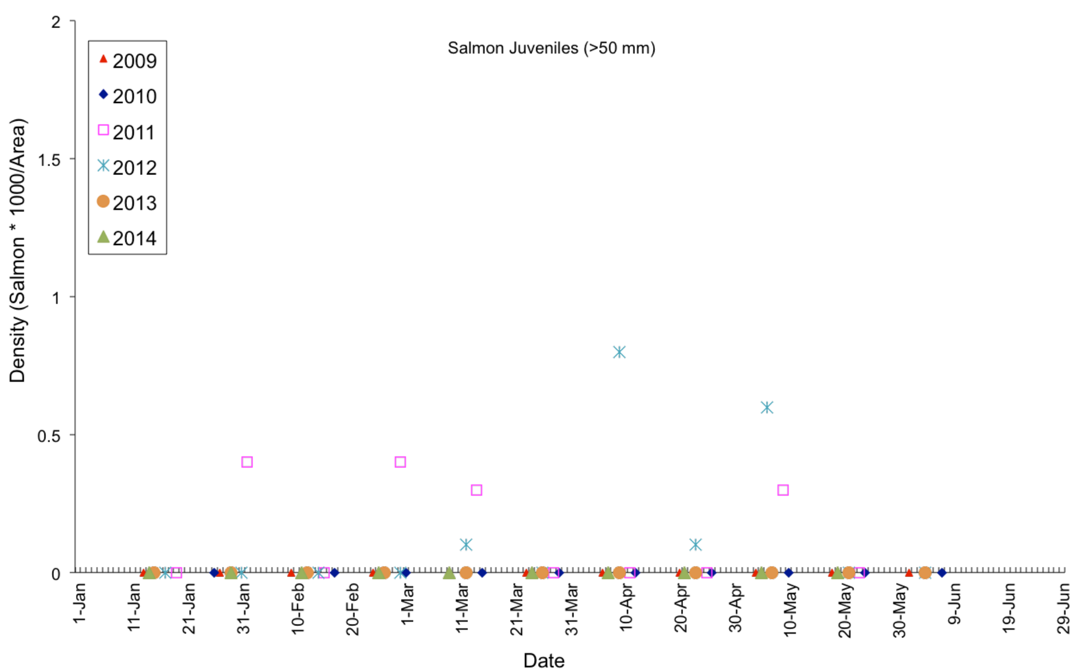


Figure 23. Lower reach density indices for Chinook salmon fry (upper panel) and juveniles (lower panel), 2009-2014. Note: the scale of the fry density graph is double the scale of the juvenile density graph.

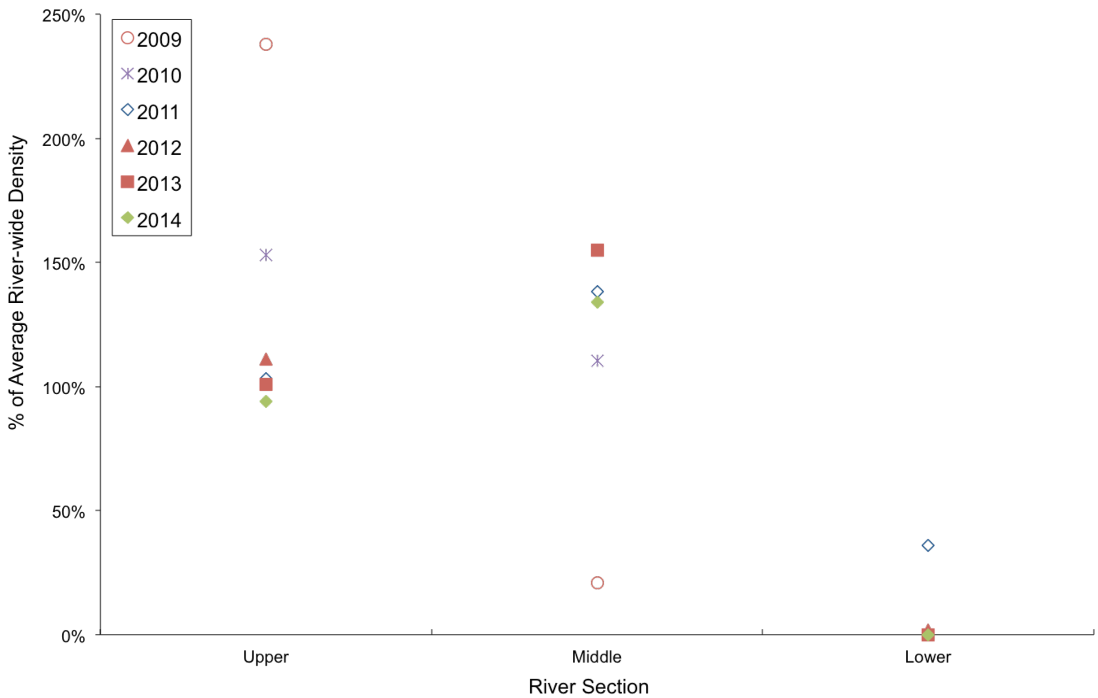


Figure 24. Tuolumne River Chinook salmon abundance indices standardized by reach, 2009-2014.

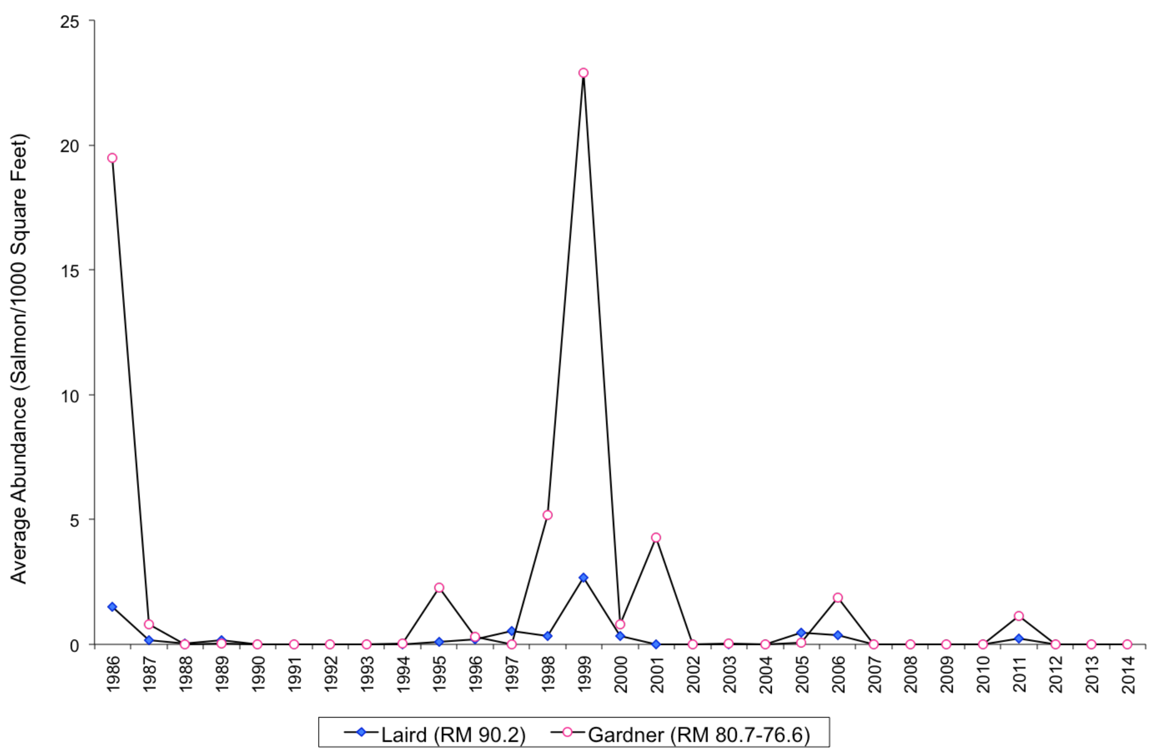


Figure 25. San Joaquin River Chinook salmon indices by location, 1986-2014. Partial sampling was done at all locations in 1986 and at Gardner Cove in 1997.

6. TABLES

Table 1. Summary table seine catch by sampling event and location for the Tuolumne and San Joaquin Rivers, 2014. Note: Headers were abbreviated in the table. ELEC COND = Electrical Conductivity, NO. MEAS = number measured, TURB = turbidity.

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 1

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN	FL MAX	FL AVG	NO. MEAS	REACH DENSITY UPPER	MIDDLE	LOWER	WATER TEMP	ELEC COND	TURB (NTU)	D.O. (mg/L)
14-Jan	OLGB	50.5	0	3,600	0.0	-	-	-	0				8.9	32.8	0.4	no data
14-Jan	R5	48.4	77	3,200	24.1	35	58	44.0	50				9.7	36.1	0.7	11.7
14-Jan	TRR	42.0	0	3,600	0.0	-	-	-	0				9.6	46.4	0.5	9.8
14-Jan	Hickman	31.6	0	2,800	0.0	-	-	-	0				9.4	47.3	0.5	9.8
14-Jan	Charles	24.9	0	3,600	0.0	-	-	-	0				10.7	84.0	0.4	10.0
14-Jan	Legion	17.2	0	3,600	0.0	-	-	-	0				11.7	112.2	0.2	9.6
14-Jan	Service	6.4			no sample								11.1	147.1	0.4	9.5
14-Jan	Shiloh	3.4	0	2,400	0.0	-	-	-	0				11.3	187.0	0.1	9.3
14-Jan	Laird	90.2			no sample								12.0	1510.0	4.5	9.8
14-Jan	Gardner	79.5	0	1,600	0.0								10.9	893.0	3.4	9.3
	TR TOT.		77	22,800	3.4	35	58	44.3	50	7.4	0.0	0.0				
	SJR TOT.		0	1,600	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 2

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN	FL MAX	FL AVG	NO. MEAS	REACH DENSITY UPPER	MIDDLE	LOWER	WATER (NTU)	ELEC COND	TURB (NTU)	D.O. (mg/L)
29-Jan	OLGB	50.5	2	3,600	0.6	46	47	47.0	2				11.1	33.0	1.3	9.4
29-Jan	R5	48.0	291	3,000	97.0	33	59	37.0	50				10.7	32.3	0.7	10.3
29-Jan	TRR	42.3	50	3,600	13.9	29	43	37.0	50				11.8	43.3	0.9	10.2
29-Jan	Hickman	31.6	1	2,600	0.4	36	36	36.0	1				11.9	45.0	2.1	10.7
29-Jan	Charles	24.9	0	3,600	0.0	-	-	-	0				12.2	79.0	1.2	11.0
29-Jan	Legion	17.2	0	3,600	0.0	-	-	-	0				14.2	115.0	1.0	10.7
29-Jan	Service	6.4			no sample									no sample		
29-Jan	Shiloh	3.4	0	1,200	0.0	-	-	-	0				15.3	189.1	1.1	10.0
29-Jan	Laird	90.2	0	1,200	0.0	-	-	-	0				14.9	1785.0	16.3	10.7
29-Jan	Gardner	79.5	0	1,200	0.0	-	-	-	0				14.3	1137.0	8.1	10.6
	TR TOT.		344	21,200	16.2	29	59	37.0	103	33.6	0.1	0.0				
	SJR TOT.		0	2,400	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 3																	
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
11-Feb	OLGB	50.5	17	3,600	4.7	36	40	37.0	15				10.9	30.0	0.7	no data
11-Feb	R5	48.0	280	2,800	100.0	34	45	38.0	50				10.9	40.0	0.5	no data
11-Feb	TRR	42.3	379	3,600	105.3	34	44	39.0	50				11.9	50.0	0.5	9.4
11-Feb	Hickman	31.6	328	2,800	117.1	34	42	38.0	50				12.5	49.8	0.7	9.5
11-Feb	Charles	24.9	25	3,600	6.9	36	40	37.0	22				12.8	94.7	0.7	8.3
11-Feb	Legion	17.2	0	3,600	0.0	-	-	-	0				15.2	120.0	0.9	no data
11-Feb	Service	6.4			no sample									no sample		
11-Feb	Shiloh	3.4	0	2,400	0.0	-	-	-	0				14.9	192.7	0.6	9.0
11-Feb	Laird	90.2	0	800	0.0	-	-	-	0				15.4	1682.0	7.8	8.4
11-Feb	Gardner	79.5	0	1,600	0.0	-	-	-	0				14.8	1259.0	7.1	8.9
	TR TOT.		1029	22,400	45.9	34	45	37.8	187	67.6	35.3	0.0				
	SJR TOT.		0	2,400	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 4																	
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
25-Feb	OLGB	50.5	0	3,600	0.0	-	-	-	0				11.5	36.2	0.5	8.6
25-Feb	R5	48.0	7	3,200	2.2	30	48	36.0	7				10.8	36.7	0.5	9.2
25-Feb	TRR	42.3	187	3,600	51.9	33	62	42.0	50				13.4	46.1	0.2	9.4
25-Feb	Hickman	31.6	825	3,100	266.1	32	40	36.0	50				14.4	46.9	0.1	9.3
25-Feb	Charles	24.9	8	3,400	2.4	34	46	42.0	8				15.4	85.8	0.6	9.7
25-Feb	Legion	17.2	0	3,600	0.0	-	-	-	0				16.9	122.2	0.6	9.1
25-Feb	Service	6.4			no sample									no sample		
25-Feb	Shiloh	3.4	0	2,400	0.0	-	-	-	0				17.5	176.0	0.8	9.3
25-Feb	Laird	90.2	0	1,200	0.0	-	-	-	0				18.0	1908.0	5.9	9.8
25-Feb	Gardner	79.5			no sample											
	TR TOT.		1027	22,900	44.8	30	62	39.1	115	18.7	82.5	0.0				
	SJR TOT.		0	1,200	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 5																	
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
10-Mar	OLGB	50.5	0	3,600	0.0	-	-	-	0				12.2	45.3	1.0	9.1
10-Mar	R5	48.0	12	2,800	4.3	35	41	38.0	12				11.7	49.6	0.5	9.8
10-Mar	TRR	42.3	153	3,600	42.5	33	59	41.0	50				13.5	55.1	1.1	9.0
10-Mar	Hickman	31.6	649	3,400	190.9	33	49	37.0	50				15.1	54.2	1.8	9.6
10-Mar	Charles	24.9	3	3,300	0.9	57	66	62.0	3				17.1	89.4	no data	10.7
10-Mar	Legion	17.2	0	3,400	0.0	-	-	-	0				18.1	125.7	no data	9.5
10-Mar	Service	6.4			no sample								17.9	149.7	10.3	9.3
10-Mar	Shiloh	3.4	0	1,575	0.0	-	-	-	0				19.4	203.0	7.0	8.7
10-Mar	Laird	90.2	0	1,575	0.0	-	-	-	0				18.8	1905.0	32.3	10.5
10-Mar	Gardner	79.5			no sample									no sample		
	TR TOT.		817	21,675	37.7	33	66	39.6	115	16.5	64.6	0.0				
	SJR TOT.		0	1,575	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 6

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN	FL MAX	FL AVG	NO. MEAS	REACH DENSITY UPPER	REACH DENSITY MIDDLE	REACH DENSITY LOWER	WATER TEMP	ELEC COND	TURB (NTU)	D.O. (mg/L)
25-Mar	OLGB	50.5	9	3,600	2.5	32	45	36.0	9				12.5	31.9	1.4	9.3
25-Mar	R5	48.0	27	3,600	7.5	34	46	38.0	26				12.0	36.0	1.2	10.3
25-Mar	TRR	42.3	38	3,600	10.6	36	54	68.0	38				15.5	39.6	0.7	10.0
25-Mar	Hickman	31.6	168	3,000	56.0	35	70	46.0	50				17.1	40.1	0.8	9.6
25-Mar	Charles	24.9	31	3,600	8.6	48	82	68.0	31				18.6	69.2	1.6	10.2
25-Mar	Legion	17.2	0	3,600	0.0	-	-	-	0				20.9	94.1	0.7	9.9
25-Mar	Service	6.4			no sample								18.9	158.6	1.5	9.8
25-Mar	Shiloh	3.4	0	2,000	0.0	-	-	-	0				19.6	221.0	1.9	9.2
25-Mar	Laird	90.2	0	1,500	0.0	-	-	-	0				19.5	1420.0	13.1	6.0
25-Mar	Gardner	79.5	0	900	0.0	-	-	-	0				18.7	1169.0	8.5	12.0
	TR TOT.		273	23,000	11.9	32	82	50.6	154	6.9	19.5	0.0				
	SJR TOT.		0	2,400	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 7

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN	FL MAX	FL AVG	NO. MEAS	REACH DENSITY UPPER	REACH DENSITY MIDDLE	REACH DENSITY LOWER	WATER TEMP	ELEC COND	TURB (NTU)	D.O. (mg/L)
8-Apr	OLGB	50.5	1	3,600	0.3	38	38	38.0	1				11.8	34.1	0.9	8.5
8-Apr	R5	48.0	7	3,000	2.3	34	43	40.0	7				12.0	39.3	0.5	9.9
8-Apr	TRR	42.3	1	3,600	0.3	61	61	61.0	1				15.8	53.1	1.1	9.4
8-Apr	Hickman	31.6	51	3,000	17.0	39	58	81.0	50				18.4	59.1	0.5	9.0
8-Apr	Charles	24.9	9	3,200	2.8	75	87	81.0	9				19.3	96.6	1.0	9.7
8-Apr	Legion	17.2	0	3,600	0.0	-	-	-	0				21.6	120.3	0.4	9.1
8-Apr	Service	6.4	0	2,700	0.0	-	-	-	0				21.1	218.0	5.4	9.4
8-Apr	Shiloh	3.4	0	2,000	0.0	-	-	-	0				23.3	201.0	1.4	8.8
8-Apr	Laird	90.2	0	1,600	0.0	-	-	-	0				22.6	1440.0	9.2	12.2
8-Apr	Gardner	79.5	0	1,200	0.0	-	-	-	0				21.9	1182.0	9.5	13.4
	TR TOT.		69	24,700	2.8	34	87	59.0	68	0.9	6.1	0.0				
	SJR TOT.		0	2,800	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 8

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN	FL MAX	FL AVG	NO. MEAS	REACH DENSITY UPPER	REACH DENSITY MIDDLE	REACH DENSITY LOWER	WATER TEMP	ELEC COND	TURB (NTU)	D.O. (mg/L)
22-Apr	OLGB	50.5	0	2,400	0.0	-	-	-	0				11.7	30.0	0.5	12.8
22-Apr	R5	48.0	0	2,250	0.0	-	-	-	0				11.8	30.0	0.7	12.6
22-Apr	TRR	42.3	11	3,600	3.1	56	74	67.0	11				12.1	30.0	0.6	11.0
22-Apr	Hickman	31.6	9	2,200	4.1	45	63	55.0	9				13.7	40.0	0.6	10.5
22-Apr	Charles	24.9			no sample									no sample		
22-Apr	Legion	17.2	0	2,400	0.0	-	-	-	0				16.9	40.0	0.8	9.0
22-Apr	Service	6.4			no sample									no sample		
22-Apr	Shiloh	3.4	0	400	0.0	-	-	-	0				18.3	50.0	1.5	8.9
22-Apr	Laird	90.2	0	2,200	0.0	-	-	-	0				19.7	1870.0	4.4	10.6
22-Apr	Gardner	79.5	0	800	0.0	-	-	-	0				18.5	300.0	2.8	8.9
	TR TOT.		20	13,250	1.5	45	74	62.0	20	1.3	2.0	0.0				
	SJR TOT.		0	3,000	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 9																
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
6-May	OLGB	50.5	0	3,200	0.0	-	-	-	0				11.8	28.0	1.0	9.7
6-May	R5	48.0	1	3,600	0.3	43	43	43.0	1				12.5	34.1	0.8	10.3
6-May	TRR	42.3	0	3,600	0.0	-	-	-	0				15.3	47.3	3.1	9.3
6-May	Hickman	31.6	0	3,200	0.0	-	-	-	0				18.2	46.8	1.5	9.0
6-May	Charles	24.9	0	3,200	0.0	-	-	-	0				21.1	86.1	0.7	9.0
6-May	Legion	17.2	0	4,500	0.0	-	-	-	0				22.3	111.0	0.9	9.0
6-May	Service	6.4	0	3,600	0.0	-	-	-	0				21.4	153.4	1.3	10.0
6-May	Shiloh	3.4	0	2,200	0.0	-	-	-	0				22.2	175.5	8.7	9.5
6-May	Laird	90.2	0	800	0.0	-	-	-	0				21.5	1294.0	11.4	no data
6-May	Gardner	79.5	0	1,500	0.0	-	-	-	0				19.8	727.0	no data	no data
	TR TOT.		1	27,100	0.0	43	43	43.0	1	0.1	0.0	0.0				
	SJR TOT.		0	2,300	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 10																
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
20-May	OLGB	50.5	4	3,600	1.1	39	49	42.0	4				11.7	29	0.9	8.9
20-May	R5	48.0	0	3,200	0.0	-	-	-	0				12.3	33	1.4	10.1
20-May	TRR	42.3	0	3,600	0.0	-	-	-	0				16.1	39	0.5	9.4
20-May	Hickman	31.6	0	3,000	0.0	-	-	-	0				19.5	41	0.6	9.2
20-May	Charles	24.9	0	3,400	0.0	-	-	-	0				22.9	90	0.7	9.2
20-May	Legion	17.2	0	3,600	0.0	-	-	-	0				23.1	109	1.0	9.3
20-May	Service	6.4	0	1,550	0.0	-	-	-	0				22.4	163	2.1	10.4
20-May	Shiloh	3.4	0	2,200	0.0	-	-	-	0				23.2	172	1.9	9.3
20-May	Laird	90.2	0	800	0.0	-	-	-	0				22.4	1324	8.5	no data
20-May	Gardner	79.5	0	1,500	0.0	-	-	-	0				21.1	418	6.5	10.8
	TR TOT.		4	24,150	0.2	39	49	42.0	4	0.4	0.0	0.0				
	SJR TOT.		0	2,300	0.0	-	-	-	0							

2014 TUOLUMNE RIVER SEINING STUDY (TID/MID)-SURVEY 11																
		RIVER			DENSITY	FL	FL	FL	NO.	REACH DENSITY			WATER	ELEC	TURB	D.O.
DATE	LOCATION	MILE	CATCH	AREA	(/1000ft^2)	MIN	MAX	AVG	MEAS	UPPER	MIDDLE	LOWER	TEMP	COND	(NTU)	(mg/L)
4-Jun	OLGB	50.5	3	3,600	0.8	50	68	58.0	3				13.9	30	0.59	10.0
4-Jun	R5	48.4	0	3,000	0.0	-	-	-	0				14.9	30	0.7	9.9
4-Jun	TRR	42.0	0	3,600	0.0	-	-	-	0				15.3	39	1.8	8.6
4-Jun	Hickman	31.6	0	2,800	0.0	-	-	-	0				24.4	48	1.2	9.5
4-Jun	Charles	24.9	0	2,400	0.0	-	-	-	0				25.0	79	0.7	9.2
4-Jun	Legion	17.2	0	3,600	0.0	-	-	-	0				28.0	134	1.1	10.2
4-Jun	Service	6.4			no sample								26.7	205	1.2	10.2
4-Jun	Shiloh	3.4			no sample								27.8	190	2.0	8.8
4-Jun	Laird	90.2			no sample								26.6	1420	9.2	8.2
4-Jun	Gardner	79.5			no sample										no sample	
	TR TOT.		3	19,000	0.2	50	68	58.0	3	0.3	0.0	0.0				
	SJR TOT.				no sample											

Table 2. Summary of salmon catch by sampling event date in the Tuolumne River in 2014. Note: No catch in the San Joaquin River in 2014.

TUOLUMNE RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.
14-Jan	77	22,800	3.4	35	58	44.3	50
29-Jan	344	21,200	16.2	29	59	37.0	103
11-Feb	1,029	22,400	45.9	34	45	37.8	187
25-Feb	1,027	22,900	44.8	30	62	39.1	115
10-Mar	817	21,675	37.7	33	66	39.6	115
25-Mar	273	23,000	11.9	32	82	50.6	154
8-Apr	69	24,700	2.8	34	87	59.0	68
22-Apr	20	13,250	1.5	45	74	62.0	20
6-May	1	27,100	0.0	43	43	43.0	1
20-May	4	24,150	0.2	39	49	42.0	4
4-Jun	3	19,000	0.2	50	68	58	3
TOTAL:	3,664	242,175	15.1	29	87		820

Table 3. Summary table of fry and juvenile density by sampling event and location for the Tuolumne and San Joaquin Rivers in 2014. Density is reported as number of salmon/1000 ft^2. Meas. = measured.

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Fry Density	Estimated Juvenile Density	Estimated Total Density	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
14-Jan	OLGB	0	3,600	0	0	0.0	0.0	0.0	-						
14-Jan	R5	77	3,200	39	11	18.8	5.3	24.1	44						
14-Jan	TRR	0	3,600	0	0	0.0	0.0	0.0	-						
14-Jan	Hickman	0	2,800	0	0	0.0	0.0	0.0	-						
14-Jan	Charles	0	3,600	0	0	0.0	0.0	0.0	-						
14-Jan	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
14-Jan	Service				no sample										
14-Jan	Shiloh	0	2,400	0	0	0.0	0.0	0.0	-						
14-Jan	Laird				no sample										
14-Jan	Gardner	0	1,600	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		77	22,800	39	11	2.6	0.7	3.4	44	5.8	0.0	0.0	1.6	0.0	0.0
SJR. TOT.		0	1,600	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
29-Jan	OLGB	2	3,600	2	0	0.6	0.0	0.6	47						
29-Jan	R5	291	3,000	49	1	95.1	1.9	97.0	37						
29-Jan	TRR	50	3,600	50	0	13.9	0.0	13.9	37						
29-Jan	Hickman	1	2,600	1	0	0.4	0.0	0.4	36						
29-Jan	Charles	0	3,600	0	0	0.0	0.0	0.0	-						
29-Jan	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
29-Jan	Service				no sample										
29-Jan	Shiloh	0	1,200	0	0	0.0	0.0	0.0	-						
29-Jan	Laird	0	1,200	0	0	0.0	0.0	0.0	-						
29-Jan	Gardner	0	1,200	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		344	21,200	102	1	16.1	0.2	16.2	37	33.3	0.1	0.0	0.3	0.0	0.0
SJR. TOT.		0	2,400	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
11-Feb	OLGB	17	3,600	15	0	4.7	0.0	4.7	37						
11-Feb	R5	280	2,800	50	0	100.0	0.0	100.0	38						
11-Feb	TRR	379	3,600	50	0	105.3	0.0	105.3	39						
11-Feb	Hickman	328	2,800	50	0	117.1	0.0	117.1	38						
11-Feb	Charles	25	3,600	22	0	6.9	0.0	6.9	37						
11-Feb	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
11-Feb	Service				no sample										
11-Feb	Shiloh	0	2,400	0	0	0.0	0.0	0.0	-						
11-Feb	Laird	0	800	0	0	0.0	0.0	0.0	-						
11-Feb	Gardner	0	1,600	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		1029	22,400	187	0	45.9	0.0	45.9	38	67.6	35.3	0.0	0.0	0.0	0.0
SJR. TOT.		0	2,400	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
25-Feb	OLGB	0	3,600	0	0	0.0	0.0	0.0	-						
25-Feb	R5	7	3,200	7	0	2.2	0.0	2.2	36						
25-Feb	TRR	187	3,600	44	6	45.7	6.2	51.9	42						
25-Feb	Hickman	825	3,100	50	0	266.1	0.0	266.1	36						
25-Feb	Charles	8	3,400	8	0	2.4	0.0	2.4	42						
25-Feb	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
25-Feb	Service				no sample										
25-Feb	Shiloh	0	2,400	0	0	0.0	0.0	0.0	-						
25-Feb	Laird	0	1,200	0	0	0.0	0.0	0.0	-						
25-Feb	Gardner				no sample										
TUOL.TOT.		1027	22,900	109	6	42.5	2.3	44.8	39	16.7	82.5	0.0	2.0	0.0	0.0
SJR. TOT.		0	1,200	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
10-Mar	OLGB	0	3,600	0	0	0.0	0.0	0.0	-						
10-Mar	R5	12	2,800	12	0	4.3	0.0	4.3	38						
10-Mar	TRR	153	3,600	46	4	39.1	3.4	42.5	41						
10-Mar	Hickman	649	3,400	50	0	190.9	0.0	190.9	37						
10-Mar	Charles	3	3,300	0	3	0.0	0.9	0.9	62						
10-Mar	Legion	0	3,400	0	0	0.0	0.0	0.0	-						
10-Mar	Service				no sample										
10-Mar	Shiloh	0	1,575	0	0	0.0	0.0	0.0	-						
10-Mar	Laird	0	1,575	0	0	0.0	0.0	0.0	-						
10-Mar	Gardner				no sample										
TUOL.TOT.		817	21,675	108	7	35.4	2.3	37.7	40	15.4	60.9	0.0	1.1	3.7	0.0
SJR. TOT.		0	1,575	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
25-Mar	OLGB	9	3,600	9	0	2.5	0.0	2.5	36						
25-Mar	R5	27	3,600	26	0	7.5	0.0	7.5	38						
25-Mar	TRR	38	3,600	11	27	3.1	7.5	10.6	68						
25-Mar	Hickman	168	3,000	41	9	45.9	10.1	56.0	46						
25-Mar	Charles	31	3,600	1	30	0.3	8.3	8.6	68						
25-Mar	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
25-Mar	Service				no sample										
25-Mar	Shiloh	0	2,000	0	0	0.0	0.0	0.0	-						
25-Mar	Laird	0	1,500	0	0	0.0	0.0	0.0	-						
25-Mar	Gardner	0	900	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		273	23,000	88	66	6.8	5.1	11.9	51	4.3	10.1	0.0	2.5	9.4	0.0
SJR. TOT.		0	2,400	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
8-Apr	OLGB	1	3,600	1	0	0.3	0.0	0.3	38						
8-Apr	R5	7	3,000	7	0	2.3	0.0	2.3	40						
8-Apr	TRR	1	3,600	0	1	0.0	0.3	0.3	61						
8-Apr	Hickman	51	3,000	11	39	3.7	13.3	17.0	81						
8-Apr	Charles	9	3,200	0	9	0.0	2.8	2.8	81						
8-Apr	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
8-Apr	Service	0	2,700	0	0	0.0	0.0	0.0	-						
8-Apr	Shiloh	0	2,000	0	0	0.0	0.0	0.0	-						
8-Apr	Laird	0	1,600	0	0	0.0	0.0	0.0	-						
8-Apr	Gardner	0	1,200	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		69	24,700	19	49	0.78	2.01	2.8	59	0.8	1.1	0.0	0.1	5.0	0.0
SJR. TOT.		0	2,800	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
22-Apr	OLGB	0	2,400	0	0	0.0	0.0	0.0	-						
22-Apr	R5	0	2,250	0	0	0.0	0.0	0.0	-						
22-Apr	TRR	11	3,600	0	11	0.0	3.1	3.1	67						
22-Apr	Hickman	9	2,200	2	7	0.9	3.2	4.1	55						
22-Apr	Charles					no sample									
22-Apr	Legion	0	2,400	0	0	0.0	0.0	0.0	-						
22-Apr	Service					no sample									
22-Apr	Shiloh	0	400	0	0	0.0	0.0	0.0	-						
22-Apr	Laird	0	2,200	0	0	0.0	0.0	0.0	-						
22-Apr	Gardner	0	800	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		20	16,250	2	18	0.1	1.1	1.2	62	0.0	0.4	0.0	1.3	1.5	0.0
SJR. TOT.		0	3,000	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
6-May	OLGB	0	3,200	0	0	0.0	0.0	0.0	-						
6-May	R5	1	3,600	1	0	0.3	0.0	0.3	43						
6-May	TRR	0	3,600	0	0	0.0	0.0	0.0	-						
6-May	Hickman	0	3,200	0	0	0.0	0.0	0.0	-						
6-May	Charles	0	3,200	0	0	0.0	0.0	0.0	-						
6-May	Legion	0	4,500	0	0	0.0	0.0	0.0	-						
6-May	Service	0	3,600	0	0	0.0	0.0	0.0	-						
6-May	Shiloh	0	2,200	0	0	0.0	0.0	0.0	-						
6-May	Laird	0	800	0	0	0.0	0.0	0.0	-						
6-May	Gardner	0	1,500	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		1	29,400	1	0	0.03	0.0	0.03	43	0.1	0.0	0.0	0.0	0.0	0.0
SJR. TOT.		0	2,300	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
20-May	OLGB	4	3,600	4	0	1.1	0.0	1.1	42						
20-May	R5	0	3,200	0	0	0.0	0.0	0.0	-						
20-May	TRR	0	3,600	0	0	0.0	0.0	0.0	-						
20-May	Hickman	0	3,000	0	0	0.0	0.0	0.0	-						
20-May	Charles	0	3,400	0	0	0.0	0.0	0.0	-						
20-May	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
20-May	Service	0	1,550	0	0	0.0	0.0	0.0	-						
20-May	Shiloh	0	2,200	0	0	0.0	0.0	0.0	-						
20-May	Laird	0	800	0	0	0.0	0.0	0.0	-						
20-May	Gardner	0	1,500	0	0	0.0	0.0	0.0	-						
TUOL.TOT.		4	24,150	4	0	0.2	0.0	0.2	42	0.4	0.0	0.0	0.0	0.0	0.0
SJR. TOT.		0	2,300	0	0	0.0	0.0	0.0	-						

2014 Weekly Summary of TID/MID Seining Study

Date	Location	Total Catch	Area	Meas. Fry	Meas. Juveniles	Estimated Density Fry	Estimated Density Juvenile	Estimated Density Total	Average FL	Fry Density UPPER REACH	Fry Density MIDDLE REACH	Fry Density LOWER REACH	Juvenile Density UPPER REACH	Juvenile Density MIDDLE REACH	Juvenile Density LOWER REACH
4-Jun	OLGB	3	3,600	1	2	0.3	0.6	0.8	58						
4-Jun	R5	0	3,000	0	0	0.0	0.0	0.0	-						
4-Jun	TRR	0	3,600	0	0	0.0	0.0	0.0	-						
4-Jun	Hickman	0	2,800	0	0	0.0	0.0	0.0	-						
4-Jun	Charles	0	2,400	0	0	0.0	0.0	0.0	-						
4-Jun	Legion	0	3,600	0	0	0.0	0.0	0.0	-						
4-Jun	Service				no sample										
4-Jun	Shiloh				no sample										
4-Jun	Laird				no sample										
4-Jun	Gardner				no sample										
TUOL.TOT.		3	19,000	1	2	0.1	0.1	0.2	58	0.1	0.0	0.0	0.2	0.0	0.0
SJR. TOT.					no sample										

Table 4. Seining survey data summary from the Tuolumne, San Joaquin and Stanislaus Rivers, 1986-2014.

TUOLUMNE RIVER						SAN JOAQUIN			STANISLAUS				
Sampling Year	Sampling Periods	Salmon Captured	Sites Sampled	Average Density (/1000ft^2)	Growth Rate Index (mm/day)	Salmon Captured	Sites Sampled	Average Density (/1000ft^2)	Salmon Captured	Sites Sampled	Average Density (/1000ft^2)	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
2005	10	1341	8	8.9	0.53	8	2*	0.2	---	---	---	19JAN	25MAY
2006	11	1558	8	10.2	0.79	39	2	1.2	---	---	---	20JAN	15JUN
2007	10	204	8	1.5	0.58	0	2	0	---	---	---	17JAN	23MAY
2008	10	198	8	1.4	0.66	0	2	0	---	---	---	22JAN	27MAY
2009	11	779	8	4.7	0.64	0	2	0	---	---	---	13JAN	02JUN
2010	10	386	8	2.9	0.65	0	2	0	---	---	---	26JAN	08JUN
2011	10	164	8	1.2	No estimate	19	2	0.6	---	---	---	19JAN	24MAY
2012	11	1881	8*	6.9	0.47	0	2*	0	---	---	---	18JAN	5JUN
2013	11	1763	8*	7.1	0.63	0	2	0	---	---	---	15JAN	4JUN
2014	11	3664	8*	15.1	0.35	0	2	0	---	---	---	14JAN	4JUN

--- Not Sampled

*All locations were not always sampled

Table 5. Number of individuals of other species captured by location and sampling event during the 2014 Tuolumne and San Joaquin River seining study. Key to other species codes is in Table 6.

SURVEY 1

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
14-Jan	1	OLGB	50.5													
14-Jan	2	R5	48.4								2					
14-Jan	3	TRR	42.0													
14-Jan	4	Hickman	31.6													
14-Jan	5	Charles	24.9													
14-Jan	6	Legion	17.2													
14-Jan	7	Service	6.4													
14-Jan	8	Shiloh	3.4													
14-Jan	9	Laird	90.2													
14-Jan	10	Gardner	79.5	2					20			11				

SURVEY 2

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
29-Jan	1	OLGB	50.5													
29-Jan	2	R5	48.4					6							2	
29-Jan	3	TRR	42.0													
29-Jan	4	Hickman	31.6													
29-Jan	5	Charles	24.9													
29-Jan	6	Legion	17.2													
29-Jan	7	Service	6.4													
29-Jan	8	Shiloh	3.4													
29-Jan	9	Laird	90.2									8				
29-Jan	10	Gardner	79.5						5			4				

SURVEY 3

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
11-Feb	1	OLGB	50.5													
11-Feb	2	R5	48.4													
11-Feb	3	TRR	42.0													
11-Feb	4	Hickman	31.6													
11-Feb	5	Charles	24.9	1												
11-Feb	6	Legion	17.2													
11-Feb	7	Service	6.4													

11-Feb	8	Shiloh	3.4													
11-Feb	9	Laird	90.2						6			16				
11-Feb	10	Gardner	79.5													

SURVEY 4

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
25-Feb	1	OLGB	50.5													
25-Feb	2	R5	48.4					1								
25-Feb	3	TRR	42.0													
25-Feb	4	Hickman	31.6													
25-Feb	5	Charles	24.9													
25-Feb	6	Legion	17.2													
25-Feb	7	Service	6.4													
25-Feb	8	Shiloh	3.4													
25-Feb	9	Laird	90.2									8				
25-Feb	10	Gardner	79.5													

SURVEY 5

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
10-Mar	1	OLGB	50.5													
10-Mar	2	R5	48.4					3								
10-Mar	3	TRR	42.0													
10-Mar	4	Hickman	31.6													
10-Mar	5	Charles	24.9													
10-Mar	6	Legion	17.2													
10-Mar	7	Service	6.4													
10-Mar	8	Shiloh	3.4							1						
10-Mar	9	Laird	90.2	1					1			15				
10-Mar	10	Gardner	79.5													

SURVEY 6

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
25-Mar	1	OLGB	50.5											1		
25-Mar	2	R5	48.4					8							2	
25-Mar	3	TRR	42.0	1	1		1									
25-Mar	4	Hickman	31.6													
25-Mar	5	Charles	24.9	4												
25-Mar	6	Legion	17.2													
25-Mar	7	Service	6.4													

25-Mar	8	Shiloh	3.4													
25-Mar	9	Laird	90.2									17				
25-Mar	10	Gardner	79.5	5								17				

SURVEY 7

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
8-Apr	1	OLGB	50.5													
8-Apr	2	R5	48.4								2					
8-Apr	3	TRR	42.0													
8-Apr	4	Hickman	31.6													
8-Apr	5	Charles	24.9													
8-Apr	6	Legion	17.2		1											
8-Apr	7	Service	6.4	1											1	1
8-Apr	8	Shiloh	3.4	1												
8-Apr	9	Laird	90.2									13				
8-Apr	10	Gardner	79.5	3								18				

SURVEY 8

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
22-Apr	1	OLGB	50.5													
22-Apr	2	R5	48.4													
22-Apr	3	TRR	42.0													
22-Apr	4	Hickman	31.6													
22-Apr	5	Charles	24.9													
22-Apr	6	Legion	17.2													
22-Apr	7	Service	6.4													
22-Apr	8	Shiloh	3.4													
22-Apr	9	Laird	90.2									18				
22-Apr	10	Gardner	79.5													

SURVEY 9

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
6-May	1	OLGB	50.5											2		
6-May	2	R5	48.4													
6-May	3	TRR	42.0													
6-May	4	Hickman	31.6													
6-May	5	Charles	24.9	1												
6-May	6	Legion	17.2													
6-May	7	Service	6.4	1												

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
6-May	8	Shiloh	3.4													
6-May	9	Laird	90.2									19				
6-May	10	Gardner	79.5		2		15		11			20				

SURVEY 10

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
20-May	1	OLGB	50.5										3	5		
20-May	2	R5	48.4								1		1			
20-May	3	TRR	42.0			2					8					
20-May	4	Hickman	31.6		6											
20-May	5	Charles	24.9	2		3										
20-May	6	Legion	17.2		1							1				
20-May	7	Service	6.4			5										
20-May	8	Shiloh	3.4		2	3										
20-May	9	Laird	90.2			1						41				
20-May	10	Gardner	79.5	7	13	78										

SURVEY 11

DATE	SITE	LOCATION	MILE	BG	CENT	GAM	GSF	HH	ISS	LMB	PM	PRS	PSCP	RT	SKR	WCF
4-Jun	1	OLGB	50.5											2	1	
4-Jun	2	R5	48.4												1	
4-Jun	3	TRR	42.0								16					
4-Jun	4	Hickman	31.6	1	1											
4-Jun	5	Charles	24.9													
4-Jun	6	Legion	17.2		1											
4-Jun	7	Service	6.4													
4-Jun	8	Shiloh	3.4													
4-Jun	9	Laird	90.2													
4-Jun	10	Gardner	79.5													

Table 6. Key to other species sampled. Native species are indicated by an “N”. X’s denote species captured in 2014.

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	SAN JOAQUIN	TUOL.
Salmonidae	Chinook salmon	N	CS		X
Salmonidae	rainbow trout	N	RT		X
Cyprinidae	hardhead	N	HH		X
Cyprinidae	Sacramento pikeminnow	N	PM		X
Cyprinidae	red shiner		PRS	X	X
Catostomidae	Sacramento sucker	N	SKR		X
Ictaluridae	white catfish		WCF		X
Poeciliidae	western mosquitofish		GAM	X	X
Atherinidae	inland silverside		ISS	X	
Centrarchidae	green sunfish		GSF	X	X
Centrarchidae	bluegill		BG	X	X
Centrarchidae	largemouth bass		LMB		X
Cottidae	prickly sculpin	N	PSCP		X
TOTAL:	13			5	12

Table 7. Summary of *O. mykiss* caught in the Tuolumne River during the 2014 seining study.

2014 Summary of Rainbow Trout caught during the Seining Study

Date	Location	River Mile	Catch	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Average Fork Length (mm)
3/25/14	OLGB	50.5	1	29	29	29
5/6/14	OLGB	50.5	2	39	48	44
5/20/14	OLGB	50.5	5	46	52	49
6/4/14	OLGB	50.5	2	44	50	47

Table 8. Summary table of locations sampled during the Tuolumne, Stanislaus, and San Joaquin Rivers seining studies, 1986-2014.

Site	Location	River Mile	1986	1987[a]	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
TUOLUMNE RIVER																															
1	Old La Grange Bridge	50.5	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Riffle 4B	48.4	X	X	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	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	X	X	X	X	X	X		X	X	X
5	Turlock Lake State Recreation Area	42.0	X	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	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	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	X	X	X	X	X	X	X	X	X	X
10	RPD/Service Rd./Venn	12.3-7.4		X	X	X	X	X								X	X	X	X	X	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	X	X	X	X	X	X	X	X	X	X
SAN JOAQUIN RIVER																															
13	Laird Park	90.2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	Gardner Cover	77.8		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
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																						
18	Old River	53.7		X																											
STANISLAUS RIVER																															
19	Caswell State Park	8.5			X	X		X	X	X																					
DRY CREEK																															
20	Beard Brook Park	0.5							X	X																					

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

Table 9. Tuolumne River Chinook salmon data for the analysis of female spawners to fry density relationship.

			Juvenile Seining	
Escapement Year	Total Female Spawners[a]	Outmigration Year	Peak Fry Density 15JAN-15MAR	Average Fry Density 15JAN-15MAR
1985	22600	1986	158.8	59.5
1986	3800	1987	69.3	46.2
1987	4600	1988	70.2	33.9
1988	4100	1989	115.1	39.7
1989	680	1990	11.4	5.0
1990	28	1991	1.3	0.5
1991	28	1992	6.1	2.9
1992	55	1993	1.7	0.9
1993	237	1994	79.5	41.5
1994	249	1995	12.5	9.8
1995	522	1996	16.1	13.0
1996	1142	1997	2.8	2.1
1997	4224	1998	49.3	24.6
1998	4527	1999	78.0	39.3
1999	3535	2000	78.8	48.0
2000	11260	2001	126.3	85.6
2001	4970	2002	92.8	41.5
2002	3876	2003	164.3	68.8
2003	1768	2004	38.8	27.2
2004	1004	2005	20.5	14.6
2005	478	2006	28.7	12.7
2006	282	2007	3.7	2.2
2007	80	2008	2.4	1.7
2008	212	2009	9.7	4.8
2009	170	2010	6.1	3.5
2010	258	2011	3.6	2.0
2011	712	2012	16.8	10.0
2012	806	2013	30.6	12.1
2013	1864	2014	45.9	28.5

[a]Female spawner data from 1985-2008 were obtained from CDFG annual carcass surveys; 2009-2013 data were obtained from annual monitoring at the Tuolumne River weir.

Table 10. Occurrence of other species captured in the Tuolumne River seining studies, 1986-2014.

Common Name	Native Species	Code	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pacific lamprey	N	LP	X	X															X		X									
threadfin shad		TFS	X	X	X	X							X	X			X													
Chinook salmon	N	CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
rainbow trout	N	RT	X	X	X									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
carp		CP	X																			X					X			
goldfish		GF			X																									
golden shiner		GSH	X	X	X	X		X	X	X	X							X		X		X		X	X	X				
Sacramento blackfish	N	SBF	X																											
hardhead	N	HH	X	X	X				X		X						X	X		X	X	X	X	X	X	X	X		X	X
Sacramento pikeminnow	N	PM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sacramento splittail	N	ST		X	X	X																								
red shiner		PRS				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
fathead minnow		FHM														X														
Sacramento sucker	N	SKR	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
channel catfish		CCF			X											X			X						X	X				
white catfish		WCF	X		X	X		X		X	X						X													X
back bullhead		BLBH					X																							
brown bullhead		BBH									X																			
western mosquitofish		GAM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
inland silverside		ISS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X			X	
striped bass		SB															X													
white/black crappie		WCR/BCR			X																									
warmouth		WM								X																				
green sunfish		GSF	X		X	X	X	X	X	X		X				X	X	X	X	X	X	X			X	X			X	X
bluegill		BG	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
redear sunfish		RSF			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	
largemouth bass		LMB	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X			X	X
smallmouth bass		SMB	X	X	X	X	X	X	X		X						X	X	X	X				X	X	X				
bigscale logperch		BLP		X				X	X			X		X	X								X	X						
tule perch	N	TP																												
prickly sculpin	N	PSCP		X								X	X	X						X	X	X					X	X	X	X
riffle sculpin	N	RSCP	X		X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
TOTAL:	32		18	16	20	16	12	15	15	13	15	12	11	14	11	14	17	15	15	16	15	16	12	15	15	16	11	6	12	12

7. REFERENCES

Becker, C., R. Cuthbert, and A. Fuller. 2011. Fall/winter migration monitoring at the Tuolumne River weir 2010 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2011.

Becker, C., J. Guignard, and A. Fuller. 2014. Fall migration monitoring at the Tuolumne River weir 2013 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2014.

Cuthbert, R., C. Becker, and A. Fuller. 2012. Fall/winter migration monitoring at the Tuolumne River weir 2011 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2012.

Cuthbert, R., A. Fuller, and S. Snider. 2010. Fall/winter migration monitoring at the Tuolumne River weir 2009 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2010.

Pacific Fishery Management Council. 2005. Klamath River Fall Chinook Stock-Recruitment Analysis. Prepared by the Salmon Technical Team, Portland, Oregon. Report available at: *http://www.pcouncil.org/wp-content/uploads/G1b_KlamathConsObj_STT_Rpt.pdf*

Quinn II, T.J. and R.B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press, New York, New York.

TID/MID (Turlock Irrigation District and Modesto Irrigation District). 2008. Spawning Survey Summary Update. Report 2007-2 to the Federal Energy Regulatory Commission.

Wright, T., J. Guignard, and A. Fuller. 2013. Fall migration monitoring at the Tuolumne River weir 2012 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2013.

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-4

Outmigrant Trapping of Juvenile Salmon in the
Lower Tuolumne River, 2014

Prepared by

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Outmigrant Trapping of Juvenile Chinook Salmon in the Lower Tuolumne River, 2014

FISHBIO

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INTRODUCTION

Study Area Description

The Tuolumne River is the largest of three major tributaries (Tuolumne, Merced, and Stanislaus Rivers) to the San Joaquin River. The Tuolumne River originates in Yosemite National Park, in the central Sierra Nevada Mountains, and flows west between the Merced River to the south and the Stanislaus River to the north (Figure 1). The San Joaquin River itself flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta within California's Central Valley. The Tuolumne River is dammed at several locations for the purposes of power generation, water storage, and flood control – the largest impoundment is Don Pedro Reservoir.

The lower Tuolumne River corridor extends from the confluence with the San Joaquin River to La Grange Dam at river mile (RM) 52.2. The La Grange Dam site has been the upstream limit for anadromous fish migration since at least 1871.

Purpose and History of Study

Rotary screw traps (RST) have been operated since 1995 at various locations in the Tuolumne River during the winter/spring period. RST monitoring was intended to meet several objectives including estimating abundance and migration characteristics of juvenile salmonids and other fishes, and evaluating reach survival relative to environmental conditions (Figure 1). The Turlock Irrigation District and Modesto Irrigation District (Districts), and the City and County of San Francisco have funded the majority of the RST monitoring efforts in the Tuolumne River.

Current sampling locations are Grayson River Ranch (Grayson – RM 5.2) near the mouth of the Tuolumne River and a site downstream of the City of Waterford (RM 29.8). Rotary screw trapping has been conducted annually near the mouth of the Tuolumne River since 1995 (Shiloh from 1995-1998; and Grayson from 1999-2014). Since 2006, sampling has also been conducted annually near Waterford, approximately 25 miles upstream of the Grayson site, to provide comparative information on the size, migration timing, and production of juvenile fall-run Chinook salmon, as well as data on other fishes.

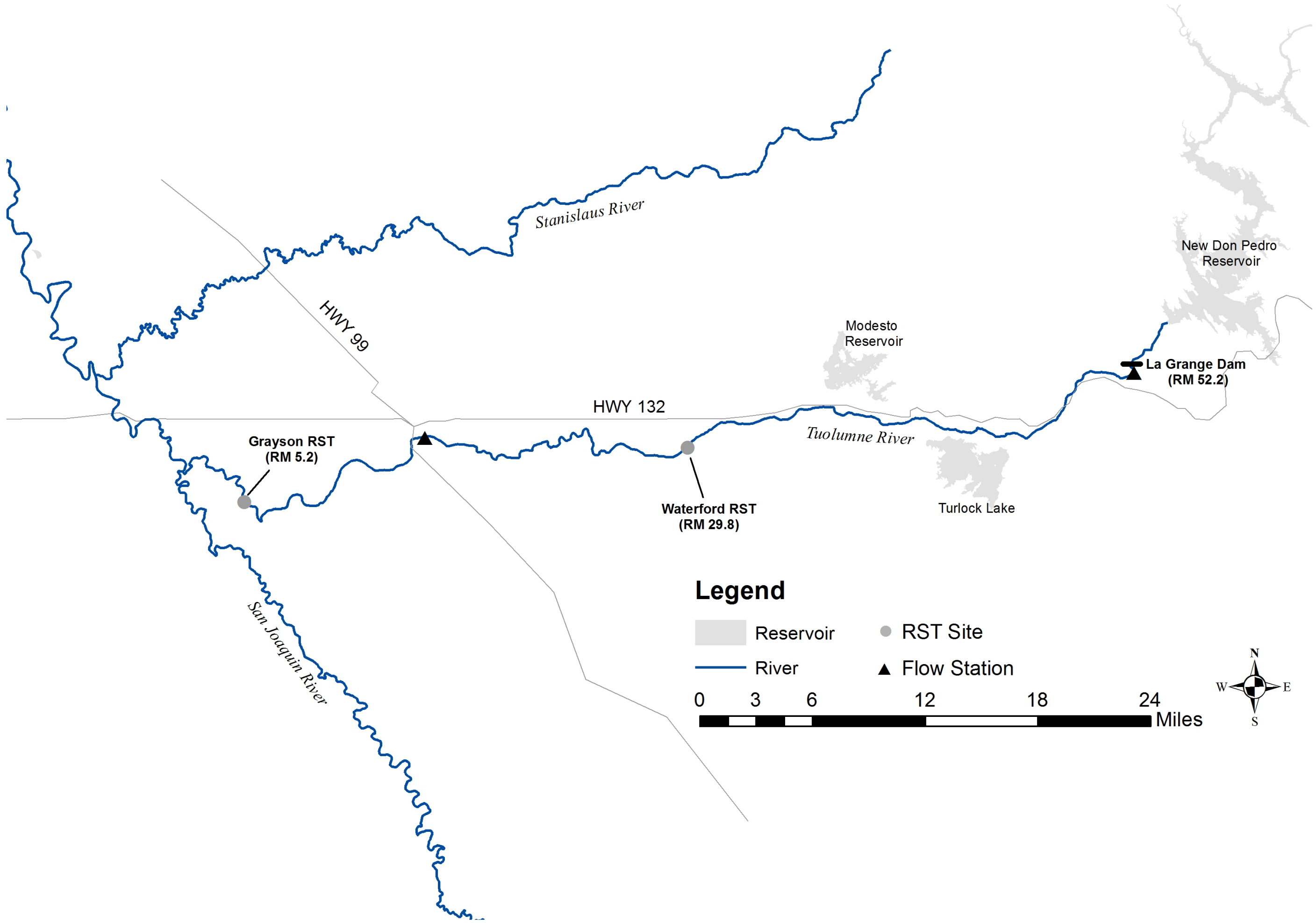

Figure 1. Location map of study area on the Tuolumne River.

Table 1. Rotary screw trap monitoring in the Lower Tuolumne River, 1995-2014.

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Results Reported In
1995	Shiloh (RM 3.4)	Apr 25-Jun 01	24%	141	15,667[1]	Heyne and Loudermilk 1997
1996	Shiloh	Apr 18 - May 29	27%	610	40,385[1]	
1997	Shiloh	Apr 18 - May 24	24%	57	2,850[1]	Heyne and Loudermilk 1998
1998	Turlock Lake State Rec.	Feb 11-Apr 13	41%	7,125	259,581[1]	Vick and others 1998
	7/11 (RM 38.5)	Apr 15-May 31	31%	2,413		
	Charles Road (RM 25.0)	Mar 27-Jun 01	43%	981	66,848[1]	
	Shiloh	Feb 15-Jul 01	70%	2,546	1,615,673[1]	Blakeman 2004a
1999	7/11	Jan 19-May 17	79%	80,792	1,737,052[1]	Vick and others 2000
	Hughson (RM 23.7)	Apr 08-May 24	31%	449	7,175[1]	
	Grayson (RM 5.2)	Jan 12-Jun 06	93%	19,327	852,711[2]	Vasques and Kundargi 2001
2000	7/11	Jan 10-Feb 27	32%	61,196	298,755[1]	Hume and others 2001
	Deardorff (RM 35.5)	Apr 09-May 25	31%	634	15,845[1]	
	Hughson	Apr 09-May 25	31%	264	2,942[1]	
	Grayson	Jan 09-Jun 12	95%	2,250	124,765	Vasques and Kundargi 2001
2001	Grayson	Jan 03-May 29	97%	6,478	164,095[2]	Vasques and Kundargi 2002
2002	Grayson	Jan 15-Jun 06	91%	436	13,111[2]	Blakeman 2004b
2003	Grayson	Apr 01-Jun 06	40%	359	11,273[2]	Blakeman 2004c
2004	Grayson	Apr 01-Jun 09	40%	509	23,556[2]	Fuller 2005
2005	Grayson	Apr 02-Jun 17	39%	1,317	112,788[2]	Fuller and others 2006
2006	Waterford 1 (RM 29.8)	Jan 25-Apr 12	79%	8,648	374,474[2]	Fuller and others 2007

1 Passage estimate reported in the annual report cited.

2 Estimates derived using a linear regression model reported in Robichaud and English 2013 and 2015.

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Results Reported In
	Waterford 2 (RM 33.5)	Apr 21-Jun 21		458	144,226[2]	
	Grayson	Jan 25-Jun 22	84%	1,594	84,802[2]	
2007	Waterford (RM 29.8)	Jan 11-Jun 05	93%	3,312	53,487[2]	Fuller 2008
2007	Grayson	Mar 23-May 29	45%	27	952[2]	Fuller 2008
2008	Waterford	Jan 8-Jun 2	96%	3,350	48,677[2]	Palmer and Sonke 2008
2008	Grayson	Jan 29-Jun 4	82%	193	3,016[2]	Palmer and Sonke 2008
2009	Waterford	Jan 7- Jun 9	96%	3,725	55,178[2]	Palmer and Sonke 2010
2009	Grayson	Jan 8-Jun 11	95%	155	4,072[2]	Palmer and Sonke 2010
2010	Waterford	Jan 5-Jun 11	97%	2,281	74,836[2]	Sonke and others 2010
2010	Grayson	Jan 6-Jun 17	97%	52	2,056[2]	Sonke and others 2010
2011	Waterford	Dec 5-Jun 30	100%	4,394	375,465[2]	Sonke and others 2012
2011	Grayson	Jan 6-Jun 30	97%	1,645	94,895[2]	Sonke and others 2012
2012	Waterford	Jan 3-Jun 15	99%	3,696	63,116[2]	Sonke and others 2013
2012	Grayson	Jan 3-Jun 15	99%	85	2,268[2]	Sonke and others 2013
2013	Waterford	Jan 2-May 31	99.3%	3,103	41,060[2]	Sonke 2014
2013	Grayson	Jan 3-May 23	93.3%	35	642[2]	Sonke 2014
2014	Waterford	Jan 2 –May16	89.3%	12,358	137,013[2]	This report
2014	Grayson	Jan 27 – May 2[3]	63.3%	8	211[2,4]	This report

[3] Sampling was initiated on January 2 but was suspended from January 6-January 27 due to inadequate depth and water velocity.
[4] Abundance estimate likely underestimated due to heavy debris loads of hyacinth and inadequate water velocities at the RSTs.

METHODS

Juvenile Outmigrant Monitoring

Sampling Gear and Trapping Site Locations

Rotary screw traps (E.G. Solutions, Eugene, OR) were installed and operated at the Waterford and Grayson sites. The RSTs consist of a funnel-shaped core suspended between two pontoons. RSTs are positioned in the current so that water enters the 8 ft wide funnel mouth and strikes the internal screw core, causing the funnel to rotate. As the funnel rotates, fish are trapped in pockets of water and moved rearward into a livebox where they remain until they are processed by technicians.

The single Waterford RST was located at RM 29.8, approximately two miles downstream of the Hickman Bridge. The RST was held in place by a 3/8-inch overhead cable strung between two large trees located on opposite banks. Cables fastened to the front of each pontoon were attached to the overhead cable. For public safety reasons, warning signs, flashing safety lights and buoys marked the location of the RST and cables. Due to the low discharge at Waterford for a majority of the 2014 trapping season, there was not enough current velocity to turn the cone of the RST. In order to divert more water and turn the cone, "wing" structures were constructed (Figure 2). Similar techniques were used in 2008 and a portion of 2009 to increase RST efficiencies. The "wing" structure was installed at the onset of sampling and remained in place throughout the monitoring season with the exception of the spring pulse flow period.

Figure 2. Waterford RST with "wing" structures on upstream end of pontoons.

The tandem Grayson RSTs were located at RM 5.2, approximately two miles upstream of Shiloh Road. The two RSTs were fastened together in a side-by-side configuration, with ½ inch Ultra High Molecular Weight (UHMW) plastic strips that were bolted to each inner-pontoon at the crossbars. The RSTs were positioned and secured in place by two 50 lb plow-style anchors (Delta Fast-Set model, Lewmar, Havant, UK). The anchors were fastened to the outer-pontoons of the RSTs using 3/8-inch stainless steel leader cables (each outer-pontoon was attached to a separate in-line anchor) and the length of each leader cable was adjusted using a manual winch that was bolted to the outer-pontoon. The downstream force of the water on the RSTs kept the leader cables taut. Similar to the Waterford trapping site, a "wing" structure used to increase catch efficiency during the 2014 trapping season at Grayson, and was installed on January 2, and remained in place for the duration of the season. It was also used in the 2008, 2009, 2012, and 2013 seasons.

RST Monitoring

Sampling at Waterford began on January 2, 2014. The RST was operated continuously (24 hours per day, 7 days per week) until May 16, 2014, when sampling was terminated due to low catch.

Sampling at Grayson began on January 2, 2014 and was terminated on May 2, 2014, due to low catch and heavy accumulations of water hyacinth at the RSTs. Sampling was temporarily suspended from January 6 through January 27 due to insufficient water depth and heavy accumulations of water hyacinth at the RSTs. Abnormally heavy loads of water hyacinth combined with low water velocities at the RSTs hindered effective sampling at Grayson for most of the season. At times, the traps could not be kept fishing even with constant attention.

RSTs at both locations were checked at least every morning throughout the sampling period, with additional RST checks conducted as conditions required. During each RST check, the contents of the liveboxes were removed, all fish were identified and enumerated, and any marked fish were noted. In addition, random samples of fish were collected to assess size and growth rate. At each RST, up to 50 Chinook salmon and 20 individuals of each non-salmon species were randomly collected and measured during each morning check. Methods were slightly different during evening RST checks with up to only 20 Chinook salmon and only 10 individuals of each non-salmon species were measured. These fish were anesthetized for safe handling using AlkaSeltzer® (1916 mg Sodium Bicarbonate/4 liters of water; Bayer HealthCare, Whippany, NJ), measured (fork length [FL], standard length [SL], and total length [TL] in millimeters [mm]), and recorded. Chinook salmon were assigned to a lifestage category based on a fork length scale, where <50 mm = fry, 50-65 mm = parr, and $\geq$ 65 mm = smolt. In addition, the smolting appearance of all measured Chinook salmon and *O. mykiss* was rated based on a seven category scale, where 1 = yolk-sac fry, 2 = fry, 3 = parr, 4 = silvery parr, 5 = smolt, 6 = mature adult, and IAD = immature adult (Interagency Ecological Program, unpublished). Weights (to nearest tenth of a gram [g]) were taken from up to 50 Chinook salmon each week (i.e., Monday through Sunday) and from all *O. mykiss* using a digital balance (Ohaus Corporation, Pine Brook, NJ). Fish were weighed in a small, plastic container partially filled with stream water, which was tared prior to weighing each individual fish. Fish were then placed in a bucket with freshwater and allowed to recover before release.

Daily salmon catch was equivalent to the number of salmon captured during a morning RST check, plus the number of salmon captured during any RST check(s) that occurred within the period after the previous morning check. For example, the daily salmon catch for April 10 was the sum of salmon from the morning RST check on April 10 and the evening RST check conducted on April 9. Separate daily catch data was maintained for marked (i.e., dye inoculated fish used for RST efficiency tests) and unmarked Chinook salmon.

After all fish were measured and recorded, the RSTs were cleaned to prevent accumulation of debris that might impair RST rotation or cause fish mortality within the liveboxes. RST cleaning included removal of debris from all RST surfaces and from within the liveboxes. The amount of debris load in the livebox was estimated (i.e., light = less than one 10-gallon tub; medium = one to three 10-gallon tubs; heavy = four to six 10-gallon tubs; very heavy = more than six 10-gallon tubs) and recorded whenever a RST was checked.

RST Efficiency Releases

RST efficiency releases using natural or hatchery produced juvenile salmon were conducted to estimate the probability of capturing juvenile Chinook salmon at the Waterford and Grayson RSTs. Juvenile salmon captured in the RSTs were used to conduct releases whenever catches were sufficient (i.e., daily catch > 25 fish). Nineteen groups of naturally produced juvenile salmon (ranging in number from 26 to 300 fish) and one group of hatchery produced juvenile salmon (201 fish; from the Merced River Hatchery) were marked and released at RM 30 (approximately 0.2 miles upstream of the Waterford RST) between January 28 and April 10 to estimate RST efficiency at the Waterford RST. Catches of naturally produced juvenile salmon at Waterford after April 10 were insufficient for RST efficiency releases. Due to the low numbers of natural fish captured at the Grayson RSTs, only hatchery produced fish were used to estimate RST efficiency at the Grayson RSTs. Ten groups of hatchery produced juvenile salmon (average size = 487 [range = 385 – 626]) were marked and released at RM 6.2 (approximately one mile upstream of the Grayson RSTs) between March 13 and April 10.

Marking Procedure

All juvenile salmon release groups (hatchery and naturally produced) were marked onshore immediately adjacent to the corresponding trapping site. Naturally produced salmon were marked on the date that they were acquired from the RST and hatchery fish were marked on the date that they were transported from MRH to the marking site. A photonic marking system was used for marking all of the release groups because of the high quality of marks and efficiency of the marking process. All fish were anesthetized with AlkaSeltzer® before the appropriate mark was applied. A marker tip was placed against the caudal fin and orange or pink photonic dye was injected into the fin rays. The photonic dye (DayGlo Color Corporation, Cleveland, OH) was chosen because of its known ability to provide a highly visible, long-lasting mark.

Holding Facility and Transport Method

Unmarked hatchery fish were transported to the marking site from MRH in a 500-gallon insulated hauling tank 1-2 days prior to their release. Time to haul fish (1 group) to Waterford took 47 minutes, and ranged from 1 hour 35 minutes to 2 hours 15 minutes to haul fish (10 groups) to Grayson.

Juvenile salmon were transported from the marking sites to the release sites in either 5-gallon buckets or 20-gallon insulated coolers depending on the number of fish, temperature, and distance traveled.

At the release sites, fish were held in livecars constructed of 15” diameter PVC pipe cut into varying lengths ranging from 18 to 36 inches (Figure 3). The end caps were fitted with nylon mesh. Livecars were tethered to vegetation or other structures and kept in areas of low water velocity to reduce fish stress.

Figure 3. Livecar used for holding RST efficiency test fish.

Release Procedure

All marked fish were released after nightfall. Livecars were located several feet away from the specific release point, and fish were poured from the live cars into buckets for release. Fish were released by placing a dip net into the bucket, scooping up a "net-full" of fish, and then emptying the fish into the river and allowing them to swim away. After releasing a "net-full" of fish, approximately 30 seconds to 3 minutes time elapsed before another "net-full" was released. The amount of time between “net-full” releases varied depending on how fast fish swam away after they were released. Depending on the group size, total release time for marked groups ranged from 15 minutes to 30 minutes.

Monitoring Environmental Factors

Flow Measurements and RST Speed

Provisional daily average flow for the Tuolumne River at La Grange was obtained from USGS, as downloaded from http://waterdata.usgs.gov. Provisional daily average flow for the Tuolumne River at Modesto was obtained from the USGS, as downloaded from http://waterdata.usgs.gov. The Modesto flow station is below Dry Creek, the largest seasonal tributary entering the river downstream of La Grange Dam. As a result, that site includes flow associated with major winter runoff events. Two methods were used to measure the velocity of water entering the RSTs. First, instantaneous measurements were taken daily with a Global Flow Probe (Global Water, Fair Oaks, CA). Second, an average daily RST rotation speed was calculated for each RST, by recording the time (measured in seconds) for three continuous revolutions of the cone, once before, and once after, the morning RST cleaning. The average of the two times was considered the average daily RST rotation speed.

River Temperature, Relative Turbidity, and Dissolved Oxygen

Instantaneous water temperature and dissolved oxygen were measured daily with a YSI ProODO (YSI Incorporated, Yellow Springs, OH) at the RST site. Temperature data was also available from hourly recording thermographs maintained by the Districts at both trapping sites. Conductivity (µS) was measured using an ExStik® II EC500 Electrical Conductivity Meter (Extech Instruments Corporation, Waltham, MA). To measure daily instantaneous turbidity, a water sample was collected each morning and later tested at the field station using a LaMotte turbidity meter (Model 2020e, LaMotte Company, Chestertown, MD). Turbidity was recorded in nephelometric turbidity units (NTU).

Estimating Chinook Salmon Abundance

The number of fish passing each site each day was estimated using a linear regression model at each trapping location and abundance estimates are presented in Table 1.

Linear regression model

RST efficiency data collected at Waterford (2006-2014) and Grayson (1999-2011) was used to create a linear regression model in order to predict daily Chinook abundance at each trapping location. Abundance estimates were calculated for Waterford and Grayson using methods described in Robichaud and English (2013 and 2015). Below is a brief summary of calculations used to estimate abundance.

For each RST efficiency release, the mean fish fork length at release and recapture were calculated. For each release (i) at each RST (t), the percent of flow sampled (Φ_{ti}) was calculated as the proportion flow through the RST ($F_{RST_{ti}}$) to that of whole-river flow ($F_{RIVER_{ti}}$):

$$(\Phi_{ti}) = F_{RST_{ti}} / F_{RIVER_{ti}} \qquad \text{(Eq. 1)}$$

Flow through each RST was calculated by multiplying the water velocity at the RST by the surface area of the RST opening. RST efficiency (i.e., catchability) was calculated as the proportion of the total adjusted number of individuals released that were recaptured. The mean length at release was used to statistically separate the releases by life-history stage. Thus, RST efficiencies were calculated for fry (mean length at release < 50 mm), parr (50 mm ≥ fork length < 65 mm) and smolts (≥ 65 mm).

For each life stage (s) at each RST (t), if sample-size sufficed, catchability (C_{tsi}) was regressed against percent of flow sampled (Φ_{ti}) during RST efficiency release i. Linear regression was used to estimate the slope of the line (m_{ts}), with the intercept forced through 0, as

$$C_{tsi} = (m_{ts} \cdot \Phi_{ti}) \qquad \text{(Eq. 2)}$$

Daily counts of fry, parr, and smolts were summed at each trapping location for all days the RSTs were sampled each year. The percent of the flow sampled was estimated for each day at each RST as described above. Missing velocity observations were interpolated from adjacent values. Instantaneous measurements of turbidity were also recorded daily at the RSTs, and daily average water temperatures were obtained from thermographs recording hourly deployed at or near each RST site.

To account for varying catchability, a four-stage process was used to estimate total fish passage (N) from catch numbers, as follows. First, proportional catch contributions (ρ_{jw}) were calculated for the three life stages for each week (w) as:

$$\rho_{tsw} = \frac{A_{tsw}}{\sum_s^3 A_{tsw}} \qquad \text{(Eq. 3)}$$

Where

$$A_{tsw} = \frac{\sum_d^7 O_{tswd}}{\left(m_{ts} \cdot \frac{\sum_d^7 \Phi_{twd}}{7}\right)} \qquad \text{(Eq. 4)}$$

and where O_{tswd} was the observed catch of life stage s at RST t on day d in week w, and Φ_{twd} was the percent flow sampled by RST t on day d in week w. Average catchability was then calculated for each day at each RST, weighted by the proportional life-stage-specific catch contributions, as:

$$\overline{C_{twd}} = \sum_s^3 \left[\, \rho_{tsw} \cdot (m_{ts} \cdot \Phi_{td}) \,\right] \qquad \text{(Eq. 5)}$$

Third, daily total Chinook salmon passage was calculated by dividing total observed catch (of all life stages combined) by the weighted average catchability:

$$N_{twd} = \frac{\sum_s^3 O_{tswd}}{\overline{C_{twd}}} \qquad \text{(Eq. 6)}$$

Lastly, the daily total Chinook salmon passage was partitioned into the three life stages, based on the proportional catch rates from Equation 3:

$$N_{tswd} = N_{twd} \cdot \rho_{tsw} \quad \text{(Eq. 7)}$$

If total fish passage on a given day was below the level of measurement error (i.e., the inverse of catchability for that day), this method produced passage estimates of zero fish.

Missing abundance estimates (*Ni*, number of fish on day *i*) for non-sample days were interpolated using the following formula:

$$N_i = e^{\frac{\sum_{j=1}^{5}[6-j]\left[\ln\left(N_{i-j}+1\right)+\ln\left(N_{i+j}+1\right)\right]}{\sum_{j=1}^{5} 2(6-j)}} - 1 \ .$$

The interpolation is an average of the previous and subsequent 5 observations, weighted stronger toward the adjacent days, and weaker as the number of days increases away from the missing value. If any of the 5 previous or 5 subsequent days also had missing values, they were excluded from the calculation (i.e., the interpolation was based on fewer observations). The interpolation formula was used to separately calculate the fry, parr and smolts from adjacent life-stage-specific values; and the interpolated values for the three life stages were summed to calculate total catch for the missed day.

RESULTS AND DISCUSSION

Chinook Salmon

Number of Unmarked Chinook Salmon Captured

The fall-run juvenile salmon outmigration in the San Joaquin Basin typically occurs during the winter and spring, largely during the months January through May. The outmigration consists primarily of fry in winter (typically <50 mm fork length), and smolts in spring (typically >65 mm fork length). It is not uncommon to observe some larger fish migrating in winter and some fry migrating in late spring. These fish may be the progeny of individuals that spawned outside the reproductive period typical of fall-run Chinook salmon.

During 2014, daily catches of juvenile salmon at Waterford ranged from zero to 939 fish (Figure 4), with a total catch of 12,358 salmon (Table 2). Catches of juvenile Chinook salmon at Waterford were highest from mid-February to mid-March (peaking on March 2), and 90% consisted of fry (<50 mm; Figure 4). Daily salmon catch during this period was variable and did not correlate with trends in flow or turbidity, which were both low and relatively stable (Figure 4). During late-April, catches increased in response to brief pulse flow spikes[5] of approximately 900 cfs and 1,400 cfs.

[5] The flow peaked for approximately 24 hours and spanned two calendar days. Daily average flows do not reflect the maximum peak flow.

Conditions at the Grayson RSTs were not ideal for effective rotary screw trap sampling for the duration of the 2014 outmigration period. During the fall of 2013, extensive water hyacinth growth was observed throughout the lower Tuolumne River. As the water hyacinth died off during the winter months, massive amounts of the dead debris accumulated in the RSTs daily causing them to stop spinning whenever the RSTs were not monitored continuously. As water temperatures increased, new water hyacinth growth blanketed the river causing even more debris to accumulate in the RSTs. Sampling effort was increased to at least two RST checks per day during most of the season at base flow conditions and to 24-hours a day during the spring pulse period. Unfortunately, even with increased effort, the RSTs were usually stopped when the crews arrived at the sampling site (i.e., 75% of days sampled, traps were stopped). Even with continuous monitoring, crews were often unable to keep up with the massive amounts of debris stopping the traps during the spring pulse period. The traps were raised for a brief period on the evening of April 30 and then for the season on May 2 when conditions were no longer safe for the crews to be on the traps. The average total number of revolutions the cone completed in a 24-hour period was 50-70% less in 2014, when compared to years with similar flow. If the RSTs were not spinning, they were not capturing fish as they passed downstream of the RSTs, and fish previously captured may have also been able to swim out of the RST before they were processed. Based on the challenges faced while sampling the Grayson RSTs this year, it is highly likely that the number of Chinook captured is an underestimate of the number of Chinook salmon passing the Grayson RSTs in 2014.

At Grayson, daily catches of juvenile salmon ranged from zero to 2 fish (Figure 5), with a total catch of 8 juvenile salmon captured (Table 2). Four of the eight (50%) juvenile salmon captured at Grayson during 2014 were smolts, and all were captured during the pulse flow period in late-April (Figure 5).

Table 2. Catch by lifestage at Waterford and Grayson, 2014.

Trapping Site	***Fry (<50 mm)***	***Parr (50-65 mm)***	***Smolt (≥ 65 mm)***
Waterford	10,441	1,335	582
Grayson	1	3	4

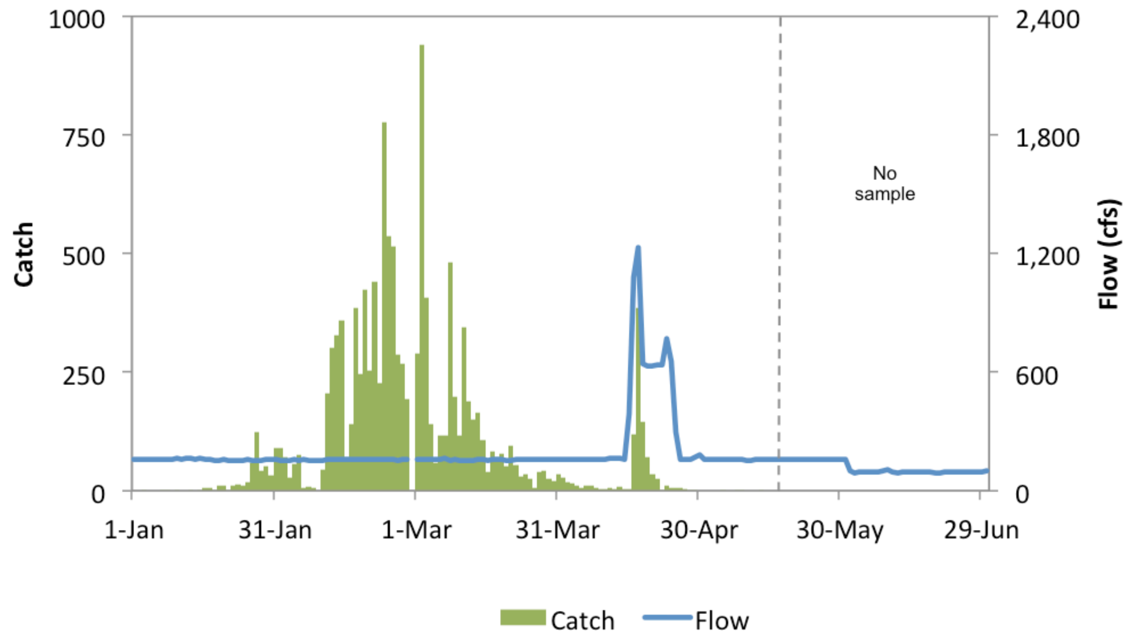

Figure 4. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2014. Note: Maximum peak flow during the spring pulse period is not reflected in the daily averages.

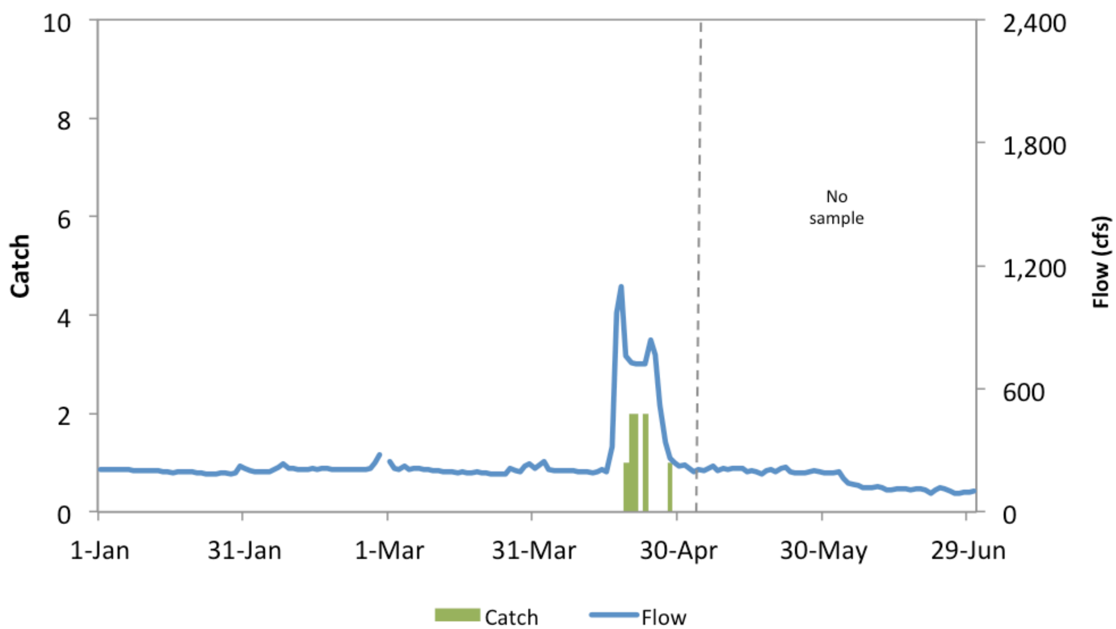

Figure 5. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2014. Note: Maximum peak flow during the spring pulse period is not reflected in the daily averages.

RST Efficiency Releases

Twenty RST efficiency releases were conducted during 2014 at Waterford using naturally produced (19 groups) and hatchery produced (one group) salmon fry and parr. Resulting efficiency estimates from these releases ranged from 3.2% to 21.4% at flows (La Grange) between 160 cfs and 166 cfs (Table 3). Results from RST efficiency releases at Waterford from 2006-2014 were used to derive the linear regression model for estimating Chinook abundance, and the observed efficiencies ranged from 0% to 34.4% at flows (La Grange) between 160 cfs and 8,870 cfs (Table 3; Figure 6 and Figure 7). Previous years' abundance estimates were adjusted based on the updated linear regression model (Table 1 and Table 5).

Ten RST efficiency releases were conducted during 2014 at Grayson using hatchery produced salmon fry and parr. The first five releases (all three fry release and two parr releases) were excluded entirely from this analysis because water hyacinth hampered operations of the trap. Efficiency estimates from the remainder of the parr releases ranged from 1.9% to 7.1% at flows (Modesto) between 195 cfs and 209 cfs (Table 3). The current linear regression model only includes data from fry and smolt efficiency releases and not parr releases due to an inadequate sample size for parr. Since there are not enough data to develop a robust regression curve for parr, the model currently uses an average of the fry and smolt slopes to estimate efficiencies for parr. Results from fry and smolt RST efficiency releases at Grayson from 1999-2008, and 2011, were used to derive the linear regression model for estimating Chinook abundance, and the observed efficiencies ranged from 0% to 21.2% at flows (Modesto) between 190 cfs and 7,942 cfs (Table 4; Figure 8 and Figure 9). Previous years' abundance estimates were adjusted based on the updated linear regression model (Table 1 and Table 5).

Daily catch, predicted catchability, and estimated passage at Waterford and Grayson during 2014 are provided in Appendices A and B, respectively.

Table 3. RST efficiency results from 2014 used to update the linear regression model at Waterford.

Release Date	Origin	Mark[a]	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) LGN
1/28/14	Wild	CFO	116	12	10.3%	36.5	37.0	161
1/29/14	Wild	CFO	38	3	7.9%	36.7	36.7	162
2/3/14	Wild	CFO	38	6	15.8%	37.0	35.5	160
2/6/14	Wild	CFO	52	10	19.2%	36.9	37.1	161
2/11/14	Wild	CFO	35	6	17.1%	36.6	36.0	162
2/12/14	Wild	CFO	189	18	9.5%	37.1	37.6	161
2/17/14	Wild	CFO	57	7	12.3%	37.3	34.4	163
2/18/14	Wild	CFO	295	28	9.5%	37.0	37.3	164
2/22/14	Wild	CFO	300	34	11.3%	35.7	37.7	161
2/24/14	Wild	CFO	290	62	21.4%	38.3	36.6	161
2/25/14	Wild	CFO	298	57	19.1%	36.5	36.6	162
3/3/14	Wild	CFO	297	14	4.7%	37.2	37.2	164

Release Date	Origin	Mark[a]	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) LGN
3/7/14	Wild	CFO	114	11	9.6%	37.6	40.0	166
3/10/14	Wild	CFO	116	13	11.2%	42.3	38.2	161
3/11/14	Wild	CFO	95	8	8.4%	37.9	35.6	161
3/19/14	Wild	CFO	56	8	14.3%	43.9	43.1	162
3/25/14	Wild	CFO	26	2	7.7%	46.3	40.0	163
4/3/14	Hatchery	BCO	201	9	4.5%	52.2	49.3	164
4/3/14	Wild	DCO	31	1	3.2%	63.9	56.0	164
4/10/14	Wild	CFO	199	8	4.0%	53.9	52.8	165

[a]Mark codes: CFO = caudal fin orange; BCO = bottom caudal fin orange; and DCO = double orange mark on caudal fin

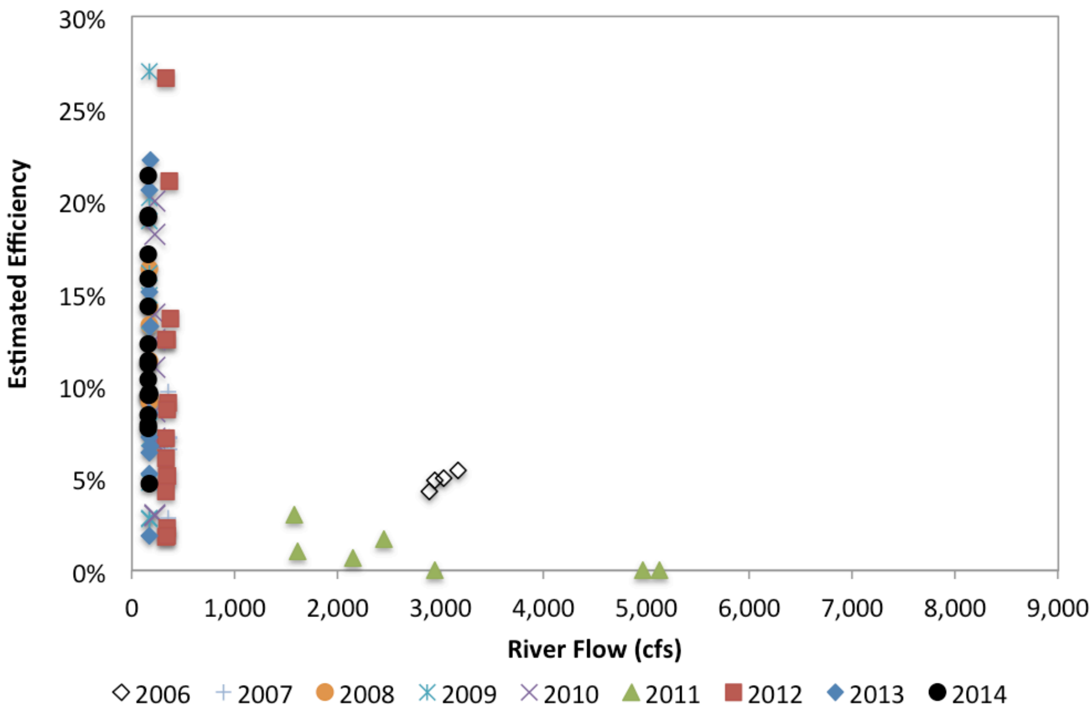

Figure 6. RST fry efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2006-2014.

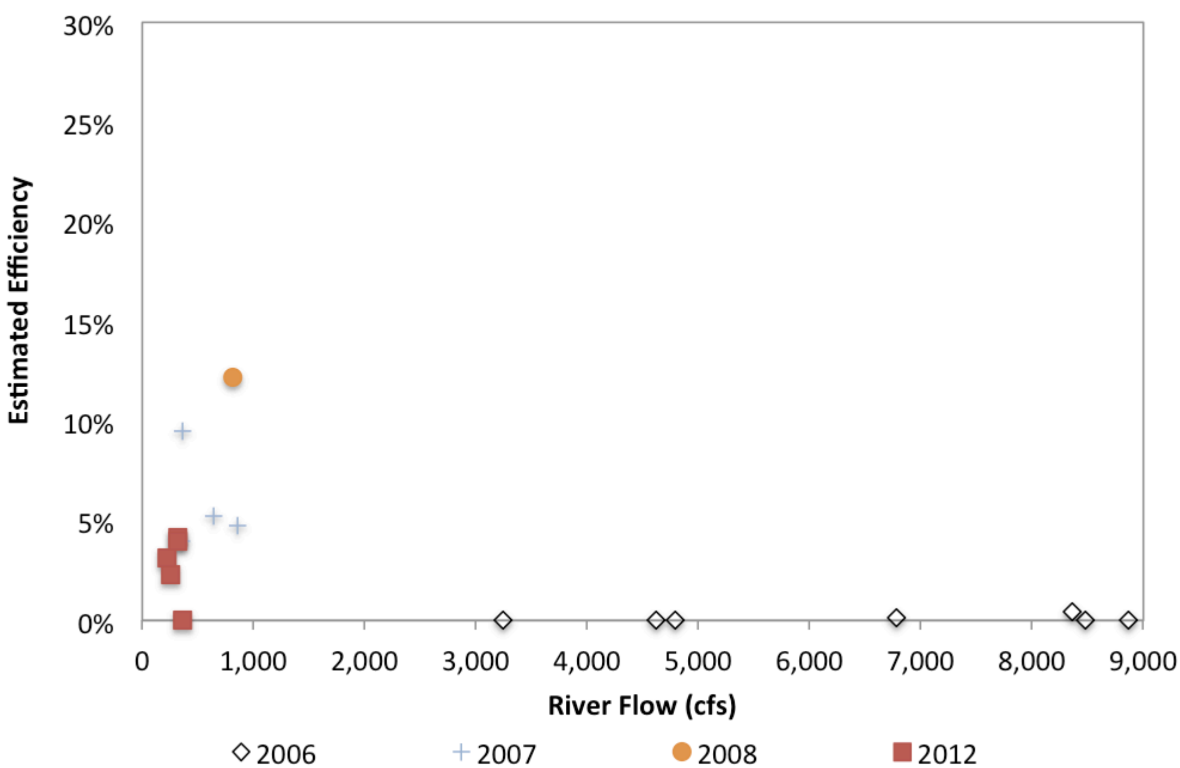

Figure 7. RST smolt efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2006-2014.

Table 4. RST efficiency results from 2014.

Release Date	Origin	Mark[1]	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) LGN
3/13/14[2]	Hatchery	CFP	500	1	0.2%	52.8	49.0	195
3/14/14[2]	Hatchery	CFP	594	1	0.2%	52.6	55.0	193
3/20/14[2]	Hatchery	TCP	579	7	1.2%	47.8	50.1	192
3/21/14[2]	Hatchery	BCP	385	1	0.3%	47.2	53.0	190
3/27/14[2]	Hatchery	BCP	498	59	11.8%	49.7	50.4	202
3/28/14	Hatchery	TCP	470	9	1.9%	50.6	47.4	197
4/3/14	Hatchery	TCP	626	30	4.8%	52.1	53.3	209
4/4/14	Hatchery	BCP	396	28	7.1%	53.9	52.5	200
4/10/14	Hatchery	TCP	398	21	5.3%	55.2	53.5	195
4/10/14	Hatchery	BCP	422	16	3.8%	54.6	51.8	195

[1]Mark codes: CFP = caudal fin pink; TCP = top caudal fin pink; and BCP = bottom caudal fin pink.
[2]Releases were excluded from analyses because water hyacinth hampered trap operations.

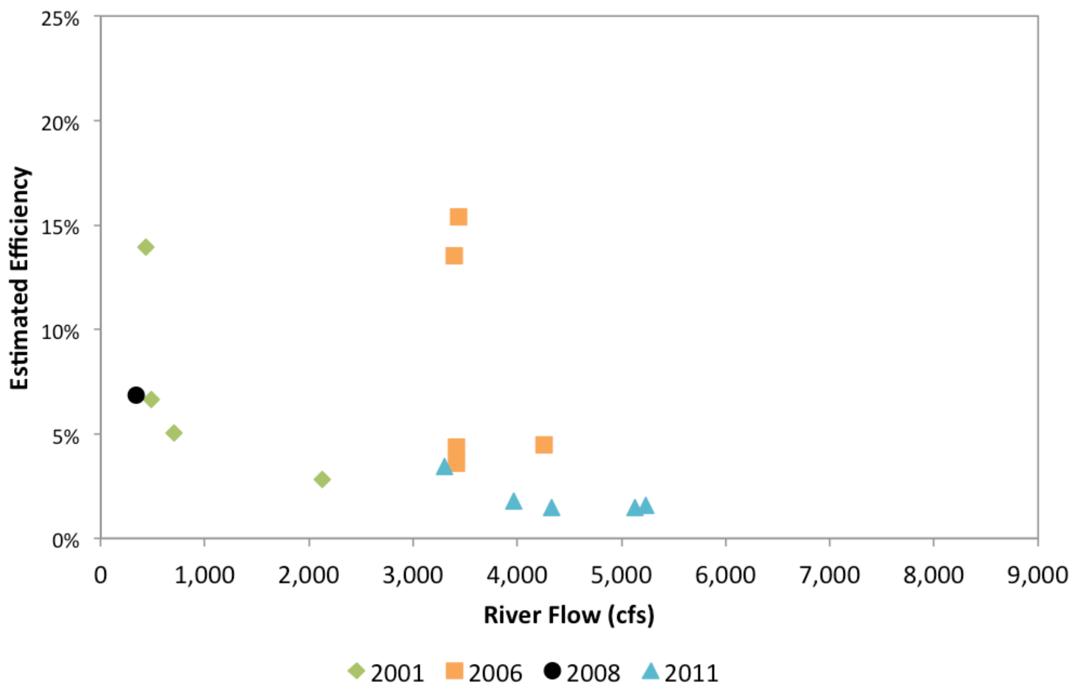

Figure 8. RST fry efficiency observations at Grayson relative to river flow at Modesto (MOD), 2011, 2006, 2008, and 2011.

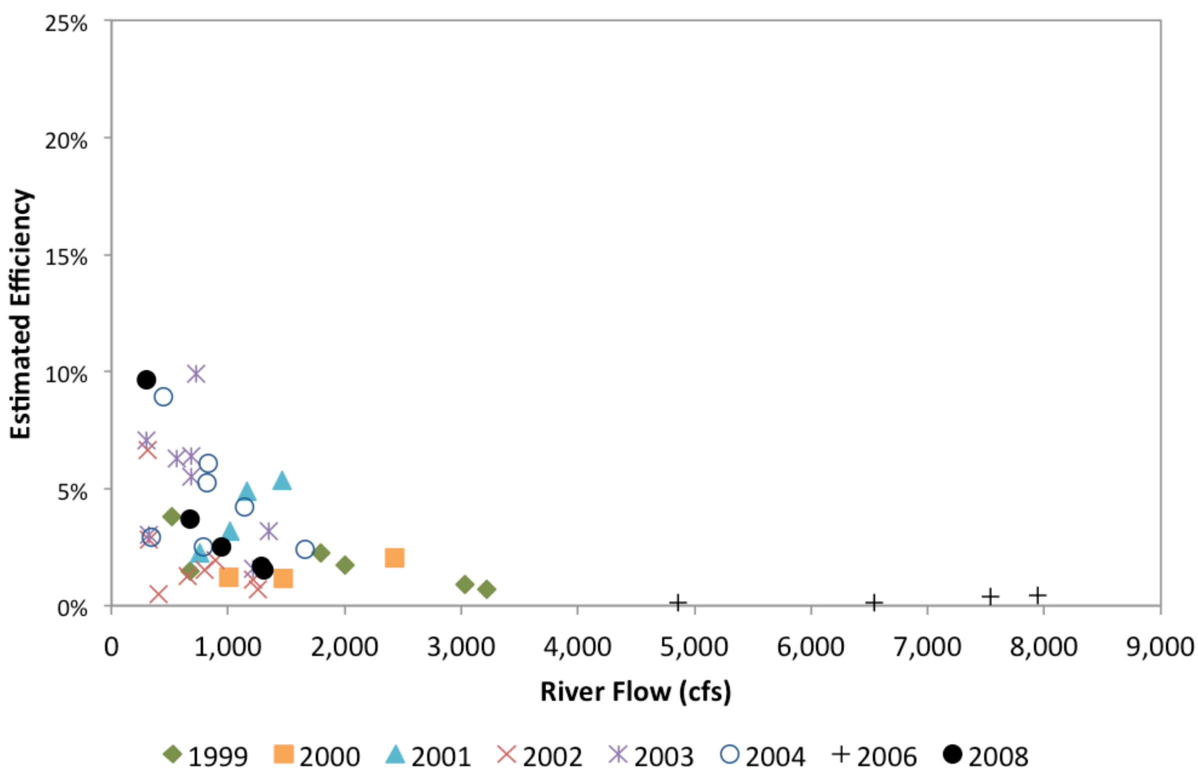

Figure 9. RST smolt efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2004, 2006, and 2008.

Estimated Chinook Salmon Abundance

Based on daily passage estimates, an estimated 137,013 Chinook salmon passed Waterford during 2014, of which 65.3% were fry (Table 5). In 2014, as in previous years, a majority of the salmon observed passing Waterford prior to mid-March were fry; passage was then dominated by smolts from late-March through mid-May (Table 5; Figure 10). The peak in daily passage for fry occurred on March 2, and smolt passage peaked on April 17 (Figure 10). Daily estimated Chinook salmon passage at Waterford ranged from 0 to 19,122. In previous years sampled at Waterford (i.e., 2006-2014), total estimated passage ranged from as high as 518,669 in 2006, to as low as 41,067 in 2013 (Figure 11). The proportion of passage as smolts ranged from 17.9% in 2014 to 84% in 2010 (Table 5). In 2006, sampling efforts were affected by high spring flows resulting in passage estimates that were likely underestimated (particularly for smolts).

An estimated 211 unmarked Chinook salmon passed the Grayson RST during 2014 and of these, 9% were fry, 34.6% were parr, and 56.4% were smolts (Table 5). Daily estimated passage at Grayson ranged from 0 to 74 salmon. Peak daily passage for smolts occurred on April 23 (Figure 12). It is reasonable to assume the estimated abundance for 2014 (based on only 8 salmon captured) is likely underestimated based on the challenges with sampling at the Grayson RSTs in 2014. Further, sampling in 2014 was incomplete for both the fry and smolt lifestage with less than 65% of the entire outmigration season sampled (i.e., January 27-May 2). In 1998, sampling was initiated in mid-February, but extended through the end of the outmigration period (i.e., May 31). In previous years at Grayson, when the entire outmigration period was sampled (i.e., winter/spring sampling in 1999-2002, 2006, and 2008-2013), total estimated passage ranged from a high of 852,711 in 1999 to a low of 642 in 2013 (Table 1; Figure 13). The proportion of passage as smolts was the highest in 2013 (98%) and the lowest in 1999 (3.2%). In spring-only sampling years at Grayson/Shiloh (i.e., 2003-2005 and 2007 at Grayson and 1995-1997 at Shiloh), total estimated passage ranged from a high of 112,788 in 2005 to a low of 952 in 2007 (Table 1; Figure 13). The majority of migrants in all spring-only years were smolts (≥95.0%; Table 5). Among all years, estimated passage was the highest during 1998 (Table 1; Figure 13), when sampling effort was intermediate, and the proportion passing as smolts was low (5.7%). However, the 1998 passage estimate of 1,615,673 fish may be inflated and the proportion passing as smolts may be underestimated because no RST efficiency tests were conducted with fry. In 1998, estimates for RST efficiency were only conducted for smolts, which were subsequently applied to other life stages. The use of the smolt-specific (i.e., low) capture probability to extrapolate on fry captures may result in drastic overestimation of fish passage.

Juvenile Chinook salmon sampled in the 2014 RST operation were the progeny of an estimated 3,664 adult Chinook salmon (1,864 females) that spawned in the fall of 2013 (Becker et al. 2014). During the 2013-14 spawning season, approximately 74 juveniles were produced per female spawner, based on the estimated 1,864 female spawners, and the total estimated passage at the Waterford RST. This is low compared to the number of juveniles per female produced between 2006-2011 (range: 190-1,151), but similar to the number produced between 2012-2014 (range: 51-89; Table 6).

Table 5. Estimated passage by lifestage at Waterford and Grayson during 1995-2014.

		Sampling Period	Fry		Parr		Smolts		Total
			Number	%	Number	%	Number	%	
Waterford	2006	w/s	332,870	65.9%	16,592	3.2%	169,238	30.9%	518,699
	2007	w/s	12,921	25.5%	5,094	9.6%	35,473	64.9%	53,487
	2008	w/s	18,347	37.7%	1,967	4.0%	28,364	58.3%	48,677
	2009	w/s	18,016	33.6%	7,453	13.7%	29,708	52.7%	55,178
	2010	w/s	10,913	15.2%	1,070	1.5%	62,854	83.3%	74,836
	2011	w/s	292,973	79.3%	5,804	1.5%	76,688	19.2%	375,465
	2012	w/s	30,804	49.8%	7,720	12.3%	24,592	37.9%	63,116
	2013	w/s	21,951	54.6%	2,011	4.9%	17,098	40.5%	41,060
	2014	w/s	89,411	66.0%	23,137	16.8%	24,465	17.2%	137,013
Shiloh	1995	spring	-	-	-	-	22,067	100%	22,067
	1996	spring	-	-	-	-	16,533	100%	16,533
	1997	spring	-	-	-	-	1,280	100%	1,280
	1998	intermediate	1,196,625	74.1%	327,422	20.3%	91,626	5.7%	1,615,673
Grayson	1999	w/s	814,286	95.5%	11,534	1.4%	26,890	3.2%	852,711
	2000	w/s	74,473	59.7%	9,533	19.9%	40,759	32.7%	124,765
	2001	w/s	118,459	72.2%	16,681	25.0%	28,955	17.6%	164,095
	2002	w/s	80	0.6%	483	41.0%	12,549	95.7%	13,111
	2003	spring	19	0.2%	174	1.5%	11,081	98.3%	11,273
	2004	spring	79	0.3%	800	4.1%	22,677	96.3%	23,556
	2005	spring	-	-	236	0.2%	112,553	99.8%	112,788
	2006	w/s	47,516	54.0%	2,415	2.8%	34,872	41.1%	84,802
	2007	spring	-	-	-	-	952	100%	952
	2008	w/s	1,246	39.2%	25	0.8%	1,744	57.8%	3,016
	2009	w/s	57	1.3%	138	3.2%	3,877	95.2%	4,072
	2010	w/s	92	4.1%	0	0%	1,964	95.5%	2,056
	2011	w/s	70,815	72.9%	2,125	2.3%	21,955	23.1%	94,895
	2012	w/s	72	2.9%	10	0.4%	2,186	96.4%	2,268
	2013	w/s	6	0.9%	7	1.0%	629	98.0%	642
	2014	w/s	19	8.5%	73	33.9%	119	56.4%	211

Table 6. Estimated number of juvenile salmon at Waterford produced per female spawner, 2006-2014.

Outmigration Year	Females[6]	Juveniles/female spawner
2006	478	1,085
2007	282	190
2008	80	608
2009	212	260
2010	87	860
2011	326	1,151
2012	712	89
2013	806	51
2014	1,864	74

[6] Based on estimated abundance and gender ratios from carcass surveys during 2005-2008 (Blakeman 2006-2008; O'Brien 2009), and number of female Chinook salmon observed (excluding salmon of undetermined gender) at the Tuolumne River weir during 2009-2013 (Becker et al., 2014; Wright et al., 2013; Cuthbert et al., 2012; Becker et al 2011, Cuthbert et al., 2010).

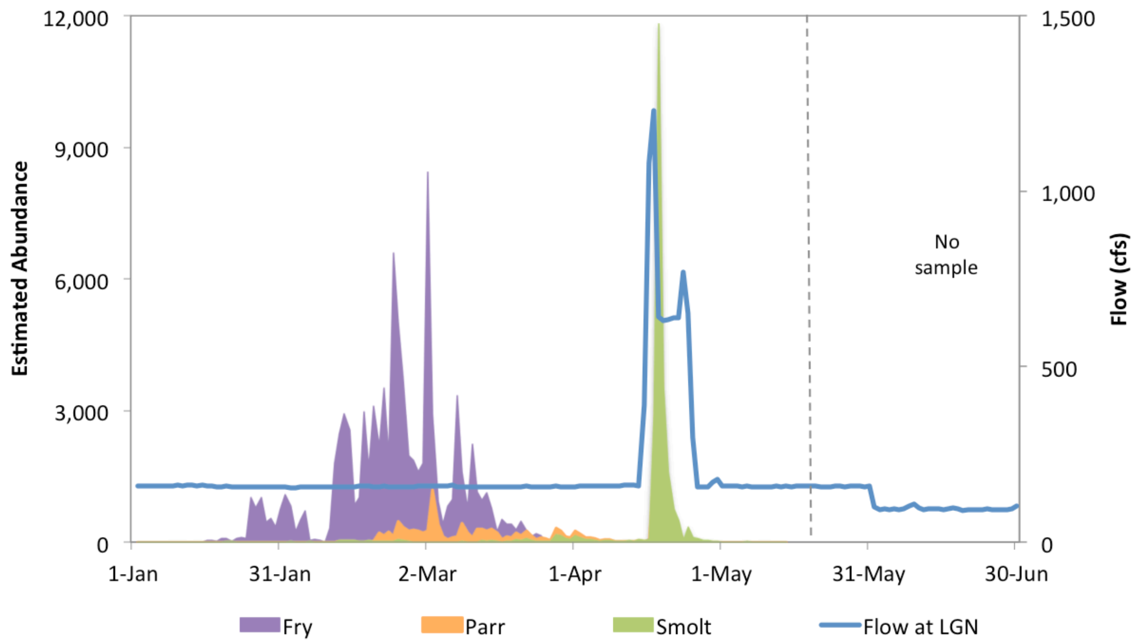

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2014.

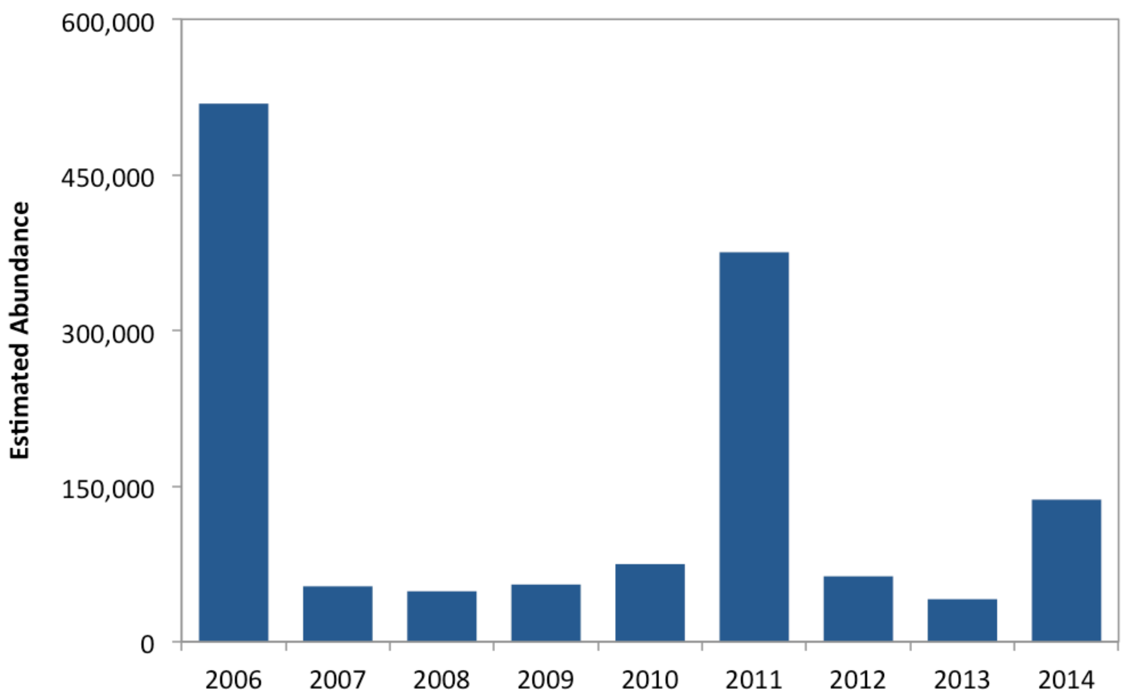

Figure 11. Total estimated Chinook passage at Waterford, 2006-2014.

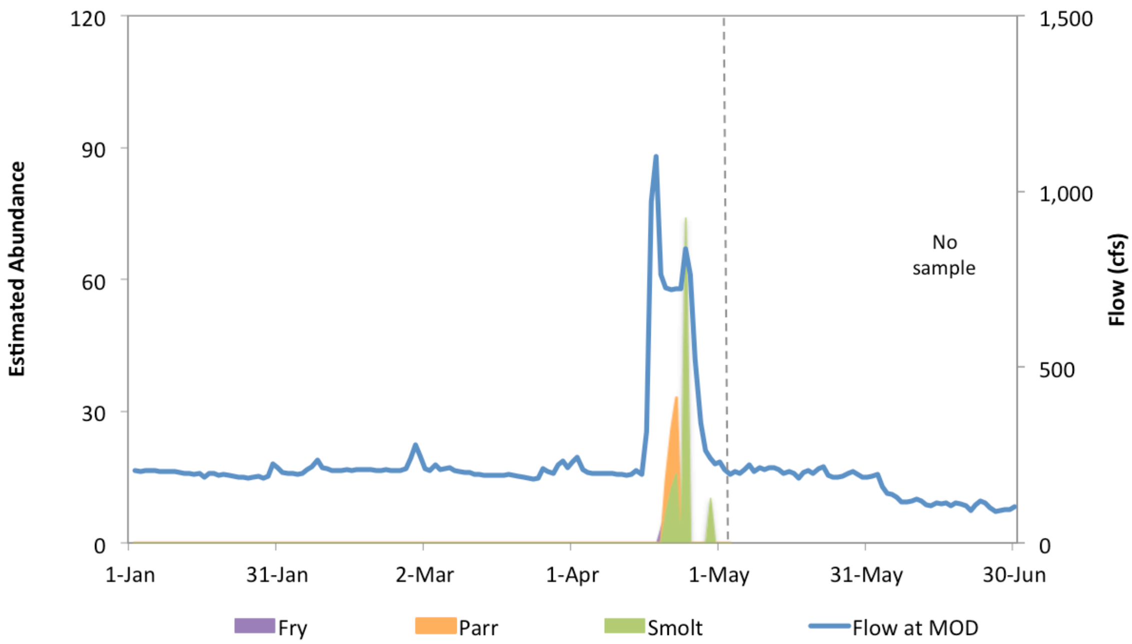

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2014.

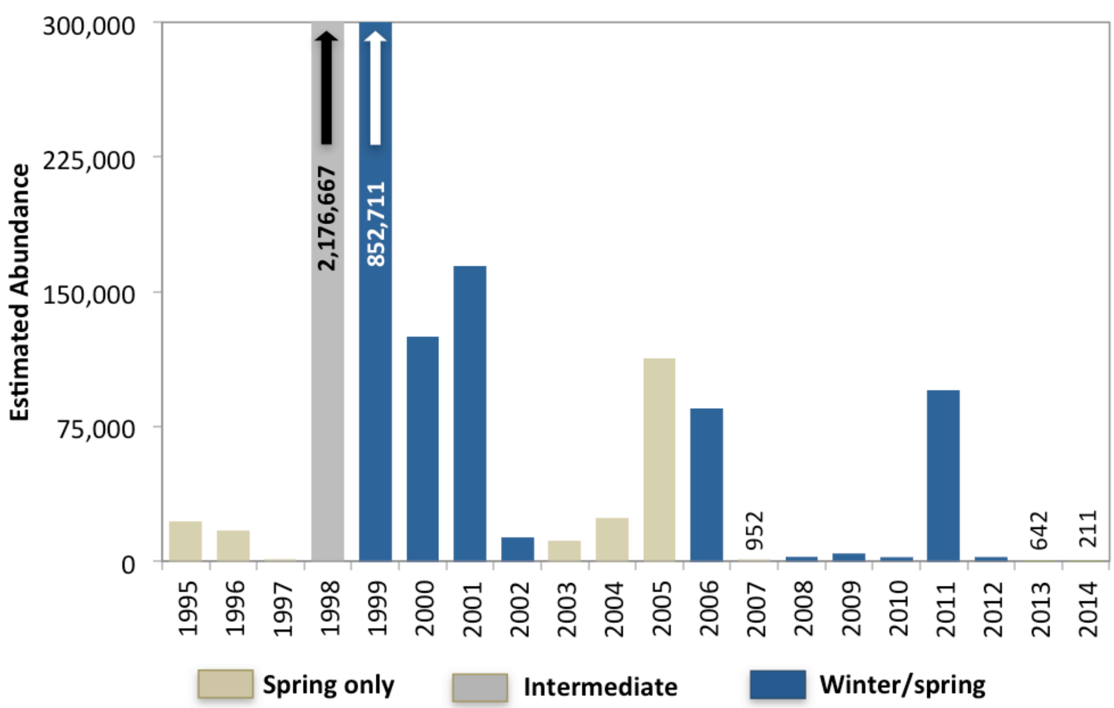

Figure 13. Total estimated Chinook passage at Shiloh and Grayson during 1995-2014. The color of the column defines the sampling period for that year.

Estimated Chinook Salmon Abundance and Environmental Factors

Discharge in the Tuolumne River, downstream of La Grange Dam, was approximately 160 cfs during January through mid-April. During this time there were no obvious correlations between peaks in salmon passage and changes in flow, rainfall, or turbidity at Waterford. River flow near Grayson during this period was slightly more variable as a result of storm run-off early in the season, particularly from Dry Creek, and ranged from 182 cfs to 279 cfs at Modesto. There were no passages detected at Grayson during this time.

Between April 15 and April 25 there were two short pulse flows designed by the U.S. Fish and Wildlife Service (USFWS) to mimic the natural run-off pattern in the Tuolumne River prior to impoundment. Peaks in daily average flow during the spring pulse period ranged from 1,213 cfs (maximum hourly peak: 1,400 cfs) on April 17 to 776 cfs (maximum hourly peak 900 cfs) on April 23. Following the pulse period, flows decreased to approximately 160 cfs through the end of May, then decreased to 100 cfs by early June. Peaks in smolt migration activity were observed at both the Waterford and Grayson RSTs in response to the spring pulse flows (Figure 10 and Figure 12).

During 2014, daily average water temperatures ranged from 47.5°F to 74.3°F at the Waterford RST (Figure 14) and from 47.2°F to 74.7°F at the Grayson RSTs (Figure 15). Water temperatures generally increased throughout the outmigration season. There were no obvious correlations between trends in fry passage and water temperature during 2014 (Figure 14), but smolt passage appeared to peak when temperatures decreased slightly as a result of the pulse flows at both RSTs during the spring (Figure 14 and Figure 15).

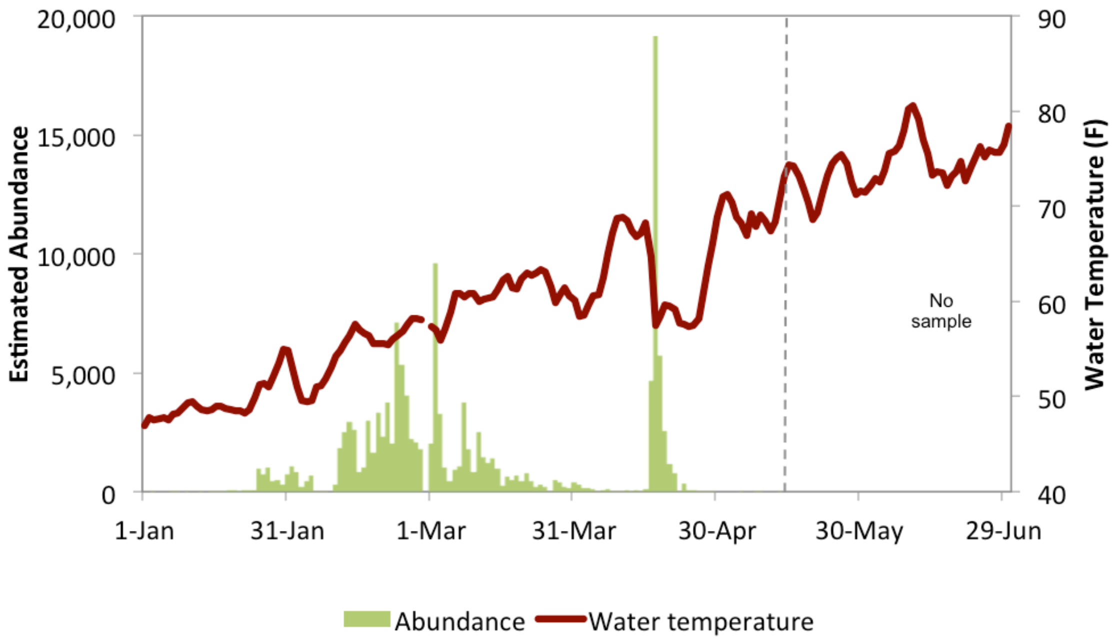

Figure 14. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Waterford RST during 2014.

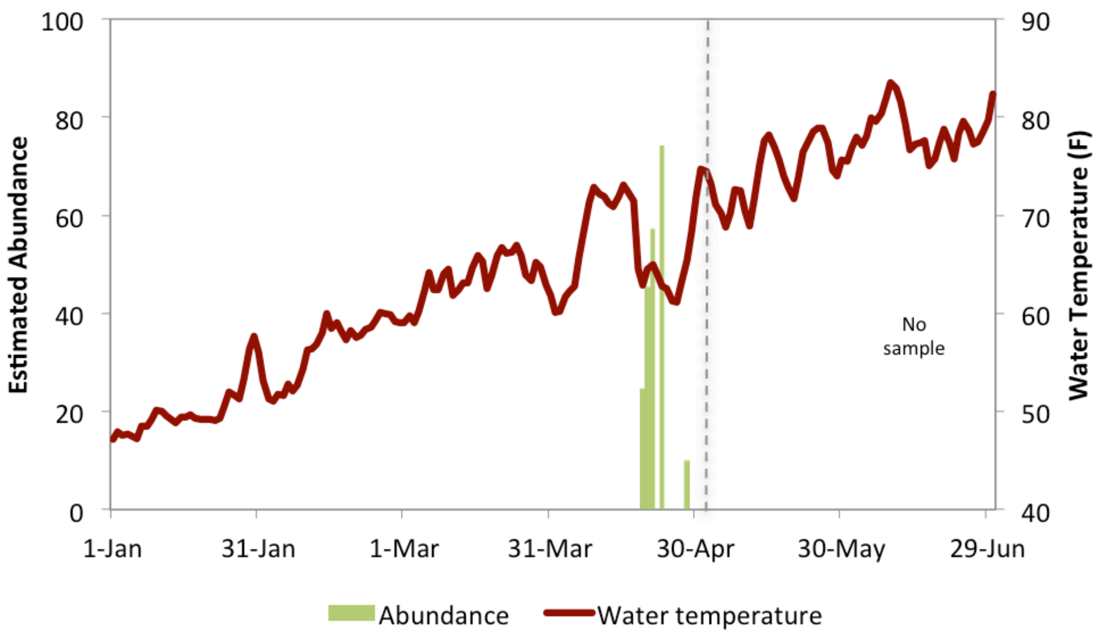

Figure 15. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Grayson RST during 2014.

Background turbidity was generally less than 5.0 NTU at Waterford (Figure 16) and less than 10 NTU at Grayson (Figure 17) during the 2014 monitoring period. Smolt passage peaked at Waterford as turbidity increased to as much as 15.2 NTU following the initial change in flow during the spring pulse period (Figure 16). There was no obvious increase in turbidity at Grayson following the initial spring flow increase but a peak in smolt passage was observed (Figure 17) during this time. Slight increases in turbidity (<15 NTU) were observed at Grayson following run-off events but no apparent increase in juvenile migration activity was observed during these events (Figure 18).

The ratio of estimated total passage at Grayson relative to the estimated total passage at Waterford provides an index of annual juvenile survival through the river between the sites (24.6 miles) during years when the majority of the outmigration period is sampled at both sites (2008-2013). Due to the issues associated with sampling at Grayson this past season, a survival estimate was not calculated for 2014. Total juvenile survival indices have ranged from a high of 25.3% in 2011 to a low of 1.6% in 2013, and with the exception of 2011 have been lower than 8% (Table 7). During 2011, when heavy run-off and flood control releases resulted in flows approaching 7,500 cfs at Modesto, approximately 79% of juveniles passed Waterford as fry (Table 5) and an estimated 23% of the fry passing Waterford survived to pass Grayson (Table 7). In contrast, both the proportion of juveniles migrating as fry and the proportion of fry surviving to Grayson were substantially lower in years without flood control releases, with 15-66% (Table 5) migrating as fry and generally less than 1% estimated to have survived to Grayson (Table 7). Estimated fry survival was 6.5% in 2008 (Table 7), and a key difference between this year and other years without flood control releases was the occurrence of five run-off events from Dry Creek resulting in peak flows ranging from approximately 750 cfs to 1,700 cfs as measured at Modesto.

Using relative passage of Chinook salmon smolts, survival indices ranged from a high of 32.1% in 2011 to a low of 2.9% in 2007 (Table 7). Spring pulse flows, designed to stimulate salmon migration and improve juvenile survival out of the lower river, occur annually. In some years, such as 2011, spring flows are driven by flood control operations. With the exception of 2011, peak spring pulse flows measured at La Grange have ranged from approximately 900 cfs in 2007 to approximately 3,200 cfs in 2010 with no clear correlation between total smolt survival indices and peak pulse flow magnitudes (Table 7).

Analyses of event-specific smolt survival indices calculated from relative passage between Waterford and Grayson during discrete flow periods found positive relationships between survival and river flow measured at La Grange (Robichaud and English 2015). Further, abundance of smolts, duration of the pulse flow, and turbidity also appear to explain variations in the calculated survival indices. In 2012, a pulse flow of 2,100 cfs for approximately one week resulted in the highest smolt survival (18.7%) observed during any of the pulses in the 2007-2014 period. A similar, but lower magnitude pulse of approximately 1,000 cfs in 2009 resulted in an estimated smolt survival of 16.2% during the pulse flow event. During 2014, the majority (89%) of smolt migration occurred during a shaped pulse flow event with two descending peaks. Smolt response was highest when the first pulse of approximately 1,200 cfs occurred, and there was only a brief lower magnitude response to the subsequent lower magnitude pulse of approximately 775 cfs (Figure 10 and Figure 12).

Table 7. Survival indices through the lower Tuolumne River between Waterford and Grayson.

Year	Total Survival Index	Fry Survival Index	Peak Fry Daily Avg. Flow	Smolt Survival Index	Peak Smolt Daily Avg. Flow
2007	-	-	957	2.7	869
2008	6.2	6.8	1,690	6.1	1,310
2009	7.4	0.3	1,300	13.1	955
2010	2.7	0.8	767	3.1	3,300
2011	25.3	24.2	7,490	28.6	8,380
2012	3.6	0.2	599	8.9	2,120
2013	1.6	<0.1	510	3.7	1,190
2014	-[1]	-[1]	279	-[1]	1,230

[1] Survival index not calculated due to incomplete sampling at Grayson.

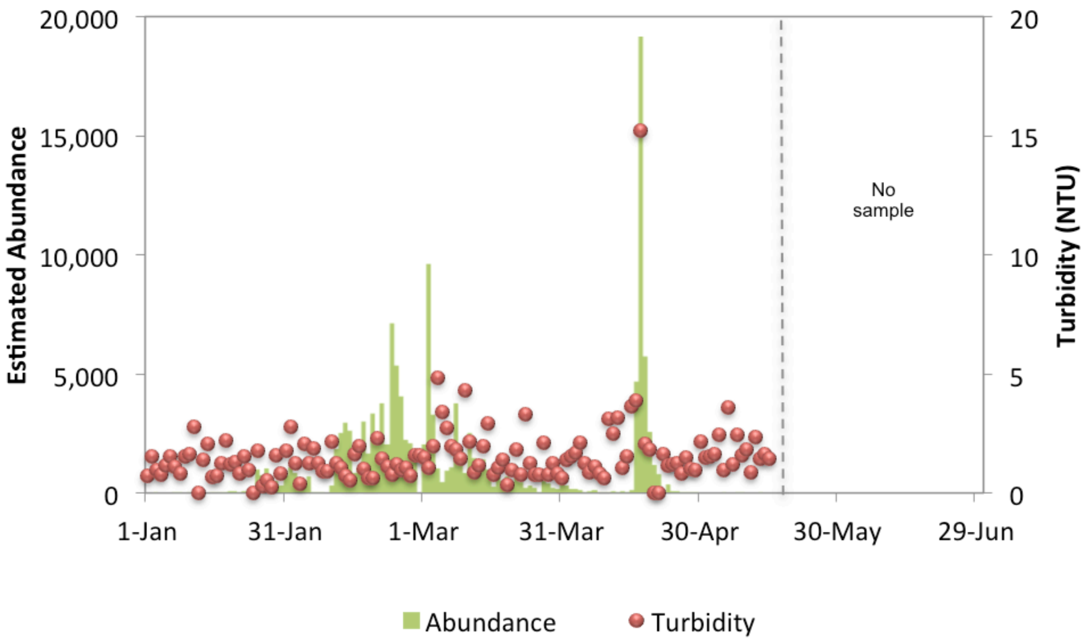

Figure 16. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2014.

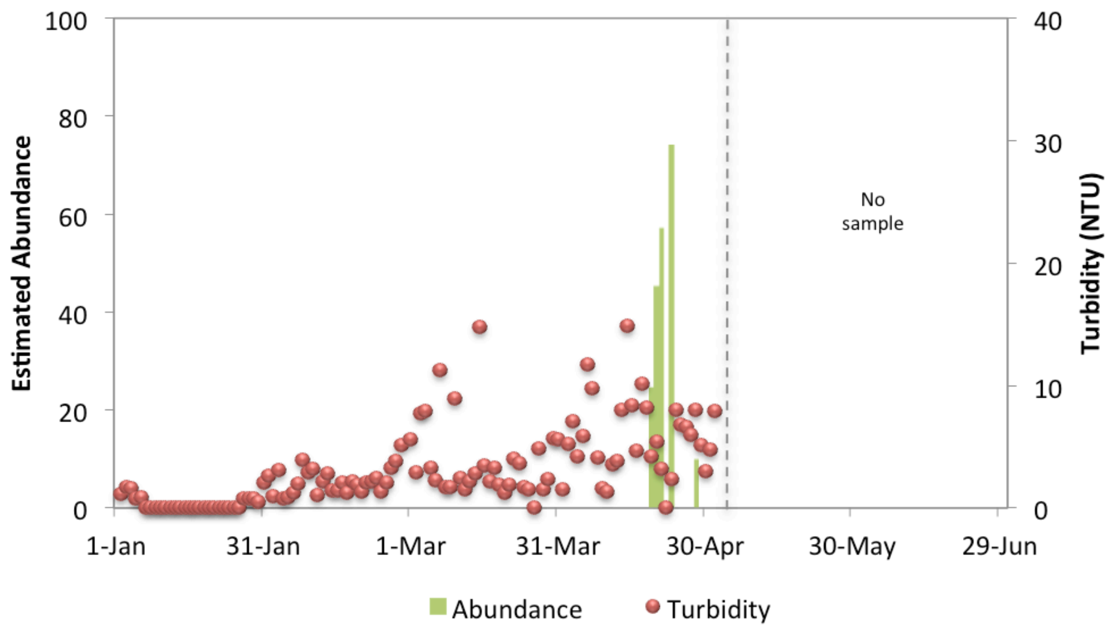

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2014.

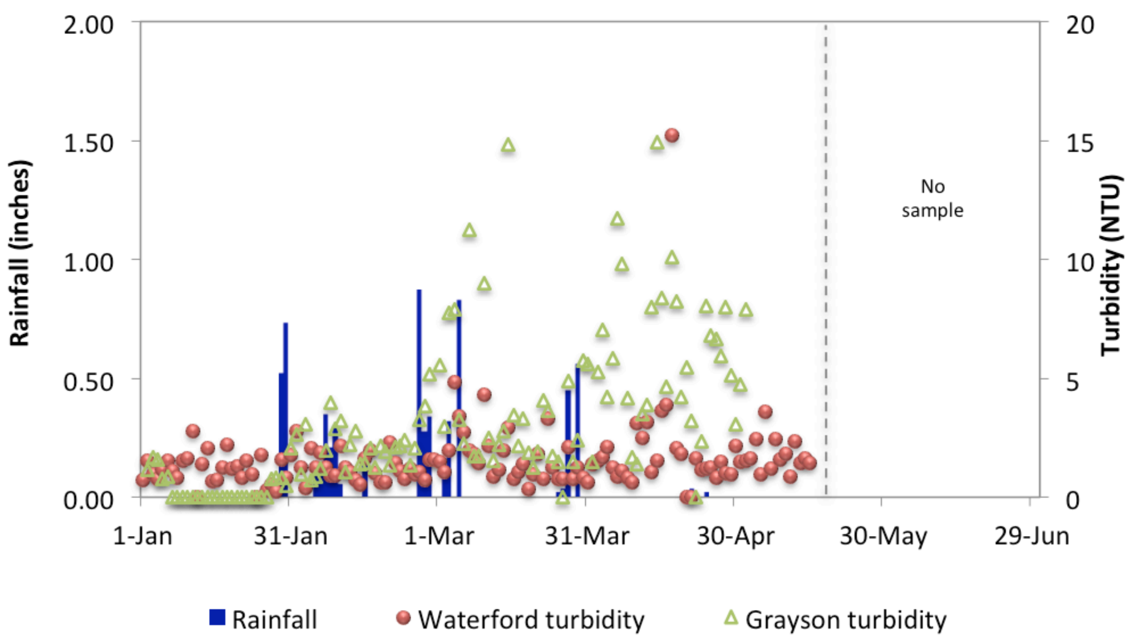

Figure 18. Daily rainfall measured at Don Pedro Reservoir and instantaneous turbidity at Waterford during 2014.

Chinook Salmon Length at Migration

Individual fork lengths of unmarked salmon captured at Waterford during 2014 ranged from 26 mm to 140 mm (Figure 19). Daily average length gradually increased from approximately 34 mm to 88 mm during the course of the sampling period (Figure 20). Most of the juvenile salmon passing Waterford during 2014 were fry measuring 30-39 mm (Figure 21). In total, it is estimated that 89,411 fry (<50 mm), 23,137 parr (50-65 mm), and 24,465 smolts (>65 mm) passed Waterford during 2014 (Table 5). Individual fork lengths of unmarked Chinook salmon captured at Grayson during 2014 ranged from 47 mm to 76 mm (Figure 22), and daily average length ranged between 50 mm and 75 mm during the sampling period (Figure 23). Approximately 56% of the salmon estimated to have passed Grayson during 2014 were smolts (Figure 24). In total, it is estimated that 19 fry (<50 mm), 73 parr (50-65 mm), and 119 smolts (>65 mm) passed Grayson during 2014 (Table 5).

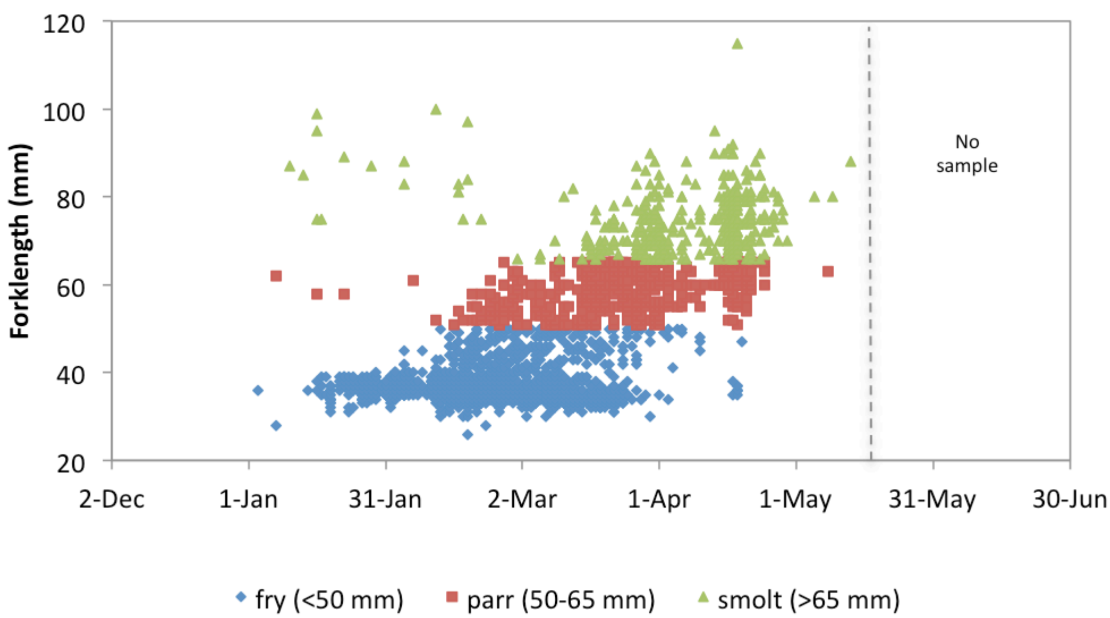

Figure 19. Individual fork lengths of juvenile salmon captured at Waterford during 2014.

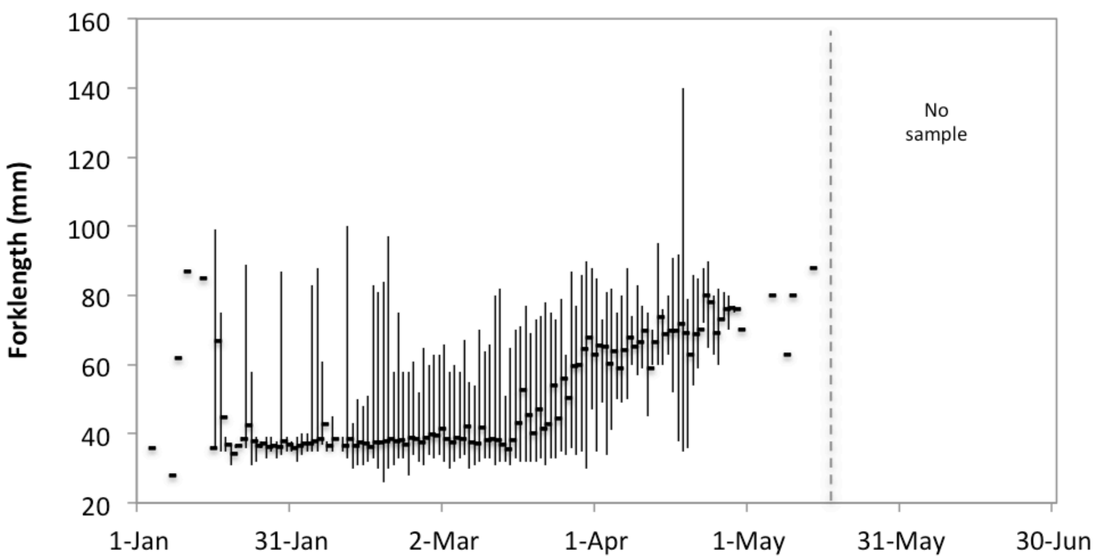

Figure 20. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2014.

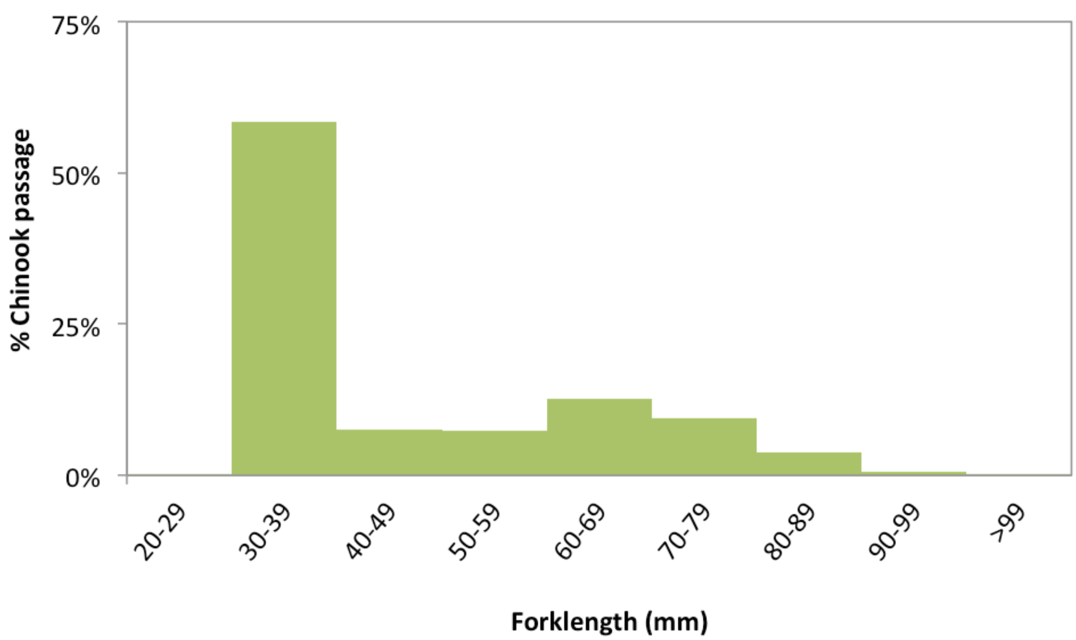

Figure 21. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Waterford during 2014.

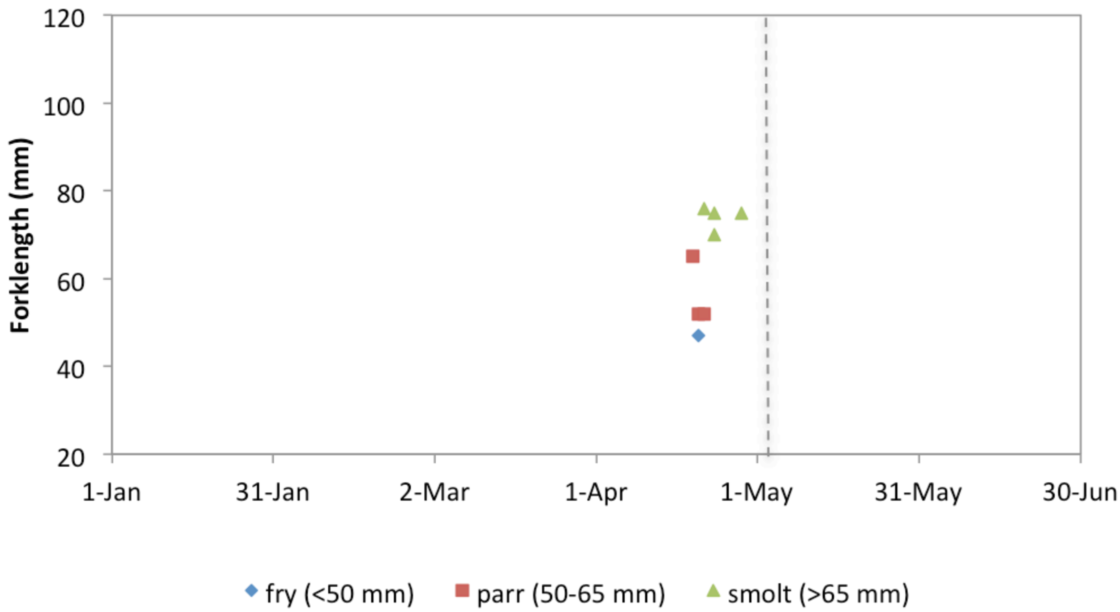

Figure 22. Individual fork lengths of juvenile salmon captured at Grayson during 2014.

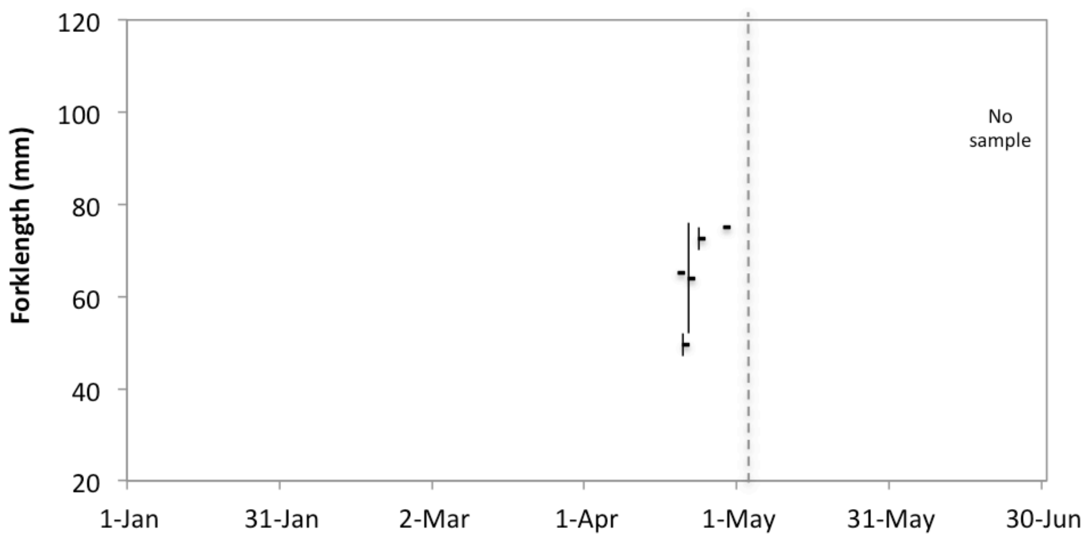

Figure 23. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2014.

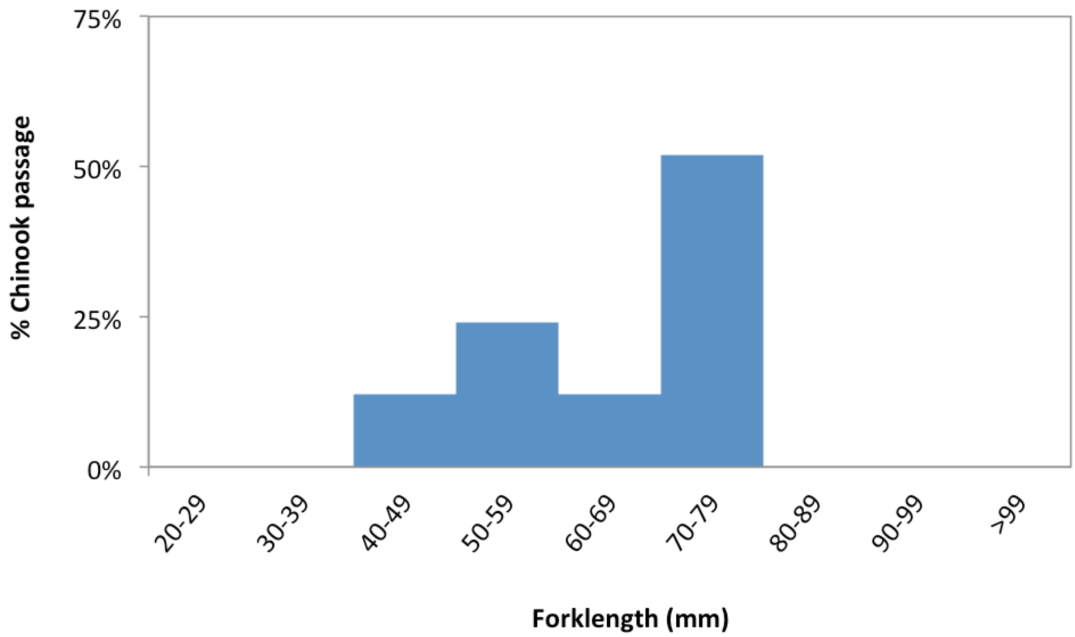

Figure 24. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Grayson during 2014.

Chinook Salmon Condition at Migration

Juvenile salmon captured at both Waterford and Grayson during 2014 appeared healthy without visually discernible signs of disease or stress. Length-weight relationships were similar between sites (Figure 25).

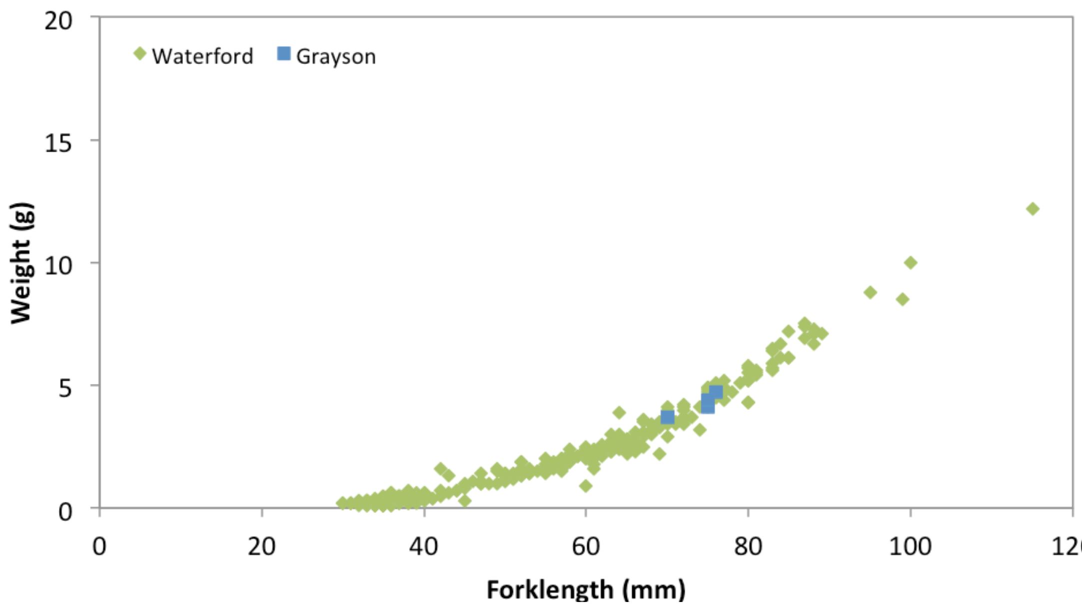

Figure 25. Length-weight relationship of juvenile Chinook salmon measured at Waterford and Grayson during 2014.

Oncorhynchus mykiss **(Rainbow Trout/Steelhead)**

Zero *O. mykiss* were captured at Waterford and Grayson in 2014. Total annual *O. mykiss* catch at the Grayson and Waterford RSTs between 2000 and 2014 ranged from 0 to 11 (Figure 26).

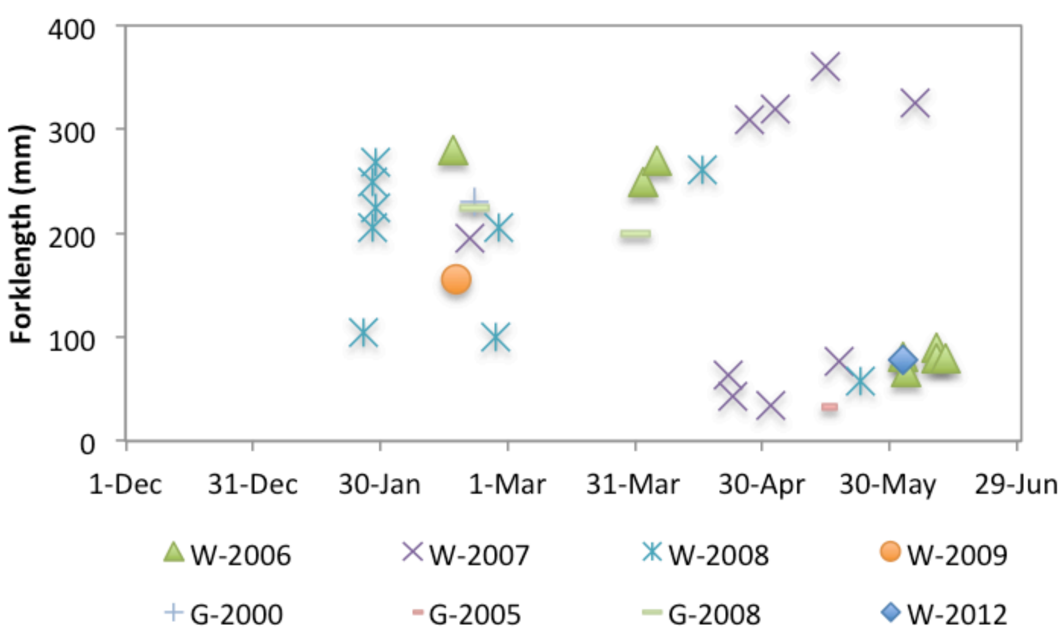

Figure 26. Date, size, and location of *O. mykiss* captured at Waterford (W) and Grayson (G).

Other Fish Species Captured

A total of 3,839 non-salmonids representing 21 species (5 native and 16 introduced) were captured during operation of the Waterford and Grayson RSTs in 2014 (Table 7; Appendices C and D). The same species were generally observed at both sites, with the exception of black crappie, hardhead, prickly sculpin, redear sunfish, and Sacramento sucker, which were only observed at Waterford. Black bullhead, brown bullhead, inland silverside, and red-eye bass were only observed at Grayson. Native species comprised 74% of the total combined (i.e., Waterford and Grayson) non-salmonid catch, consisting primarily of lamprey (n=2,811). Lampreys captured in the RSTs were primarily ammocoetes and were not identified to species or measured. No adult lamprey were captured at either trapping location.

Table 8. Non-salmonid species captured at Waterford and Grayson during 2014. Native species are indicated in bold.

			Waterford				Grayson			
	Common Name	Scientific Name	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Catfish Family										
	Black bullhead	*Ameiurus melas*	0	-	-	-	1	187	187	187
	Brown bullhead	*Ameiurus nebulosus*	0	-	-	-	3	54	127	167
	Channel catfish	*Ictalurus punctatus*	10	49	66	112	85	43	62	131
	White catfish	*Ictalurus catus*	135	40	90	320	177	35	76	290
	Unidentified catfish	Not applicable	0	-	-	-	3	53	53	53
Lamprey Family										
	Lamprey - unidentified	Not applicable	1650	-	-	-	1161	-	-	-
Livebearer Family										
	Mosquitofish	*Gambusia affinis*	25	27	34	49	33	18	30	48
Minnow Family										
	Golden shiner	*Notemigonus crysoleucas*	2	38	43	48	1	48	81	135
	Hardhead	*Mylopharodon conocephalus*	3	103	264	350	0	-	-	-
	Hitch	*Lavinia exilicauda*	2	41	68	95	2	47	70	93
	Sacramento pikeminnow	*Ptychochelius grandis*	1	44	44	44	1	35	35	35
Sculpin Family										
	Prickly Sculpin	*Cottus asper*	7	59	72	86	0	-	-	-
	Unidentified sculpin	Not applicable	1	60	60	60	0	-	-	-
Silverside Family										
	Inland silverside	*Menidia beryllina*	0	-	-	-	1	98	98	98
Sucker Family										
	Sacramento sucker	*Catostomus occidentalis*	1	-	-	-	0	-	-	-

			Waterford				Grayson			
	Common Name	Scientific Name	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)	Total Catch	Minimum Length (mm)	Average Length (mm)	Maximum Length (mm)
Sunfish Family										
	Bluegill	*Lepomis macrochirus*	211	26	67	152	34	24	79	162
	Black crappie	*Pomoxis annularis*	10	45	55	67	0	-	-	-
	Green sunfish	*Lepomis cyanellus*	6	35	67	135	1	145	145	145
	Largemouth bass	*Micropterus salmoides*	5	183	219	255	11	118	199	390
	Redear sunfish	*Lepomis microlophus*	43	41	71	144	0	-	-	-
	Redeye bass	*Micropterus coosae*	0	-	-	-	1	264	264	264
	Smallmouth bass	*Micropterus dolomieu*	13	88	176	300	21	61	159	240
	Warmouth	*Lepomis gulosus*	14	56	82	151	1	38	38	38
	Unidentified bass	Not applicable	88	16	94	253	63	22	129	306
	Unidentified species	Not applicable	1	40	40	40	4	35	42	54
Total Species Captured = 21 (16 introduced, 5 native)										
Total Native Individuals Captured = 2,828 (1,664 at Waterford; 1,164 at Grayson)										

REFERENCES CITED

Becker, C., J. Guignard, and A. Fuller. 2014. Fall migration monitoring at the Tuolumne River weir 2013 annual report. FISHBIO, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2014.

Becker, C., R. Cuthbert, and A. Fuller. 2011. Fall/winter migration monitoring at the Tuolumne River weir 2010 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2011.

Blakeman, D. 2008. 2007 Spawning Survey Report. California Department of Fish and Game, La Grange Field Office, CA. Federal Energy Regulatory Commission annual report, FERC project No. 2299.

Blakeman, D. 2007. 2006 Tuolumne River Fall Chinook Salmon Escapement Survey. California Department of Fish and Game, La Grange Field Office, CA. Federal Energy Regulatory Commission annual report, FERC project No. 2299.

Blakeman, D. 2006. 2005 Tuolumne River Fall Chinook Salmon Escapement Survey. California Department of Fish and Game, La Grange Field Office, CA. Federal Energy Regulatory Commission annual report, FERC project No. 2299.

Blakeman, D. 2004a.1998 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Blakeman, D. 2004b.2002 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Blakeman, D. 2004c.2003 juvenile Chinook salmon capture and production indices using rotary-screw traps on the lower Tuolumne River. California Department of Fish and Game, Technical report submitted to Tuolumne River Technical Advisory Committee, Turlock, CA.

Cuthbert, R., C. Becker, and A. Fuller. 2012. Fall/winter migration monitoring at the Tuolumne River weir 2011 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2012.

Cuthbert, R., A. Fuller, and S. Snider. 2010. Fall/winter migration monitoring at the Tuolumne River weir 2009/10 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2010.

Fuller, A.N. 2005. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River at Grayson 2004. S.P. Cramer & Associates, Gresham, OR. Final Report submitted to Turlock and Modesto Irrigation Districts.

Fuller, A.N. 2008. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River, 2007. Prepared by FISHBIO Environmental, Chico, California for Turlock Irrigation District and Modesto Irrigation Districts.

Fuller, A.N., M. Simpson, and C. Sonke. 2006. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River at Grayson 2005. S.P. Cramer & Associates, Gresham, OR. Final Report submitted to Turlock and Modesto Irrigation Districts.

Fuller, A.N., M. Simpson, and C. Sonke. 2007. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River 2006. FISHBIO Environmental, Chico, CA. Final Report submitted to Turlock and Modesto Irrigation Districts.

O'Brien, J. 2006. 2005 Tuolumne River Fall Chinook Salmon Escapement Survey. California Department of Fish and Game, La Grange Field Office, CA. Federal Energy Regulatory Commission annual report, FERC project No. 2299.

Palmer, M., and C. Sonke. 2008. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River 2008. FISHBIO Environmental, Chico, CA. Final Report submitted to Turlock and Modesto Irrigation Districts.

Palmer, M., and C. Sonke. 2010. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River 2009. FISHBIO Environmental, Chico, CA. Final Report submitted to Turlock and Modesto Irrigation Districts.

Robichaud, D. and K. English. 2015. Re-analysis of Tuolumne River Rotary Screw Trap Data to examine the relationship between river flow and survival rates for Chinook smolts migrating between Waterford and Grayson (2006-14). LGL Limited, British Columbia, Canada. Draft Report submitted to Turlock and Modesto Irrigation Districts.

Robichaud, D. and K. English. 2013. Analysis of Tuolumne River Rotary Screw Trap Data to examine the relationship between river flow and survival rates for Chinook smolts migrating between Waterford and Grayson (2006-12). LGL Limited, British Columbia, Canada. Draft Report submitted to Turlock and Modesto Irrigation Districts.

Sonke, C., S. Ainsley, and A. Fuller. 2010. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River 2010. FISHBIO Environmental, Chico, CA. Final Report submitted to Turlock and Modesto Irrigation Districts.

Sonke, C., S. Ainsley, and A. Fuller. 2012. Outmigrant trapping of juvenile salmonids in the lower Tuolumne River 2011. FISHBIO Environmental, Chico, CA. Final Report submitted to Turlock and Modesto Irrigation Districts.

Heyne, T. and W. Loudermilk. 1997. Rotary screw trap capture of Chinook salmon smolts on the Tuolumne River in 1995 and 1996: Contribution of assessment of survival and production estimates. Federal Energy Regulatory Commission annual report, FERC project #2299-024.

Heyne, T. and W. Loudermilk. 1998. Rotary screw trap capture of Chinook salmon smolts with survival and production indices for the Tuolumne River in 1997. Federal Energy Regulatory Commission annual report, FERC project #2299-024.

Nichols K, 2013. FY2013 Technical Report: San Joaquin, Stanislaus, Tuolumne and Merced River Chinook Smolt Quality Assessment. US Fish and Wildlife Service California-Nevada Fish Health Center, Anderson, CA.

Stillwater Sciences. 2001. 2000 Tuolumne River smolt survival and upper screw traps report. Report 2000-4 in 2000 Lower Tuolumne River annual report, Project No. 2299. Prepared by Noah Hume, Peter Baker, Anthony Keith and Jennifer Vick of Stillwater Ecosystem, Watershed & Riverine Sciences, Berkeley, CA and Tim Ford, Turlock and Modesto Irrigation Districts with assistance from S.P. Cramer and Associates. March 2001.

Vasques, J. and K. Kundargi. 2001. 1999-2000 Grayson screw trap report. California Department of Fish and Game Anadromous Fisheries Project, San Joaquin Valley Southern Sierra Region (Region 4). March 2001.

Vasques, J. and K. Kundargi. 2002. 2001 Juvenile Chinook capture and production indices using rotary screw traps on the lower Tuolumne River. California Department of Fish and Game, San Joaquin Valley Southern Sierra Region, Anadromous Fisheries Program.

Vick, J., P. Baker, and T. Ford. 1998. 1998 Lower Tuolumne river annual report, Report 98-3, 1998 Tuolumne River Outmigrant Trapping Report. December 1998

Vick, J., A. Keith, and P. Baker. 2000. 1999 Lower Tuolumne River annual report, Report 99-5, 1999 Tuolumne River Upper Rotary Screw Trap Report. March 2000.

Wright, T., J. Guignard, and A. Fuller. 2013. Fall migration monitoring at the Tuolumne River weir 2012 annual report. FISHBIO Environmental, Oakdale, CA. Final Report submitted to Turlock and Modesto Irrigation Districts. March 2013.

Appendix A. Daily Chinook catch, length, predicted catchability, and estimated passage at Waterford and associated environmental data from 2014.

	Unmarked Chinook Salmon									Environmental Conditions			
		Fork Length (mm)				Estimated Passage				Flow (cfs)			
Date	Catch	Min	Avg	Max	Average Catchability	Fry	Parr	Smolt	Total	La Grange	Velocity (ft/s)	Temp at RST (F)	Turbidity
1/2/14	0	-	-	-	10.9%	0	0	0	0	160	1.4	47.8	0.72
1/3/14	1	36	36	36	12.7%	8	0	0	8	161	1.3	47.5	1.53
1/4/14	0	-	-	-	11.8%	0	0	0	0	161	1.4	47.7	0.95
1/5/14	0	-	-	-	12.7%	0	0	0	0	161	1.4	47.8	0.77
1/6/14	0	-	-	-	12.7%	0	0	0	0	161	1.3	47.6	1.14
1/7/14	1	28	28	28	11.8%	8	0	0	8	161	1.3	48.1	1.55
1/8/14	1	62	62	62	6.4%	0	4	12	16	161	1.1	48.3	1.11
1/9/14	0	-	-	-	5.4%	0	0	0	0	161	1.4	48.9	0.82
1/10/14	1	87	87	87	6.9%	0	4	11	15	162	1.3	49.3	1.54
1/11/14	0	-	-	-	6.4%	0	0	0	0	161	1.5	49.4	1.65
1/12/14	0	-	-	-	7.4%	0	0	0	0	162	1.3	49.0	2.76
1/13/14	1	85	85	85	6.4%	0	4	12	16	162	1.3	48.7	nd
1/14/14	0	-	-	-	6.4%	0	0	0	0	161	1.4	48.5	1.38
1/15/14	1	36	36	36	11.2%	7	0	2	9	162	1.3	48.6	2.04
1/16/14	6	36	67	99	10.5%	44	2	11	57	161	1.4	48.9	0.67
1/17/14	5	35	45	75	11.4%	34	1	9	44	159	1.0	49.0	0.74
1/18/14	2	35	37	39	8.3%	19	1	5	24	156	1.3	48.8	1.23
1/19/14	11	31	34	37	10.8%	79	3	20	102	156	1.2	48.6	2.19
1/20/14	11	36	37	37	9.8%	87	4	22	112	159	1.1	48.5	1.22
1/21/14	2	38	39	39	9.2%	17	1	4	22	156	1.3	48.4	1.28
1/22/14	12	36	42	89	12.1%	98	0	1	99	156	1.2	48.3	0.84
1/23/14	13	31	38	58	11.2%	115	1	1	117	156	1.3	48.7	1.52
1/24/14	11	32	37	39	12.1%	90	0	1	91	156	0.2	49.9	0.94
1/25/14	19	36	37	38	1.8%	1,016	5	8	1,029	157	0.8	51.2	nd
1/26/14	59	33	36	39	7.4%	783	4	6	794	156	1.3	51.3	1.76
1/27/14	125	35	37	39	12.1%	1,021	5	8	1,035	156	1.0	51.0	0.29
1/28/14	43	33	36	38	9.3%	457	2	4	463	156	1.0	52.1	0.52
1/29/14	51	34	38	87	9.2%	546	0	7	553	157	1.0	53.5	0.26
1/30/14	33	35	37	39	9.2%	356	0	4	360	158	1.3	55.0	1.59
1/31/14	91	35	36	38	11.9%	754	0	9	764	158	0.9	54.8	0.80
2/1/14	91	32	37	39	8.4%	1,076	0	13	1,089	156	0.9	52.9	1.76
2/2/14	71	34	37	40	8.4%	834	0	10	844	155	1.2	51.0	2.77
2/3/14	28	35	37	40	11.2%	247	0	3	250	155	1.2	49.6	1.26
2/4/14	56	35	38	83	11.1%	500	0	6	506	157	1.1	49.5	0.39
2/5/14	75	35	38	88	10.1%	712	12	18	742	156	1.5	49.5	2.06
2/6/14	5	37	43	61	13.7%	35	1	1	37	157	1.5	51.0	1.26
2/7/14	9	35	37	38	13.8%	63	1	2	65	156	1.3	51.1	1.87
2/8/14	6	35	39	45	11.9%	48	1	1	50	156	1.3	51.9	1.25
2/9/14	0	-	-	-	11.9%	0	0	0	0	156	1.4	53.0	0.92
2/10/14	45	35	37	39	12.9%	336	5	9	350	156	1.2	54.3	0.89
2/11/14	206	33	38	100	11.0%	1,805	29	46	1,880	157	1.3	54.8	2.18
2/12/14	302	30	36	43	11.9%	2,469	18	40	2,528	157	1.2	55.7	1.25
2/13/14	328	31	38	50	11.0%	2,924	22	48	2,993	158	1.5	56.4	1.04
2/14/14	360	31	37	48	13.7%	2,567	19	42	2,628	158	0.9	57.6	0.74
2/15/14	72	32	36	51	8.2%	856	6	14	876	158	1.5	57.0	0.51
2/16/14	141	33	37	83	13.6%	1,012	7	17	1,036	159	1.4	56.7	1.63
2/17/14	385	30	38	81	12.7%	2,960	22	49	3,030	159	1.6	56.4	1.97
2/18/14	247	26	38	84	14.5%	1,662	12	27	1,701	159	1.4	55.6	1.00
2/19/14	423	30	39	97	12.6%	3,099	220	26	3,346	158	1.2	55.5	0.64
2/20/14	254	31	38	58	10.8%	2,171	154	18	2,344	158	1.3	55.6	0.64

	Unmarked Chinook Salmon									Environmental Conditions			
		Fork Length (mm)				Estimated Passage				Flow (cfs)			
Date	Catch	Min	Avg	Max	Average Catchability	Fry	Parr	Smolt	Total	La Grange	Velocity (ft/s)	Temp at RST (F)	Turbidity
2/21/14	440	33	38	75	11.6%	3,516	250	30	3,795	160	1.2	55.5	2.31
2/22/14	227	33	37	58	10.9%	1,928	137	16	2,081	157	1.2	56.0	1.43
2/23/14	776	28	39	58	10.9%	6,591	468	56	7,115	157	1.1	56.3	1.11
2/24/14	537	34	39	61	10.0%	4,976	354	42	5,371	157	1.4	56.9	0.79
2/25/14	515	32	37	52	12.7%	3,749	266	32	4,047	157	1.4	57.6	1.20
2/26/14	286	31	39	65	12.7%	1,978	281	0	2,259	156	1.4	58.2	0.96
2/27/14	267	34	40	60	12.6%	1,859	264	0	2,122	157	1.2	58.2	1.06
2/28/14	194	33	39	63	10.6%	1,606	228	0	1,834	160	1.6	58.1	0.70
3/1/14	290	34	42	63	14.2%	1,789	254	0	2,043	159	1.1	57.3	1.56
3/2/14	939	32	39	66	9.8%	8,425	1,196	0	9,621	159	1.4	57.0	1.50
3/3/14	408	30	38	58	12.3%	2,894	411	0	3,305	160	1.5	55.9	1.05
3/4/14	141	32	39	60	13.2%	934	133	0	1,066	160	1.4	57.1	1.96
3/5/14	59	33	39	58	12.3%	420	56	2	478	160	1.4	58.9	4.86
3/6/14	117	34	42	67	12.3%	833	111	4	948	160	1.2	60.8	3.41
3/7/14	117	30	38	55	10.4%	984	131	4	1,120	162	1.4	60.8	2.72
3/8/14	481	31	37	54	12.7%	3,340	445	15	3,800	156	1.2	60.4	1.96
3/9/14	198	32	42	70	10.8%	1,614	215	7	1,837	157	1.5	60.8	1.80
3/10/14	117	33	38	64	13.6%	758	101	3	863	156	1.5	60.8	1.43
3/11/14	344	33	39	66	13.6%	2,230	297	10	2,536	156	nd	60.0	4.29
3/12/14	189	31	38	80	12.7%	1,151	305	38	1,494	156	1.4	60.2	2.18
3/13/14	150	32	37	82	12.2%	946	251	31	1,228	156	1.3	60.3	0.87
3/14/14	164	32	35	51	11.3%	1,121	297	37	1,455	157	1.2	60.4	1.17
3/15/14	106	31	38	65	10.4%	785	208	26	1,019	157	1.5	61.1	1.98
3/16/14	39	33	43	70	13.1%	230	61	7	298	156	1.4	62.3	2.91
3/17/14	82	32	53	71	12.1%	520	138	17	675	157	1.5	62.6	0.77
3/18/14	70	32	45	77	13.0%	415	110	14	538	157	1.4	61.5	1.05
3/19/14	79	32	40	69	11.3%	409	226	65	700	157	1.3	61.4	1.41
3/20/14	51	32	47	73	10.5%	282	156	45	484	156	nd	62.4	0.33
3/21/14	95	33	41	74	11.4%	488	271	78	837	156	nd	62.9	0.95
3/22/14	55	31	43	78	11.9%	269	149	43	461	159	1.6	62.8	1.84
3/23/14	30	33	54	75	12.9%	136	75	22	233	157	1.3	62.9	0.79
3/24/14	35	33	44	73	10.5%	195	108	31	334	157	1.2	63.4	3.30
3/25/14	25	35	56	79	9.6%	152	84	24	260	158	1.5	63.1	1.26
3/26/14	7	34	50	63	9.4%	6	44	25	74	157	1.2	61.5	0.79
3/27/14	41	36	59	87	7.5%	43	323	183	549	158	nd	59.9	0.75
3/28/14	42	34	60	77	9.3%	35	267	151	453	159	1.8	60.7	2.13
3/29/14	26	35	64	86	11.2%	18	137	77	232	158	1.8	61.4	0.76
3/30/14	20	30	68	90	11.2%	14	105	59	179	158	1.3	60.6	1.25
3/31/14	35	47	63	88	8.1%	34	255	144	433	158	1.3	60.1	0.84
4/1/14	27	35	65	85	8.1%	26	196	111	334	158	1.7	58.4	0.6
4/2/14	18	49	65	73	10.4%	12	99	62	174	159	1.4	58.6	1.37
4/3/14	16	34	60	81	8.5%	13	107	67	187	159	nd	59.6	1.55
4/4/14	11	41	64	82	7.9%	10	79	50	139	159	1.2	60.6	1.66
4/5/14	5	50	59	75	7.3%	5	39	25	68	159	1.4	60.7	2.10
4/6/14	10	49	64	80	8.5%	8	67	42	118	160	1.5	62.5	1.24
4/7/14	12	50	68	88	9.1%	9	75	47	132	160	1.6	65.1	0.85
4/8/14	5	60	65	74	9.7%	4	29	19	52	160	1.3	67.2	1.12
4/9/14	3	57	67	83	7.2%	2	16	23	42	160	1.7	68.7	0.84
4/10/14	4	59	70	77	9.4%	2	16	24	42	160	1.5	68.8	0.65
4/11/14	7	45	59	75	8.2%	5	33	48	85	162	1.5	68.4	3.11
4/12/14	4	60	67	70	8.2%	3	19	27	49	162	1.4	67.4	2.48
4/13/14	8	60	74	95	7.6%	6	41	59	105	163	1.2	66.8	3.18
4/14/14	4	60	69	76	6.6%	3	23	34	60	161	1.3	67.2	1.08
4/15/14	4	63	70	80	3.0%	7	52	76	135	391	3.2	68.2	1.5
4/16/14	119	52	70	91	2.5%	98	1,700	2,905	4,703	1080	2.9	64.7	3.66

	Unmarked Chinook Salmon									Environmental Conditions			
		Fork Length (mm)				Estimated Passage				Flow (cfs)			
Date	Catch	Min	Avg	Max	Average Catchability	Fry	Parr	Smolt	Total	La Grange	Velocity (ft/s)	Temp at RST (F)	Turbidity
4/17/14	385	38	72	92	2.0%	397	6,912	11,813	19,122	1230	1.9	57.5	3.87
4/18/14	146	35	69	140	2.5%	120	2,085	3,563	5,768	641	nd	58.4	15.20
4/19/14	72	36	63	79	2.8%	54	940	1,606	2,599	632	nd	59.6	2.04
4/20/14	36	54	69	86	3.0%	25	438	749	1,213	633	nd	59.5	1.84
4/21/14	25	59	70	85	3.1%	16	287	491	795	638	2.5	59.1	nd
4/22/14	2	72	80	88	3.3%	1	22	37	60	638	2.5	57.7	nd
4/23/14	10	65	78	90	2.5%	0	59	348	407	770	3.5	57.6	1.61
4/24/14	5	63	69	80	4.1%	0	18	105	123	652	2.8	57.4	1.13
4/25/14	7	60	73	82	7.1%	0	14	84	98	298	1.8	57.5	1.22
4/26/14	5	73	76	81	8.7%	0	8	49	58	157	nd	58.2	1.23
4/27/14	3	70	76	80	7.6%	0	6	34	40	157	nd	61.0	0.81
4/28/14	2	75	76	77	6.4%	0	5	27	31	158	1.1	63.7	1.48
4/29/14	1	70	70	70	4.9%	0	3	18	21	171	1.0	66.1	1.02
4/30/14	0	-	-	-	3.9%	0	0	0	0	180	1.5	68.9	0.98
5/1/14	0	-	-	-	6.6%	0	0	0	0	159	nd	71.0	2.2
5/2/14	0	-	-	-	7.3%	0	0	0	0	159	1.8	71.2	1.50
5/3/14	0	-	-	-	7.9%	0	0	0	0	159	1.4	70.3	1.55
5/4/14	0	-	-	-	6.1%	0	0	0	0	160	1.8	68.9	1.64
5/5/14	1	80	80	80	8.0%	0	0	13	13	158	nd	68.2	2.44
5/6/14	0	-	-	-	7.5%	0	0	0	0	159	1.6	66.9	0.96
5/7/14	0	-	-	-	8.0%	0	0	0	0	158	1.7	69.2	3.61
5/8/14	1	63	63	63	8.5%	0	3	9	12	158	nd	67.9	1.18
5/9/14	1	80	80	80	7.3%	0	3	10	14	157	1.2	69.0	2.44
5/10/14	0	-	-	-	6.1%	0	0	0	0	156	1.7	68.5	1.57
5/11/14	0	-	-	-	8.7%	0	0	0	0	156	1.7	67.3	1.84
5/12/14	0	-	-	-	8.4%	0	0	0	0	160	1.9	68.4	0.86
5/13/14	1	88	88	88	9.6%	0	3	8	0	157	1.8	70.7	2.37
5/14/14	0	-	-	-	0.0%	0	0	0	0	161	1.8	73.1	1.46
5/15/14	0	-	-	-	0.0%	0	0	0	0	158	1.6	74.3	1.64

Appendix B. Daily Chinook catch, length, average catchability, and estimated passage at Grayson and associated environmental data from 2014.

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Average Catchability	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temp at the RSTs (F)	Turbidity (NTU)
1/2/14	0	-	-	-	0.0%	0	0	0	0	205	1.1	0.7	47.96	1.13
1/3/14	0	-	-	-	0.0%	0	0	0	0	204	1.2	0.9	47.60	1.69
1/4/14	0	-	-	-	0.0%	0	0	0	0	205	1.1	1.1	47.73	1.59
1/5/14	0	-	-	-	0.0%	0	0	0	0	205	1.5	1.1	47.49	0.76
1/6/14	0	-	-	-	0.0%	0	0	0	0	205	1.2	1.4	47.20	0.87
1/7/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	204	ns	ns	48.50	ns
1/8/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	202	ns	ns	48.46	ns
1/9/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	203	ns	ns	49.19	ns
1/10/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	202	ns	ns	50.14	ns
1/11/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	200	ns	ns	49.97	ns
1/12/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	199	ns	ns	49.52	ns
1/13/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	199	ns	ns	49.21	ns
1/14/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	196	ns	ns	48.88	ns
1/15/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	197	ns	ns	49.48	ns
1/16/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	188	ns	ns	49.48	ns
1/17/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	198	ns	ns	49.62	ns
1/18/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	197	ns	ns	49.32	ns
1/19/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	193	ns	ns	49.17	ns
1/20/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	194	ns	ns	49.25	ns
1/21/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	192	ns	ns	49.17	ns
1/22/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	190	ns	ns	49.11	ns
1/23/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	187	ns	ns	49.32	ns
1/24/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	186	ns	ns	50.63	ns
1/25/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	185	ns	ns	51.94	ns
1/26/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	188	ns	ns	51.63	ns
1/27/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	190	1.0	0.9	51.33	0.79
1/28/14	0	-	-	-	0.0%	0	0	0	0	185	nd	nd	53.30	0.81
1/29/14	0	-	-	-	0.0%	0	0	0	0	191	0.6	0.4	56.39	0.80
1/30/14	0	-	-	-	0.0%	0	0	0	0	224	1.0	1.2	57.67	0.49
1/31/14	0	-	-	-	0.0%	0	0	0	0	213	0.4	0.8	56.06	2.07
2/1/14	0	-	-	-	0.0%	0	0	0	0	200	0.2	0.4	53.20	2.63
2/2/14	0	-	-	-	0.0%	0	0	0	0	198	0.2	0.4	51.30	0.97
2/3/14	0	-	-	-	0.0%	0	0	0	0	198	1.2	1.1	51.07	3.07
2/4/14	0	-	-	-	0.0%	0	0	0	0	196	0.9	0.9	51.73	0.74
2/5/14	0	-	-	-	0.0%	0	0	0	0	197	1.3	0.9	51.63	0.88
2/6/14	0	-	-	-	0.0%	0	0	0	0	208	1.1	0.9	52.80	1.22
2/7/14	0	-	-	-	0.0%	0	0	0	0	216	0.8	0.9	52.07	1.99
2/8/14	0	-	-	-	0.0%	0	0	0	0	237	0.9	0.6	52.71	3.96
2/9/14	0	-	-	-	0.0%	0	0	0	0	214	1.0	0.9	54.35	2.87
2/10/14	0	-	-	-	0.0%	0	0	0	0	211	1.1	1.3	56.28	3.21
2/11/14	0	-	-	-	0.0%	0	0	0	0	207	1.1	1.1	56.44	1.07
2/12/14	0	-	-	-	0.0%	0	0	0	0	205	1.3	1.0	56.85	2.21
2/13/14	0	-	-	-	0.0%	0	0	0	0	207	1.2	1.0	57.99	2.80
2/14/14	0	-	-	-	0.0%	0	0	0	0	210	1.1	1.2	59.99	1.39
2/15/14	0	-	-	-	0.0%	0	0	0	0	207	0.9	1.1	58.52	1.43
2/16/14	0	-	-	-	0.0%	0	0	0	0	210	1.3	1.1	59.10	2.05
2/17/14	0	-	-	-	0.0%	0	0	0	0	210	1.1	1.3	58.16	1.27
2/18/14	0	-	-	-	0.0%	0	0	0	0	208	1.0	1.4	57.27	2.14
2/19/14	0	-	-	-	0.0%	0	0	0	0	208	1.2	1.0	58.28	1.91
2/20/14	0	-	-	-	0.0%	0	0	0	0	207	1.0	1.0	57.52	1.33
2/21/14	0	-	-	-	0.0%	0	0	0	0	206	1.1	1.0	57.79	2.09
2/22/14	0	-	-	-	0.0%	0	0	0	0	209	1.1	0.9	58.35	2.17

	Unmarked Chinook Salmon									Environmental Conditions				
Date	Catch	Fork Length (mm) Min	Avg	Max	Average Catchability	Estimated Passage Fry	Parr	Smolt	Total	Flow (cfs) Modesto Flow	Velocity (ft/s) North	South	Temp at the RSTs (F)	Turbidity (NTU)
2/23/14	0	-	-	-	0.0%	0	0	0	0	207	1.1	1.1	58.56	2.41
2/24/14	0	-	-	-	0.0%	0	0	0	0	206	1.1	1.0	59.27	1.33
2/25/14	0	-	-	-	0.0%	0	0	0	0	206	1.1	0.9	60.11	2.08
2/26/14	0	-	-	-	0.0%	0	0	0	0	211	1.3	1.3	60.00	3.28
2/27/14	0	-	-	-	0.0%	0	0	0	0	242	1.3	1.2	59.87	3.84
2/28/14	0	-	-	-	0.0%	0	0	0	0	279	1.3	1.2	59.22	5.18
3/1/14	0	-	-	-	0.0%	0	0	0	0	246	1.6	1.7	59.10	5.57
3/2/14	0	-	-	-	0.0%	0	0	0	0	211	0.7	1.0	59.72	2.96
3/3/14	0	-	-	-	0.0%	0	0	0	0	205	1.0	1.2	59.11	7.77
3/4/14	0	-	-	-	0.0%	0	0	0	0	221	1.1	1.4	60.27	7.89
3/5/14	0	-	-	-	0.0%	0	0	0	0	208	1.3	1.3	62.34	3.28
3/6/14	0	-	-	-	0.0%	0	0	0	0	211	1.2	1.2	64.19	2.26
3/7/14	0	-	-	-	0.0%	0	0	0	0	214	1.0	1.0	62.40	11.27
3/8/14	0	-	-	-	0.0%	0	0	0	0	207	1.0	0.9	62.39	1.71
3/9/14	0	-	-	-	0.0%	0	0	0	0	204	1.4	1.2	64.02	1.73
3/10/14	0	-	-	-	0.0%	0	0	0	0	201	1.1	0.8	64.55	8.98
3/11/14	0	-	-	-	0.0%	0	0	0	0	200	1.5	1.4	61.80	2.48
3/12/14	0	-	-	-	0.0%	0	0	0	0	196	nd	nd	62.40	1.52
3/13/14	0	-	-	-	0.0%	0	0	0	0	195	1.4	1.2	63.15	2.21
3/14/14	0	-	-	-	0.0%	0	0	0	0	193	1.3	1.4	63.13	2.79
3/15/14	0	-	-	-	0.0%	0	0	0	0	192	1.2	1.2	64.59	14.82
3/16/14	0	-	-	-	0.0%	0	0	0	0	193	1.4	1.3	65.90	3.43
3/17/14	0	-	-	-	0.0%	0	0	0	0	192	1.3	1.1	65.34	2.17
3/18/14	0	-	-	-	0.0%	0	0	0	0	192	1.2	1.2	62.54	3.31
3/19/14	0	-	-	-	0.0%	0	0	0	0	194	1.3	1.2	63.80	1.85
3/20/14	0	-	-	-	0.0%	0	0	0	0	192	1.3	1.1	65.90	1.27
3/21/14	0	-	-	-	0.0%	0	0	0	0	190	nd	1.0	66.68	1.92
3/22/14	0	-	-	-	0.0%	0	0	0	0	186	nd	0.9	66.19	4.06
3/23/14	0	-	-	-	0.0%	0	0	0	0	185	1.5	1.4	66.26	3.64
3/24/14	0	-	-	-	0.0%	0	0	0	0	182	1.3	0.8	66.91	1.72
3/25/14	0	-	-	-	0.0%	0	0	0	0	185	1.9	0.9	65.95	1.50
3/26/14	0	-	-	-	0.0%	0	0	0	0	211	2.0	1.7	63.95	nd
3/27/14	0	-	-	-	0.0%	0	0	0	0	202	2.2	1.5	63.35	4.88
3/28/14	0	-	-	-	0.0%	0	0	0	0	197	2.0	1.1	65.18	1.49
3/29/14	0	-	-	-	0.0%	0	0	0	0	223	2.2	2.0	64.70	2.40
3/30/14	0	-	-	-	0.0%	0	0	0	0	234	2.0	2.2	62.93	5.74
3/31/14	0	-	-	-	0.0%	0	0	0	0	215	2.0	1.6	61.84	5.61
4/1/14	0	-	-	-	0.0%	0	0	0	0	230	1.8	1.4	60.06	1.51
4/2/14	0	-	-	-	0.0%	0	0	0	0	243	1.9	1.6	60.2	5.3
4/3/14	0	-	-	-	0.0%	0	0	0	0	209	2.0	1.9	61.67	7.06
4/4/14	0	-	-	-	0.0%	0	0	0	0	200	1.9	1.8	62.27	4.20
4/5/14	0	-	-	-	0.0%	0	0	0	0	199	1.7	1.7	62.79	5.86
4/6/14	0	-	-	-	0.0%	0	0	0	0	199	1.7	1.7	65.76	11.74
4/7/14	0	-	-	-	0.0%	0	0	0	0	199	1.4	1.5	68.87	9.82
4/8/14	0	-	-	-	0.0%	0	0	0	0	199	1.6	1.5	71.34	4.16
4/9/14	0	-	-	-	0.0%	0	0	0	0	197	1.7	2.0	72.91	1.66
4/10/14	0	-	-	-	0.0%	0	0	0	0	195	1.6	1.5	72.21	1.38
4/11/14	0	-	-	-	0.0%	0	0	0	0	194	1.5	1.6	71.98	3.52
4/12/14	0	-	-	-	0.0%	0	0	0	0	192	1.3	1.5	71.24	3.86
4/13/14	0	-	-	-	0.0%	0	0	0	0	196	1.3	0.9	70.91	8.00
4/14/14	0	-	-	-	0.0%	0	0	0	0	206	1.3	1.8	71.98	14.91
4/15/14	0	-	-	-	0.0%	0	0	0	0	195	0.9	0.8	73.14	8.38
4/16/14	0	-	-	-	0.0%	0	0	0	0	316	0.6	0.8	72.4	4.6
4/17/14	0	-	-	-	0.0%	0	0	0	0	972	1.3	1.0	71.43	10.11
4/18/14	0	-	-	-	0.0%	0	0	0	0	1100	2.1	2.2	64.47	8.22
4/19/14	1	65	65	65	4.1%	4	14	7	25	763	1.6	1.6	62.89	4.22

	Unmarked Chinook Salmon									Environmental Conditions				
Date	Catch	Fork Length (mm) Min	Avg	Max	Average Catchability	Estimated Passage Fry	Parr	Smolt	Total	Flow (cfs) Modesto Flow	Velocity (ft/s) North	South	Temp at the RSTs (F)	Turbidity (NTU)
4/20/14	2	47	50	52	4.4%	7	26	13	45	726	1.7	1.6	64.50	5.45
4/21/14	2	52	64	76	3.5%	8	33	16	57	721	1.1	1.5	64.96	3.23
4/22/14	0	-	-	-	3.5%	0	0	0	0	723	1.5	1.7	63.95	nd
4/23/14	2	70	73	75	2.7%	0	0	74	74	723	1.6	1.2	62.79	2.34
4/24/14	0	-	-	-	2.7%	0	0	0	0	838	nd	nd	62.56	8.02
4/25/14	0	-	-	-	2.7%	0	0	0	0	764	nd	nd	61.28	6.81
4/26/14	0	-	-	-	2.7%	0	0	0	0	522	nd	nd	61.14	6.67
4/27/14	0	-	-	-	2.7%	0	0	0	0	341	nd	nd	63.16	5.93
4/28/14	1	75	75	75	9.9%	0	0	10	10	263	nd	nd	65.39	7.99
4/29/14	0	-	-	-	9.9%	0	0	0	0	242	1.7	2.2	68.30	5.11
4/30/14	0	-	-	-	9.9%	0	0	0	0	225	2.0	2.1	71.93	3.05
5/1/14	0	-	-	-	9.9%	0	0	0	0	229	1.6	2.0	74.69	4.75
5/2/14	0	-	-	-	9.9%	0	0	0	0	210	nd	nd	74.5	7.9

Appendix C. Daily counts of non-salmonids captured at Waterford during 2014. See key below for species codes.

	BAS	BGS	BKS	CHC	GSF	GSN	HH	HH	LAM	LMB	MQK	PRS	RES	SASQ	SASU	SCP	SMB	UNID	W	WHC
1/2/14																				
1/3/14																				
1/4/14																				
1/5/14																				
1/6/14																				
1/7/14																				
1/8/14																				
1/9/14																				
1/10/14																				
1/11/14																				
1/12/14																				
1/13/14																				
1/14/14		2											1							
1/15/14																				
1/16/14		1										1								
1/17/14		1																		
1/18/14																				
1/19/14																				
1/20/14																				
1/21/14																				
1/22/14		1																		
1/23/14												1								1
1/24/14												1								
1/25/14																				
1/26/14											1									
1/27/14																				1
1/28/14																				

	BAS	BGS	BKS	CHC	GSF	GSN	HH	HH	LAM	LMB	MQK	PRS	RES	SASQ	SASU	SCP	SMB	UNID	W	WHC
1/29/14		1																		
1/30/14																				
1/31/14		1																		
2/1/14		1																		
2/2/14		1																		
2/3/14																				
2/4/14																				
2/5/14																				
2/6/14																				
2/7/14																				
2/8/14				1																1
2/9/14																				
2/10/14																				1
2/11/14		3										1								
2/12/14	1	5																		
2/13/14		1																		1
2/14/14		2									1									
2/15/14	1	2																		1
2/16/14		5											1							
2/17/14		4											1							
2/18/14		3											1							
2/19/14		1										1								
2/20/14		2																		
2/21/14				1									1							
2/22/14		2		1																
2/23/14		2																		1
2/24/14																				1
2/25/14		3									1	1								
2/26/14																				

	BAS	BGS	BKS	CHC	GSF	GSN	HH	HH	LAM	LMB	MQK	PRS	RES	SASQ	SASU	SCP	SMB	UNID	W	WHC
2/27/14		2							10		1									1
2/28/14		1							1				1							
3/1/14		1																		1
3/2/14		3																	1	
3/3/14		3							1											
3/4/14		5																		
3/5/14								1												1
3/6/14											1									
3/7/14											2									
3/8/14		8		1							1									
3/9/14		2							3											
3/10/14											1									
3/11/14		8							1	1	1					1				
3/12/14		6										1								
3/13/14		4		1									1							
3/14/14		1																		
3/15/14		1						1												
3/16/14		2									1									
3/17/14		2							1											
3/18/14								1			1									
3/19/14		1							1		1		2							2
3/20/14		1																		
3/21/14									4	1							1			1
3/22/14		1		1					1		1									1
3/23/14		2		1																1
3/24/14									3											2
3/25/14		1		1													3			
3/26/14									2								1			
3/27/14		1							8								2			1

	BAS	BGS	BKS	CHC	GSF	GSN	HH	HH	LAM	LMB	MQK	PRS	RES	SASQ	SASU	SCP	SMB	UNID	W	WHC
3/28/14																				
3/29/14																				
3/30/14													1							
3/31/14																				1
4/1/14									1								1			1
4/2/14																				
4/3/14		1																		
4/4/14																				
4/5/14																				1
4/6/14																				
4/7/14													1							
4/8/14		2											1				1			1
4/9/14																			1	
4/10/14		1							1											
4/11/14		2							1		1									1
4/12/14															1					
4/13/14		1							6	3										
4/14/14									3								2			
4/15/14		3							1								1			
4/16/14	2	2			2						2		1						1	1
4/17/14	57	21			3				972		2		12						5	6
4/18/14	10	26					1		516		1								1	58
4/19/14		28			1	1			89										1	15
4/20/14	1	1	9						3				3					1		2
4/21/14		1				1			2		2		12							3
4/22/14	1	1																		
4/23/14											1		1							1
4/24/14		4																		4
4/25/14		4							1				1						1	

	BAS	BGS	BKS	CHC	GSF	GSN	HH	HH	LAM	LMB	MQK	PRS	RES	SASQ	SASU	SCP	SMB	UNID	W	WHC
4/26/14							1		5											
4/27/14		1									1									1
4/28/14		1												1						2
4/29/14		1																		1
4/30/14		1															1			3
5/1/14	3	2							2											1
5/2/14		2							2											2
5/3/14		1											1							
5/4/14																				3
5/5/14																				1
5/6/14		1																		3
5/7/14	1			2					2										1	2
5/8/14																			1	
5/9/14									4											
5/10/14		1																		
5/11/14		1							1											
5/12/14									2		1								1	
5/13/14	1																			1
5/14/14	1	1																		
5/15/14	9																			1

Appendix D. Daily counts of non-salmonids captured at Grayson during 2014. See key below for species codes.

	BAS	BGS	BKB	BRB	CAT	CHC	GSF	GSN	HCH	LAM	LMB	MQK	MSS	REB	SASQ	SMB	UNID	W	WHC
1/2/14																			
1/3/14																			
1/4/14	1																		
1/5/14																			1
1/6/14																			
1/7/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/8/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/9/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/10/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/11/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/12/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/13/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/14/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/15/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/16/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/17/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/18/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/19/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/20/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/21/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/22/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/23/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/24/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/25/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/26/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/27/14	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1/28/14																			

	BAS	BGS	BKB	BRB	CAT	CHC	GSF	GSN	HCH	LAM	LMB	MQK	MSS	REB	SASQ	SMB	UNID	W	WHC
1/29/14																			
1/30/14																1			1
1/31/14										1									
2/1/14																			
2/2/14																			
2/3/14																			
2/4/14																			
2/5/14		1																	1
2/6/14																			2
2/7/14												1							
2/8/14												2							1
2/9/14	1																		
2/10/14												1							2
2/11/14											1								2
2/12/14												1							4
2/13/14												1							
2/14/14		1								1		1							7
2/15/14		1										1							
2/16/14		1				1	1					1							1
2/17/14						1													
2/18/14																			
2/19/14										1		1							
2/20/14																			
2/21/14										1									3
2/22/14	2					1													1
2/23/14	2																		
2/24/14		1										1							
2/25/14	2	1																	2
2/26/14																			

	BAS	BGS	BKB	BRB	CAT	CHC	GSF	GSN	HCH	LAM	LMB	MQK	MSS	REB	SASQ	SMB	UNID	W	WHC
2/27/14		1																	2
2/28/14	2	1				2				31									12
3/1/14										15									
3/2/14						1				4									1
3/3/14	1									1									
3/4/14																			
3/5/14	1					2				1									
3/6/14												1					2		1
3/7/14										2									
3/8/14						3					1								3
3/9/14																			
3/10/14	3																		1
3/11/14		2				1						1		1		2			3
3/12/14											1								2
3/13/14																			1
3/14/14										1									
3/15/14	1					2				1									1
3/16/14										1									
3/17/14																			
3/18/14						1													1
3/19/14																			1
3/20/14												1							1
3/21/14	1									1		3							
3/22/14		3										2				1			3
3/23/14																			
3/24/14		1								1									
3/25/14	3	1				12			1	22			1						5
3/26/14	1	2				11				3									
3/27/14	14	1			1	2				922						6	1		16

	BAS	BGS	BKB	BRB	CAT	CHC	GSF	GSN	HCH	LAM	LMB	MQK	MSS	REB	SASQ	SMB	UNID	W	WHC
3/28/14	2	2				5		1	1	66		1				1			16
3/29/14	1							1			7								4
3/30/14										2									
3/31/14	5				2	3				12		1							16
4/1/14	1	1								1									6
4/2/14						3				6									
4/3/14	4			1		15		1		7	1								1
4/4/14		2				5													
4/5/14		1				1				3									1
4/6/14	1									3						1			3
4/7/14						1				3									
4/8/14	2	1																	10
4/9/14										15									2
4/10/14	2	2	1							3									10
4/11/14	2															1			4
4/12/14																			1
4/13/14										3									1
4/14/14																2			
4/15/14												1							1
4/16/14																			
4/17/14										6		1				2			1
4/18/14																			
4/19/14						4				6		1			1				
4/20/14						4				15		1				1			
4/21/14	3					2						1				1	1	1	
4/22/14		3										1							2
4/23/14	1	1										3				2			1
4/24/14								1											
4/25/14																			1

	BAS	BGS	BKB	BRB	CAT	CHC	GSF	GSN	HCH	LAM	LMB	MQK	MSS	REB	SASQ	SMB	UNID	W	WHC
4/26/14		1				1		1											
4/27/14				1		1													1
4/28/14	1			1				2				1							1
4/29/14	2	1										1							3
4/30/14	1	1																	1
5/1/14								1				1							6
5/2/14																			2

Appendix E. Key to species codes.

BAS	Unidentified bass
BGS	Bluegill
BKB	Black bullhead
BKS	Black crappie
BRB	Brown bullhead
CAT	Unidentified catfish
CHC	Channel catfish
CHN	Chinook
GSF	Green sunfish
GSN	Golden shiner
HCH	Hitch
HH	Hardhead
LAM	Lamprey, unidentified species
LMB	Largemouth bass
MQK	Mosquitofish
MSS	Inland silverside
PRS	Prickly sculpin
REB	Red-eyed bass
RES	Redear sunfish
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SCP	Unidentified sculpin
SMB	Smallmouth bass
UNID	Unidentified species
W	Warmouth
WHC	White catfish

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-5

2014 Snorkel Report and Summary Update

Prepared for

Turlock and Modesto Irrigation Districts

By

Stillwater Sciences
Berkeley, CA

March 2015

SUMMARY

In 2014, a routine snorkel survey was conducted on July 29–31 within the 20-mile reach of the Tuolumne River below La Grange Dam. Preliminary USGS flow at La Grange averaged 104 cfs and water temperature ranged from 13.6°C (56.5 °F) to 29.2°C (84.6 °F). A total of six juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and 53 rainbow trout (*Oncorhynchus mykiss*) were observed in various habitats. Chinook salmon were observed at Riffle A7 (River Mile [RM] 50.7) and rainbow trout downstream to Riffle 13B (RM 45.5). Other native fish species observed were Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), and riffle sculpin (*Cottus gulosus*). Non-native species observed included bluegill sunfish (*Lepomis macrochirus*), redear sunfish (*L. microlophus*), green sunfish (*L. cyanellus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), and spotted bass (*M. punctulatus*).

Early summer surveys conducted in June/July have been completed in most years since 1986 except in years with extended high flows into the summer survey period (i.e., 1995, 1998, 2005, 2006, 2010, and 2011) that precluded the surveys. Rainbow trout were absent in surveys from 1987 through 1994 (with the exception of a single observation in June 1992). Since 1996, rainbow trout have been observed in each of the June/July surveys conducted, with the highest counts seen in June 1996 and second highest counts in June 2007. With the exception of 1991 and 1992, Chinook salmon have been observed in each year when an early summer survey was conducted, with the highest counts seen in June 2009. Beginning in 2012, the summer survey has been conducted during July.

Late summer surveys have been conducted in September of most years during the 2001–2011 period with the exception of 2008 and 2009. Beginning in 2012, the September survey has not been conducted. Rainbow trout were observed in all years surveyed with the highest counts seen in 2011 and the second highest counts seen in 2006. Chinook salmon were seen in much lower numbers or not at all for the same period of years with the highest counts observed in 2010.

The river-wide distribution of non-salmonid species (species other than trout or salmon) encountered in either routine or reference count snorkel surveys shifted beginning in the summer of 1996. In surveys from 1982–1996, warm water species (e.g. common carp, goldfish, catfish species, and sunfish species) were commonly observed, even upstream to Riffle 2 (RM 49.9). After 1996, these species were observed less frequently and typically only farther downstream. The change in species distribution coincided with higher required summer flows implemented with the 1996 FERC Order and lower upstream water temperatures associated with these flows.

CONTENTS

1 INTRODUCTION

Annual snorkel surveys have been conducted by the Turlock and Modesto Irrigation Districts (Districts) at locations along the lower Tuolumne River since 1982, with standard "reference" locations established since 2001. The location, area sampled by site, and season has varied over the years prior to 2001. The surveys completed from 1982–1987 were in limited locations and in varying seasons. A June/July snorkel survey has often been conducted since 1986 to evaluate the abundance, size, and distribution of salmonids and other fish species in "early summer" when required flow releases are less than in other seasons and is after the primary outmigration period of juvenile salmon. Summer surveys during June through September have been conducted in most years since 1988, although very wet years with high summer flows were not sampled for safety reasons. The surveys in 1988–1994 were part of the Districts' "summer flow" studies examining conditions affecting Chinook salmon while those since 1996 were part of the Tuolumne River fish management program implemented under the current FERC license for the Don Pedro Project. A total of 12 sites per survey have been done since 2001 with a comparable September snorkel survey in 2001–2007 and again in 2010–2011. Beginning in 2012, a single survey has been conducted during July at a total of 12 of the historic sampling sites.

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 general areas of suitable access. The overall river section examined is limited to the reach with suitable underwater visibility, this generally being about a 20-mile section from La Grange Dam (RM 52.2) downstream to near the city of Waterford (RM 31.5), although one site near RM 25 was sampled in 1988–1993.

1.1 2014 STUDY SITES

The area studied was the Tuolumne River from La Grange Dam (RM 52.2) to Hickman Bridge (RM 31.5) (Figure 1). Sites were selected based upon historical observations of fish habitat use, with presence/absence of fish at these sites and relative numbers used as indicators of river conditions such as flow and temperature. A total of eleven sites sampled are listed below. Riffle names are interchangeably designated with an "R" in this report (i.e. R2 = Riffle 2).

Site	Location	River Mile
1	Old La Grange Bridge (Riffle A7)	50.7
2	Riffle 2	49.9
3	Riffle 3B	49.1
4	Basso Bridge (R5B)	47.9
5	Riffle 7	46.9
6	Zanker Farm (R13B)	45.5
7	Bobcat Flat (R21)	42.9
8	Tuolumne River Resort (R23C)	42.3
9	7/11 Gravel (R31)	38.0
10	Santa Fe Gravel (R35A)	37.1
11	Deardorff Farm (R41A)	35.3
12	Hickman Bridge (R57)	31.5

1.2 2014 SAMPLING CONDITIONS

The flow at La Grange (USGS #11289650) during the 29–31 July surveys averaged 104 cfs (Figure 2). Water temperature collected during the surveys ranged from 13.6 °C (56.5 °F) at Riffle A7 on 29 July to 29.2 °C (84.6 °F) at Riffle 57 on 31 July.

2 METHODS

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 was observed; including riffles, runs, and pools. The snorkeling method provides for an index of species composition and relative abundance.

Each habitat type sampled usually involved one observer who snorkeled the specified habitat area for a certain time period. Whenever feasible, the surveys were conducted moving upstream against the current. A side-to-side (zigzag) pattern was used as the width of the survey section required. Occasionally, two snorkelers moved upstream in tandem, with each person counting fish on their side of the center of the survey section. Whenever possible, the entire width of the habitat section selected was surveyed. The only exceptions were the habitat areas that were too wide to effectively cover, in these cases the width of the survey area was estimated based on visibility. If high water velocity precluded upstream movement, snorkelers would float downstream with the current, remaining as motionless as possible through the study area, although stream margins at those sites would still be viewed in an upstream direction.

Usually the total length of an observed fish was estimated using a ruler outlined on the diving slate and recorded 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 estimated the length range and number of fish in the group. Care was taken to observe and count each fish just once in the survey area.

Other data recorded for each location included water temperature, electrical conductivity, turbidity, dissolved oxygen, and horizontal visibility. Site-specific data that was recorded included area sampled, average depth, sample time, general habitat type, and substrate type.

3 RESULTS AND DISCUSSION

Survey conditions and fish observations from the snorkel survey conducted on 29–31 July are summarized in Table 1. The six native fish species observed were characteristic of the lower elevation zone adjacent to the Sierra foothills. These species were Chinook salmon, rainbow trout, Sacramento sucker, Sacramento pikeminnow, hardhead, and riffle sculpin. The non-native species observed were; bluegill sunfish, redear sunfish, green sunifish, largemouth bass, smallmouth bass, and spotted bass. Chinook salmon were observed only at RA7 (RM 50.7) and rainbow trout were observed downstream to R13B (RM 45.5).

During the July survey, there were six juvenile Chinook salmon observed in riffle-run habitat at RA7 (RM 50.7) near La Grange Dam, ranging in size from 50–70 mm total length (TL). There were 53 rainbow trout observed ranging in size from 40–350 mm TL, seen in riffle, run, and pool habitats. A total of 38 juvenile (<150 mm TL) and 15 adult (≥150 mm TL) rainbow trout were observed. Water temperature at those locations where rainbow trout were observed ranged from 13.6 ºC (56.5 ºF) to 20.7 ºC (69.3 ºF). Sacramento sucker, along with Sacramento pikeminnow and hardhead were often co-occurring, while riffle sculpin were observed at two locations in low numbers usually hidden under cobble/boulder substrate.

4 COMPARISON WITH OTHER YEARS

4.1 Rainbow trout and Chinook salmon: 1982-2014

Tables 2 and 3 summarize rainbow trout and Chinook salmon observations for all snorkel surveys conducted between 1982 and 2014. Low numbers of rainbow trout were observed downstream of La Grange Dam to Riffle 5 (RM 48.0) in limited surveys from 1982 to 1986. Rainbow trout were almost entirely absent from the lower Tuolumne River in surveys from 1987 to 1995 surveys. Beginning with the increased summer base flows implemented under the 1996 FERC Order, the number and distribution of rainbow trout increased and since 1999 these fish have been observed intermittently at locations downstream to RM 35.3. For the 1982–2014 period, Chinook salmon were recorded in all years except 1991 and 1992 although in some years the counts were very low after May. Chinook salmon were intermittently seen downstream to RM 31.5. Figures 3 and 4 graphically represent Tables 2 and 3, respectively, for the June–September period. Dates and locations where rainbow trout and Chinook salmon were observed for the 2001-2014 period are shown in Figures 5 and 6 respectively, and include November surveys conducted in years 2010 and 2011. The July counts in 2014 for both rainbow trout and Chinook salmon were lower than the July counts in 2012 and 2013.

4.2 Recent surveys: 2001-2014

The locations sampled since 2001 were the same each year, with the exception of the Bobcat Flat (R21) [RM 42.9] site in 2012. These surveys were the most comparable for showing presence or absence along the lower Tuolumne River by year, and allowing for a general indication of abundance based on observed counts. Rainbow trout counts increased from 2001 to 2006 and were much higher in 2011, with relatively lower counts in 2007 and 2010 (Figure 7) and decreasing counts in 2012–2014. The observed increases in counts of rainbow trout in 2006 and 2011, especially of fish less than 250 mm TL, may be the result of increased spawning and rearing habitat downstream of the La Grange Dam combined with the potential introduction of trout from overflows of the La Grange reservoir during flood control releases during the spring of those years. Chinook salmon counts in were high in years 2001–2004 and 2009, with comparatively low counts during 2007–2008 and 2012–2014 (Figure 8).

4.3 Other species observed: 1986-2014

The distribution and abundance of non-salmonid fish species observed during the summer snorkel surveys has changed over time. Prior to 1996, more introduced warmwater species were commonly seen with goldfish (*Carassius auratus*), common carp (*Cyprinus carpio*), brown bullhead (*Ameiurus nebulosus*), white catfish (*Ameiurus catus*), and various sunfish species usually observed (Table 4). After 1996 these species were often absent at upstream sites or observed in lower numbers. The change in species distribution of warmwater species appears to be associated with higher minimum summer flow releases. In 2014, sunfish species in relatively higher abundance were observed at the two downstream sampling locations (R41A [RM 35.3] and R57 [RM 31.5]).

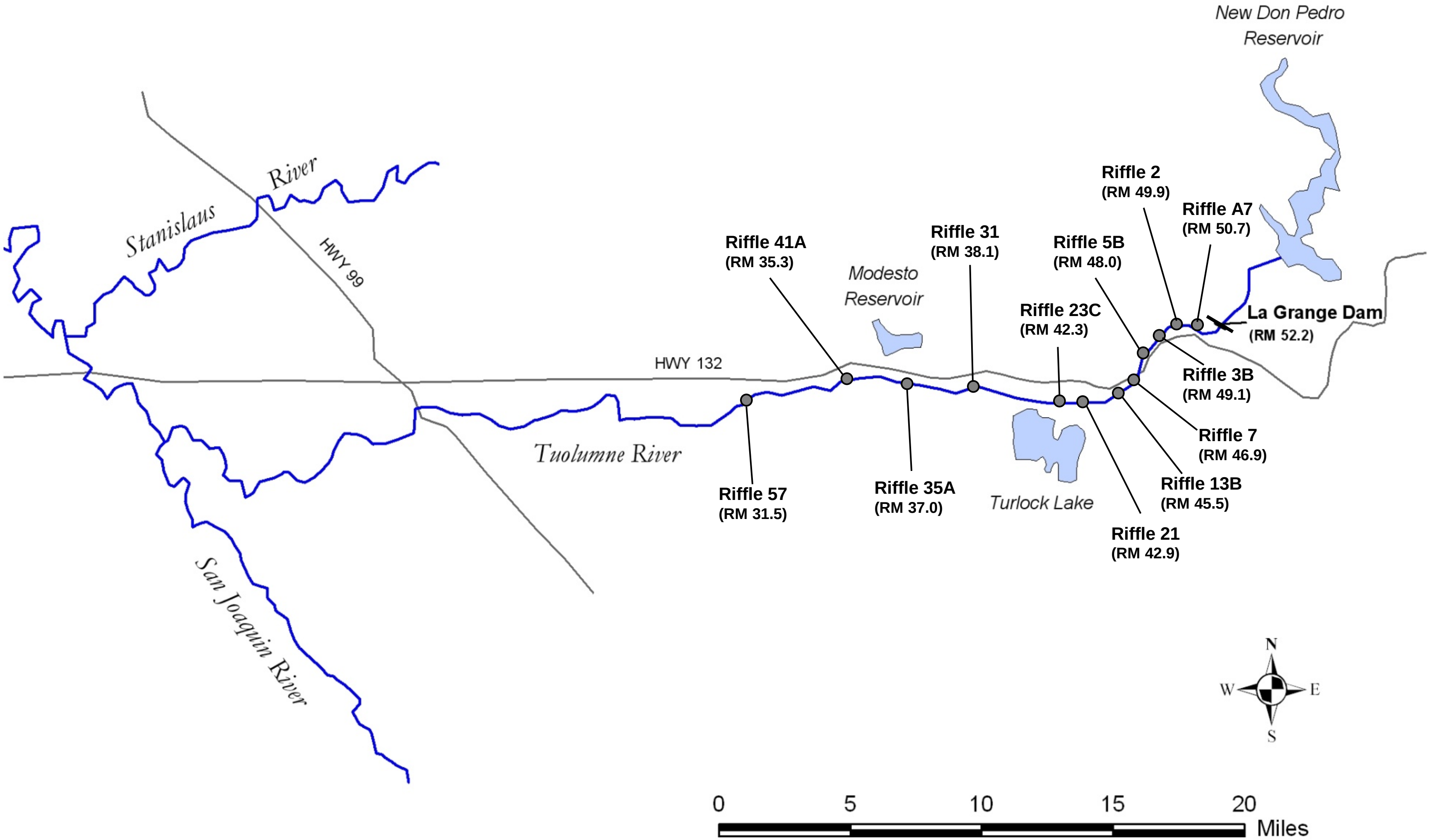

Figure 1. Locations of snorkel survey sites on the lower Tuolumne River, 2014.

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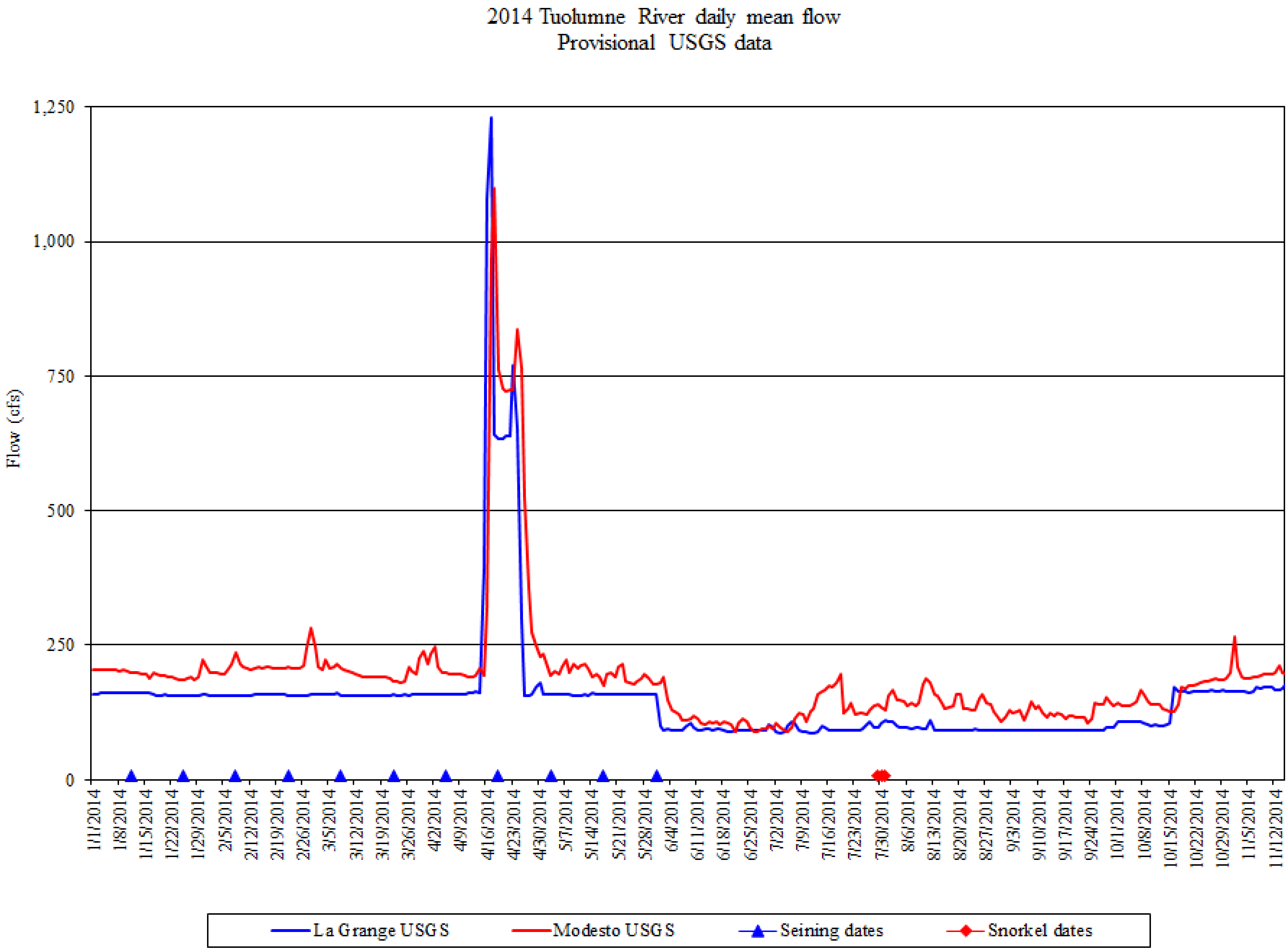

Figure 2. Tuolumne River flows at La Grange and Modesto USGS stations during 2014

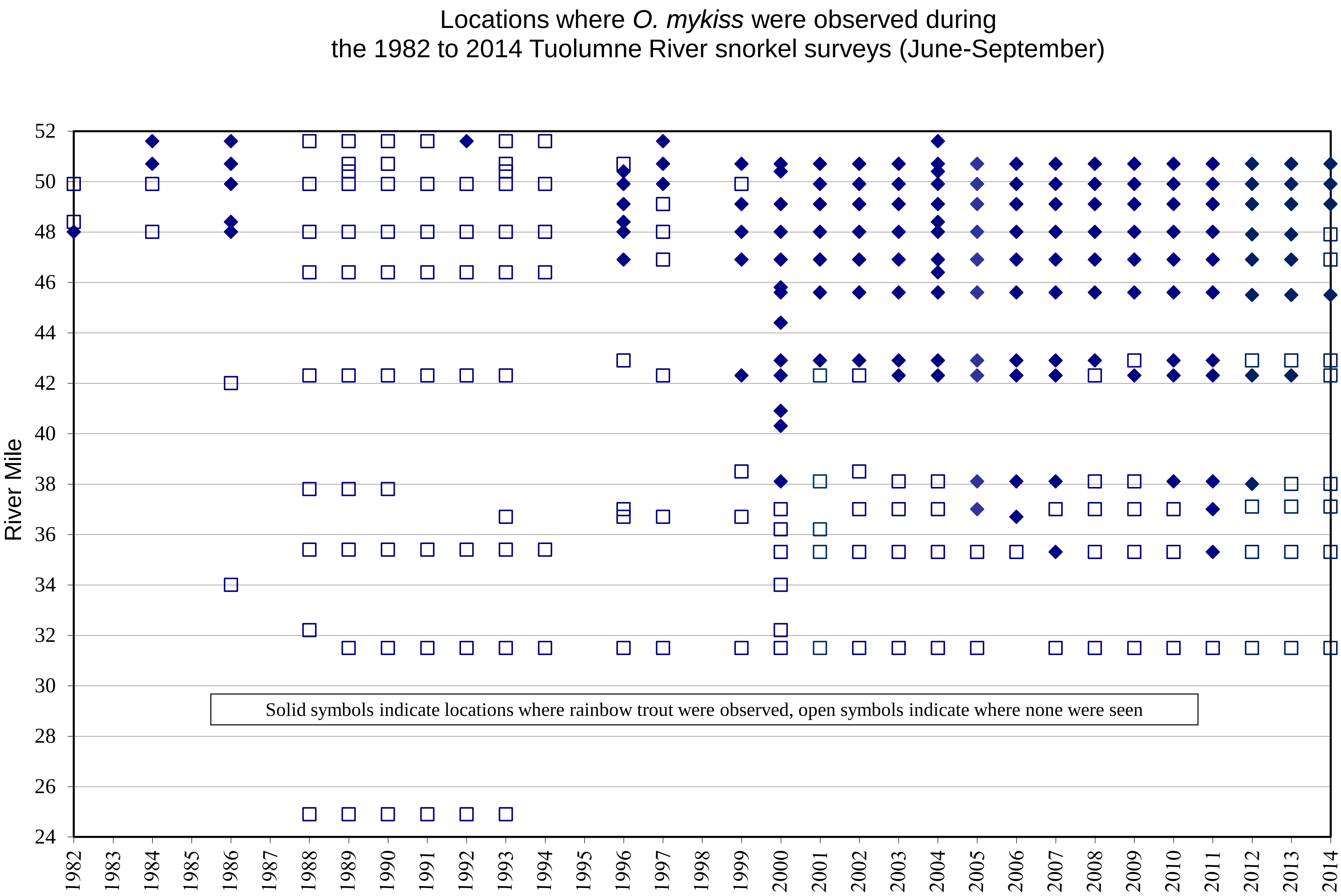

Figure 3. Locations where *O. mykiss* were observed

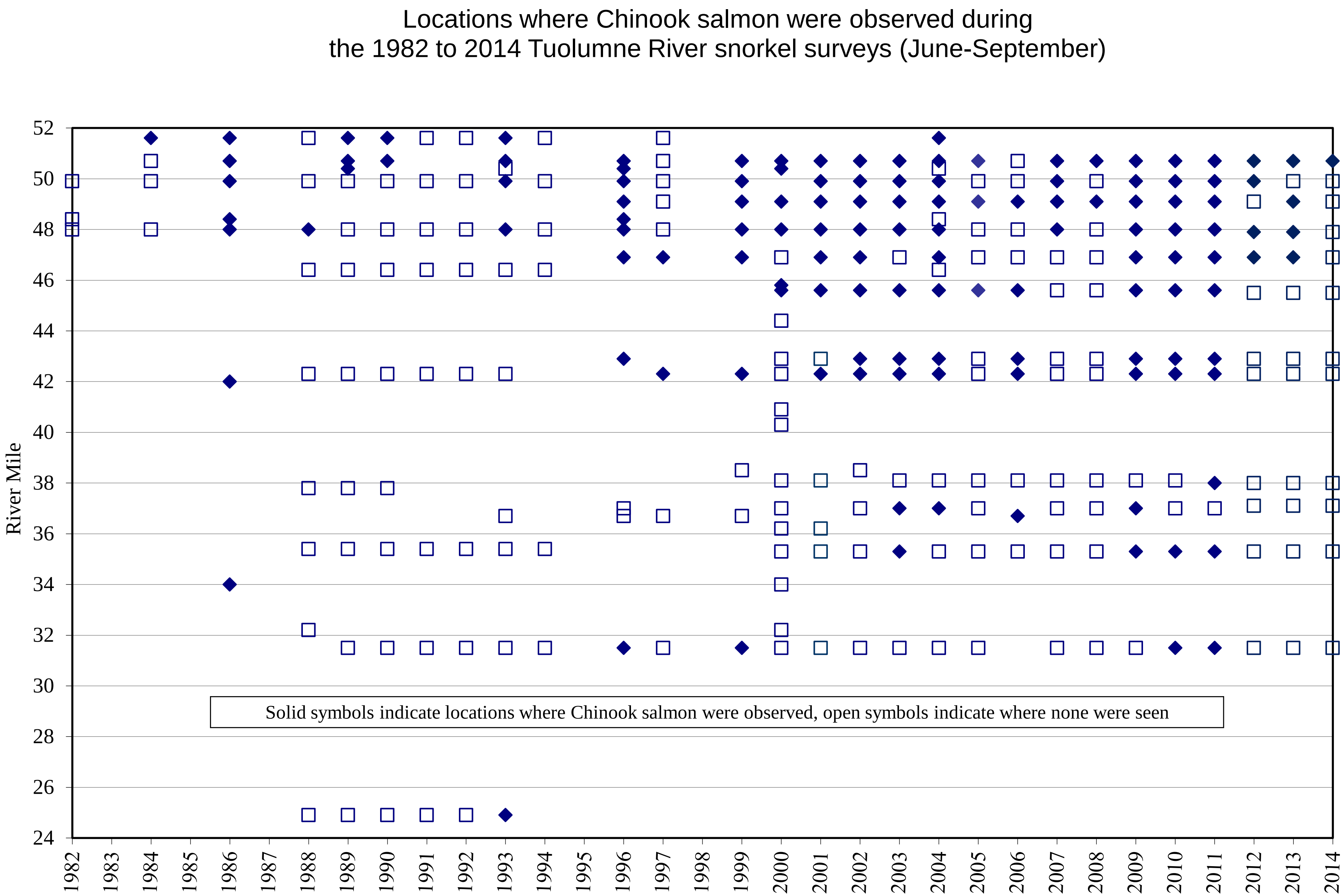

Figure 4. Locations where Chinook salmon were observed

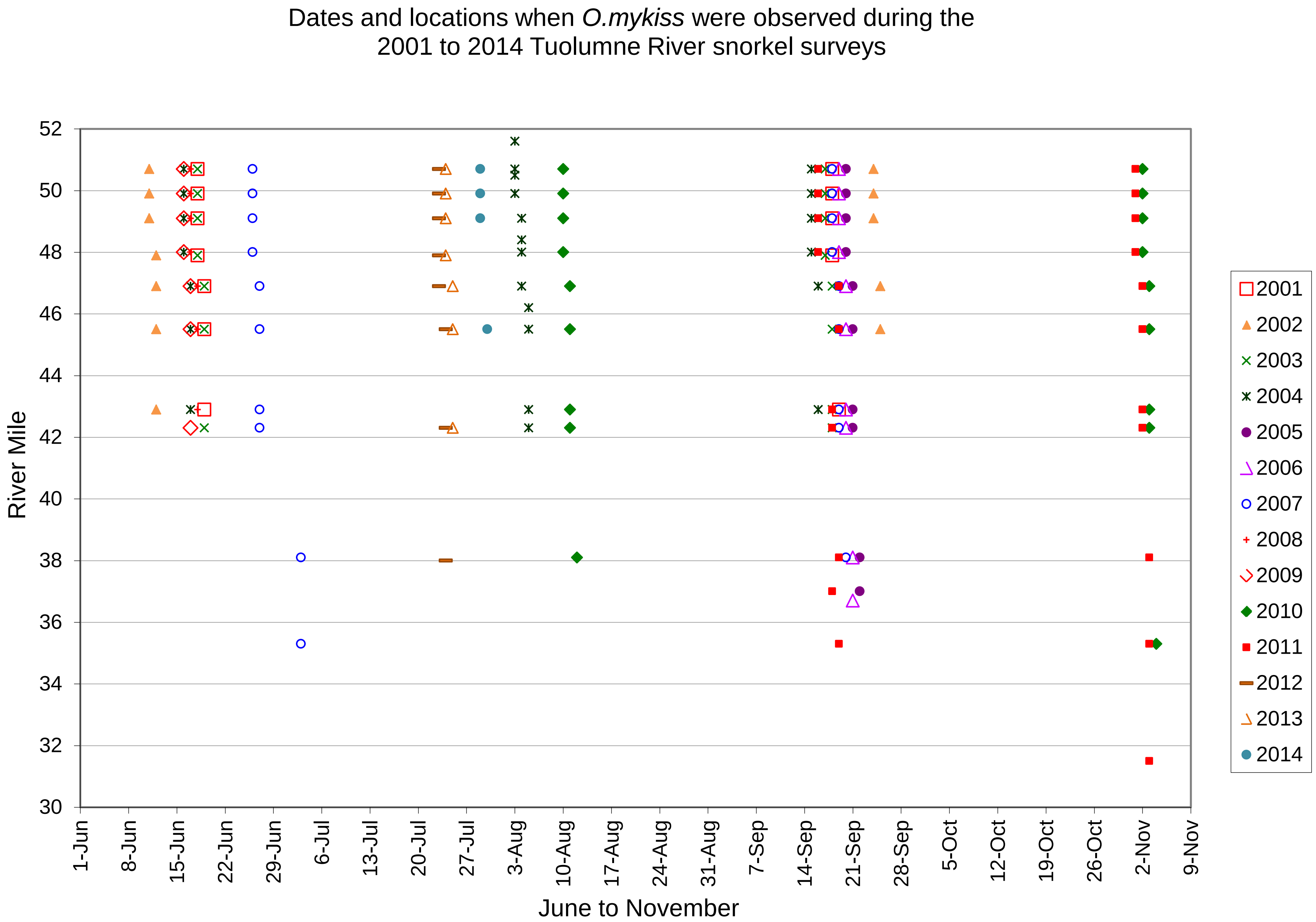

Figure 5. Dates and locations where *O. mykiss* were observed during the snorkel surveys

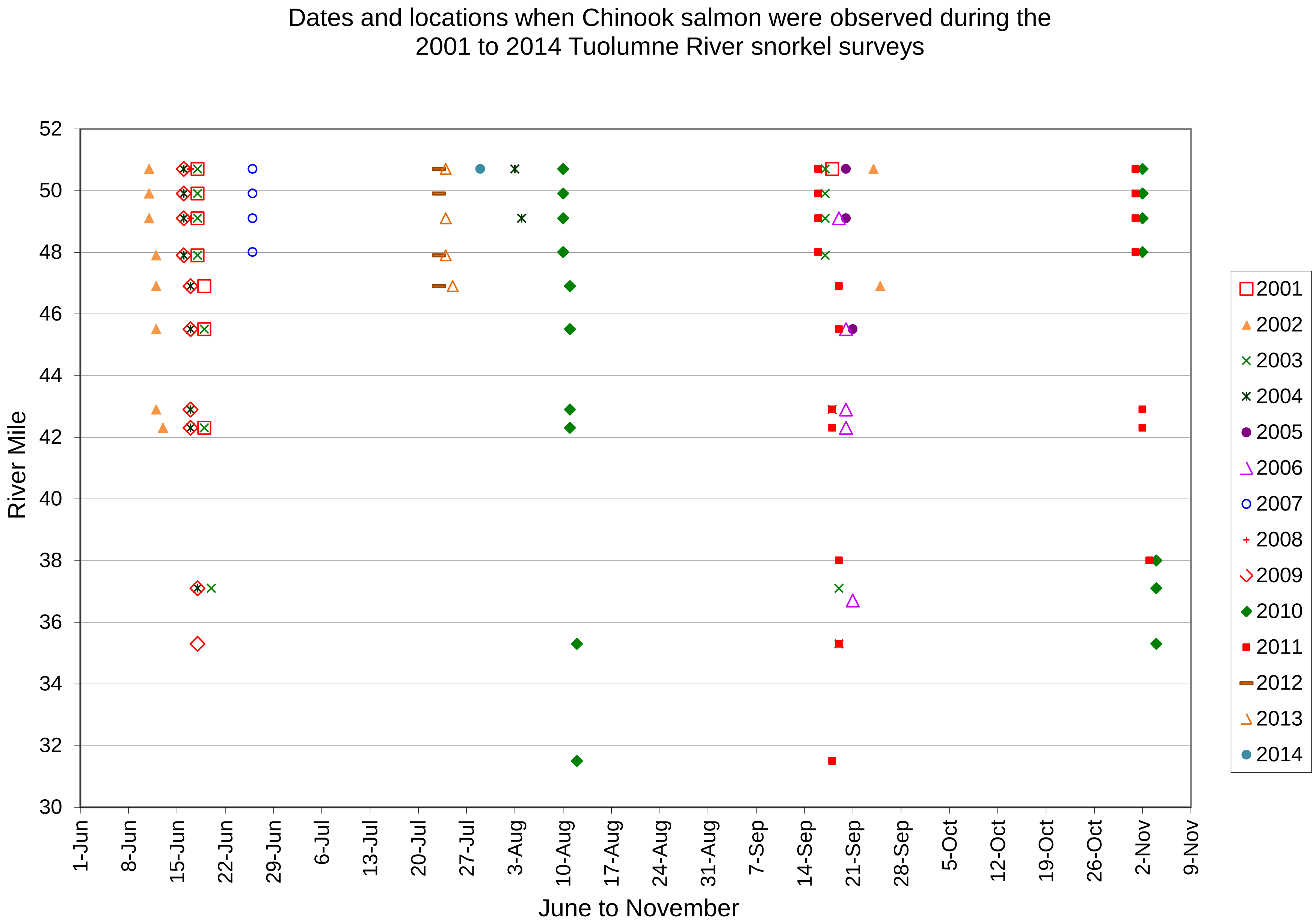

Figure 6. Dates and locations where Chinook salmon were observed during the snorkel surveys.

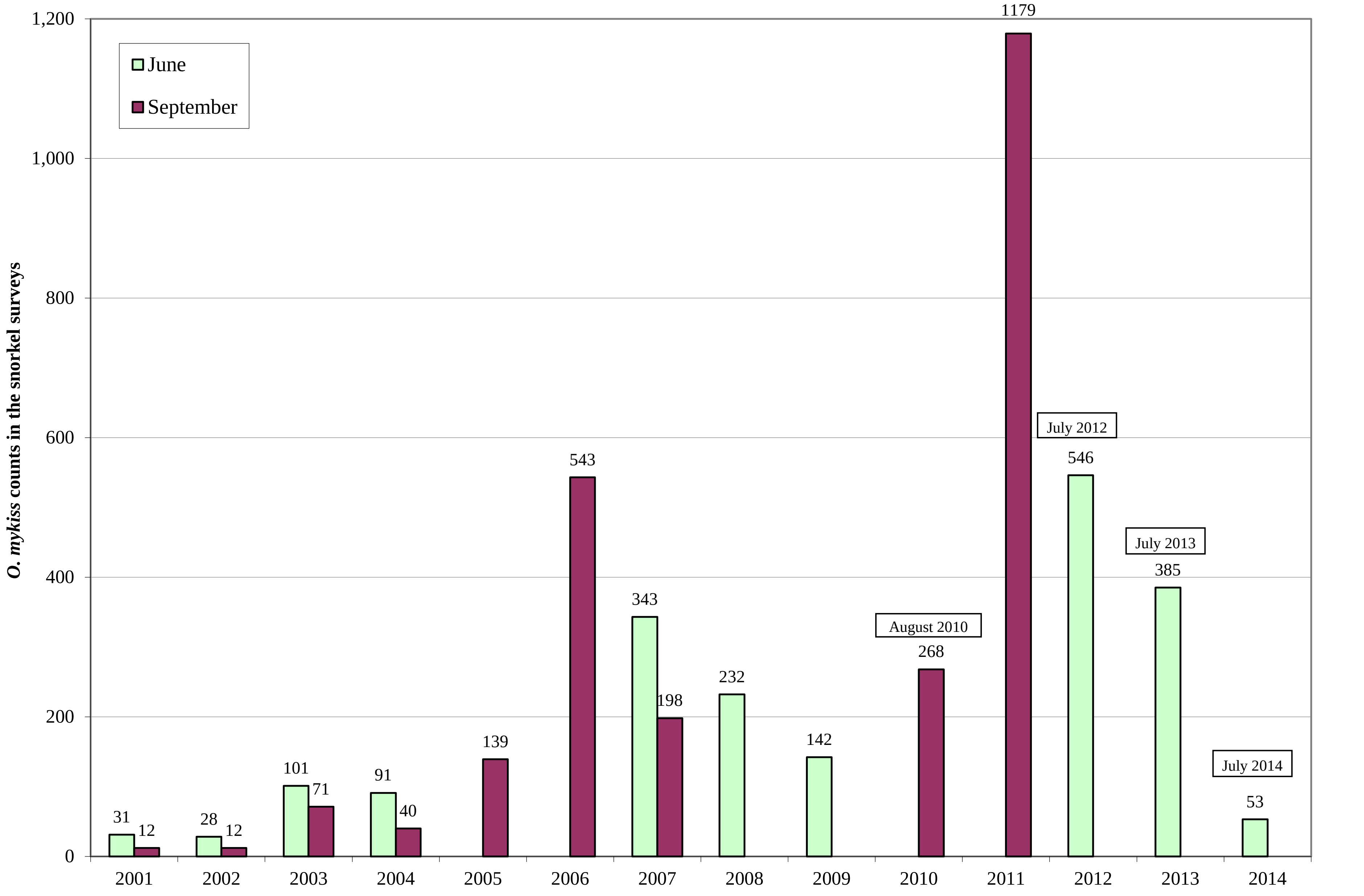

Figure 7. *O. mykiss* counts during the June and September snorkel surveys

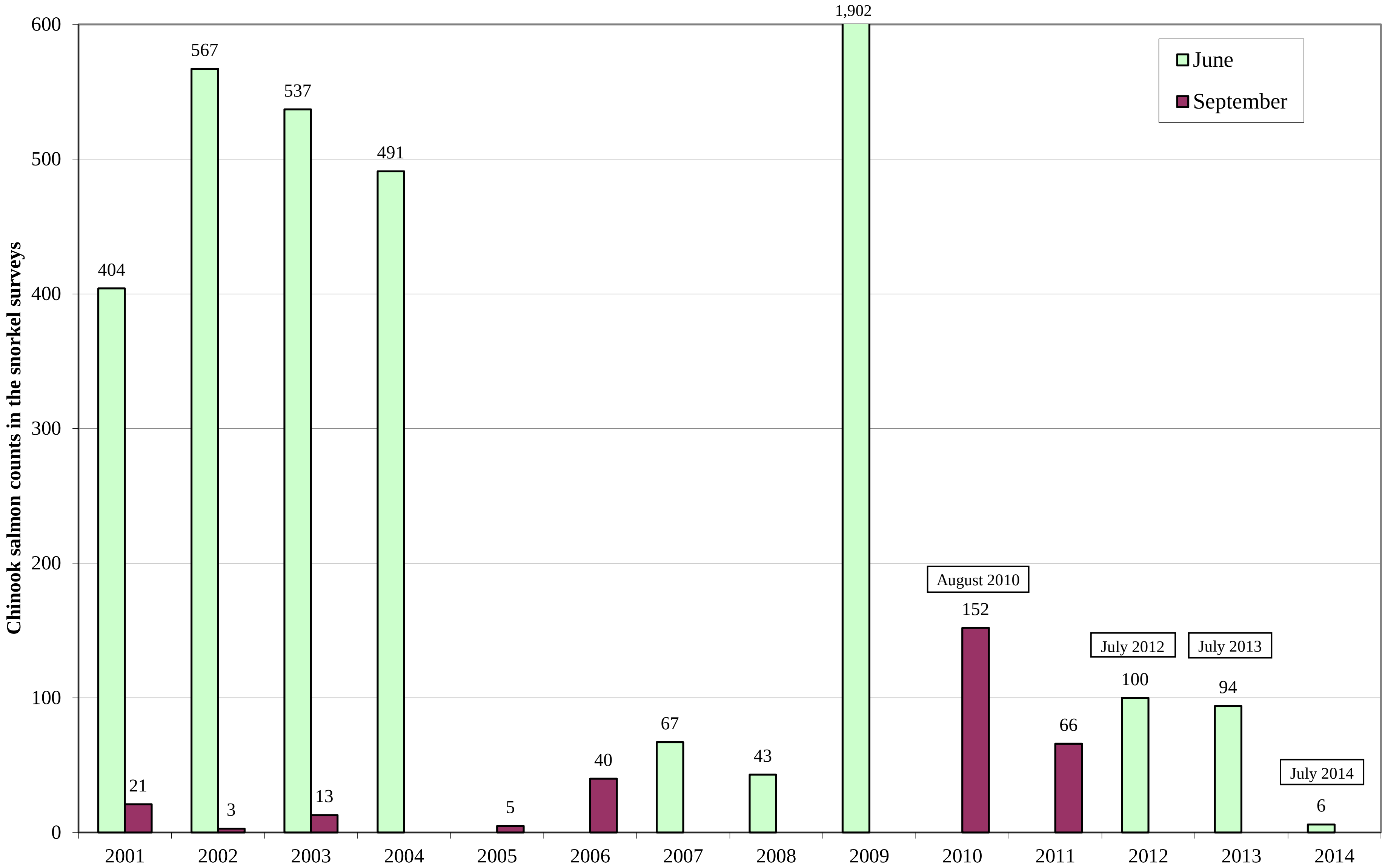

Figure 8. Chinook salmon counts during the June and September snorkel surveys

Table 1. July 2014 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)[1]	COND. (S/cm)	TURB. (NTU)	HORIZ. VISIB. (FEET)	CHINOOK count/est.	CHINOOK size	O. mykiss count/est.	O. mykiss size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	BLUEGILL SUNFISH	REDEAR SUNFISH	GREEN SUNFISH	SPOTTED BASS	SMALLMOUTH BASS	LARGEMOUTH BASS
															NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM)													
29JUL	0945	Riffle A7	50.7	1	16,000	1.8	25	Run-Riffle	cobble,boulder,algae	13.6	9.25	34	1.85	16	--	--	5	(40-50)										
				2	4,375	3.5	10	Riffle-Run	cobble,gravel,sand						6	(50-70)	11	(80-140)		10 (100-180)								
																	9	(150-300)										
29JUL	1120	Riffle 2	49.9	1	7,500	0.8	10	Riffle	cobble,gravel,sand	16.7	10.08	36	4.33	15	--	--	--	--										
				2	1,440	2.5	10	Pool	boulder,cobble,bedrock								1	(140)										
																	1	(320)										
				3	10,000	4.0	17	Run-Pool	cobble,boulder,sand						--	--	--	--										
29JUL	1320	Riffle 3B	49.1	1	7,250	2.0	15	Riffle	cobble,gravel,sand	17.4	10.37	37	1.26	16	--	--	20	(80-120)										
																	2	(150,280)										
				2	5,000	2.5	20	Run	cobble,bedrock,boulder						--	--	3	(160-350)	22 (40-50)	2 (380,400)								
29JUL	1445	Riffle 5B	47.9	1	3,900	5.0	10	Run-Pool	sand,cobble,gravel	19.8	7.02	37	1.20	12	--	--	--	--	25 (80-100)	120 (80-200)		1 (70)						
				2	10,000	6.0	14	Pool-Run	cobble,bedrock,silt						--	--	--	--	1 (60)									
				3	8,750	4.0	14	Run-Pool	cobble,bedrock,boulder						--	--	--	--	1 (500)	31 (140-410)								5 (160-200)
					74,215		**145**			**Subtotal**					**6**		**52**		**49**	**163**	**0**	**1**	**0**	**0**	**0**		**0**	**5**
30JUL	1045	Riffle 7	46.9	1	5,000	1.0	19	Riffle	cobble,algae,gravel	17.9	9.22	38	1.07	12	--	--	--	--		20 (140-250)	10 (140-250)							
				2	6,250	2.5	15	Run	cobble,sand,cobble						--	--	--	--										
30JUL	1215	Riffle 13B	45.5	1	5,400	1.5	14	Riffle-Run	cobble,sand,gravel	20.7	8.80	39	0.93	12	--	--	--	--	12 (250-350)	85 (100-300)								
				2	1,800	0.5	20	Riffle	cobble,sand,bedrock						--	--	1	(80)	34 (70-250)	99 (50-250)	2 (200)							1 (120)
31JUL	1020	Riffle 21	42.9	1	7,500	1.8	16	Run-Riffle	cobble,gravel,sand	21.4	--	39	1.13	12	--	--	--	--		90 (150-250)	60 (150-250)						8 (120-200)	7 (140-300)
				2	3,600	4.0	10	Pool	cobble,sand,gravel						--	--	--	--		270 (100-250)	20 (150-170)					1 (150)		2 (170)
31JUL	1120	Riffle 23C	42.3	1	3,125	1.5	10	Run-Riffle	cobble,gravel,sand	22.8	--	40	1.92	--	--	--	--	--	2 (270,300)	65 (120-240)	35 (140-250)							1 (90)
				2	4,000	0.9	12	Riffle	cobble,boulder,gravel						--	--	--	--		40 (100-150)	30 (150-250)							
					36,675		**116**			**Subtotal**					**0**		**1**		**48**	**669**	**157**	**0**	**0**	**0**	**0**	**1**	**8**	**11**
30JUL	1440	Riffle 31	38.0	1	5,400	1.5	15	Riffle	cobble,gravel,sand	25.9	5.48	44	1.15	15	--	--	--	--		54 (175-250)	7 (150-250)					2 (110,300)	12 (130-160)	1 (75)
				2	8,750	2.0	15	Run	cobble,gravel,sand						--	--	--	--									9 (60-200)	10 (160-180)
31JUL	0845	Riffle 35A	37.1	1	6,250	1.5	11	Riffle-Run	cobble,gravel,sand	24.4	--	47	2.74	15	--	--	--	--	5 (200-250)	108 (150-300)	53 (100-300)					4 (200)	4 (200)	2 (200,320)
				2	5,250	2.0	18	Run	gravel,sand,cobble						--	--	--	--									3 (70-170)	2 (140,150)
31JUL	1240	Riffle 41A	35.3	1	2,500	2.0	12	Run-Riffle	gravel,sand,cobble	26.6	--	37	1.72	15	--	--	--	--		6 (110-170)	14 (160-240)		47 (90-170)				4 (220-240)	3 (80-280)
				2	900	4.0	10	Run-Pool	sand,gravel,silt						--	--	--	--		19 (140-350)	16 (150-300)						11 (140-350)	12 (70-280)
				3	4,500	1.0	20	Riffle	cobble,gravel,sand						--	--	--	--		8 (150-200)	2 (200,250)						7 (80-120)	8 (60-150)
31JUL	1340	Riffle 57	31.5	1	3,125	1.0	14	Riffle	cobble,gravel,sand	29.2	--	46	0.89	12	--	--	--	--		5 (200-250)			8 (100-140)	3 (150-180)			11 (110-210)	9 (90-180)
				2	3,600	1.5	15	Run	cobble,gravel,boulder						--	--	--	--			1 (200)				29 (100-120)	5 (100-200)	4 (100-200)	
					40,275		**130**			**Subtotal**					**0**		**0**		**5**	**200**	**93**	**0**	**55**	**3**	**29**	**11**	**65**	**47**
					151,165		**391**			**TOTAL#**					**6**		**53**		**102**	**1,032**	**250**	**1**	**55**	**3**	**29**	**12**	**73**	**63**

[1] DO meter malfunction on 7/31/2014

Table 2. Tuolumne River snorkel survey locations (1982-2014) with number of *O. mykiss* observed, otherwise none were seen.

	1982	1984		1985	1986		1987			1988					1989				1990				1991		1992		1993			
	AUG	APR	AUG	MAR	JUL	AUG	JAN	APR	OCT	MAY	JUN	JUL	AUG	SEP	MAY	JUN	JUL	SEP	MAY	JUN	JUL	SEP	JUN	SEP	JUN	SEP	MAY	JUN	JUL	OCT
LOCATIONS																														
Riffle A3/A4 (RM 51.6)			27	2		6			X	X				X	X	X	X	X	X	X	X	X	X	X	1	X	X	X	X	X
Riffle A7 (RM 50.7)			26			13			X						X	X		X	X		X						X	X	X	X
Riffle 1A (RM 50.4)								X									X										X	X		X
Riffle 2 (RM 49.9)	X		X			25	X	X		X				X	X			X	X	X		X	X	X	X	X	X	X		X
Riffle 3B (RM 49.1)																														
Riffle 4B (RM 48.4)	X	12		X	5	10																					X			
Riffle 5B (RM 48.0)	2	X	X	X		10	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
Riffle 7 (RM 46.9)																														
Riffle 9 (RM 46.4)										X				X	X			X		X		X	X	X	X	X	X	X		X
Riffle 12 (RM 45.8)																														
Riffle 13A-B (RM 45.6)																											X			
Riffle 17A2 (RM 44.4)																														
Riffle 21 (RM 42.9)																														
Riffle 23B-C (RM 42.3)										X				X	X			X		X		X	X	X	X	X			X	
Riffle 24 (RM 42.0)					X																						X			
Riffle 26 (RM 40.9)																														
Riffle 27(RM 40.3)																														
Riffle 30B (RM 38.5)																														
Riffle 31 (RM 38.1)																														
Riffle 33 (RM 37.8)										X				X	X			X		X		X								
Riffle 35A (RM 37.0)																														
Riffle 36A (RM 36.7)																											X		X	
Riffle 37 (RM 36.2)								X																						
Riffle 39-40 (RM 35.4)										X				X	X			X		X		X	X	X	X	X		X		X
Riffle 41A (RM 35.3)																														
Riffle 46 (RM 34.0)					X		X																							
Riffle 52B (RM 32.2)										X				X																
Riffle 57-58 (RM 31.5)		X		X											X			X		X		X	X	X	X	X	X	X		X
Charles (RM 24.9)										X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X		X
Total O.mykiss	2	12	53	2	5	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table 2 (cont). Tuolumne River snorkel survey locations (1982-2012) with number of O. mykiss observed, otherwise none were seen.

	1994			1995	1996	1997	1999	2000	2001		2002		2003		2004			2005	2006	2007		2008	2009	2010		2011		2012	2013	2014
	MAY	JUL	OCT	NOV	JUL	JUN	JUN	JUN	JUN	SEP	JUN	SEP	JUN	SEP	JUN	AUG	SEP	SEP	SEP	JUN	SEP	JUN	JUN	AUG	NOV	SEP	NOV	JUL	JUL	JUL
LOCATIONS																														
Riffle A3/A4 (RM 51.6)		X	X	X		4										5														
Riffle A7 (RM 50.7)	X			1	**X**	2	14	14	7	3	5	1	66	16	12	6	11	10	115	106	75	76	80	35	33	249	6	115	258	25
Riffle 1A (RM 50.4)					**51**			3								4														
Riffle 2 (RM 49.9)		X	X		**91**	2	X		3	3	1	4	8	2	23	2	7	7	15	34	16	9	12	58	67	203	27	151	10	2
Riffle 3B (RM 49.1)					**138**	X	31	14	8	1	11	1	5	21	22	5	7	6	66	45	12	78	27	73	67	261	8	98	83	25
Riffle 4B (RM 48.4)					**55**											8														
Riffle 5B (RM 48.0)	X	X	X	2	**45**	X	10	19	4	2	3	X	6	10	11	15	6	36	54	92	10	21	11	26	16	149	41	70	10	X
Riffle 7 (RM 46.9)					4	X	15	52	4	X	5	2	14	9	13	5	2	2	106	22	7	13	6	25	6	88	9	18	10	X
Riffle 9 (RM 46.4)		X	X													3														
Riffle 12 (RM 45.8)								5																						
Riffle 13A-B (RM 45.6)								20	3	X	2	4	1	6	5	13	X	46	103	15	57	24	4	33	14	129	8	69	13	1
Riffle 17A2 (RM 44.4)								14																						
Riffle 21 (RM 42.9)					X			27	2	3	1	X	X	6	5	9	7	15	32	10	10	11	X	8	2	33	8		X	X
Riffle 23B-C (RM 42.3)	X					X	9	4	X	X	X	X	1	1	X	1	X	14	27	5	7	X	2	9	10	52	32	24	1	X
Riffle 24 (RM 42.0)				X																										
Riffle 26 (RM 40.9)								4																						
Riffle 27(RM 40.3)								2																						
Riffle 30B (RM 38.5)							X				X	X																		
Riffle 31 (RM 38.1)								2	X	X			X	X	X	X	X	1	21	12	4	X	X	1	X	10	2	1	X	X
Riffle 33 (RM 37.8)																														
Riffle 35A (RM 37.0)					X			X			X	X	X	X	X	X	X	2		X	X	X	X	X	X	3	X	X	X	X
Riffle 36A (RM 36.7)	X				X	X	X												4											
Riffle 37 (RM 36.2)								X	X	X																				
Riffle 39-40 (RM 35.4)		X	X																											
Riffle 41A (RM 35.3)								X	X	X	X	X	X	X	X	X	X	X	X	2	X	X	X	X	3	2	6	X	X	X
Riffle 46 (RM 34.0)								X																						
Riffle 52B (RM 32.2)								X																						
Riffle 57-58 (RM 31.5)	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	1	X	X	X
Charles (RM 24.9)			X																											
Total O.mykiss	0	0	0	3	**384**	8	79	180	31	12	28	12	101	71	91	76	40	139	543	343	198	232	142	268	218	1179	148	546	385	53

Data in bold type (JUL96, RA7 to R5B) was collected by CDFG using different survey methods that are not comparable

Table 3. Tuolumne River snorkel survey locations (1982-2014) with number of Chinook salmon observed, otherwise none were seen.

	1982	1984		1985	1986		1987			1988					1989				1990				1991		1992		1993			
	AUG	APR	AUG	MAR	JUL	AUG	JAN	APR	OCT	MAY	JUN	JUL	AUG	SEP	MAY	JUN	JUL	SEP	MAY	JUN	JUL	SEP	JUN	SEP	JUN	SEP	MAY	JUN	JUL	OCT
LOCATIONS																														
Riffle A3/A4 (RM 51.6)			7	X		75			X	3				X	127	56	18	X	135	12	X	X	X	X	X	X	9	35	X	10
Riffle A7 (RM 50.7)			X			20			X						X	11		X	144		3						54	X	2	7
Riffle 1A (RM 50.4)								150		22							25										14	X		7
Riffle 2 (RM 49.9)	?		X			50	100+	100+		1				X	X			X	11	X		X	X	X	X	X	6	2		11
Riffle 3B (RM 49.1)										1																				
Riffle 4B (RM 48.4)	?	?		60	30	25				1																	5			
Riffle 5B (RM 48.0)	?	?	X	X		40	130	400		129	1	X	X	X	X	X	X	X	4	X	X	X	X	X	X	X	33		3	3
Riffle 7 (RM 46.9)																														
Riffle 9 (RM 46.4)										3				X	X			X		X		X	X	X	X	X	3	X		7
Riffle 12 (RM 45.8)																														
Riffle 13A-B (RM 45.6)																											X	X		X
Riffle 17A2 (RM 44.4)																														
Riffle 21 (RM 42.9)																														
Riffle 23B-C (RM 42.3)										X				X	X			X		X		X	X	X	X	X			X	X
Riffle 24 (RM 42.0)					10																						X	X		
Riffle 26 (RM 40.9)																														
Riffle 27(RM 40.3)																														
Riffle 30B (RM 38.5)																														
Riffle 31 (RM 38.1)																														
Riffle 33 (RM 37.8)										1				X	X			X		X		X								
Riffle 35A (RM 37.0)																														
Riffle 36A (RM 36.7)																											8		X	X
Riffle 37 (RM 36.2)								40																						
Riffle 39-40 (RM 35.4)										X				X	X			X		X		X	X	X	X	X		X		X
Riffle 41A (RM 35.3)																														
Riffle 46 (RM 34.0)					8		800+																							
Riffle 52B (RM 32.2)										X				X																
Riffle 57-58 (RM 31.5)		?		40											X			X		X		X	X	X	X	X	X	X		X
Charles (RM 24.9)										X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		1		X
Total Chinook Salmon	0	0	7	100	48	210	1030+	690+	0	161	1	0	0	0	127	67	43	0	294	12	3	0	0	0	0	0	132	38	5	45

Table 3 (cont). Tuolumne River snorkel survey locations (1982-2013) with number of Chinook Salmon observed, otherwise none were seen.

	1994			1995	1996	1997	1999	2000	2001		2002		2003		2004			2005	2006	2007		2008	2009	2010		2011		2012	2013	2014
	MAY	JUL	OCT	NOV	JUL	JUN	JUN	JUN	JUN	SEP	JUN	SEP	JUN	SEP	JUN	AUG	SEP	SEP	SEP	JUN	SEP	JUN	JUN	AUG	NOV	SEP	NOV	JUL	JUL	JUL
LOCATIONS																														
Riffle A3/A4 (RM 51.6)		X	X	2		X										X														
Riffle A7 (RM 50.7)	X			17	**20**	X	23	211	277	21	429	2	426	2	390	77	X	1	X	13	X	26	1401	22	51	20	6	77	52	6
Riffle 1A (RM 50.4)					**29**			47								X														
Riffle 2 (RM 49.9)		X	X		**16**	X	3		4	X	10	X	72	1	16	X	X	X	X	18	X	X	43	21	32	1	3	15	X	X
Riffle 3B (RM 49.1)					**4**	X	108	34	52	X	83	X	16	3	59	3	X	3	10	32	X	17	333	68	35	7	2	X	40	X
Riffle 4B (RM 48.4)					**43**											X														
Riffle 5B (RM 48.0)	29	X	X	3	**154**	X	20	35	47	X	17	X	4	4	4	X	X	X	X	4	X	X	92	14	20	4	2	4	1	X
Riffle 7 (RM 46.9)					20	1	57	X	17	X	15	1	X	X	4	X	X	X	X	X	X	X	9	10	X	5	X	4	1	X
Riffle 9 (RM 46.4)		X	X													X														
Riffle 12 (RM 45.8)								6																						
Riffle 13A-B (RM 45.6)								5	6	X	10	X	9	X	3	X	X	1	8	X	X	X	2	2	X	13	X	X	X	X
Riffle 17A2 (RM 44.4)								X																						
Riffle 21 (RM 42.9)					2			X	X	X	1	X	X	1	7	X	X	X	10	X	X	X	7	2	X	2	1		X	X
Riffle 23B-C (RM 42.3)	2			1		2	1	X	1	X	2	X	8	X	1	X	X	X	8	X	X	X	12	3	X	5	10	X	X	X
Riffle 24 (RM 42.0)				1																										
Riffle 26 (RM 40.9)								X																						
Riffle 27(RM 40.3)								X																						
Riffle 30B (RM 38.5)							X				X	X																		
Riffle 31 (RM 38.1)								X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	30	4	1	X	X	X
Riffle 33 (RM 37.8)																														
Riffle 35A (RM 37.0)	X				X			X			X	X	2	1	7	X	X	X		X	X	X	1	X	1	X	X	X	X	X
Riffle 36A (RM 36.7)	X				X	X	X												4											
Riffle 37 (RM 36.2)								X	X	X																				
Riffle 39-40 (RM 35.4)		X	X																											
Riffle 41A (RM 35.3)								X	X	X	X	X	X	1	X	X	X	X	X	X	X	X	2	6	1	4	X	X	X	X
Riffle 46 (RM 34.0)								X																						
Riffle 52B (RM 32.2)								X																						
Riffle 57-58 (RM 31.5)	5	X	X		1	X	1	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	4	X	1	X	X	X	X
Charles (RM 24.9)			X																											
Total Chinook Salmon	36	0	0	24	**289**	3	213	338	404	21	567	3	537	13	491	80	0	5	40	67	0	43	1902	152	170	66	25	100	94	6

Data in bold type (JUL96, RA7 to R5B) was collected by CDFG using different survey methods that are not comparable

Table 4. Fish species observed in the Tuolumne River snorkel surveys during the June-September period.

Summary table of fish species observed in the Tuolumne River snorkel studies 1986 to 2014, June to September survey period.

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	1986	1988	1989	1990	1991	1992	1993	1994	1996	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Petromyzontidae	Pacific lamprey	N	LP	X										X					X						X				
Salmonidae	Chinook salmon	N	CS	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Salmonidae	rainbow trout	N	RT	X					X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinidae	goldfish		GF		X	X	X	X	X	X	X																		
Cyprinidae	carp		CP	X	X	X	X	X	X	X	X						X	X											
Cyprinidae	hardhead	N	HH	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X		X	X	X	X		X	X	X
Cyprinidae	Sacramento pikeminnow	N	PM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Catostomidae	Sacramento sucker	N	SKR	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ictaluridae	brown bullhead		BBH				X	X	X																				
Ictaluridae	white catfish		WCF		X	X	X	X	X	X	X								X			X		X					
Centrarchidae	green sunfish		GSF		X	X	X	X	X		X																		X
Centrarchidae	bluegill		BG	X	X	X	X	X	X		X						X	X	X			X	X	X				X	X
Centrarchidae	redear sunfish		RSF		X	X	X	X	X	X	X		X				X	X	X				X	X	X				X
Centrarchidae	warmouth		WM						X																				
Centrarchidae	largemouth bass		LMB	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Centrarchidae	smallmouth bass		SMB	X	X	X	X	X	X	X	X					X	X	X	X	X		X	X	X	X	X	X	X	X
Centrarchidae	spotted bass		SPB																										X
Cottidae	riffle sculpin	N	RSCP	X	X		X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Moronidae	striped bass		SB																						X	X			

(List includes all species observed during 1986-2014 snorkel studies)

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BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2014 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2014-6

Fall Migration Monitoring at the Tuolumne River Weir
2014 Annual Report

Prepared by

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Jason Guignard
and
Andrea Fuller

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Fall Migration Monitoring at the Tuolumne River Weir

2014 Annual Report

Submitted To:
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Modesto Irrigation District

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Introduction

The California Department of Fish and Wildlife (CDFW) has reported salmon escapement estimates on the Tuolumne River since 1940 (Fry 1961). Estimates of adult fall-run Chinook salmon *(Oncorhynchus tshawytscha)* escapement varied from about 100 to 130,000 from 1940 to 1997 (mean: 18,300; median: 7,100) (Ford and Brown 2001). During 1998 - 2013 estimates of adult fall-run Chinook salmon ranged from a high of 17,873 in 2000 (Vasques 2001) to a low of 124 in 2009 (mean: 3,827; median: 1,410) (Azat 2014). Until 2009, most estimates of escapement were obtained using carcass surveys (some weir counts were made at Modesto in the 1940's). While carcass surveys provide data to coarsely describe timing and distribution of spawning, population estimates from mark-recapture models are prone to bias if rigid assumptions are not met. Alternatively, resistance board weirs have been widely used in Alaska to estimate salmonid escapement since the early 1990's (Tobin 1994), and were introduced in the San Joaquin Basin in 2003. Resistance board weirs provide direct counts that are not subject to the same biases, and precise migration timing data.

Annual Tuolumne River Weir monitoring began in fall 2009, and is jointly supported by the Turlock Irrigation District (TID), Modesto Irrigation District (MID), and the City and County of San Francisco. Monitoring objectives include:

- Determine escapement of fall-run Chinook salmon and Central Valley steelhead (*Oncorhynchus mykiss*) to the Tuolumne River through direct counts.
- Document migration timing of adult fall-run Chinook salmon and Central Valley steelhead in the Tuolumne River and evaluate potential relationships with environmental factors.
- Determine size and gender composition of adult salmon population.
- Estimate hatchery contribution to spawning population.
- Document passage of non-salmonid fishes.

Study Area

The Tuolumne River is the largest tributary to the San Joaquin River, draining a 1,900 square-mile watershed that includes the northern half of Yosemite National Park (McBain and Trush 2000). The Tuolumne River originates in the central Sierra Nevada

Mountains and flows 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 within California's Central Valley.

The Tuolumne River is dammed at several locations for power generation, water supply, and flood control, with Don Pedro Reservoir being the largest impoundment. The lower Tuolumne River corridor extends from its confluence with the San Joaquin River to La Grange Dam at river mile (RM) 52.2. The La Grange Dam site has been the upstream limit for anadromous migration since 1871. The spawning reach of the Tuolumne River has been defined as extending 28.1 miles downstream of La Grange Dam to below the location of the Tuolumne weir RM 24.1 (O'Brien 2009).

The weir is located at RM 24.5 (Figure 1), and this site was selected for weir operation because it is located downstream of the majority of spawning. Site selection was also based on operational criteria that include water velocity, channel width, bank slope, channel gradient, channel uniformity, and substrate type.

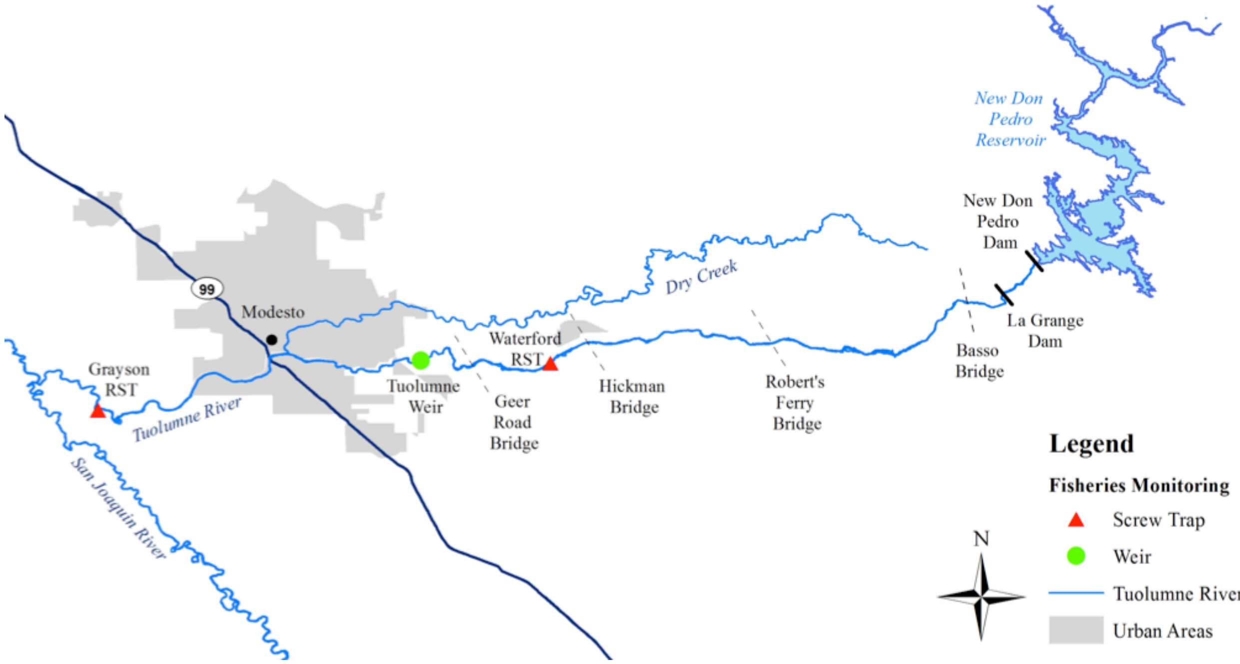

Figure 1. Map of the Tuolumne River displaying the location of the Tuolumne River Weir and other key points of interest.

Methods

A resistance board weir (Tobin 1994; Stewart 2002, 2003) and Vaki Riverwatcher fish counting system (Vaki system) were installed in the Tuolumne River at RM 24.5 on September 29, 2014. Monitoring occurred continuously throughout the fall-run Chinook salmon migration period.

Weir Operations

The Tuolumne River weir guides upstream migrating adult salmonids through a confined passage area where they can be observed and counted, while allowing water to pass unimpeded across the entire stream width (Figure 2). The weir consists of several components including a substrate rail, resistance board panels, bulkheads, rigid weir panels, and a passing chute (Figure 3). The resistance board portion of the weir is an array of 25 rectangular panels that measure 3 feet by 20 feet and consist of evenly spaced (2-5/8 inches on-center) polyvinyl chloride (PVC) pickets that are aligned parallel to the direction of stream flow. The upstream end of each panel is hinged to a rail that is anchored in the stream bottom, and the downstream end is held at the water surface by a resistance board that planes upward in flowing water. Sealed plastic barrels were occasionally used to provide additional flotation during periods of heavy debris or high flows (Figure 2).

Bulkheads consist of aluminum frames with PVC pickets that run parallel to the water surface, and provide an interface between resistance board panels and the rigid weir panels or passing chute (Figure 3). Bulkheads are the same length as the resistance board panels and are tall enough to remain above the surface of the water during high flows. Bulkheads are attached to the resistance board panels allowing them to float up and down with the resistance board panels for unobstructed lateral fish movement.

Two sections of rigid, stationary weir (one for each stream bank) block fish passage between the stream bank and the bulkheads (Figure 3). The rigid weir panels are 3-foot x 10-foot panels consisting of steel angle and spaced pipe held in place by 8-foot tall aluminum tripod supports. Metal cross braces connect adjacent tripods to each other.

The weir was inspected and cleaned a minimum of once per day between September 29 and December 15, and a minimum of three days were week between December 16 and December 31. During periods of heavy debris or high flows, the weir was checked more frequently. Weir performance was documented during each check by recording any observations of scouring beneath the substrate rail or overtopping of resistance board panels. If overtopping occurred, the number of affected panels was recorded.

Figure 2. Photograph of the weir with sealed plastic barrels used for additional flotation.

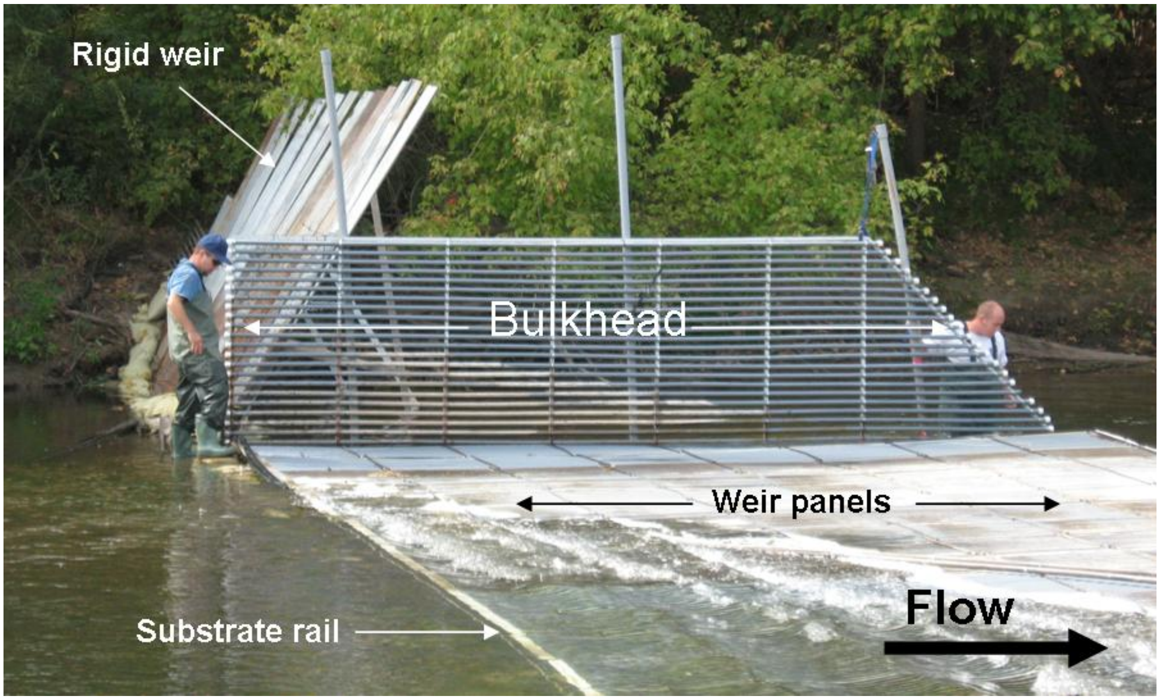

Figure 3. Photograph of weir components.

Vaki Operations

In conjunction with the weir, a Vaki Riverwatcher fish counting system (Vaki system) was used during the study period to monitor fish passage without the need to capture or handle fish. The Vaki system is comprised of three main components: an infrared scanner, a digital video camera with lights, and a computer system (Figure 4). The Vaki infrared scanner was attached to a fyke at an opening in the weir where data was relayed to a computer system that generated infrared silhouettes and video clips of objects passing upstream (Figure 5), and silhouettes only for objects passing downstream. The system also recorded the time, speed, and direction of passage, as well as the depth of the passing object. Data was downloaded and reviewed daily between September 29 and December 15 and three days a week from December 15 through December 31. Any outages in operation of the Vaki system were documented.

Infrared silhouettes were used in conjunction with digital video to identify passing objects. Quality of infrared silhouettes and video clips were ranked as good, fair, poor, or none. Identity to species can be uncertain if based on infrared silhouettes alone, or if the quality of the video is reduced by elevated turbidity. ID certainty for each passing object was ranked as positive, very likely, or likely. Video provides the only means of distinguishing morphologically similar species such as Chinook salmon and *O. mykiss*.

Figure 4. Left: Downstream photo of the fyke that contains Vaki system. Right: Upsteam side of livebox where fish migrating upstream of the weir exit the Vaki system.

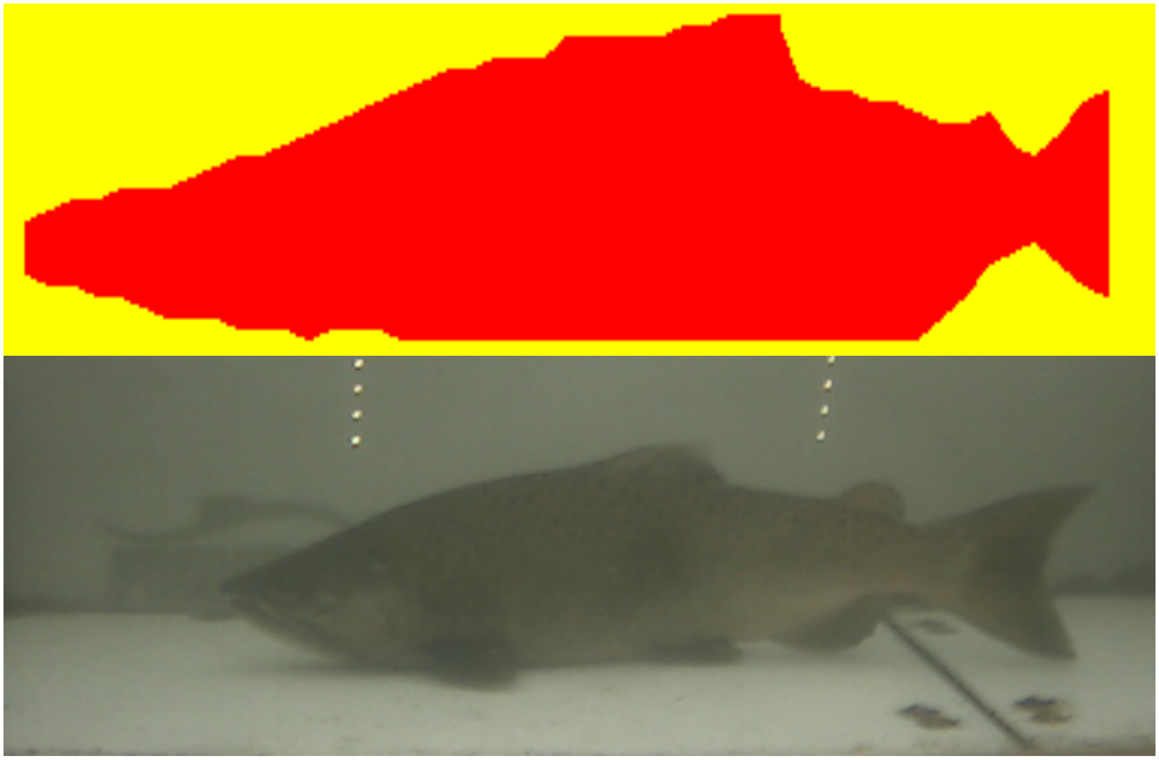

Figure 5. Example of a typical salmonid silhouette and a screen capture from a video clip of the same fish.

After each passage was identified to species, other data was recorded from video clips and silhouettes including the presence/absence of an adipose fin, fish condition (abrasion, laceration, fungal infection, hook scar, or lamprey scar), gender (male, female, or unknown), and life stage (Adult, Grilse, Juvenile, or unknown). Lengths of fish were estimated by applying user-defined length coefficients to body depths recorded by the Vaki system. User-defined coefficients for Chinook salmon were derived from measurements of body depth to total length ratios from 846 fish handled at the Stanislaus River during 2003-2010 using the following equation:

$$l = \frac{tl}{d}$$

where, *l* is the length coefficient, *tl* is the total length, and *d* is the body depth of the measured fish. Chinook salmon length coefficients used in 2014 were 4.1 for male, 4.29 for female and 4.18 for undetermined gender. Coefficients used for non-salmonids are provided in Table 4. Total length was estimated by the equation:

$$L = D \times l$$

where, *L* is the estimated total length, *D* is the body depth measured by the Vaki system, and *l* is the length coefficient.

Monitoring Fish Presence Upstream and Downstream of Weir

Visual assessments were conducted a half-mile upstream and a half-mile downstream of the weir site to monitor for potential migration delays and/or redd construction activity within this reach. Boat surveys were conducted daily from October 1 through December 15. After December 15 boat surveys were conducted Monday, Wednesday and Friday. A “stacking ratio” was calculated each day by dividing the sum of salmon observed downstream of the weir on that day plus the preceeding 2 days by the sum of passages through the Vaki system over the previous three days.

Environmental Data Collection

Environmental data collected during each weir check included conductivity (µS/ml), dissolved oxygen (mg/L), stream gauge (ft), turbidity (NTU), water temperature (°F), water velocity (ft/s) at the opening of the Vaki system scanner, and weather conditions (RAN = rain, CLD = cloudy, CLR = clear, FOG = fog). Instantaneous water temperature and dissolved oxygen were recorded using a YSI ProODO (YSI Incorporated) and instantaneous conductivity was recorded using an ExStik II model EC500 Conductivity Meter (Extech Intruments Corporation). Hourly water temperature data was logged using a Hobo Water Temp Pro V2 submersible data logger (Onset Computer Corporation). Turbidity was recorded using a T-100 Turbidimeter (Oakton Instruments), and water velocity was measured using a digital Flow Probe model FP-111 (Global Water Instrumentation, Inc.). Flow and water temperature records were also downloaded from the United States Geological Survey (USGS) water data website. (La Grange: 11289650; Modesto: 11290000)

Results

Weir Performance

The weir generally performed well during 2014, with few instances of minor overtopping recorded. Between October 2 and November 1 there were three instances when a single panel was overtopped and four instances when two panels were overtopped due to heavy clumps of water hyacinth washing onto the weir (Table 1). On the morning of December 12 a large amount of water hyacinth had accumulated upstream of the weir due to increased flows associated with a run-off event and six panels were submerged on arrival. Since the precise timing that the weir was overtopped is unknown, the maximum duration of each overtopping event was estimated as the time elapsed between identification of overtopping and the previous weir check.

Table 1. Summary of instances when one or more weir panels were overtopped.

Date	# of Submerged Panels	Observation Time (hhmm)	Previous Observation Time (hhmm)	Maximum Duration (hhmm)	Average Daily Flow (cfs) at La Grange	Average Daily Flow (cfs) at Modesto
Oct. 2	1	1245	1130	2515	111	136
Oct. 19	2	815	200	615	163	170
Oct. 20	1	0000	1915	245	162	175
Nov. 1	1	745	0000	745	165	265
Nov. 20	2	100	2130	330	177	210
Nov. 22	2	1030	800	2530	176	208
Nov. 22	2	2130	1030	1100	176	208
Dec. 12	6	815	800	2415	177	482

Vaki Performance

The Vaki system performed well during 2014, with only one confirmed outage that was resulting from an animal (likely a beaver) chewing through the Riverwatcher cable on October 22. Based on the time of last recorded passage and the time that the connection was fixed, the Riverwatcher did not record data for a maximum of nearly twelve hours.

Chinook salmon stacking ratio

Stacking ratios during the 2014 sampling season ranged from zero to 0.33 (mean: 0.03), and remained below the threshold of 1.15. Stacking ratios were highest on October 2 and October 3, which were days when Chinook salmon passage was low and one Chinook salmon was observed below the weir.

Chinook salmon abundance and migration timing

Between September 29, 2014 and December 31, 2014, the Vaki system detected net passage of 638 adult fall-run Chinook salmon moving upstream of the weir. The first salmon was observed on September 30, and peak daily passage of 34 Chinook salmon occurred on November 14 Figure 6). Cumulatively, 10% of passages (n=62) occurred by November 1, 75% (n = 480) occurred by December 1 and 90% (n = 576) occurred by December 7 (Figure 7).

Chinook salmon gender and size

Gender was determined for 98% of salmon observed, with 56% (n = 360) of the run composed of males, 42% (n = 268) of the run composed of females. Estimated sizes of Chinook salmon ranged from 217 mm to 1,021 mm (Figure 8). Mean sizes of upstream migrating Chinook salmon were 626 TL mm (n = 296) for male, 683 TL mm (n = 496) for female, and 502 TL mm (n = 38) for undetermined gender (Table 2).

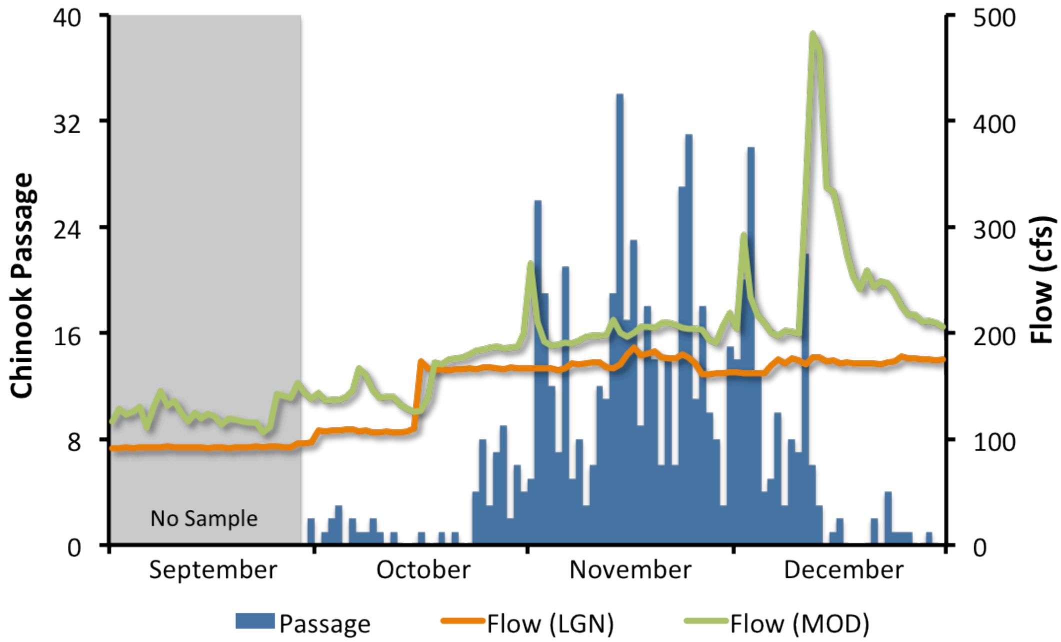

Figure 6. Daily upstream Chinook salmon passage recorded at the Tuolumne River Weir in relation to daily average flows recorded in the Tuolumne River at La Grange (LGN) and Modesto (MOD) between September 1, 2014 and December 31, 2014.

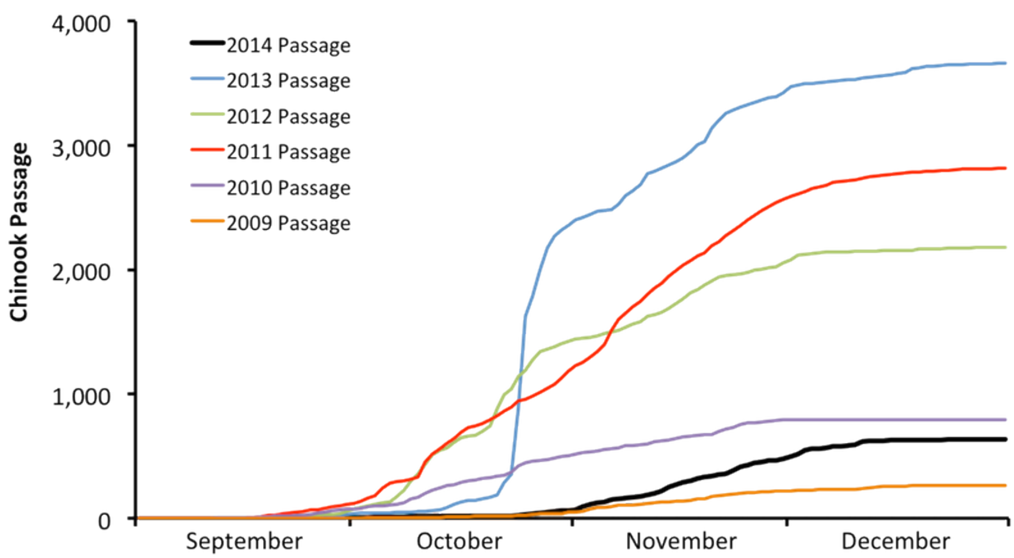

Figure 7. Cumulative adult fall-run Chinook salmon passage from September 1 through December 31 during 2009 - 2014.

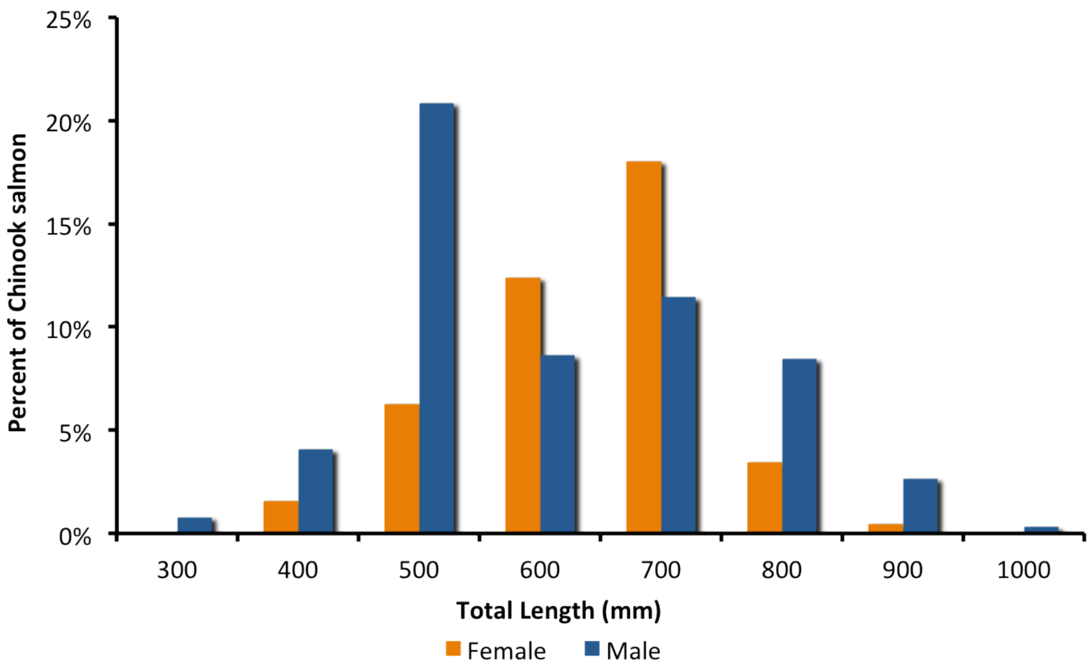

Figure 8. Length distributions of male and female Chinook salmon upstream passage.

Origin of Chinook salmon production

Adipose fin clips (ad-clips), suggesting hatchery origin, were observed in 15% (n = 97) of the Chinook salmon for which a positive identification of presence/absence of an adipose fin could be made. Since not all hatchery fish are ad-clipped, the actual proportion of hatchery origin fish cannot be estimated until coded wire tags recovered by CDFW during carcass surveys are read to determine the hatchery of origin. Both un-clipped male and female Chinook salmon were larger than ad-clipped fish (Table 2).

Observation of *O. mykiss*

No *O. mykiss* were recorded passing the weir between September 29, 2014 and December 31, 2014.

Table 2. Summary of Fall-run Chinook salmon gender, size, and presence/ absence of adipose fin. Note: Upstream passage counts only; data are not directly comparable to net passage. Parenthesis indicates range.

Gender	*Adipose Fin Clip*	*Mean TL (mm)*	*95% CI (mm)*	*n*
Male	No	656 (344-1,021)	656 ± 15	356
	Yes	577 (422-972)	577 ± 25	72
	Undetermined	-	-	-
Female	No	695 (429-952)	695 ± 12	244
	Yes	655 (480-824)	655 ± 32	36
	Undetermined	543 (536-549)	543 ± 13	2
Undetermined	No	496 (217-736)	496 ± 70	18
	Yes	587 (502-694)	587 ± 63	5
	Undetermined	589	-	1

Non-salmonids

The majority of non-salmonid species (94%) were non-native, and many of the non-native species are known to prey on juvenile Chinook salmon (e.g. largemouth bass, smallmouth, and catfish) (Tabor et. al. 2007). A total of 9 non-salmonid species were identified at the weir including Bluegill sunfish *(Lepomis macrochirus)*, common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), hardhead (*Mylopharodon conocephalus*), largemouth bass (*Micropterus salmoides*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), smallmouth bass (*Micropterus dolomieu*), white catfish (*Ictalurus catus*); as well black bass (*Micropterus spp.*), catfish (*Ameiurus spp. and Ictalurus spp.*), and sunfish (Lepomis spp.) that could only be identified to the genus. Black bass were most abundant after mid-October and continued through early December (Figure 9).

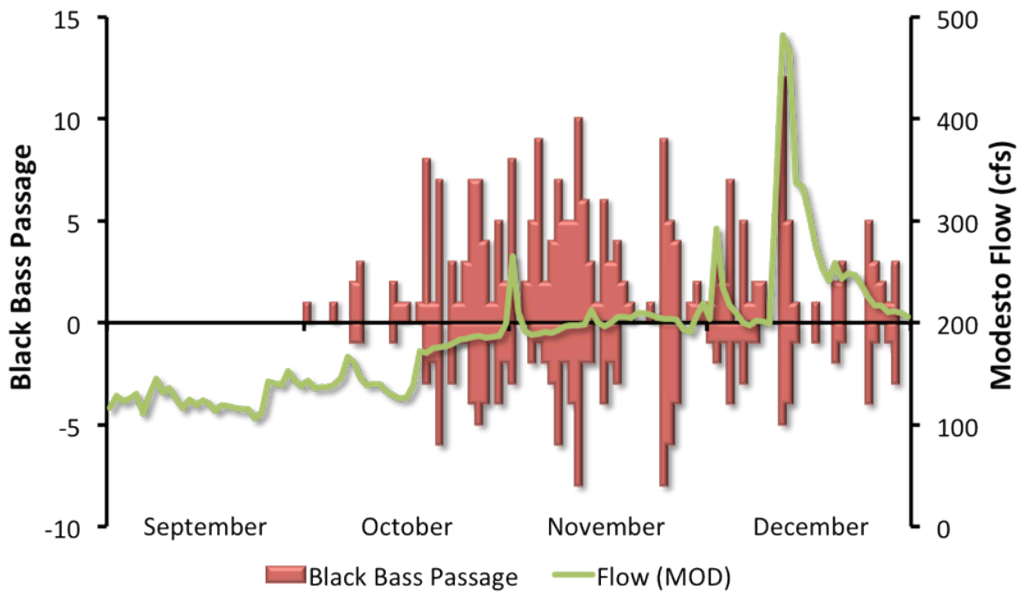

Figure 9. Black bass passages recorded at the Tuolumne River Weir between September 29, 2014 and December 31, 2014.

Environmental Conditions

Average daily base flows at La Grange (RM 51.8) averaged approximately 90 cfs during September, 140 cfs during October, and 170 cfs during November and December (Figure 6). Resulting flows at Modesto were approximately 40 cfs greater than at La Grande (RM 17; Figure 6). Due to the critical water year type no pulse occurred during the fall of 2014. Peak flows of approximately 480 cfs occurred at Modesto on December 12 associated with a rain evernt (Figure 6). Daily average water temperaures measured at the weir ranged between 46.7˚F and 74.6˚F (Figure 10). Instantaneous turbidity ranged between 0.33 NTU and 5.35 NTU (1.45 NTU season average; Figure 11). Instantaneous dissolved oxygen ranged between 7.62 mg/L and 11.38 mg/L (9.22 mg/L season average; Figure 12).

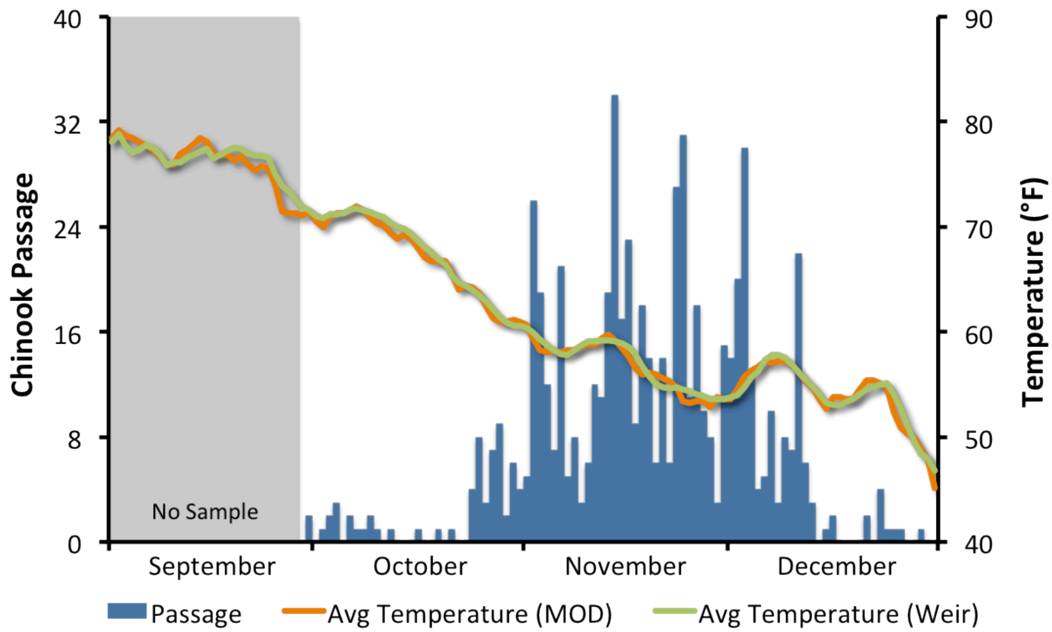

Figure 10. Daily Chinook salmon passage and daily average water temperature at the Tuolumne River Weir and daily average water temperature at Modesto (MOD) between September 1, 2014 and December 31, 2014.

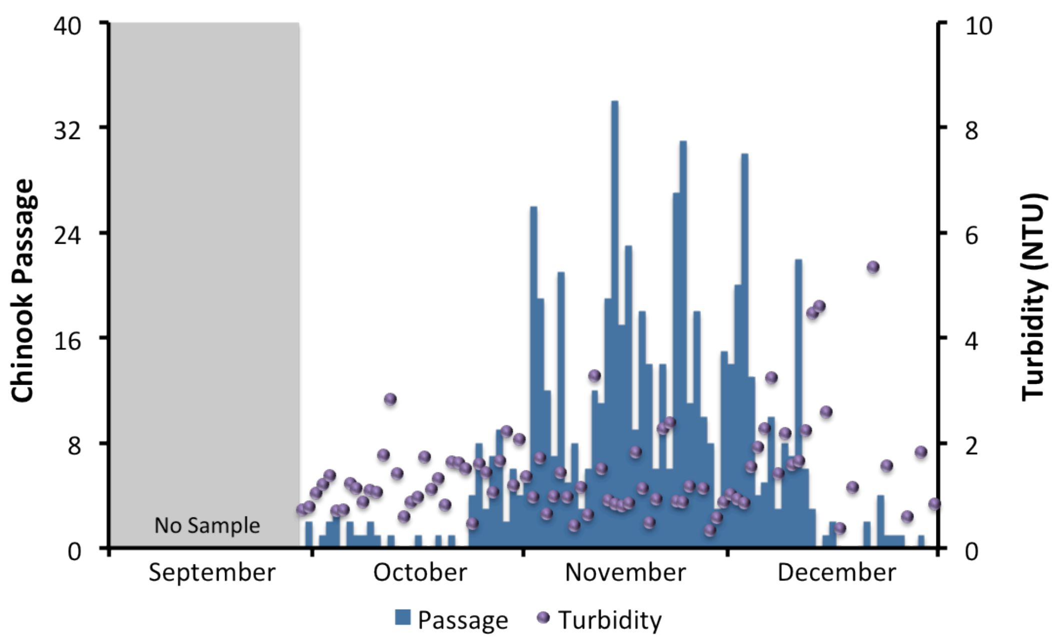

Figure 11. Daily Chinook salmon passage and instantaneous turbidy recorded at the Tuolumne River Weir between September 1, 2014 and December 31, 2014.

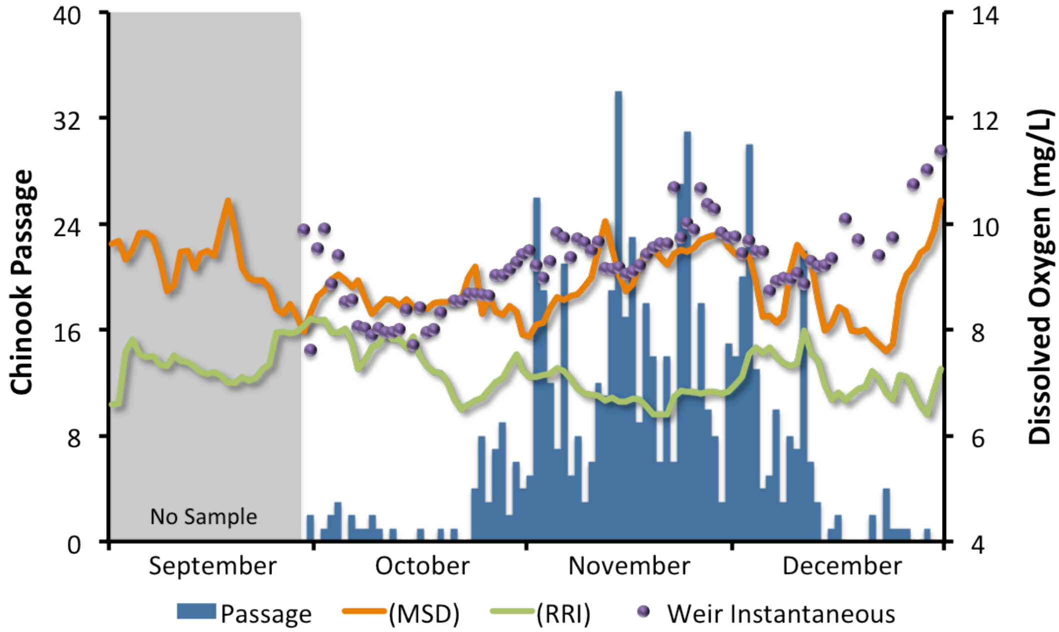

Figure 12. Daily Chinook salmon passage recorded at the Tuolumne River Weir in relation to instantaneous dissolved oxygen and daily average dissolved oxygen measured at Mossdale (MSD) and Rough and Ready Island (RRI) between September 1, 2014 and December 31, 2014.

Spring 2014 Monitoring

After the fall 2013 season (Becker et al. 2014), weir monitoring continued through the winter and spring from January 1 through May 7, 2014. Net upstream passage of 80 Chinook salmon was observed during this period. Daily passage and environmental data are provided in Appendix A. Total Chinook salmon passage for this period was composed of 50% male (n = 40), 36% female (n = 29) and 14% undetermined gender (n = 11). Adipose fin-clips were observed in 6% of fish examined in the spring of 2014.

No *O. mykiss* were recorded passing the weir between January 1, 2014 and May 7, 2014.

A total of 311 black bass and 11 striped bass were recorded between January 1, 2014 and May 7, 2014.

Discussion

Net upstream passage of 638 fall-run Chinook salmon during 2014 represents the second lowest season total escapement to the Tuolumne River since weir monitoring began in 2009. Carcass surveys conducted by CDFW during 2014 were used to generate an escapement estimate of 438 Chinook salmon (PFMC 2015). Weir counts and and carcass survey estimates (Azat 2014) differed greatly during 2009-2014, with carcass surveys underestimating abundance in all years (Table 3).

Migration timing appeared to be later in 2014 when 50% of salmon passed the weir by November 19 as compared to October 31 in past years. This later timing was suggestive of a delayed Chinook fall-run migration in the Tuolumne River during 2014. Low early-season passage counts during 2013 were also suggestive of a delayed migration in the Tuolumne River. Unique to both of these years was the extensive growth of water hyacinth that occurred in the lower Tuolumne and San Joaquin Rivers.

Table 3. Annual adult Chinook salmon passage counts by run-type and range of dates that adult Chinook salmon passed the Tuolumne River Weir with CDFW annual escapement counts.

Year	Monitoring Type	Passage Date Range	Total Passage Count
2014	Fall Weir	September 29 - December 31	638
	CDFW Carcass Survey	Fall Run	438
	Winter/Spring Weir	January 1 – February 15*	32*
2013	Fall Weir	September 24 - December 31	3,664
	CDFW Carcass Survey	Fall Run	1,926
	Winter/Spring Weir	January 1 - May 7	80
2012	Fall Weir	September 24 - December 31	2,180
	CDFW Carcass Survey	Fall Run	783
	Winter/Spring Weir	January 1 - May 22	122
2011	Fall Weir	September 16 - December 31	2,817
	CDFW Carcass Survey	Fall Run	893
	Winter/Spring Weir	January 1 - May 30	90
2010	Fall Weir	September 9 - December 1	785
	CDFW Carcass Survey	Fall Run	540
	Winter/Spring Weir	No Sample	-
2009	Fall Weir	September 22 - December 31	264
	CDFW Carcass Survey	Fall Run	124
	Winter/Spring Weir	January 1 - February 10	31

*Preliminary passage through February 15, 2015. Monitoring still in progress.

Coverage and distribution of water hyacinth was evaluated using satellite imagery obtained through Apollo Mapping (Boulder, Colorado). The area from Vernalis (RM 66.4) on the San Joaquin River to Highway 99 (RM 16.1) on the Tuolumne River was evaluated using WorldView-2 (50-cm resolution) images captured on October 23, 2014. The remaining area of the Tuolumne River from Highway 99 to Fox Grove (RM 27.8), was evaluated using Pléiades-1 (50-cm resolution) imagery captured on November 28, 2014. Constituent orthomosaic images were delivered in North American Datum 1984 and projected in State Plane Zone III (ft.) formats, and imported to GIS (ESRI, Redlands, CA; ArcMap v10.2.2) for analysis. Area of water hyacinth blockages were delineated using polygons, and minimum blockage length was measured using polylines. The polyline attributes were joined to polygon attribute table; the resulting features were stored in a file geodatabase. The polygon attribute table was exported to Excel (Microsoft, Redmond, WA).

For the purposes of this analysis, a fully bedded raft of water hyacinth was one that covered the entire width of the channel from bank to bank. A total of 39 fully bedded rafts of water hyacinth covering 12.1% (16,556.8 ft) of riverine habitat were identified on the Tuolumne River between the weir location (RM 24.5) and the confluence with the San Joaquin River (RM 0). Additionally, 11 fully bedded rafts covering 15.0% (5,957.9 ft) of riverine habitat were identified in the San Joaquin River between the Tuolumne River confluence (RM 78.2) and Vernalis (Figure 13). The linear extent of these blockages ranged from 45 ft to 1,137 ft (mean= 345 ft) and total blockage between the San Joaquin River at Vernalis and the Tuolumne River weir covered 12.7% (22,514.7 ft) of riverine habitat.

Ground surveys of select water hyacinth blockage locations were conducted between September 24 and December 19, 2014, and heavy blockages were confirmed to be present throughout the entire migration season (Figure 14). These locations, individually, did not appear to present a complete physical barrier to upstream fish passage, as water depth seemed sufficient for salmon to pass beneath the water hyacinth barrier. However, the dense cover over such large areas might have created a behavioral impediment, as fish may have been reluctant to swim under the hyacinth, delaying upstream migration.

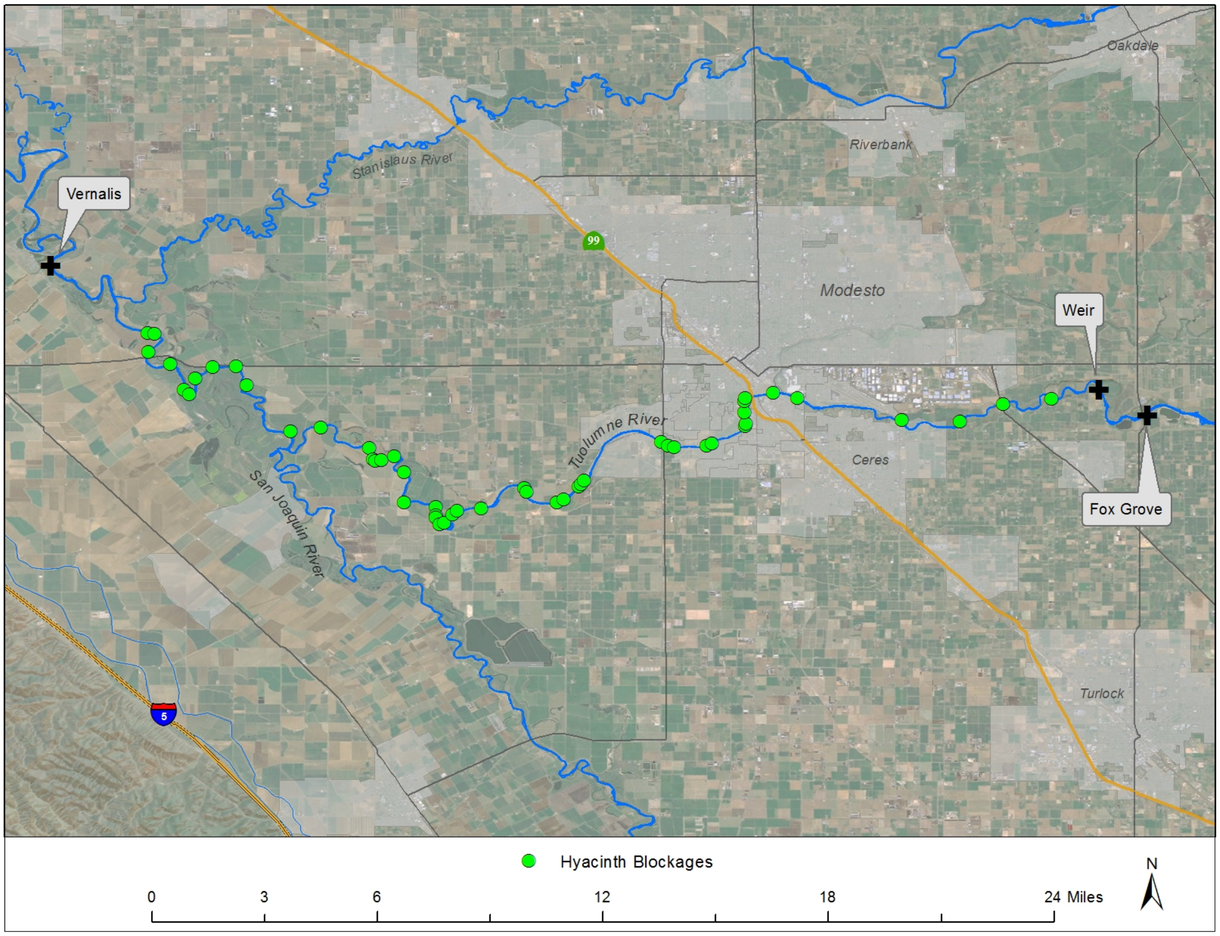

Figure 13. Water hyacinth blockages identified between Vernalis and Fox Grove based on analysis of aerial imagery (Imagery dates: 10/23/14 and 11/28/14).

Figure 14. Water hyacinth observed in the San Joaquin River below Highway 132 Bridge, October 27, 2014.

Approximately 34% of the Chinook salmon observed at the Tuolumne River weir were less than 600 mm TL, and the majority (74%) of these were males. During 2013, only 5% of the Chinook salmon observed were less than 600 mm and 87% were males. Small males are commonly known as jacks and these fish may contribute up to 67% of all runs in some years (Moyle 2002). Jacks are widely used in escapement prediction models (Beer et. al. 2006) where a large return of jacks suggests an increase in escapement for the following year. However, a large variation in forecast predictions and actual abundance has forced the Pacific Fishery Management Council to modify the prediction model (Winship et. al. 2013).

The Tuolumne River Chinook salmon population is not supplemented with hatchery fish however, 15% of the salmon observed in 2014 were ad-clipped suggesting hatchery origin. Given that roughly 75% of hatchery fish are not clipped, and assuming that un-clipped and clipped hatchery fish are equally likely to stray, it is likely that many of the un-clipped fish observed in 2014 were of hatchery origin. In previous years, straying of fish released off-site into San Pablo Bay has been estimated to be as high as 70% (CDFG & NMFS 2001). The Constant Fractional Marking Program (CFM) was initiated in 2007 as a means of effectively estimating hatchery production (Buttars, 2013). The analysis of 2010 and 2011 recovered CWT's (Kormos et al. 2012 and Palmer-Zwahlen and Kormos, 2013) found that hatchery-origin Chinook salmon comprised 49% and 73% of the Tuolumne River Fall-run spawning population, respectively.

References

Azat, J. 2013. GrandTab 2013.04.18. California Central Valley Chinook Population Database Report. California Department of Fish and Wildlife.

Beer, W. N., D. Salinger, S. Iltis, J. J. Anderson 2006. Evaluation of the 2004 Predictions of Run-size and Passage Distributions of Adult Chinook Salmon (*Oncorhynchustschawytscha*) Returning to the Columbia and Snake Rivers. Prepared by Columbia Basin Research School of Aquatic and Fishery Sciences, University of Washington. Seattle, WA, for the United States Department of Energy Bonneville Power Administration Division of Fish and Wildlife, Portland, OR. Annual Report January 2004 – December 2004 Project # 1989-108-00, 17 pp.

Buttars, B. 2013. Constant Fractional Marking/Tagging Program for Central Valley Fall Chinook Salmon, 2013 Marking Season. Pacific States Marine Fisheries Commission.

Demko, Doug B. Memo to O'Laughlin & Paris LLP, Sacramento, CA. Delay of 2013 Tuolumne River fall-run Chinook salmon migration due to potential water hyacinth barrier. 25 November 2013.

CDFG and NMFS 2001. Final Report on Anadromous Salmonid Fish Hatcheries in California. California Department of Fish and Game National Marine Fisheries Service Joint Hatchery Review Committee Final Report, December 3, 2001.

Ford, T. and L. R. Brown, 2001. Distribution and Abundance of Chinook Salmon and Resident Fishes of the Lower Tuolumne River, California. In R.L. Brown (ed.) Fish Bulletin 179 Contributions to the Biology of Central Valley Salmonids Vol. 2:253-304. California Department of Fish and Game, Sacramento, California.

Fry, D. H., Jr. 1961. King Salmon Spawning Stocks of the California Central Valley, 1940-1959.24 *California Fish and Game* 47(1): 55-71.

Kormos BM, M. Palmer-Zwahlen, A. Low. 2012. Recovery of coded-wire tags from Chinook salmon in California's Central Valley escapement and ocean harvest in

2010. Santa Rosa (CA): California Department of Fish and Game, Fisheries Branch Administrative Report 2012-02.

McBain and Trush 2000.Habitat Restoration Plan for the Lower Tuolumne River Corridor.Arcata, CA, Prepared for the Tuolumne River Technical Advisory Committee. 240 pp.

Moyle, P. B. 2002. Inland fishes of California, revised and expanded. University of California Press, California. 502 pp.

O'Brien, J. 2009. 2008 Tuolumne River Fall Chinook Salmon Escapement Survey. California Department of Fish and Game, Tuolumne River Restoration Center, La Grange Field Office.

Palmer-Zwahlen M, M. Kormos. 2013. Recovery of coded-wire tags from Chinook salmon in California's Central Valley escapement and ocean harvest in 2011. Santa Rosa (CA): California Department of Fish and Game, Fisheries Branch Administrative Report 2013-02.

PFMC, 2015. Review of 2014 Ocean Salmon Fisheries. Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. Pacific Fishery Management Council. February 2015.

Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game.

Ricker, W. E. 1975.Computation and interpretation of biological statistics of fish populations. *Dept. of the Env. Fisheries and Marine Service, Bull.*,191, 382pp.

Seber, G. A. F., 1973, Estimation of animal abundance and related parameters, Griffin, London, 506 pp.

Schaefer, M. B. 1951.Estimation of the size of animal populations by marking experiments.*U.S. Fish and Wildlife Service Bull.*,52:189-203.

Stewart, R. 2002. Resistance board weir panel construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Artic-Yukon-Kuskokwim Region, Regional Information Report No. 3A02-21, Fairbanks, Alaska.

Stewart, R. 2003.Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Artic-Yukon-Kuskokwim Region, Regional Information Report No. 3A02-21, Fairbanks, Alaska.

Tabor, R. A., B. A. Footen, K. L. Fresh, M. T. Celedonia, F. Mejia, D. L. Low, and L. Park 2007. Smallmouth bass and largemouth bass predation on juvenile Chinook salmon and other salmonids in the Lake Washington Basin. North American Journal of Fisheries Management 27: 1174-1188.

Tobin, J. H. 1994.Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U. S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Vasques, J. 2001. 2000 Tuolumne River Chinook Salmon Spawning Escapement Survey. Federal Energy Regulatory Commission Annual Report FERC Project #2299, Report 2002-2.

Winship, A. J., M. R. O’Farrell, W. H. Satterthwaite, B. K. Wells, and M. S. Mohr. 2013. Expected future performance of abundance forecast models with application to Sacramento River fall Chinook salmon. Pacific Fishery Management Council, Agenda Item C.2.a, Attachment 5, November 2013.

Wright, T., J. Guignard, and A. Fuller. Fall migration monitoring at the Tuolumne River weir, 2012 annual report. Submitted to Turlock Irrigation District and Modesto Irrigation District. March 2013.

Yoshiyama, R. M., E. R. Gerstrung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Pages 71-176 in R. L. Brown, editor. Contributions to the Biology of

Central Valley Salmonids, Fish Bulleting 179. California Department of Fish and Game, Sacramento

Appendix A

Chinook salmon passages and instantaneous environmental measuremeants at the Tuolumne River weir between January 1, 2014 and May 7, 2014.

Date	Female	Male	Unknown	Adipose Clipped	Cummulative Passage	Percent Adclip	Water Temp.	D.O.	Turbidity
1/1/14		1			1	0.0%			
1/2/14	1				2	0.0%	47.8	11.76	0.98
1/3/14					2	0.0%			
1/4/14		1			3	0.0%	49.4	12.62	2.17
1/5/14	3				6	0.0%			
1/6/14					6	0.0%			
1/7/14	1				7	0.0%	48.7	11.76	1.82
1/8/14					7	0.0%			
1/9/14	1				8	0.0%			
1/10/14	1	1			10	0.0%	51.8	11.98	2.02
1/11/14		1			11	0.0%			
1/12/14		1	1		13	0.0%	51	11.6	1.25
1/13/14		1	1		15	0.0%	51.2		1.29
1/14/14	1	1			17	0.0%			
1/15/14	1	1		1	19	5.3%			
1/16/14	1	2	1		23	4.3%	50.7	11.75	1.09
1/17/14	1				24	4.2%			
1/18/14		2			26	3.8%	59.3	8.61	1.71
1/19/14					26	3.8%			
1/20/14					26	3.8%	50.5	10.67	0.52
1/21/14		1		1	27	7.4%			
1/22/14	1	1		2	29	13.8%	49.2	12.71	0.86
1/23/14					29	13.8%			
1/24/14					29	13.8%			
1/25/14	1				30	13.3%	52.3	12.37	2.43
1/26/14					30	13.3%			
1/27/14		2			32	12.5%			
1/28/14					32	12.5%	54.4	11.75	0.73
1/29/14		1			33	12.1%			
1/30/14					33	12.1%			
1/31/14	1				34	11.8%	57.7		3.11
2/1/14		2			36	11.1%			
2/2/14					36	11.1%			
2/3/14					36	11.1%	53.1	10.59	0.91
2/4/14					36	11.1%			
2/5/14					36	11.1%	52.7	11.3	1.18
2/6/14					36	11.1%			
2/7/14					36	11.1%	51.8	11.7	0.97
2/8/14					36	11.1%			
2/9/14					36	11.1%			
2/10/14		1	1	1	38	13.2%			

Date	Female	Male	Unknown	Adipose Clipped	Cummulative Passage	Percent Adclip	Water Temp.	D.O.	Turbidity
2/11/14	1	2			41	12.2%			
2/12/14		1			42	11.9%	58.8	11.17	0.67
2/13/14					42	11.9%	59.3	10.3	1.77
2/14/14					42	11.9%	59.1	10.49	1.58
2/15/14					42	11.9%	59.1	10.5	2.05
2/16/14					42	11.9%	50.2	10.08	1.57
2/17/14					42	11.9%	59.9	9.82	0.78
2/18/14					42	11.9%	58.4	10.96	3.26
2/19/14					42	11.9%	58.4	10.82	0.68
2/20/14					42	11.9%			
2/21/14					42	11.9%	57.8	10	1.66
2/22/14					42	11.9%			
2/23/14		1			43	11.6%			
2/24/14	1				44	11.4%	59.7	10.03	1.47
2/25/14					44	11.4%			
2/26/14					44	11.4%	58.7	9.88	3.24
2/27/14					44	11.4%			
2/28/14	2	1	1		48	10.4%			
3/1/14	4				52	9.6%			
3/2/14		2	2		56	8.9%			
3/3/14		2			58	8.6%	58.9	9.28	1.64
3/4/14					58	8.6%			
3/5/14	1				59	8.5%	59.8	10.57	1.71
3/6/14	1				60	8.3%			
3/7/14		1			61	8.2%	64	10.94	2.72
3/8/14					61	8.2%			
3/9/14					61	8.2%			
3/10/14					61	8.2%	63.1	10.24	3.13
3/11/14					61	8.2%			
3/12/14					61	8.2%	62.9	10.17	1.87
3/13/14					61	8.2%			
3/14/14					61	8.2%	62.8	10.52	0.99
3/15/14					61	8.2%			
3/16/14					61	8.2%			
3/17/14		1			62	8.1%	63.7	10.61	1.07
3/18/14	2	2			66	7.6%			
3/19/14					66	7.6%			
3/20/14					66	7.6%	65.6	10.82	0.95
3/21/14		1			67	7.5%			
3/22/14					67	7.5%			
3/23/14					67	7.5%			
3/24/14		2			69	7.2%	65.4	10.28	5.95
3/25/14					69	7.2%			
3/26/14					69	7.2%			
3/27/14	1	1			71	7.0%			
3/28/14					71	7.0%	62.9	9.42	0.76

Date	Female	Male	Unknown	Adipose Clipped	Cummulative Passage	Percent Adclip	Water Temp.	D.O.	Turbidity
3/29/14					71	7.0%			
3/30/14					71	7.0%			
3/31/14		1			72	6.9%	62	9.68	2.4
4/1/14					72	6.9%			
4/2/14	1	1			74	6.8%			
4/3/14	1				75	6.7%			
4/4/14					75	6.7%	60.7	10.09	1.19
4/5/14					75	6.7%			
4/6/14					75	6.7%			
4/7/14					75	6.7%	65.1	9.9	1.72
4/8/14					75	6.7%			
4/9/14					75	6.7%			
4/10/14					75	6.7%			
4/11/14					75	6.7%			
4/12/14					75	6.7%	71.4	9	2.23
4/13/14					75	6.7%			
4/14/14					75	6.7%	72.2	9.2	1.8
4/15/14					75	6.7%	69.8	8.52	1.6
4/16/14					75	6.7%	70.4	9.85	5.27
4/17/14					75	6.7%			
4/18/14					75	6.7%			
4/19/14					75	6.7%	61.1	9.94	2.26
4/20/14					75	6.7%	60.5	9.6	2.44
4/21/14		1			76	6.6%	63.5	9.96	0.69
4/22/14					76	6.6%	59.9	10.24	1.37
4/23/14					76	6.6%	58.5	10.06	0.81
4/24/14					76	6.6%			1.26
4/25/14					76	6.6%	58.7	10.02	0.77
4/26/14					76	6.6%			
4/27/14			1		77	6.5%			
4/28/14			2		79	6.3%	62.6	10.33	0.85
4/29/14					79	6.3%			
4/30/14					79	6.3%	69.7	10.12	1.12
5/1/14					79	6.3%			
5/2/14			1		80	6.3%	73.1	9.52	1.15
5/3/14					80	6.3%			
5/4/14					80	6.3%			
5/5/14					80	6.3%	71.5	9.03	1.46
5/6/14					80	6.3%			
5/7/14					80	6.3%	68.1	8.64	2.05