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March 30, 2011

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 2011.

Please find the enclosed 2011 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). In addition to annual updates of Project operations and ongoing Chinook salmon monitoring activities required under Article 58, the annual report includes final *O. mykiss* population estimates and acoustic tracking study results in fulfillment of the requirements for these studies under ordering paragraph (C) of the April 3, 2008 Order. If you have any questions, please contact Robert Nees at 209-883-8214.

Respectfully submitted,

MODESTO IRRIGATION DISTRICT

Greg Dias
Project Manager

TURLOCK IRRIGATION DISTRICT

Robert M. Nees
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	)	

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

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- FERC PROJECT NO. 2299 –

2011 ANNUAL SUMMARY REPORT

Turlock and Modesto Irrigation Districts

Introduction

This is the Districts' 16th annual report to the Federal Energy Regulatory Commission (FERC) in a series begun pursuant to Article 58 of the July 31,1996 Order on FERC Project License 2299 (1996 Order) and the 1995 Don Pedro Project FERC Settlement Agreement (FSA). This is also the third annual report pursuant to the "Order on Ten-Year Summary Report Under Article 58" issued on April 3, 2008 (2008 Order).

This report covers the 2011 calendar year and contains:

(1) Fishery monitoring
(2) Other monitoring
(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

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 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. The Article 58 annual reports filed since 1997 have been of 1–3 volumes.

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. 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. The 2008 Order required (1) continued annual reporting by April 1 of San Joaquin River tributary salmon escapement numbers, (2) implementation of certain *Oncorhynchus mykiss* monitoring elements, and (3) an annual *O. mykiss* monitoring report most recently filed on January 15, 2012 for studies conducted in calendar year 2011.

<u>1 - Fishery Monitoring</u>

<u>1.1 Fall-run Salmon Counts and Estimates</u>

The commercial and sport ocean harvest season for salmon was restored to traditional standards as the partial ban enforced in 2010 was lifted. The Central Valley fall Chinook runs, which have been the lowest on record, showed some improvement but did not meet pre-season projections. Exhibits 1 and 2 contain graphs of run estimates/counts.

1.1.1 San Joaquin Tributary Chinook Salmon Run Estimates

The San Joaquin River tributaries presently have primarily fall run Chinook salmon, with incidental numbers of Chinook salmon observed with other run timing outside of the September to mid-January period. The FERC Order of April 3, 2008 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 Game (CDFG) 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 CDFG estimates, previously obtained indirectly through an online CDFG "GrandTab" compilation, were not available as of March 15, 2011. 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 initiated in 2009 was continued in both the Tuolumne and Stanislaus rivers, 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 the Stanislaus counting weir. Weir operation in 2011 for the Tuolumne River was initiated in mid-September, while weir operation in the Stanislaus began in early November. The delayed start in the Stanislaus River likely resulted in an underestimate of total escapement. The 2011 fall run weir count for the Tuolumne was 2,847 adult Chinook salmon, while a total of 818 salmon were counted at the Stanislaus weir (both counts through February 19, 2012). These counts represent an increase from the 2010 count of 766 salmon in the Tuolumne River and a decrease from the count of 1,379 salmon in the Stanislaus River.

In contrast to weir counts, the CDFG float surveys, using the customary carcass survey method by boat, were conducted in 2011, however no results have been provided to date. Summary details for these surveys, dating back to 1973 can be found in Report 2011-2, while specific details for any given year are in the annual survey reports as available.

The CDFG along with the Pacific States Marine Fisheries Commission (PSFMC) and Western EcoSytems Technology, Inc. have produced a Central Valley Chinook salmon escapement monitoring plan (Bergman et. al. 2012) addressing improvements to the monitoring adult escapement in Central Valley streams. This comprehensive approach reviews current methods employed throughout the Central Valley and makes specific recommendations by stream. The plan also addresses improvements to population modeling estimates along with data management and online reporting. The plan calls for use of fish counting devices along with carcass surveys for the Tuolumne, Stanislaus, and Merced Rivers as methods for collecting escapement data.

The annual CDFG Tuolumne River fall spawning survey report for 2011 (Report 2011-1) along with preliminary carcass count data was not available in time for this submittal. The most recent CDFG spawning survey report is for the 2009 escapement and the most recent carcass count data is from 2010. Consequently, Report 2011-2 only contains an abbreviated update for 2011, along with existing summary data from prior years. Report 2011-8 has a detailed review of the Tuolumne River counting weir operation in 2011.

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 2011 due to the unavailability of data from the "Grand Tab" estimates. However, the Pacific Fishery

Management Council (PFMC) also provides estimates for the Central Valley. The PFMC reports a total of 233,226 fall Chinook for the Central Valley in 2011 (PFMC 2012a), which is greater than the total of 161,917 reported for 2010 and the highest since the 2006 total of 294,056.

The 2011 estimate of adult fall-run in the Sacramento basin was 121,742, slightly lower than the 2010 total of 124,270 and slightly below the PFMC lower management target of 122,000 to 180,000 hatchery and natural area adults for the Sacramento River system (PFMC 2012a). The 2011 estimate was also much lower than the PFMC preseason forecast of 377,000 (PFMC 2012a).

The 2011 total number of estimated 2-year olds in the Sacramento basin was 85,719 and is an indication that the cohort of 3-year olds (year class from 2009 run) in 2012 runs may be higher (PFMC 2010b). The PFMC uses those estimates in their Sacramento Index (SI) as a predictor of population abundance for fishery management purposes. The SI forecast for the Sacramento basin in 2012 is 819,400 adults. This forecast results in no projected restrictions during the 2012 salmon fishing season. Exhibits 1 and 2 contain graphs of historical harvest and abundance through 2011.

1.2 Seine Sampling

Report 2011-3 reviews the routine seine monitoring conducted in eleven surveys during January-May 2011 at eight Tuolumne River sites from RM 50.5-3.4 and two San Joaquin River locations. A total of 164 natural Chinook salmon were caught in the Tuolumne River and 16 in the San Joaquin River. This was the 4th lowest number of salmon caught during the 1986-2011 period, although salmon were captured at all Tuolumne River locations from RM 50.5-3.4 (La Grange to Shiloh Bridge) and at both San Joaquin River sites. This was the first year since 2006 that salmon were captured at the San Joaquin sites.

Density of fry (≤ 50 mm) peaked on 15 February, similar in timing to other years of the 2005–2010 period. The density of juveniles (> 50 mm) peaked on 01 February, which was much earlier than in most other years of the period. Fork length (FL) ranged from 31–76 mm, fry were caught throughout the sampling season. A comparative review with other years is included in Report 2011-3. The seine report classifies "juvenile" salmon as >50 mm, whereas the rotary screw trap report distinguishes parr (50–69 mm) and smolt (≥ 70 mm) size ranges.

A total of seven *O. mykiss* (21–40 mm FL) were caught in the Tuolumne River from February1–April 26. A total of 10 fish species were recorded in the Tuolumne River and 11 species in the San Joaquin River during the season.

1.3 Rotary Screw Trapping

Report 2011-4 reviews the 2011 rotary screw trap monitoring conducted near Waterford (RM 29.8) from December 5, 2010 through June 30, 2011 and near Grayson (RM 5.2) from January 6, 2011 through June 30, 2011 and includes a comparison with other years. Total juvenile salmon catches were 4,394 at the Waterford trap and 1,645 at the Grayson trap.

Fry (< 50 mm) capture at the Waterford screw trap occurred from December 5, 2010 through late-April 2011 with an estimated passage of 400,478 for that life stage. This represents a significant increase over the estimate of 10,735 fry during the previous year. The estimated peak passage of fry was in late January. Grayson had an estimated passage of 45,781 fry, also significantly higher than the estimate of 173 in the previous year.

The Waterford passage estimate of 4,884 parr (50-69 mm) and 15,608 smolts (≥ 70 mm), represented an increase for the number of parr over the previous year estimate of 1,030 and a decrease for the estimate of smolts compared with the previous estimate of 29,728. The Grayson passage estimate showed a significant increase for both parr and smolts, with an estimate of 1,654 parr in 2011 compared with a zero parr passage estimate the previous year, and an estimate of 39,737 smolts compared with an estimate from the previous year of 4,060. The peak smolt passage at both traps was in mid-May, similar to the previous year.

The survival index calculated to estimate survival between the upstream trap at Waterford and the downstream trap at Grayson was 20.7% in 2011. This estimate should be interpreted with caution, since there is some uncertainty in the total passage estimate for Waterford. Similar survival indices of 23.6%, 13.2% and 11.9% were calculated for years 2008–2010, respectively, with similar precautions. These estimates do not account for any salmon produced from spawning below the Waterford trap site.

There were no captures of *O. mykiss* at either the Waterford or Grayson traps in 2011. There were 23 other fish species captured in the traps in 2011.

1.4 Reference Count Snorkeling

Report 2011-5 reviews the snorkel surveys that were conducted on September 16-19 and November 1-3, 2011 within the RM 31.5-50.7 (Waterford to La Grange) reach of the Tuolumne River. High spring and early summer flows, due to above-normal rainfall and snowpack runoff, prevented sampling during the more typical sampling dates of June and September. The September survey was conducted at a flow of approximately 336 cfs with water temperature ranging from 13.5°C (56.3 F) to 18.6°C (65.5 F). A total of 66 juvenile Chinook salmon and 1,179 *O. mykiss* were recorded in the September survey. The November survey was conducted at a flow of approximately 356 cfs with water temperature ranging from 12.7°C (54.9 °F) to 14.7°C (58.5 °F). A total of 25 Chinook salmon (including adult spawners) and 148 *O. mykiss* were recorded in the November survey.

Chinook salmon were observed downstream to Riffle 57 (RM 31.5) and rainbow trout downstream to Riffle 41A (RM 35.3) in September. Chinook salmon were observed downstream to Riffle 31 (RM 38.0) and *O. mykiss* were observed downstream to Riffle 57 (RM 31.5) in November. Other native fish species observed were Sacramento sucker, Sacramento pikeminnow, hardhead, and riffle sculpin. The non-native species recorded were largemouth bass, smallmouth bass, and striped bass. Report 2011-5 also contains a comparison with other years, dating back to 1982.

1.5 *O. mykiss* Population Estimate Surveys

This snorkeling study pursuant to the April 2008 FERC Order was first conducted in July 2008. Additional surveys were conducted in March and July of 2009, then again in March and August of 2010. The September 2011 survey represents the final requirement of the *O. mykiss* population estimate study. Separately required annual *O. mykiss* monitoring reports were also submitted in January 2010, 2011, and 2012. These reports summarize all monitoring activities associated with *O. mykiss*, including the population estimate surveys.

Report 2011-6 presents the population estimates for *O. mykiss* and Chinook salmon based on surveys conducted in 2011 and provides a comparison of these results with those from previous surveys. The population estimates are based on habitat mapping completed in 2008 (RM 52.0–39.5) and 2009 (RM 39.5 – 29.0).

The *O. mykiss* population estimates from habitat-specific counts (in parentheses) for YOY/juvenile (< 150 mm FL) and adult (> 150 mm FL) were:

- July 2008: 2,472 (128) YOY/juvenile and 643 (41) adult *O. mykiss*
- March 2009: 63 (5) YOY/juvenile and 170 (7) adult *O. mykiss*
- July 2009: 3,475 (641) YOY/juvenile and 963 (105) adult *O. mykiss*
- March 2010[1]: 109 (13) adult *O. mykiss*
- August 2010: 2,405 (313) YOY/juvenile and 2,139 (324) adult *O. mykiss*
- September 2011: 47,432 (4,913) YOY/juvenile and 9,541 (813) adult *O. mykiss*

The September 2011 survey extended from RM 51.8 to RM 35.0. During the survey *O. mykiss* were observed downstream to RM 36.3. The population estimates for both juveniles and larger fish exceeded estimates from all previous years (2008–2010) during which these surveys have been conducted.

The comparable estimates for Chinook salmon (*O. tshawytscha*) in these surveys were:

- July 2008: 2,636 (96) YOY/juvenile
- March 2009: 39,563 (4,281) YOY/juvenile
- July 2009: 29,389 (4,696) YOY/juvenile
- March 2010: 6,141 (574) YOY/juvenile
- August 2010: 6,338 (973) YOY/juvenile
- September 2011: 24,299 (2,576) YOY/juvenile

The September 2011 population estimate of juvenile salmon was similar to the July 2009 estimate and higher than the August 2010 estimate.

1.6 *O. mykiss* Acoustic Tag and Tracking

This tracking study pursuant to the May 2010 FERC Order was initiated by FISHBIO in March

[1] No estimate of YOY/juvenile *O. mykiss* due to only a single observation in March 2010.

2010. Report 2011-7 presents results from the 2011 study which included the continuation of tracking fish tagged in the fall of 2010. No additional tags were implanted in 2011 and preliminary results show all 14 *O. mykiss* tagged in October 2010 were detected, indicating all tagged fish remained in the Tuolumne River. Two tagged fish exhibited upstream and downstream movement in 2011 of up to 10,940 meters (6.8 miles) while all other fish remained at or near their original release locations. No tagged fish from this study were detected downstream of RM 44 in either 2010 or 2011.

1.7 Counting Weir

The year 2011 represents the third 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 2011-8 provides detailed results and sampling conditions for the Tuolumne River weir during the 2011-2012 Fall/Winter monitoring season, which totaled 2,487 adult Chinook salmon counted for the lower Tuolumne River. The weir was deployed at RM 24.5 from September 15, 2011 through February 18, 2012. 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.

2 - Other Monitoring

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 SJR, and the South Delta. Those include 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. Fry density increased in 2011 compared with 2010 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 2011 as being a continuation of La Nina conditions initiated in July 2010. These conditions were characterized as being “intermediate” in terms of salmon production with a positive bio-physical outlook offset by low ichtyoplankton abundance and poor upwelling. The 2011 conditions represented an improvement over the previous two-year period of poor ocean conditions and the trend for 2012 is for improving overall conditions. 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. In addition, conditions for southern salmon populations (i.e. Central Valley salmon) may differ from those reported by the NWFSC, particularly as related to the continuing decline of Sacramento River and other Central Valley fall-run salmon populations.

3.2 Delta Issues

3.2.1. Salmon salvage and losses at Delta water export facilities

Exhibit 4 contains 2011 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 higher in 2011 with combined facility estimates of 14,156 salmon salvaged compared with 9,325 in 2010. The number of salmon losses at the facilities was also higher in 2011 (total estimate of 29,210) compared with 2010 (total estimate of 14,203). The average export rate for this period was also higher in 2011 compared with 2010. The reported numbers do not include associated indirect losses within the Delta, plus 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).

Few salmon fry (<50mm) were reported at the facilities from January-April. There was a dominant salvage of larger juveniles/smolts (75-110 mm) from late May through late June. Weekly density (combined salvage and loss/1000 AF of export) was highest during May and June at both facilities.

3.2.2 Spring smolt conditions and evaluation

The San Joaquin River Agreement (SJRA) and the Vernalis Adaptive Management Plan (VAMP) are elements for meeting the objectives of the 1995 State Water Resources Control Board (SWRCB) Bay-Delta Water Quality Control Plan over a 12 year period beginning in 2000, pursuant to SWRCB Decision 1641. The program includes a 31-day period, from about mid-Apr to mid-May, with an experimental combination of salmon protective measures: specified San Joaquin River flows at Vernalis, Head of Old River Barrier (HORB), and reduced State and Federal delta exports. The Tuolumne River outmigration pulse volume has been scheduled to partly coincide with the VAMP period, accounting for a 2-day lead time for flows from La Grange to arrive at Vernalis, and to provide transition days to and from base flows. An additional Tuolumne River spring pulse flow volume of up to 22,000 acre-feet (AF) from TID/MID, supplemental to FERC pulse allocations, can be required under the SJRA to help meet target flows at Vernalis. The year 2011 represents the final year of the current SJRA.

Additional information on the SJRA can be found at: http://www.sjrg.org/agreement.htm.

Flood control releases throughout the San Joaquin Basin in 2011 exceeded the VAMP requirement flows during the target period of May 16–31. Likewise, flows in the Tuolumne River also exceeded the VAMP requirement during this same time period (See Attachment A). As appended to a report by the Delta Operations for Salmonids and Sturgeon (DOSS), during the VAMP test period, daily exports rand from 4,000–2,500 cfs then increased to 9,200 cfs by June 2 (DOSS 2011). Actual flows at Vernalis during the VAMP test period averaged 10,890 cfs.

The 2011 VAMP smolt tracking study used a total of 960 hatchery smolts with implanted acoustic transmitters, representing the 6th year that acoustic technology was used to estimate juvenile salmon survival through the southern Sacramento-San Joaquin Delta (DOSS 2011). There were two releases made in 2011 of 480 smolts each during mid- and late-May at Durham Ferry on the San Joaquin River. The mid-May VAMP release coincided with a release of 480 steelhead smolts as part of a 6-year steelhead study (other steelhead releases of 480 fish at Durham Ferry were made in mid-March and early-May as part of the study). The late-May VAMP release coincided with a release of 480 steelhead smolts that were part of the south Delta temporary barriers program, which also released an additional 480 salmon in early-June and a paired release of 480 steelhead and 480 salmon in mid-June (DOSS 2011).

Tracking of these fish incorporated the use of several stationary receivers downstream into the central delta, including evaluation arrays near the behavioral barrier and the export facilities, and a mobile receiver. An additional set of four new receiver arrays were added in 2011 at Jersey Point, False River, and both upstream and downstream of the Durham Ferry release site (DOSS 2011). Due to high flows, the non-physical barrier at the Head of Old River was not installed in 2011. No survival estimates from the 2011 study are available at this time. Additional information on Delta salmonid survival and operations can be found at: http://www.swr.noaa.gov/ocap/doss.htm

3.2.3 Other Delta issues

There continues to be several other recognized issues of concern for salmon and steelhead in the Delta region. Water quality issues, from toxicants in general to low dissolved oxygen in the Stockton Deep Water Ship Channel, are being addressed by various agencies. A National Research Council (NRC) panel studying sustainable water and environmental management in the California Bay-Delta provided a review of the draft Bay Delta Conservation Plan (BDCP) which raised concerns about the structure, completeness, and scientific credibility of the plan (NRC 2011). A report of the Independent Review Panel (Kneib et. al. 2011) on the 2011 implementation of Reasonable an Prudent Alternative (RPA) actions affecting the Operations Criteria and Plan (OCAP) adopted as part of the 2009 National Marine Fisheries Service (NMFS) Biological Opinion stated that even though physical water operations were not challenged in 2011, due to wet conditions, population responses of listed species “remain inadequately articulated”. Survival estimates for salmon in the Delta were also subject to review based on an evaluation of acoustic tagged predators (Vogel 2011) that suggested previous analysis of tagged salmon movements through the Delta may be altered based on predation of these fish by striped bass.

4 – Hydrology, Flow Schedules, and River Operations

The 2011 calendar year included part of the 2011 and 2012 water years (WY) from October 1st through September 30th. The WY2011 Tuolumne River preliminary computed natural runoff was 181% of the long-term average (http://cdec.water.ca.gov/cgi-progs/reports/FLOWOUT.201109). The 2011 San Joaquin Basin 60-20-20 Water Supply Index was 5,530,540 – corresponding to releases associated with "Intermediate BN-AN through Median Wet / Maximum" Fish Flow Year (FFY) 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 2011 and 2012 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 2011 included Article 37 minimum flow and pulse flow requirements spanning the 2010 and 2011 FFYs. Part 3 of Attachment A contains the primary flow schedule correspondence. The initial volume used in the April 2011 scheduling process was 300,923 AF representing the maximum requirement due to above average runoff conditions, similar to the previous year.

Flood management releases pursuant to ACOE criteria were required as the Don Pedro Reservoir storage was encroaching the designated flood control space as shown in the graph in Part 1 of Attachment A. Flood management flows due to above average runoff conditions ranged between approximately 2,000–5,000 cfs occurred from December 2010 through early-April 2011. Flows near 8,500 cfs occurred during April 2011. Flows ranged from approximately 1,000–7,000 cfs during May through mid-September 2011, followed by base flows of 300 cfs. A fall pulse flow volume of 5,950 AF occurred during October 12–16, with scheduled flows providing a peak of 1,100 cfs prior to decreasing back to base flows of 300 cfs.

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.

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.

Funding for a CALFED approved proposal to provide for three years of restoration project monitoring/river-wide monitoring was withdrawn by CDFG in 2005. At this time, no TRTAC restoration project activity is occurring.

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.

6 – Tuolumne River Technical Advisory Committee (TRTAC)

Four quarterly TRTAC meetings were held in 2011: March, June, September, and December; the fishery agencies attended none of the meetings in 2011. Attachment B contains the 2011 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

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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
CDFG or DFG	California Department of Fish and Game
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
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
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
ORNL	Oak Ridge National Laboratory
PFMC	Pacific Fishery Management Council
R(letter and/or #)	specific riffle (location identifier, e.g. RA7 is Riffle A7)
RM	river mile
RST	rotary screw trap
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
WT	water temperature
WY	Water Year
YOY	Young of Year

9 - List of 1992-2011 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 Reports

2010-2:	Spawning Survey Summary Update
2010-8:	2010 Counting Weir Report
2011-1:	2011 Spawning Survey Report
2011-2:	Spawning Survey Summary Update
2011-8:	2011 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
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

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

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 2011 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 2011 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

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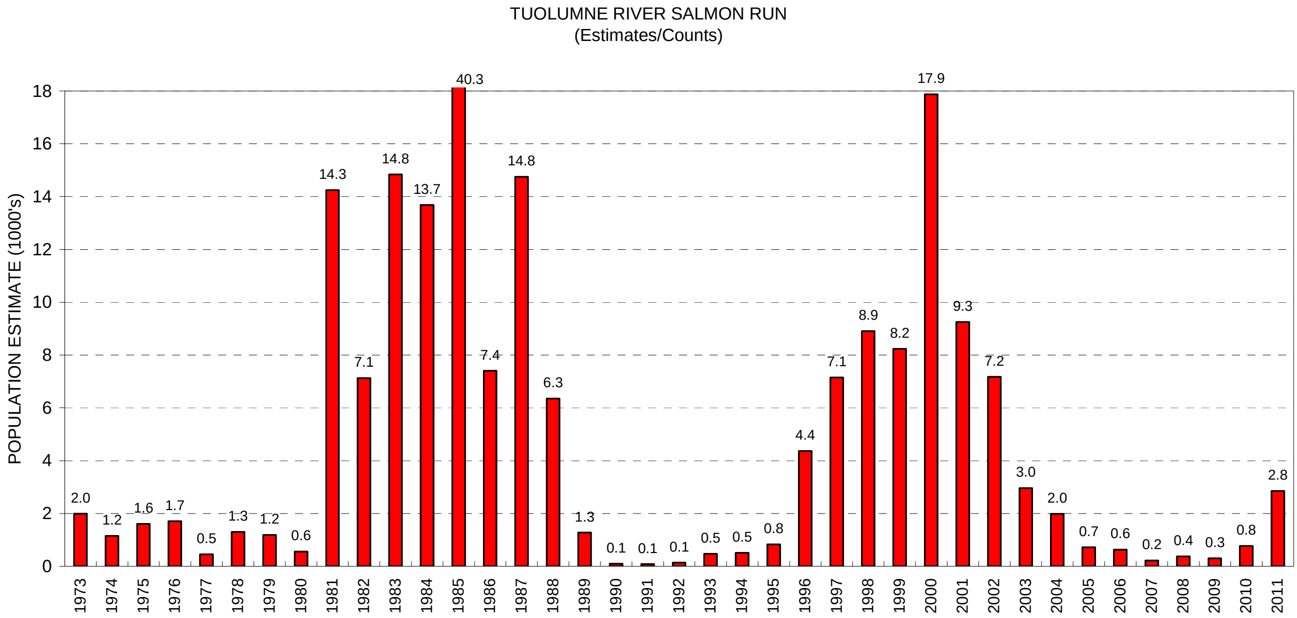
Exhibit 1 – Spawning run estimates



Years 2009-2011 are based on counting weir results. All previous years from CDFG surveys. Survey periods may vary over the years for both methods.

Exhibit 1A

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

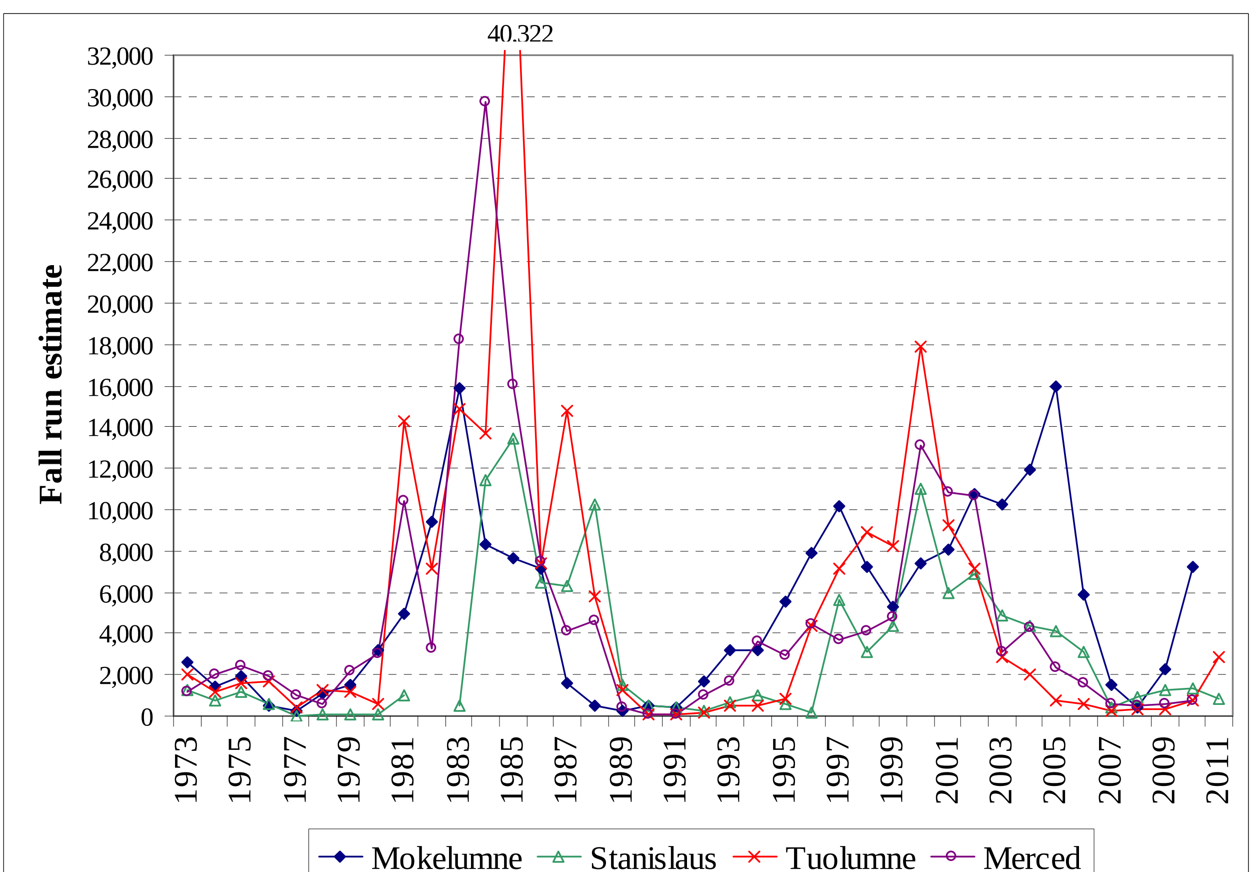


Exhibit 1B [2011 data for Mokelumne and Merced Rivers not available as of March 2012.]

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

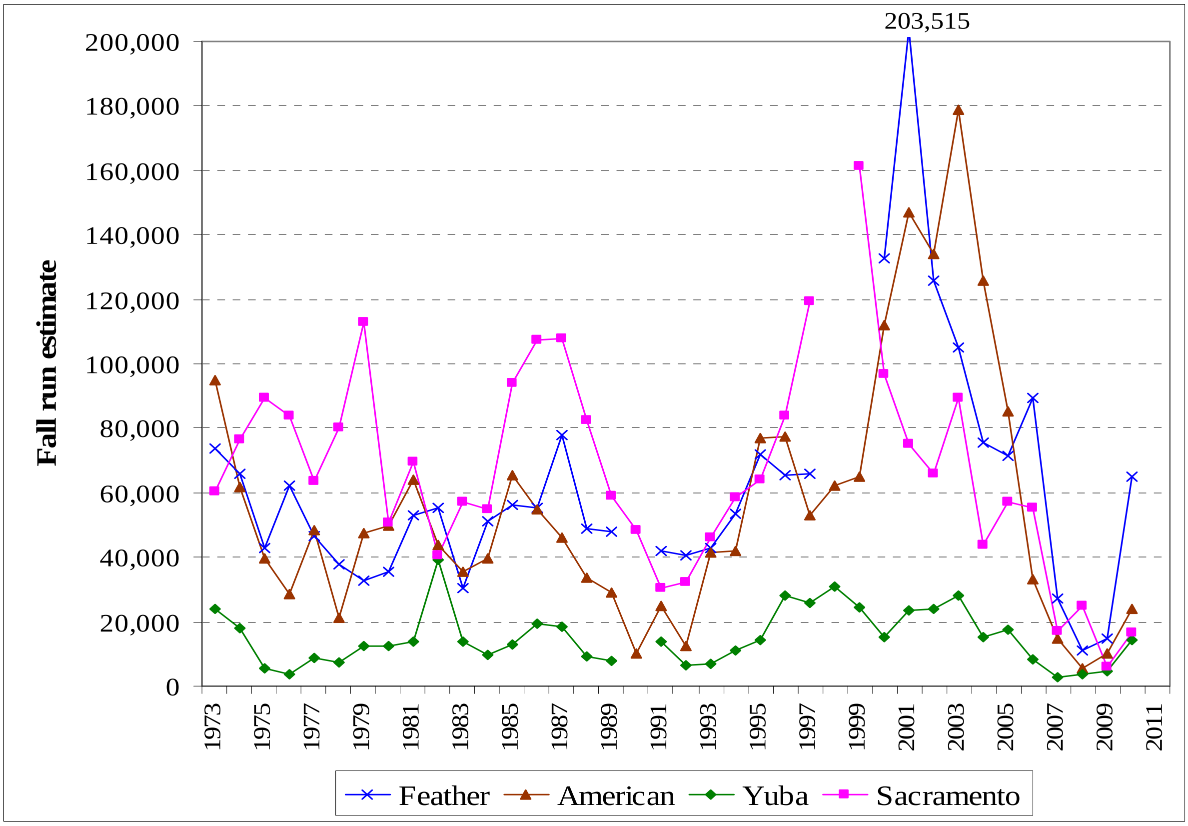


Exhibit 1C [2011 data not available as of March 2012]

Combined Natural Spawning and Hatchery Fall-run Total Since 1973

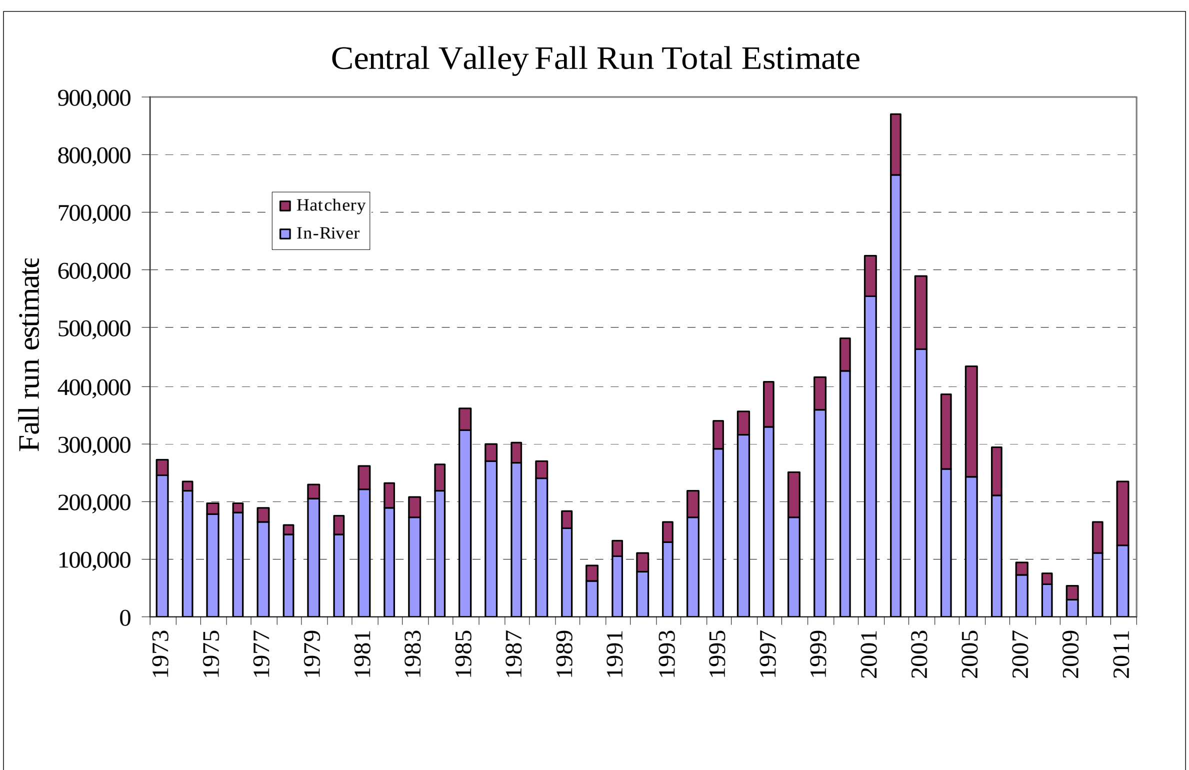


Exhibit 1D [2011 data from PFMC (2012a)]

Exhibit 2 – Salmon harvest and Sacramento abundance data

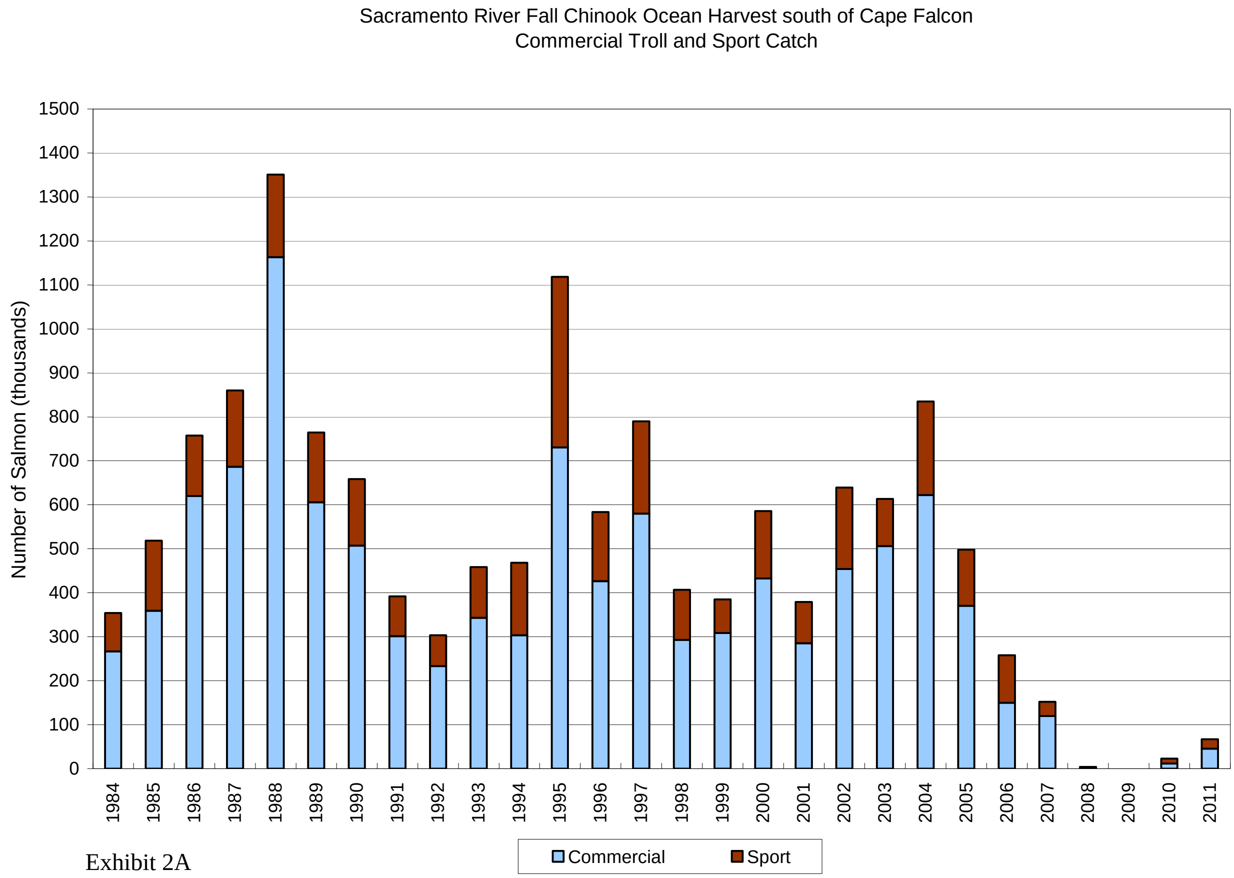


Exhibit 2A

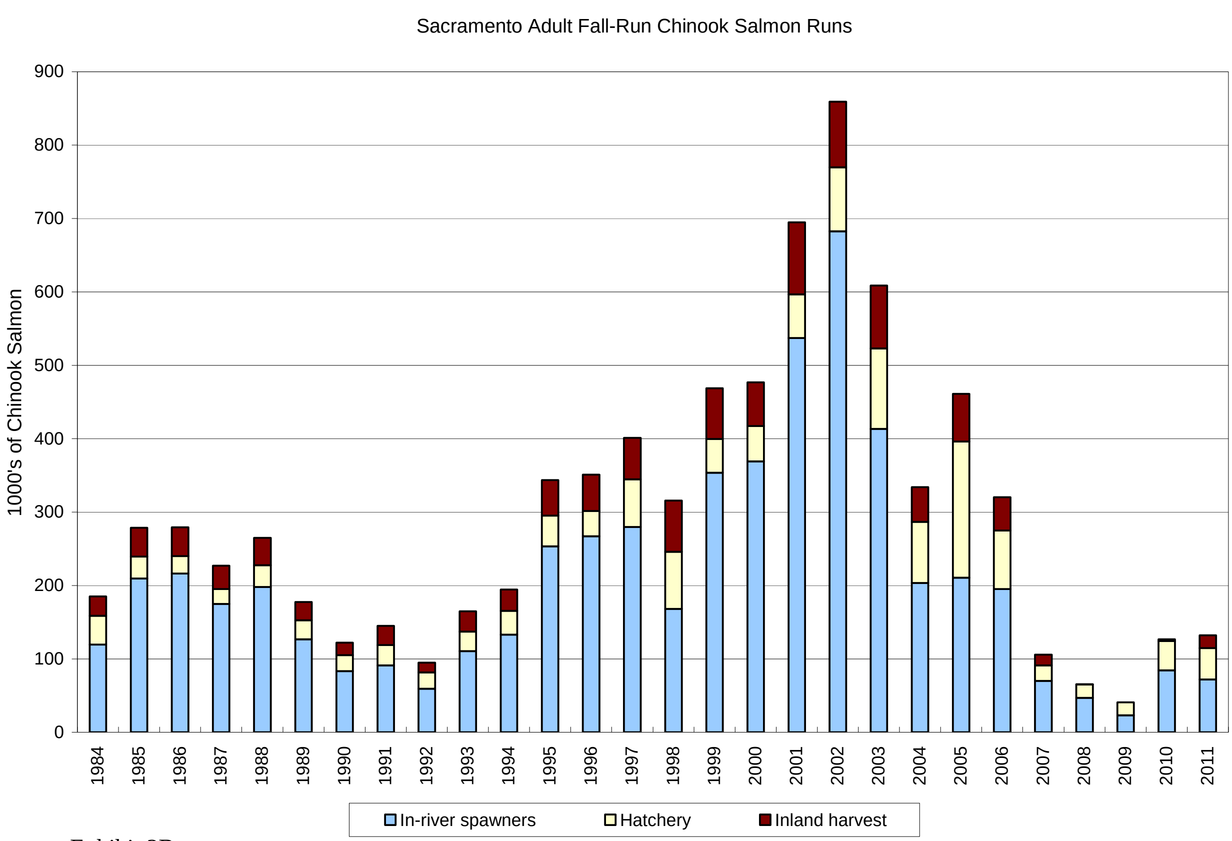


Exhibit 2B

Sacramento Harvest Rate (south of Cape Falcon, OR)

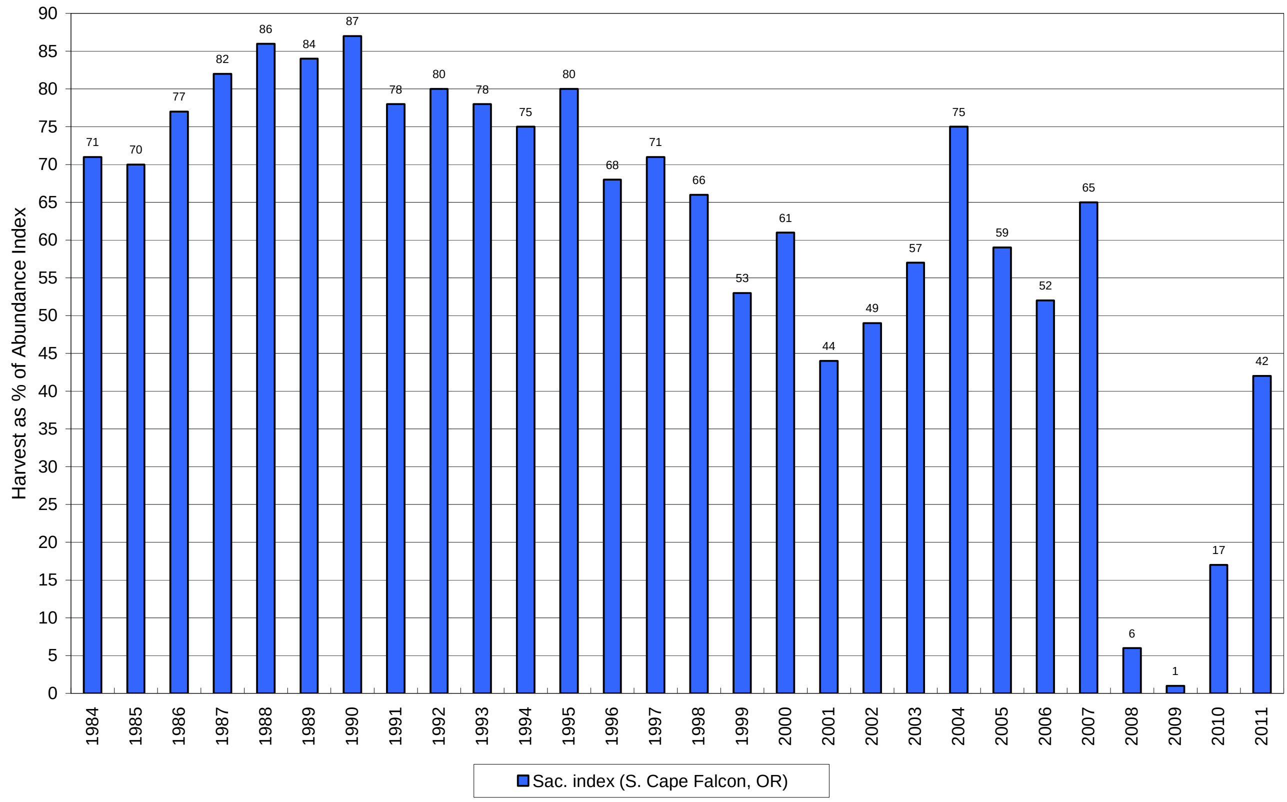


Exhibit 2C

Sacramento River Chinook Abundance Index: River and Ocean Totals

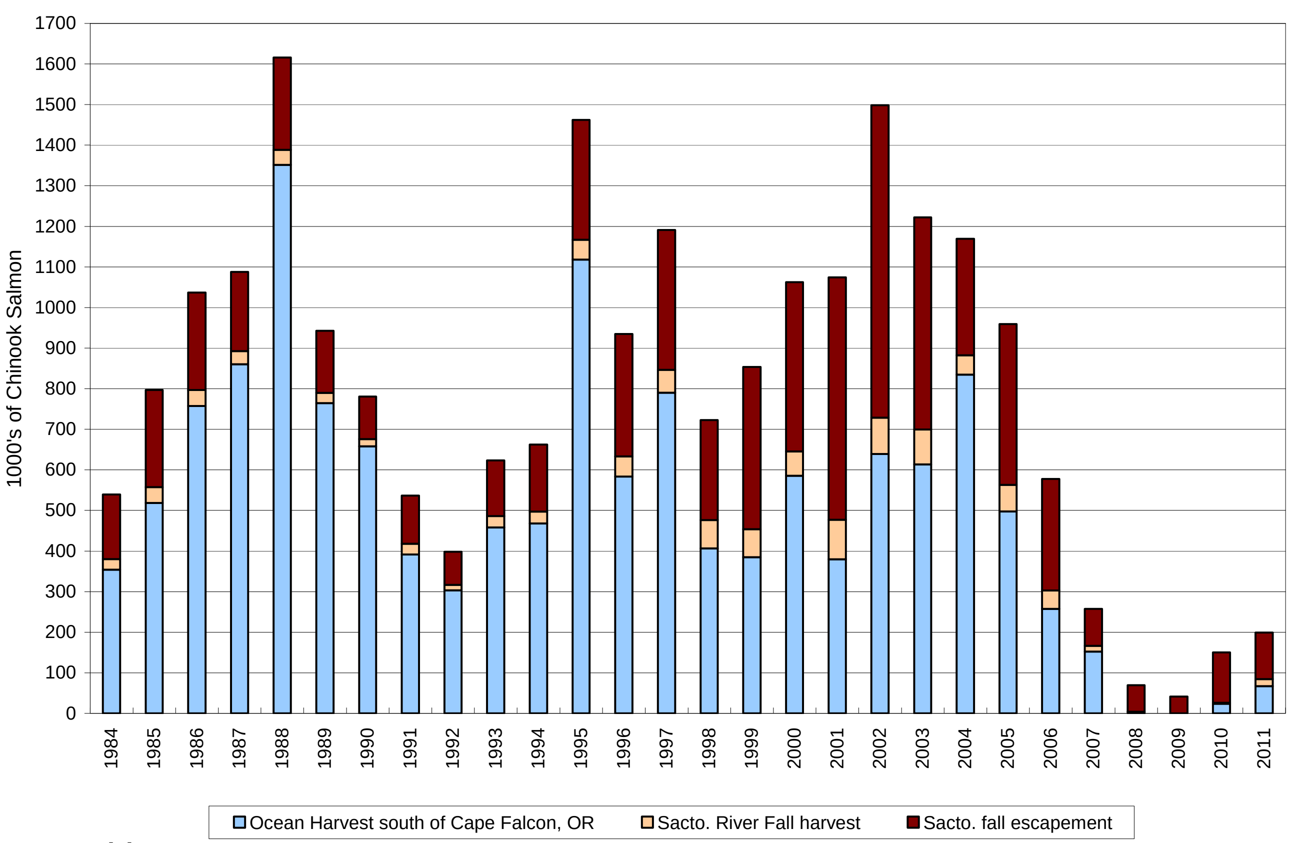


Exhibit 2D

Exhibit 3 – January-June 2011 Basin salmon rearing/outmigration data

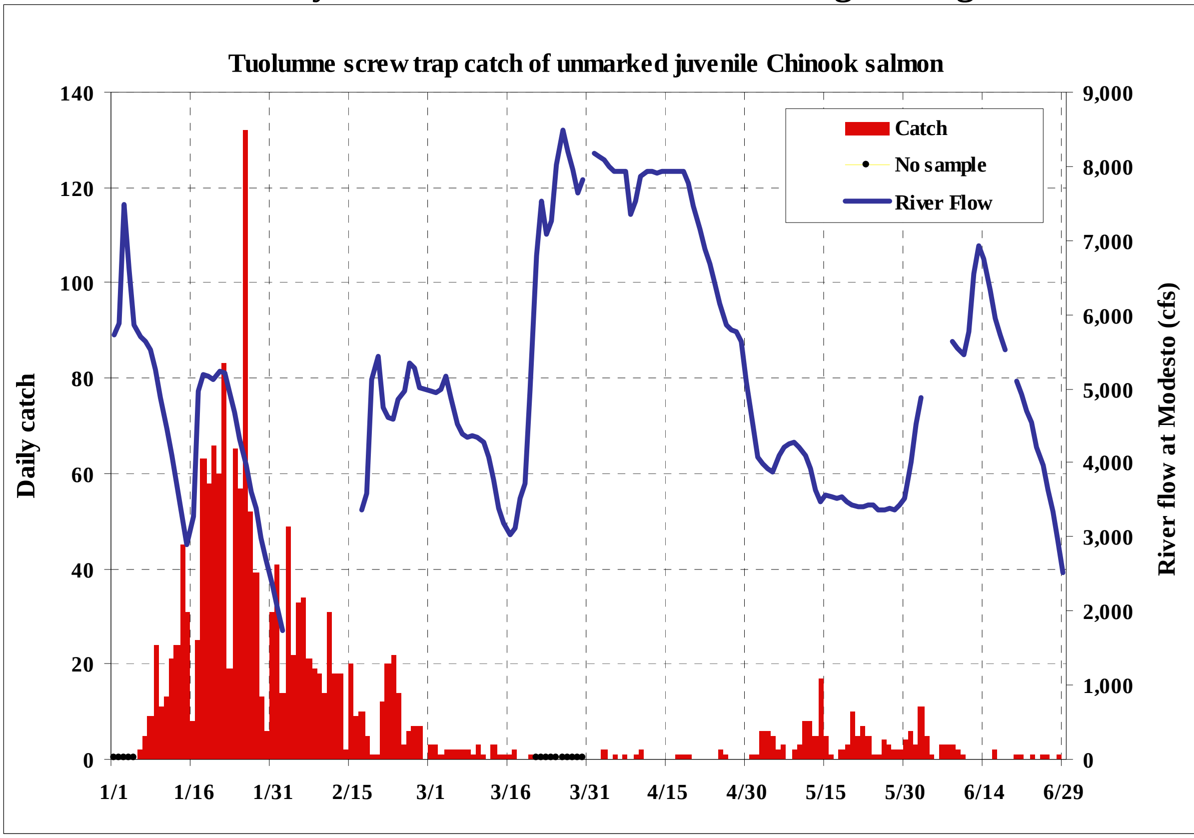


Exhibit 3A

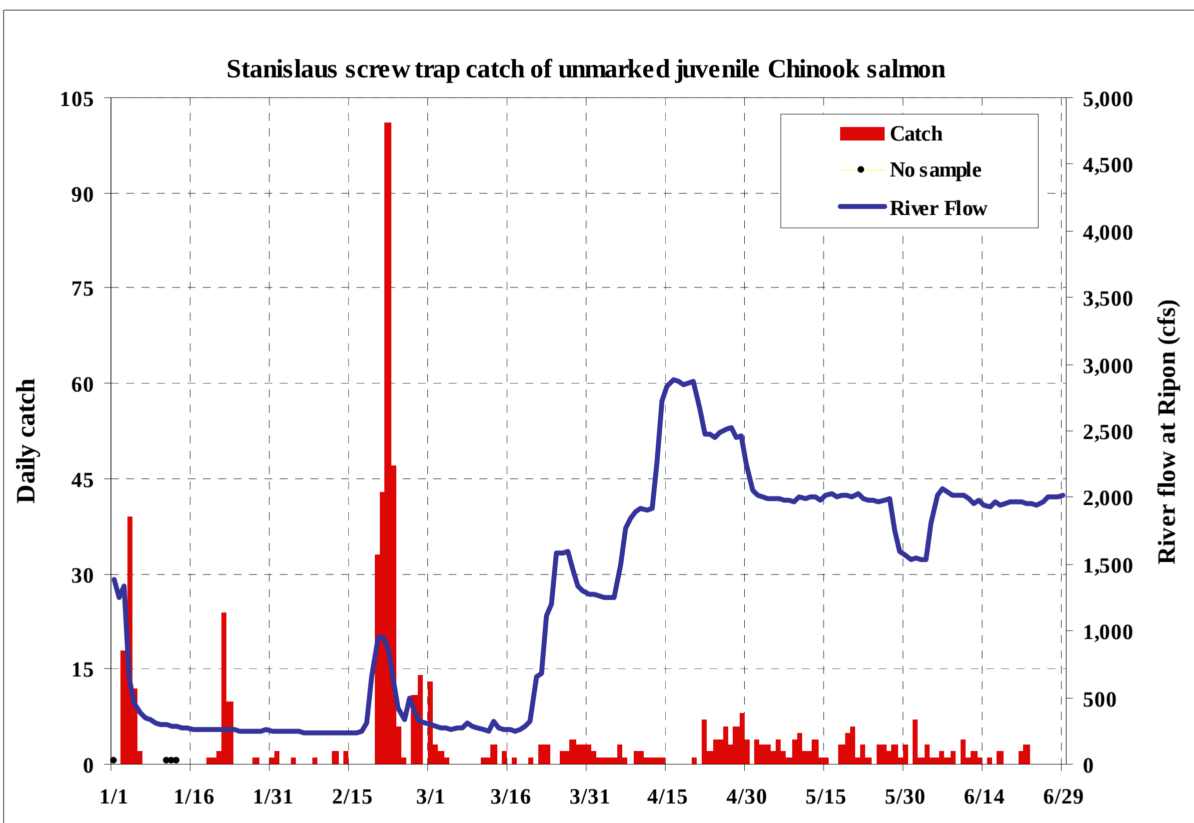
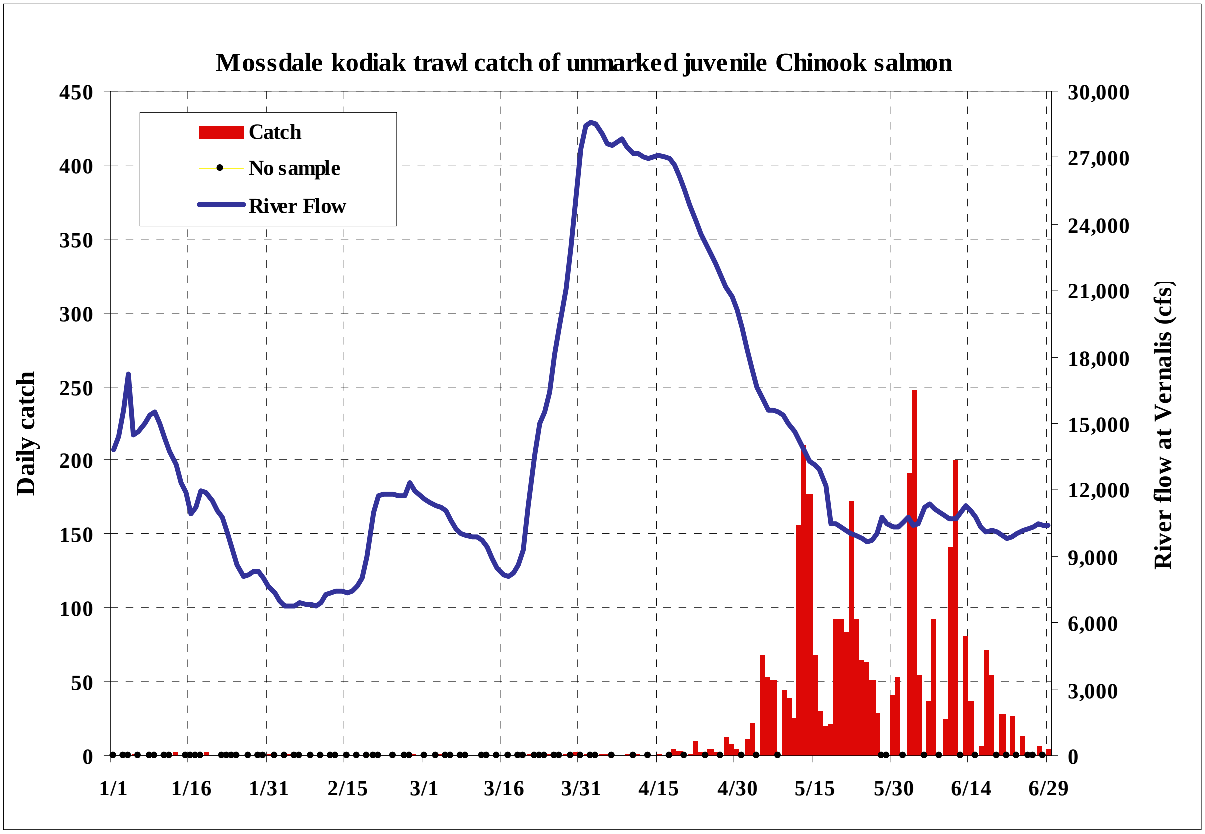


Exhibit 3B



Mossdale kodiak trawl catch of unmarked juvenile Chinook salmon
Catch
No sample
River Flow
Daily catch
River flow at Vernalis (cfs)
450
400
350
300
250
200
150
100
50
0
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
1/1
1/16
1/31
2/15
3/1
3/16
3/31
4/15
4/30
5/15
5/30
6/14
6/29

Exhibit 3C

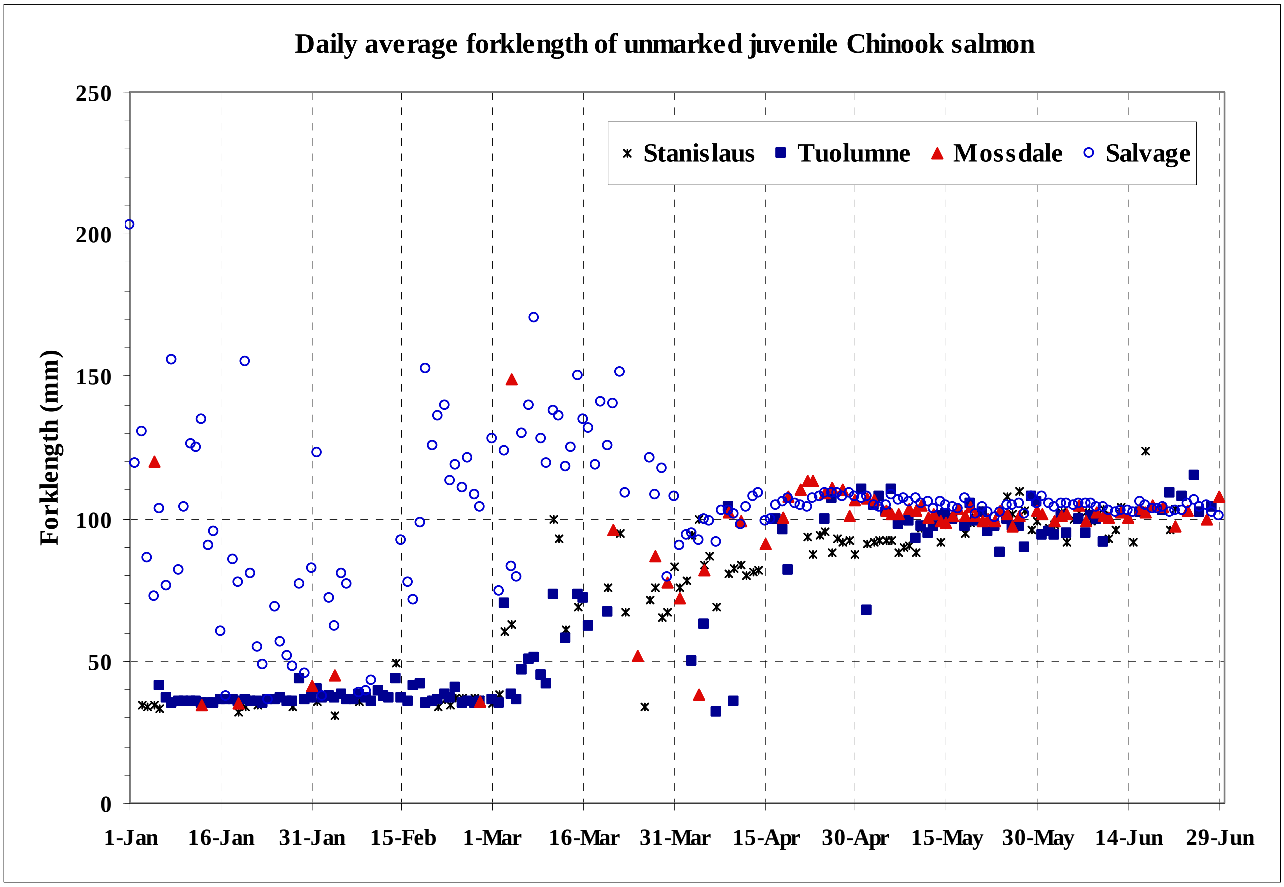


Exhibit 3D

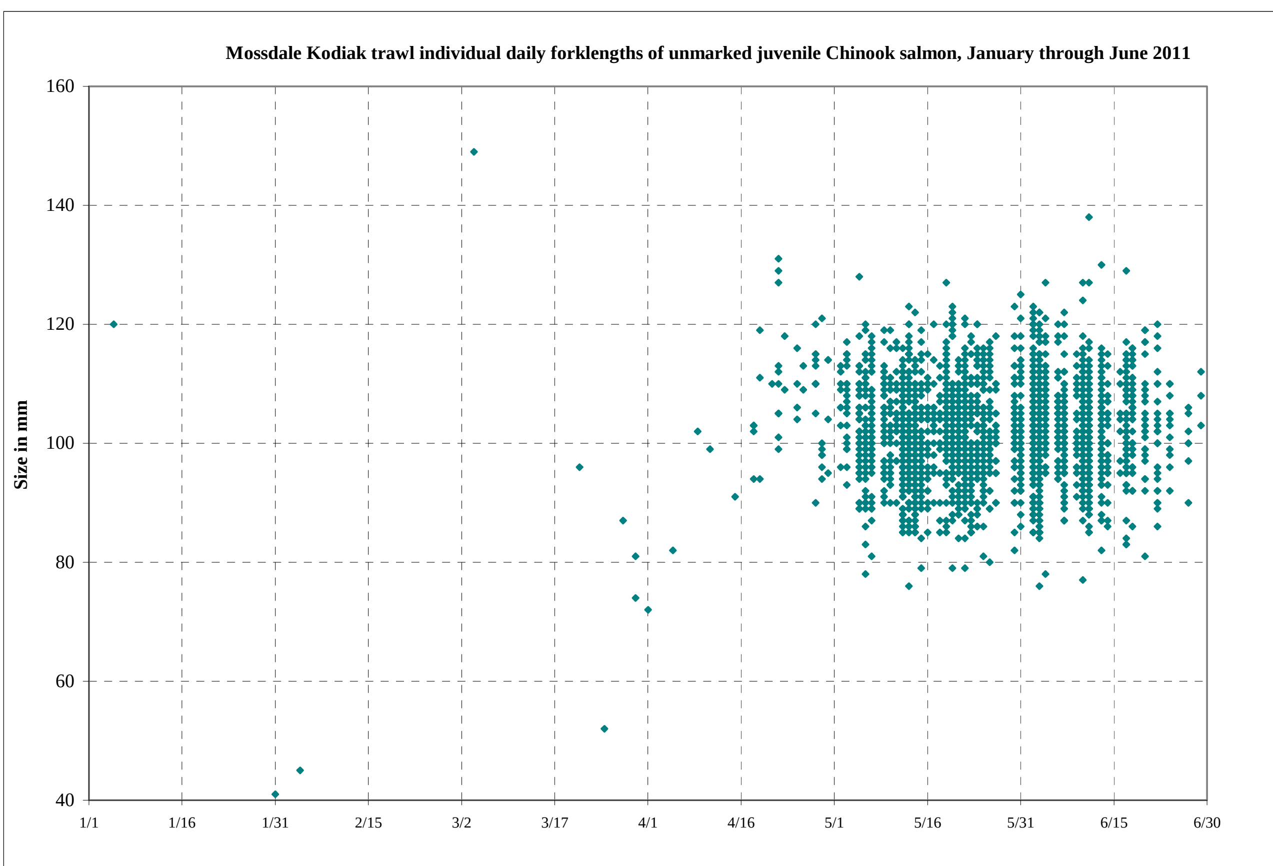


Exhibit 3E

Exhibit 4 – January-June 2011 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	1000 ac.ft.	per 1000 ac.ft.	(cfs)
7-Jan	2	6	24.65	30.65	14,674	203,684	0.0	0.2	22,732
14-Jan	1	6	24.99	30.99	15,585	216,331	0.0	0.1	23,663
21-Jan	4	14	58.31	72.31	14,101	195,730	0.1	0.4	22,057
28-Jan	6	24	96.34	120.34	10,846	150,553	0.2	0.8	18,158
4-Feb	4	14	56.93	70.93	9,985	138,608	0.1	0.5	17,999
11-Feb				0	11,495	159,558	0.0	0.0	17,528
18-Feb				0	13,138	182,367	0.0	0.0	17,692
25-Feb				0	12,259	170,161	0.0	0.0	18,008
4-Mar	2	8	33.46	41	9,824	136,361	0.1	0.3	17,169
11-Mar	1	4	16.98	21	7,632	105,938	0.0	0.2	15,925
18-Mar				0	7,001	97,185	0.0	0.0	14,386
25-Mar	1	4	17.05	21	5,765	80,018	0.0	0.3	12,472
1-Apr	3	12	50.00	62	7,791	108,149	0.1	0.6	10,703
8-Apr	3	10	42.13	52	5,357	74,361	0.1	0.7	10,611
15-Apr	1	2	8.32	10	8,990	124,794	0.0	0.1	12,369
22-Apr	1	4	17.08	21	7,027	97,536	0.0	0.2	12,156
29-Apr	9	31	131.59	163	9,453	131,211	0.2	1.2	13,286
6-May	16	41	171.32	212	4,606	63,938	0.6	3.3	9,722
13-May	53	181	803.05	984	3,800	52,744	3.4	18.7	7,603
20-May	60	355	1,662.81	2,018	3,467	48,121	0.0	0.0	6,498
27-May	63	605	3,039.74	3,645	2,660	36,921	16.4	98.7	4,649
3-Jun	134	995	4,838.59	5,834	6,085	84,468	11.8	69.1	10,120
10-Jun	211	2072	9,745.01	11,817	11,774	163,439	12.7	72.3	18,840
17-Jun	156	962	4,417.31	5,379	12,300	170,738	5.6	31.5	18,189
24-Jun	55	560	2,529.38	3,089	13,220	183,505	3.1	16.8	19,698
1-Jul	18	130	594.48	724	13,081	181,573	0.7	4.0	21,367
Tot&avg	**804**	**6,040**	**28,380**	**34,420**	**9,304**	**3,357,993**	**2.1**	**12.3**	**15,138**
VAMP	138	608	2,769	3,377	5,331	296,015	1	6	9,277

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	1000 ac.ft.	per 1000 ac.ft.	(cfs)
7-Jan	29	48	27.96	75.96	8058	111,859	0.4	0.7	15021
14-Jan	6	12	6.99	18.99	8078	112,133	0.1	0.2	14215
21-Jan	20	40	23.30	63.3	7956	110,441	0.4	0.6	11475
28-Jan	90	180	106.82	286.82	7312	101,500	1.8	2.8	9072
4-Feb	40	79	46.53	125.53	8013	111,232	0.7	1.1	7401
11-Feb	18	36	24.05	60.05	6033	83,748	0.4	0.7	6901
18-Feb	12	23.5	16.48	39.98	4554	63,216	0.4	0.6	7505
25-Feb	18	35	23.71	58.71	5750	79,812	0.4	0.7	11259
4-Mar	26	56	34.71	90.71	7346	101,968	0.5	0.9	11666
11-Mar	4	8	4.66	12.66	8293	115,111	0.1	0.1	10235
18-Mar	2	2	1.16	3.16	7385	102,505	0.0	0.0	8722
25-Mar	6	8	6.28	14.28	6708	93,111	0.1	0.2	12809
1-Apr	1	0	0.00	0	2911	40,413	0.0	0.0	23226
8-Apr				0	5254	72,929	0.0	0.0	27998
15-Apr				0	3379	46,898	0.0	0.0	27128
22-Apr	6	24	16.56	40.56	5129	71,196	0.3	0.6	25889
29-Apr	4	16	11.04	27.04	3833	53,210	0.3	0.5	22146
6-May	35	105	69.44	174.44	5116	71,013	1.5	2.5	17640
13-May	55	173.4	130.40	303.8	3803	52,791	3.3	5.8	14839
20-May	104	382	295.85	677.85	3031	42,077	9.1	16.1	11829
27-May	167	608	519.01	1127.01	1989	27,613	22.0	40.8	9905
3-Jun	368	1325.5	944.87	2270.37	4035	56,012	23.7	40.5	10511
10-Jun	295	1924	1,325.12	3249.12	7066	98,081	19.6	33.1	10958
17-Jun	340	1681.6	1,246.11	2927.71	5889	81,747	20.6	35.8	10751
24-Jun	296	1036	750.70	1786.7	6478	89,927	11.5	19.9	10009
1-Jul	96	313	197.75	510.75	8286	115,016	2.7	4.4	10552
Tot&avg	**2,038**	**8,116**	**5,830**	**13,946**	**5,834**	**2,105,560**	**4.6**	**8.0**	**13,833**
VAMP	361	1,268	1,015	1,183	3,946	219,092	4	6	16,614

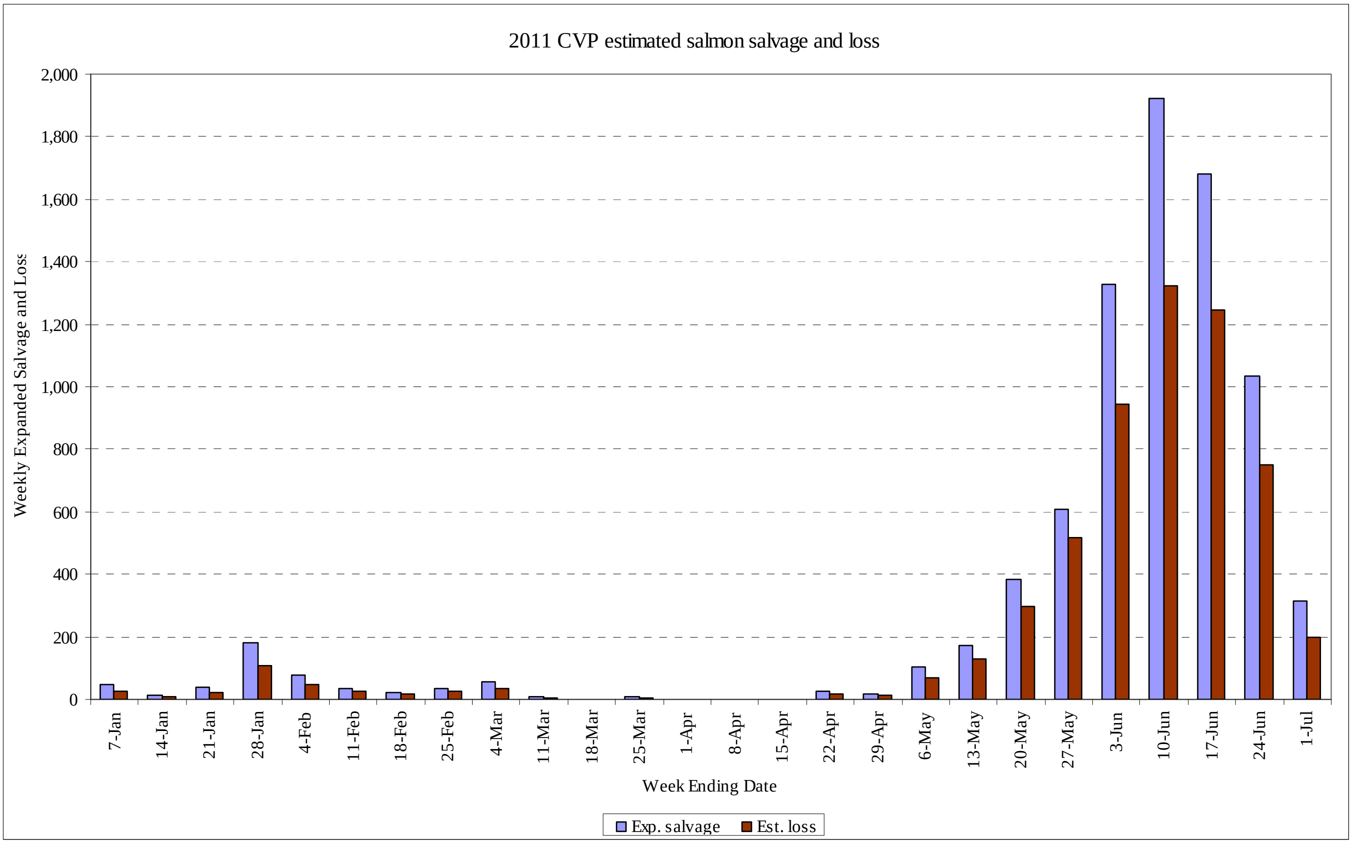


Exhibit 4B

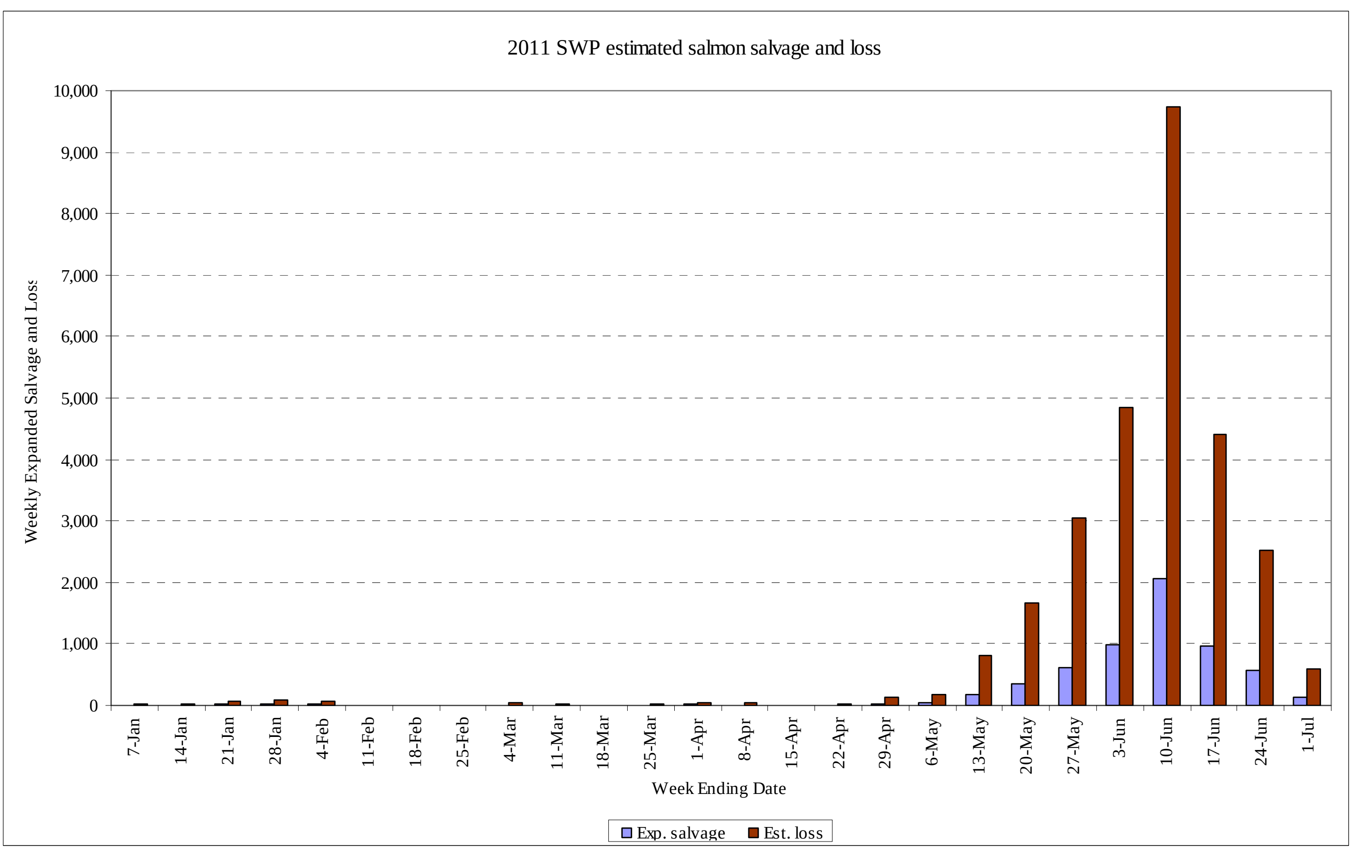


Exhibit 4C

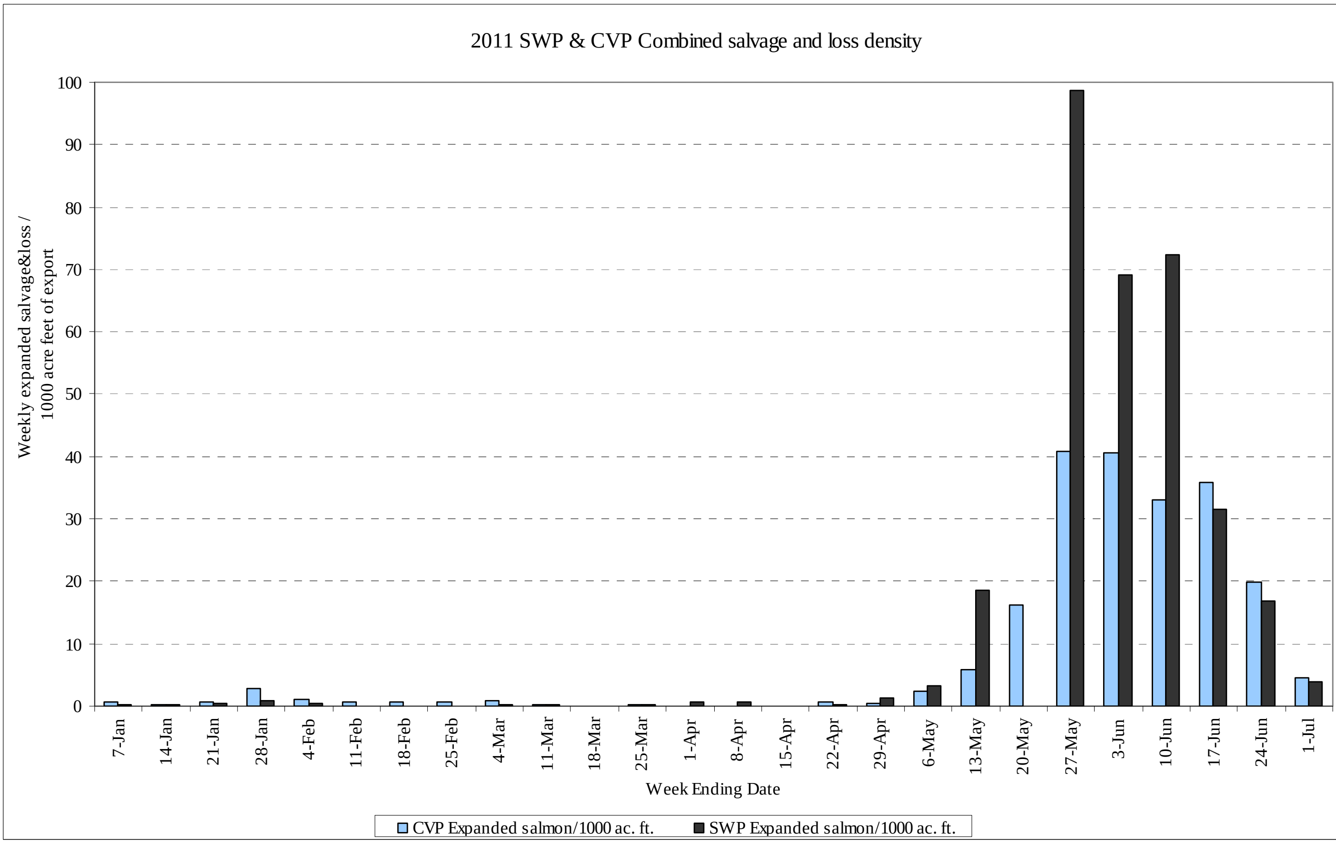


Exhibit 4D

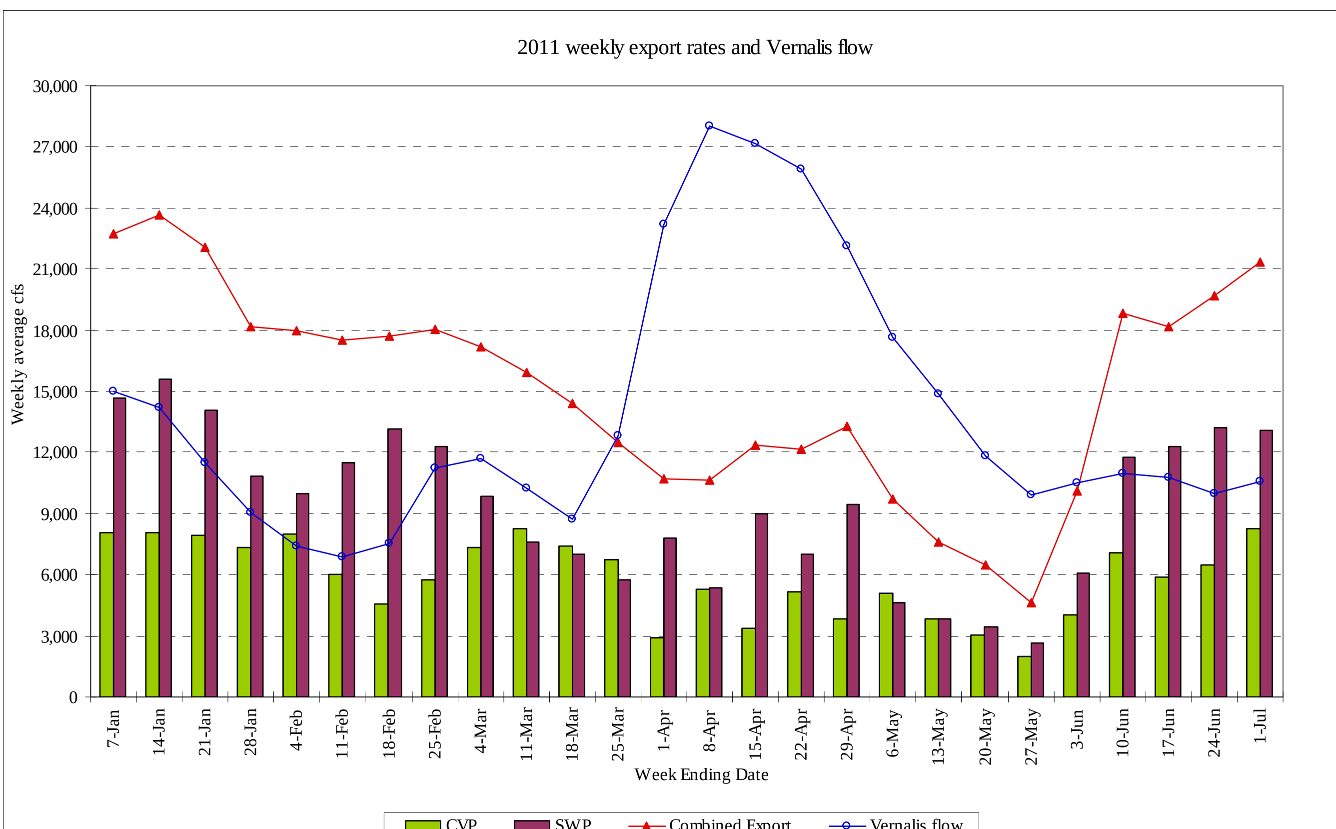


Exhibit 4E

OBSERVED CHINOOK SALVAGE AT THE SWP & CVP

DELTA FISH FACILITIES 8/1/2010 THROUGH 7/31/2011

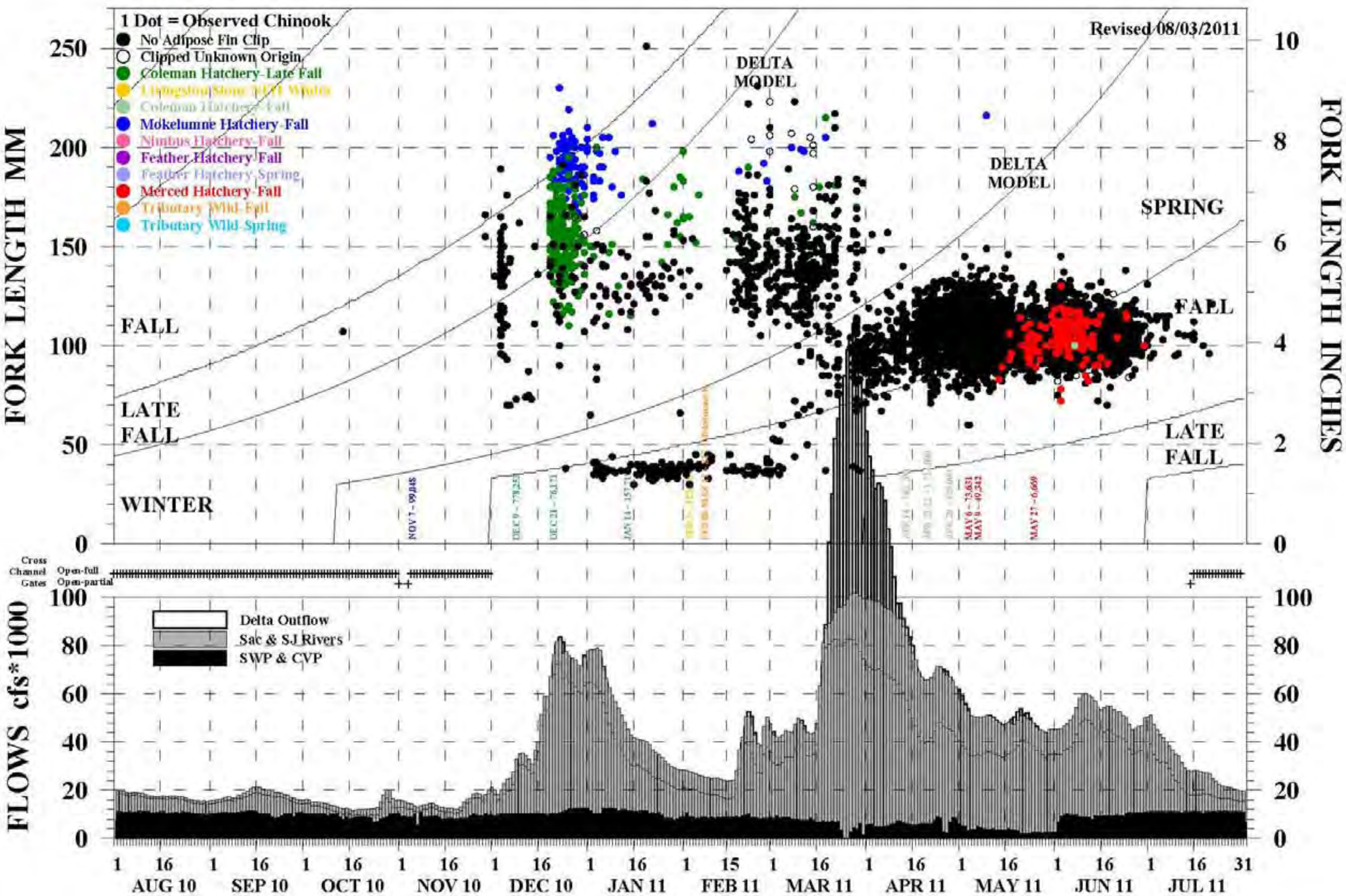
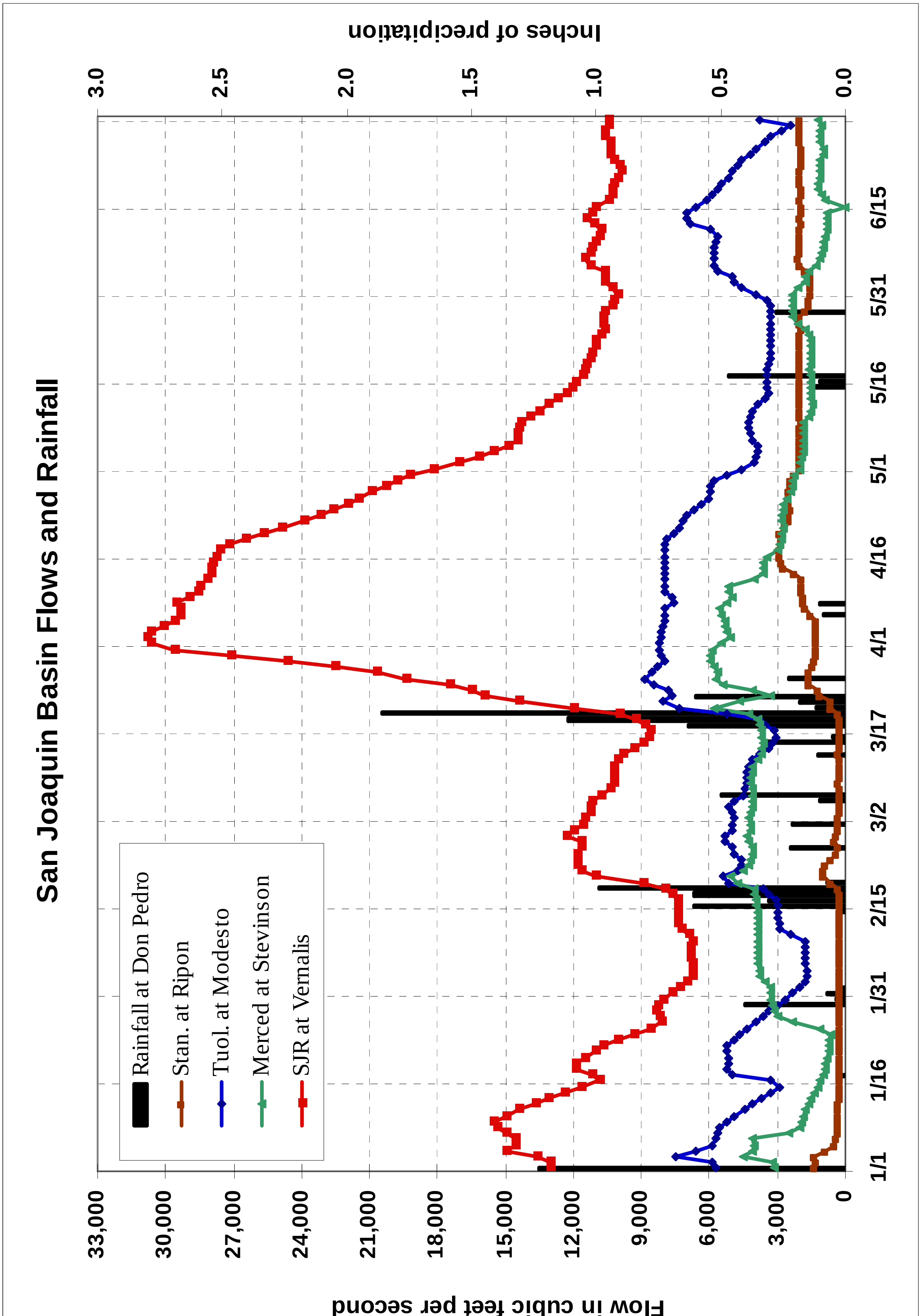


Exhibit 4F



San Joaquin Basin Flows and Rainfall
Flow in cubic feet per second
Inches of precipitation
33,000
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
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
Rainfall at Don Pedro
Stan. at Ripon
Tuol. at Modesto
Merced at Stevinson
SJR at Vernalis

Exhibit 4G

Attachment -A-

Water, Flows, Temperature, and Flow Schedule Correspondence

1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data
    1.1. 2011/2012 Water Years (Oct-Sep) daily average computed natural flow, actual flow, and FERC flow schedule at La Grange
    1.2. 2011/2012 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. 2011/2012 Water Years Don Pedro Reservoir storage
    1.5. 2011/2012 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 2011 daily average water temperature for Tuolumne and San Joaquin Rivers
    2.2. Modesto air temperature for Water Year 2011
3. Flow schedule correspondence for 2011
    3.1. Apr 22 – Minimum Flow Coordination Process for 2010-2011 Fish Flow Year

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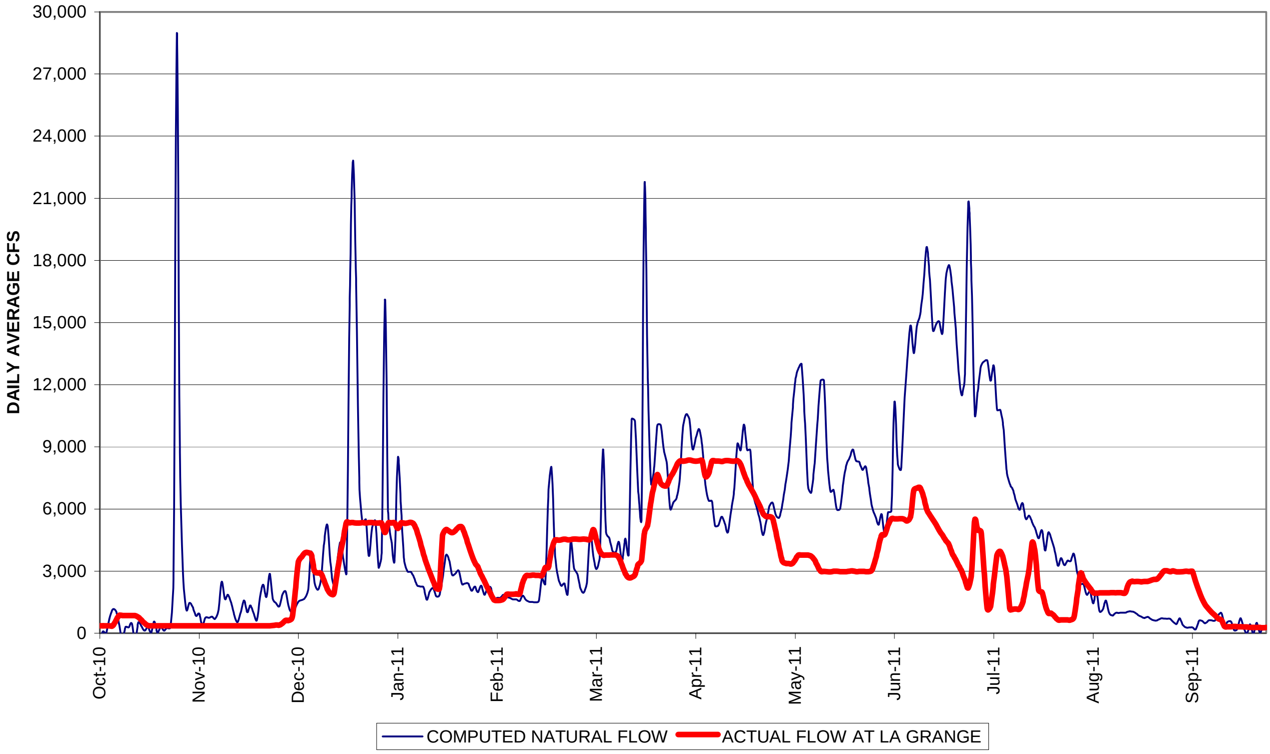
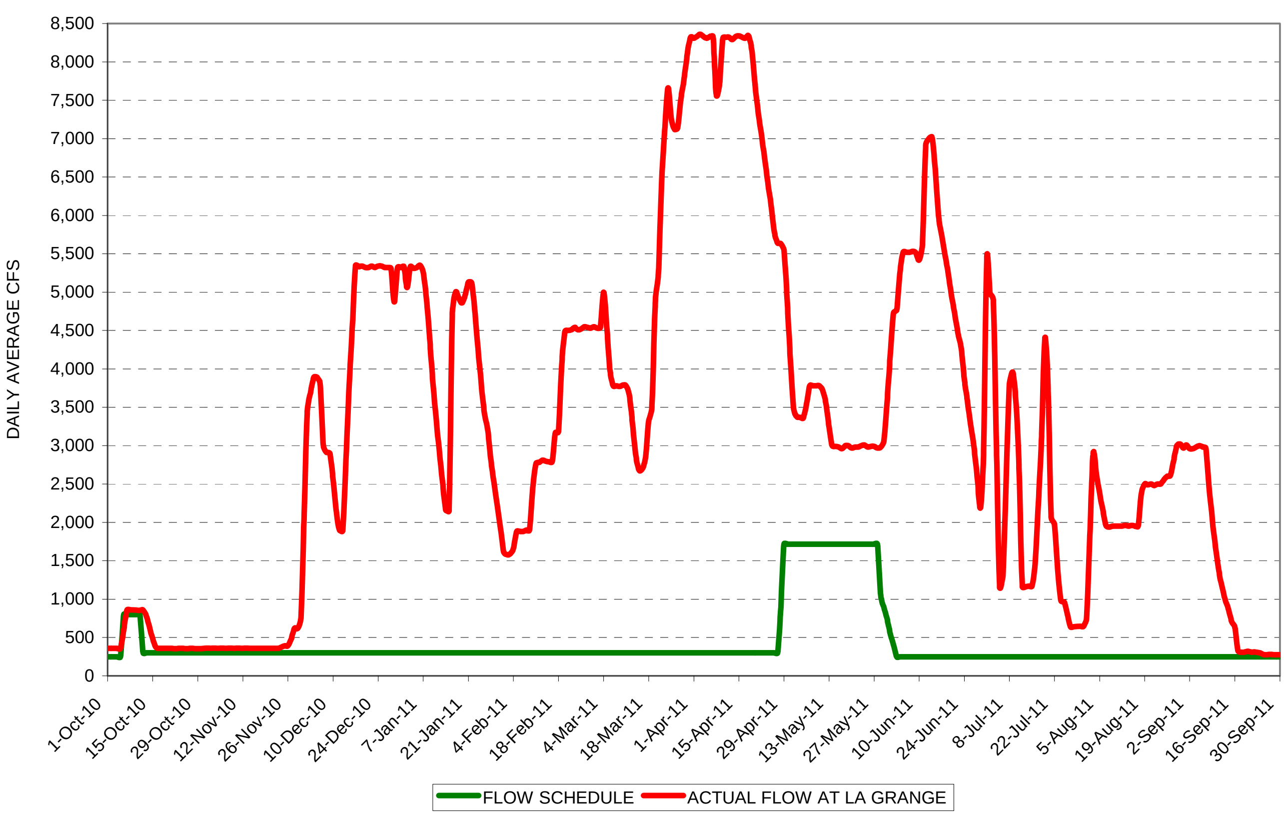
1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data

TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2011
BASED ON USGS PROVISIONAL DATA

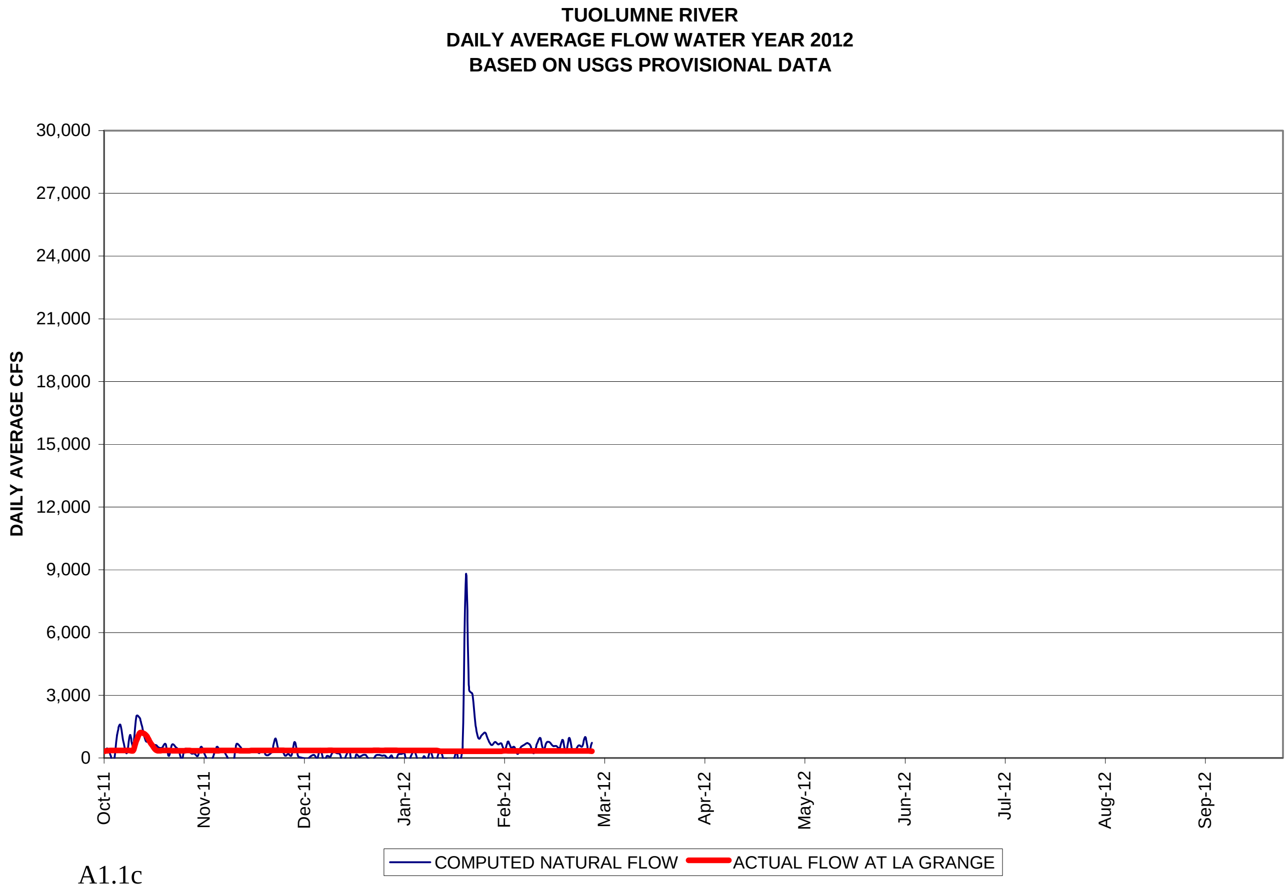


A1.1a

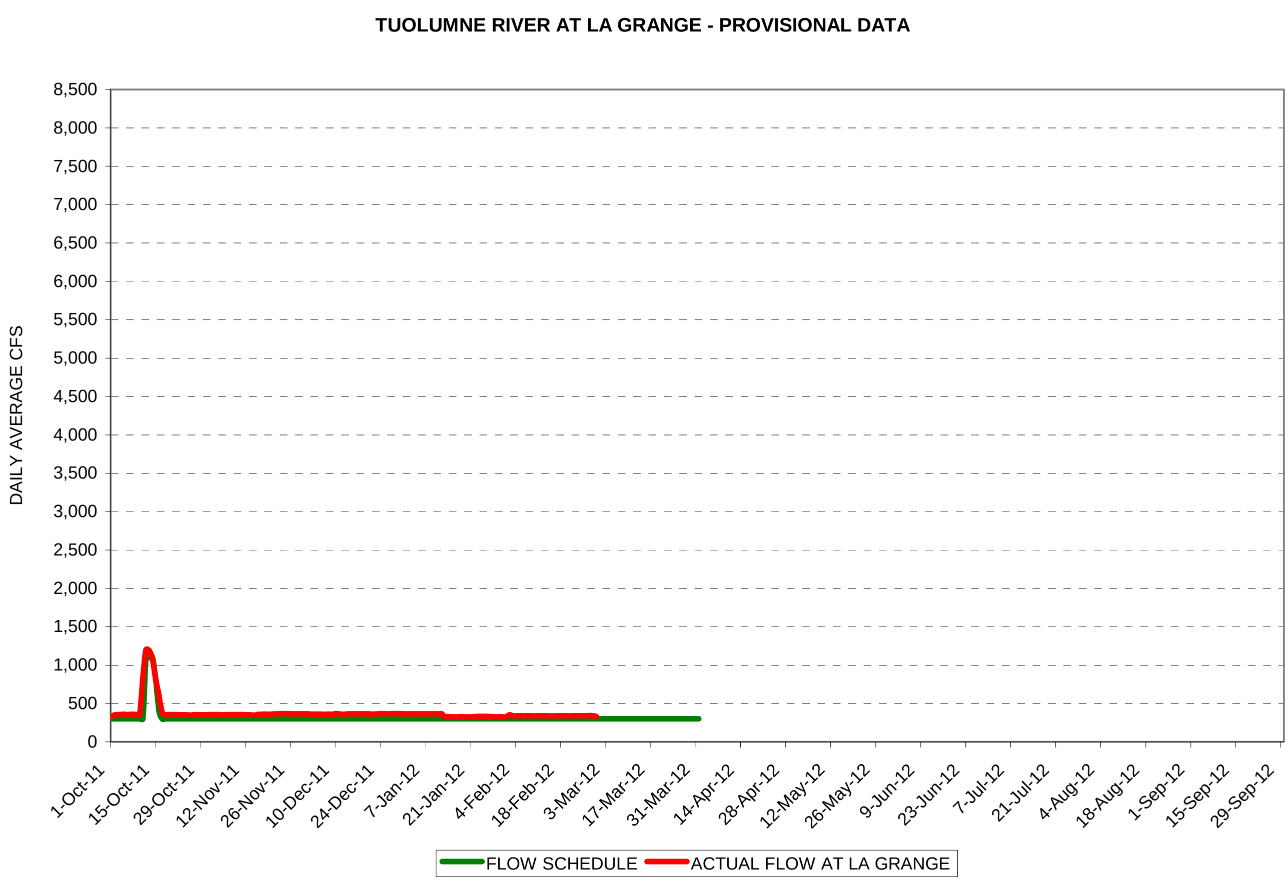
TUOLUMNE RIVER AT LA GRANGE - PROVISIONAL DATA



A1.1b

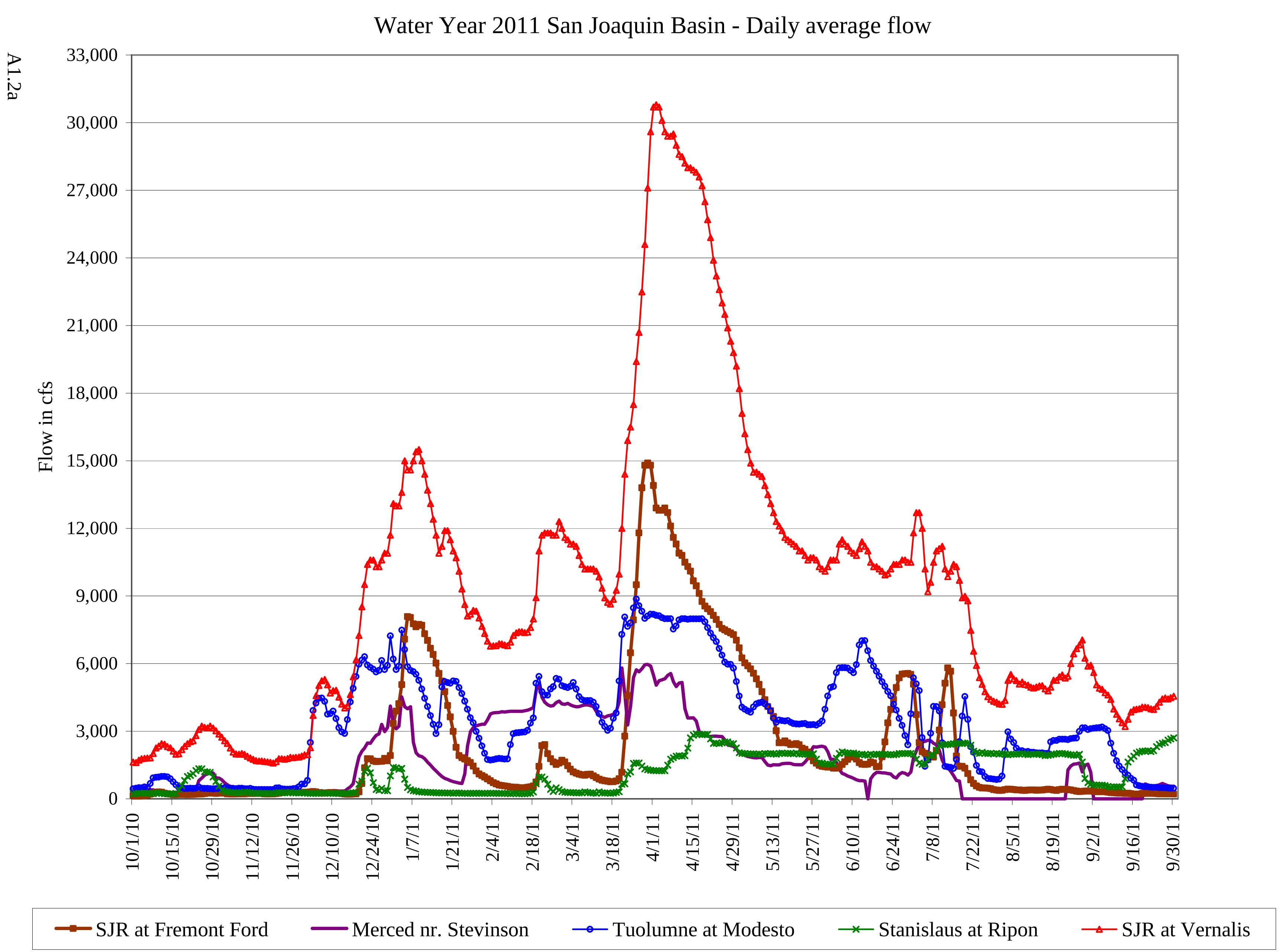

TUOLUMNE RIVER
DAILY AVERAGE FLOW WATER YEAR 2012
BASED ON USGS PROVISIONAL DATA
DAILY AVERAGE CFS
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
Oct-11
Nov-11
Dec-11
Jan-12
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
COMPUTED NATURAL FLOW
ACTUAL FLOW AT LA GRANGE

A1.1c

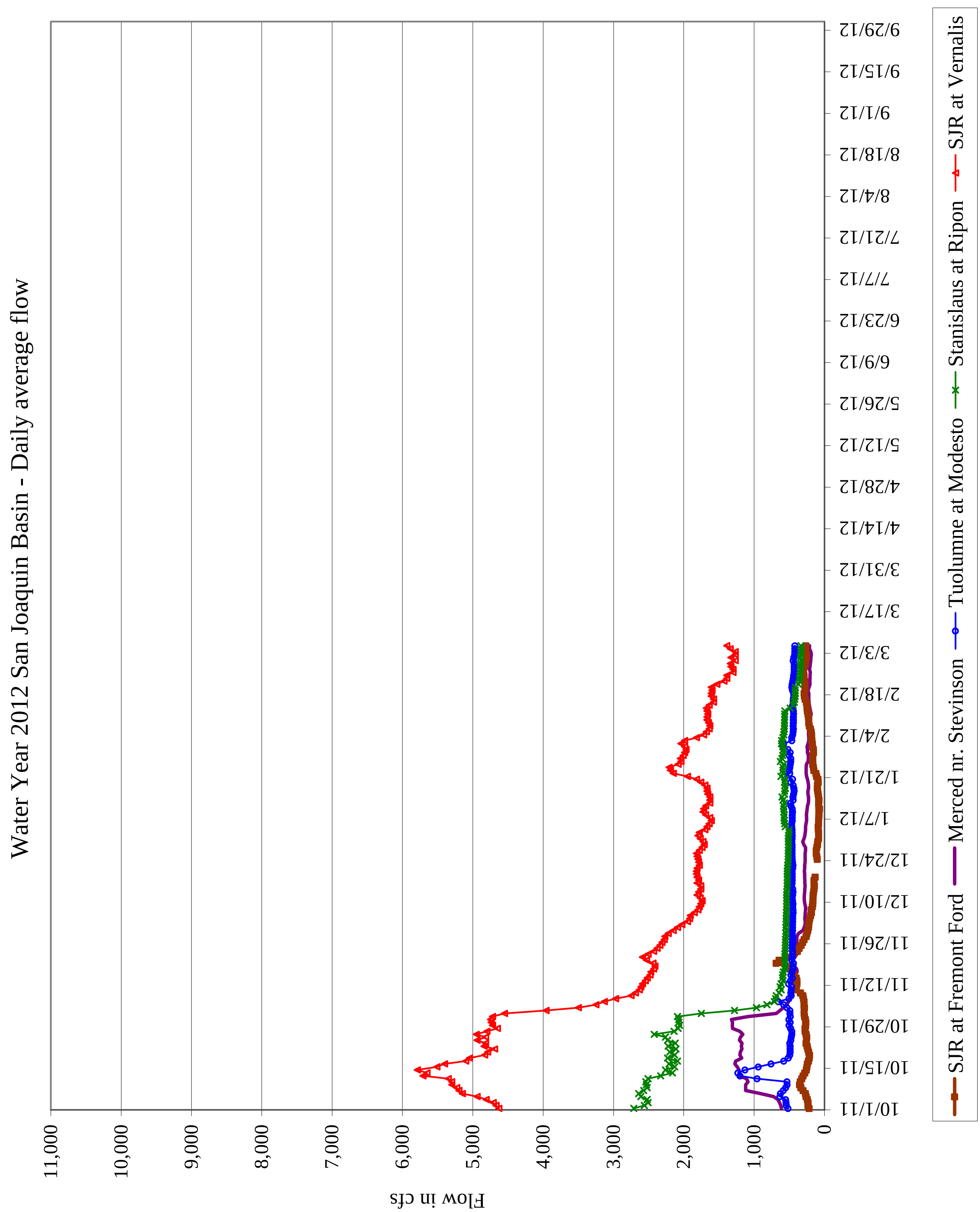

TUOLUMNE RIVER AT LA GRANGE - PROVISIONAL DATA
DAILY AVERAGE CFS
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1-Oct-11
15-Oct-11
29-Oct-11
12-Nov-11
26-Nov-11
10-Dec-11
24-Dec-11
7-Jan-12
21-Jan-12
4-Feb-12
18-Feb-12
3-Mar-12
17-Mar-12
31-Mar-12
14-Apr-12
28-Apr-12
12-May-12
26-May-12
9-Jun-12
23-Jun-12
7-Jul-12
21-Jul-12
4-Aug-12
18-Aug-12
1-Sep-12
15-Sep-12
29-Sep-12
FLOW SCHEDULE
ACTUAL FLOW AT LA GRANGE

A1.1d

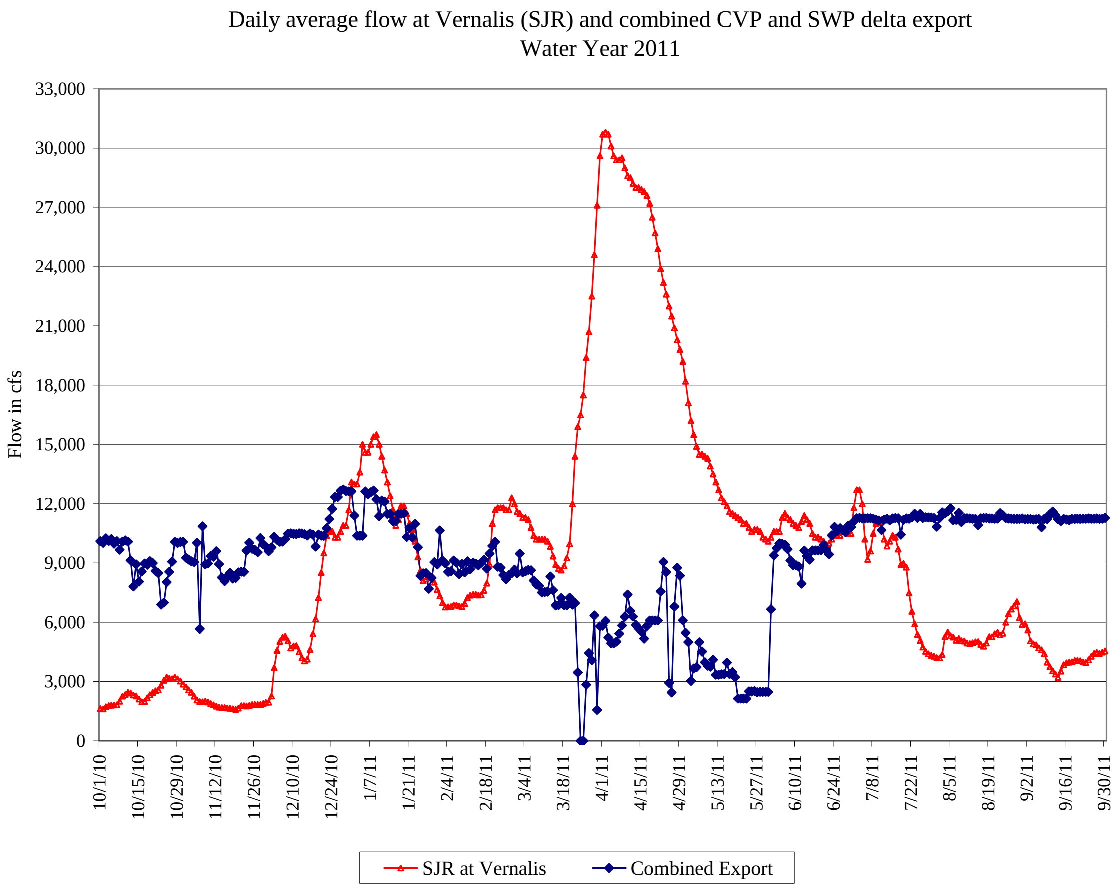
A1.2a



Water Year 2011 San Joaquin Basin - Daily average flow
Flow in cfs
0
3,000
6,000
9,000
12,000
15,000
18,000
21,000
24,000
27,000
30,000
33,000
10/1/10
10/15/10
10/29/10
11/12/10
11/26/10
12/10/10
12/24/10
1/7/11
1/21/11
2/4/11
2/18/11
3/4/11
3/18/11
4/1/11
4/15/11
4/29/11
5/13/11
5/27/11
6/10/11
6/24/11
7/8/11
7/22/11
8/5/11
8/19/11
9/2/11
9/16/11
9/30/11
SJR at Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis

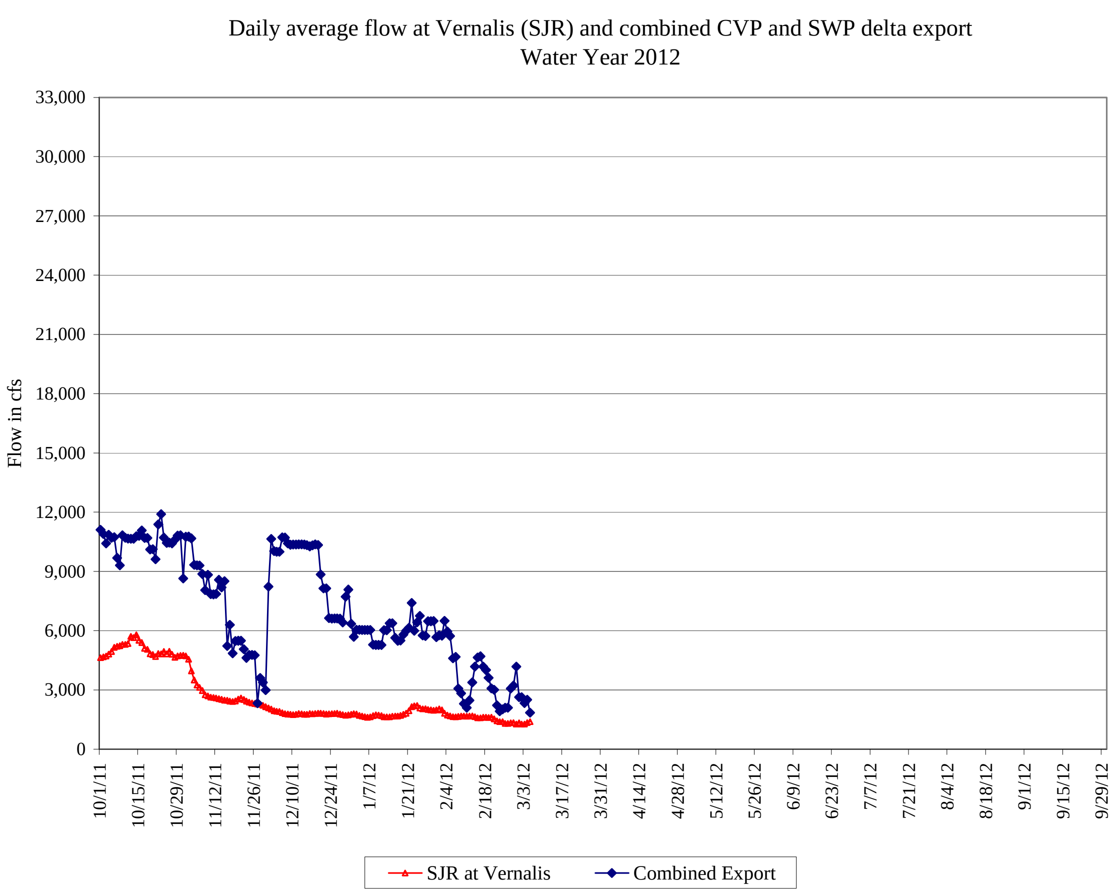

Water Year 2012 San Joaquin Basin - Daily average flow
Flow in cfs
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
10/1/11
10/15/11
10/29/11
11/12/11
11/26/11
12/10/11
12/24/11
1/7/12
1/21/12
2/4/12
2/18/12
3/3/12
3/17/12
3/31/12
4/14/12
4/28/12
5/12/12
5/26/12
6/9/12
6/23/12
7/7/12
7/21/12
8/4/12
8/18/12
9/1/12
9/15/12
9/29/12
SJR at Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis

A1.2b



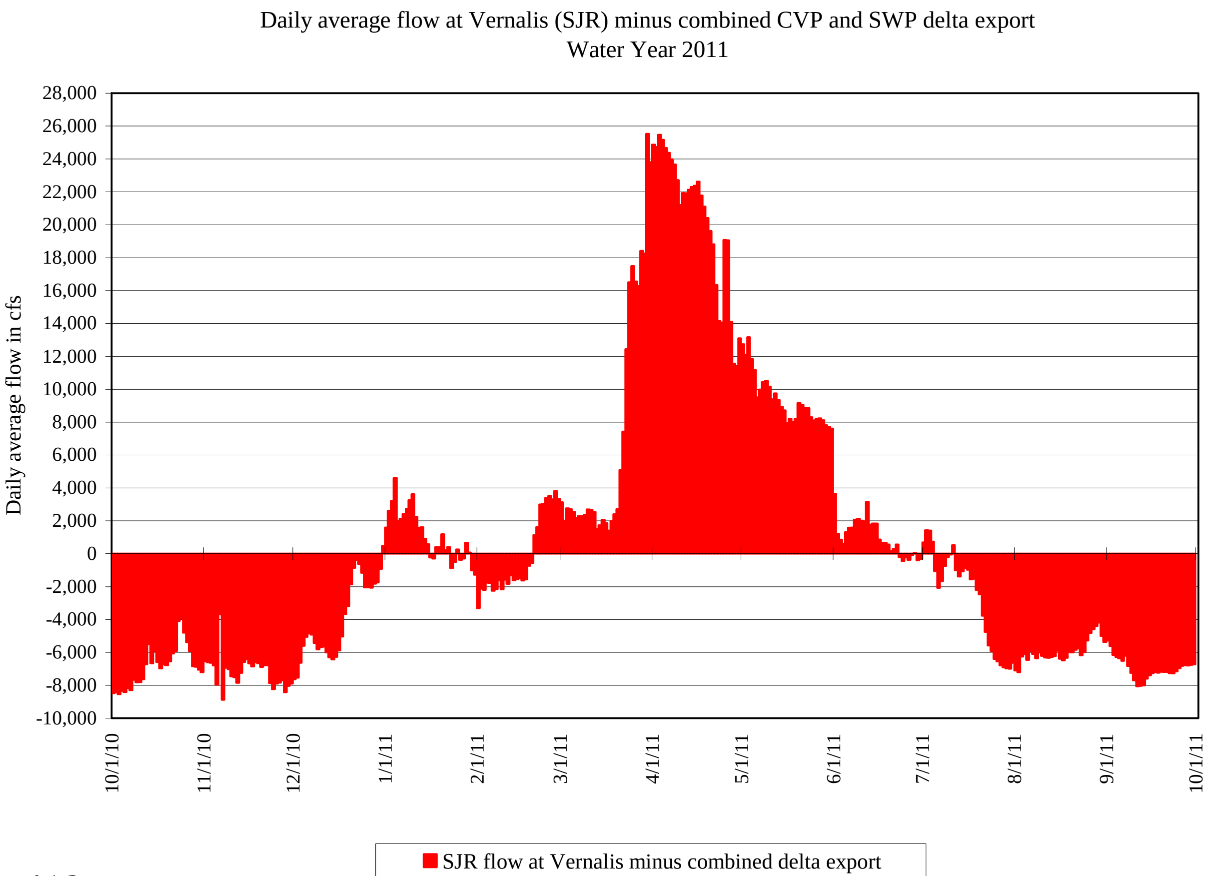
Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2011
Flow in cfs
33,000
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
10/1/10
10/15/10
10/29/10
11/12/10
11/26/10
12/10/10
12/24/10
1/7/11
1/21/11
2/4/11
2/18/11
3/4/11
3/18/11
4/1/11
4/15/11
4/29/11
5/13/11
5/27/11
6/10/11
6/24/11
7/8/11
7/22/11
8/5/11
8/19/11
9/2/11
9/16/11
9/30/11
SJR at Vernalis
Combined Export

A1.2c

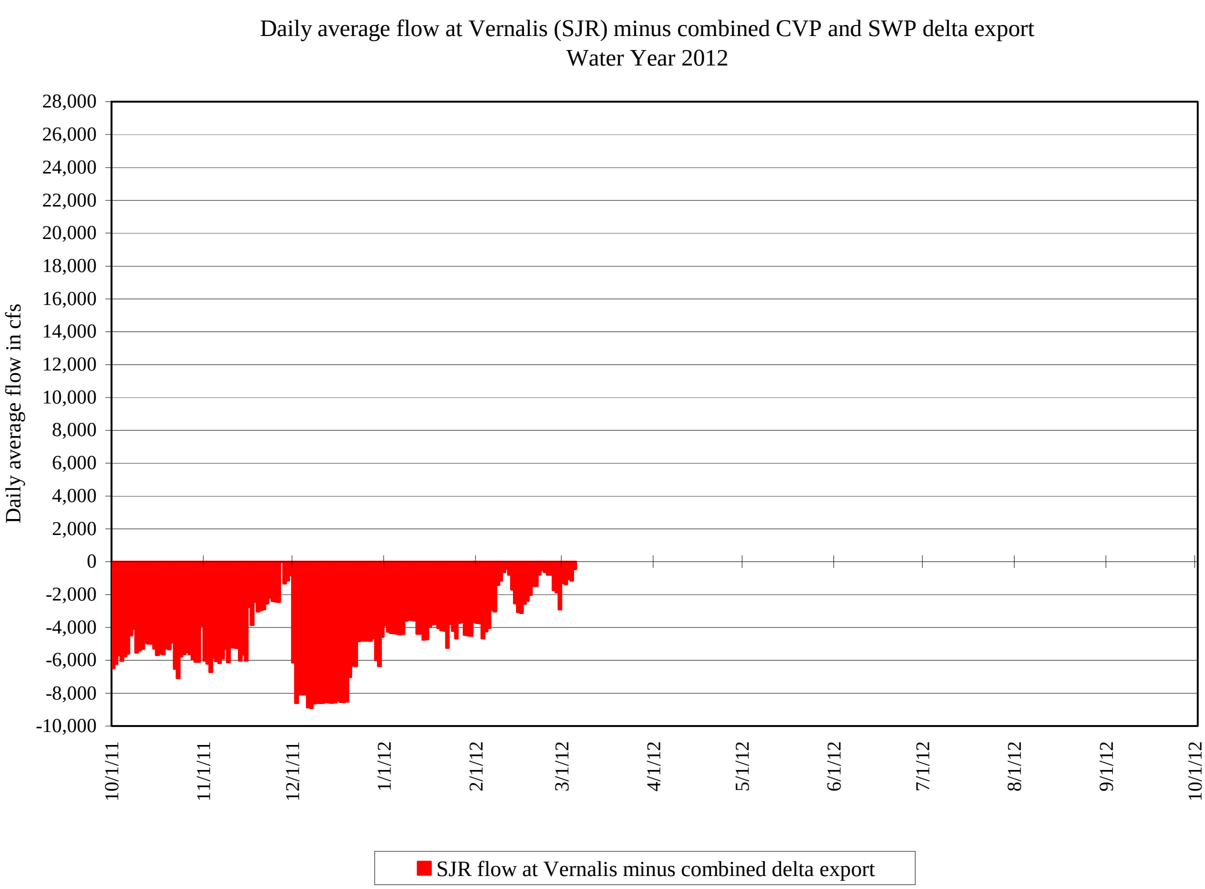


Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2012
Flow in cfs
33,000
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
10/1/11
10/15/11
10/29/11
11/12/11
11/26/11
12/10/11
12/24/11
1/7/12
1/21/12
2/4/12
2/18/12
3/3/12
3/17/12
3/31/12
4/14/12
4/28/12
5/12/12
5/26/12
6/9/12
6/23/12
7/7/12
7/21/12
8/4/12
8/18/12
9/1/12
9/15/12
9/29/12
SJR at Vernalis
Combined Export

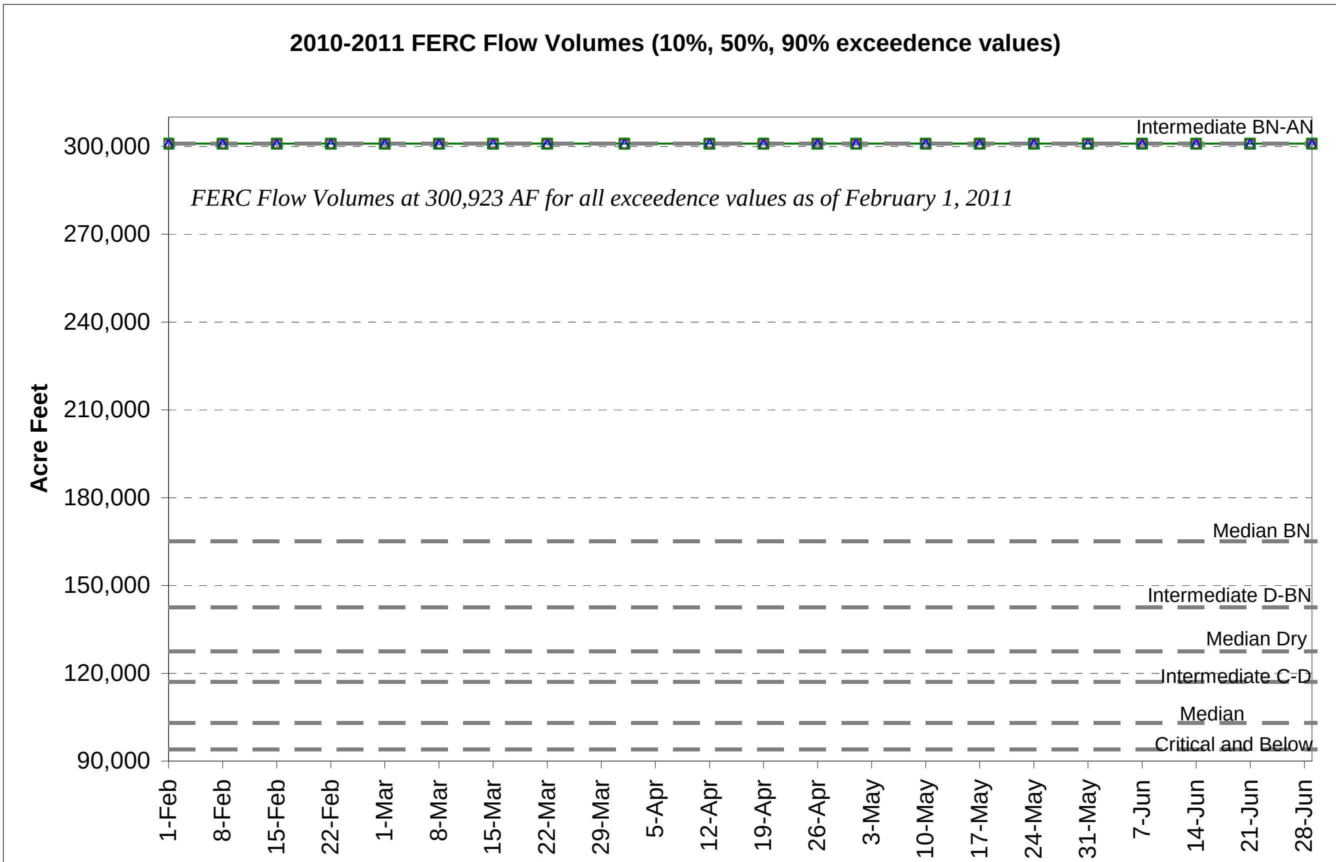
A1.2d


Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2011
Daily average flow in cfs
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
10/1/10
11/1/10
12/1/10
1/1/11
2/1/11
3/1/11
4/1/11
5/1/11
6/1/11
7/1/11
8/1/11
9/1/11
10/1/11
SJR flow at Vernalis minus combined delta export

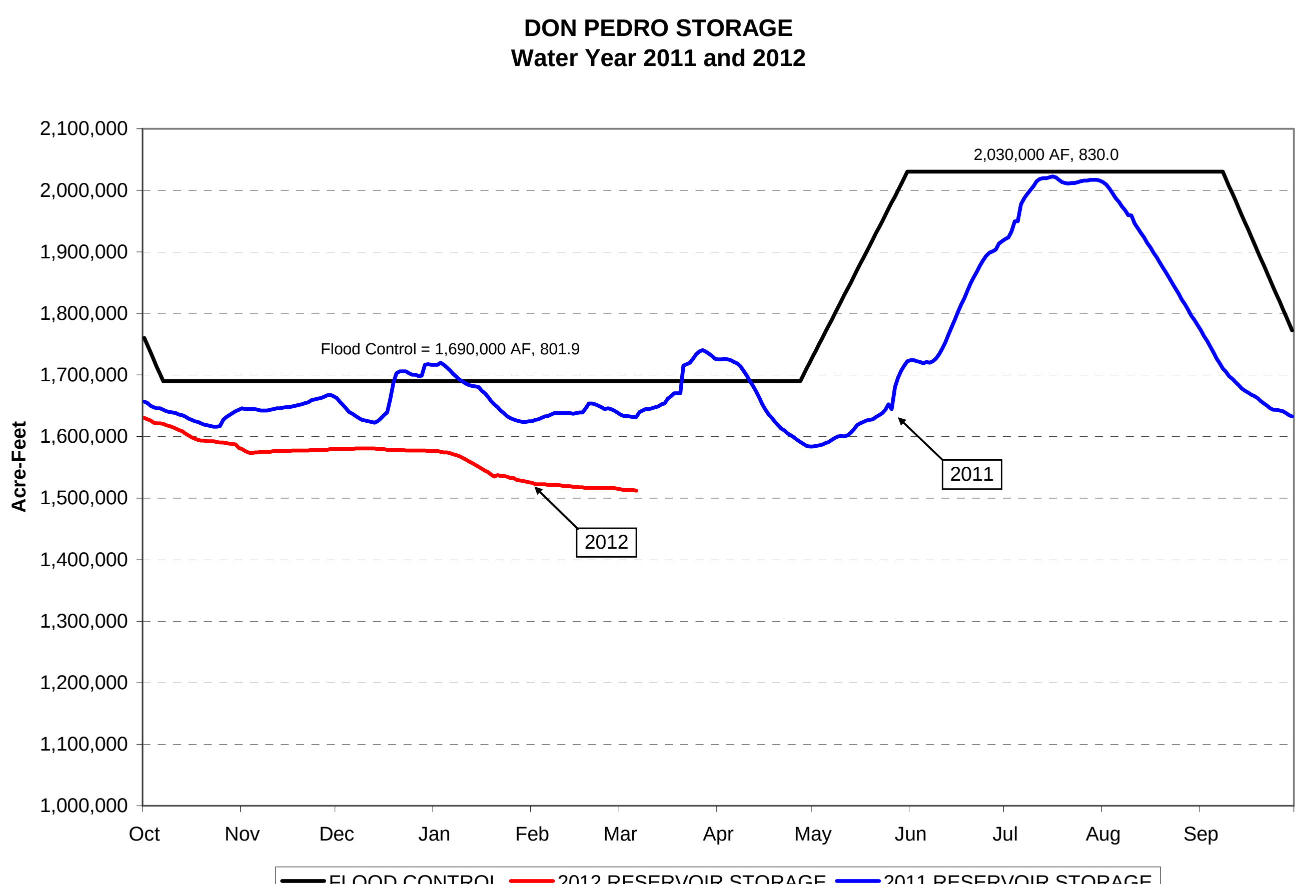
A1.2e


Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2012
Daily average flow in cfs
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
10/1/11
11/1/11
12/1/11
1/1/12
2/1/12
3/1/12
4/1/12
5/1/12
6/1/12
7/1/12
8/1/12
9/1/12
10/1/12
SJR flow at Vernalis minus combined delta export

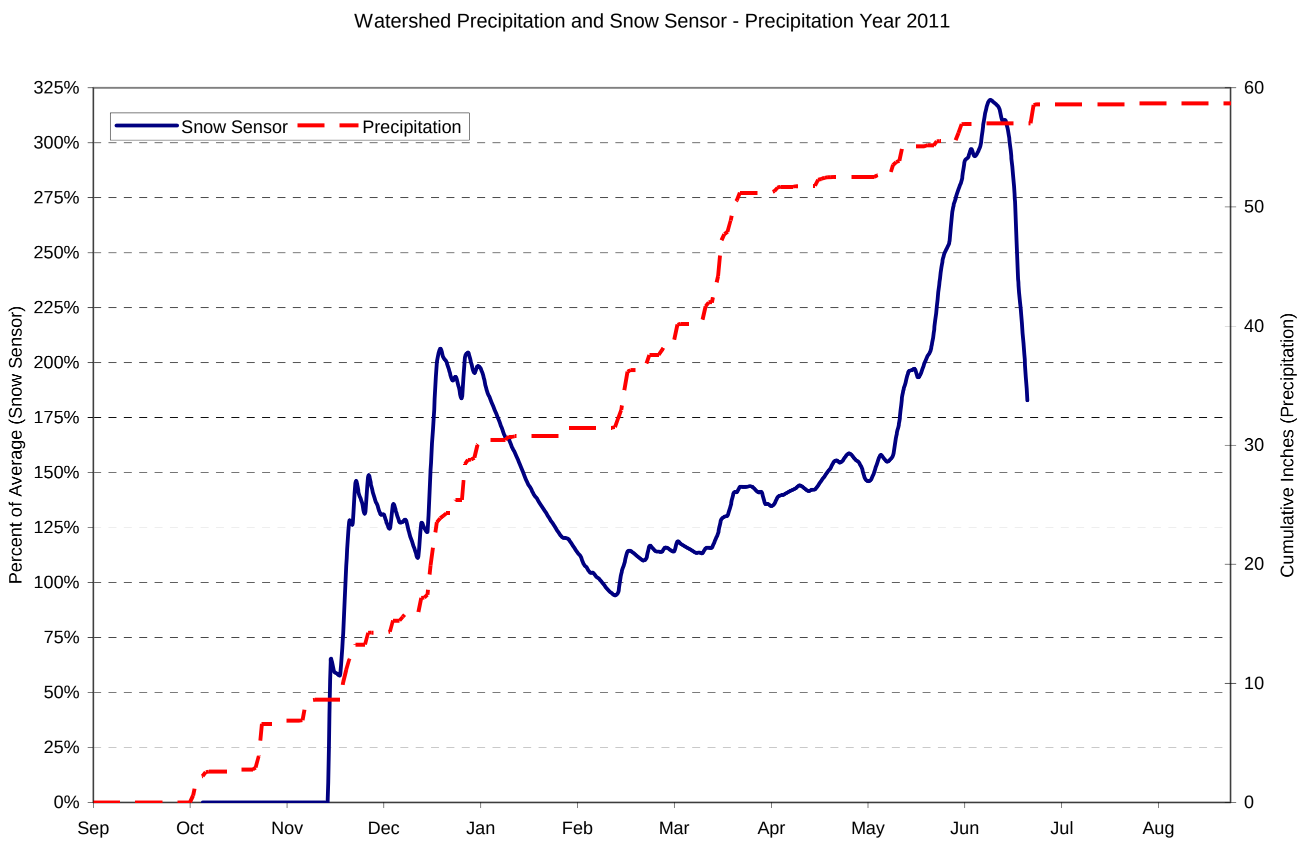
A1.2f


2010-2011 FERC Flow Volumes (10%, 50%, 90% exceedence values)
Intermediate BN-AN
300,000
FERC Flow Volumes at 300,923 AF for all exceedence values as of February 1, 2011
270,000
240,000
210,000
180,000
Median BN
150,000
Intermediate D-BN
Median Dry
120,000
Intermediate C-D
Median
90,000
Critical and Below
Acre Feet
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
31-May
7-Jun
14-Jun
21-Jun
28-Jun
DWR Forecast Date

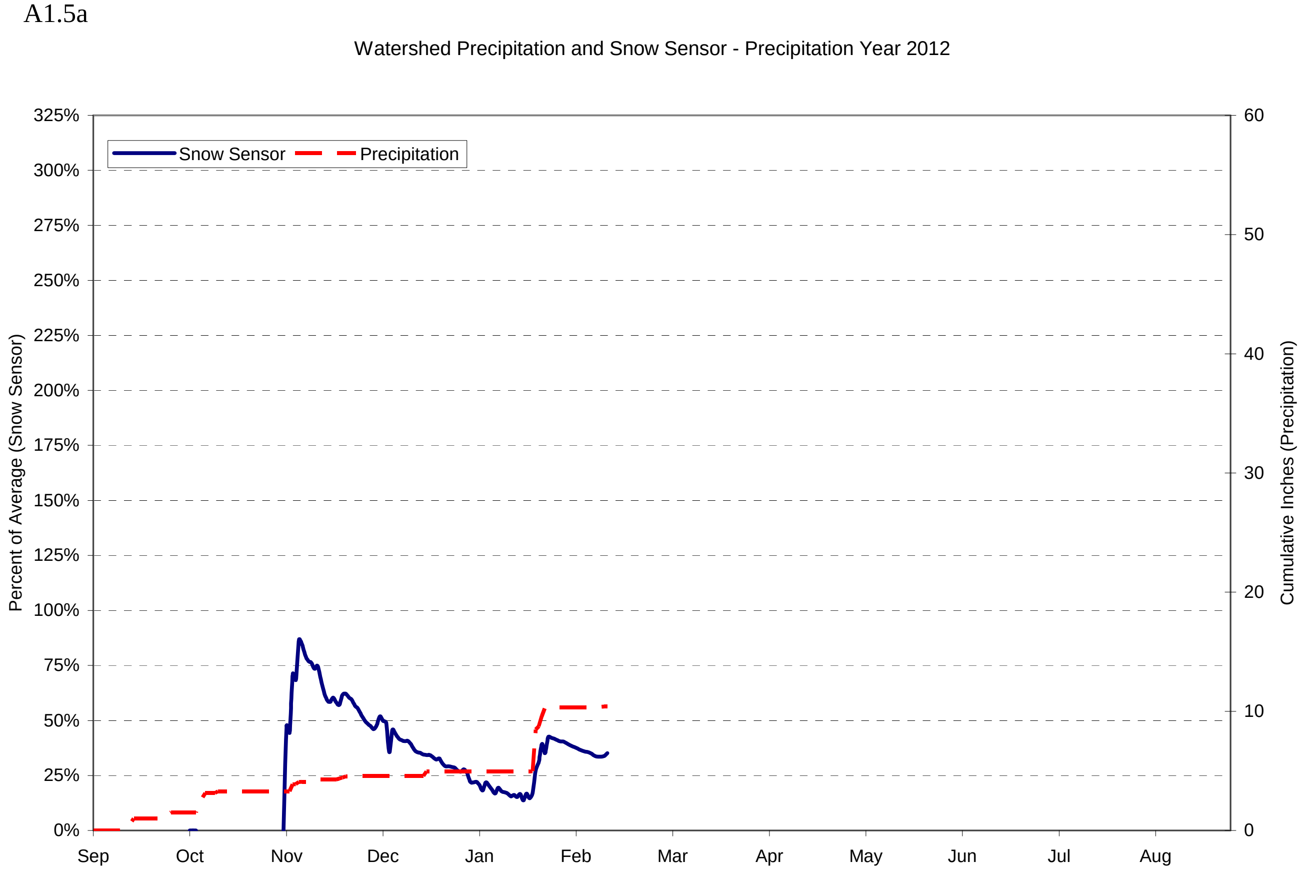
A1.3


DON PEDRO STORAGE
Water Year 2011 and 2012
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
Acre-Feet
2,030,000 AF, 830.0
Flood Control = 1,690,000 AF, 801.9
2011
2012
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
FLOOD CONTROL
2012 RESERVOIR STORAGE
2011 RESERVOIR STORAGE

A1.4

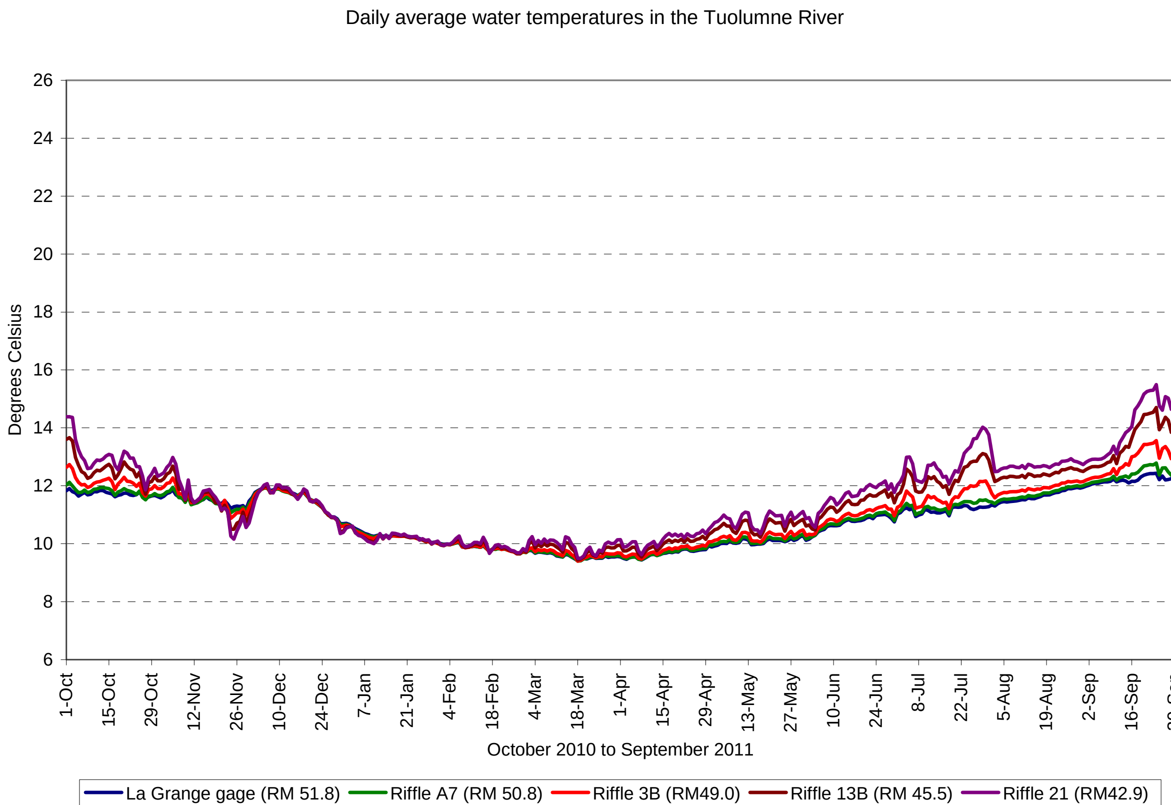

Watershed Precipitation and Snow Sensor - Precipitation Year 2011
Snow Sensor
Precipitation
325%
300%
275%
250%
225%
200%
175%
150%
125%
100%
75%
50%
25%
0%
60
50
40
30
20
10
0
Percent of Average (Snow Sensor)
Cumulative Inches (Precipitation)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

A1.5a

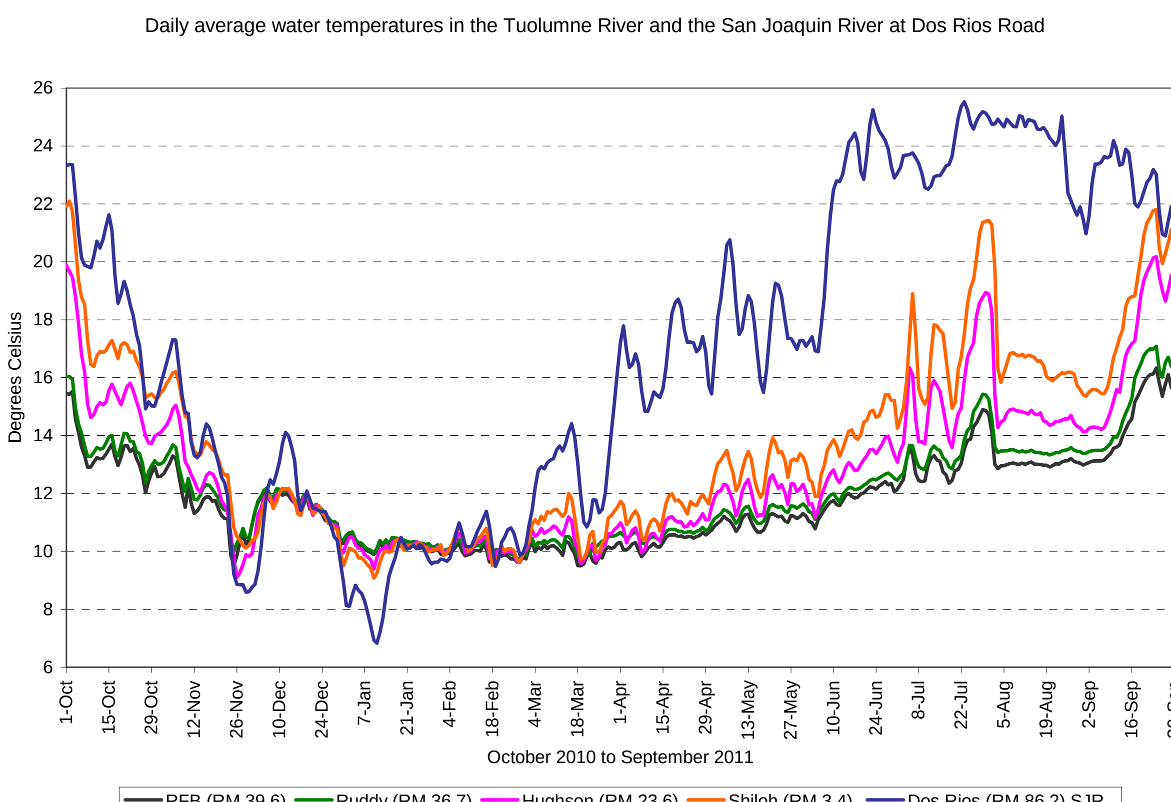

Watershed Precipitation and Snow Sensor - Precipitation Year 2012
Snow Sensor
Precipitation
325%
300%
275%
250%
225%
200%
175%
150%
125%
100%
75%
50%
25%
0%
60
50
40
30
20
10
0
Percent of Average (Snow Sensor)
Cumulative Inches (Precipitation)
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

A1.5b

2. Graphs of water temperature and air temperature

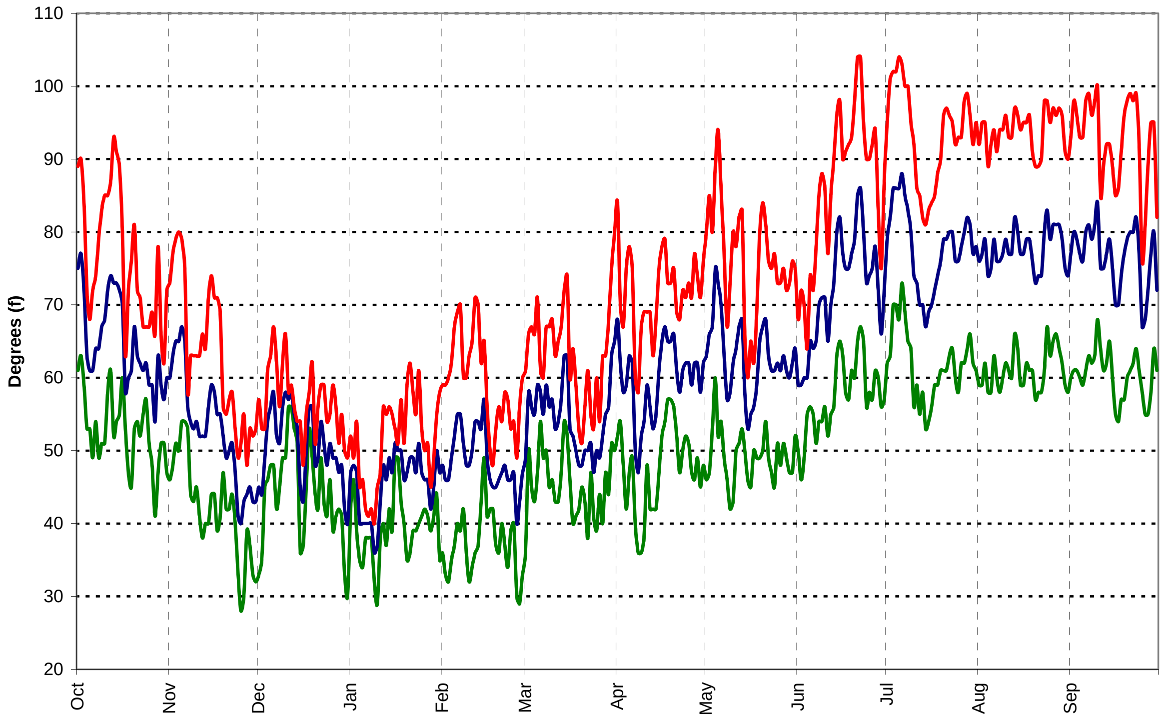


A2.1a



A2.1b

Modesto Airport Air Temperature - Max, Min, Avg (Water Year 2011)



A2.2

WATER & POWER
Serving Central California since 1887

April 12, 2011

VIA E-MAIL

Tim Heyne	Deborah Giglio	Jeff Stuart
California Dept. of Fish and Game	U.S. Fish and Wildlife Service	National Marine Fisheries Service
P.O. Box 10	2800 Cottage Way, W-2605	650 Capitol Mall, Suite 8-300
La Grange, CA 95329	Sacramento, CA 95825	Sacramento, CA 95814-4708

RE: Project 2299 – Minimum Flow Coordination Process for 2010-2011 Fish Flow Year

Dear Fishery Agency Representatives:

The 1996 FERC Order, Amended Article 37, contained a Water Year Classification Index for determining the volume of scheduled stream flows for each fish flow year. The classifications are based on the San Joaquin Basin 60-20-20 Indices for water years. The index has been updated in a continuous fashion based on the Department of Water Resources (DWR) monthly forecasts. Updates of those forecasts are provided in Table 1. We are in a wet year with respect to the 50% and 90% exceedence levels.

Based upon applying the current DWR April-July runoff forecast to the DWR 60-20-20 basin index, the annual minimum flow requirements are 300,923 AF under both the 90% Exceedence case and the 50% Exceedence case. These values are also shown on Table 1 with the respective 60-20-20 index.

Based upon the above, a daily schedule is provided and will be followed. The thought process that went into the schedule is as follows:

1) The base flow and pulse flow amounts are based upon those specified in the 1996 FERC Order.
2) The timing of the spring pulse flow amounts are consistent with the VAMP period starting May 1, 2011.
3) The spring pulse flows are shown as steady with a ramp down.
4) A ramp down to the June flow is shown.
5) There is no "interpolation water" volume for this year.
6) The initial timing of the fall pulse flow shown is based on a default schedule of October 6 through 10 that was established in 1996, that may be adjusted later.

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

Sincerely,

Robert M. Nees
Assistant General Manager
Civil Engineering and Water Resources

C: Casey Hashimoto - TID
Allen Short - MID
FERC Secretary

Table 1

SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION

602020 INDEX

YEAR	APRIL-JULY RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	OCTOBER-MARCH RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	602020 INDEX	TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT	San Joaquin Index (not the FERC Index) RANKING
Feb 1 Forecast													
Dry	590,000	1,080,000	580,000	1,330,000	3,580,000	610,000	1,020,000	535,000	740,000	2,905,000	3,438,540	300,923	Above Normal
Average	820,000	1,470,000	760,000	1,690,000	4,740,000	685,000	1,130,000	605,000	840,000	3,260,000	4,205,540	300,923	Wet
Wet	1,280,000	2,260,000	1,270,000	2,510,000	7,320,000	850,000	1,390,000	795,000	1,070,000	4,105,000	5,922,540	300,923	Wet
Feb 08 Update													
Dry	580,000	1,060,000	560,000	1,290,000	3,490,000	610,000	1,020,000	535,000	740,000	2,905,000	3,384,540	300,923	Above Normal
Average	790,000	1,420,000	730,000	1,630,000	4,570,000	685,000	1,130,000	605,000	840,000	3,260,000	4,103,540	300,923	Wet
Wet	1,230,000	2,170,000	1,200,000	2,390,000	6,990,000	850,000	1,390,000	795,000	1,070,000	4,105,000	5,724,540	300,923	Wet
Feb 15 Update													
Dry	560,000	1,020,000	530,000	1,230,000	3,340,000	610,000	1,020,000	535,000	740,000	2,905,000	3,294,540	300,923	Above Normal
Average	760,000	1,340,000	690,000	1,550,000	4,340,000	685,000	1,130,000	605,000	840,000	3,260,000	3,965,540	300,923	Wet
Wet	1,190,000	2,050,000	1,120,000	2,260,000	6,620,000	850,000	1,390,000	795,000	1,070,000	4,105,000	5,502,540	300,923	Wet
Feb 22 Update													
Dry	640,000	1,190,000	610,000	1,360,000	3,800,000	610,000	1,020,000	535,000	740,000	2,905,000	3,570,540	300,923	Above Normal
Average	820,000	1,480,000	760,000	1,660,000	4,720,000	685,000	1,130,000	605,000	840,000	3,260,000	4,193,540	300,923	Wet
Wet	1,230,000	2,140,000	1,150,000	2,310,000	6,830,000	850,000	1,390,000	795,000	1,070,000	4,105,000	5,628,540	300,923	Wet
Mar 1 Forecast													
Dry	680,000	1,210,000	630,000	1,350,000	3,870,000	630,000	1,015,000	560,000	740,000	2,945,000	3,620,540	300,923	Above Normal
Average	850,000	1,470,000	770,000	1,630,000	4,720,000	670,000	1,065,000	595,000	795,000	3,125,000	4,166,540	300,923	Wet
Wet	1,240,000	2,090,000	1,120,000	2,220,000	6,670,000	760,000	1,185,000	670,000	900,000	3,515,000	5,414,540	300,923	Wet
Mar 08 Update													
Dry	740,000	1,310,000	670,000	1,420,000	4,140,000	630,000	1,015,000	560,000	740,000	2,945,000	3,782,540	300,923	Above Normal
Average	900,000	1,550,000	800,000	1,680,000	4,930,000	670,000	1,065,000	595,000	795,000	3,125,000	4,292,540	300,923	Wet
Wet	1,260,000	2,120,000	1,130,000	2,210,000	6,720,000	760,000	1,185,000	670,000	900,000	3,515,000	5,444,540	300,923	Wet
Mar 15 Update													
Dry	750,000	1,320,000	660,000	1,400,000	4,130,000	630,000	1,015,000	560,000	740,000	2,945,000	3,776,540	300,923	Above Normal
Average	900,000	1,540,000	780,000	1,640,000	4,860,000	670,000	1,065,000	595,000	795,000	3,125,000	4,250,540	300,923	Wet
Wet	1,230,000	2,060,000	1,080,000	2,120,000	6,490,000	760,000	1,185,000	670,000	900,000	3,515,000	5,306,540	300,923	Wet
Mar 22 Update													
Dry	880,000	1,590,000	820,000	1,630,000	4,920,000	630,000	1,015,000	560,000	740,000	2,945,000	4,250,540	300,923	Wet
Average	1,020,000	1,790,000	930,000	1,850,000	5,590,000	670,000	1,065,000	595,000	795,000	3,125,000	4,688,540	300,923	Wet
Wet	1,320,000	2,250,000	1,210,000	2,270,000	7,050,000	760,000	1,185,000	670,000	900,000	3,515,000	5,642,540	300,923	Wet
Apr 1 Forecast													
Dry	1,060,000	1,880,000	940,000	1,910,000	5,790,000	820,000	1,250,000	725,000	880,000	3,675,000	4,918,540	300,923	Wet
Average	1,180,000	2,050,000	1,040,000	2,100,000	6,370,000	820,000	1,250,000	725,000	880,000	3,675,000	5,266,540	300,923	Wet
Wet	1,430,000	2,440,000	1,280,000	2,440,000	7,590,000	820,000	1,250,000	725,000	880,000	3,675,000	5,998,540	300,923	Wet

TABLE 2

Tuolumne River Flow Schedule

Default

SCHEDULE FOR 2011 - 2012 Fish Flow Year

DATE		Number of	BASE FLOW			PULSE FLOW			ADDITIONAL FLOW			TOTAL FERC FLOW	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
15-Apr-2011	15-Apr-2011	1	300	595	595		0	0	0	0	0	300	595
16-Apr-2011	16-Apr-2011	1	300	595	1,190		0	0	0	0	0	300	1,190
17-Apr-2011	17-Apr-2011	1	300	595	1,785		0	0	0	0	0	300	1,785
18-Apr-2011	18-Apr-2011	1	300	595	2,380		0	0	0	0	0	300	2,380
19-Apr-2011	19-Apr-2011	1	300	595	2,975		0	0	0	0	0	300	2,975
20-Apr-2011	20-Apr-2011	1	300	595	3,570		0	0	0	0	0	300	3,570
21-Apr-2011	21-Apr-2011	1	300	595	4,165		0	0	0	0	0	300	4,165
22-Apr-2011	22-Apr-2011	1	300	595	4,760		0	0	0	0	0	300	4,760
23-Apr-2011	23-Apr-2011	1	300	595	5,355		0	0	0	0	0	300	5,355
24-Apr-2011	24-Apr-2011	1	300	595	5,950		0	0	0	0	0	300	5,950
25-Apr-2011	25-Apr-2011	1	300	595	6,545		0	0	0	0	0	300	6,545
26-Apr-2011	26-Apr-2011	1	300	595	7,140		0	0	0	0	0	300	7,140
27-Apr-2011	27-Apr-2011	1	300	595	7,736		0	0	0	0	0	300	7,736
28-Apr-2011	28-Apr-2011	1	300	595	8,331	550	1,091	1,091	0	0	0	850	9,421
29-Apr-2011	29-Apr-2011	1	300	595	8,926	1,417	2,811	3,902	0	0	0	1,717	12,827
30-Apr-2011	30-Apr-2011	1	300	595	9,521	1,417	2,811	6,713	0	0	0	1,717	16,233
01-May-2011	01-May-2011	1	300	595	10,116	1,417	2,811	9,524	0	0	0	1,717	19,639
02-May-2011	02-May-2011	1	300	595	10,711	1,417	2,811	12,335	0	0	0	1,717	23,045
03-May-2011	03-May-2011	1	300	595	11,306	1,417	2,811	15,146	0	0	0	1,717	26,451
04-May-2011	04-May-2011	1	300	595	11,901	1,417	2,811	17,957	0	0	0	1,717	29,857
05-May-2011	05-May-2011	1	300	595	12,496	1,417	2,811	20,767	0	0	0	1,717	33,263
06-May-2011	06-May-2011	1	300	595	13,091	1,417	2,811	23,578	0	0	0	1,717	36,669
07-May-2011	07-May-2011	1	300	595	13,686	1,417	2,811	26,389	0	0	0	1,717	40,075
08-May-2011	08-May-2011	1	300	595	14,281	1,417	2,811	29,200	0	0	0	1,717	43,481
09-May-2011	09-May-2011	1	300	595	14,876	1,417	2,811	32,011	0	0	0	1,717	46,887
10-May-2011	10-May-2011	1	300	595	15,471	1,417	2,811	34,822	0	0	0	1,717	50,293
11-May-2011	11-May-2011	1	300	595	16,066	1,417	2,811	37,633	0	0	0	1,717	53,699
12-May-2011	12-May-2011	1	300	595	16,661	1,417	2,811	40,444	0	0	0	1,717	57,105
13-May-2011	13-May-2011	1	300	595	17,256	1,417	2,811	43,255	0	0	0	1,717	60,511
14-May-2011	14-May-2011	1	300	595	17,851	1,417	2,811	46,066	0	0	0	1,717	63,917
15-May-2011	15-May-2011	1	300	595	18,446	1,417	2,811	48,877	0	0	0	1,717	67,323
16-May-2011	16-May-2011	1	300	595	19,041	1,417	2,811	51,688	0	0	0	1,717	70,729
17-May-2011	17-May-2011	1	300	595	19,636	1,417	2,811	54,499	0	0	0	1,717	74,135
18-May-2011	18-May-2011	1	300	595	20,231	1,417	2,811	57,310	0	0	0	1,717	77,541
19-May-2011	19-May-2011	1	300	595	20,826	1,417	2,811	60,121	0	0	0	1,717	80,947
20-May-2011	20-May-2011	1	300	595	21,421	1,417	2,811	62,931	0	0	0	1,717	84,353
21-May-2011	21-May-2011	1	300	595	22,017	1,417	2,811	65,742	0	0	0	1,717	87,759
22-May-2011	22-May-2011	1	300	595	22,612	1,417	2,811	68,553	0	0	0	1,717	91,165
23-May-2011	23-May-2011	1	300	595	23,207	1,417	2,811	71,364	0	0	0	1,717	94,571
24-May-2011	24-May-2011	1	300	595	23,802	1,417	2,811	74,175	0	0	0	1,717	97,977
25-May-2011	25-May-2011	1	300	595	24,397	1,417	2,811	76,986	0	0	0	1,717	101,383
26-May-2011	26-May-2011	1	300	595	24,992	1,417	2,811	79,797	0	0	0	1,717	104,789
27-May-2011	27-May-2011	1	300	595	25,587	1,417	2,811	82,608	0	0	0	1,717	108,195
28-May-2011	28-May-2011	1	300	595	26,182	1,417	2,811	85,419	0	0	0	1,717	111,601
29-May-2011	29-May-2011	1	300	595	26,777	750	1,488	86,907	0	0	0	1,050	113,683
30-May-2011	30-May-2011	1	300	595	27,372	600	1,190	88,097	0	0	0	900	115,468
31-May-2011	31-May-2011	1	300	595	27,967	450	893	88,989	0	0	0	750	116,956
01-Jun-2011	01-Jun-2011	1	250	496	28,463	300	595	89,584	0	0	0	550	118,047
02-Jun-2011	02-Jun-2011	1	250	496	28,959	150	298	89,882	0	0	0	400	118,840
03-Jun-2011	03-Jun-2011	1	250	496	29,455	0	0	89,882	0	0	0	250	119,336
04-Jun-2011	04-Jun-2011	1	250	496	29,950	0	0	89,882	0	0	0	250	119,832
05-Jun-2011	30-Jun-2011	26	250	12,893	42,843	0	0	89,882	0	0	0	250	132,725
01-Jul-2011	31-Jul-2011	31	250	15,372	58,215	0	0	89,882	0	0	0	250	148,097
01-Aug-2011	31-Aug-2011	31	250	15,372	73,587	0	0	89,882	0	0	0	250	163,468
01-Sep-2011	30-Sep-2011	30	250	14,876	88,463	0	0	89,882	0	0	0	250	178,345
01-Oct-2011	01-Oct-2011	1	300	595	89,058	0	0	89,882	0	0	0	300	178,940
02-Oct-2011	05-Oct-2011	4	300	2,380	91,438	0	0	89,882	0	0	0	300	181,320
06-Oct-2011	08-Oct-2011	3	300	1,785	93,223	800	4,760	94,642	0	0	0	1,100	187,865
09-Oct-2011	09-Oct-2011	1	300	595	93,818	500	992	95,634	0	0	0	800	189,452
10-Oct-2011	10-Oct-2011	1	300	595	94,413	100	198	95,832	0	0	0	400	190,245
11-Oct-2011	31-Oct-2011	21	300	12,496	106,909	0	0	95,832	0	0	0	300	202,741
01-Nov-2011	30-Nov-2011	30	300	17,851	124,760	0	0	95,832	0	0	0	300	220,592
01-Dec-2011	31-Dec-2011	31	300	18,446	143,207	0	0	95,832	0	0	0	300	239,039
01-Jan-2012	31-Jan-2012	31	300	18,446	161,653	0	0	95,832	0	0	0	300	257,485
01-Feb-2012	29-Feb-2012	29	300	17,256	178,909	0	0	95,832	0	0	0	300	274,741
01-Mar-2012	31-Mar-2012	31	300	18,446	197,355	0	0	95,832	0	0	0	300	293,187
01-Apr-2012	14-Apr-2012	14	300	8,331	205,686	0	0	95,832	0	0	0	300	301,518
No. of days		366	(April 15 through April 14)										

1 cfs day = 1.983471 acre-feet (af)

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Attachment -B-

<u>2011 Tuolumne River</u>
<u>Technical Advisory Committee Materials:</u>

- List of 2011 TRTAC Activities/Materials

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

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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
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TECHNICAL ADVISORY COMMITTEE MEETING

March 10, 2011 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 2010 meeting
   - Items since last meeting

3. Monitoring/Reports:
   - Fall run information – weir; river surveys
   - Ongoing monitoring – seine, screw trap, weir (NA)
   - *O. mykiss* Monitoring Summary Report
   - 2010 Tuolumne River *O. mykiss* Acoustic Tracking Report
   - High flow and IFIM studies
   - 2010 annual FERC report

4. Flow Operations:
   - Current watershed conditions, runoff and flow volume forecasts
   - VAMP and potential spring flow schedule(s)

5. Agency/NGO updates

6. Additional items

7. Next meeting Dates – June 9, September 8, December 8

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

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TECHNICAL ADVISORY COMMITTEE MEETING

10 March 2011 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. INTRODUCTION AND ANNOUNCEMENTS

- None

2. ADMINISTRATIVE ITEMS:

- Review/Revise agenda – No changes
- Approve notes from December 2010 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. The list included meeting summaries, notes, and handouts from the December 2010 TRTAC Meeting, and correspondence regarding submittal of the IFIM Study Progress Report to FERC (dated December 9, 2010) and the NOI for one year VAMP extension (dated March 1, 2011). Documents posted to the website include the 2010 rotary screw trap (RST) report, the 2010 *O. mykiss* Acoustic Tracking Report, and the 2010 2010 *O. mykiss* Summary Report.

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

- The 2010 spawning run counts from the Tuolumne River counting weir were reviewed. Due to high flows resulting from early season runoff, spawner surveys and counting weir operations were halted the week of November 30th with a cumulative season total of 766 as of that date. Walt Ward (MID) suggested that the annual escapement graph be footnoted to indicate that the 2010 escapement estimate does not include December. He also asked if the total 2010 spawning run size could be estimated based on the fraction of run sampled (FishBIO estimates that approximately 80% of the run had passed the weir as of November 30th, which would correspond to a season total of just under 1,000 fish). Ward also asked that the graph include the DFG population estimates and weir counts for 2009 and 2010. AJ Keith (Stillwater) indicated that the footnote would be added to the report graphs and tables. Keith indicated he would consult Stillwater's statistical analyst to determine whether a 2010 population estimate could reliably be made. Subsequently, the decision was made to continue to report only the numbers counted. CDFG spawner counts will be updated when they are reported.
- The ongoing RST and seine monitoring was discussed. It was noted that the number of captures at the Grayson RST this year are much greater than in most previous years, likely due to increased survival related to high flows. Meeting participants

agreed that future graphs of RST captures and size distribution should be presented with matching scales on all graphs to facilitate easy visual comparison.

- Keith provided a summary of seine results to date, noting that so far in 2011 there have been juveniles captured in the mainstem San Joaquin River both upstream and downstream of the Tuolumne. Captures upstream of the Tuolumne have been rare in previous years.
- Results of the 2010 *O. mykiss* Monitoring Summary Report and Acoustic Tracking Report were discussed, including observations that all tagged fish remained in the vicinity of where they were initially captured.
- Status of the high flow and IFIM studies were discussed, noting that studies are currently on hold due to high flows.
- A draft Cover Page for the 2010 Annual FERC Report was distributed, and the status of each Technical Report was briefly reviewed. Keith indicated that the 2010 Spawning Survey Report (DFG) and the 2010 Counting Weir Report (FishBIO) were still outstanding, but that all other reports are complete or nearly complete and the Annual Report is on track to be submitted to FERC on time by April 1.
- Other winter monitoring: Winter seining surveys are in progress. Preparations are being made for 2-D site surveys, IFIM surveys, and March 2011 snorkel survey, but cannot take place until flows go down.

4. FLOW OPERATIONS:

- Participants noted that the current water year is classified as above-normal. Reservoirs are currently full and high flows are likely into July.
- No information was available regarding the VAMP flows or potential spring flow schedule.

5. AGENCY/NGO UPDATES

- None

6. ADDITIONAL ITEMS

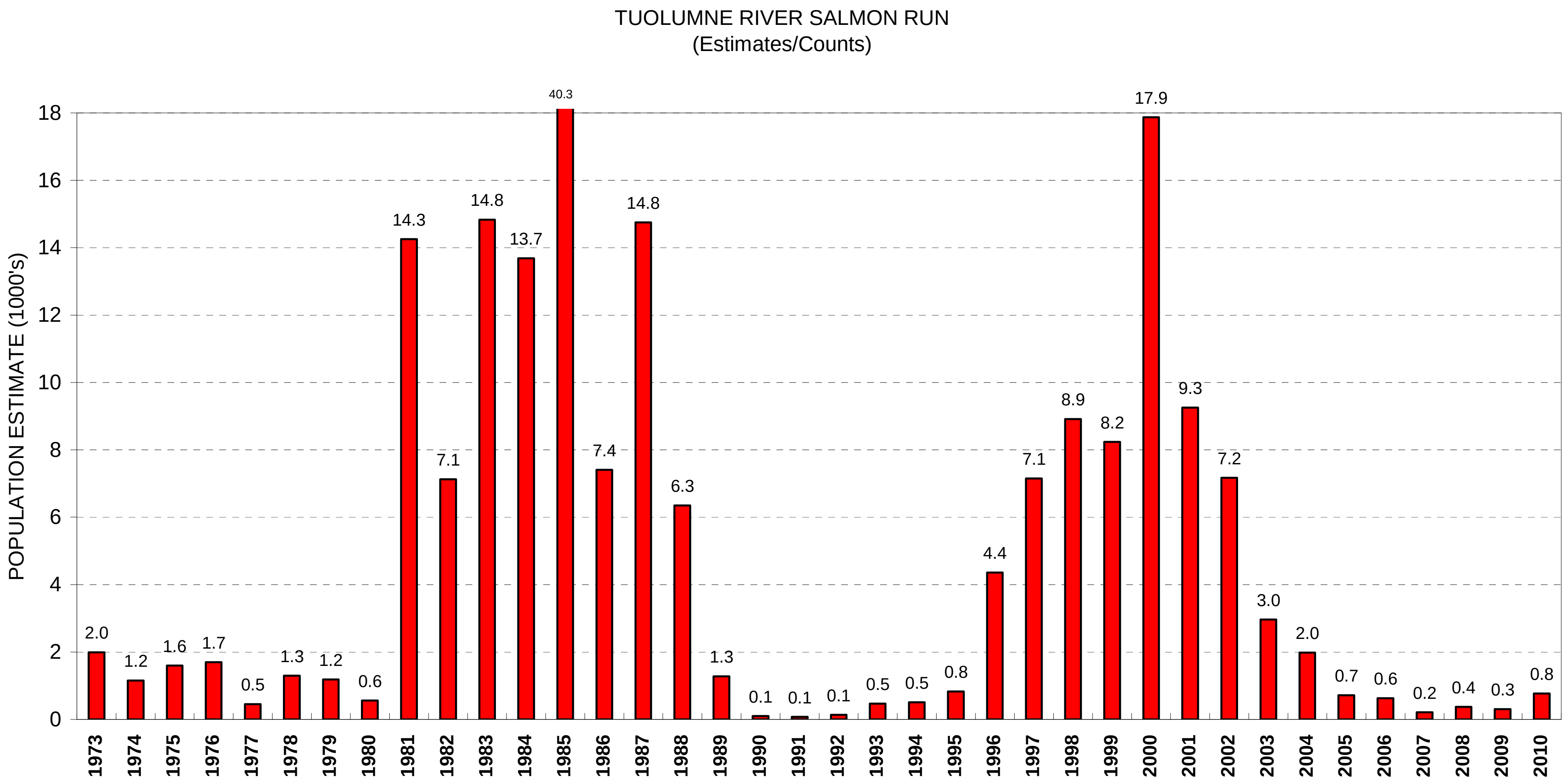
- None

7. NEXT MEETING DATES –

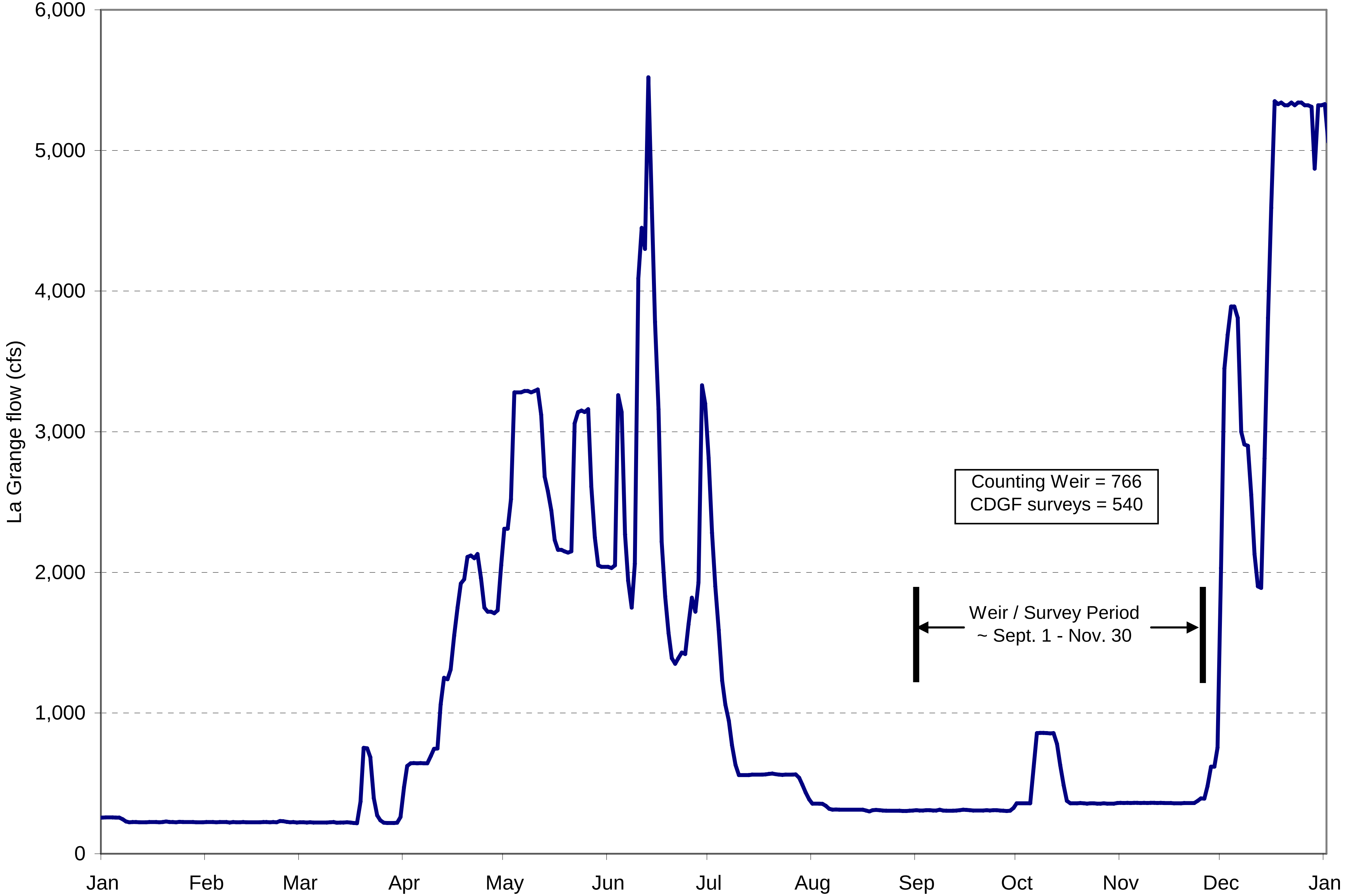
- Remaining 2011 meeting dates: June 9th, September 8th, and December 8th

TRTAC Meeting Attendees

	Name	Organization
1.	Robert Nees	TID
2.	Walter Ward	MID
3.	Roger Masuda	TID
4.	AJ Keith	Stillwater Sciences



Tuolumne River escapements 1973-2010. Years 2009 and 2010 based on Tuolumne River weir counts.



Tuolumne River spawning surveys 2010. Counting weir (FISHBIO) and CDFG surveys (www.calfish.org)

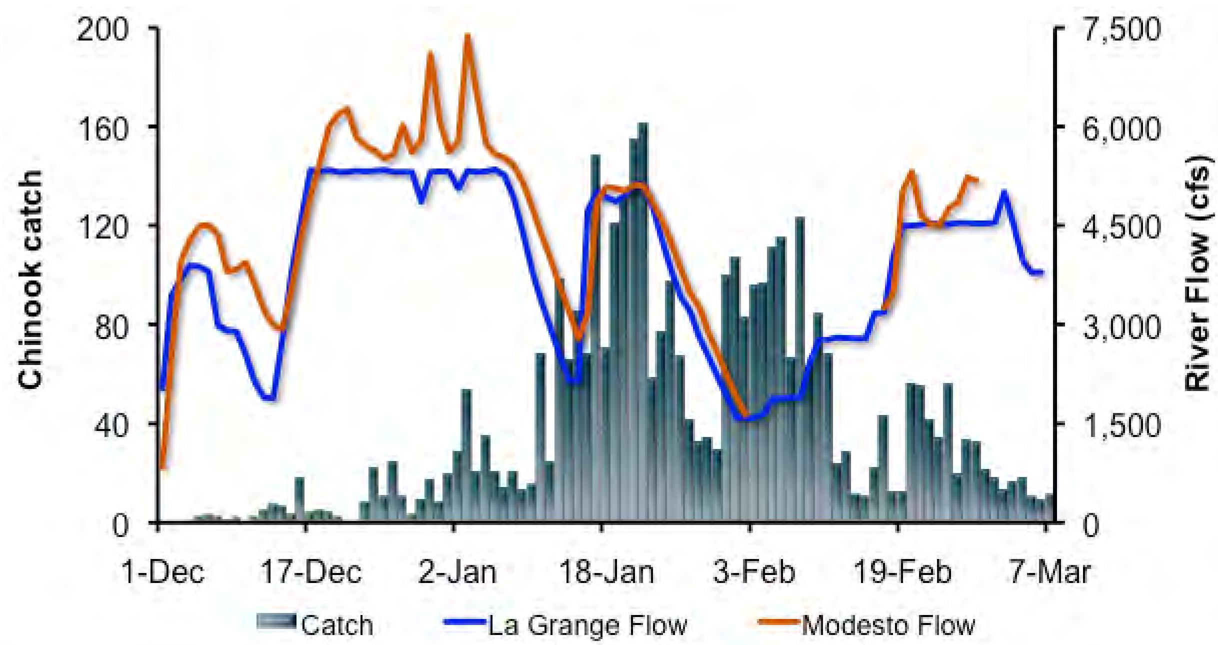


Figure 1. Juvenile Chinook salmon catch at Waterford and Tuolumne River flow at La Grange (LGN) and Modesto (MOD).

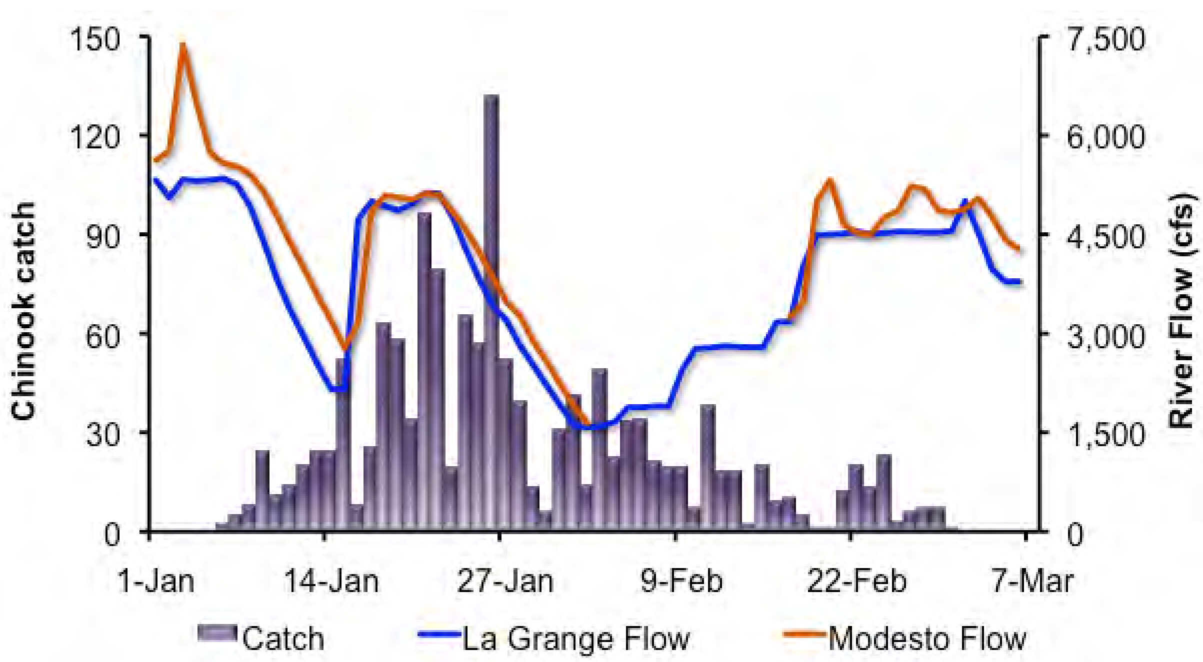


Figure 2. Juvenile Chinook salmon catch at Grayson and Tuolumne River flow at La Grange (LGN) and Modesto (MOD).

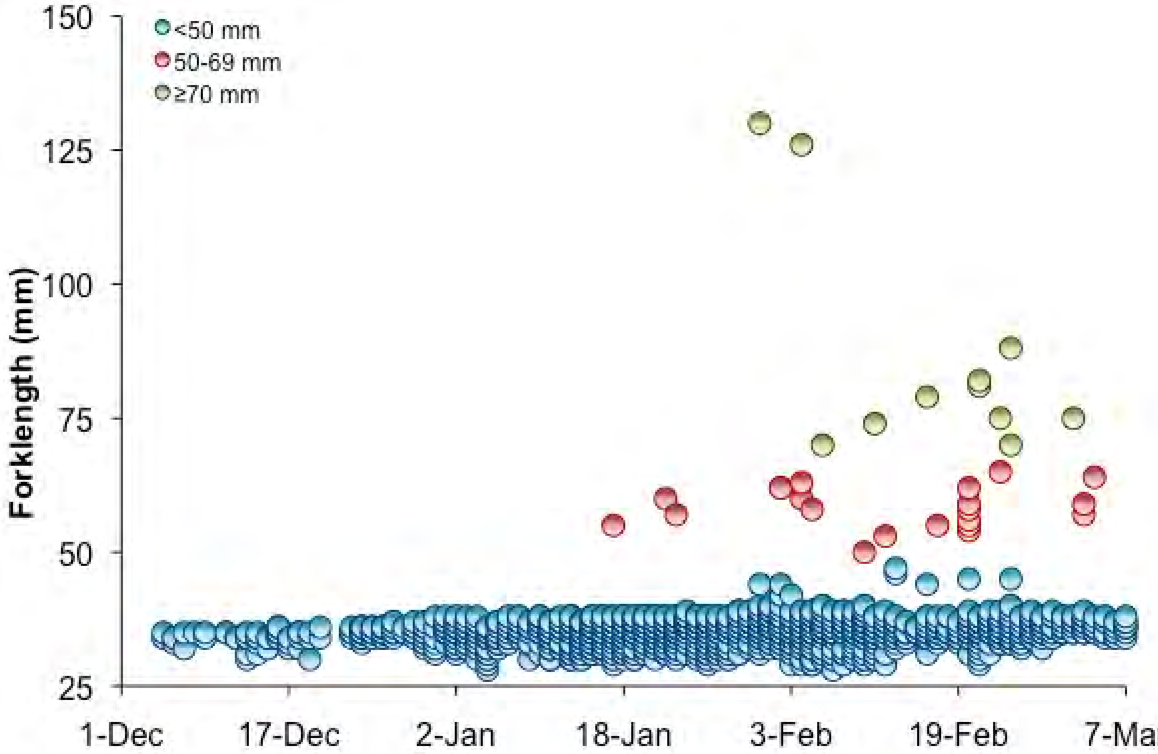


Figure 3. Juvenile Chinook salmon length by lifestage at Waterford.

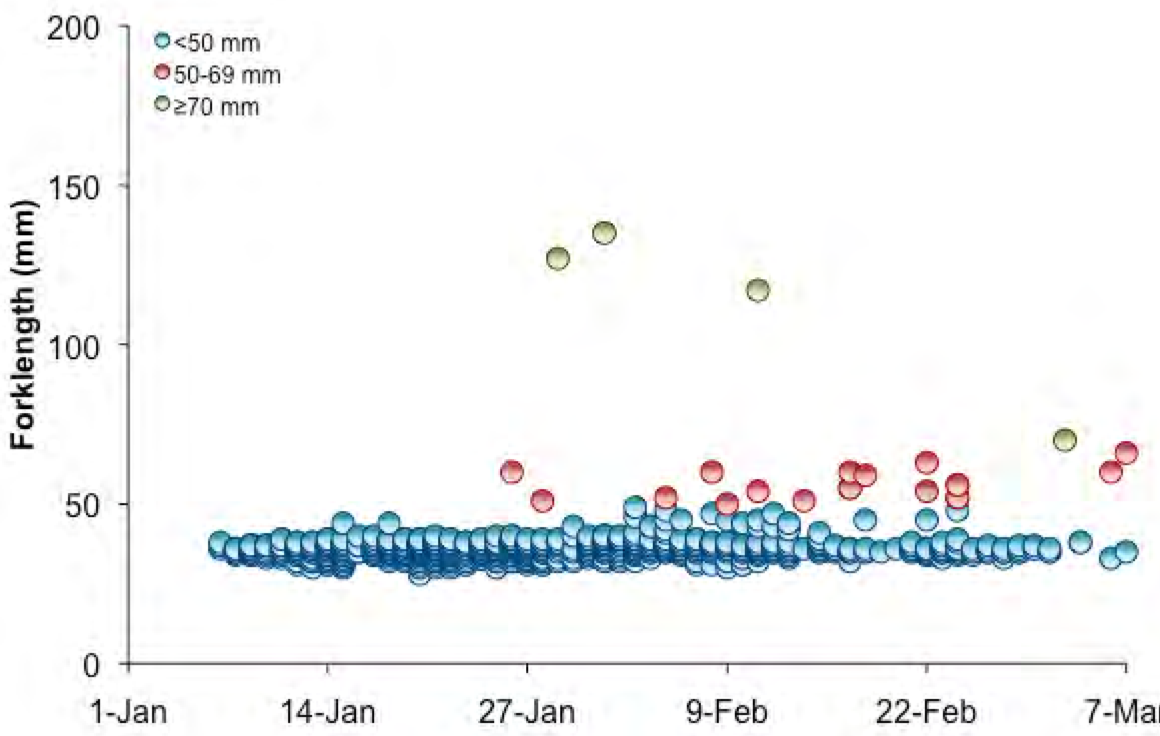


Figure 4. Juvenile Chinook length by lifestage at Grayson.

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

DRAFT COVER

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

2010 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: 2010 Tuolumne River Technical Advisory Committee Materials

Report 2010-1: 2010 Spawning Survey Report

Report 2010-2: Spawning Survey Summary Update

Report 2010-3: 2010 Seine Report and Summary Update

Report 2010-4: 2010 Rotary Screw Trap Report

Report 2010-5: 2010 Snorkel Report and Summary Update

Report 2010-6: 2010 *Oncorhynchus mykiss* Population Estimate Report

Report 2010-7: 2010 *Oncorhynchus mykiss* Acoustic Tracking Report

Report 2010-8: 2010 Counting Weir Report

2011 TRTAC Materials/Postings to Website

2010Dec9-2011Mar10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2010 TRTAC meeting summary and handouts
  - March 2011 TRTAC meeting agenda

- Correspondence
  - Tuolumne River IFIM Study: Progress Report dated December 9, 2010.
  - NOI for one year VAMP Extension, dated March 1, 2011

- Documents
  - 2010 Tuolumne River RST Report
  - 2010 Tuolumne River O. mykiss Acoustic Tracking Report
  - 2010 Tuolumne River 2010 O. mykiss Summary Report

- Data/Monitoring
  - No postings

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TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
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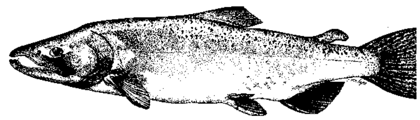

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TECHNICAL ADVISORY COMMITTEE MEETING

June 9, 2011 at 9:30 AM

Turlock Irrigation District, Room 152 (1st floor)

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from March 2011 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Review spring monitoring
   - Planned studies for summer 2011

4. FLOW OPERATIONS:
   - Review spring Tuolumne River flows and forecasted flows
   - Review spring San Joaquin River flows and delta exports

6. AGENCY/NGO UPDATES

7. ADDITIONAL ITEMS

8. NEXT MEETING DATES – SEPTEMBER 8, DECEMBER 8

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
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Turlock, CA 95381-0949
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TECHNICAL ADVISORY COMMITTEE MEETING

June 9, 2011 at 9:30 AM

Turlock Irrigation District, Room 152 (1st floor)

Summary

1. INTRODUCTION AND ANNOUNCEMENTS
    - See attendance below

2. ADMINISTRATIVE ITEMS:
    - Review/revise agenda – No changes
    - Approved notes from March 2011 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 of postings at http://tuolumnerivertac.com/ was reviewed, including:
        - meeting summaries, notes, and handouts from the March 2011 TRTAC meeting
        - correspondence regarding Don Pedro Hydroelectric Project's Scoping Document 1 (dated April 8, 2011), Notice of Intent to file a License Application, Pre Application Document, scoping request for comments etc (Dated April 8, 2011), and the Districts letter to fishery agencies regarding the minimum flow schedule for 2010–2011 (Dated April 12, 2011)
        - documents posted to the website, including the 2010 FERC Annual Report and the Lower Tuolumne River Water Temperature Modeling Study

3. MONITORING/REPORTS:
    - Reviewed the 2011 spring monitoring RST counts and seine data from the Tuolumne River. To date, 4,223 Chinook salmon have been captured at the rotary screw traps at Waterford, and 1,574 have been captured at Grayson. Debbie requested information regarding efficiency tests conducted in 2011, which will be included in the 2011 report.
    - There are potentially five studies planned during 2011:
        1. Instream Flow overbank study – fieldwork ongoing through summer 2011
        2. Instream flow IFIM study – Transect placement complete; fieldwork scheduled for July–September, depending on flows
        3. *O. Mykiss* reference count survey – requires < 300 cfs, planned for September and November.
        4. *O. Mykiss* population estimate surveys – requires < 300 cfs (final year of this study), fieldwork scheduled for July–September, depending on flows.
        5. Instream flow IFIM study habitat suitability surveys for *O. Mykiss* and Chinook salmon, delayed to 2012 due to high flows.

4. FLOW OPERATIONS:
    - Reviewed spring Tuolumne River flows and forecasted flows through summer

  - Flows depend on the weather, but anticipate ~ 4,600 cfs into mid July.
  - Low irrigation demand this spring due to wet weather conditions
  - Walt Ward mentioned a recent canal spill
- Reviewed spring San Joaquin River flows and delta exports
  - Basin flows and delta CVP/SWP exports graphs were reviewed. Vernalis flows during VAMP were high, but so were exports. It appears that DWR went with the 1:1 ratio for pumping, which resulted in large fish takes.

5. AGENCY/NGO UPDATES
- None

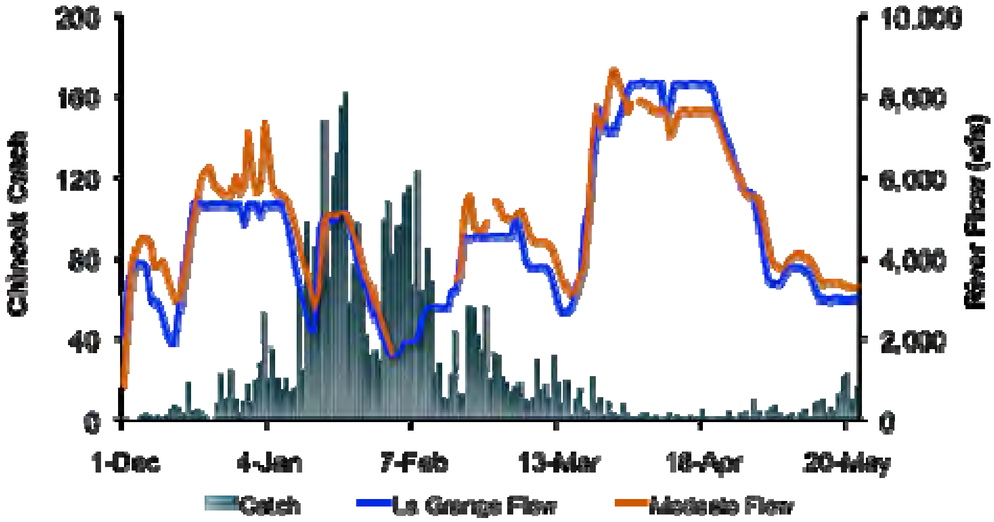
6. ADDITIONAL ITEMS
- Debbie suggested that we may want to move the September meeting to October, when more of the studies will have been completed. No decision was made.

7. NEXT MEETING DATES – SEPTEMBER 8, DECEMBER 8

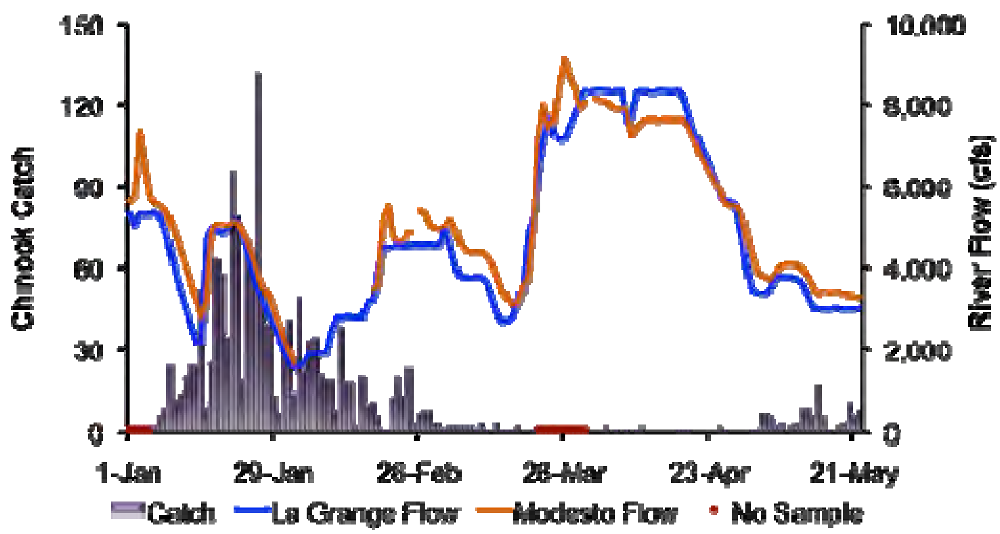
TRTAC Meeting Attendees

	Name	**Organization**
1.	Debbie Liebersbach	TID
2.	Walter Ward	MID
3.	Steve Boyd	TID
4.	Russ Liebig	Stillwater Sciences
5.	Rodger Masuda	TID

Lower Tuolumne River RST data for 2011



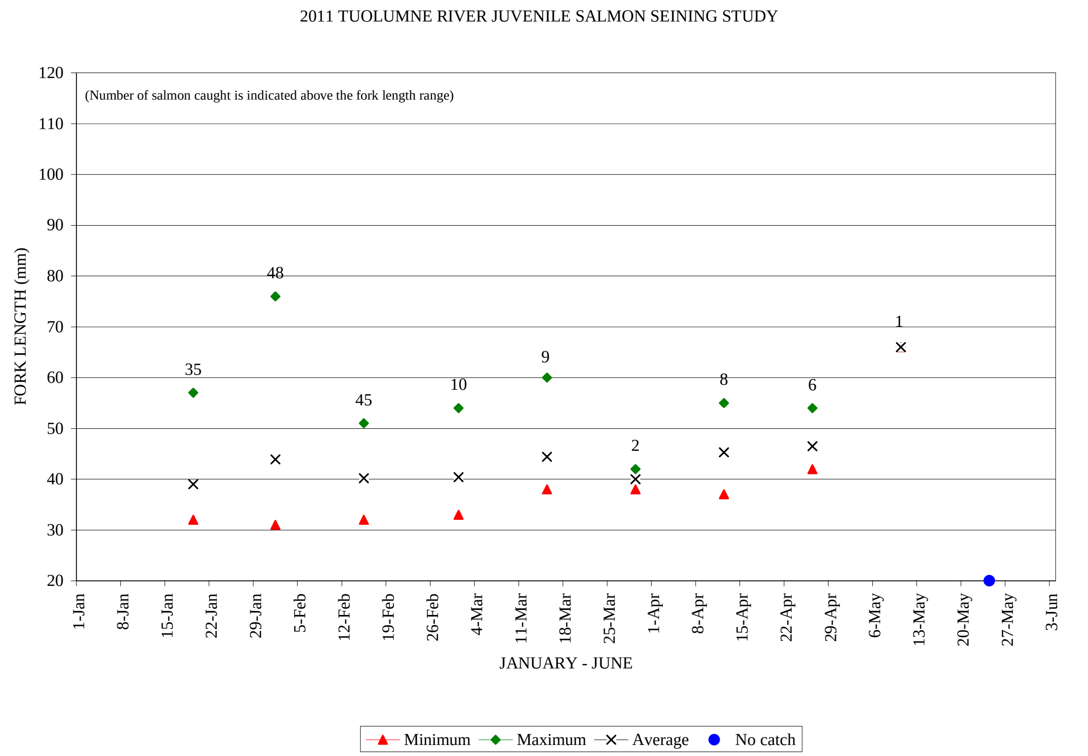
Daily Chinook salmon catch at Waterford, and Tuolumne River flow recorded at La Grange (LGN) and Modesto (MOD) between December 1, 2010, and May 22, 2011. Season total = 4,223 captures.

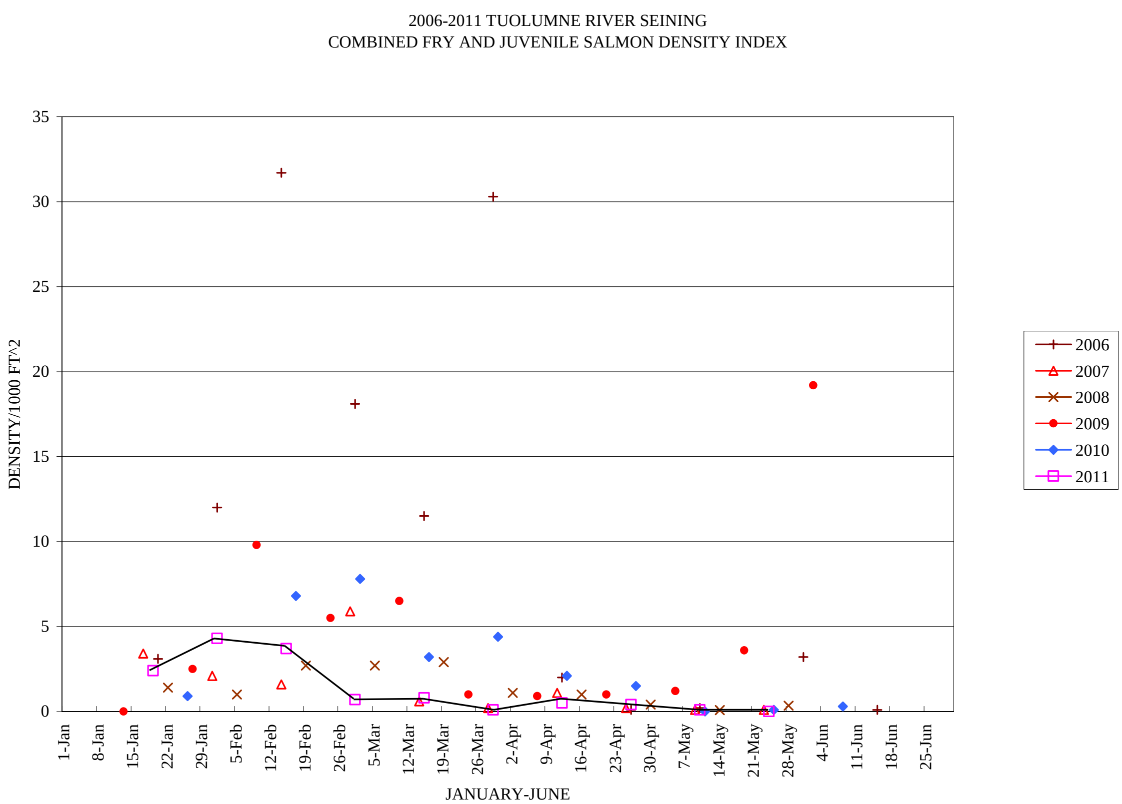


Daily Chinook salmon catch at Grayson, and Tuolumne River flow recorded at La Grange (LGN) and Modesto (MOD) between January 1 and May 22, 2011. Season total = 1,574 captures.

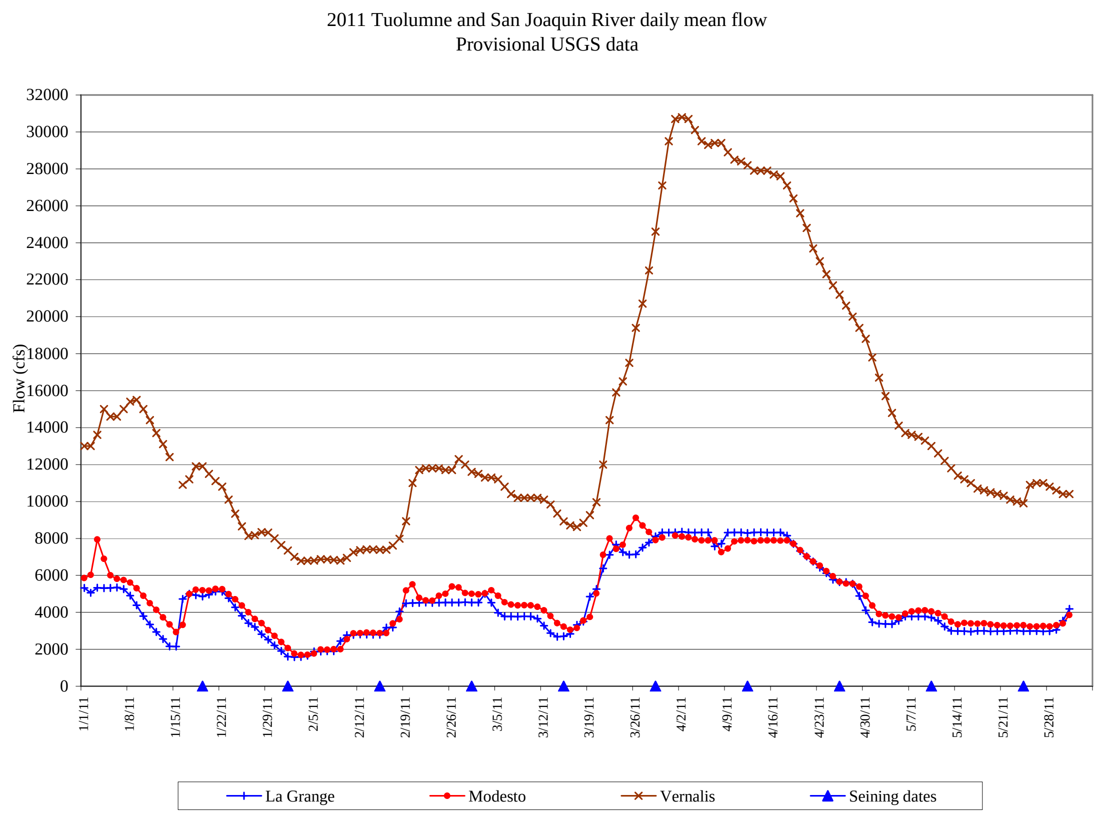
Source: San Joaquin Basin Newsletter, Volume 2010/11, Issue 14 (FISHBIO)

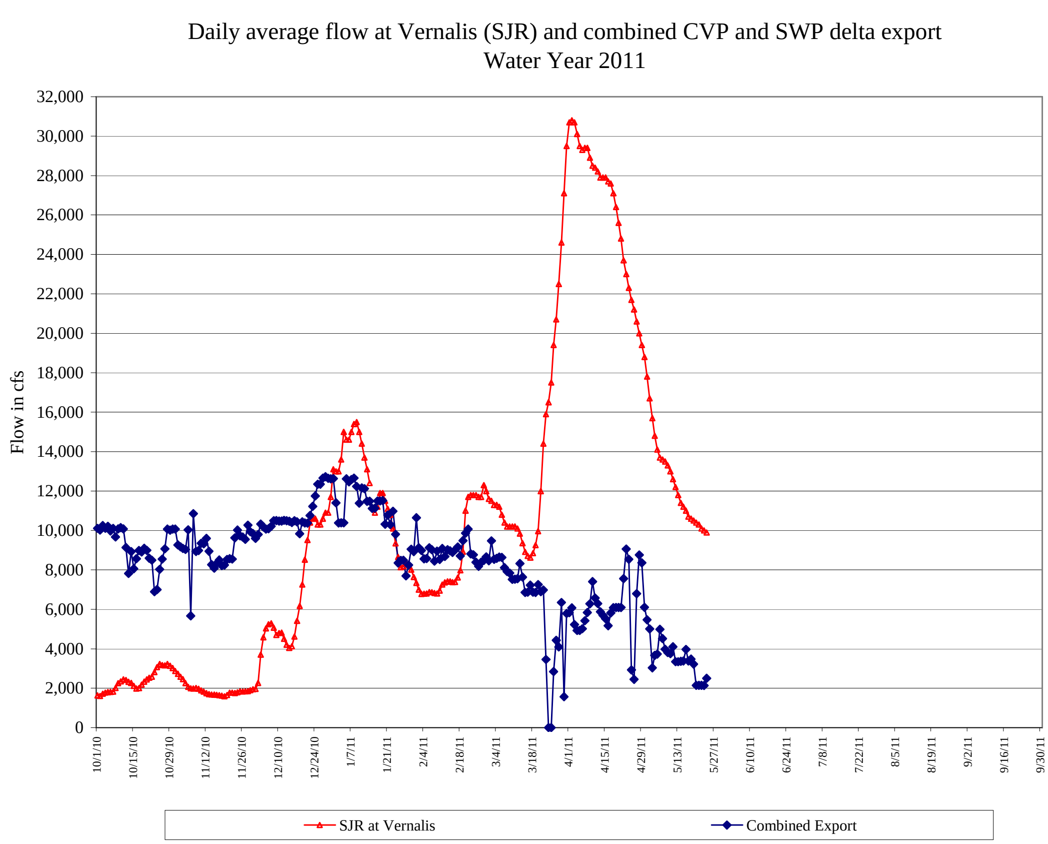
Lower Tuolumne River seine data for 2011





Tuolumne and San Joaquin River flow and delta export to date, WY 2011





2011 TRTAC Materials/Postings to Website

2010Dec9-2011Mar10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2010 TRTAC meeting summary and handouts
  - March 2011 TRTAC meeting agenda

- Correspondence
  - Tuolumne River IFIM Study: Progress Report dated December 9, 2010.
  - NOI for one year VAMP Extension, dated March 1, 2011

- Documents
  - 2010 Tuolumne River RST Report
  - 2010 Tuolumne River O. mykiss Acoustic Tracking Report
  - 2010 Tuolumne River 2010 O. mykiss Summary Report

- Data/Monitoring
  - No postings

2011Mar10-2011June9 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2011 TRTAC meeting summary and handouts
  - June 2011 TRTAC meeting agenda

- Correspondence
  - FERC; Scoping Document 1 for the Don Pedro Hydroelectric Project, P-2299. Dated April 8, 2011.
  - FERC; Notice of intent to file license application, filing of pre-application document, commencement of pre-filing process, and scoping, request for comments etc re Turlock & Modesto Irrigation Districts Don Pedro Hydroelectric Project under P-2299. Dated April 8, 2011.
  - Districts' letter to fishery agencies re: minimum flow schedule for 2010-2011 dated April 12, 2011.

- Documents
  - 2010 FERC Annual Report
  - Lower Tuolumne River Water Temperature Modeling Study

- Data/Monitoring
  - 2011 seine data
  - Basin monitoring newsletter (includes 2011 screw trap monitoring)

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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) 883-8255
Fax: (209) 656-2180

TECHNICAL ADVISORY COMMITTEE MEETING

8 September 2011 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 2011 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Discuss Summer 2011 IFIM monitoring
   - Discuss fall monitoring and in-progress FERC studies
   - Planned annual FERC report progress

4. FLOW OPERATIONS:
   - Review status of final basin index, annual fish flow volume, and flow schedule
   - Review summer flow operation

5. AGENCY/NGO UPDATES

6. ADDITIONAL ITEMS

7. NEXT MEETINGS – QUARTERLY ON 2ND THURSDAY: DECEMBER 8; MARCH 8, 2011

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
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TECHNICAL ADVISORY COMMITTEE MEETING

8 September 2011 at 9:30 AM
Turlock Irrigation District, Room 152

Summary

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/Revise agenda – No changes
   - Approve notes from September 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 listing the material posted at http://tuolumnerivertac.com/ was reviewed. Those included the Districts' ILP Proposed Study Plan and FERC Scoping Document No. 2 for the Don Pedro Relicensing, correspondences regarding a flow variance request for the planned low flow surveys as part of the ongoing IFIM studies, IFIM Progress Report No.2, correspondence regarding a schedule extension of the ongoing IFIM studies to April 2013, and updates of the basin monitoring newsletter.

3. MONITORING/REPORTS: Handouts were reviewed
   - Mid-flow IFIM surveys of 600 cfs were completed the week of July 26, 2011
   - Planning for low flow IFIM surveys (250 cfs) as well as retrieval of stage recorders for high flow (overbank) surveys were planned for late September.
   - FISHBIO to resume counting weir operations by September 16, 2011.

4. FLOW OPERATIONS:
   - Reviewed final SJ Basin Index of 5.1 MAF which corresponds to a Wet Water Year Type with a FERC Flow volume of 300,923 AF. A 5-day pulse flow at 800 cfs is planned for October 10–14, 2011. This will be added to the 300 cfs base flow for a total of 1,100 cfs for the period.
   - No summer operations related to temperature control were carried out in 2011 due to high flows and cool air temperatures throughout the Central Valley.

5. AGENCY/NGO UPDATES
   - None

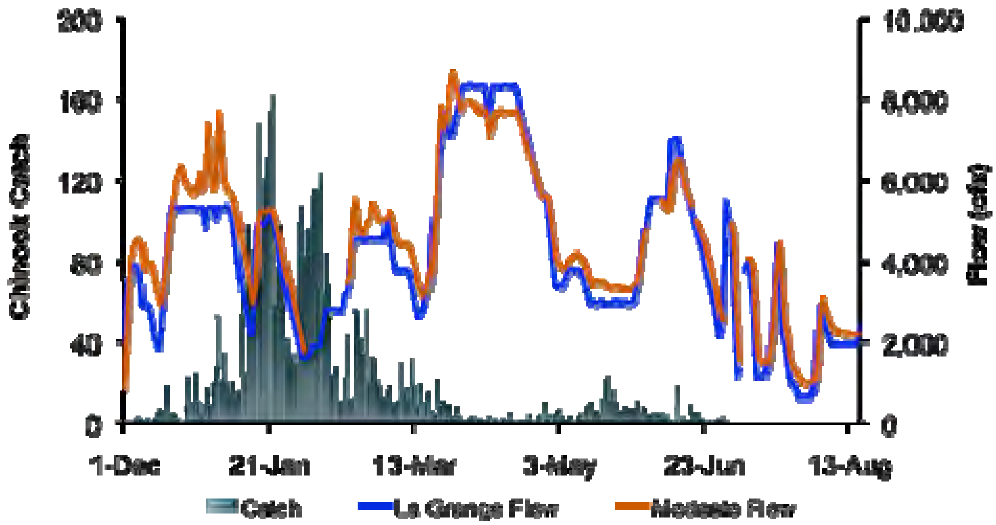
6. ADDITIONAL ITEMS
   - None.

7. NEXT MTG DATES – QUARTERLY ON 2ND THURSDAY: DECEMBER 8, MARCH 8, 2012

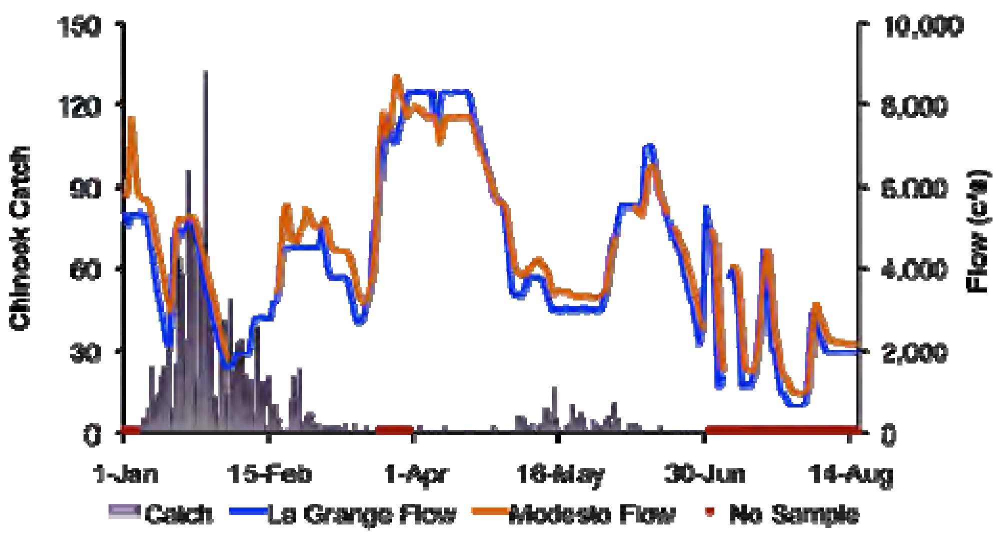
TRTAC Meeting Attendees

	Name	Organization
1.	Walter Ward	MID
2.	Robert Nees	TID
3.	Roger Masuda	TID
4.	Noah Hume	Stillwater

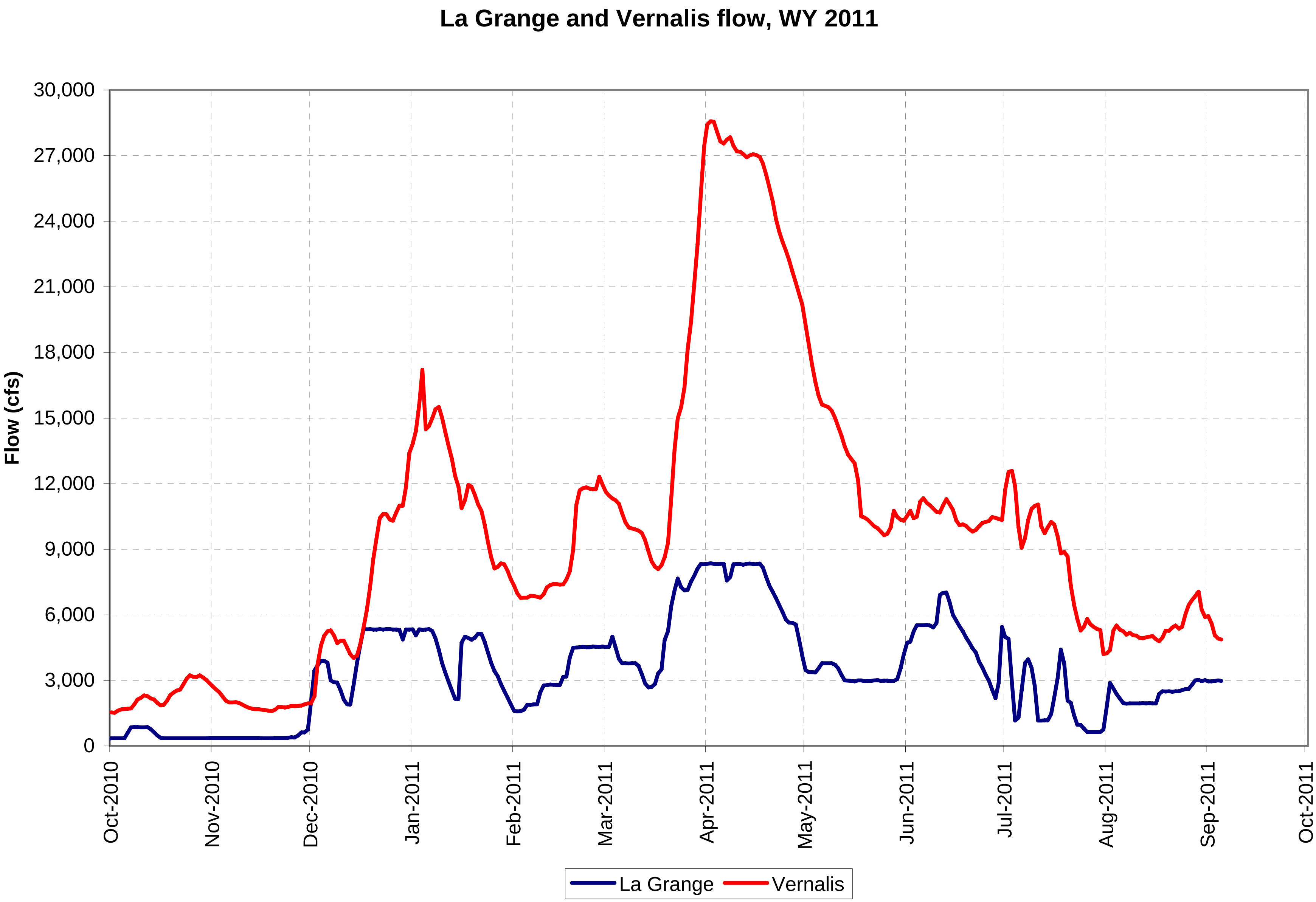
Tuolumne River rotary screw trap data, 2010-2011



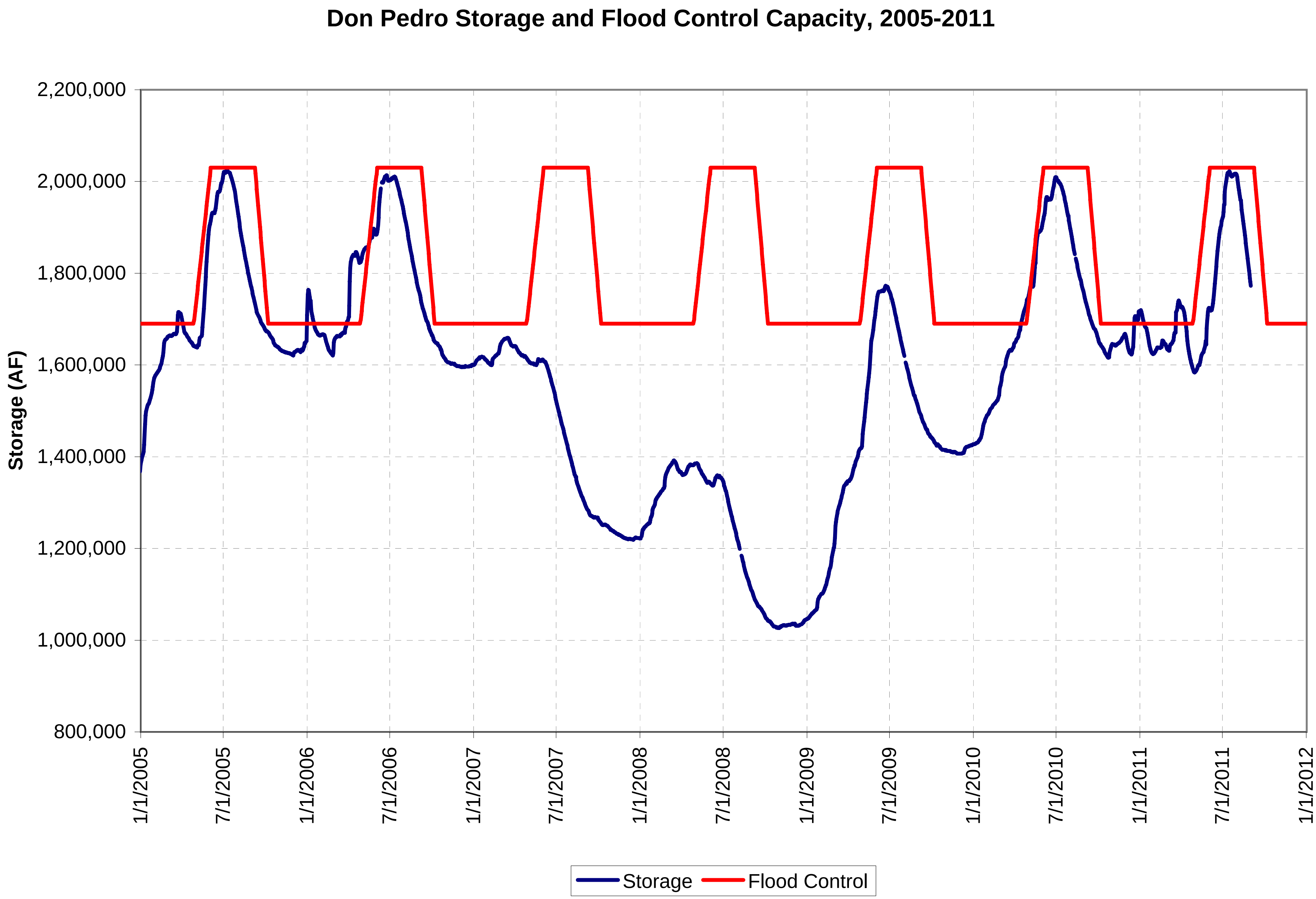
Daily Chinook salmon catch at Waterford, and Tuolumne River flow recorded at La Grange (LGN) and Modesto (MOD) between December 1, 2010, and August 16, 2011. [FISHBIO]



Daily Chinook salmon catch at Grayson, and Tuolumne River flow recorded at La Grange (LGN) and Modesto (MOD) between January 1 and August 16, 2011. [FISHBIO]



La Grange and Vernalis flow, WY 2011
Flow (cfs)
30,000
27,000
24,000
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
Oct-2010
Nov-2010
Dec-2010
Jan-2011
Feb-2011
Mar-2011
Apr-2011
May-2011
Jun-2011
Jul-2011
Aug-2011
Sep-2011
Oct-2011
La Grange
Vernalis


Don Pedro Storage and Flood Control Capacity, 2005-2011
Storage (AF)
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
1/1/2005
7/1/2005
1/1/2006
7/1/2006
1/1/2007
7/1/2007
1/1/2008
7/1/2008
1/1/2009
7/1/2009
1/1/2010
7/1/2010
1/1/2011
7/1/2011
1/1/2012
Storage
Flood Control

	Minimum Flow and Study Requirements		Pre Flood		Total River Flow	
Date	Minimum Flow	Accumulation	CFS	AF Accum	CFS	AF Accum
8/15/2011	250	496	2,310	4,582	2,560	5,077
8/16/2011	250	992	2,310	9,163	2,560	10,155
8/17/2011	250	1,488	2,310	13,745	2,560	15,232
8/18/2011	250	1,983	2,310	18,326	2,560	20,310
8/19/2011	250	2,479	2,310	22,908	2,560	25,387
8/20/2011	250	2,975	2,310	27,489	2,560	30,464
8/21/2011	250	3,471	2,310	32,071	2,560	35,542
8/22/2011	250	3,967	2,310	36,652	2,560	40,619
8/23/2011	250	4,463	2,310	41,234	2,560	45,697
8/24/2011	250	4,959	2,310	45,815	2,560	50,774
8/25/2011	250	5,455	2,310	50,397	2,560	55,851
8/26/2011	250	5,950	2,310	54,978	2,560	60,929
8/27/2011	250	6,446	2,310	59,560	2,560	66,006
8/28/2011	250	6,942	2,310	64,141	2,560	71,084
8/29/2011	250	7,438	2,310	68,723	2,560	76,161
8/30/2011	250	7,934	2,310	73,305	2,560	81,238
8/31/2011	250	8,430	2,310	77,886	2,560	86,316
9/1/2011	250	8,926	2,310	82,468	2,560	91,393
9/2/2011	250	9,421	2,310	87,049	2,560	96,471
9/3/2011	250	9,917	2,310	91,631	2,560	101,548
9/4/2011	250	10,413	2,310	96,212	2,560	106,625
9/5/2011	250	10,909	2,310	100,794	2,560	111,703
9/6/2011	250	11,405	2,310	105,375	2,560	116,780
9/7/2011	250	11,901	2000	109,342	2,250	121,243
9/8/2011	250	12,397	1660	112,635	1,910	125,031
9/9/2011	250	12,893	1360	115,332	1,610	128,225
9/10/2011	250	13,388	1100	117,514	1,350	130,903
9/11/2011	250	13,884	880	119,260	1,130	133,144
9/12/2011	250	14,380	700	120,648	950	135,028
9/13/2011	250	14,876	560	121,759	810	136,635
9/14/2011	250	15,372	430	122,612	680	137,983
9/15/2011	250	15,868	325	123,256	575	139,124
9/16/2011	250	16,364	0	123,256	250	139,620
9/17/2011	250	16,860	0	123,256	250	140,116
9/18/2011	250	17,355	0	123,256	250	140,612
9/19/2011	250	17,851	0	123,256	250	141,107
9/20/2011	250	18,347	0	123,256	250	141,603
9/21/2011	250	18,843	0	123,256	250	142,099
9/22/2011	250	19,339	0	123,256	250	142,595
9/23/2011	250	19,835	0	123,256	250	143,091
9/24/2011	250	20,331	0	123,256	250	143,587
9/25/2011	250	20,826	0	123,256	250	144,083
9/26/2011	250	21,322	0	123,256	250	144,579
9/27/2011	250	21,818	0	123,256	250	145,074
9/28/2011	250	22,314	0	123,256	250	145,570
9/29/2011	250	22,810	0	123,256	250	146,066
9/30/2011	250	23,306	0	123,256	250	146,562
10/1/2011	300	23,901	900	125,041	1,200	148,942
10/2/2011	300	24,496	900	126,826	1,200	151,322
10/3/2011	300	25,091	900	128,612	1,200	153,702
10/4/2011	300	25,686	900	130,397	1,200	156,083
10/5/2011	300	26,281	900	132,182	1,200	158,463
10/6/2011	1100	28,463	100	132,380	1,200	160,843
10/7/2011	1100	30,645	100	132,579	1,200	163,223
10/8/2011	1100	32,826	100	132,777	1,200	165,603
10/9/2011	800	34,413	400	133,570	1,200	167,983
10/10/2011	400	35,207	800	135,157	1,200	170,364
10/11/2011	300	35,802	900	136,942	1,200	172,744
10/12/2011	300	36,397	700	138,331	1,000	174,727
10/13/2011	300	36,992	560	139,441	860	176,433
10/14/2011	300	37,587	430	140,294	730	177,881
10/15/2011	300	38,182	325	140,939	625	179,121
10/16/2011	300	38,777	0	140,939	300	179,716
10/17/2011	300	39,372	0	140,939	300	180,311
10/18/2011	300	39,967	0	140,939	300	180,906
10/19/2011	300	40,562	0	140,939	300	181,501
10/20/2011	300	41,157	0	140,939	300	182,096
10/21/2011	300	41,752	0	140,939	300	182,691
10/22/2011	300	42,347	0	140,939	300	183,286
10/23/2011	300	42,942	0	140,939	300	183,881
10/24/2011	300	43,537	0	140,939	300	184,476
10/25/2011	300	44,132	0	140,939	300	185,071

2011 TRTAC Materials/Postings to Website

2010Dec9-2011Mar10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2010 TRTAC meeting summary and handouts
  - March 2011 TRTAC meeting agenda

- Correspondence
  - Tuolumne River IFIM Study: Progress Report dated December 9, 2010.
  - NOI for one year VAMP Extension, dated March 1, 2011

- Documents
  - 2010 Tuolumne River RST Report
  - 2010 Tuolumne River O. mykiss Acoustic Tracking Report
  - 2010 Tuolumne River 2010 O. mykiss Summary Report

- Data/Monitoring
  - No postings

2011Mar10-2011June9 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2011 TRTAC meeting summary and handouts
  - June 2011 TRTAC meeting agenda

- Correspondence
  - FERC; Scoping Document 1 for the Don Pedro Hydroelectric Project, P-2299. Dated April 8, 2011.
  - FERC; Notice of intent to file license application, filing of pre-application document, commencement of pre-filing process, and scoping, request for comments etc re Turlock & Modesto Irrigation Districts Don Pedro Hydroelectric Project under P-2299. Dated April 8, 2011.
  - Districts' letter to fishery agencies re: minimum flow schedule for 2010-2011 dated April 12, 2011.

- Documents
  - 2010 FERC Annual Report
  - Lower Tuolumne River Water Temperature Modeling Study

- Data/Monitoring
  - 2011 seine data
  - Basin monitoring newsletter (includes 2011 screw trap monitoring)

2011Jun10-2011September7 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
    - February 3, 2011 IFIM Habitat Suitability Criteria (HSC) workshop summary
    - June 2011 TRTAC meeting summary and handouts
    - September 2011 TRTAC meeting agenda

- Correspondence
    - Stillwater Sciences - Letter to Fishery Agency representatives regarding Flow Variance Request related to ongoing Instream Flow Study, dated June 17, 2011
    - FERC - Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 25, 2011.
    - Districts - ILP Proposed Study Plan for the Don Pedro Hydroelectric Project under P-2299-075. Submitted to FERC, July 25, 2011
    - FERC - Letter of Clarification regarding Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 29, 2011
    - NMFS, e-mail reply to Noah Hume, Stillwater Sciences regarding Flow Variance Request, dated June 30, 2011
    - CDFG, e-mail reply to Noah Hume, Stillwater Sciences regarding Flow Variance Request, dated July 21, 2011
    - Districts, Instream Flow Study Progress Report No. 2 and Flow Variance Request submitted to FERC under P-2299, dated July 29, 2011
    - NMFS; Letter to FERC regarding Flow Variance request under P-2299-075, dated August 10, 2011
    - Stillwater Sciences - Letter to Fishery Agency representatives regarding extension of ongoing Instream Flow Study, dated August 15, 2011
    - FERC; Letter acknowledging Turlock Irrigation District's et al Instream Flow Study Progress Report and Flow Variance request under P-2299-075, dated August 18, 2011

- Documents
    - ILP Proposed Study Plan for the Don Pedro Hydroelectric Project under P-2299-075. Submitted to FERC, July 25, 2011
    - Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 25, 2011

- Data/Monitoring
    - None

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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
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Phone: (209) 883-8214
Fax: (209) 656-2180
Email: rmnees@TID.org

TECHNICAL ADVISORY COMMITTEE MEETING

8 December 2011 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 2011 meeting
    - Items since last meeting

3. MONITORING/REPORTS:
    - Fall run information – weir; river surveys
    - Draft O. mykiss report posted
    - Other technical reports for 2011 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 – QUARTERLY ON 2ND THURSDAY: MARCH 8, JUNE 14, 2012

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
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TECHNICAL ADVISORY COMMITTEE MEETING

8 December 2011 at 9:30 AM

Turlock Irrigation District, Room 152

Summary

1. INTRODUCTION AND ANNOUNCEMENTS

- Participants made self introductions.
- There was a brief discussion regarding the Revised Study Plan filed with FERC for the ongoing relicensing for the Don Pedro Project. For further updates on the relicensing process, please visit: http://www.donpedro-relicensing.com/default.htm.

2. ADMINISTRATIVE ITEMS:

- Review/Revise agenda – No changes
- Approve notes from September 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. The list included meeting summaries and notes from the September TRTAC Meeting, correspondences regarding schedule extension of the ongoing FERC IFIM study, submittal of the Districts ILP Study Plan, NMFS submission of supplemental information to FERC, and updates to the 2011 Flow Schedule. Documents include the Draft 2011 *O. mykiss* monitoring report, the ILP Revised and Updated Study Plans for the Don Pedro Project Relicensing.

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

- Preliminary run estimates and fish passage on the Tuolumne and Stanislaus River counting weirs were reviewed. Tuolumne River weir counts were 2,673 as of December 4th. There was some discussion regarding hatchery releases and the higher proportion of hatchery fin-clipped fish, as well as a higher proportion of 2-year old fish in the current run which would lead to lower spawning activity than the weir counts indicate. Weir operations will continue into April 2012 unless flood control releases in excess of 1,300 cfs necessitate removal.
- Results of the 2011 *O. mykiss* population estimate and monitoring summary reports were discussed, including observations of larger numbers of fish during the late September snorkel surveys.
- Technical Reports for 2011 FERC Report were distributed as a draft Table of Contents, with a number of reports available on the TRTAC website (seine, snorkel, RST, September 2010 Population estimate, and Tracking Study Yr 2 report).
- Other winter monitoring plans: Ongoing weir operations, redd-mapping, seining surveys, rotary screw trap operations, and project relicensing studies are planned fror

winter and spring 2012.

4. FLOW OPERATIONS:

- High flows in the Tuolumne River during winter through summer 2011 were discussed. Current Tuolumne River flows are approximately 300 cfs to the lower river. The MID canal is currently out of service for winter maintenance.

5. AGENCY/NGO UPDATES

- Tuolumne River Coalition: Dave Boucher provided a written summary of site construction at Bobcat Flat (RM 43) during summer 2011. In addition to floodplain lowering, appproximately 19,000 cubic yards of coarse sediment was placed in the channel, including replenishment of one existing riffle, creation of three additional riffles as well as the placement of four new alternating point bars to serve as sediment recruitment sources as well as high velocity refuge for rearing salmonids. Although high flows limited access to the channel, construction was completed as planned.

6. ADDITIONAL ITEMS

- None

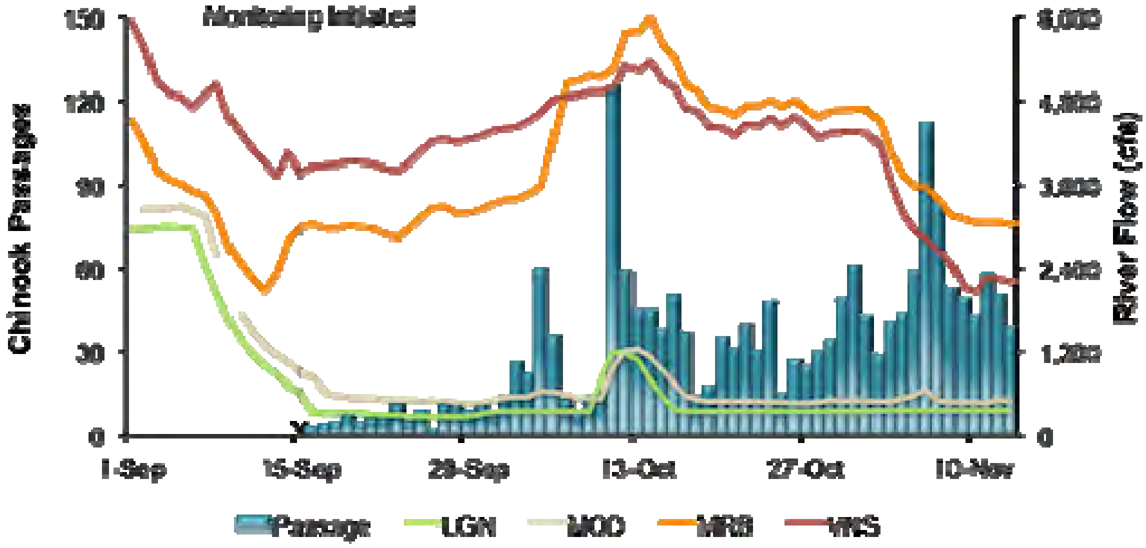
7. NEXT MEETING DATES – (*Quarterly on 2nd Thursday at 9:30am*)

- 2012 meeting dates: March 8th, June 14th, September 13th, and December 13th

TRTAC Meeting Attendees

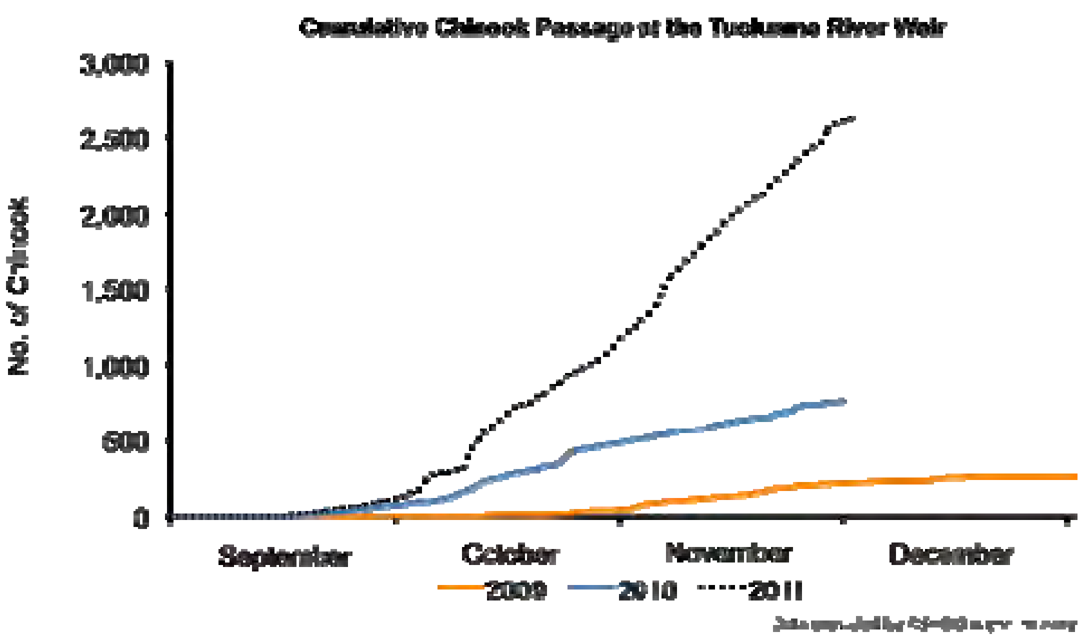
	Name	Organization
1.	Robert Nees	TID
2.	Walter Ward (phone)	MID
3.	Steve Boyd	TID
4.	Andrea Fuller	FISHBIO
5.	Noah Hume	Stillwater
6.	Roger Masuda (phone)	TID

PRELIMINARY RESULTS

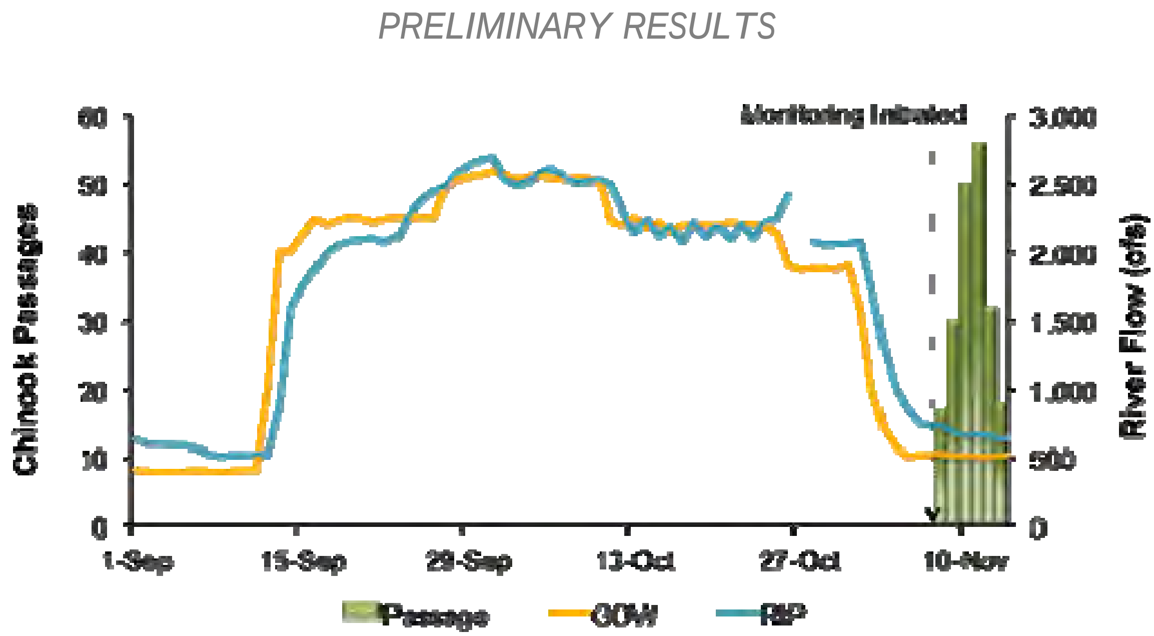


2011 Lower Tuolumne River Chinook Passage

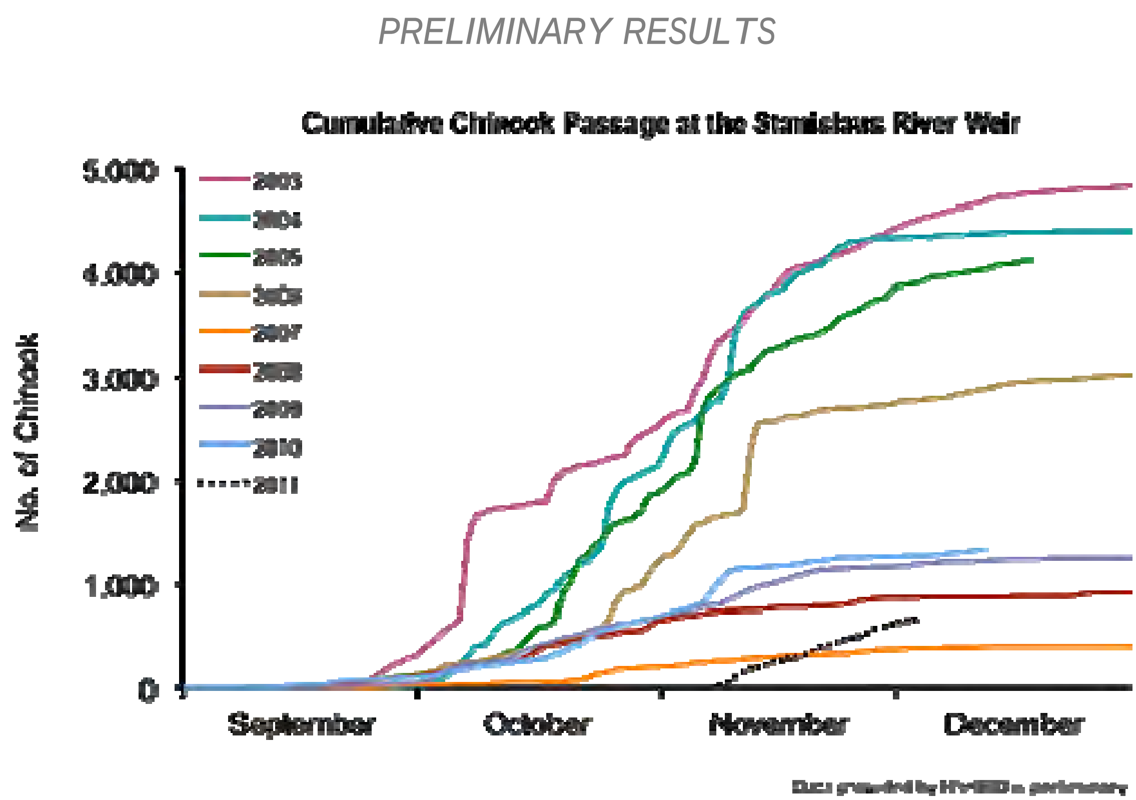
PRELIMINARY RESULTS



2009-2011 Lower Tuolumne River Chinook Passage through 12/4



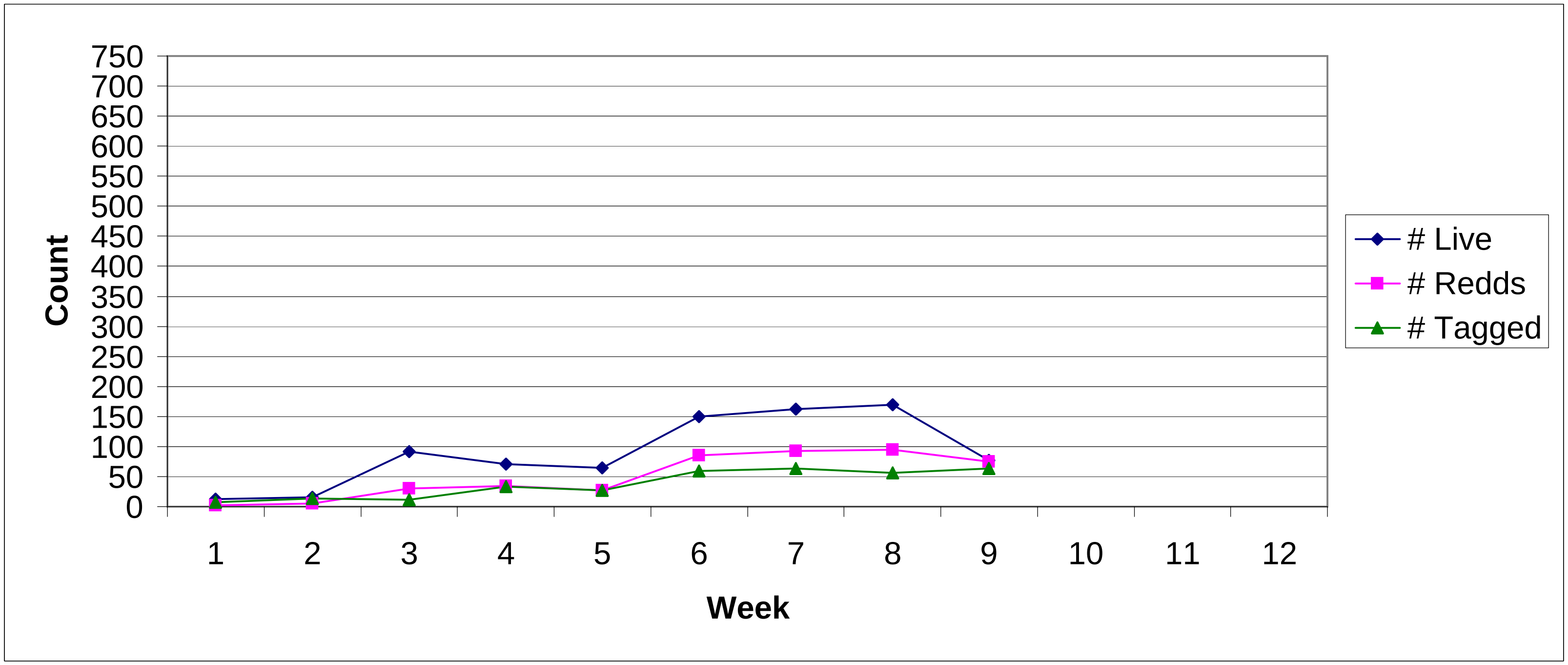
2010 Stanislaus River Chinook Passage



2003-2011 Stanislaus River Chinook Passage through 12/4

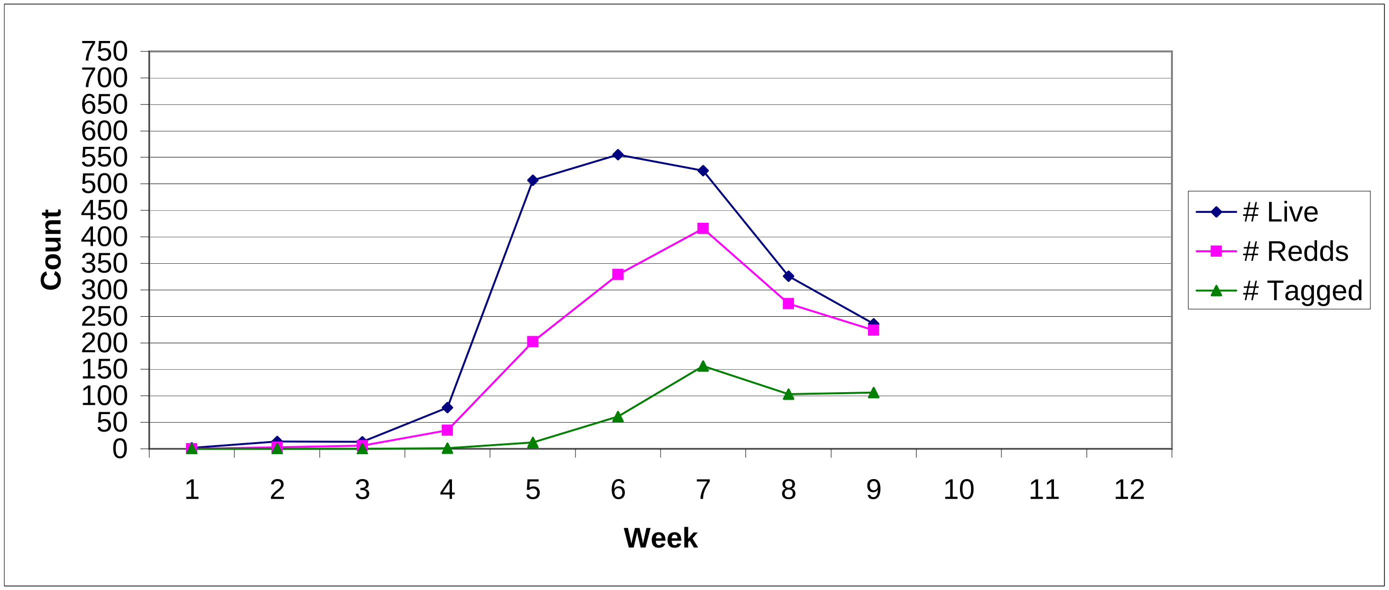
Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	CDEC station LGN Average Flow (cfs)	Comments
1	3-Oct-2011	12	2	1	7	3	7	0	343	
2	10-Oct-2011	16	5	1	14	8	14	3	1020	
3	17-Oct-2011	92	30	0	11	4	11	9	340	
4	24-Oct-2011	71	34	11	33	6	33	11	340	
5	31-Oct-2011	65	27	13	27	10	27	24	340	
6	7-Nov-2011	150	85	15	59	13	59	24	340	
7	14-Nov-2011	162	93	12	63	27	63	34	350	
8	21-Nov-2011	170	95	20	56	25	56	67	355	
9	28-Nov-2011	77	75	8	63	51	63	58	365	
10	5-Dec-2011									
11	12-Dec-2011									
12	19-Dec-2011									



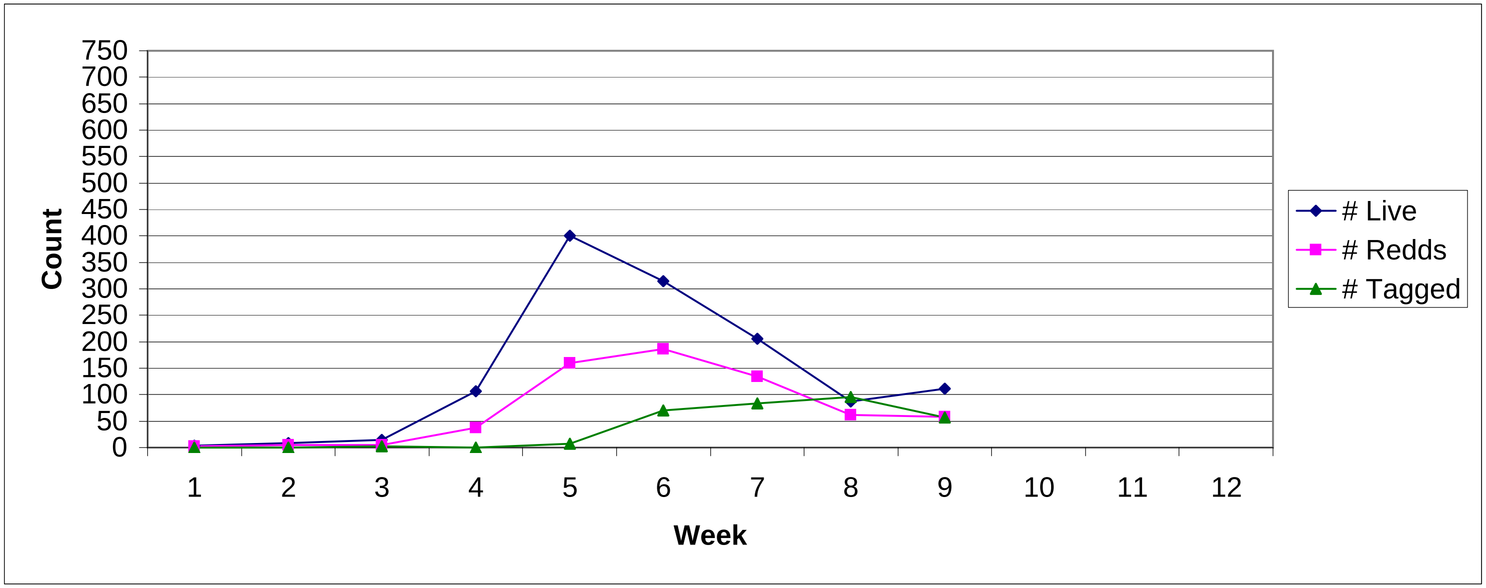
Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	CDEC station OBB Average Flow (cfs)	Comments
1	3-Oct-2011	2	0	0	0	0	0	0	2398	
2	10-Oct-2011	14	3	0	0	0	0	0	2132	Section 1 (caynon) was not survey due to high flow
3	17-Oct-2011	13	6	0	0	0	0	0	1915	Section 1 (caynon) was not survey due to high flow
4	24-Oct-2011	78	35	0	1	0	1	0	1614	Section 1 (caynon) was not survey due to high flow
5	31-Oct-2011	507	202	6	12	6	12	0	700	
6	7-Nov-2011	555	329	18	61	30	61	2	524	
7	14-Nov-2011	525	416	53	156	88	156	14	320	
8	21-Nov-2011	326	274	42	103	65	103	67	312	Section 1 (caynon) was not survey
9	28-Nov-2011	236	224	73	106	77	106	90	308	
10	5-Dec-2011									
11	12-Dec-2011									
12	19-Dec-2011									
13	26-Dec-2011									



Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	CDEC station MSN Average Flow (cfs)	# Females spawned @ MRFF	Comments
1	3-Oct-2011	4	3	0	0	0	0	0	742.5		
2	10-Oct-2011	9	5	0	0	0	0	0	980		
3	17-Oct-2011	14	5	1	2	1	2	0	1137	2	
4	24-Oct-2011	106	37	0	0	0	0	0	1155	5	
5	31-Oct-2011	400	160	1	7	2	7	0	382	14	
6	7-Nov-2011	315	186	22	70	30	70	1	375	13	
7	14-Nov-2011	206	134	39	83	56	83	19	357	13	
8	21-Nov-2011	87	62	48	95	73	95	16	454	7	
9	28-Nov-2011	111	58	79	57	47	57	43	353	14	
10	5-Dec-2011										
11	12-Dec-2011										
12	19-Dec-2011										



UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

DRAFT COVER

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

2011 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: 2011 Tuolumne River Technical Advisory Committee Materials

Report 2011-1: 2011 Spawning Survey Report

Report 2011-2: Spawning Survey Summary Update

Report 2011-3: 2011 Seine Report and Summary Update

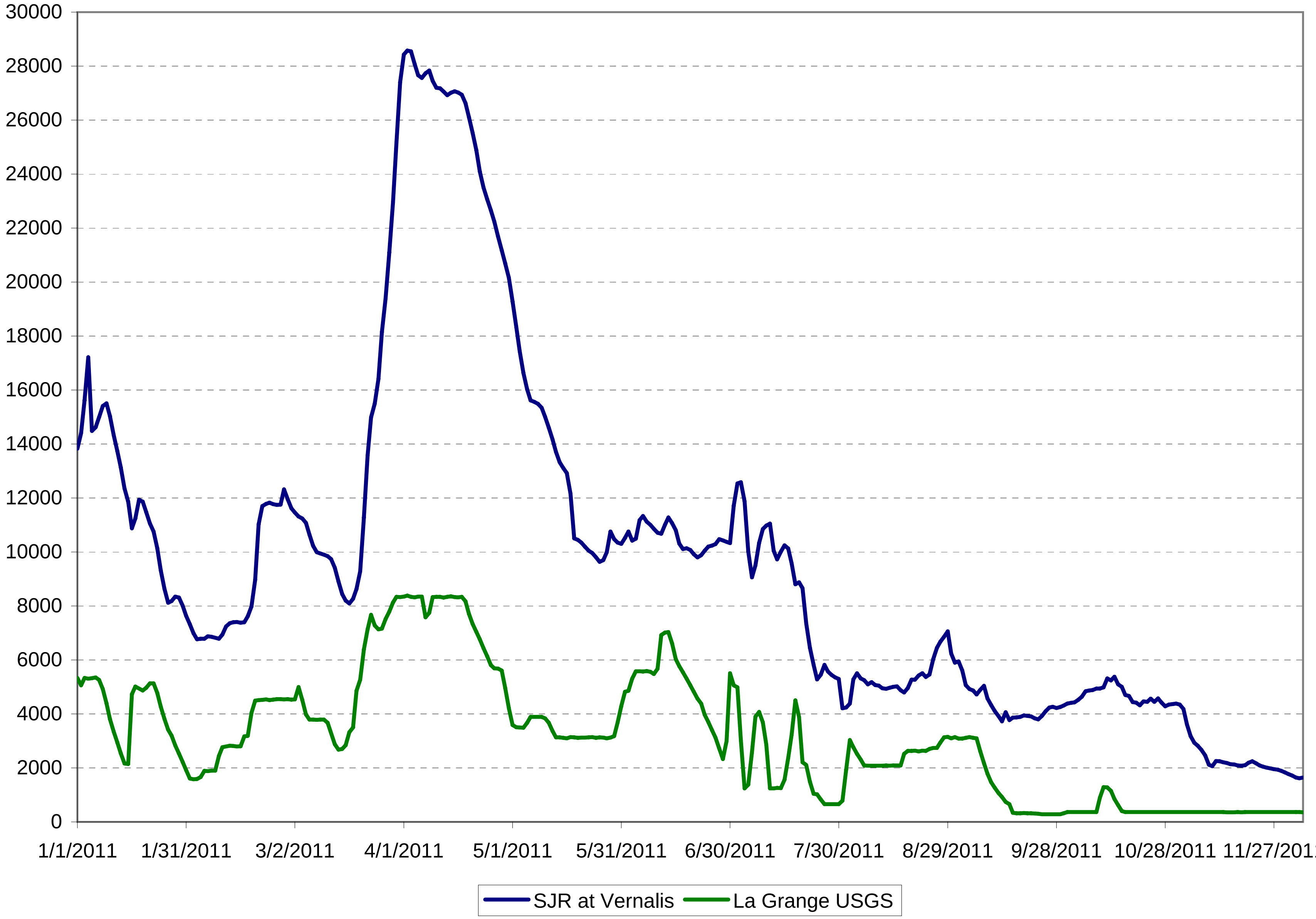
Report 2011-4: 2011 Rotary Screw Trap Report

Report 2011-5: 2011 Snorkel Report and Summary Update

Report 2011-6: 2011 *Oncorhynchus mykiss* Population Estimate Report

Report 2011-7: 2011 *Oncorhynchus mykiss* Acoustic Tracking Report

Report 2011-8: 2011 Counting Weir Report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7/30/2011
8/29/2011
9/28/2011
10/28/2011
11/27/2011
SJR at Vernalis
La Grange USGS

Tuolumne River Conservancy, Inc.

anadromous@bendbroadband.com
541-306-6887

Bobcat Flat Phase II Restoration

This restoration has goals and circumstances similar to Bobcat Flat Phase I Restoration. The river channel has suffered from an under supply of coarse sediment. Water velocities were very slow due to excessive channel width and uneven gradient distribution. These conditions created poor fishery habitat.

The associated floodplain was elevated, poorly vegetated and seldom experienced inundating river flows. Due to the poor off-channel vegetation, habitat for avian, terrestrial, and fish species (during flood flows) was of low quality.

As such, the areas of Phase I and Phase II did not provide quality instream or floodplain habitats.

Since the goals and existing conditions of Phase II were similar to those of Phase I, and since Phase I was highly successful, the techniques and approach this year mimicked the 2005 methodology.

One major difference in the implementation of Phase II restoration was the high river flows. High flows at or near 3,000 cfs for three of the six weeks of construction made the project much more difficult and hazardous. Only the final two weeks provided the flows of 300 cfs required for riffle construction.

1900 NE 3rd Street, Suite 106-314
Bend, OR 97701

Phase II restored approximately 1,500 linear feet of river channel and nine acres of floodplain.

The whole river reach was gravel poor and too wide. The downstream 800 feet was worse than the upstream section. It was characterized by a canal form; it had no gravel, square abrupt edges and a clay bottom.

Restoration objectives:
Increase instream coarse sediment supply
Construct useful riffles
Construct point bars/recruitment bars
Modify water velocities by modifying channel width and redistributing gradient
Predator isolation and reduction
Create functional floodplain

Methods:

The floodplain surface was excavated, and the material screened and cleaned onsite with a portable screen plant. The floodplain surfaces were lowered to provide coarse sediment for instream infusion. The excavation lowered the elevation of the floodplain surface so it will now receive regular seasonal inundation. Inundation will provide new seasonal off channel fish habitat and new habitats for avian and terrestrial species. Native plants will be planted to utilize the shallower water table.

19,000 cubic yards of coarse sediment was placed instream.

One riffle was enhanced and three new riffles were created. Site gradient was redistributed by placing gravel selectively to extend the riffles' lengths.

One point bar was enhanced and four new large alternating point bars were constructed. These are large volume bars and will function as habitat bars and provide gravel for downstream recruitment. Bar placement reduced channel width and increased water velocities where it had been too slow.

2011 TRTAC Materials/Postings to Website

2010Dec9-2011Mar10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2010 TRTAC meeting summary and handouts
  - March 2011 TRTAC meeting agenda

- Correspondence
  - Tuolumne River IFIM Study: Progress Report dated December 9, 2010.
  - NOI for one year VAMP Extension, dated March 1, 2011

- Documents
  - 2010 Tuolumne River RST Report
  - 2010 Tuolumne River O. mykiss Acoustic Tracking Report
  - 2010 Tuolumne River 2010 O. mykiss Summary Report

- Data/Monitoring
  - No postings

2011Mar10-2011June9 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2011 TRTAC meeting summary and handouts
  - June 2011 TRTAC meeting agenda

- Correspondence
  - FERC; Scoping Document 1 for the Don Pedro Hydroelectric Project, P-2299. Dated April 8, 2011.
  - FERC; Notice of intent to file license application, filing of pre-application document, commencement of pre-filing process, and scoping, request for comments etc re Turlock & Modesto Irrigation Districts Don Pedro Hydroelectric Project under P-2299. Dated April 8, 2011.
  - Districts' letter to fishery agencies re: minimum flow schedule for 2010-2011 dated April 12, 2011.

- Documents
  - 2010 FERC Annual Report
  - Lower Tuolumne River Water Temperature Modeling Study

- Data/Monitoring
  - 2011 seine data
  - Basin monitoring newsletter (includes 2011 screw trap monitoring)

2011Jun10-2011September7 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - February 3, 2011 IFIM Habitat Suitability Criteria (HSC) workshop summary
  - June 2011 TRTAC meeting summary and handouts
  - September 2011 TRTAC meeting agenda

- Correspondence
  - Stillwater Sciences - Letter to Fishery Agency representatives regarding Flow Variance Request related to ongoing Instream Flow Study, dated June 17, 2011
  - FERC - Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 25, 2011.
  - Districts - ILP Proposed Study Plan for the Don Pedro Hydroelectric Project under P-2299-075. Submitted to FERC, July 25, 2011
  - FERC - Letter of Clarification regarding Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 29, 2011
  - NMFS, e-mail reply to Noah Hume, Stillwater Sciences regarding Flow Variance Request, dated June 30, 2011
  - CDFG, e-mail reply to Noah Hume, Stillwater Sciences regarding Flow Variance Request, dated July 21, 2011
  - Districts, Instream Flow Study Progress Report No. 2 and Flow Variance Request submitted to FERC under P-2299, dated July 29, 2011
  - NMFS; Letter to FERC regarding Flow Variance request under P-2299-075, dated August 10, 2011
  - Stillwater Sciences - Letter to Fishery Agency representatives regarding extension of ongoing Instream Flow Study, dated August 15, 2011
  - FERC; Letter acknowledging Turlock Irrigation District's et al Instream Flow Study Progress Report and Flow Variance request under P-2299-075, dated August 18, 2011

- Documents
  - ILP Proposed Study Plan for the Don Pedro Hydroelectric Project under P-2299-075. Submitted to FERC, July 25, 2011
  - Scoping Document 2 for the Don Pedro Hydroelectric Project under P-2299-075, dated July 25, 2011

- Data/Monitoring
  - None

2011September8-2011December7 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - September 2011 TRTAC meeting summary and handouts
  - December 2011 TRTAC meeting agenda

- Correspondence
  - Stillwater Sciences - Schedule extension request to FERC for the Lower Tuolumne River Instream Flow Studies Final Study implemented by Ordering paragraphs A) through E) of the May 12, 2010 order, dated November 1, 2011.

- Districts - ILP Revised Study Plan, with Appendices A-D, of Turlock Irrigation District and Modesto Irrigation District under P-2299 Don Pedro Project, dated November 22, 2011
- NMFS - Supplemental Information of NOAA Fisheries Service, Southwest Region, under UL11-1-000, and P-2299, FERC Jurisdictional Review - La Grange Dam and Hydroelectric Facility, Tuolumne River, CA, dated October 18, 2011
- Districts - ILP Updated Study Plan of Turlock Irrigation District and Modesto Irrigation District under P-2299, Don Pedro Project, dated October 14, 2011
- Districts, e-mail correspondence to fishery agency representatives regarding Tuolumne River Minimum Flow Requirement for 2011-2012, dated September 30, 2011

- Documents
  - DRAFT, 2011 *O. mykiss* Monitoring Summary Report
  - ILP Revised Study Plan, with Appendices A-D, of Turlock Irrigation District and Modesto Irrigation District under P-2299 Don Pedro Project, dated November 22, 2011
  - Districts - ILP Updated Study Plan of Turlock Irrigation District and Modesto Irrigation District under P-2299, Don Pedro Project, dated October 14, 2011

- Data/Monitoring
  - None

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-1

2011 Spawning Survey Report

Prepared by

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

March 2011

No report available at this time from CDFG

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-2

Spawning Survey Summary Update

Prepared by

Stillwater Sciences
Berkeley, CA

March 2012

SPAWNING SURVEY SUMMARY UPDATE

1. INTRODUCTION

The California Department of Fish and Game (CDFG) 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 2011 data from CDFG at this time, this report provides only a minimal update for 2011 (Figure 2, Tables 1, 2, and 4) and a summary for the 1971-2010 period.

2. SUMMARY UPDATE

2.1 Survey Reach

The reach surveyed by CDFG 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 2011. If this is the case, then our records indicate this would be the second year in a row that Section 5 has been included in the CDFG survey. It is thought that previous surveys extending into Section 5 ended about 1989. The survey was extended downstream 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. The 2009 carcass data do not include Section 5 where CDFG reported an additional 15 total carcasses, including 13 tagged and 7 recovered in that mark/recapture effort. The 2009 run estimate of 300 is based on 280 counted at the Tuolumne weir through Jan 15 and 20 more salmon estimated below the weir (Figure 2). The 2010 run estimate of 766 was also taken from the weir counts which ended early, on 30 Nov., due to high flows. The 2011 run estimate of 2,487 is based on weir counts from the period September 15, 2011 through February 18, 2012.

The initial CDFG estimates based on carcasses surveys were 112 and 540 for 2009 and 2010, respectively. The 2010 estimates (both weir count and CDFG survey) do not account for salmon spawning after November. The Tuolumne salmon run estimates for 1971-2010 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 2009–2011 Tuolumne River fall Chinook salmon are based on calculations utilizing the weir count numbers and may differ from numbers contained in CDFG 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 CDFG 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 has the maximum weekly counts of live salmon and redds from the CDFG surveys. The earliest date of peak weekly live count for the 1971–2011 period was Oct 31, 1996 and the latest peak was November 27, 1972 with a median date of November 12 (Table 4). The 2011 run had a peak live count of 170 salmon and a peak redd count of 95 during the week of November 21.

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

Tsao, S. and O'Brien, J., 2011. Preliminary 2010 Tuolumne River Chinook Salmon Spawning Escapement Survey Data. California Department of Fish and Game, La Grange, California.

CDFG (California Department of Fish and Game) [1971-2009]. San Joaquin River Chinook salmon Enhancement Project. Annual Reports and preliminary data, Region 4, Fresno.

Ford, T., and S. Kirihara. 2009. Spawning Survey Summary Update. Prepared by Turlock Irrigation District/Modesto Irrigation District, California and Stillwater Sciences, Berkeley, California for Federal Energy Regulatory Commission, Washington, D.C.

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 (Turlock Irrigation District and Modesto Irrigation District). 1997. Tuolumne River Salmon Spawning Summary, Supplement to 1992 FERC Report Appendix 3. 1996 Federal Energy Regulatory Commission Report 1996-1.

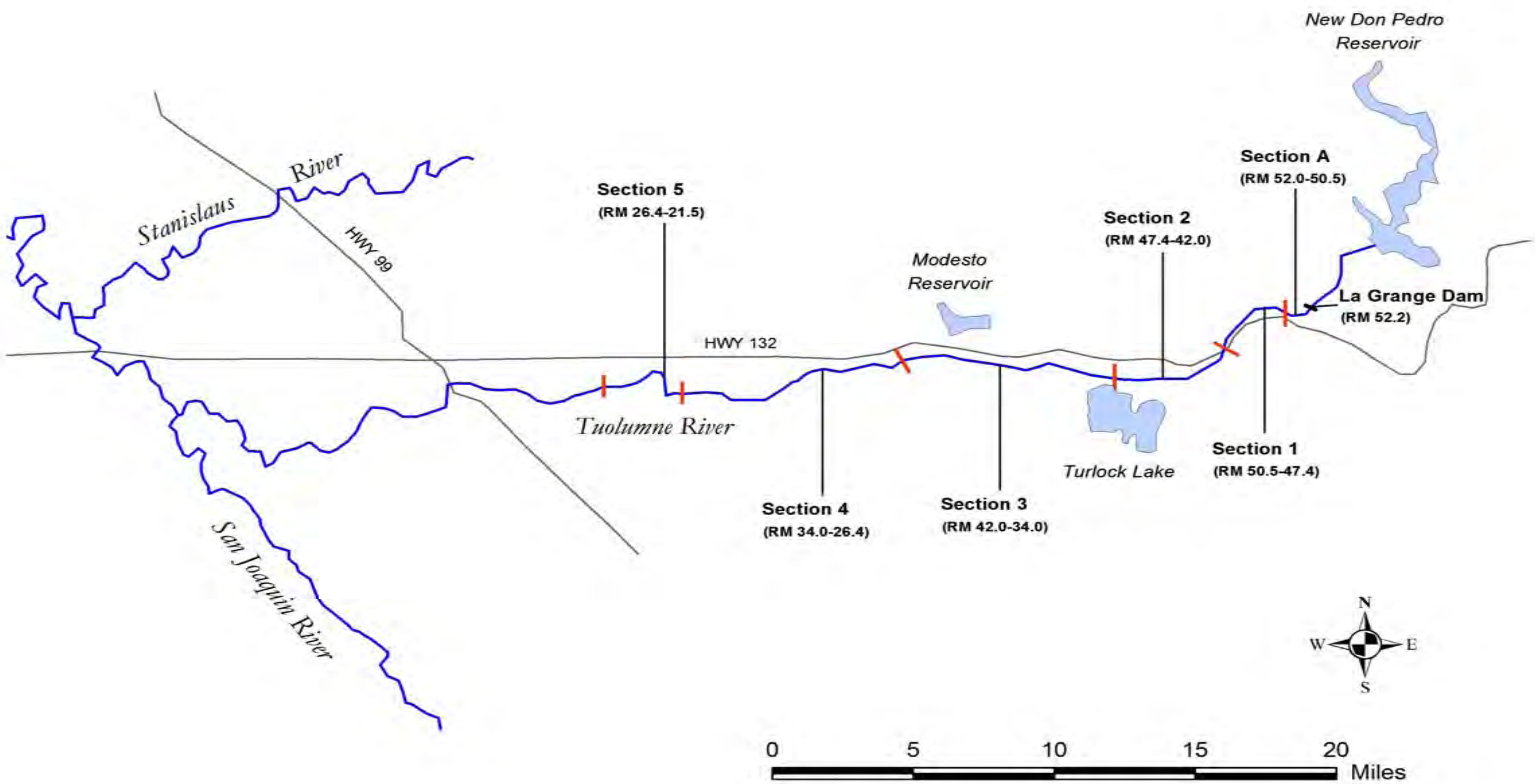


Figure 1. Map of the Tuolumne River salmon spawning survey reaches in 2010.

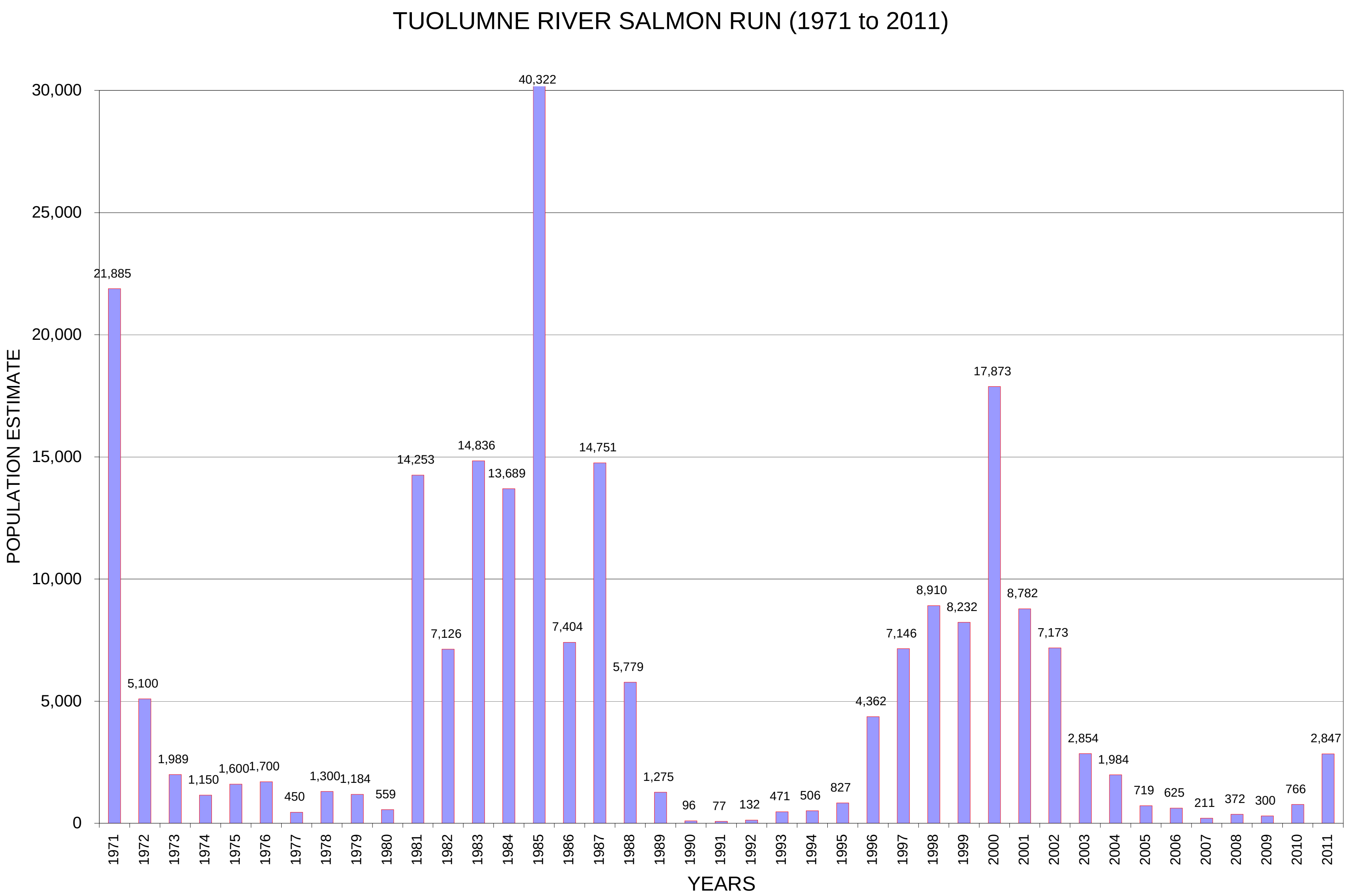


Figure 2. Tuolumne River Salmon Run Population Estimates, 1971-2011 (Years 2009-2011 based on weir counts).

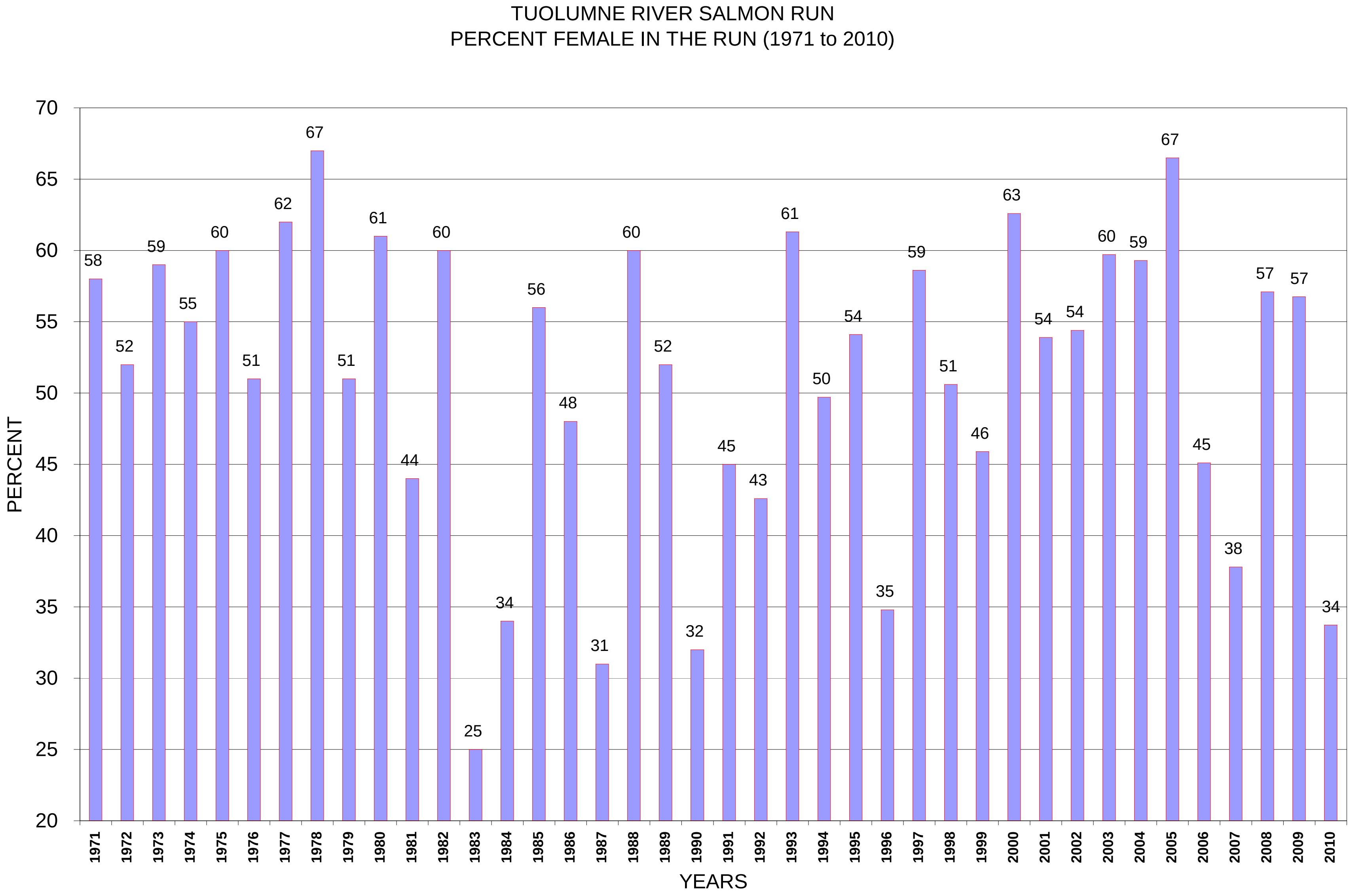


Figure 3. Percent Female salmon in the Tuolumne River runs, 1971-2010.

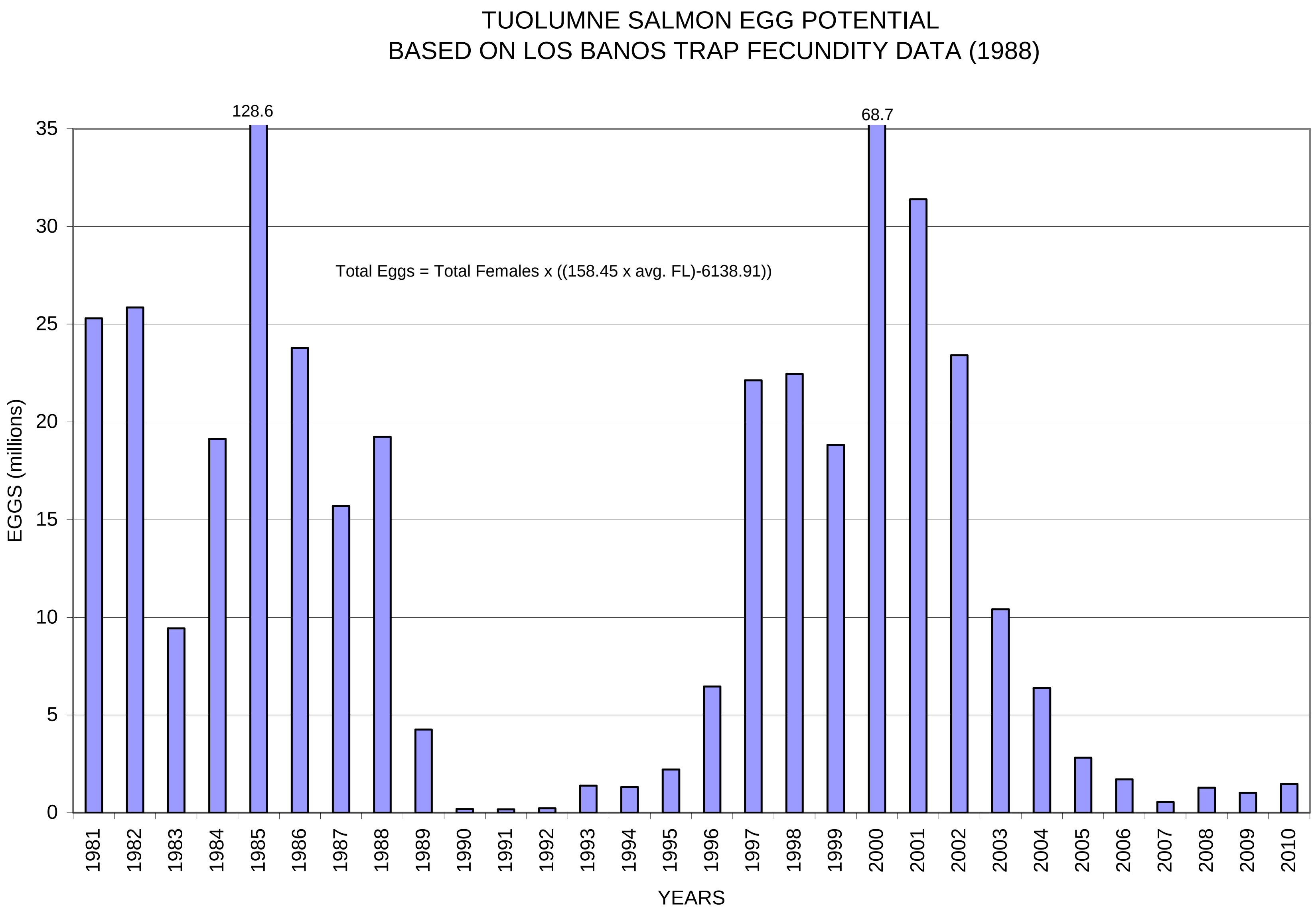


Figure 4. Potential egg deposition for Tuolumne River Chinook salmon, 1981-2010.

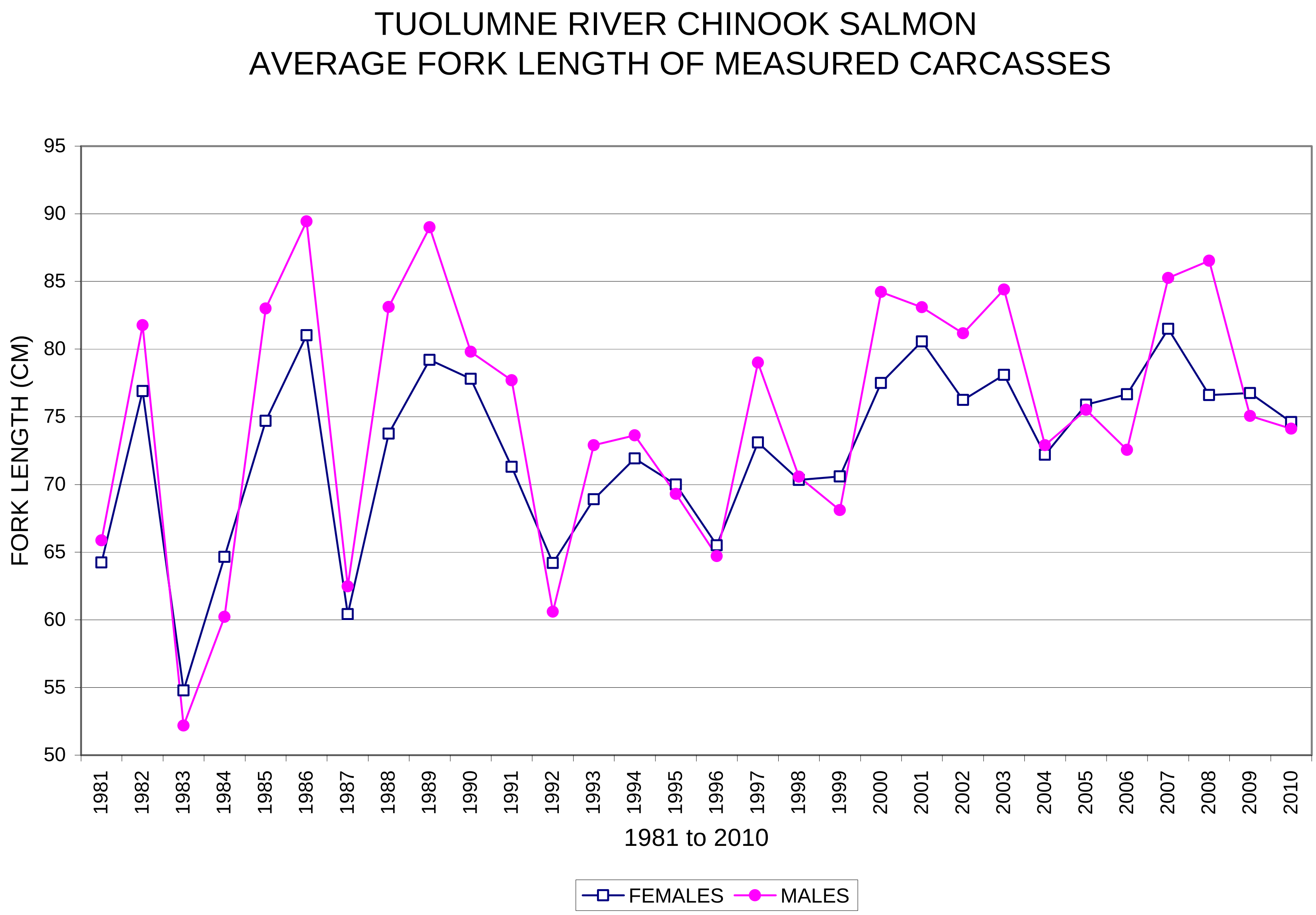
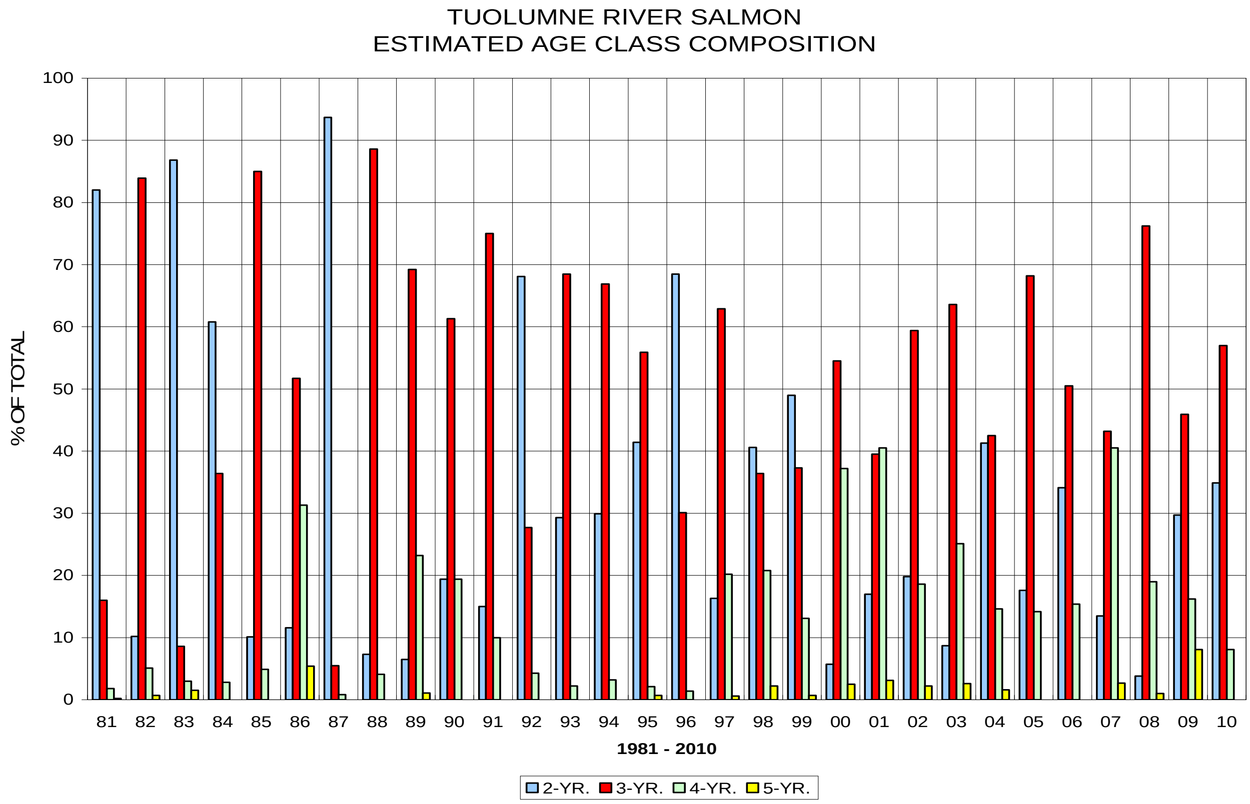


Figure 5. Average fork length of Tuolumne River salmon based on all measured carcasses, 1981-2010.



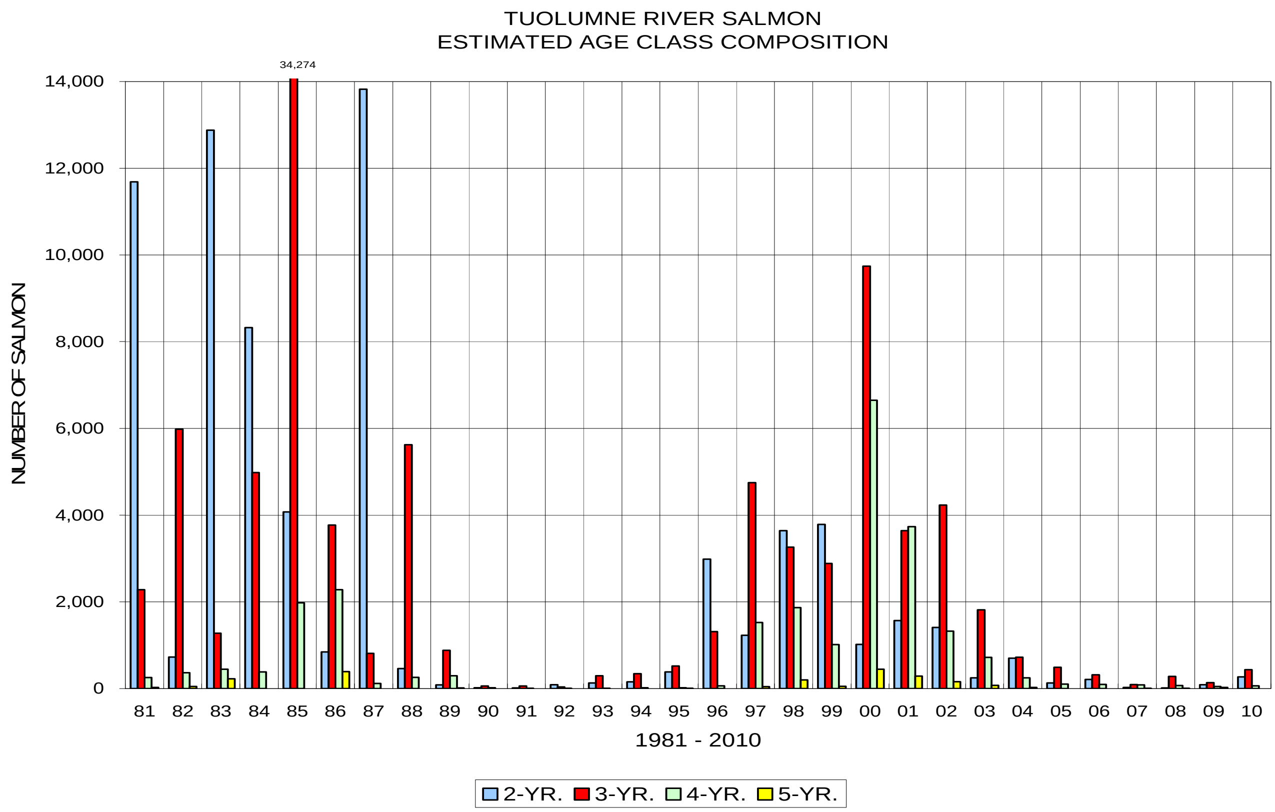
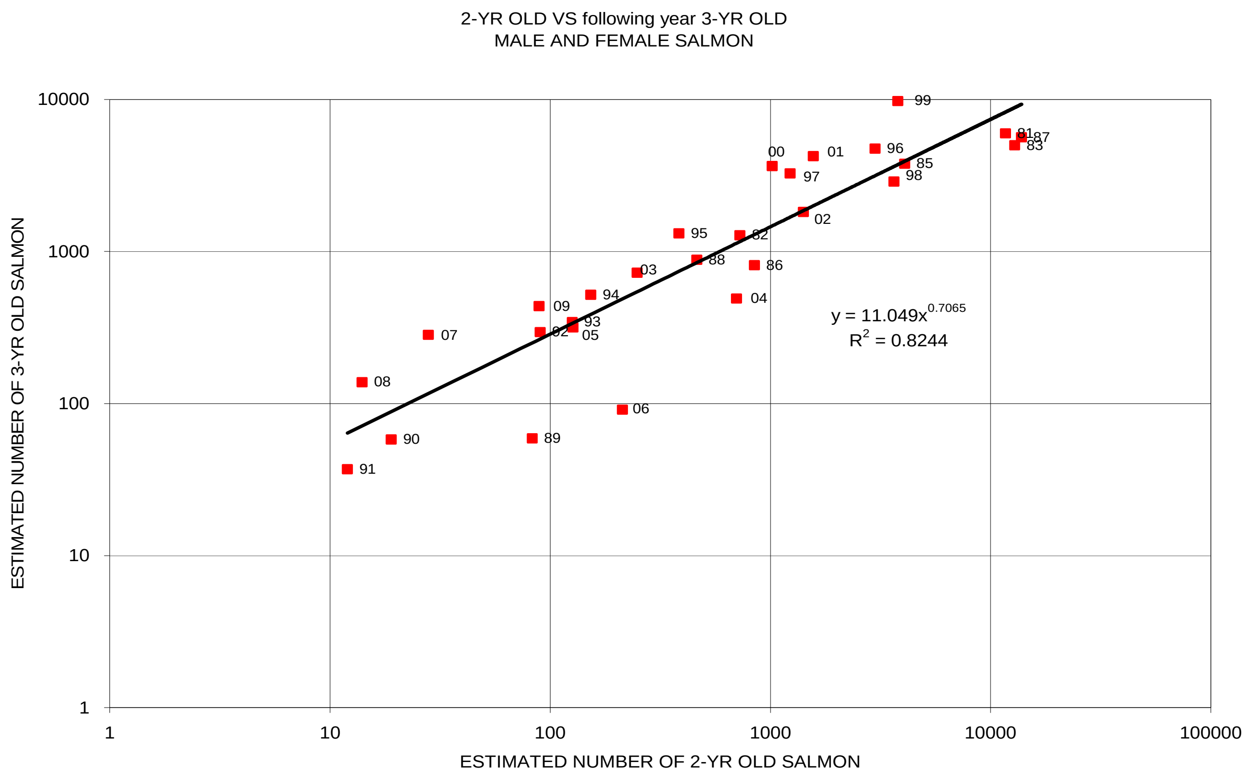


Figure 6. Estimated percent and number by age class for Tuolumne River salmon, 1981-2010.



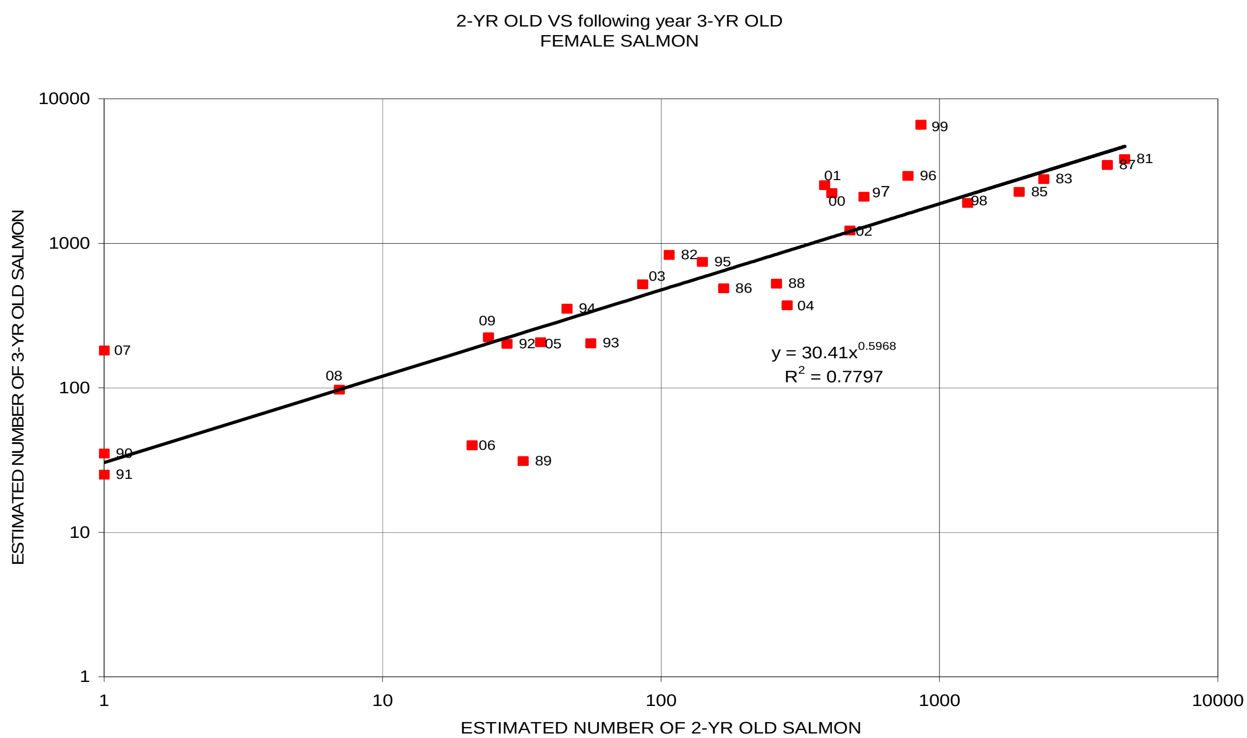


Figure 7. Estimated 2-yr-old salmon versus the following year 3-yr-old (1981-2009 Tuolumne River runs) excluding 1984 outlier, run years are for the 2-yr-olds.

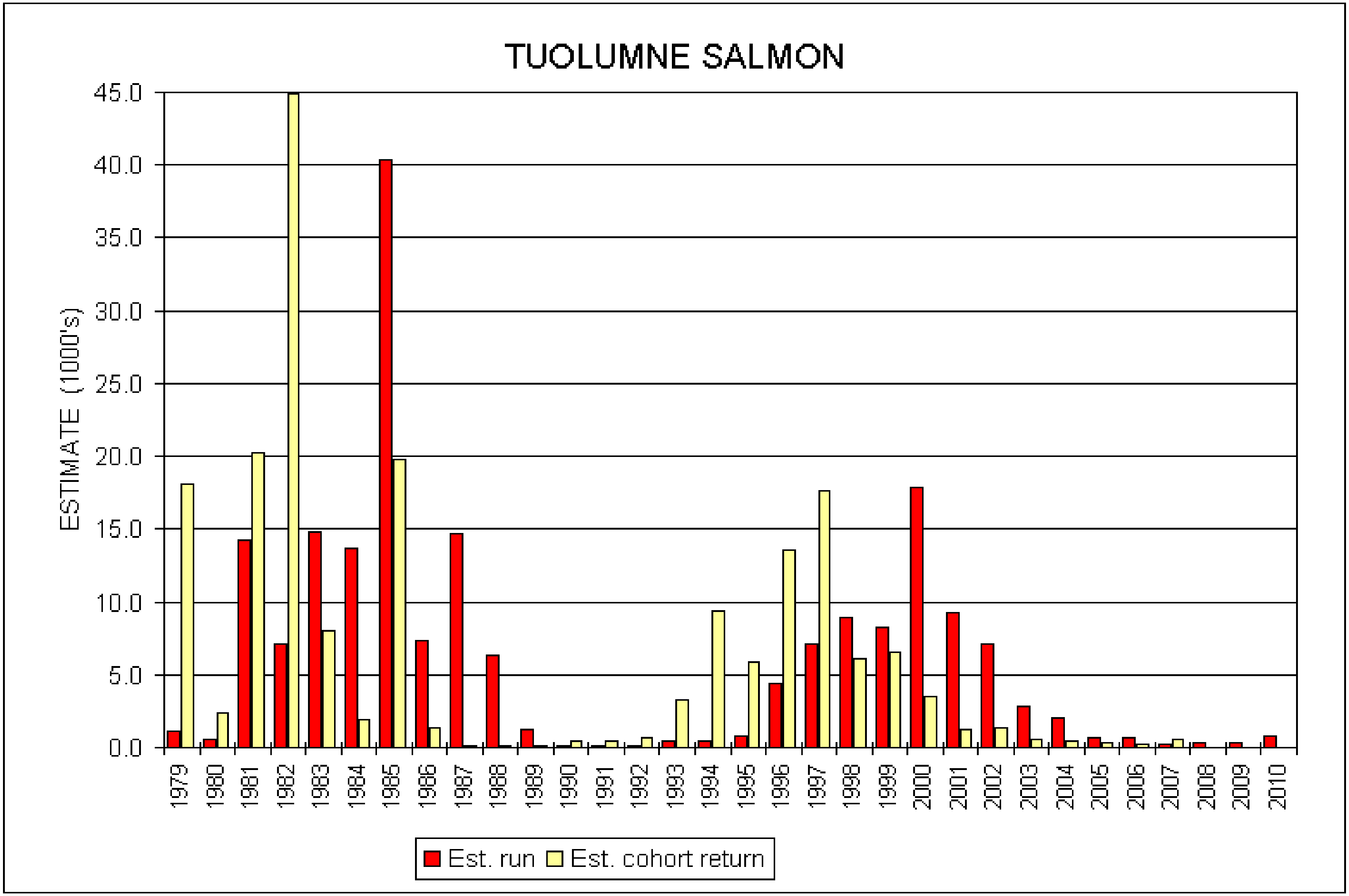


Figure 8. Estimated Tuolumne run numbers and spawner cohort returns, 1979-2010.

TABLE 1. TUOLUMNE RIVER SPAWNING SALMON SURVEY COUNTS AND ESTIMATES, 1971-2011.

YEAR	TOTAL CARCASSES	% FEMALE	TAGGED CARCASSES NUMBER TAGGED	TAGGED CARCASSES NUMBER RECOVERED	TAGGED CARCASSES % RECOVERED	(WEEKLY) MAXIMUM LIVE COUNT	(1) (WEEKLY) MAXIMUM REDD COUNT	ESTIMATED RUN
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(2)	40	56.8	23	18	78.3	69	62	300
2010(2)	151	33.7	85	37	43.5	142	105	766
2011(2)	n/a	n/a	443	383	86.5	170	95	2,847

(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.

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

Tuolumne and Stanislaus estimates were based on weir count data.

(1940 Stan. and Merced, and 1941 Stan., Tuol., and Merced, are partial counts)

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	End Date	Peak Live Count Date	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%
Years 2009-2011 estimate based on weir count						
For period 1971-2010:						
Minimum	30-Sep	29-Nov	31-Oct	---	---	---
Maximum	29-Nov	23-Jan	27-Nov	---	---	---
Median	25-Oct	27-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	)	

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-3

2011 Seine Report and Summary Update

Prepared by

Stillwater Sciences
Berkeley, CA

January 2012

EXECUTIVE SUMMARY

The 2011 seining survey was conducted at two-week intervals from 19 January to 24 May for a total of 10 sample periods. This was the 26th consecutive annual seining study on the Tuolumne River conducted by the Turlock and Modesto Irrigation Districts. 2011 flow releases were significantly higher than recent years going back to 2006 when flows at La Grange last exceeded 8,000 cubic feet per second (cfs). Chinook salmon catch was much lower this year due to the increased volume of water in the river and subsequent reduction of fish density. Sampling areas were also limited to flooded margins along the floodplain and micro-habitat conditions at the survey sites were less than ideal for large catches of salmon, especially juveniles >50 mm FL.

A total of 164 natural Chinook salmon were caught in the Tuolumne River and 19 in the San Joaquin River. This was the 4th lowest number of salmon caught during the 1986-2011 period and salmon were caught throughout the Tuolumne and at both San Joaquin sites. Peak density of salmon caught in the Tuolumne was 4.3 salmon per 1,000 square feet on 01 February and 3.2 salmon per 1,000 square feet on 15 March in the San Joaquin River. Minimum and maximum fork length (FL) in the Tuolumne River both occurred on 01 February and were 31 and 76 mm FL, respectively. Minimum Fl in the San Joaquin River was 37 mm FL on 15 February and 01 March and maximum FL was 68 mm FL on 15 March.

Flows during the sampling period ranged from about 1,600 to 8,300 cubic feet per second (cfs) in the Tuolumne River at La Grange and from about 6,800 to 31,000 cfs in the San Joaquin River at Vernalis. Flows in 2011 were significantly higher than average due to abundant precipitation.

Water temperature in the Tuolumne ranged from 10.0°C to 16.8°C and in the San Joaquin from 10.7°C to 20.1°C. Conductivity in the Tuolumne River ranged from 24 to 57 µS and in the San Joaquin from 123 to 514 µS.

A comparative review of fork length and salmon density for the 2006-2011 period is included. Increase in average fork length in 2011 was much smaller in magnitude to the pattern observed in other years, due to low catch numbers.

Density of fry (≤ 50 mm) peaked on 15 February, similar in timing to other years of the 2006-2011 period. The density of juveniles (> 50 mm) peaked on 01 February, which was much earlier than other years in the period. In 2011, the average density of salmon in the Tuolumne River was 1.2 salmon per 1,000 ft^2, similar to 2007 and 2008.

CONTENTS

1 INTRODUCTION

Stillwater Sciences with assistance from FISHBIO conducted Chinook salmon seine surveys in the Tuolumne and San Joaquin Rivers in 2011 for the Turlock and Modesto Irrigation Districts (TID/MID). Seine sampling was done in both rivers pursuant to the Don Pedro Project (FERC #2299) river-wide monitoring program. The purpose of the seine monitoring program was to document juvenile Chinook salmon size, abundance and distribution in the Tuolumne and San Joaquin rivers. The Chinook salmon captured during the 2011 seine surveys were the progeny of the 2010 fall spawning run, which was estimated at about 766 fish as counted at the Tuolumne River weir (through Nov 2010).

This report, which is the 26th in the annual series, contains the results of the 2011 seining effort and a summary of monitoring data collected since 1996.

1.1 STUDY SITES

The seining study area includes the Tuolumne River, from La Grange Dam (river mile [RM] 52.0) to its confluence (RM 0) with the San Joaquin River at RM 83.8, and the San Joaquin River from Laird Park (RM 90.2) downstream to Gardner Cove (RM 79.4) (Figure 1). A total of 10 sites were sampled each survey period, eight on the Tuolumne and two on the San Joaquin. These sites have generally been sampled since the beginning of the program in 1986. However, alternate sites were utilized as necessary during high flows when conditions at the primary study locations were unsuitable for monitoring activities. The locations of the monitoring sites were as follows:

Site	Location	River Mile
	Tuolumne River	
1	Old La Grange Bridge (OLGB)	50.5[a]
2	Riffle 4B, 5	48.4, 48.0
3	Turlock Lake State Recreation Area (TLSRA)	42.0
4	Hickman Bridge	31.6
5	Charles Road	24.9
6	Legion Park	17.2
7	Riverdale Park, Venn Ranch	12.3, 6.4
8	Shiloh Road	3.4
	San Joaquin River	
9	Laird Park	90.2[b]
10	Gardner Cove, Old Fishermen's Club	79.4, 80.7

[a] As measured from the confluence with the San Joaquin River
[b] As measured from the confluence with the Sacramento River

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

2 METHODS

2.1 STUDY TIMING

The 2011 seining study began on 19 January and ended on 24 May. Seining efforts were conducted on two-week intervals for a total of 10 sampling dates.

2.2 SAMPLING METHODS AND DATA RECORDING

Seining was conducted using a 4-foot high, 1/8-inch mesh nylon seine net 20 feet in length. Seine hauls were made with the current and parallel to shore. The captured Chinook salmon were anesthetized with MS-222, measured (FL in mm) and then revived before being released. Other data recorded during the seine surveys included the area sampled (determined from estimating average length and width of a seine haul), water temperature in degrees Celsius (C), dissolved oxygen in milligrams per liter (mg/L), underwater visibility, conductivity in microsiemens (µS), turbidity in Nephelometric Turbidity Units (NTU), and maximum depth. Other recorded observations included time of day, weather conditions, habitat type, substrate type, and other fish species captured in the seine hauls. Also noted were any salmon displaying signs of smoltification, such as losing scales or silvering up.

2.3 DATA ANALYSIS

Seining catch data were analyzed, arranged, and reported on a site, river section, and river-wide basis. Catch densities of salmon were divided into two size groups for analysis. The density index for "fry" (fish ≤50 mm FL) and for "juveniles" (>50 mm FL) were computed by multiplying the number of salmon caught by 1,000 and dividing it by the area of the site or section that was sampled. The 2011 density indices were compared to previous years catch and density data. Densities and sizes of salmon fry and juveniles were analyzed for each of the upper, middle, and lower river sections.

3 RESULTS AND DISCUSSION

3.1 2011 TUOLUMNE AND SAN JOAQUIN RIVER SAMPLING CONDITIONS

Flow releases during the 2011 study period were similar to those in 2006, which was the last wet year. Flows at the U.S. Geological Survey (USGS) gage (#11289500) in the Tuolumne River below La Grange Dam were approximately 1,600 cubic feet per second (cfs) in early February, which was the lowest level during the 2011 seine study period (Figure 2). Flows were gradually increased through the month, were lowered slightly in mid-March and then increased to over 8,000 cfs through mid-April. Flows remained above 3,000 cfs through the end of May. Although seine surveys were terminated at the end of May due to low capture numbers, flows to the lower river increased to about 7,000 cfs in June, before decreasing through July.

The USGS stream gage at Vernalis (#11303500) (RM 72.5) and the California Department of Water Resources gage at Patterson Bridge (SJP) (RM 98.5) were used to represent flow levels at the Laird Park and Gardner Cove sampling locations. Laird Park and Gardner Cove are located on the San Joaquin River, upstream and downstream of the mouth of the Tuolumne River, respectively. Flows in the San Joaquin River at Vernalis (RM 72.5) ranged from 6,800 to 31,000 cfs from January through June 2011. Flows at Patterson ranged from 3,600 to 22,700 cfs from January through June 2011.

The minimum water temperature recorded in the Tuolumne River during the study period, based on hand-held temperature measurements, was 10.0°C (50.0°F) at Hickman Bridge on 01 March and the maximum temperature was 16.8°C (62.2°F) at the Venn Ranch on 24 May (Figure 3). The lowest San Joaquin River water temperature, 10.7°C (51.3°F) was at Laird Park on 01 February; the highest was 20.1°C (68.2°F) at Laird Park on 24 May.

Dissolved oxygen concentration in the Tuolumne River ranged from 8.7 to 14.1 mg/L and 7.0 to 11.2 mg/L in the San Joaquin River (Figure 3).

Conductivity in the Tuolumne River generally increased with increasing distance below La Grange Dam, from a low of 24 μS at OLGB to a high of 57 μS at Venn Ranch (Table 1). Conductivity was relatively low throughout the year due to high flows (Figure 4).

Conductivity in the San Joaquin River was much higher than in the Tuolumne and ranged from a low of 123 μS at the Old Fishermen's Club to a high of 514 μS at Laird Park (Table 1 and Figure 4).

Turbidity in the Tuolumne River was less than 7.5 NTU except for one reading at Legion Park on 01 February that was likely the result of storm runoff (Table 1). Turbidity also generally increased with increasing distance below La Grange Dam and generally decreased with higher flows.

Turbidity in the San Joaquin River ranged from 11.3 at Gardner Cove to 33.4 NTU measured at Laird Park (Table 1 and Figure 4)

3.2 SEINE CATCH

A total of 164 fry and juvenile Chinook salmon were caught in the Tuolumne River and 19 in the San Joaquin (Table 2). Although the 2011 salmon catch was relatively low when compared to past years, salmon were caught at all of the Tuolumne and San Joaquin River survey sites.

3.2.1 Density of Fry and Juvenile Salmon

3.2.1.1 Tuolumne River

The highest density of Chinook salmon fry (14.5/1000 ft²) was recorded at the TLSRA site on 15 February (Table 3). The highest density of juvenile Chinook salmon (4.8/1000 ft²) was recorded at the Hickman site on 1 February (Table 3). On 1 February, the Hickman site also had the highest combined density of fry and juveniles at 15.2 fish/1000 ft² (Table 3). The density of salmon fry by location exhibited a peak from 19 January to 15 February (Figure 5). The density of juveniles generally peaked from 01 February to 01 March for most locations (Figure 5).

The density of Chinook salmon fry in the Tuolumne River peaked in the upper section on 15 February with 4.3/1,000 ft² (Table 3 and Figure 6). The fry densities in the middle and lower sections peaked on 01 February with 6.2/1,000 ft² and 2.3/1,000 ft², respectively (Table 2 and Figure 6). The density of juveniles in the Tuolumne River peaked in the upper section on 26 April with 0.3/1,000 ft² (Table 2 and Figure 6). The juvenile densities in the middle and lower sections peaked on 01 February with 1.7/1,000 ft² and 0.4/1,000 ft², respectively (Table 2 and Figure 6).

The peak density of salmon fry in the Tuolumne River for the combined survey locations was 3.6/1,000 ft^2 found on 15 February (Table 2). The peak density of juvenile salmon in the Tuolumne River was 0.8/1,000 ft^2 found on 01 February. The highest combined fry and juvenile density for the entire Tuolumne River survey reach was 4.3/1000 ft² (Table 2). The average combined density of fry and juveniles for the entire survey period was 1.2/1000 ft² (Table 2).

3.2.1.2 San Joaquin River

A total of 19 fry and juvenile Chinook salmon were caught in the San Joaquin River from 01 February to 15 March at the Laird and Gardner Cove survey locations. The last year Chinook salmon were caught at these locations was in 2006 under similar high flow conditions. The peak fry density (2.7/1000 ft^2) and juvenile density (2.0/1000 ft^2) both occurred on 15 March at Gardner Cove (Table 2). The peak combined fry and juvenile density at this location and date was 4.7/1000 ft^2.

The peak combined fry and juvenile Chinook salmon density for both the Laird and Gardner Cove sites was 3.2/1000 ft^2. The average combined density of fry and juveniles for the entire survey period was 0.6/1000 ft² (Table 2).

3.2.2 Size, Growth, and Smoltification

The fork length of salmon caught in the Tuolumne River ranged from 31 mm to 76 mm (Tables 1 and 3). The average fork length (FL) of salmon generally increased throughout the survey period (Table 2 and Figure 7). The indirect method to estimate growth rate usually made by dividing the increase in maximum FL, over a period of time was not calculated in 2011 due to low numbers of juvenile salmon caught.

Length frequency distributions by survey period are shown in Figures 8 and 9. The change in FL by location generally shows no pattern throughout the survey period (Figure 10). Usually a pattern of increasing FL in a downstream direction is observed. None of the salmon that were caught in 2011 exhibited smolting characteristics.

3.2.3 Other Fish Species Caught

A list of other fish species caught during the seining study by species, location, and date is in Table 4. Ten species other than Chinook salmon were caught in the Tuolumne River and 11 other species in the San Joaquin River. Seven of these species were common to both rivers and 14 species were caught overall. Seven rainbow trout (*O. mykiss*) fry (21–40 mm FL) were caught in the Tuolumne River between 01 February and 26 April at OLGB, R4B, and R5 (Table 4).

4 COMPARATIVE REVIEW

The comparative review of Chinook salmon fork lengths and densities in this report is primarily for the 2006 to 2011 period.

4.1 SEINE: 1986–2011

Annual TID/MID Tuolumne River seining surveys began in 1986. Up to 11 sites and varying degrees of effort have been employed in the Tuolumne River during the course of the 1986 to 2011 study period (Tables 5 and 6). Beginning in 1999, the sites discussed in this report have been consistently monitored. However, two alternate sites (Riffle 4B and TSLRA) were utilized during the 2011 effort because the Riffle 5 and TRR sites were unsuitable due to high flows (Tables 5 and 6). The number of salmon caught and the related density indices are subject to river conditions that affect the seining operations. For example, high flow conditions may result in marginal seining conditions at one location and improved at others, which is what occurred in 2011.

The number of salmon captured in the Tuolumne River has ranged from 120 in 1991 to 14,825 in 1987 (Table 5). The total number of salmon captured in 2011 was 164, which was the fourth lowest for the entire 26-year study period.

The San Joaquin River Laird and Gardner Cove sites have been during each of the study years. The total number of salmon captured at these sites has ranged from 0 to 854 with average densities much lower than the Tuolumne (Table 5). Nineteen salmon were captured in the San Joaquin River during 2011, which followed four years in a row of no captures.

4.1.1 Size and Growth

The average minimum FL found in 2011 remained below 43 mm through April (Figure 11). The 2011 increase in average FL during the January to March period was smaller than what was previously observed during the 2006 to 2010 period (Figure 12). In 2011, the average maximum FL for each of the survey periods was the lowest of the past six years (Figure 13). The estimated growth rate for 2011 was not calculated due to low catch numbers (Table 5).

4.1.2 Fry and Juvenile Salmon Density

4.1.2.1 Tuolumne River Section Density

For the 2006 to 2011 period, fry densities in the upper section of the river generally peaked from early February to early March and steadily declined through March (Figure 14). Peak juvenile Chinook salmon densities for the 2006 to 2011 period occur about a month later than the fry (Figure 14). In 2011, fry and juvenile salmon densities were generally low when compared to the earlier survey years.

Middle section density of fry generally peaks from early February to mid-March similar timing to the upper section (Figure 15). Middle section density of juveniles often peak from late February to late March. In 2011 juvenile density peaked on 01 February, the same date as the peak in fry occurred.

Lower section density of fry and juvenile salmon has been relatively low in most years. This section was often sampled only at the Shiloh Road location in prior years. Since 1999, two sites have been sampled. Peak density of fry occurred on 01 February in 2011 (Figure 16). Peak density of juveniles was low throughout the 2011 surveys. The capture of fry and juvenile salmon in the lower section, while low, indicates salmon survival throughout the river.

Section density indices of fry and juvenile salmon combined were standardized as a percent of the annual riverwide average density index and plotted at section midpoints for recent years (Figure 17). In 2011 the standardized section density indices was highest in the middle section.

4.1.2.2 Tuolumne River-wide Density

The density of Tuolumne River Chinook salmon fry during the early winter of 2011 remained below those that were recorded in 2006, 2009, and 2010, but were higher that in 2007 and 2008 (Figure 18). Late winter through mid-spring fry densities were similar for 2006 to 2011.

The density of Tuolumne River Chinook salmon juveniles was extremely low throughout the survey period and generally lower than those experienced during 2006 to 2010 (Figure 19). High flows during the monitoring period limited sampling to the shallower margins which reduced the likelihood of capturing larger juvenile-sized salmon.

The combined fry and juvenile densities for the Tuolumne River for the years 2006–2011 are shown in Figure 20. In general, the 2011 densities were lower than those recorded in 2006–2010 (Figure 20). The 2011 average combined density (1.2/1000 ft^2) was the third lowest recorded since 1986 (Table 5).

4.1.2.3 San Joaquin River Density

Densities of salmon caught in the San Joaquin River at Laird Park and Gardner Cove sites were reviewed to compare relative abundance of salmon upstream and downstream of the Tuolumne River confluence. The density indices were developed by combining the fry and juvenile salmon due to the low numbers of fish that were caught.

The average salmon density at Laird Park, downstream of the Merced confluence, was extremely low for all years between 1986 and 2011(Figure 21). The total number of wild Chinook salmon caught at Laird Park during the 1986 to 2011 period of record was 152. Four salmon were caught at Laird Park in 2011.

A total of 1,097 salmon were caught at Gardner Cove during the 1986–2011 period, 509 of which were caught in 1999. Fifteen salmon were caught at Gardner Cove in 2011. The average density at Gardner Cove, downstream of the Tuolumne River confluence, was much higher in 1986 and 1999 and moderately higher in 1995, 1998, 2001, 2006 and 2011.

4.1.3 Tuolumne River Fry Density versus Number of Female Spawners

An analysis to determine the relationship of adult female spawner escapement to the following peak and average fry densities was conducted using the 1986 to 2011 data sets. All fry density data for the individual study years were entered into an Excel spreadsheet and plotted on a chart. A "best fit" line was run through the data points to determine if a correlation between spawning females and fry could be identified. The best fit line through the peak fry density data points resulted in an R-squared of .732 for the 1986–2011 period (Figure 22, Table 7). A similar result with R-squared of .780 was found using average fry density from 15 January to 15 March (Figure 23). However, a review of Figures 20 and 21 show a wide variation between relatively similar female spawner numbers and the subsequent fry densities.

4.1.4 Other Fish Species

Between 10 and 16 fish species, other than Chinook salmon, were caught during 1992–2011 seining efforts in the Tuolumne River (Table 8). The numbers of captured individuals of each species for the 2011 survey season are listed by site and date of capture in Table 4. Ten other species were caught in the Tuolumne River during 2011, including 5 native species. Eleven other fish species, including 3 native, were caught in the San Joaquin River in 2011.

Sacramento pikeminnow, Sacramento sucker and prickly sculpin, all native species, were caught in both the Tuolumne and San Joaquin rivers. Other native species including rainbow trout, hardhead, and riffle sculpin were caught only in the Tuolumne River. Native species recorded in prior years, but not caught in either river in 2011, were Pacific lamprey, Sacramento blackfish, hitch, Sacramento splittail, and tule perch. The number of species observed in the Tuolumne River during the 1992–2011 period of years has remained fairly constant (Table 8). The number of species observed in the San Joaquin River has decreased since 2005.

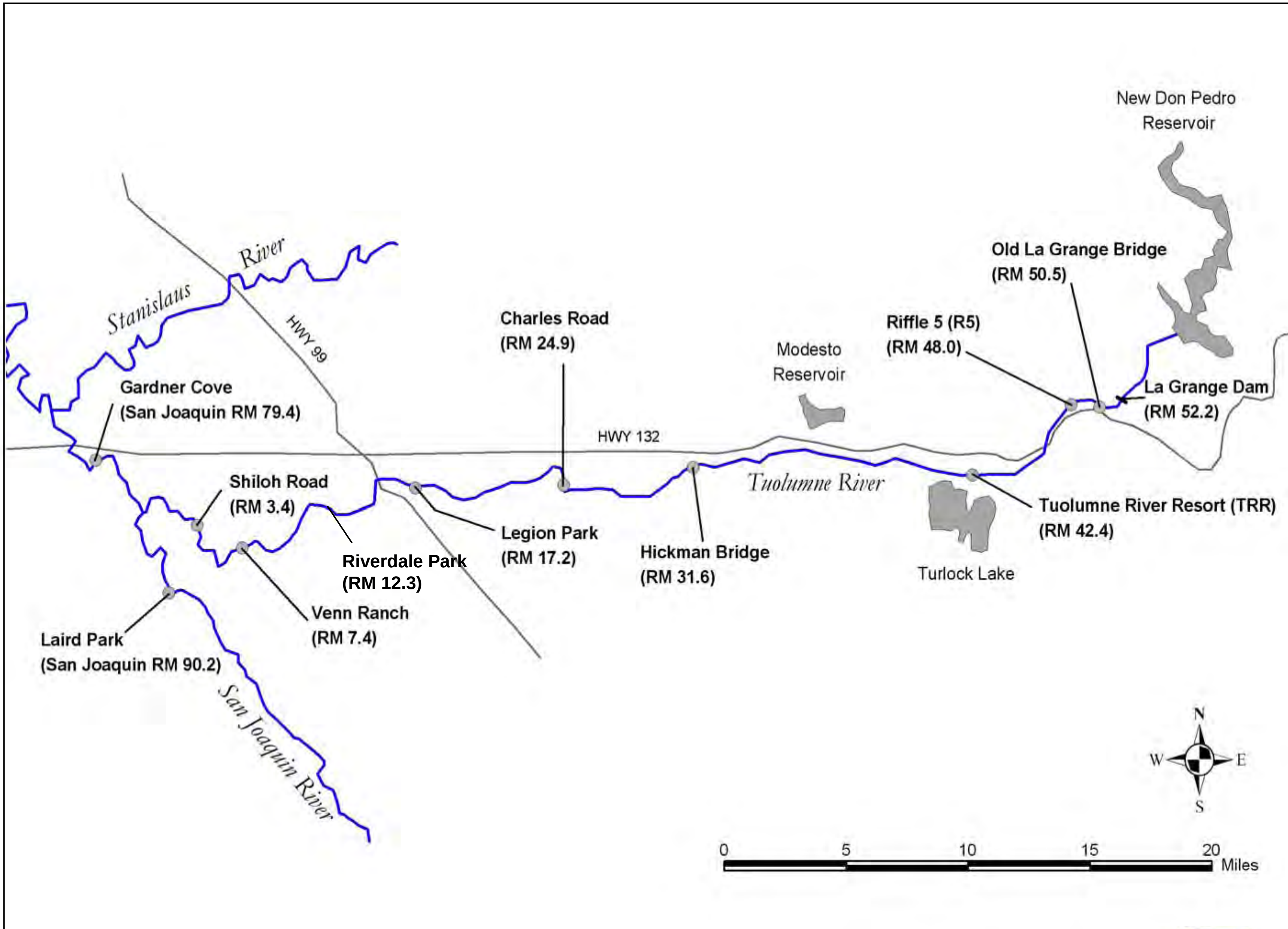
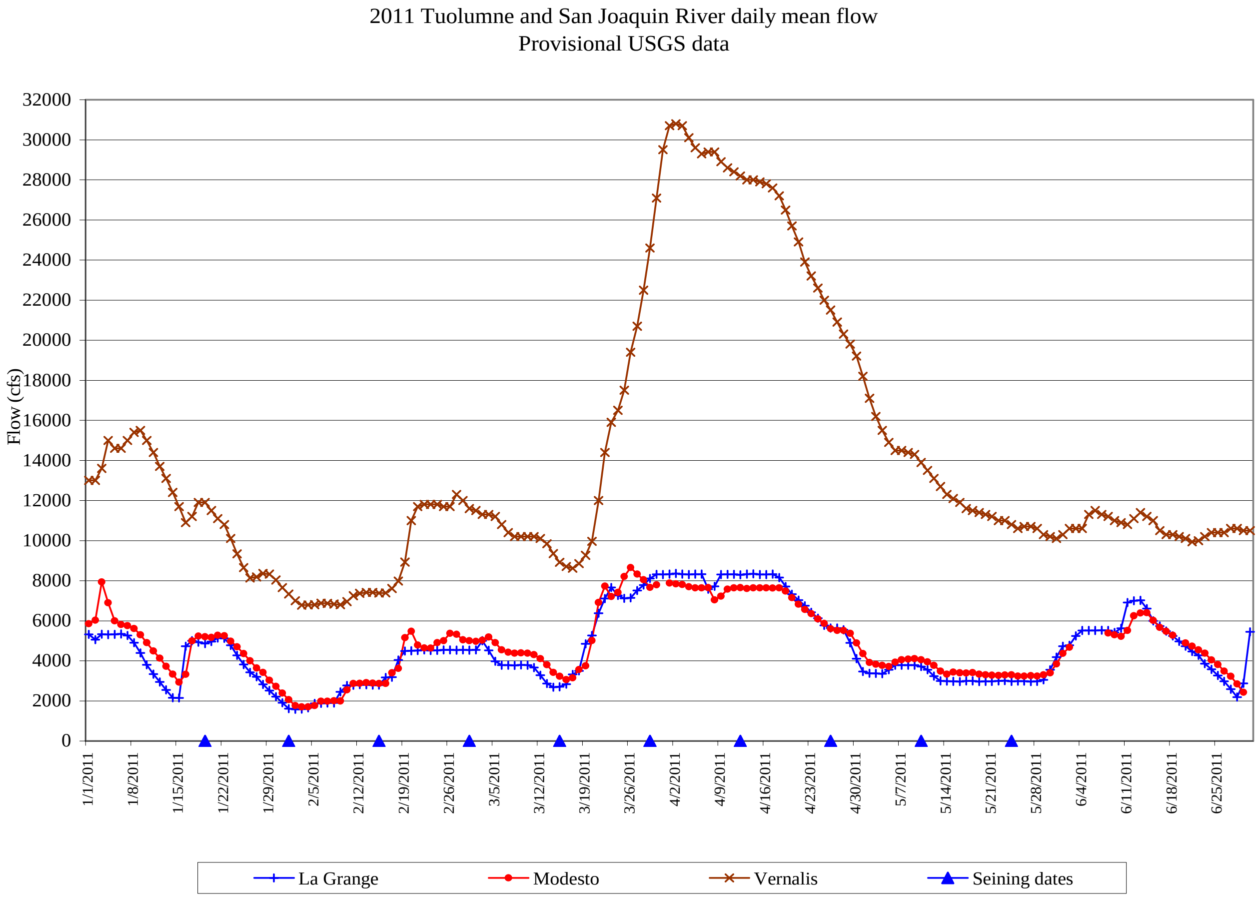


Figure 1. Locations of seine sampling sites on the lower Tuolumne and San Joaquin Rivers, 2011.

Stillwater Sciences



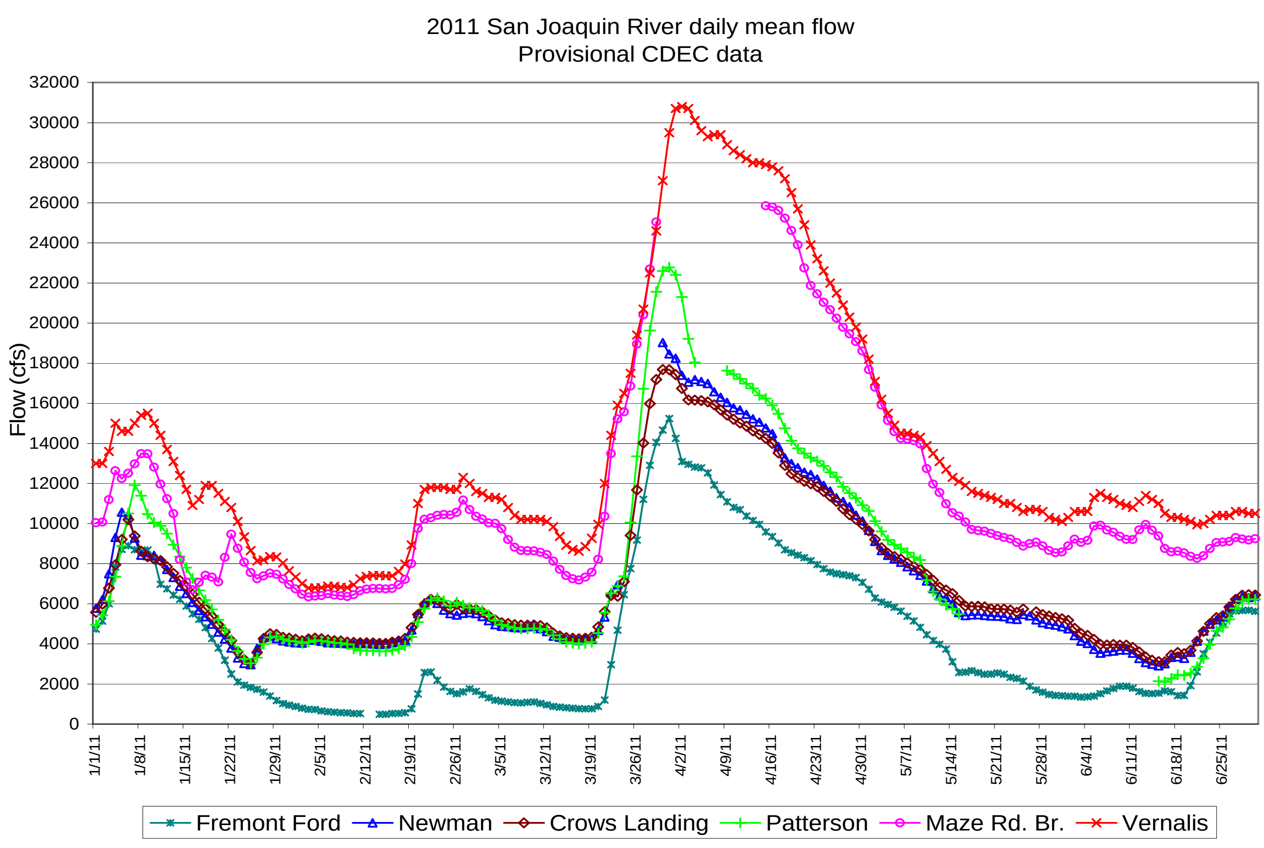
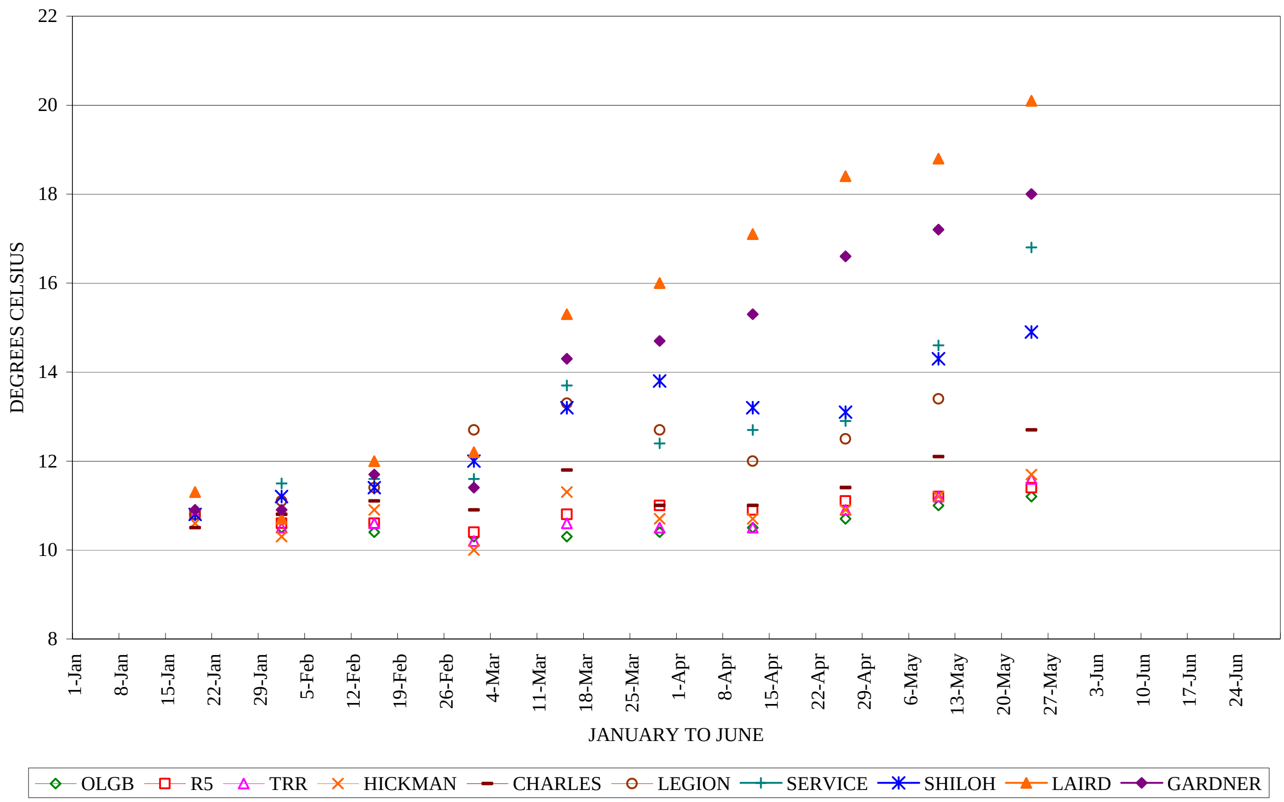


Figure 2. 2011 Tuolumne and San Joaquin River daily mean flows.

2011 TUOLUMNE AND SAN JOAQUIN RIVER WATER TEMPERATURE



2011 TUOLUMNE AND SAN JOAQUIN RIVER DISSOLVED OXYGEN

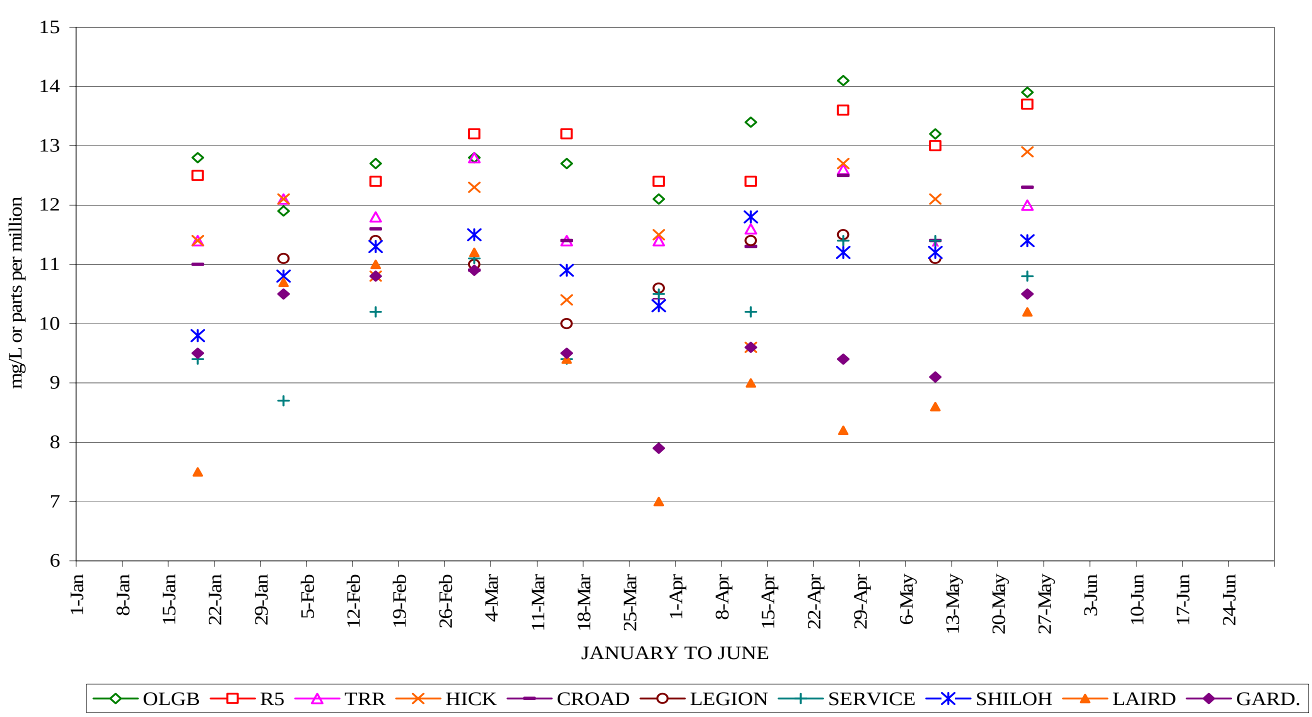
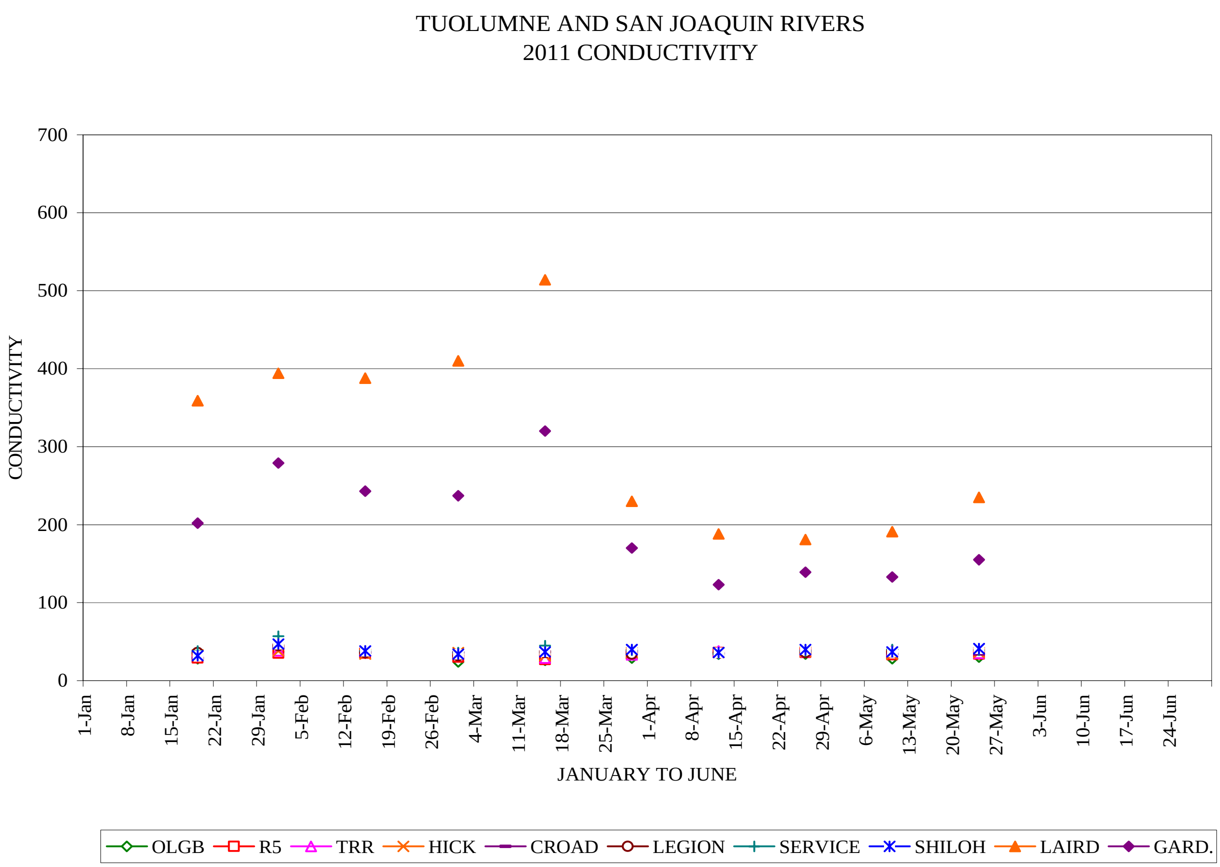


Figure 3. 2011 Tuolumne and San Joaquin River water temperature and dissolved oxygen.



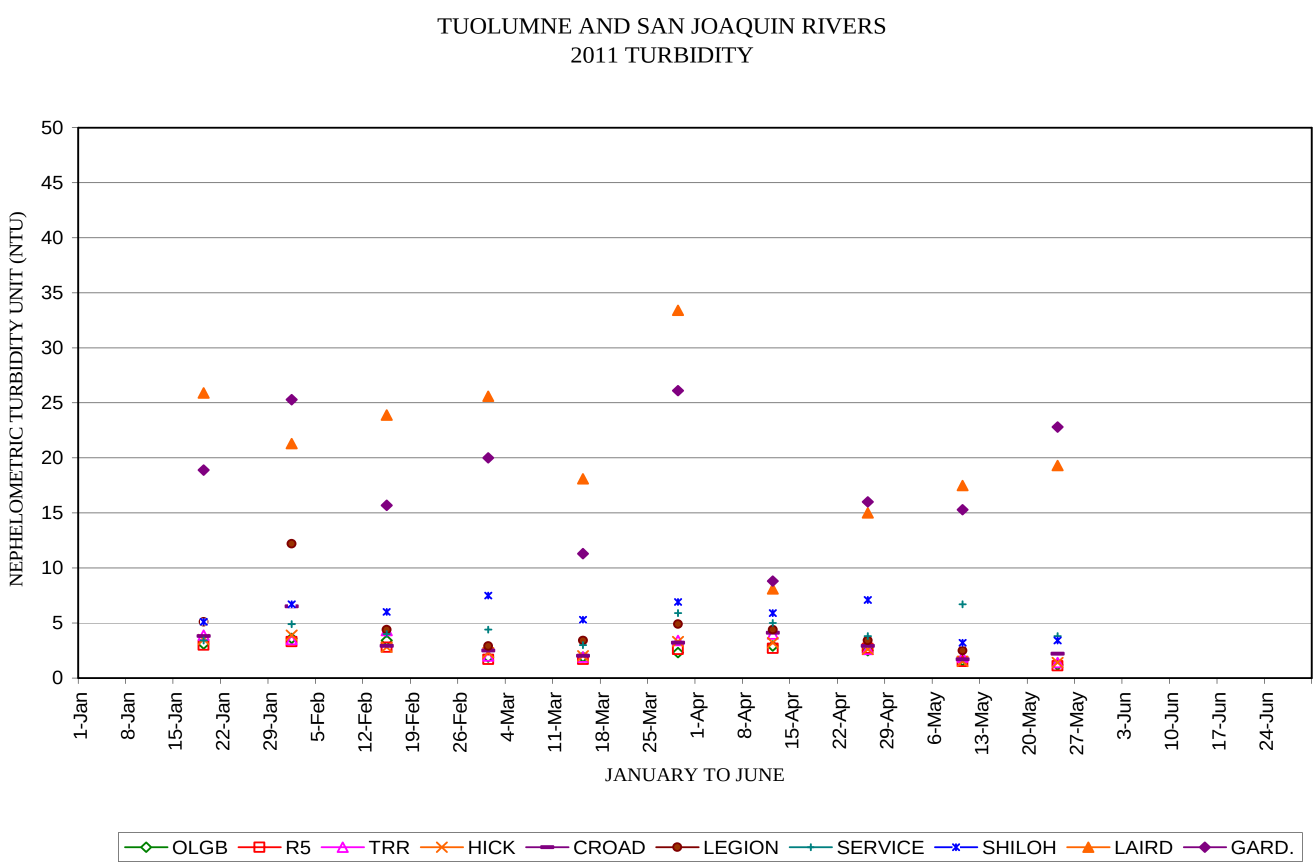
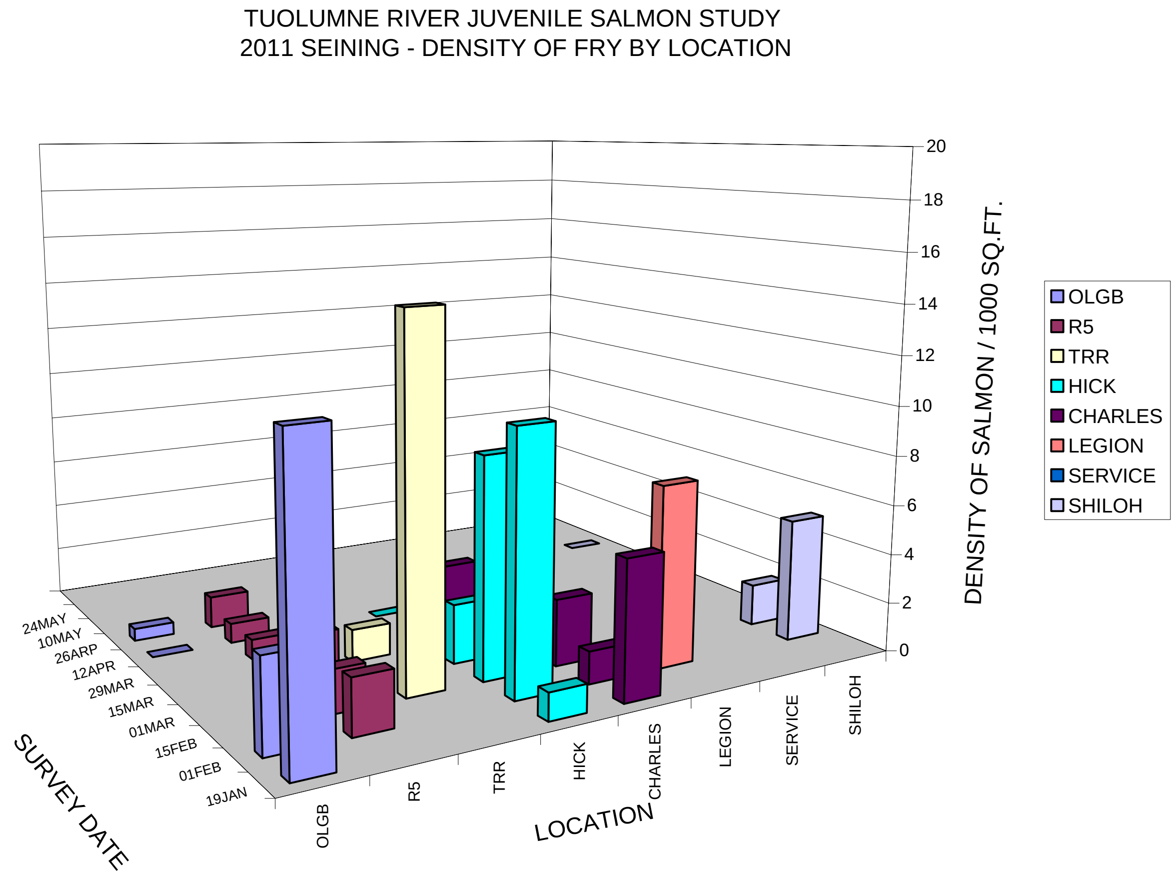


Figure 4. Conductivity and turbidity in the Tuolumne and San Joaquin Rivers, 2011.



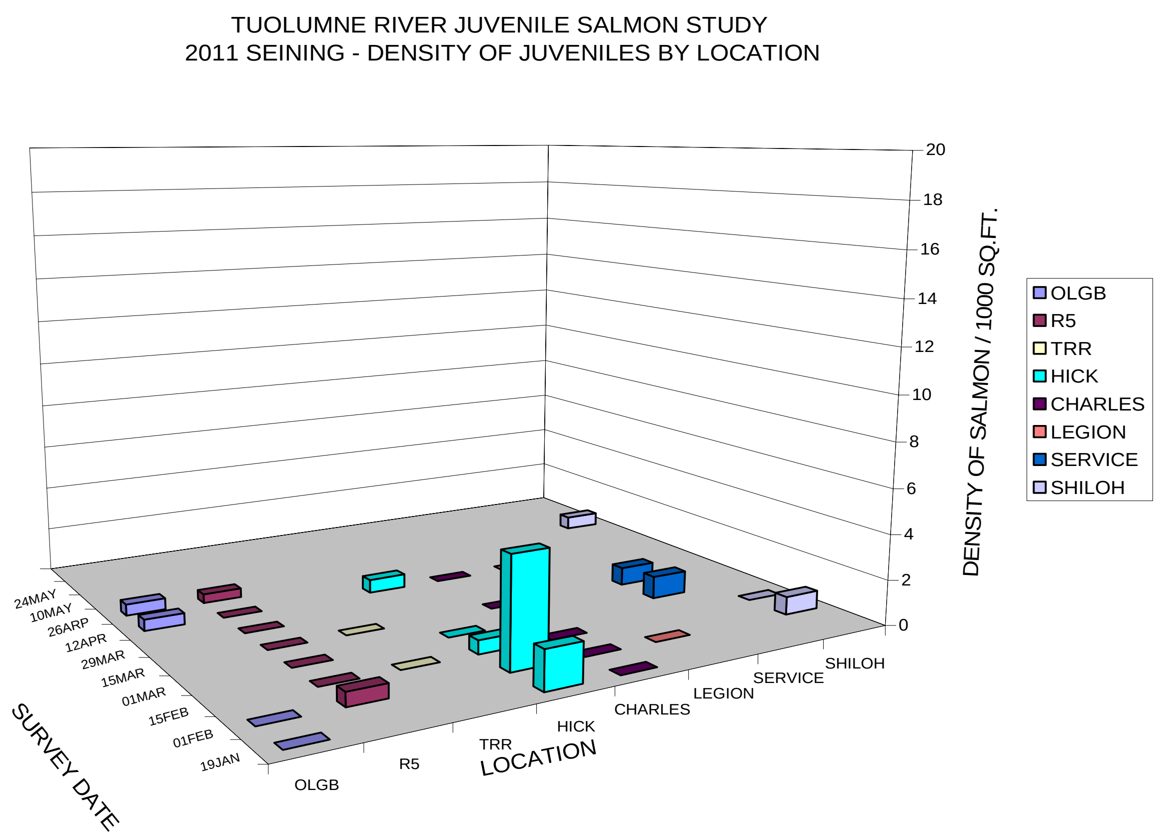


Figure 5. Tuolumne River density of fry and juvenile Chinook salmon by location.

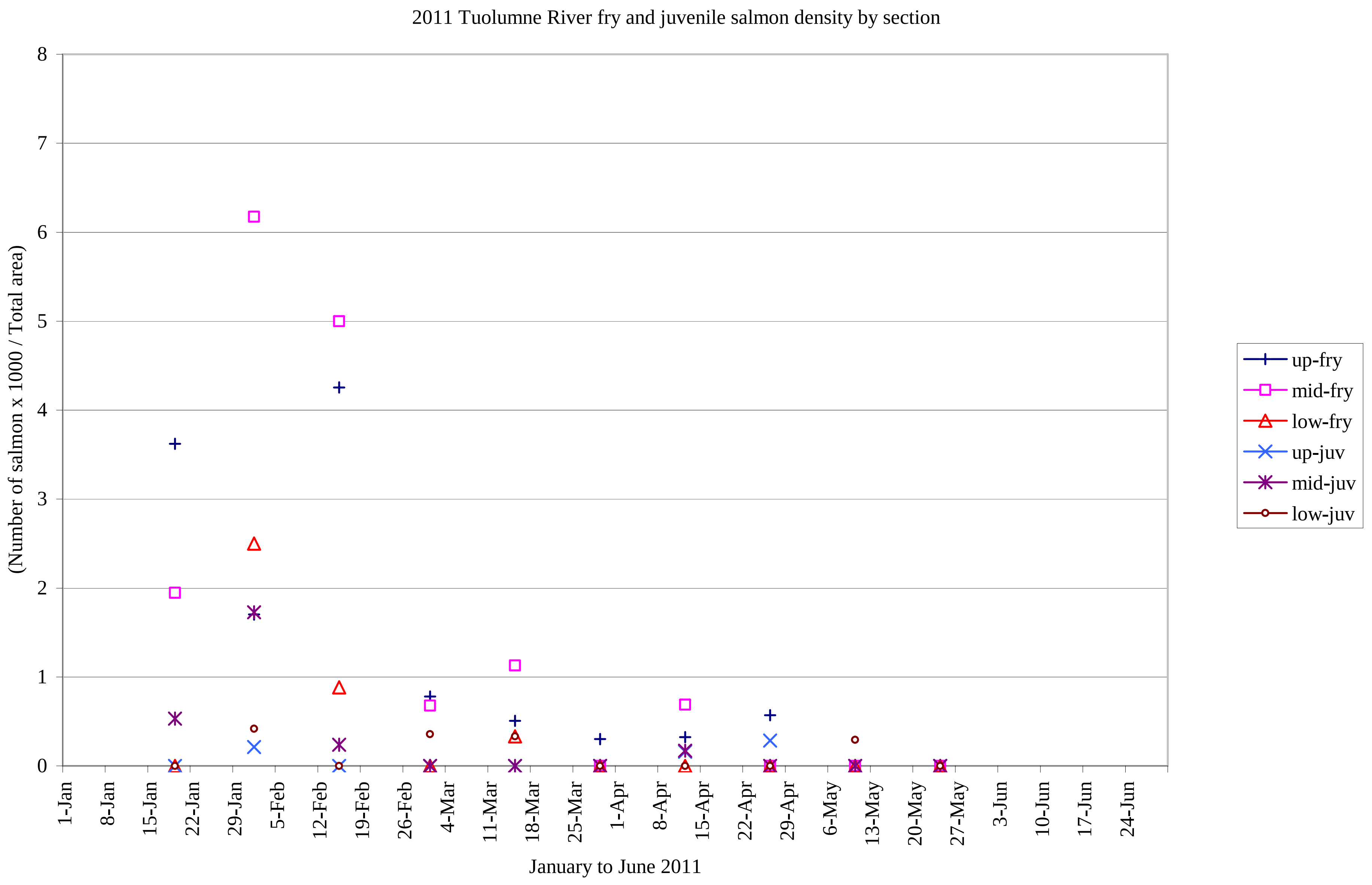


Figure 6. 2011 Tuolumne River fry and juvenile salmon density by section.

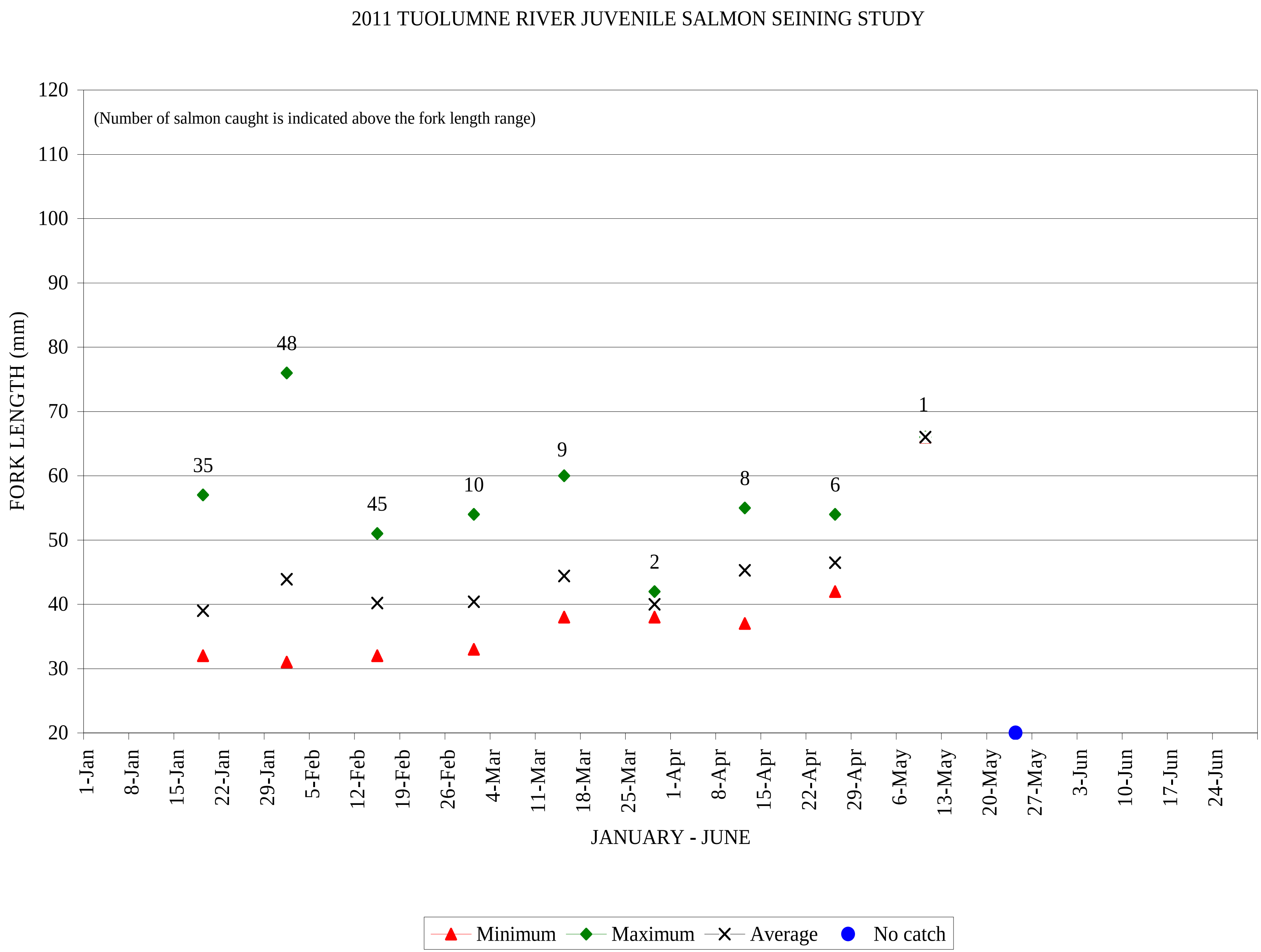
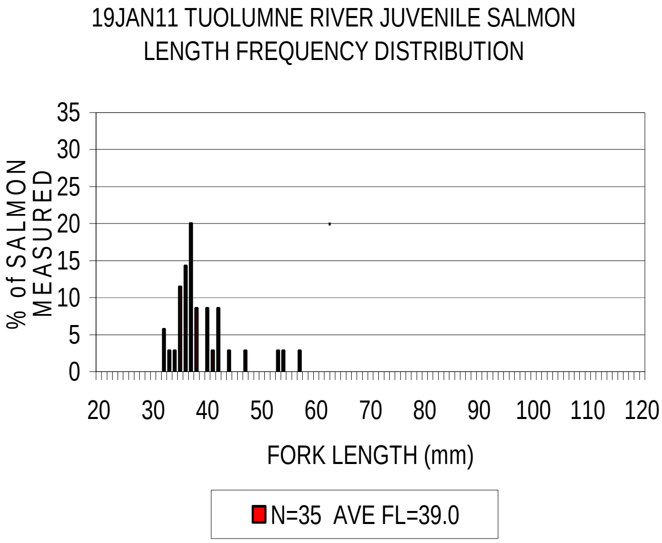
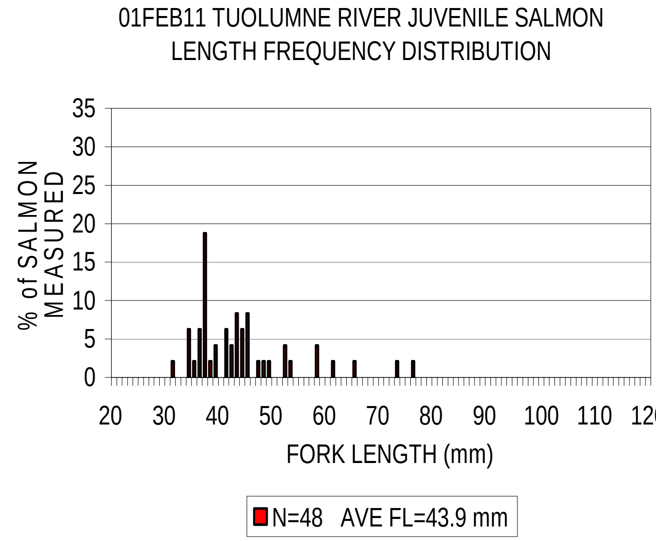
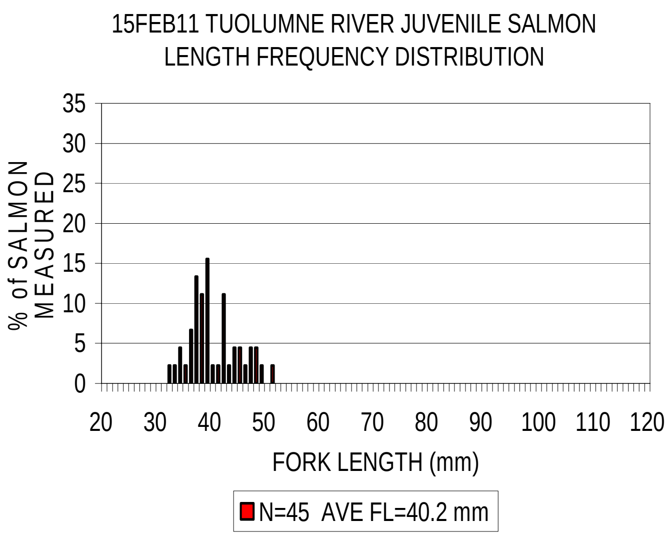
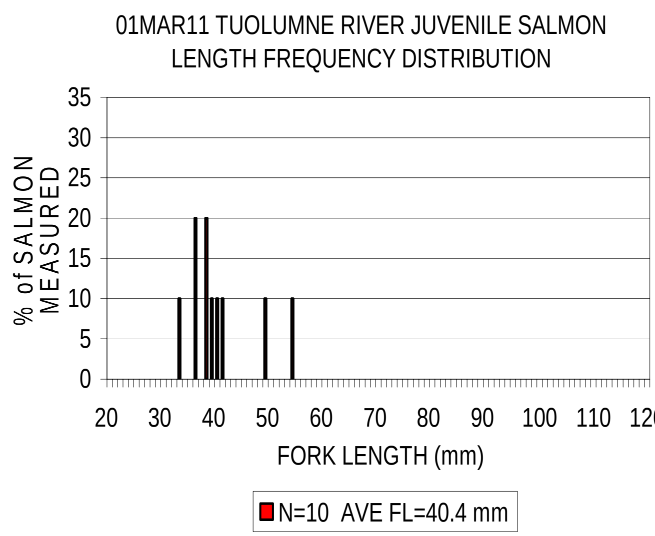


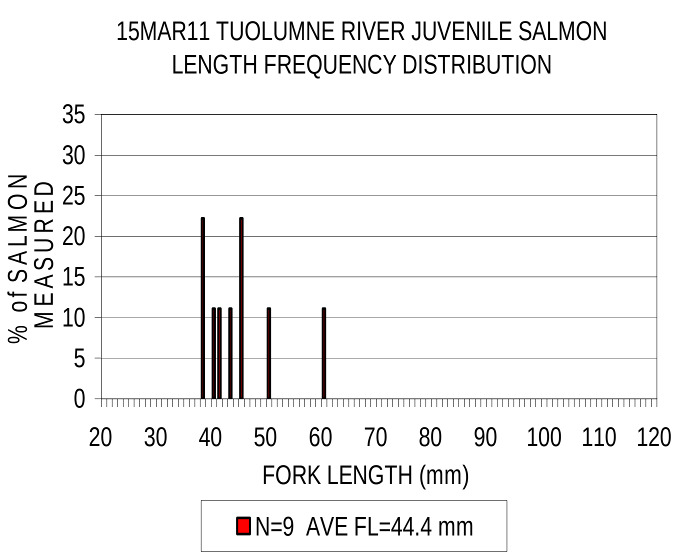
Figure 7. Fork length ranges of wild salmon in the Tuolumne River, 2011.











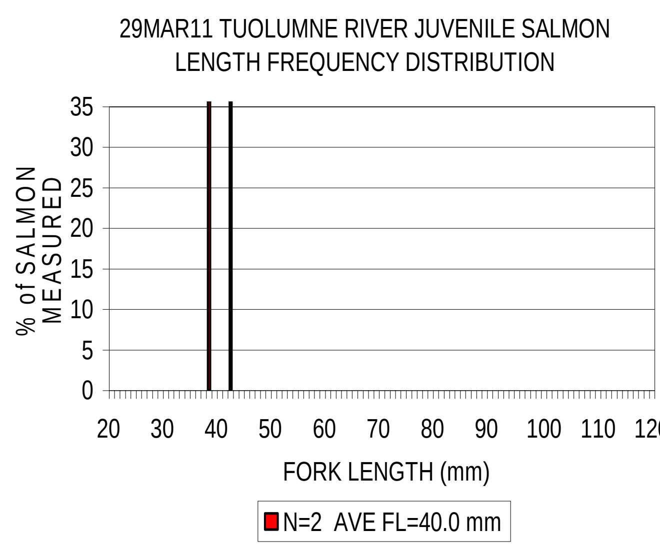


Figure 8. Length frequency distribution by date of salmon in the Tuolumne River, 2011.

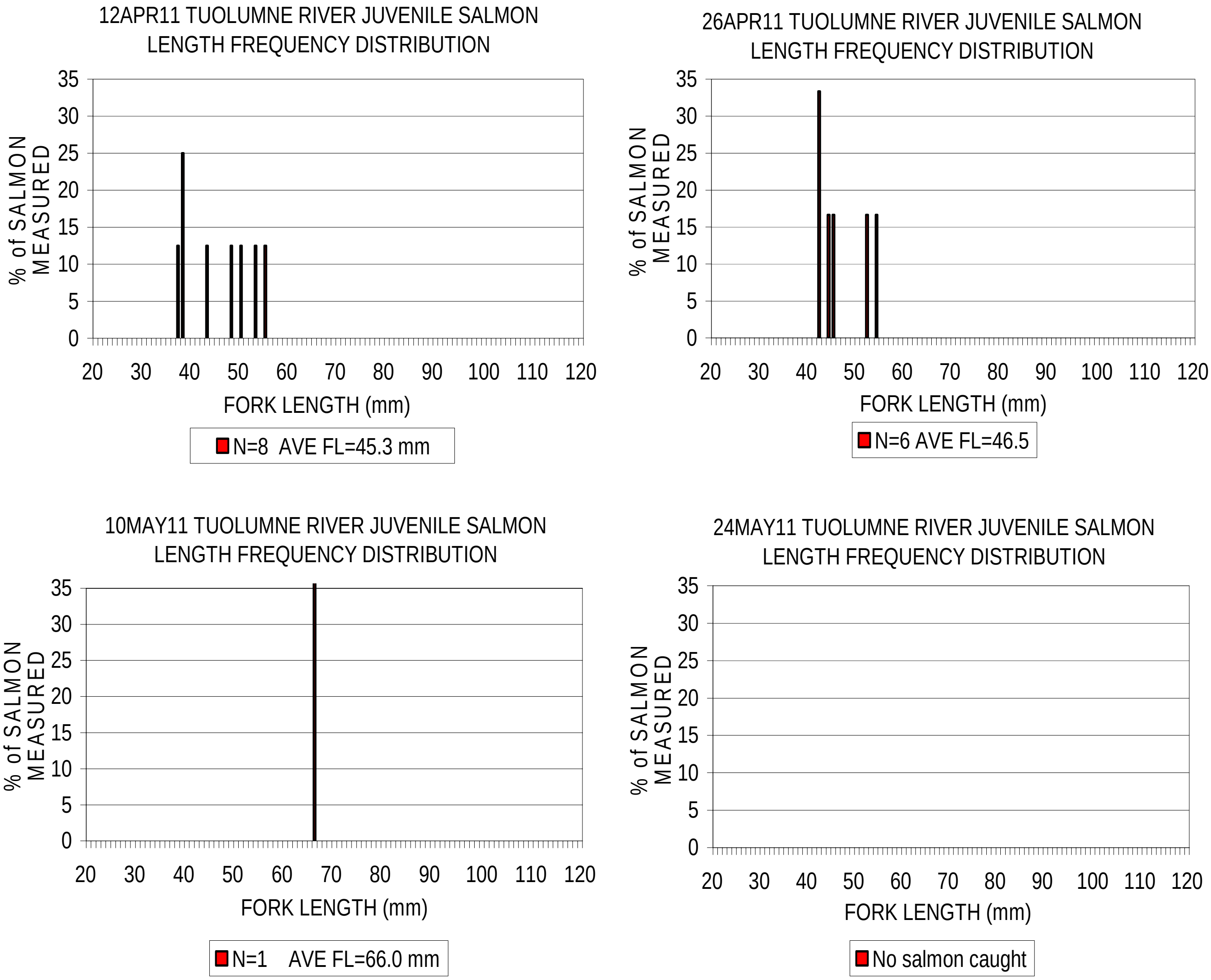
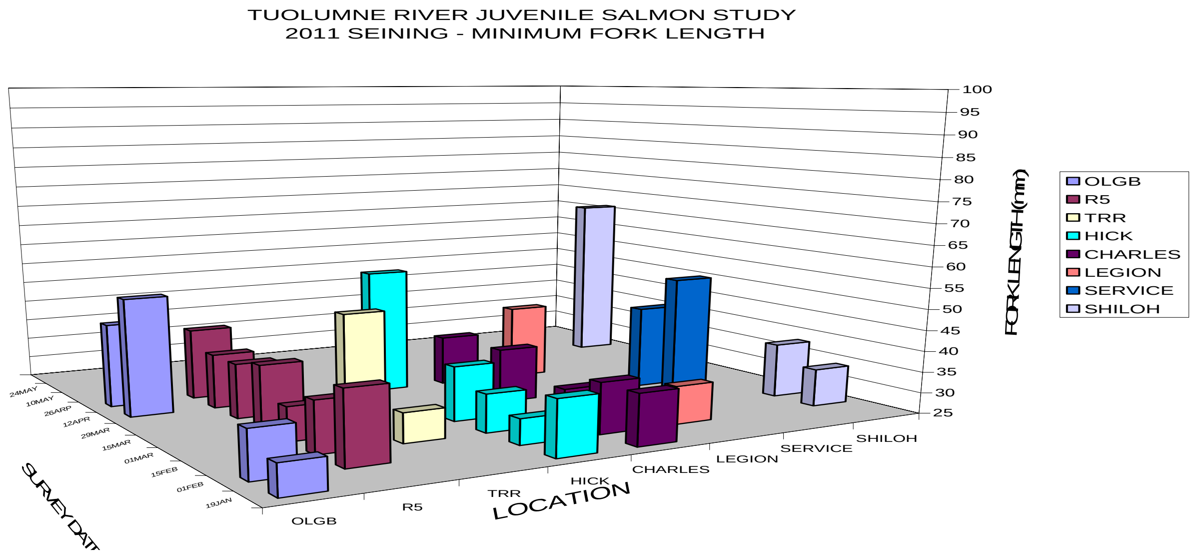
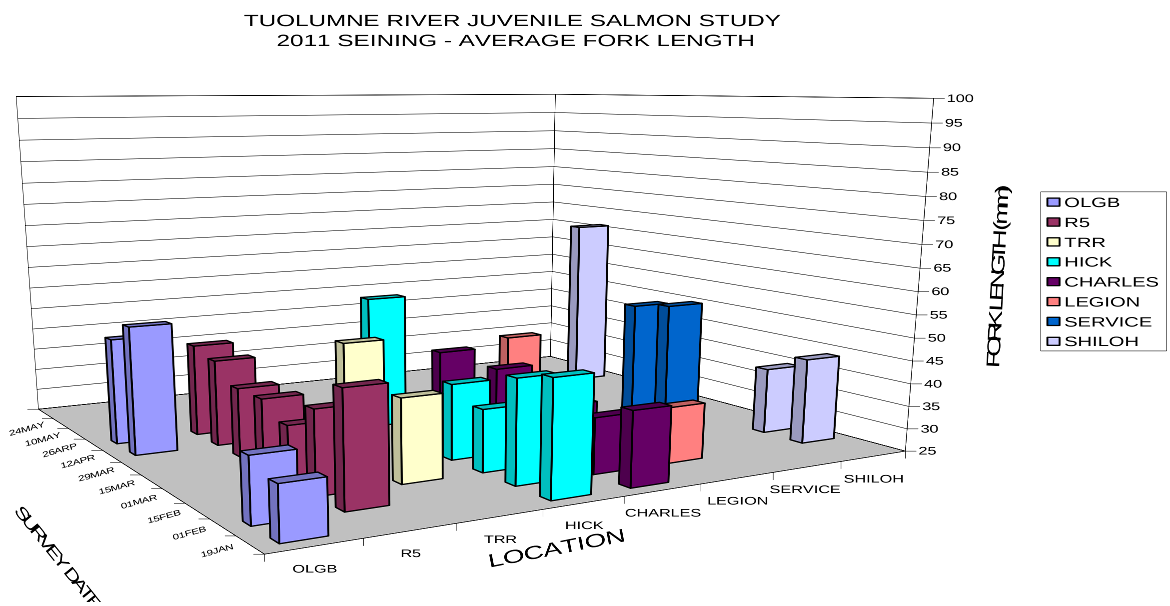


Figure 9. Length frequency distribution by date of salmon in the Tuolumne River, 2011.





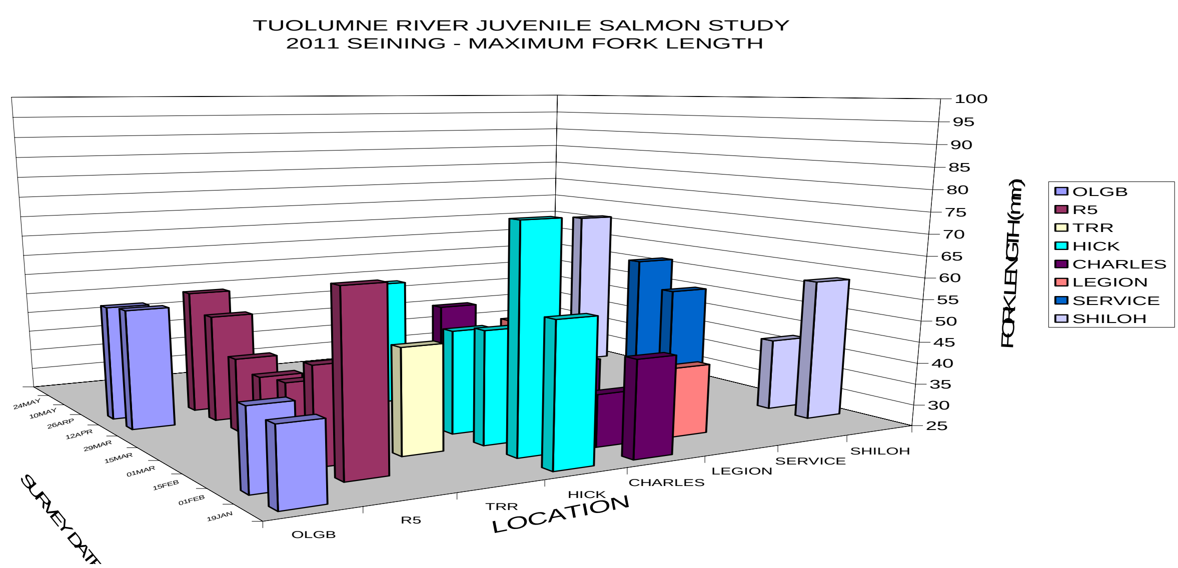
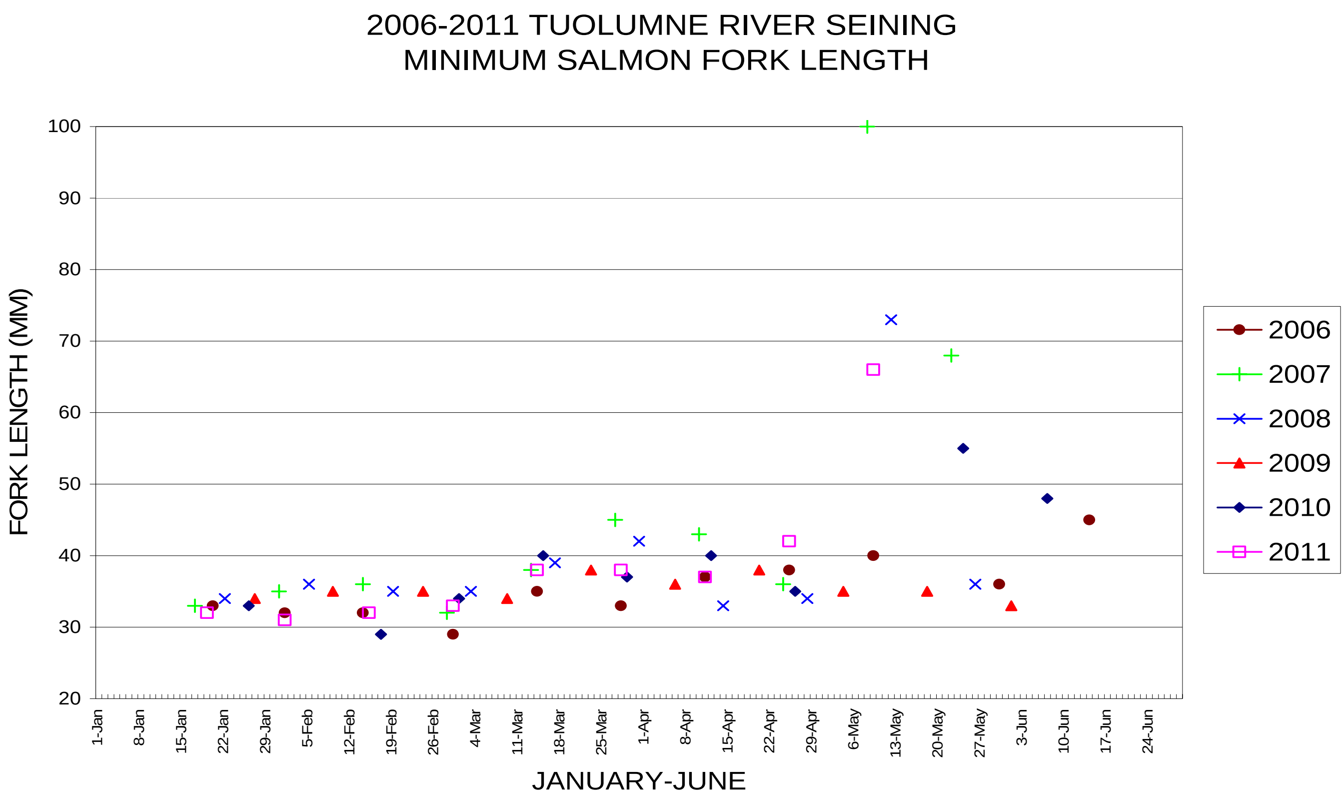
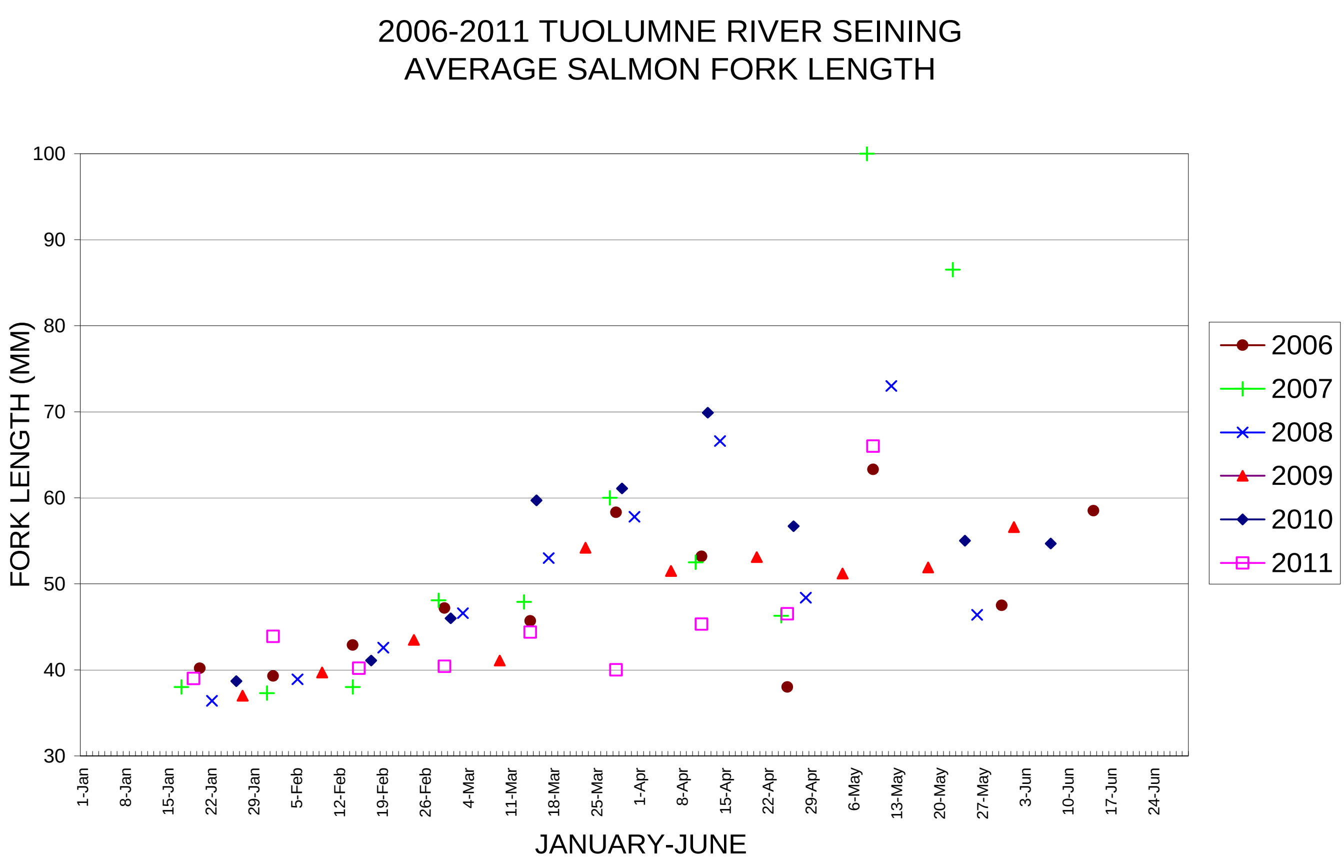


Figure 10. Minimum, average, and maximum Chinook salmon fork length by location and survey period, 2011.





Figures 11 & 12. Minimum and average fork lengths of fry and juvenile Chinook salmon, 2006-2011.

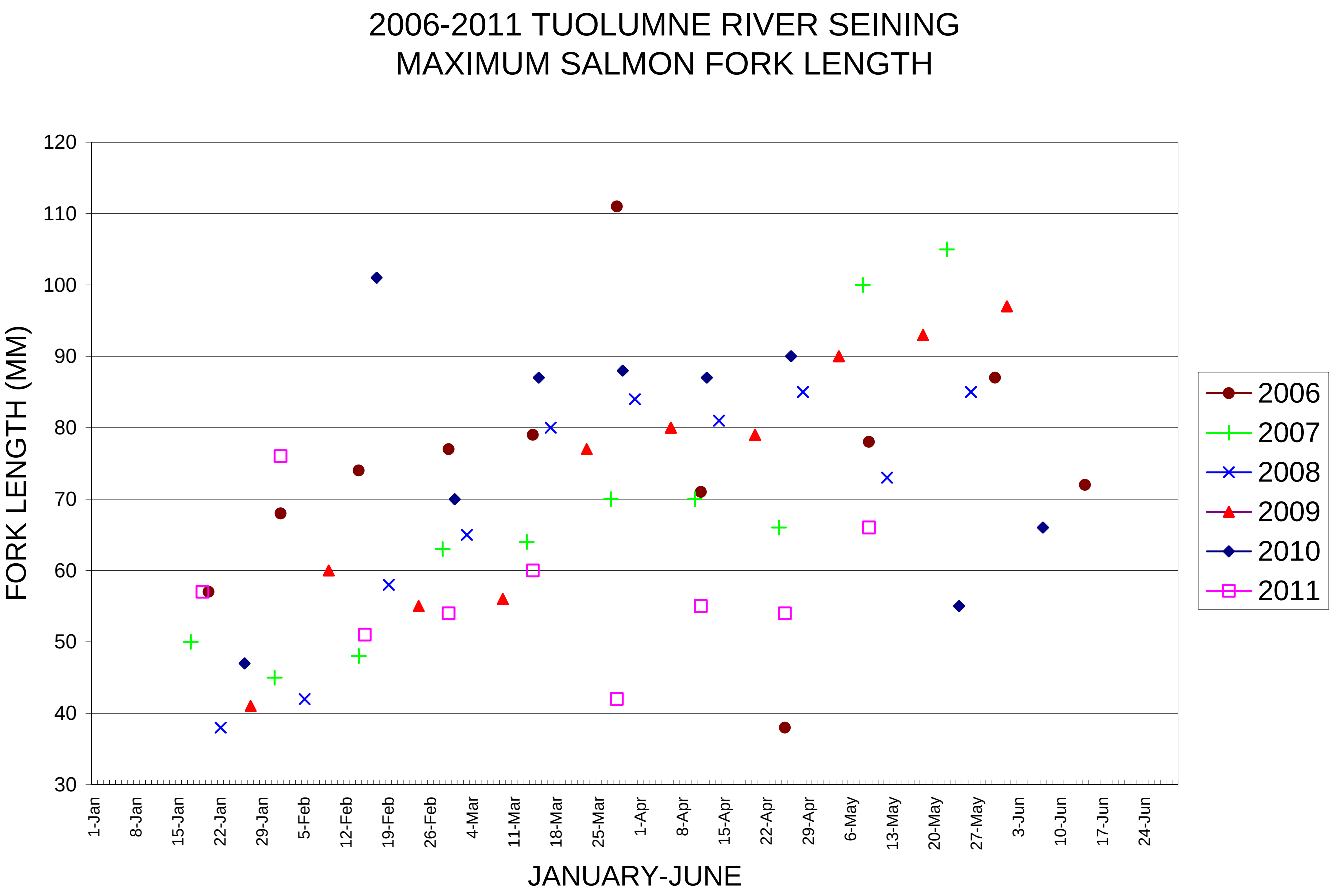
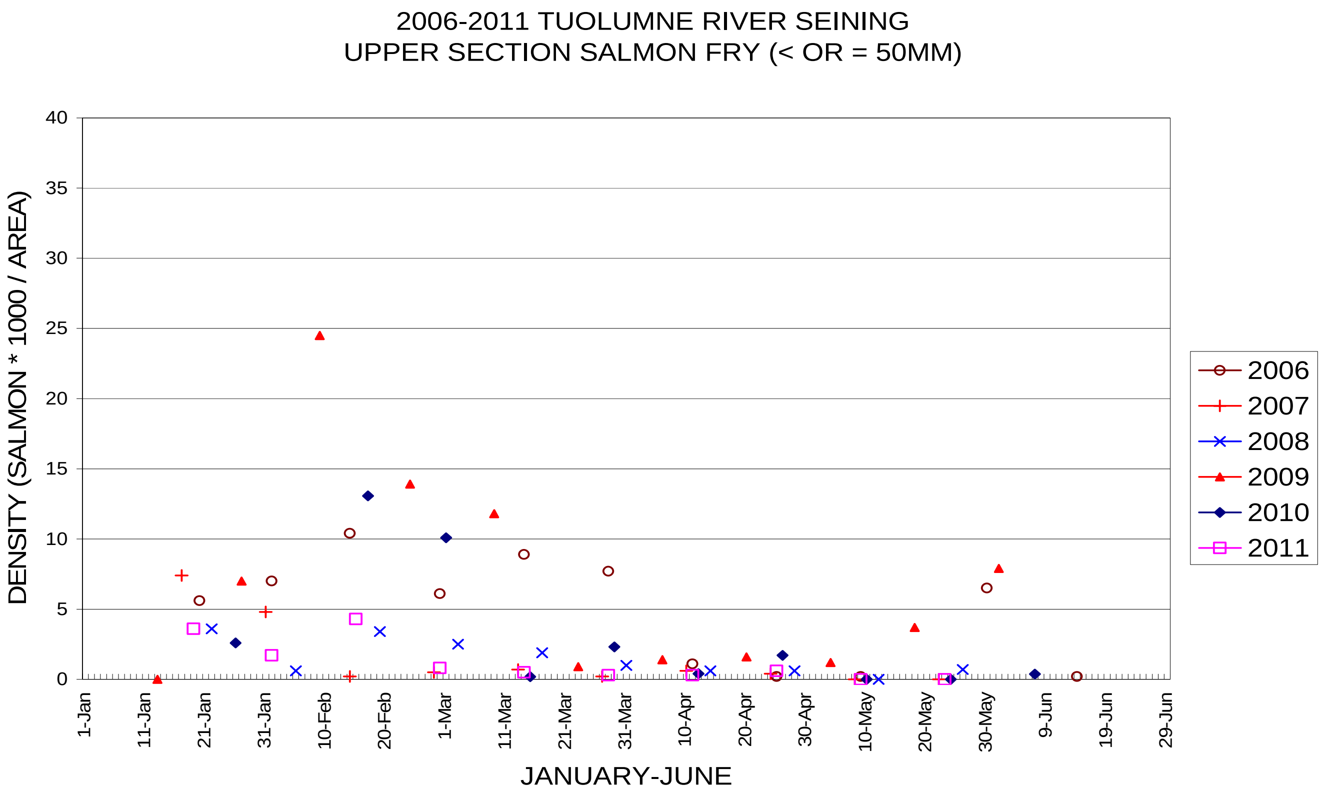


Figure 13. Maximum fork length of Tuolumne River Chinook salmon fry, 2006-2011.



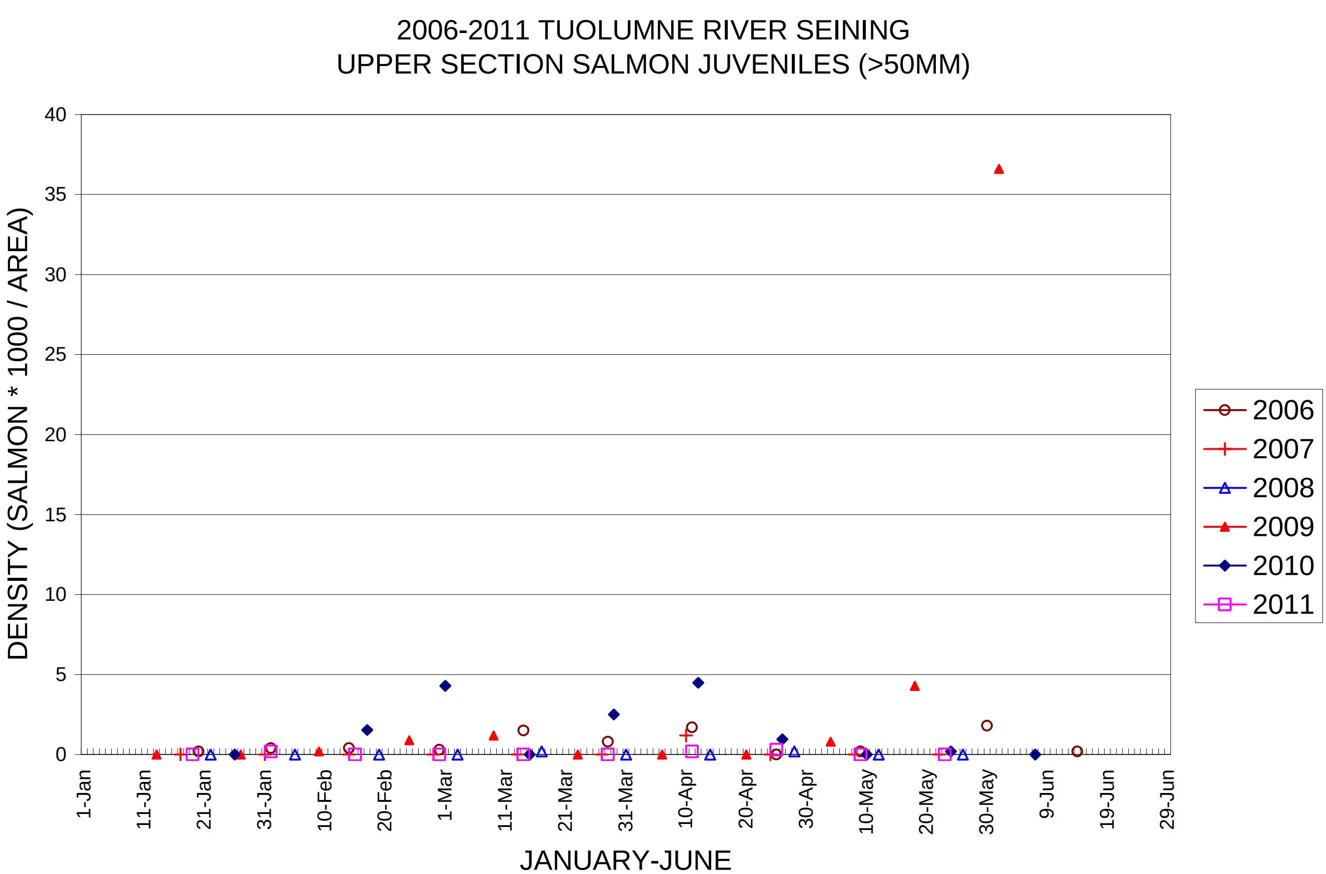
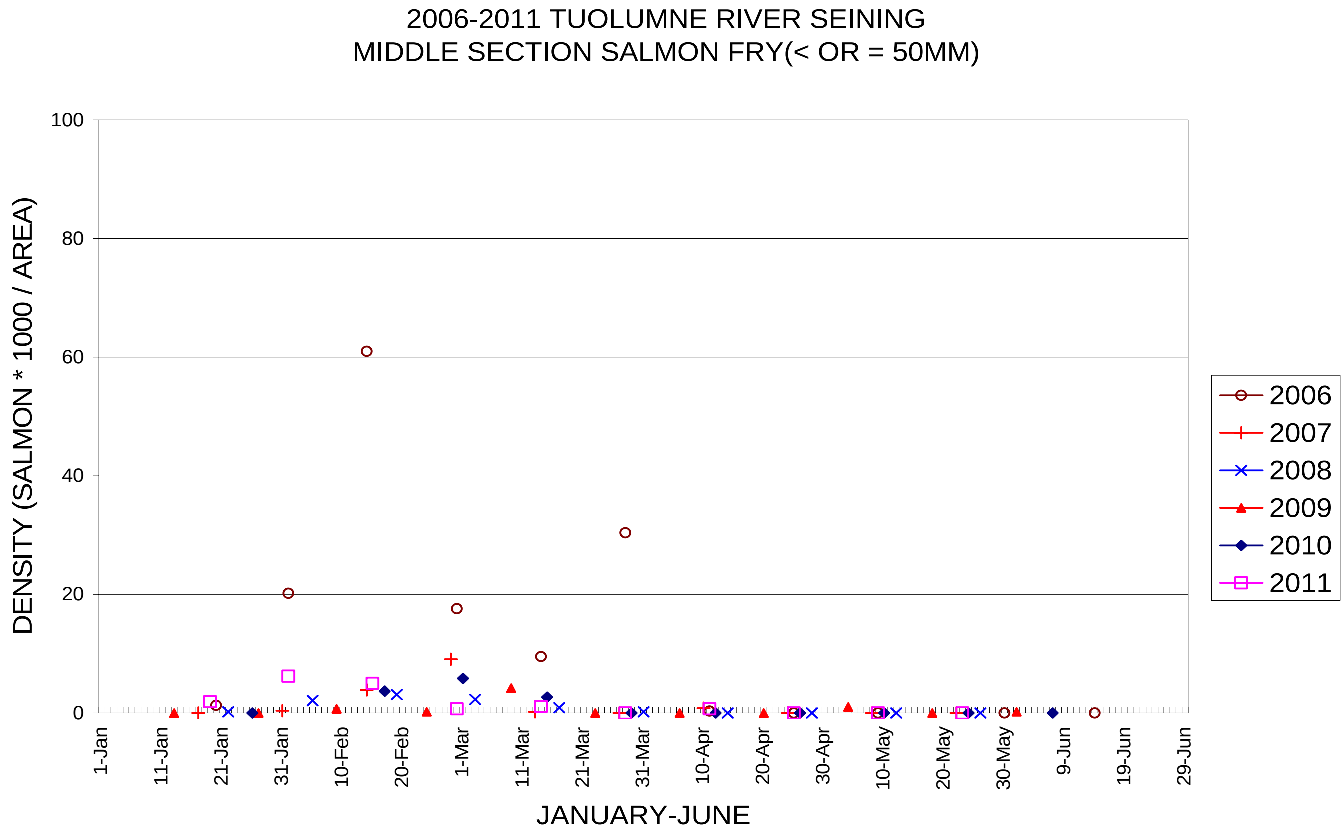


Figure 14. Upper section density indices for salmon fry and juveniles, 2006-2011.



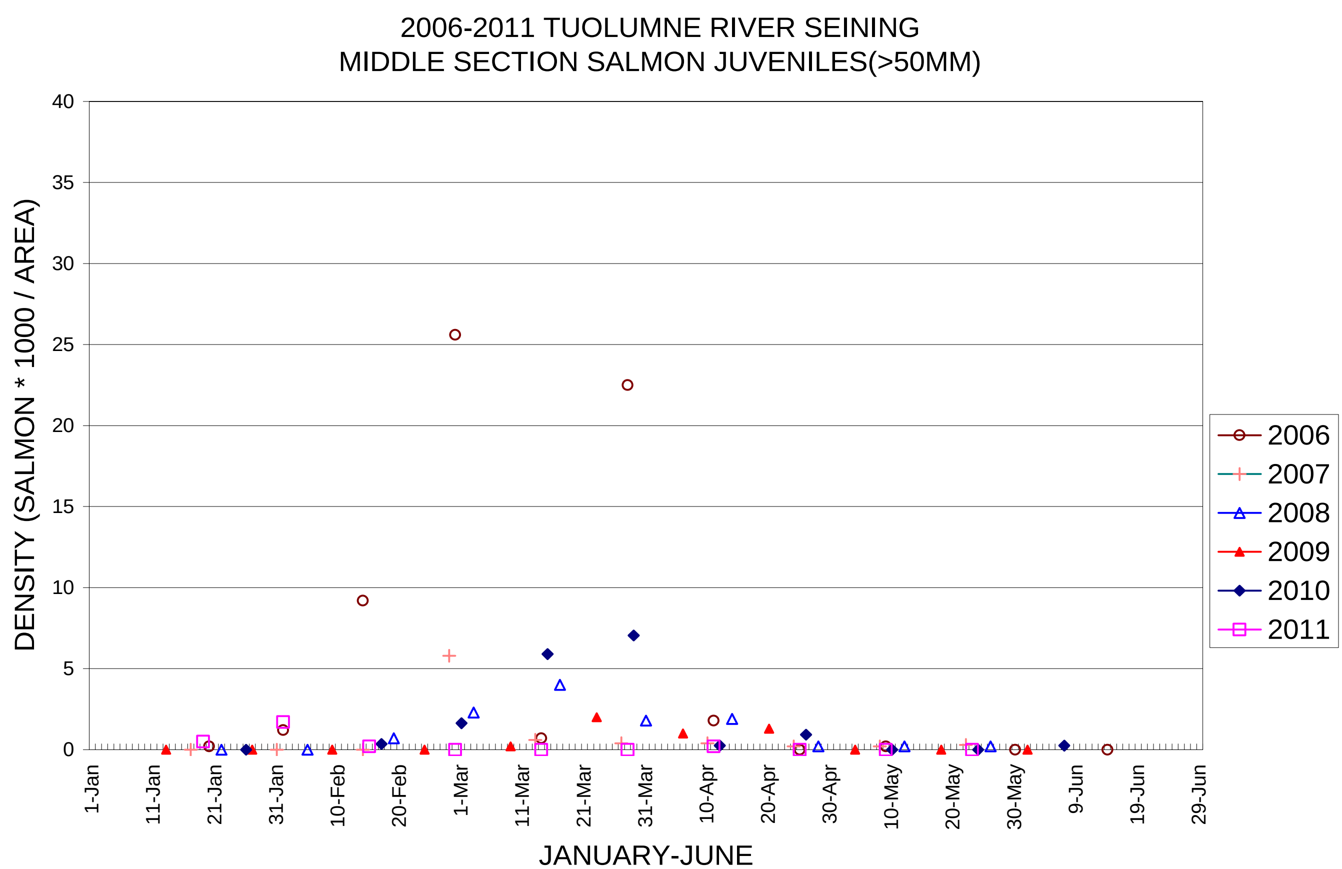
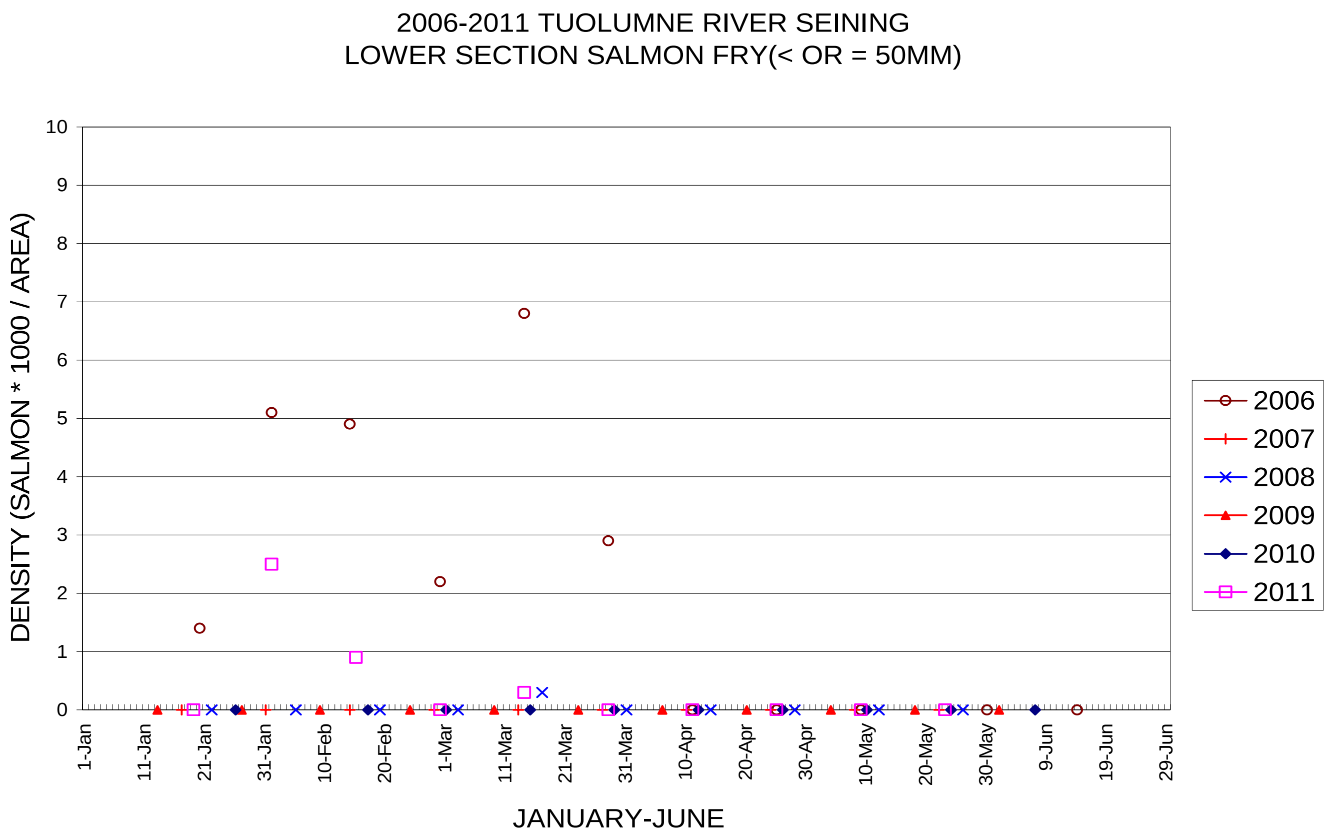


Figure 15. Middle section density indices for salmon fry and juveniles, 2006-2011.



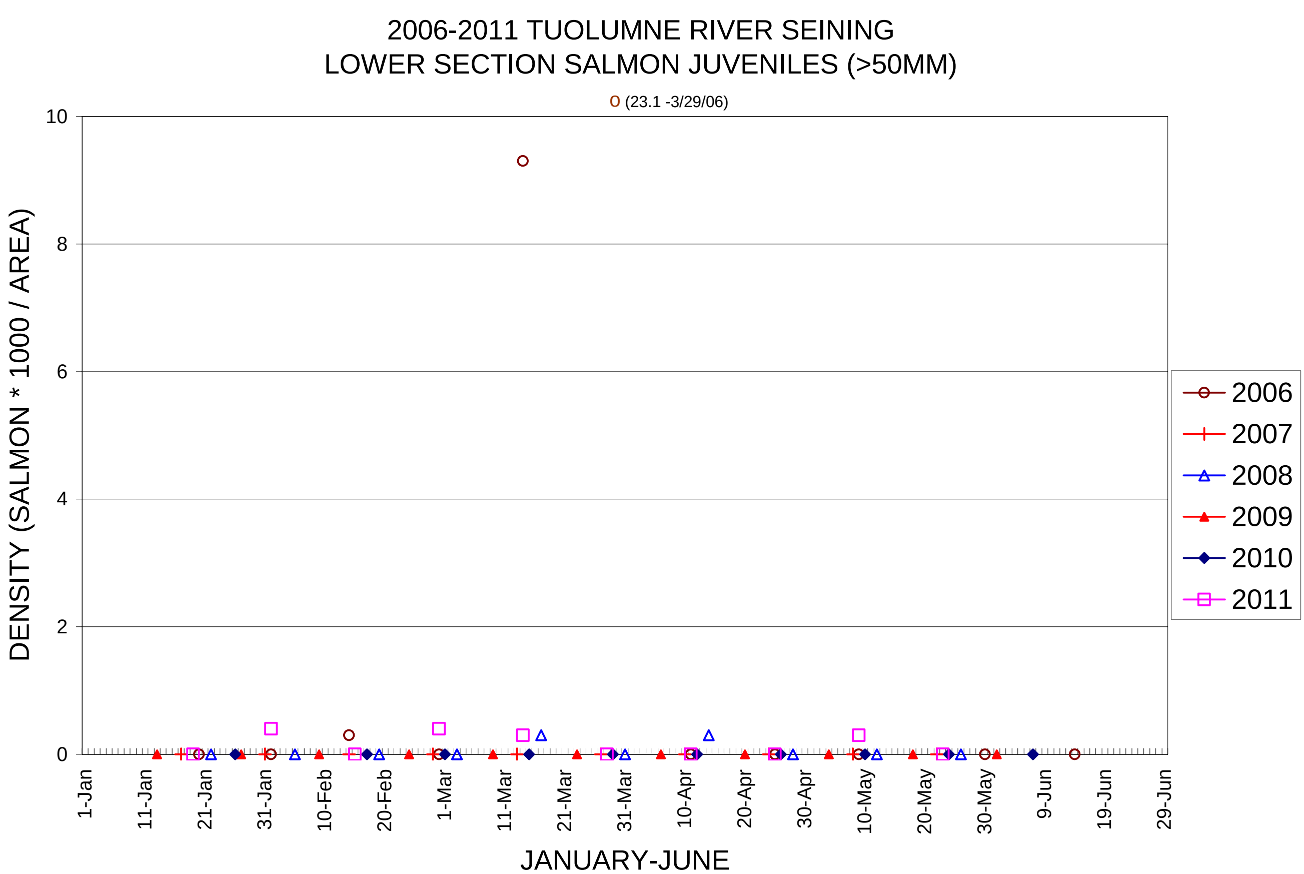


Figure 16. Lower section density indices for salmon fry and juveniles, 2006-2011.

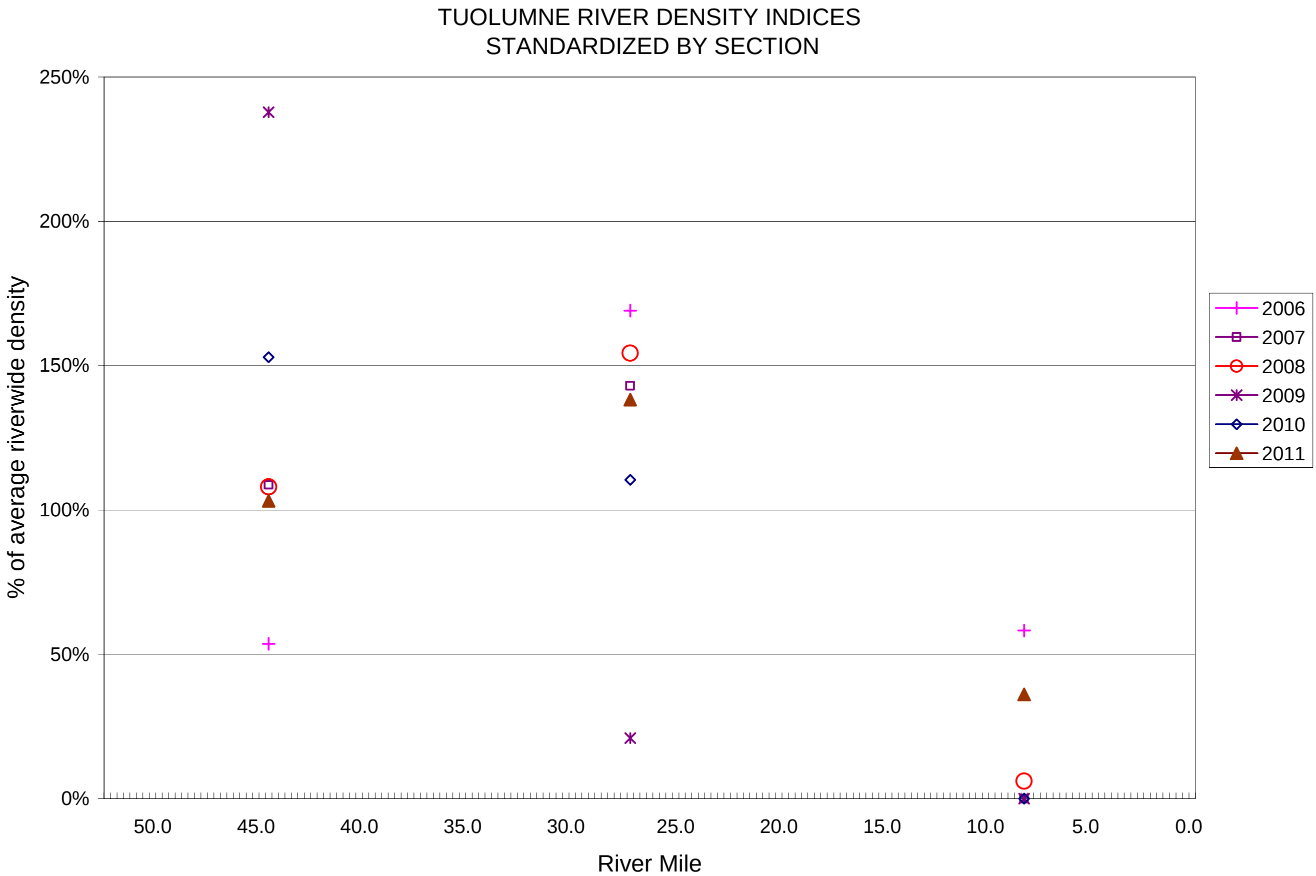


Figure 17. Tuolumne River abundance indices standardized by section, 2006-2011.

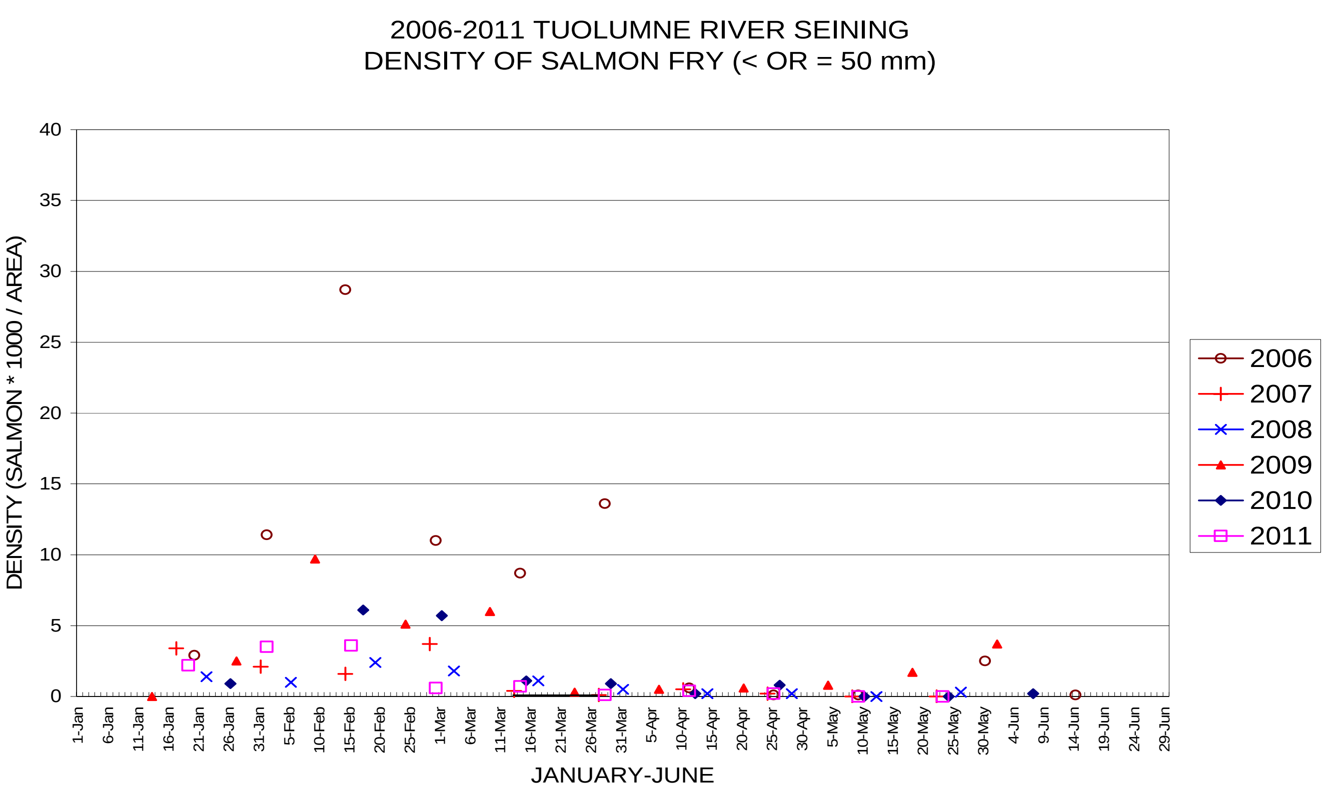
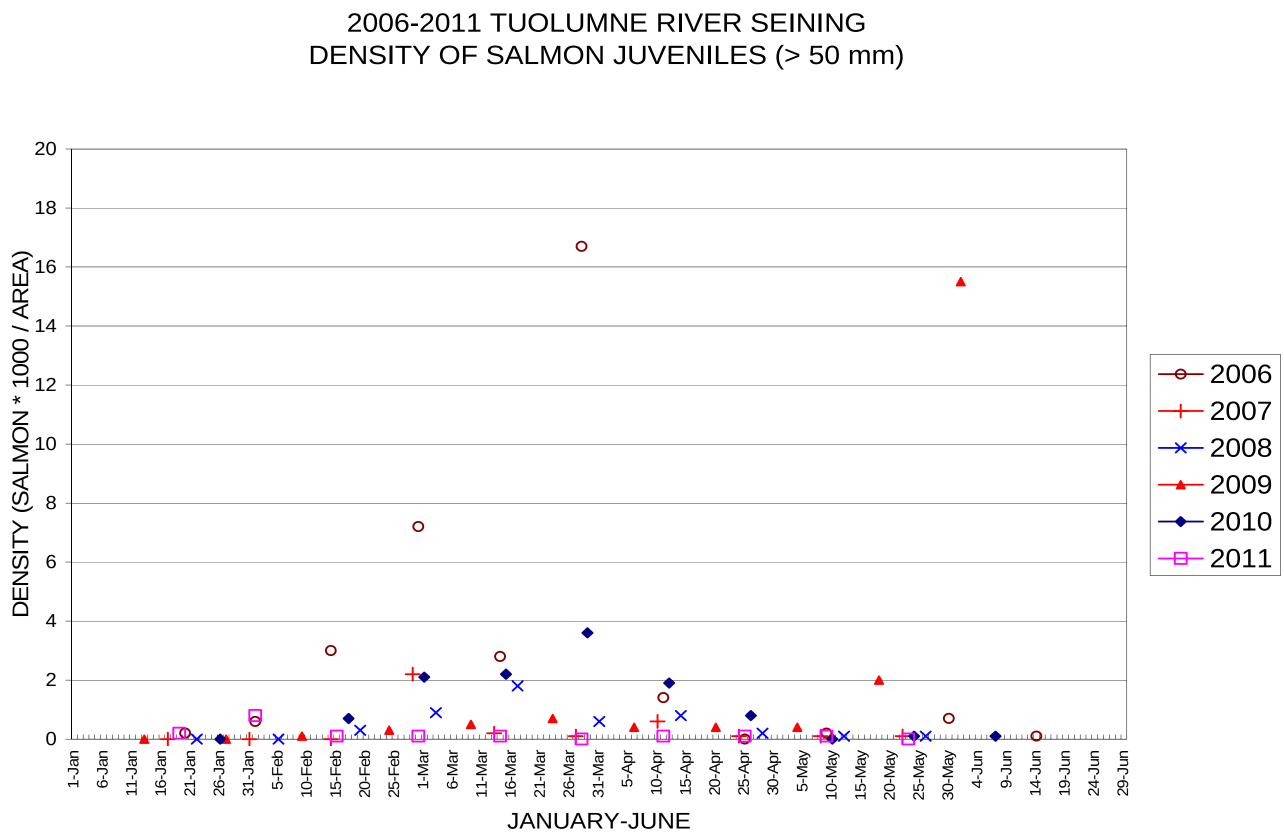
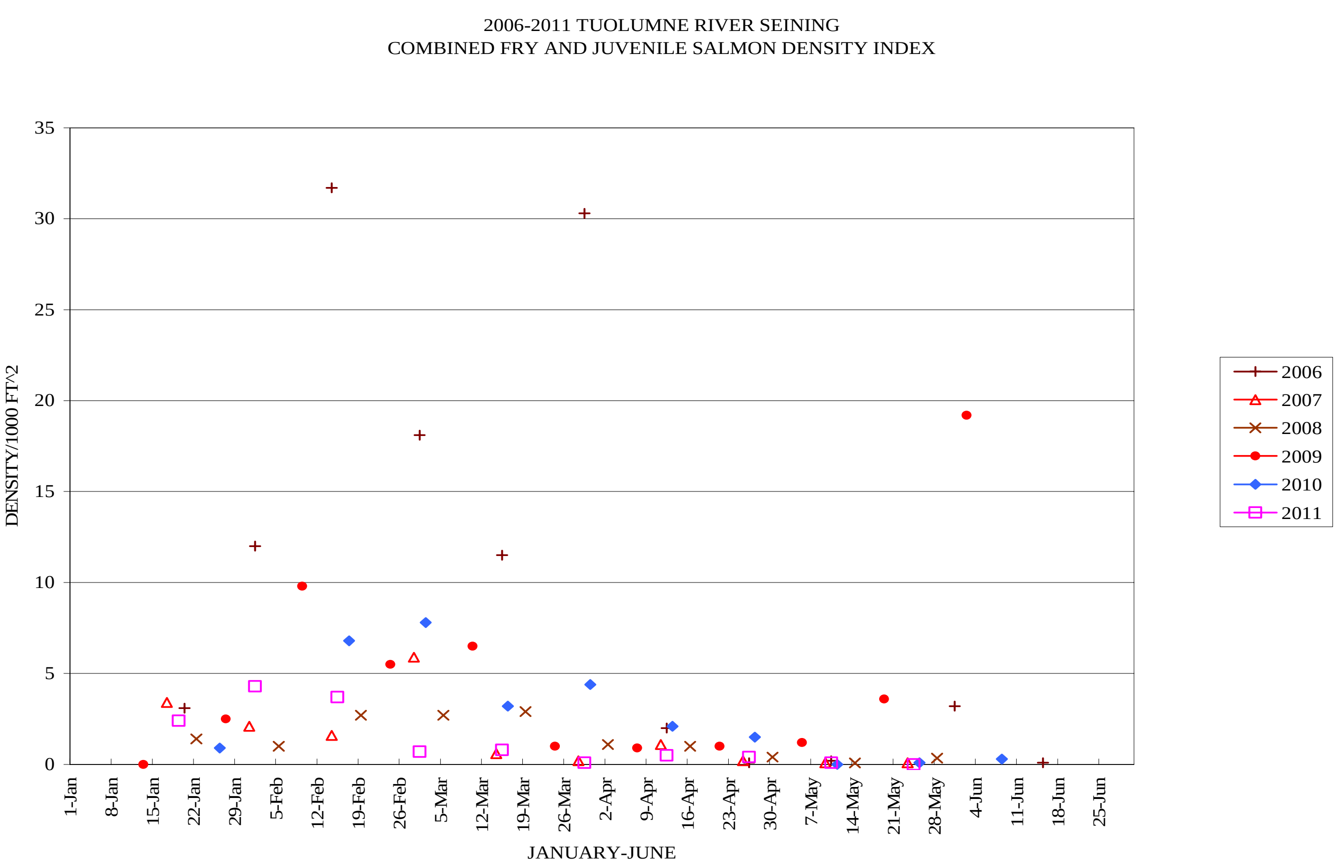


Figure 18. Density of Tuolumne River Chinook salmon fry, 2006-2011.





Figures 19 & 20. Density index of Chinook salmon juveniles (>50 mm) and combined fry and juvenile catch, 2006-2011.

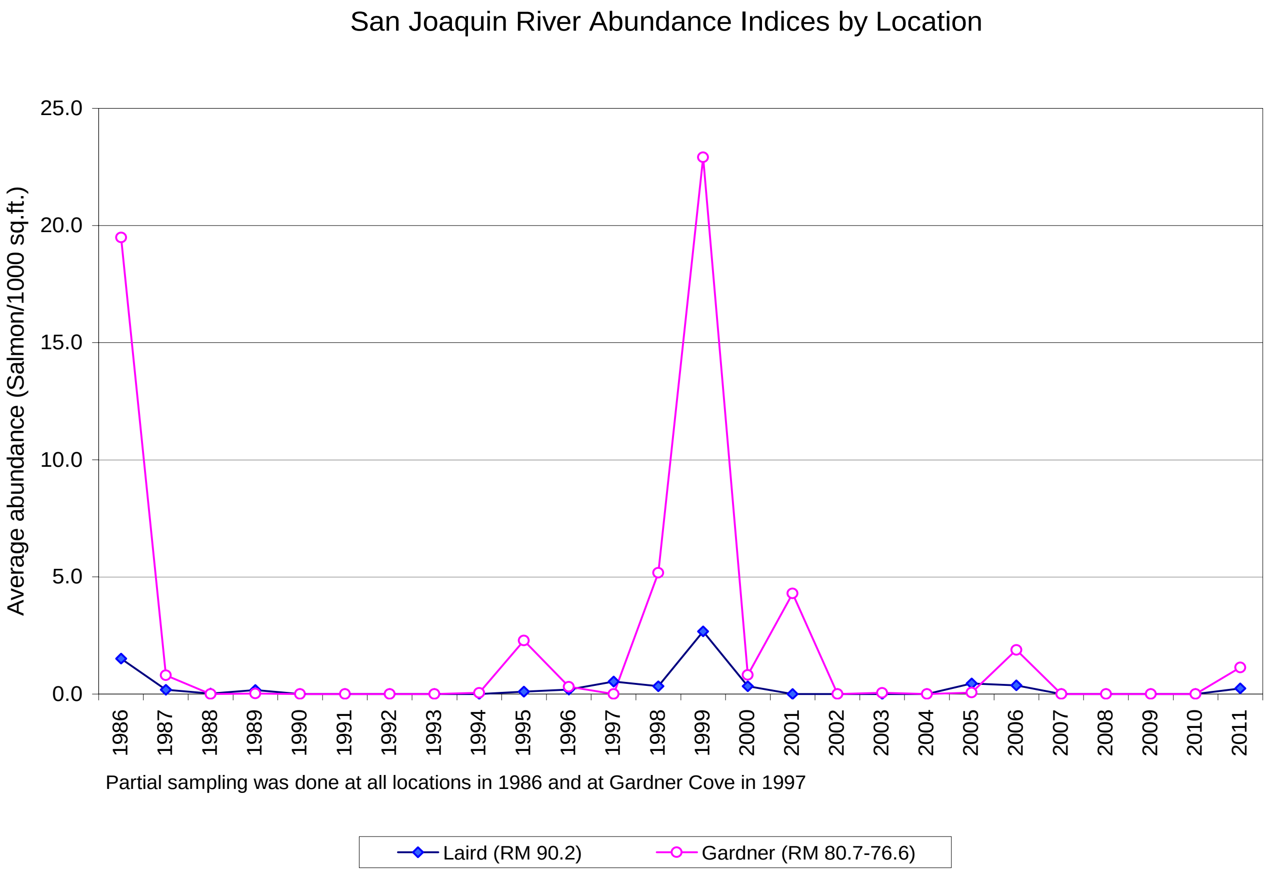


Figure 21. San Joaquin River Chinook salmon abundance indices by location, 1986-2011.

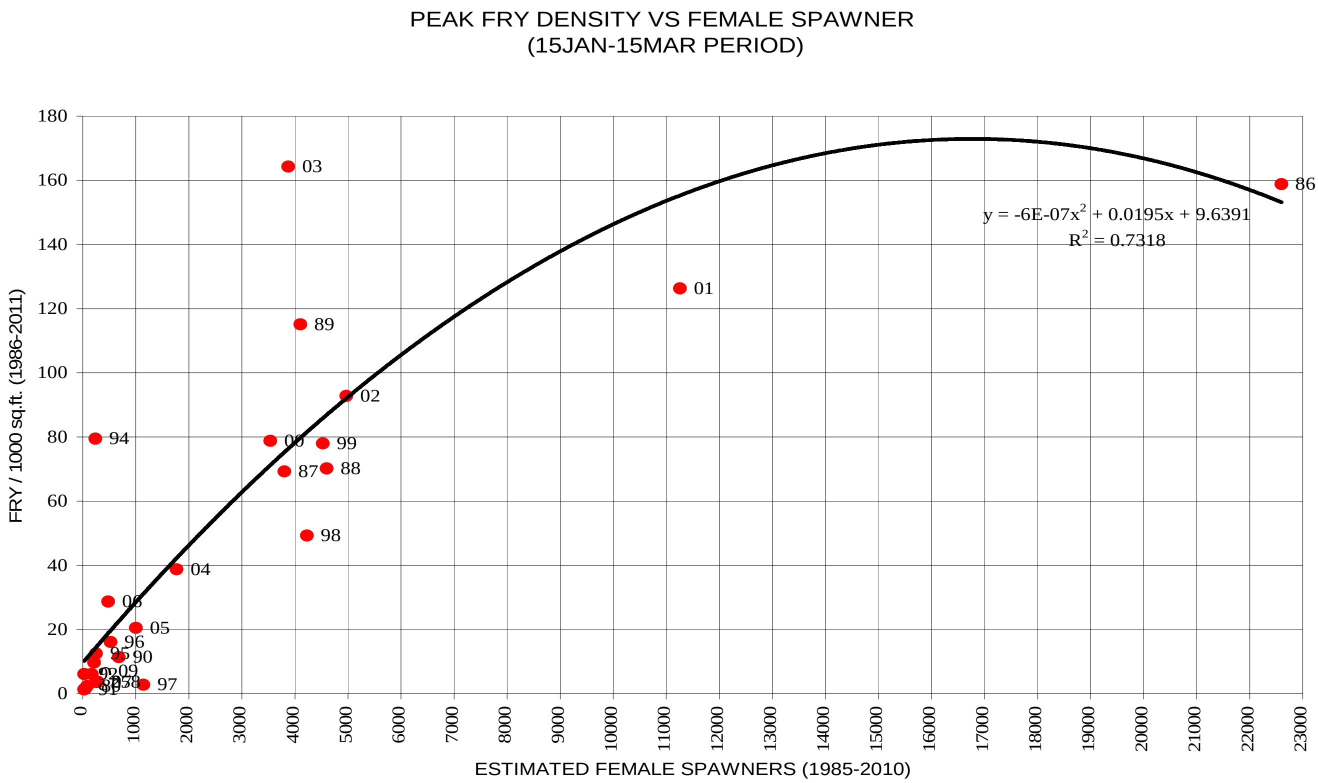


Figure 22. Tuolumne River peak Chinook salmon fry density vs female spawners.

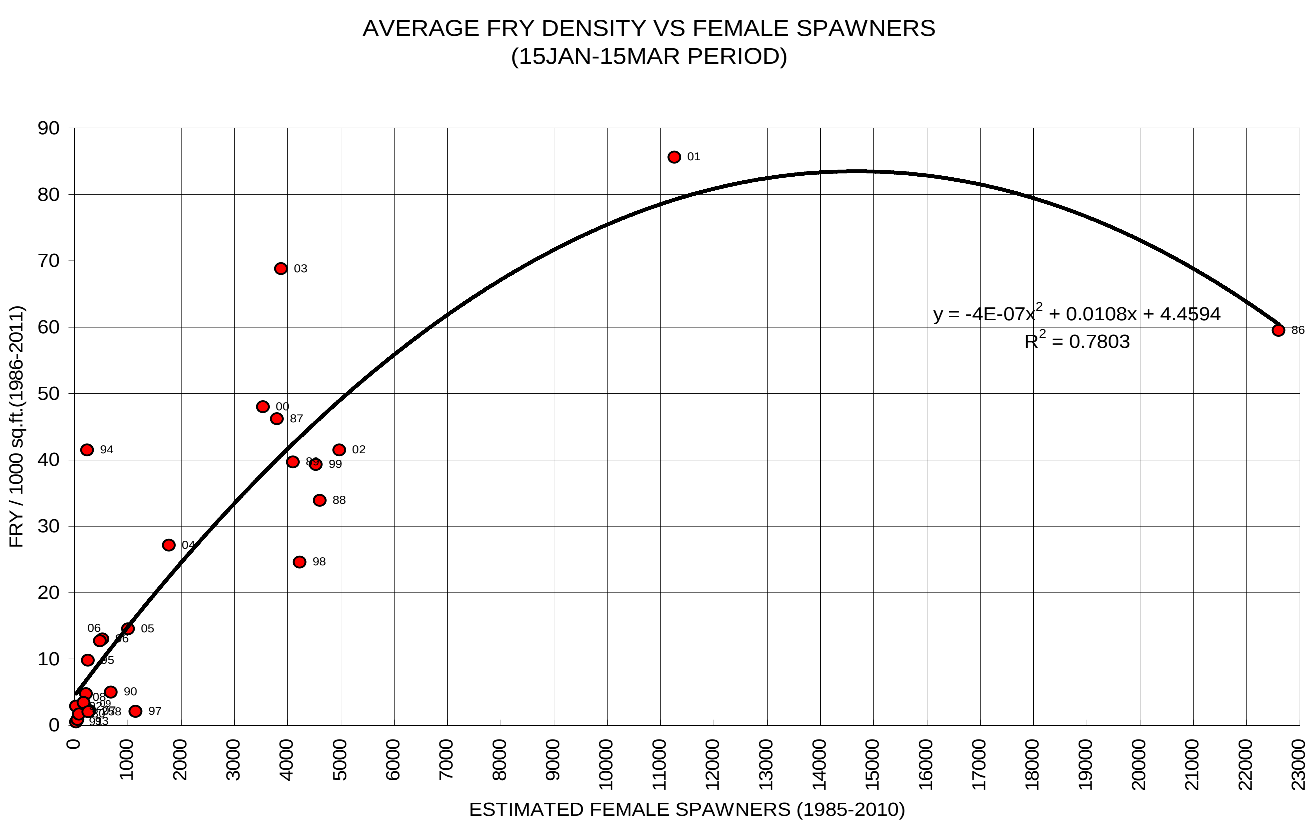


Figure 23. Tuolumne River average Chinook salmon fry density vs female spawners.

Table 1. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2011.

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
19JAN	OLGB	50.5	21	1,800	11.7	32	42	35.9	21	0	0	10.8	28		3.6	2.5	0.0	3.1	12.8
19JAN	R4B	48.4	0	2,000	0.0							10.8	29					3.0	12.5
19JAN	TLSRA	42.0	0	2,000	0.0							10.9	36					3.9	11.4
19JAN	HICK	31.6	5	1,800	2.8	38	57	49.2	5	0	0	10.6	33					3.5	11.4
19JAN	CHARLES	24.9	9	1,650	5.5	37	47	40.8	9	0	0	10.5	29					3.8	11.0
19JAN	LEGION	17.2	0	2,200	0.0							10.8	36					5.1	9.8
19JAN	VENN	6.4	0	1,650	0.0							10.9	38					3.4	9.4
19JAN	SHILOH	3.4	0	1,650	0.0							10.8	32					5.1	9.8
19JAN	LAIRD	90.2	0	1,350	0.0							11.3	359					25.9	7.5
19JAN	GARDNER	79.5	0	600	0.0							10.9	202					18.9	9.5
TR TOT.			35	14,750	2.4	32	57	39.0	35	0	0								
SJR TOT.			0	1,950	0.0														

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
01FEB	OLGB	50.5	4	1,100	3.6	36	43	38.3	4	0	0	10.5	37		1.9	7.9	2.9	3.6	11.9
01FEB	R5	48.0	5	1,800	2.8	42	65	48.8	5	0	0	10.6	35					3.3	N.A.
01FEB	TRR	42.3	0	1,800	0.0							10.5	38					3.5	12.1
01FEB	HICK	31.6	22	1,450	15.2	31	76	47.0	22	0	0	10.3	38					3.9	12.1
01FEB	CHARLES	24.9	2	1,500	1.3	37	37	37.0	2	0	0	10.8	42					6.5	10.8
01FEB	LEGION	17.2	8	1,100	7.3	34	41	37.1	8	0	0	11.1	45					12.2	11.1
01FEB	VENN	6.4	0	1,200	0.0							11.5	57					4.9	8.7
01FEB	SHILOH	3.4	7	1,200	5.8	34	58	43.9	7	0	0	11.2	47					6.7	10.8
01FEB	LAIRD	90.2	0	1,200	0.0							10.7	394					21.3	10.7
01FEB	GARDNER	79.5	2	1,200	1.7	42	43	42.5	2	0	0	10.9	279					25.3	10.5
TR TOT.			48	11,150	4.3	31	76	43.9	48	0	0								
SJR TOT.			2	2,400	0.8	42	43	42.5	2	0	0								

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
15FEB	OLGB	50.5	0	1,200	0.0							10.4	35		4.3	5.2	0.9	3.4	12.7
15FEB	R5	48.0	4	2,400	1.7	37	47	42.5	4	0	0	10.6	35					2.8	12.4
15FEB	TLSRA	42.0	16	1,100	14.5	32	49	42.7	16	0	0	10.6	38					4.3	11.8
15FEB	HICK	31.6	16	1,700	9.4	34	51	38.4	16	0	0	10.9	34					2.8	10.8
15FEB	CHARLES	24.9	6	2,200	2.7	33	42	37.2	6	0	0	11.1	36					2.9	11.6
15FEB	LEGION	17.2	0	300	0.0							11.4	36					4.4	11.4
15FEB	VENN	6.4	0	1,600	0.0							11.6	38					4.0	10.2
15FEB	SHILOH	3.4	3	1,800	1.7	38	42	39.7	3	0	0	11.4	38					6.0	11.3
15FEB	LAIRD	90.2	1	1,650	0.6	40	40	40.0	1	0	0	12.0	388					23.9	11.0
15FEB	GARDNER	79.5	4	1,650	2.4	37	45	41.3	4	0	0	11.7	243					15.7	10.8
TR TOT.			45	12300	3.7	32	51	40.2	45	0	0								
SJR TOT.			5	3300	1.5	37	45	41.0	5	0	0								

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
01MAR	OLGB	50.5	0	2,400	0.0							10.3	24		0.8	0.7	0.4	1.9	12.8
01MAR	R4B	48.4	5	2,200	2.3	33	41	36.8	5	0	0	10.4	30					1.7	13.2
01MAR	TLSRA	42.0	0	1,800	0.0							10.2	35					2.0	12.8
01MAR	HICK	31.6	4	1,700	2.4	38	49	41.5	4	0	0	10.0	36					2.3	12.3
01MAR	CHARLES	24.9	0	1,800	0.0							10.9	36					2.5	10.9
01MAR	LEGION	17.2	0	2,400	0.0							12.7	32					2.9	11.0
01MAR	VENN	6.4	1	1,000	1.0	54	54	54.0	1	0	0	11.6	36					4.4	11.1
01MAR	SHILOH	3.4	0	1,800	0.0							12.0	34					7.5	11.5
01MAR	LAIRD	90.2	0	1,650	0.0							12.2	410					25.6	11.2
01MAR	GARDNER	79.5	2	1,000	2.0	37	38	37.5	2	0	0	11.4	237					20.0	10.9
TR TOT.			10	15100	0.7	33	54	40.4	10	0	0								
SJR TOT.			2	2650	0.8	37	38	37.5	2	0	0								

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
15MAR	OLGB	50.5	0	1,350	0.0							10.3	26		0.5	1.1	0.7	1.9	12.7
15MAR	R5	48.0	1	1,800	0.6	40	40	40.0	1	0	0	10.8	27					1.7	13.2
15MAR	TLSRA	42.0	1	800	1.3	50	50	50.0	1	0	0	10.6	29					1.9	11.4
15MAR	HICK	31.6	0	1,650	0.0							11.3	32					2.0	10.4
15MAR	CHARLES	24.9	5	1,950	2.6	38	45	41.0	5	0	0	11.8	37					2.0	11.4
15MAR	LEGION	17.2	0	825	0.0							13.3	36					3.4	10.0
15MAR	VENN	6.4	2	1,200	1.7	45	60	52.5	2	0	0	13.7	45					3.0	9.4
15MAR	SHILOH	3.4	0	1,800	0.0							13.2	37					5.3	10.9
15MAR	LAIRD	90.2	3	1,600	1.9	46	59	53.0	3	0	0	15.3	514					18.1	9.4
15MAR	GARDNER	79.5	7	1,500	4.7	44	68	53.3	7	0	0	14.3	320					11.3	9.5
TR TOT.			9	11375	0.8	38	60	44.4	9	0	0								
SJR TOT.			10	3100	3.2	44	68	53.2	10	0	0								

Table 1. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2011.

continued.

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
29MAR	OLGB	50.5	0	2,200	0.0							10.4	29		0.3	0.0	0.0	2.3	12.1
29MAR	R4B	48.4	2	2,400	0.8	38	42	40.0	2	0	0	11.0	34					2.6	12.4
29MAR	TLSRA	42.0	0	2,000	0.0							10.5	33					3.4	11.4
29MAR	HICK	31.6	0	1,800	0.0							10.7	36					3.3	11.5
29MAR	CHARLES	24.9	0	1,800	0.0							11.0	37					3.2	10.4
29MAR	LEGION	17.2	0	1,800	0.0							12.7	34					4.9	10.6
29MAR	RDP	12.3	0	1,800	0.0							12.4	39					5.9	10.5
29MAR	SHILOH	3.4	0	1,800	0.0							13.8	40					6.9	10.3
29MAR	LAIRD	90.2	0	2,400	0.0							16.0	230					33.4	7.0
29MAR	GARDNER	79.5	0	1,800	0.0							14.7	170					26.1	7.9
TR TOT.			2	15600	0.1	38	42	40.0	2	0	0								
SJR TOT.			0	4200	0.0														

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
12APR	OLGB	50.5	1	2,000	0.5	53	53	53.0	1	0	0	10.5	34		0.5	0.9	0.0	2.9	13.4
12APR	R4B	48.4	2	2,400	0.8	38	50	44.0	2	0	0	10.9	36					2.7	12.4
12APR	TLSRA	42.0	0	1,800	0.0							10.5	38					4.0	11.6
12APR	HICK	31.6	1	1,600	0.6	55	55	55.0	1	0	0	10.7	36					3.2	9.6
12APR	STREETER	25.4	3	1,800	1.7	37	48	41.0	3	0	0	11.0	35					4.1	11.3
12APR	LEGION	17.2	1	2,400	0.4	43	43	43.0	1	0	0	12.0	35					4.4	11.4
12APR	RDP	12.3	0	2,200	0.0							12.7	34					5.0	10.2
12APR	SHILOH	3.4	0	2,000	0.0							13.2	36					5.9	11.8
12APR	LAIRD	90.2	0	1,800	0.0							17.1	188					8.1	9.0
12APR	OFC	80.7	0	2,400	0.0							15.3	123					8.8	9.6
TR TOT.			8	16200	0.5	37	55	45.3	8	0	0								
SJR TOT.			0	4200	0.0														

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
26APR	OLGB	50.5	2	2,200	0.9	45	52	48.5	2	0	0	10.7	34		0.9	0.0	0.0	2.5	14.1
26APR	R4B	48.4	4	2,400	1.7	42	54	45.5	4	0	0	11.1	36					2.7	13.6
26APR	TLSRA	42.0	0	2,400	0.0							10.9	37					2.6	12.6
26APR	HICK	31.6	0	2,100	0.0							10.9	37					2.6	12.7
26APR	STREETER	25.4	0	1,650	0.0							11.4	38					2.9	12.5
26APR	LEGION	17.2	0	2,400	0.0							12.5	36					3.4	11.5
26APR	RDP	12.3	0	1,800	0.0							12.9	38					3.8	11.4
26APR	SHILOH	3.4	0	1,400	0.0							13.1	40					7.1	11.2
26APR	LAIRD	90.2	0	1,800	0.0							18.4	181					15.0	8.2
26APR	OFC	80.7	0	1,300	0.0							16.6	139					16.0	9.4
TR TOT.			6	16350	0.4	42	54	46.5	6	0	0								
SJR TOT.			0	3100	0.0														

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
10MAY	OLGB	50.5	0	1,800	0.0							11.0	28		0.0	0.0	0.3	1.6	13.2
10MAY	R4B	48.4	0	1,800	0.0							11.2	33					1.5	13.0
10MAY	TLSRA	42.0	0	1,800	0.0							11.2	39					1.9	11.3
10MAY	HICK	31.6	0	1,800	0.0							11.2	34					1.5	12.1
10MAY	CHARLES	24.9	0	1,800	0.0							12.1	34					1.7	11.4
10MAY	LEGION	17.2	0	1,600	0.0							13.4	37					2.5	11.1
10MAY	VENN	6.4	0	1,600	0.0							14.6	40					6.7	11.4
10MAY	SHILOH	3.4	1	1,800	0.6	66	66	66.0	1	0	0	14.3	37					3.2	11.2
10MAY	LAIRD	90.2	0	1,800	0.0							18.8	191					17.5	8.6
10MAY	GARDNER	79.5	Not sampled due to high flow									17.2	133					15.3	9.1
TR TOT.			1	14000	0.1	66	66	66.0	1	0	0								
SJR TOT.			0	1800	0.0														

2011 TUOLUMNE RIVER SEINING STUDY (TID/MID)

DATE	LOCATION	RIVER MILE	CATCH	AREA	DENSITY (/1000ft^2)	FL MIN.	FL MAX.	FL AVG.	NO. MEAS.	SACFRY	NO. KILLED	WATER TEMP.	ELEC. COND.	SMOLT FL	SECTION DENSITY UPPER	MIDDLE	LOWER	TURB.	D.O. (ppm)
24MAY	OLGB	50.5	0	1,800	0.0							11.2	30		0.0	0.0	0.0	1.2	13.9
24MAY	R4B	48.4	0	1,800	0.0							11.4	34					1.1	13.7
24MAY	TLSRA	42.0	0	1,400	0.0							11.6	35					1.4	12.0
24MAY	HICK	31.6	0	1,600	0.0							11.7	36					1.4	12.9
24MAY	CHARLES	24.9	0	1,800	0.0							12.7	34					2.2	12.3
24MAY	LEGION	17.2	Not sampled																
24MAY	VENN	6.4	0	1,650	0.0							16.8	39					3.8	10.8
24MAY	SHILOH	3.4	0	1,800	0.0							14.9	41					3.4	11.4
24MAY	LAIRD	90.2	0	1,600	0.0							20.1	235					19.3	10.2
24MAY	GARDNER	79.5	0	1,800	0.0							18.0	155					22.8	10.5
TR TOT.			0	11850	0.0														
SJR TOT.			0	3400	0.0														

TABLE 2. 2011 JUVENILE SALMON SEINING STUDY (TID/MID)

TUOLUMNE RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.	SACFRY	NUMBER KILLED
19JAN	35	14,750	2.4	32	57	39.0	35	0	0
01FEB	48	11,150	4.3	31	76	43.9	48	0	0
15FEB	45	12,300	3.7	32	51	40.2	45	0	0
01MAR	10	15,100	0.7	33	54	40.4	10	0	0
15MAR	9	11,375	0.8	38	60	44.4	9	0	0
29MAR	2	15,600	0.1	38	42	40.0	2	0	0
12APR	8	16,200	0.5	37	55	45.3	8	0	0
26APR	6	16,350	0.4	42	54	46.5	6	0	0
10MAY	1	14,000	0.1	66	66	66.0	1	0	0
24MAY	0	11,850	0.0						
TOTAL:	164	138,675	1.2				164	0	0

SAN JOAQUIN RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.	SACFRY	NUMBER KILLED
19JAN	0	1,950	0.0						
01FEB	2	2,400	0.8	42	43	42.5	2	0	0
15FEB	5	3,300	1.5	37	45	41.0	5	0	0
01MAR	2	2,650	0.8	37	38	37.5	2	0	0
15MAR	10	3100	3.2	44	68	53.2	10	0	0
29MAR	0	4,200	0.0						
12APR	0	4,200	0.0						
26APR	0	3,100	0.0						
10MAY	0	1,800	0.0						
24MAY	0	3,400	0.0						
TOTAL:	19	30,100	0.6				19	0	0

Table 3. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2011

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
19JAN	OLGB	21	1,800	21	0	11.7	0.0	11.7	35.9	3.6	1.9	0.0	0.0	0.5	0.0
19JAN	R4B	0	2,000					0.0							
19JAN	TLSRA	0	2,000					0.0							
19JAN	HICKMAN	5	1,800	2	3	1.1	1.7	2.8	49.2						
19JAN	CHARLES	9	1,650	9	0	5.5	0.0	5.5	40.8						
19JAN	LEGION	0	2,200					0.0							
19JAN	VENN	0	1,650					0.0							
19JAN	SHILOH	0	1,650					0.0							
19JAN	LAIRD	0	1,350					0.0							
19JAN	GARDNER	0	600					0.0							
TUOL.TOT.		35	14750	32	3	2.2	0.2	2.4	39.0						
SJR. TOT.		0	1950					0.0							

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
01FEB	OLGB	4	1,100	4	0	3.6	0.0	3.6	38.3	1.7	6.2	2.5	0.2	1.7	0.4
01FEB	R5	5	1,800	4	1	2.2	0.6	2.8	48.8						
01FEB	TRR	0	1,800					0.0							
01FEB	HICKMAN	22	1,450	15	7	10.3	4.8	15.2	47.0						
01FEB	CHARLES	2	1,500	2	0	1.3	0.0	1.3	37.0						
01FEB	LEGION	8	1,100	8	0	7.3	0.0	7.3	37.1						
01FEB	VENN	0	1,200					0.0							
01FEB	SHILOH	7	1,200	6	1	5.0	0.8	5.8	43.9						
01FEB	LAIRD	0	1,200					0.0							
01FEB	GARDNER	2	1,200	2	0	1.7	0.0	1.7	42.5						
TUOL.TOT.		48	11150	39	9	3.5	0.8	4.3	43.9						
SJR. TOT.		2	2400	2	0	0.8	0.0	0.8	42.5						

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
15FEB	OLGB	0	1,200					0.0		4.3	5.0	0.9	0.0	0.2	0.0
15FEB	R5	4	2,400	4	0	1.7	0.0	1.7	42.5						
15FEB	TLSRA	16	1,100	16	0	14.5	0.0	14.5	42.7						
15FEB	HICKMAN	16	1,700	15	1	8.8	0.6	9.4	38.4						
15FEB	CHARLES	6	2,200	6	0	2.7	0.0	2.7	37.2						
15FEB	LEGION	0	300					0.0							
15FEB	VENN	0	1,600					0.0							
15FEB	SHILOH	3	1,800	3	0	1.7	0.0	1.7	39.7						
15FEB	LAIRD	1	1,650	1	0	0.6	0.0	0.6	40.0						
15FEB	GARDNER	4	1,650	4	0	2.4	0.0	2.4	41.3						
TUOL.TOT.		45	12300	44	1	3.6	0.1	3.7	40.2						
SJR. TOT.		5	3300	5	0	1.5	0.0	1.5	41.0						

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
01MAR	OLGB	0	2,400					0.0		0.8	0.7	0.0	0.0	0.0	0.4
01MAR	R4B	5	2,200	5	0	2.3	0.0	2.3	36.8						
01MAR	TLSRA	0	1,800					0.0							
01MAR	HICKMAN	4	1,700	4	0	2.4	0.0	2.4	41.5						
01MAR	CHARLES	0	1,800					0.0							
01MAR	LEGION	0	2,400					0.0							
01MAR	VENN	1	1,000	0	1	0.0	1.0	1.0	54.0						
01MAR	SHILOH	0	1,800					0.0							
01MAR	LAIRD	0	1,650					0.0							
01MAR	GARDNER	2	1,000	2	0	2.0	0.0	2.0	37.5						
TUOL.TOT.		10	15100	9	1	0.6	0.1	0.7	40.4						
SJR. TOT.		2	2650	2	0	0.8	0.0	0.8	37.5						

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
15MAR	OLGB	0	1,350					0.0		0.5	1.1	0.3	0.0	0.0	0.3
15MAR	R5	1	1,800	1	0	0.6	0.0	0.6	40.0						
15MAR	TLSRA	1	800	1	0	1.3	0.0	1.3	50.0						
15MAR	HICKMAN	0	1,650					0.0							
15MAR	CHARLES	5	1,950	5	0	2.6	0.0	2.6	41.0						
15MAR	LEGION	0	825					0.0							
15MAR	VENN	2	1,200	1	1	0.8	0.8	1.7	52.5						
15MAR	SHILOH	0	1,800					0.0							
15MAR	LAIRD	3	1,600	1	2	0.6	1.3	1.9	53.0						
15MAR	GARDNER	7	1,500	4	3	2.7	2.0	4.7	53.3						
TUOL.TOT.		9	11375	8	1	0.7	0.1	0.8	44.4						
SJR. TOT.		10	3100	5	5	1.6	1.6	3.2	53.2						

Table 3. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2011 (cont.)

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
29MAR	OLGB	0	2,200					0.0		0.3	0.0	0.0	0.0	0.0	0.0
29MAR	R4B	2	2,400	2	0	0.8	0.0	0.8	40.0						
29MAR	TLSRA	0	2,000					0.0							
29MAR	HICKMAN	0	1,800					0.0							
29MAR	CHARLES	0	1,800					0.0							
29MAR	LEGION	0	1,800					0.0							
29MAR	VENN	0	1,800					0.0							
29MAR	SHILOH	0	1,800					0.0							
29MAR	LAIRD	0	2,400					0.0							
29MAR	GARDNER	0	1,800					0.0							
TUOL.TOT.		2	15600	2	0	0.1	0.0	0.1	40.0						
SJR. TOT.		0	4200					0.0							

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
12APR	OLGB	1	2,000	0	1	0.0	0.5	0.5	53.0	0.3	0.7	0.0	0.2	0.2	0.0
12APR	R4B	2	2,400	2	0	0.8	0.0	0.8	44.0						
12APR	TLSRA	0	1,800					0.0							
12APR	HICKMAN	1	1,600	0	1	0.0	0.6	0.6	55.0						
12APR	STREETER	3	1,800	3	0	1.7	0.0	1.7	41.0						
12APR	LEGION	1	2,400	1	0	0.4	0.0	0.4	43.0						
12APR	RDP	0	2,200					0.0							
12APR	SHILOH	0	2,000					0.0							
12APR	LAIRD	0	1,800					0.0							
12APR	OFC	0	2,400					0.0							
TUOL.TOT.		8	16200	6	2	0.4	0.1	0.5	45.3						
SJR. TOT.		0	4200					0.0							

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
26APR	OLGB	2	2,200	1	1	0.5	0.5	0.9	48.5	0.6	0.0	0.0	0.3	0.0	0.0
26APR	R4B	4	2,400	3	1	1.3	0.4	1.7	45.5						
26APR	TLSRA	0	2,400					0.0							
26APR	HICKMAN	0	2,100					0.0							
26APR	STREETER	0	1,650					0.0							
26APR	LEGION	0	2,400					0.0							
26APR	RDP	0	1,800					0.0							
26APR	SHILOH	0	1,400					0.0							
26APR	LAIRD	0	1,800					0.0							
26APR	OFC	0	1,300					0.0							
TUOL.TOT.		6	16350	4	2	0.2	0.1	0.4	46.5						
SJR. TOT.		0	3100					0.0							

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
10MAY	OLGB	0	1,800					0.0		0.0	0.0	0.0	0.0	0.0	0.3
10MAY	R4B	0	1,800					0.0							
10MAY	TLSRA	0	1,800					0.0							
10MAY	HICKMAN	0	1,800					0.0							
10MAY	CHARLES	0	1,800					0.0							
10MAY	LEGION	0	1,600					0.0							
10MAY	VENN	0	1,600					0.0							
10MAY	SHILOH	1	1,800	0	1	0.0	0.6	0.6	66.0						
10MAY	LAIRD	0	1,800					0.0							
10MAY	GARDNER Not sampled due to high flow														
TUOL.TOT.		1	14000	0	1	0.0	0.1	0.1							
SJR. TOT.		0	1800					0.0							

2011 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
24MAY	OLGB	0	1,800					0.0		0.0	0.0	0.0	0.0	0.0	0.0
24MAY	R4B	0	1,800					0.0							
24MAY	TLSRA	0	1,400					0.0							
24MAY	HICKMAN	0	1,600					0.0							
24MAY	CHARLES	0	1,800					0.0							
24MAY	LEGION Not sampled														
24MAY	VENN	0	1,650					0.0							
24MAY	SHILOH	0	1,800					0.0							
24MAY	LAIRD	0	1,600					0.0							
24MAY	GARDNER	0	1,800					0.0							
TUOL.TOT.		0	11,850					0.0							
SJR. TOT.		0	3,400					0.0							

Table 4. 2011 Other species sampled during seining studies on juvenile salmon.

OTHER SPECIES SAMPLED (ACTUAL COUNTS OR ESTIMATED ABUNDANCE)

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
19JAN	1	OLGB	50.5														1															
19JAN	2	R4B	48.4																													
19JAN	3	TLSRA	42.0								10		10						20													
19JAN	4	HICK	31.6										2																			
19JAN	5	CHARLES	24.9																													
19JAN	6	LEGION	17.2														1		1													
19JAN	7	VENN	6.4														1															
19JAN	8	SHILOH	3.4												1		1															
19JAN	9	LAIRD	90.2												50		5															
19JAN	10	GARDNER	77.8												40					4												

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
01FEB	1	OLGB	50.5																													
01FEB	2	R5	48.0			1											1															
01FEB	3	TRR	42.3										40				YOY		1													
01FEB	4	HICK	31.6														1															
01FEB	5	CHARLES	24.9								1						1															
01FEB	6	LEGION	17.2														1		11													1
01FEB	7	VENN	6.4																20													
01FEB	8	SHILOH	3.4												2																	1
01FEB	9	LAIRD	90.2												200					5												
01FEB	10	GARDNER	77.8												80					15										1		

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
15FEB	1	OLGB	50.5																													
15FEB	2	R5	48.0																													
15FEB	3	TLSRA	42.0														5															
15FEB	4	HICK	31.6								1		2																			
15FEB	5	CHARLES	24.9														4															
15FEB	6	LEGION	17.2														2															
15FEB	7	VENN	6.4																													
15FEB	8	SHILOH	3.4												6																	
15FEB	9	LAIRD	90.2												40					10												
15FEB	10	GARDNER	77.8												20	1				10												

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
01MAR	1	OLGB	50.5														1		2													
01MAR	2	R4B	48.4																													
01MAR	3	TLSRA	42.0														20		3													
01MAR	4	HICK	31.6														3															
01MAR	5	CHARLES	24.9										1																			
01MAR	6	LEGION	17.2												2																	
01MAR	7	RDP	12.3																1													
01MAR	8	SHILOH	3.4												10		2		2													
01MAR	9	LAIRD	90.2												20				5													
01MAR	10	GARDNER	77.8												20					1				1								

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
15MAR	1	OLGB	50.5														1															
15MAR	2	R5	48.0																													
15MAR	3	TLSRA	42.0														2							1								
15MAR	4	HICK	31.6										1																			
15MAR	5	CHARLES	24.9										1																			
15MAR	6	LEGION	17.2																1													
15MAR	7	VENN	6.4														1															
15MAR	8	SHILOH	3.4														YOY		2													
15MAR	9	LAIRD	90.2												200	1				20												
15MAR	10	GARDNER	77.8												40					5												

Table 4. 2011 Other species sampled (Cont.)

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
29MAR	1	OLGB	50.5			1													1													
29MAR	2	R4B	48.4																													
29MAR	3	TLSRA	42.0																													
29MAR	4	HICK	31.6										1																			
29MAR	5	CHARLES	24.9																2													
29MAR	6	LEGION	17.2										10						6													
29MAR	7	RDP	12.3																1													
29MAR	8	SHILOH	3.4										3																			
29MAR	9	LAIRD	90.2												100					6												
29MAR	10	GARDNER	77.8																2													
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
12APR	1	OLGB	50.5														3															
12APR	2	R4B	48.4																													
12APR	3	TLSRA	42.0																1													
12APR	4	HICK	31.6										1																			
12APR	5	CHARLES	24.9																2													
12APR	6	LEGION	17.2																12													
12APR	7	RDP	12.3												1		YOY		5													
12APR	8	SHILOH	3.4												2				5													
12APR	9	LAIRD	90.2												1				6													
12APR	10	GARDNER	77.8												6				5				1									
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
26APR	1	OLGB	50.5			4																										
26APR	2	R4B	48.4			1																										
26APR	3	TLSRA	42.0										5						12										15			
26APR	4	HICK	31.6																													
26APR	5	CHARLES	24.9																													
26APR	6	LEGION	17.2														3		1													
26APR	7	RDP	12.3														YOY															
26APR	8	SHILOH	3.4				20										YOY												1PSCP			
26APR	9	LAIRD	90.2				1										YOY		5										4PSCP			
26APR	10	GARDNER	77.8										1		30					1												
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
10MAY	1	OLGB	50.5																													
10MAY	2	R4B	48.4																													
10MAY	3	TLSRA	42.0										20				YOY		20													
10MAY	4	HICK	31.6																													
10MAY	5	CHARLES	24.9																													
10MAY	6	LEGION	17.2												2																	
10MAY	7	RDP	12.3				5																						4PSCP			
10MAY	8	SHILOH	3.4																													
10MAY	9	LAIRD	90.2				100								300		YOY															
10MAY	10	GARDNER	77.8																													
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
24MAY	1	OLGB	50.5																													
24MAY	2	R4B	48.4																													
24MAY	3	TLSRA	42.0										1				YOY		20										4			
24MAY	4	HICK	31.6														YOY												3			
24MAY	5	CHARLES	24.9														YOY												2			
24MAY	6	LEGION	17.2																													
24MAY	7	RDP	12.3				60										YOY															
24MAY	8	SHILOH	3.4												15																	
24MAY	9	LAIRD	90.2				100								200		YOY															
24MAY	10	GARDNER	77.8				20								100					1									PSCP(3)			

Table 4. KEY TO OTHER SPECIES SAMPLED AND DISTRIBUTION
(List includes all species caught during 1986-2011 seining studies)

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	SAN JOAQUIN	TUOL.
Petromyzontidae	Pacific lamprey	N	LP		
Clupeidae	threadfin shad		TFS		
Salmonidae	Chinook salmon	N	CS	X	X
Salmonidae	rainbow trout	N	RT		X
Cyprinidae	carp		CP	X	X
Cyprinidae	goldfish		GF		
Cyprinidae	golden shiner		GSH		
Cyprinidae	Sacramento blackfish	N	SBF		
Cyprinidae	hitch	N	HCH		
Cyprinidae	hardhead	N	HH		X
Cyprinidae	Sacramento pikeminnow	N	PM	X	X
Cyprinidae	Sacramento splittail	N	ST		
Cyprinidae	red shiner		PRS	X	X
Cyprinidae	fathead minnow		FHM	X	
Catostomidae	Sacramento sucker	N	SKR	X	X
Ictaluridae	channel catfish		CCF		
Ictaluridae	white catfish		WCF		
Ictaluridae	brown bullhead		BBH		
Poeciliidae	western mosquitofish		GAM	X	X
Atherinidae	inland silverside		ISS	X	
Moronidae	striped bass		SB		
Centrarchidae	white/black crappie		WCR/BCR		
Centrarchidae	warmouth		WM		
Centrarchidae	green sunfish		GSF	X	
Centrarchidae	bluegill		BG	X	X
Centrarchidae	redear sunfish		RSF	X	
Centrarchidae	largemouth bass		LMB		
Centrarchidae	smallmouth bass		SMB		
Percidae	bigscale logperch		BLP		
Embiotocidae	tule perch	N	TP		
Cottidae	prickly sculpin	N	PSCP	X	X
Cottidae	riffle sculpin	N	RSCP		X
TOTAL:	32			12	11

2011 species presence designated with 'X'

Table 5. Tuolumne River Seining Summary, 1986-2011.

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

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

Table 6. Summary table of locations sampled, 1986-2011

1986 TO 2011 SEINING LOCATIONS

TUOLUMNE RIVER

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
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	
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	
5	Turlock Lake State Rec. 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
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
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
10	RDP / 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
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

SAN JOAQUIN RIVER

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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
14	Gardner Cove	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
15	Maze Road	76.6	X	X	X																							
16	Sturgeon Bend	74.3		X	X																							
17	Durham Ferry Park	71.3	X	X	X	X	X	X	X	X																		
18	Old River	53.7		X																								

STANISLAUS RIVER

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
19	Caswell State Park	8.5			X	X		X	X	X																		

DRY CREEK

Site	Location	River Mile	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
20	Beard Brook Park	0.5							X	X																		

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

Table 7. Tuolumne River analysis of female spawners to fry density.

Tuolumne Fall-run Estimate	Total Female Spawners		Juvenile Seining	
			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

Table 8. Summary table of fish species caught during the1992-2011 seine studies.

Tuolumne River

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Petromyzontidae	Pacific lamprey	N	LP											X		X						
Clupeidae	threadfin shad		TFS					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
Salmonidae	rainbow trout	N	RT						X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinidae	carp		CP														X					X
Cyprinidae	goldfish		GF																			
Cyprinidae	golden shiner		GSH	X	X	X							X		X		X		X	X	X	
Cyprinidae	Sacramento blackfish	N	SBF																			
Cyprinidae	hitch	N	HCH																			
Cyprinidae	hardhead	N	HH	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
Cyprinidae	Sacramento splittail	N	ST																			
Cyprinidae	red shiner		PRS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinidae	fathead minnow		FHM								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
Ictaluridae	channel catfish		CCF								X			X						X	X	
Ictaluridae	white catfish		WCF		X	X						X										
Ictaluridae	brown bullhead		BBH			X																
Poeciliidae	western mosquitofish		GAM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Atherinidae	inland silverside		ISS	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	
Moronidae	striped bass		SB									X										
Centrarchidae	white/black crappie		WCR/BCR																			
Centrarchidae	warmouth		WM		X																	
Centrarchidae	green sunfish		GSF	X	X		X				X	X	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	X	X
Centrarchidae	redear sunfish		RSF	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Centrarchidae	largemouth bass		LMB	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	
Percidae	bigscale logperch		BLP	X			X		X	X								X	X			
Embiotocidae	tule perch	N	TP																			
Cottidae	prickly sculpin	N	PSCP				X	X	X						X	X	X					X
Cottidae	riffle sculpin	N	RSCP	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TOTAL:	32			15	13	15	12	11	14	11	14	17	15	15	16	15	16	12	15	15	16	11

(List includes all species caught during 1986-2011 seining studies

San Joaquin River

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Petromyzontidae	Pacific lamprey	N	LP																			
Clupeidae	threadfin shad		TFS		X		X		X	X	X			X								
Salmonidae	Chinook salmon	N	CS	X		X	X	X	X	X	X	X	X	X		X	X					X
Salmonidae	rainbow trout	N	RT																			
Cyprinidae	carp		CP	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	X		X	X	X					
Cyprinidae	golden shiner		GSH	X			X								X							
Cyprinidae	Sacramento blackfish	N	SBF	X	X	X	X	X	X	X	X											
Cyprinidae	hitch	N	HCH					X		X	X											
Cyprinidae	hardhead	N	HH																			
Cyprinidae	Sacramento pikeminnow	N	PM	X	X		X	X	X		X	X			X	X	X		X	X	X	X
Cyprinidae	Sacramento splittail	N	ST	X			X	X	X			X					X					
Cyprinidae	red shiner		PRS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinidae	fathead minnow		FHM	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
Ictaluridae	channel catfish		CCF			X		X										X				
Ictaluridae	white catfish		WCF											X								
Ictaluridae	brown bullhead		BBH					X														
Poeciliidae	western mosquitofish		GAM	X	X		X	X	X			X	X	X	X		X			X	X	X
Atherinidae	inland silverside		ISS	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	X		X	X		X	X			X							
Centrarchidae	white/black crappie		WCR/BCR	X		X		X					X		X	X					X	
Centrarchidae	warmouth		WM																			
Centrarchidae	green sunfish		GSF	X	X		X	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	X	X
Centrarchidae	redear sunfish		RSF	X	X	X	X			X			X	X	X					X	X	X
Centrarchidae	largemouth bass		LMB		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	
Percidae	bigscale logperch		BLP			X	X	X	X	X	X	X	X	X	X							
Embiotocidae	tule perch	N	TP	X	X	X	X	X	X		X	X	X	X	X				X			
Cottidae	prickly sculpin	N	PSCP				X	X	X	X						X	X					X
Cottidae	riffle sculpin	N	RSCP																			
TOTAL:	32			19	15	17	20	21	18	16	15	15	14	14	18	12	13	5	8	9	10	12

(List includes all species caught during 1986-2011 seining studies

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-4

Outmigrant Trapping of Juvenile Salmon in the Lower Tuolumne River, 2011

Prepared by

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Submitted To:
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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, originating in the central Sierra Nevadas in Yosemite National Park and flowing 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 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 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 to meet several objectives, including monitoring the abundance and migration characteristics of juvenile salmonids and other fishes, and evaluating reach-specific 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 nearly all RST monitoring efforts in the Tuolumne River.

Figure 1.Location map of study area on 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 in 1995-1998 and Grayson in 1999-2011) for the purpose of monitoring the abundance and migration characteristics of juvenile salmonids and other fishes. Since 2006, sampling has also been conducted annually near Waterford, about 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.

Table 1. Rotary screw trap monitoring in the Lower Tuolumne River, 1995-2011.

Year	*Site*	*Period Sampled*	*Proportion of Outmigration Period Sampled*	*Total Catch*	*Total Estimated Passage*	*Method of Passage Estimation*	*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]		Heyne and Loudermilk 1997
1997	Shiloh	Apr 18 - May 24	24%	57	2,850[1]		Heyne and Loudermilk 1998
1998	Turlock Lake State Rec. (RM 42.0)	Feb 11-Apr 13	41%	7,125	259,581[1]	Mean efficiency	Vick and others 1998
	7/11 (RM 38.5)	Apr 15-May 31	31%	2,413			Vick and others 1998
	Charles Road (RM 25.0)	Mar 27-Jun 01	43%	981	66,848[1]	Mean efficiency	Vick and others 1998
	Shiloh	Feb 15-Jul 01	70%	2,546	1,615,673[1]	Regression	Blakeman 2004a
1999	7/11	Jan 19-May 17	79%	80,792	1,737,052[1]	%Flow sampled	Vick and others 2000
	Hughson (RM 23.7)	Apr 08-May 24	31%	449	7,175[1]	%Flow sampled	Vick and others 2000

[1] Passage estimate reported in the annual report cited.

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Method of Passage Estimation	Results Reported In
	Grayson (RM 5.2)	Jan 12-Jun 06	93%	19,327	869,636[2]	Multiple regression	Vasques and Kundargi 2001
2000	7/11	Jan 10-Feb 27	32%	61,196	298,755[1]	%Flow sampled	Hume and others 2001
	Deardorff (RM 35.5)	Apr 09-May 25	31%	634	15,845[1]	%Flow sampled	Hume and others 2001
	Hughson	Apr 09-May 25	31%	264	2,942[1]	%Flow sampled	Hume and others 2001
	Grayson	Jan 09-Jun 12	95%	2,250	107,6172	Multiple regression	Vasques and Kundargi 2001
2001	Grayson	Jan 03-May 29	97%	6,478	106,580[2]	Multiple regression	Vasques and Kundargi 2002
2002	Grayson	Jan 15-Jun 06	91%	436	14,135[2]	Multiple regression	Blakeman 2004b
2003	Grayson	Apr 01-Jun 06	40%	359	13,928[2]	Multiple regression	Blakeman 2004c
2004	Grayson	Apr 01-Jun 09	40%	509	9,074[2]	Multiple regression	Fuller 2005
2005	Grayson	Apr 02-Jun 17	39%	1,317	17,600[2]	Multiple regression	Fuller and others 2006
2006	Waterford 1 (RM 29.8)	Jan 25-Apr 12	79%	8,648	178,034[1]	%Flow sampled	Fuller and others 2007
	Waterford 2 (RM 33.5)	Apr 21-Jun 21		458	178,034[1]		
	Grayson	Jan 25-Jun 22	84%	1,594	181,691[2]	Multiple regression	Fuller and others 2007
2007	Waterford (RM 29.8)	Jan 11-Jun 05	93%	3,312	57,801[1]	Average trap efficiency	Fuller 2008
	Grayson	Mar 23-May 29	45%	27	937[2]	Multiple regression	Fuller 2008
2008	Waterford	Jan 8-Jun 2	96%	3,350	24,894[1]	Average trap efficiency	Palmer and Sonke 2008

[2] Passage estimate derived from multiple regression equation based on data collected from 1999-2006 and 2008 as described in this report.

Year	Site	Period Sampled	Proportion of Outmigration Period Sampled	Total Catch	Total Estimated Passage	Method of Passage Estimation	Results Reported In
	Grayson	Jan 29-Jun 4	82%	193	3,287[2]	Multiple regression	Palmer and Sonke 2008
2009	Waterford	Jan 7-June 9	96%	3,725	37,174[1]	Average trap efficiency	Palmer and Sonke 2010
	Grayson	Jan 8-Jun 11	95%	155	4,598[2]	Multiple regression	Palmer and Sonke 2010
2010	Waterford	Jan 5-Jun 11	97%	2,281	29,294-55,941[3]	Average trap	Sonke and others 2010
	Grayson	Jan 6-Jun 17	97%	52	4,233[2]	Multiple regression	Sonke and others 2010
2011	Waterford	Dec 5-Jun 30	100%	4,394	414,815-427,126[3]	Average trap efficiency[3]	This report
	Grayson	Jan 6-Jun 30	97%	1,645	87,172[2]	Multiple regression	This report

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 traps consist of a funnel-shaped core suspended between two pontoons. Traps 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

[3] Trap efficiency data not available for parr/smoltlifestage at high flows. A range of trap efficiencies from the 7/11 (RM 38) and Deardorff (RM 35.5) traps was used to obtain a range of passage estimates in 2010 and 2011.

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 trap was located at RM 29.8, approximately two miles downstream of the Hickman Bridge. The trap 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. Warning signs, flashing safety lights and buoys marked the location of the trap and cables for public safety. Sufficient velocity at the trap during 2010 and 2011 precluded the need for the “wings” used to increase catch efficiency during 2008 and a portion of 2009.

At Grayson two traps 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 cross-bars. The traps 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 traps 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 traps kept the leader cables taut. Sufficient velocity at the traps during 2010 and 2011 precluded the need for the “weir” structure used to increase catch efficiency during 2008 and 2009.

Trap Monitoring

Sampling at Waterford began on December 5, 2010. The trap was operated continuously (24 hours per day, 7 days per week) until June 30, 2011, when sampling was terminated due to consistently low catch.

Sampling at Grayson began on January 6, 2011. The traps were operated continuously (24 hours per day, 7 days per week) until March 21 when sampling was temporarily discontinued due to safety concerns associated with high flows. Sampling resumed on March 31 and continued until sampling was terminated on June 30, 2011, due to consistently low catch.

Traps at both locations were checked at least every morning throughout the sampling period, with additional trap checks conducted as conditions required. During each trap check the contents of the liveboxes were removed, all fish were identified and counted, and any marked fish were noted. In addition, random samples of up to 50 salmon and 20 of each non-salmon species during each morning check, and up to 20 salmon and 10 of each non-salmon species during each evening check, were anesthetized, measured (fork length in millimeters), and recorded. Salmon were assigned to a lifestage category based on a fork length scale, where <50 mm = fry, 50-69 mm = parr, and ≥ 70 mm = smolt. In addition, the smolting appearance of all measured 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) were taken from up to 50 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 measuring 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 trap check plus the number of salmon captured during any trap check(s) that occurred within the period after the previous morning check. For example, the daily salmon catch for April 10 is the sum of salmon from the morning trap check on April 10 and the evening trap check conducted on April 9. Separate daily catch data were maintained for marked (i.e., dye inoculated fish used for trap efficiency tests) and unmarked salmon.

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

Trap Efficiency Releases

Trap efficiency tests using naturally produced juvenile salmon were conducted to estimate the proportion of migrating juvenile salmon sampled by the Waterford and

Grayson traps. Juvenile salmon captured in the traps were used to conduct tests whenever catches were sufficient. Seven groups of naturally produced juvenile salmon (ranging in number from 22 to 142 fish) were marked and released at RM 30 (about 0.2 miles upstream of the Waterford trap) between January 12 and February 9 to estimate trap efficiencies at the Waterford trap. Five groups of naturally produced juvenile salmon (ranging in number from 45 to 87 fish) were marked and released at RM 6.2 between January 14 and January 26 to determine trap efficiencies at the Grayson traps. Catches of naturally produced juvenile salmon after February 8 and January 25 at Waterford and Grayson, respectively, were insufficient for trap efficiency tests. Additionally, hatchery produced fish were not available for tests during 2011. Trap efficiency calculations for both sites are discussed in further detail below.

Marking Procedure

At both trapping sites, naturally produced juvenile salmon were marked onshore immediately adjacent to the trap and were then transported to the release site where they were held until release. A photonic marking system was used for marking all of the release groups because of the high quality of marks and the ability to use the marking equipment in rapid succession. All fish were anesthetized with Tricaine-S before the appropriate mark was applied. A marker tip was placed against the caudal fin and orange 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

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 34” lengths (Figure 2). A rectangle approximately 6” wide by 23” long was cut longitudinally along the pipe and fitted with aluminum or stainless steel mesh. Livecars were tethered to vegetation or other structures and kept in areas of low water velocity to reduce fish stress.

Figure 2. Livecar used for holding trap efficiency test fish.

Pre-release Sampling

Prior to release, marked fish were sampled for length and mark retention. Fifty fish (or the entire release group if fewer than 50 fish) were randomly selected from each release group, anesthetized, and examined for marks; the remaining fish in each group were enumerated. Mark retention was rated as present or absent. A total of zero fish in 2011 were found to have no marks upon examination, consequently, all fish released were presumed to have visible marks.

Release Procedure

All marked fish were released after dark. 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, about 30 seconds to 3 minutes elapsed before another group of about a "net-full" was released. The amount of time between “net-full” releases varied depending on how fast fish swam away after their release. Total release time for marked groups ranged from nine minutes to 30 minutes depending on the group size.

Monitoring Environmental Factors

Flow Measurements and Trap Speed

Provisional daily average flow for the Tuolumne River at La Grange was obtained from USGS at http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11265000&agency_cd=USGS. Provisional daily average flow for the Tuolumne River at Modesto was obtained from the USGS at http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11290000&agency_cd=USGS. 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 traps. First, instantaneous measurements were taken daily with a Global Flow Probe (Global Water, Fair Oaks, CA). Second, an average daily trap rotation speed was calculated for each trap, by recording the time (in seconds) for three continuous revolutions of the cone, once before and once after the morning trap cleaning. The average of the two times was considered the average daily trap rotation speed.

River Temperature, Relative Turbidity and Dissolved Oxygen

Instantaneous water temperature was measured daily with a mercury thermometer at the trap site. Data were also available from hourly recording thermographs maintained by the Districts at both trapping sites. To measure daily instantaneous turbidity, a water sample was collected each morning and later tested at the field station with a LaMotte turbidity meter (Model 2020e, LaMotte Company, Chestertown, MD). Turbidity was recorded in nephelometric turbidity units (NTU). Instantaneous dissolved oxygen was measured during trap checks with an ExStik® II D600 Dissolved Oxygen Meter (Extech Instruments Corporation, Waltham, MA) at the trapping sites and recorded in milligrams per liter (mg/L).

Estimating Trap Efficiency and Chinook Salmon Abundance

An estimate of the number of fish passing each site daily was generated by either expanding the catch data by the average estimated trap efficiency for the lifestage captured (Waterford) or by a trap efficiency predictor equation (Grayson).

Waterford Trap Efficiency

There is a limited trap efficiency dataset for Waterford primarily due to the lack of fish available to conduct trap efficiency tests. The existing data are currently inadequate for developing regression relationships between trap efficiency and explanatory variables such as river flow, fish size, or turbidity. In the future, when more tests have been conducted with each lifestage over a range of flows, a multiple regression may be developed similar to the one described below for the Grayson traps. In the interim, an estimate of salmon relative abundance for the sampling season was calculated by expanding the daily number of fish by the average observed trap efficiency for each lifestage using the best available data. Trap efficiency releases were only conducted for the fry lifestage in 2011 due to insufficient catch during the parr/smolt outmigration period. In some situations hatchery origin fish have also been used for trap efficiency tests, however, fish from the Merced River Hatchery were not available during 2011.

Salmon fry abundance estimates were generated based on trap efficiency tests conducted at Waterford in 2011. Trap efficiency was calculated by pooling data from all release events conducted under similar conditions (i.e., fish size and flow at release), then dividing the total number of fish released by the total number of fish recovered. Theresulting trap efficiency (TE) was then applied to the daily catch (DC) to estimate daily passage as follows:

Estimated Daily Passage= DC/TE

During the parr/smolt outmigration period in 2011, flows on the Tuolumne River were unusually high (averaging over 5,400 cfs). As a result of high flows, trap efficiency was severely limited, and daily catches were insufficient to conduct trap efficiency tests at Waterford. In order to mitigate for this shortcoming, efficiency estimates obtained between 1998 and 2000 during similarly high flows at 7/11 (RM 38) and Deardorff (RM 35.5) were used to provide an approximate abundance estimate (fish size 60-95mm FL, Stillwater Sciences 2001).Since these efficiency estimates were taken from different (but comparable) locations, a range of parr/smolt abundances were calculated to account for the uncertainty in trap efficiencies at Waterford during higher flows (i.e., greater than 1,000cfs). The range was determined by using the lowest and highest trap efficiencies observed at both sites.

Thus, salmon abundance estimate calculations at Waterford in 2011 were based on (Table 3):

Fry:

- trap efficiency tests conducted in 2011 at Waterford = 0.98%

Parr/Smolt:

- trap efficiency tests conducted in 1998-2000 at the 7/11 trap (RM 38; 1998 and 1999) and the Deardorff trap (RM 35.5; 2000) = 2.0-5.6%

Rough estimates of daily passage were also calculated using the proportion of flow sampled by the trap as a surrogate for trap efficiency. The proportion of flow sampled at each site was estimated by the following equation:

$$N_e = C_d \sqrt{\frac{V_d \left(3.14 * \frac{r^2}{2}\right)}{F_d}}$$

where N_e is the expanded daily number of fish; C_d is the daily catch; V_d is the daily velocity; r is the radius of the trap; and F_d is the daily flow measured at La Grange.

Grayson Trap Efficiency

At Grayson, daily trap efficiencies were estimated based on a multiple regression equation developed using flow and trap efficiency data collected from 1999 through 2008 and 2011. Specifically, average daily river flow at Modesto, average fish size at release, and proportions of fish (natural log transformed) recovered from each release event were used to develop the following trap efficiency predictor equation (adjusted R^2 =0.62):

Daily Predicted Trap Efficiency= EXP(-0.479988+(-0.00043*flow at MOD)+(-0.03153* fish size))

whereflow at MOD= daily average river flow (cfs) at Modesto

fish size= daily average fork length (mm) of fish captured at Grayson

These daily predicted trap efficiencies (DPTE) were then applied to the daily catch (DC) to estimate daily passage as follows:

Estimated Daily Passage= DC/DPTE

RESULTS AND DISCUSSION

Chinook Salmon

<u>Number of Unmarked Chinook Salmon Captured</u>

Juvenile salmon sampled in the 2011 RST operation were the progeny of an estimated 785 salmon (326 females) that spawned in the fall of 2010 (Becker et al. 2011). However, the total number of salmon and the number of females is most likely an underestimate since monitoring was truncated and ended on December 1 due to flood control releases from New Don Pedro Reservoir. Further, there were 142 adult Chinook that were not identified to sex.

The fall-run juvenile salmon outmigration in the San Joaquin Basin typically occurs during the winter and spring, extending mainly from January through May. The outmigration consists largely of fry in winter that are typically less than 50 mm fork length, and smolts in spring, which are typically greater than 69 mm fork length. There are also some larger fish that migrate mostly in winter and some fry observed in late spring, which may be from salmon with different spawn timing than fall-run.

During 2011, catches of juvenile Chinook salmon at Waterford were highest in late January to mid-March, peaking on January 22, and primarily consisted of fry (<50 mm; Figure 3). Daily salmon catch did not correlate with any significant changes in environmental variables (Figure 3). Daily catches of juvenile salmon at Waterford between December 5 and June 30 ranged from zero to 161 fish, with a total catch of 4,394 salmon (Figure 3).

At Grayson, catches of juvenile salmon in 2011 were highest in late January and February during the fry outmigration period. Daily catches of juvenile salmon at Grayson between January 6 and June 17 ranged from zero to 132 fish (Figure 4), with a total catch of 1,645 salmon (Table 2).

Table 2. Catch by lifestage at Waterford and Grayson, 2011.

Trapping Site	*Fry (<50 mm)*	*Parr (50-69 mm)*	*Smolt (≥ 70 mm)*
Waterford	3,958	45	391
Grayson	1,434	29	182

The length of the sampling season and the trap efficiencies will affectthe total RST catch for any given season. Sampling at Waterford is generally considered comprehensive,covering January through May each year the trap was sampled. However, in 2006 the sampling was initiated a few weeks later than usual and there was an extended non-sampling period (April 12-21) due to high flows; therefore, outmigration was not fully sampled during the 2006 season. Trap efficiency decreases at higher flows, specifically when flows are higher than approximately 1,000 cfs. During 2011, flows were elevated during the entire outmigration season and ranged from 1,580 cfs to 8,360 cfs.

Total annual trap catch at Waterford from 2006-2011 ranged from a high of 9,106 in 2006 to a low of 2,281 in 2010, and averaged 4,337 juvenile salmon (Figure 5). In 2011, the total annual catch of juvenile salmon at Waterford was approximately doublethat of the previous year and one-quarter more than 2007-2009(Table 1; Figure 5). However, the total catch in 2011 was only half of the number of Chinook captured in 2006, despite the abbreviated sampling during that year. The variation in catch during 2006 is likely due to environmental conditions, specifically high flows that averaged approximately 5,300 cfs during the juvenile migration season (i.e., January-May/June) and the higher overall abundance. The lower catch in 2010 is likely due to environmental conditions during the smolt outmigration period when flows averaged approximately 2,400 cfs and the lower overall abundance.

Total annual catch of juvenile salmon has varied substantially between years at Grayson/Shiloh (Table 1; Figure 6). This variation is likely due to differences in one or more factors including, the duration and timing of the sampling periods, environmental conditions, and overall fish abundance and survival (Table 1). Sampling periods have varied between years, with sampling initiated as early as January or as late as April and continuing through May/June.

During 1999-2002, 2006, and 2008-2011, sampling at Grayson encompassed the majority of the expected winter/spring outmigration season (i.e., January-May/June) and can be described as comprehensive (Table 1; Figure 6). In contrast, sampling was only conducted during the spring smolt outmigration period (i.e., April-May/June) in 1995-1997 at Shiloh and 2003-2005 and 2007 at Grayson, therefore sampling was incomplete for those years. Sampling during 1998 began in February but was limited to a single trap (Note: two traps were operated in all other years); thus, 1998 sampling covered an intermediate proportion of the entire outmigration period. The proportion of the Jan-May outmigration period monitored each year ranged from 82% to 98% during winter/spring sampling years, from 24% to 44% during spring-only sampling years, and was 70% in the intermediate sampling year (Table 1). The proportion of the outmigration period sampled may not be representative of the proportion of the juvenile population migrating during the sample period because the migration pattern is not uniform. Migration timing can be influenced by environmental factors such as flow and turbidity, which are often highly variable during the outmigration period.

Of the winter/spring sampling years, total annual trap catch at Grayson ranged from a high of 19,327 during 1999 to a low of 52 during 2010, and averaged 3,566 juvenile salmon (Figure 6). In all years of spring-only sampling, catches ranged from a high of 1,239 during 2001 to a low of 27 during 2007.

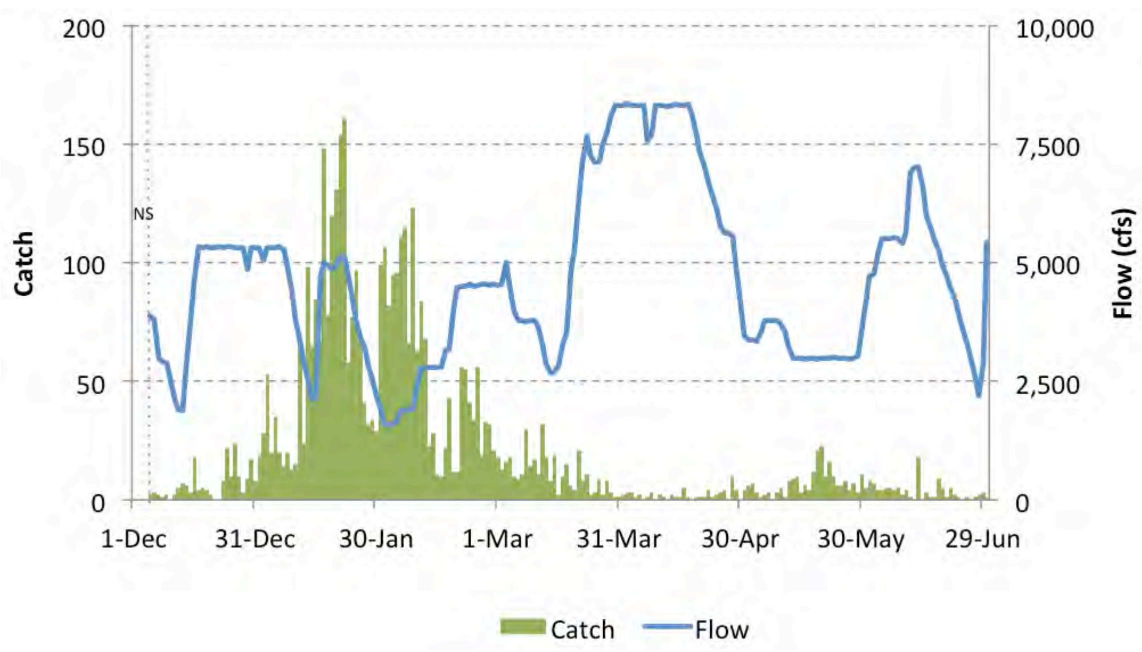

Figure 3. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2011.

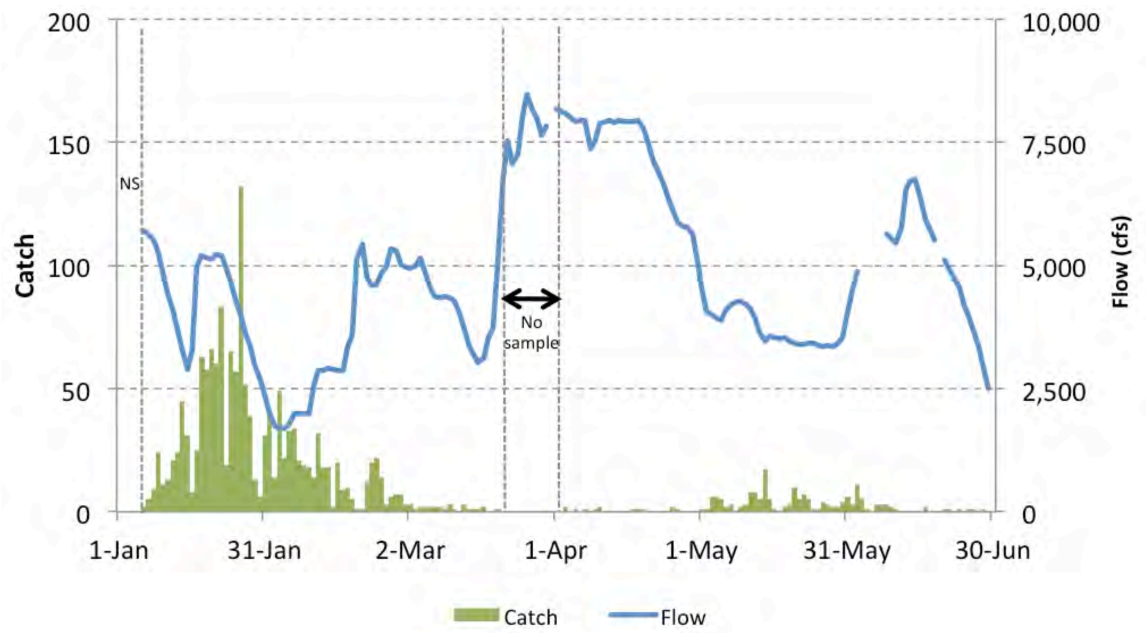

Figure 4. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2011. Note: Flow at MOD is estimated on February 3-16 due to a malfunctioning gage.

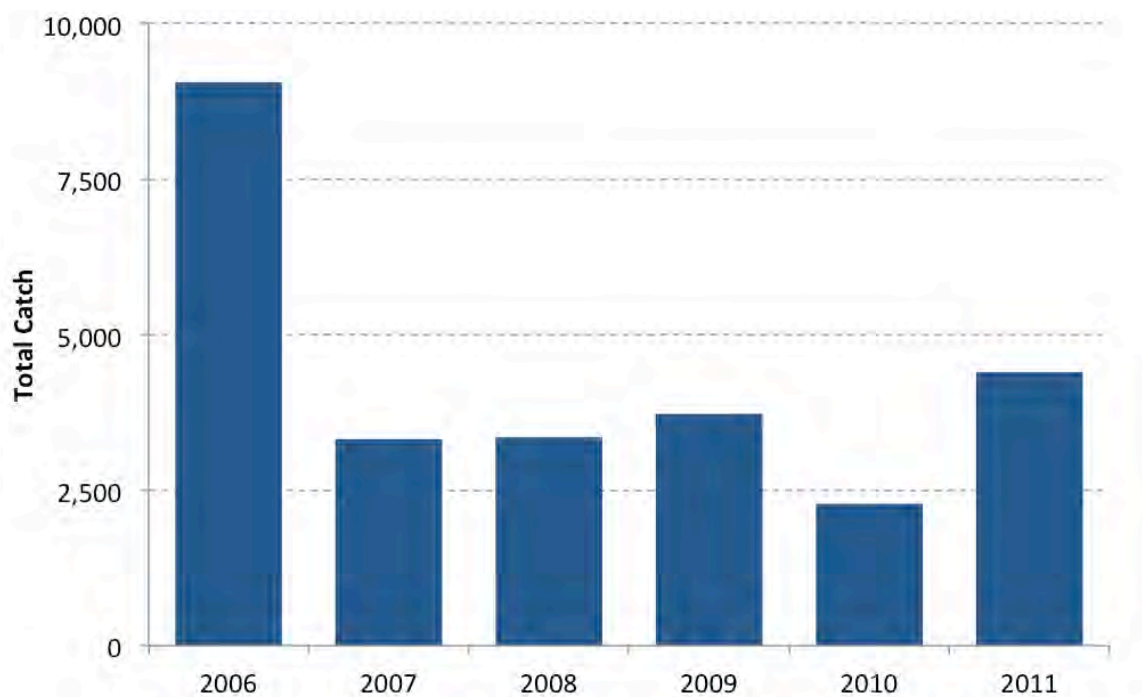

Figure 5. Total annual salmon catch at Waterford during 2006-2011.

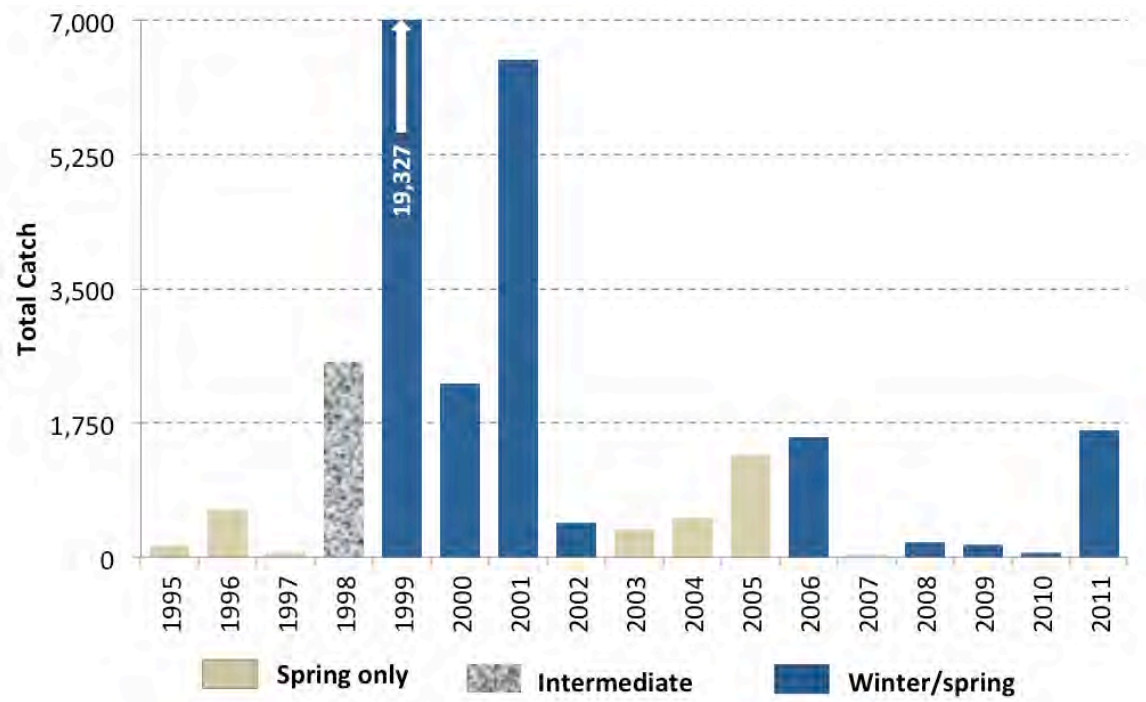

Figure 6. Total annual salmon catch at Shiloh/Grayson during 1995-2011.

Trap Efficiency

In 2011, seven trap efficiency tests were conducted at Waterford using naturally produced salmon fry. Results from these tests ranged from 0% to 3.0% at flows (La Grange) between 1,580 cfs and 5,130 cfs (Table 3).

As mentioned previously, since there were no comparable trap efficiency data available for the Waterford trap, a range of parr/smolt abundances were calculated based on data from past test results conducted under similar flow conditions at the 7/11 (RM 38) and Deardorff (RM 35.5) traps (Table 3; Stillwater Sciences 2001).

Table 3. Trap efficiency results used to estimate daily trap efficiencies at Waterford. Note: Only releases for the fry lifestage were conducted in 2011. Historical trap efficiency data from the 7/11 (RM 38) and Deardorff (RM 35.5) traps were used during the parr/smoltlifestage.

Lifestage	Release Date	Location	Origin	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at LGN	Turbidity
Fry	1/12/11	Waterford	Wild	22	0	20.0%	35	35	225	33.3
	1/15/11	Waterford	Wild	142	1	11.0%	35	35	225	21.2
	1/20/11	Waterford	Wild	116	0	2.9%	37	40	225	7.99
	1/21/11	Waterford	Wild	120	0	6.9%	37	37	225	1.16
	2/1/11	Waterford	Wild	96	1	7.1%	35	32	225	1.66
	2/2/11	Waterford	Wild	100	3	3.0%	36	35	225	1.14
	2/9/11	Waterford	Wild	116	2	6.9%	36	37	225	0.2
		TOTAL		712	7	0.98%				
Parr/smolt	4/26/98	7-Eleven	Hatchery	1504	54	3.6%	79.9	-	4051	3.5
	5/5/98	7-Eleven	Hatchery	4408	184	4.2%	88.1	-	2300	2.45
	5/11/98	7-Eleven	Hatchery	1560	88	5.6%	88.2	-	3244	2.3
	5/20/98	7-Eleven	Hatchery	877	21	2.4%	92.6	-	4768	1.95
	4/10/99	7-Eleven	Hatchery	295	6	2.0%	61.3	-	2721	1.3
	4/18/99	7-Eleven	Hatchery	2401	113	4.7%	70.8	-	2027	1.1
	4/30/99	7-Eleven	Hatchery	912	33	3.6%	78.3	-	3018	2.3
	4/27/00	Deardorff	Hatchery	1003	41	4.1%	np	-	1275	np
	5/4/00	Deardorff	Hatchery	1000	24	2.4%	np	-	2368	np
					Minimum TE	2.0%				
					Maximum TE	5.6%				

np=not provided

At Grayson, observed trap efficiency estimates from 1999-2008 and 2011 were used to derive the regression equation for predicting daily trap efficiencies, and the observed efficiencies ranged from zero to 21.2% at flows (Modesto) ranging between 280 cfs and 7,942 cfs (Table 4; Figure 8).

Daily predicted trap efficiency, and daily estimated passage at Waterford and Grayson in 2011 are provided in Appendices A and B, respectively.

Table 4. Trap efficiency results from 1998-2008 and 2011 used to derive the regression equation for predicting trap efficiencies at Grayson.

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
11-Mar-99	Hatchery	anal fin blue	1946	28	1.4%	54	53	4620
24-Mar-99	Hatchery	bottom caudal blue, ad-clip	1938	67	3.5%	61	61	3130
31-Mar-99	Hatchery	top caudal blue, ad-clip	1885	73	3.9%	65	64	2250
7-Apr-99	Hatchery	bottom caudal blue, ad-clip	1949	50	2.6%	68	68	2280

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
14-Apr-99	Hatchery	anal fin blue, ad-clip	1953	34	1.7%	73	72	2000
20-Apr-99	Hatchery	top caudal blue, ad-clip	2007	45	2.2%	73	75	1800
29-Apr-99	Hatchery	bottom caudal blue, ad-clip	1959	14	0.7%	79	80	3220
4-May-99	Hatchery	anal fin blue, ad-clip	2008	18	0.9%	83	82	3030
18-May-99	Hatchery	top caudal blue, ad-clip	2001	29	1.4%	86	84	677
26-May-99	Hatchery	bottom caudal blue, ad-clip	1984	75	3.8%	96	92	518
1-Mar-00	Hatchery	top caudal blue	1964	30	1.5%	56	53	4690
16-Mar-00	Hatchery	bottom caudal blue	1548	22	1.4%	56	56	5980
23-Mar-00	Hatchery	anal fin blue	1913	55	2.9%	59	60	3190
30-Mar-00	Hatchery	top caudal blue	1942	60	3.1%	62	63	2820
29-Apr-00	Hatchery	top caudal blue, ad-clip	1931	22	1.1%	81	82	1470
6-May-00	Hatchery	bottom caudal blue, ad-clip	1987	41	2.1%	85	85	2430
24-May-00	Hatchery	top caudal blue, ad-clip	2010	24	1.2%	85	85	1010
18-Jan-01	Hatchery	top caudal blue	1810	120	6.6%	37	np	487
8-Feb-01	Hatchery	bottom caudal blue	1980	276	13.9%	47	np	434
1-Mar-01	Hatchery	top caudal yellow	2017	57	2.8%	41	np	2130
14-Mar-01	Hatchery	bottom caudal yellow	1487	75	5.0%	46	np	703
21-Mar-01	Hatchery	bottom caudal blue, dorsal fin blue, top caudal yellow	3025	207	6.8%	61	np	519
28-Mar-01	Hatchery	anal fin blue	1954	219	11.2%	51	np	515
11-Apr-01	Hatchery	bottom caudal yellow, ad-clip	2021	141	7.0%	66	np	535
18-Apr-01	Hatchery	top caudal blue, ad-clip	2060	95	4.6%	68	np	483
25-Apr-01	Hatchery	ad-clip dorsal fin yellow, bottom caudal blue, dorsal fin blue	1515	34	2.2%	71	np	753
2-May-01	Hatchery	anal fin blue, ad-clip	3053	163	5.3%	72	np	1460
9-May-01	Hatchery	bottom caudal yellow, ad-clip	3002	147	4.9%	75	np	1160
16-May-01	Hatchery	top caudal blue, ad-clip	2942	93	3.2%	76	np	1020
20-Feb-02	Hatchery	bottom caudal red	2094	444	21.2%	57	np	265
6-Mar-02	Hatchery	anal fin red	2331	316	13.6%	68	np	278
13-Mar-02	Hatchery	top caudal red	2042	324	15.9%	65	np	300
20-Mar-02	Hatchery	dorsal fin red	2105	242	11.5%	68	np	328
27-Mar-02	Hatchery	bottom caudal red	2121	147	6.9%	68	np	314
3-Apr-02	Hatchery	anal fin red, ad-clip	1962	130	6.6%	76	np	312
9-Apr-02	Hatchery	top caudal red, ad-clip	1995	56	2.8%	79	np	319
17-Apr-02	Hatchery	dorsal fin red, ad-clip	2048	40	2.0%	84	np	889
25-Apr-02	Hatchery	bottom caudal red,	2001	22	1.1%	86	np	1210

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
		ad-clip						
1-May-02	Hatchery	anal fin red, ad-clip	2033	14	0.7%	89	np	1250
8-May-02	Hatchery	dorsal fin red, ad-clip	2021	31	1.5%	95	np	798
15-May-02	Hatchery	top caudal red, ad-clip	2047	26	1.3%	97	np	653
22-May-02	Hatchery	bottom caudal red, ad-clip	2043	10	0.5%	94	np	403
10-Apr-03	Hatchery	top caudal green	1956	138	7.1%	77	np	297
17-Apr-03	Hatchery	bottom caudal green	2047	65	3.2%	77	np	1350
24-Apr-03	Hatchery	anal fin green	1979	31	1.6%	88	np	1210
1-May-03	Hatchery	dorsal fin green	2044	113	5.5%	96	np	685
8-May-03	Hatchery	top caudal green	2078	206	9.9%	83	np	726
15-May-03	Hatchery	bottom caudal green	1996	125	6.3%	83	np	559
20-May-03	Hatchery	anal fin green	1989	60	3.0%	89	np	317
28-May-03	Hatchery	dorsal fin green	1950	125	6.4%	94	np	685
13-Apr-04	Hatchery	dorsal fin green	1992	84	4.2%	79	74	1140
20-Apr-04	Hatchery	anal fin green	1980	48	2.4%	81	79	1660
27-Apr-04	Hatchery	top caudal green	1941	118	6.1%	86	85	826
4-May-04	Hatchery	bottom caudal green	2008	50	2.5%	90	87	789
11-May-04	Hatchery	anal fin green	1972	104	5.3%	86	79	815
18-May-04	Hatchery	dorsal fin green	1996	178	8.9%	88	77	446
25-May-04	Hatchery	top caudal green	2013	59	2.9%	92	90	337
9-Feb-06	Wild	caudal fin pink	37	5	13.5%	34.6	35.2	3393
11-Feb-06	Wild	caudal fin pink	26	4	15.4%	34.9	37.3	3437
12-Feb-06	Wild	caudal fin pink	23	1	4.3%	36.1	37.0	3416
13-Feb-06	Wild	caudal fin pink	28	1	3.6%	35.5	33.0	3418
3-Mar-06	Wild	caudal fin green	89	4	4.5%	34.8	35.3	4261
5-May-06	Hatchery	caudal fin yellow	949	4	0.4%	73.2	74.3	7942
12-May-06	Hatchery	caudal fin yellow	1,286	5	0.4%	81.8	76.6	7534
25-May-06	Hatchery	top caudal yellow	1,532	2	0.1%	83.7	69.5	6537
1-Jun-06	Hatchery	top caudal yellow	1,694	0	0.0%	91.9	-	
14-Jun-06	Hatchery	top caudal yellow	1,507	2	0.1%	85.4	83.0	4864
3/1/08	Wild	caudal fin yellow	73	5	6.9%	38	38	342
4/15/08	Hatchery	caudal fin orange	1131	109	9.6%	77	76	300
4/25/08	Hatchery	dorsal fin orange	1005	17	1.7%	86	84	1290
5/7/08	Hatchery	anal fin orange	526	8	1.5%	96	96	1310
5/14/08	Hatchery	caudal fin orange	519	13	2.5%	93	91	941
5/21/08	Hatchery	lower caudal/anal fin orange	515	19	3.7%	92	91	678
1/14/11	Wild	caudal fin pink	87	3	3.45%	36	35	3,300
1/20/11	Wild	caudal fin pink	51	1	1.50%	36	32	5,130
1/21/11	Wild	caudal fin pink	63	1	1.60%	36	30	5,230
1/25/11	Wild	caudal fin pink	62	1	1.50%	36	36	4,330
1/26/11	Wild	caudal fin pink	45	1	1.80%	36	29	3,970

np= not provided

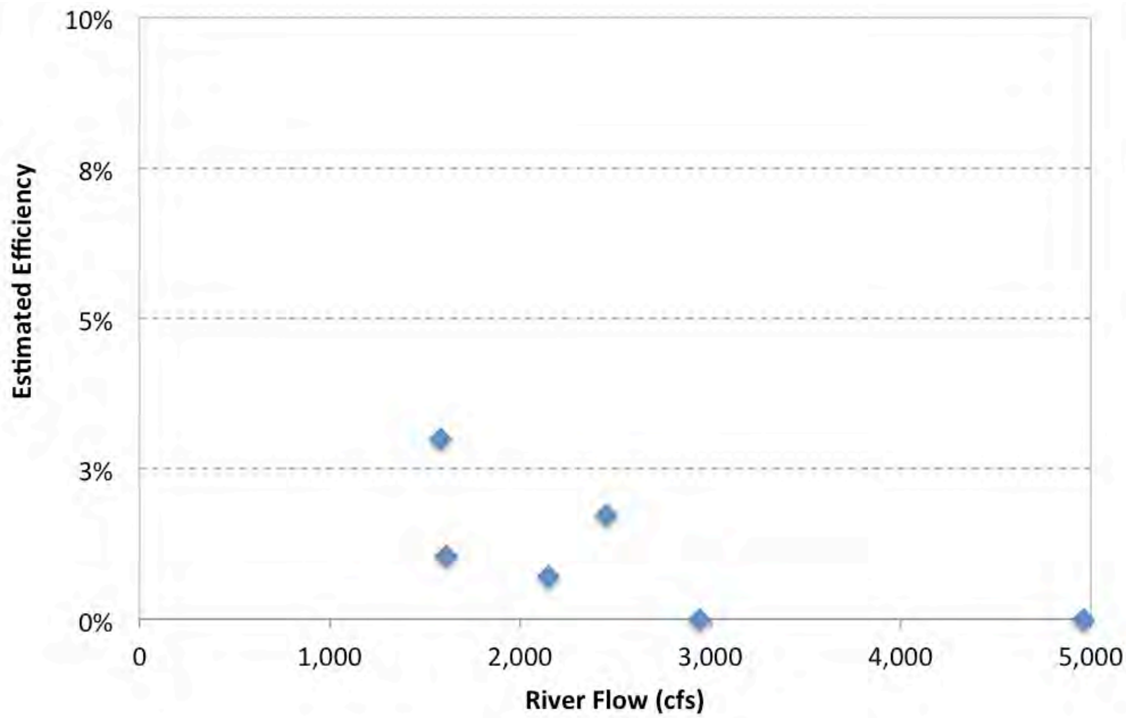

Figure 7. Trap efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2011.

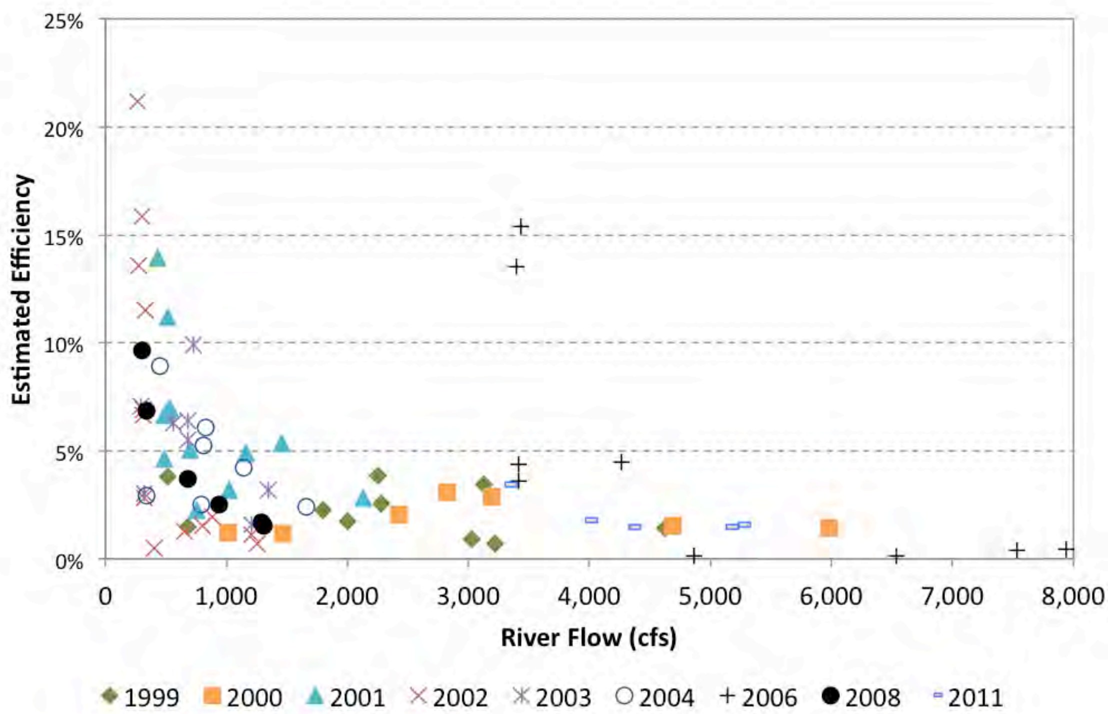

Figure 8.Trap efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2008 and 2011.

<u>Estimated Chinook Salmon Abundance</u>

As mentioned previously, in order to account for the uncertainty in trap efficiencies at Waterford during periods of parr/smolt outmigration (March 16-June 30), a range of abundances were calculated using trap efficiency data from previous study years. In this section, for ease of explanation, the population estimate was calculated using the median historical efficiency with the range in parentheses (Figure 9). Based on calculated daily passage estimates, an estimated 420,971 (414,815-427,126) Chinook salmon passed Waterford during 2011, of which 3.7% (2.4%-5.0%) were smolts (Table 5). In comparison, the percentage of fish passing Waterford as smolts was 71.6% in 2010, 51.7% in 2009, 34.3% in 2008, and 51.1% in 2007. In 2006, sampling efforts were affected by high spring flows resulting in passage estimates that were likely underestimated (particularly for smolts). In 2011, and in previous years, a majority of the salmon observedpassing Waterford prior to mid-March were fry and passage was then dominated by smolts from late-March through June (Table 5; Figure 10). Daily estimated salmon passage at Waterford ranged from 0to 16,376. The peak in daily passage for fry occurred on January 22 and smolt passage peaked on May 20 (Figure 11).

For comparisons, passage estimates at Waterford were also calculated based on the estimated proportion of flow sampled during 2011. This method produced an estimate of 428,317 at Waterford. This estimate is provided for the purpose of comparison only and is not reflected in the tables and figures in this report.

An estimated 87,172 unmarked Chinook salmon passed Grayson during 2011 and of these 52.5% were fry and 45.6% were smolts (Table 5). Daily estimated passage at Grayson ranged from 0 to 3,969 salmon. Peak daily passage for fry and smolts occurred on January 22 and May 14, respectively (Figure 11). During comparable seasonal sampling in previous years at Grayson (i.e., winter/spring sampling in 1999-2002, 2006, and 2008-2011), total estimated passage ranged from a high of 869,636 in 1999 to a low of 3,287 in 2008 (Table 1; Figure 14); the proportion of passage as smolts was the highest in 2010 (95.9%) and the lowest in 1999 (2.9%). 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 254,981 in 2005 to a low of 905 in 2007 (Table 1; Figure 14); the vast 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 14), 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 trap efficiency tests were conducted with fry. In 1998, estimates for trap efficiency only existed for smolts, which were subsequently applied to other life stages. The use of smolt-specific (low) capture probability to extrapolate on fry captures may result in drasticoverestimation of fish passage.

During the 2010-11 spawning season, approximately 1,291 (1,272-1,310) juveniles were produced per female spawner, based on the estimated 326 female spawners[4] and the total estimated passage at the Waterford trap. This is high compared to 490 (337-643) juveniles per female in 2010, 175 in 2009, 311 in 2008, and 205 in 2007 (Table 6). However, the number of female spawners may have been underestimated due to

[4] Excludes 142 adult salmon of unknown gender and does not take into account the salmon undetected in December 2010 when sampling was terminated due to flood releases from Don Pedro Reservoir.

sampling in 2010-11 spawning season; thus, increasing the estimated juveniles per female spawner ratio. Beginning in2010 the number of female spawners was estimated based oncounts from a VakiRiverwatcher used in conjunction with a resistance board weir, rather than the traditional carcass surveys. This estimate of spawner abundance is believed to be more accurate than carcass surveys, especially during years of lower abundance (Cuthbert et al. 2010).

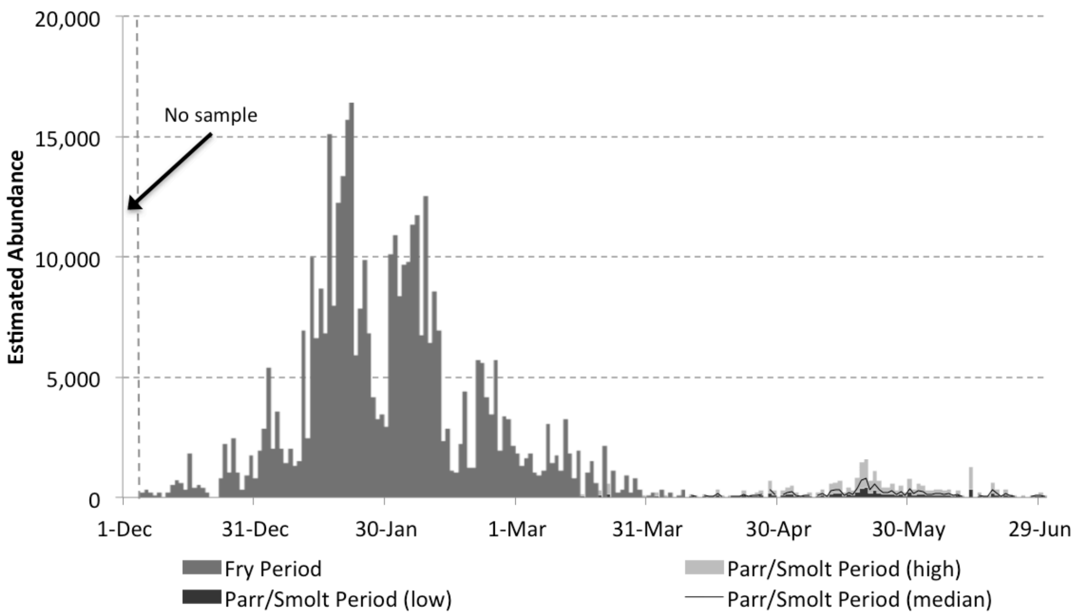

Figure 9. Daily estimated abundance of Chinook salmon at Waterford based on trap efficiencies conducted in 2011 at Waterford during the fry periodand at the 7/11 and Deardorff traps in 1998-2000 (at flows > 1,000cfs) for the parr/smolt period. A range of abundances were calculated for the parr/smolt period and the median and range are presented in this graph.

Table 5. Estimated passage by lifestage at Waterford and Grayson during 1995-2011. *For 2010-2011 the estimated passage values used in this table for Waterford are the median values of the estimated ranges.

		Sampling Period	Fry		Parr		Smolts		Total
			Number	%	Number	%	Number	%	
Waterford	2006	w/s	163,805	54.0%	6,550	2.2%	133,127	43.9%	303,482
	2007	w/s	20,633	35.7%	7,614	13.2%	29,554	51.1%	57,801
	2008	w/s	15,259	61.3%	1,102	4.4%	8,534	34.3%	24,894
	2009	w/s	13,399	36.0%	4,562	12.3%	19,213	51.7%	37,174
	2010*	w/s	10,735	25.9%	1,030	2.5%	29,728	71.6%	41,493
	2011*	w/s	400,478	95.1%	4,884	1.2%	15,608	3.7%	420,971
Grayson	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
	1999	w/s	830,064	95.4%	14,379	1.7%	25,193	2.9%	869,636
	2000	w/s	55,309	51.4%	21,396	19.9%	30,912	28.7%	107,617
	2001	w/s	65,845	61.8%	26,620	25.0%	14,115	13.2%	106,580
	2002	w/s	75	0.5%	5,705	41.0%	8,147	58.5%	13,928
	2003	spring	26	0.3%	128	1.4%	8,920	98.3%	9,074
	2004	spring	155	0.9%	727	4.1%	16,718	95.0%	17,600
	2005	spring	-	-	442	0.2%	254,539	99.8%	254,981
	2006	w/s	35,204	19.4%	17,550	9.7%	128,937	71.0%	181,691
	2007	spring	-	-	-	-	905	100%	905
	2008	w/s	981	29.9%	15	0.5%	2,291	69.7%	3,287
	2009	w/s	139	3.0%	162	3.5%	4,047	88.0%	4,598
	2010	w/s	173	4.1%	0	0%	4,060	95.9%	4,060
	2011	w/s	45,781	52.5%	1,654	1.9%	39,737	45.6%	87,172

Table 6. Estimated number of juvenile salmon produced per female spawner, 2006-2011.

Year	Females	Juveniles/female spawner
2006	478	635
2007	282	205
2008	80	311
2009	212	175
2010	87	337 to 643
2011	326[5]	1,272 to 1,310

[5] Excludes 142 adult salmon of unknown gender and does not take into account the salmon undetected in December 2010 when sampling was terminated due to flood releases from Don Pedro Reservoir.

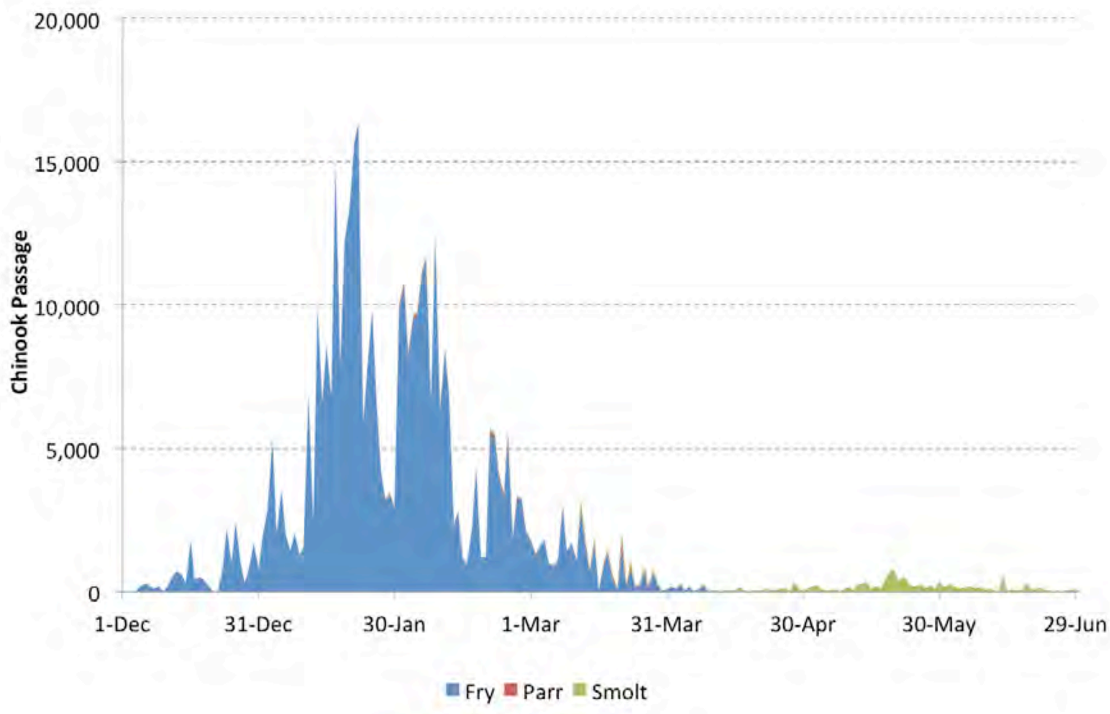

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2011.

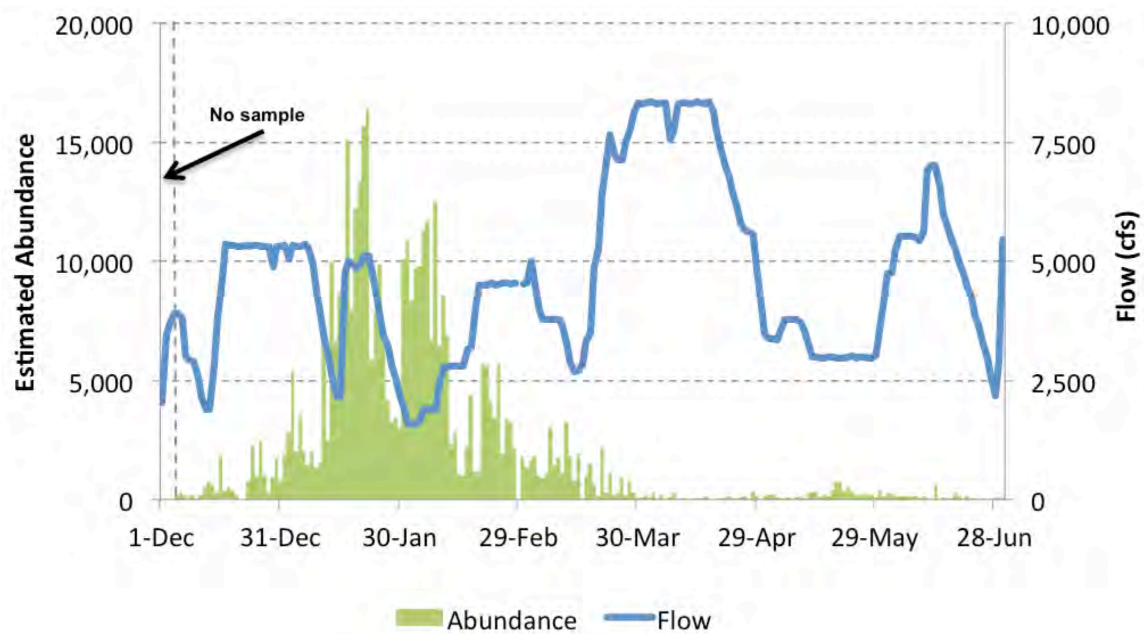

Figure 11. Daily estimated passage of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2011.*NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See* Figure 9*.*

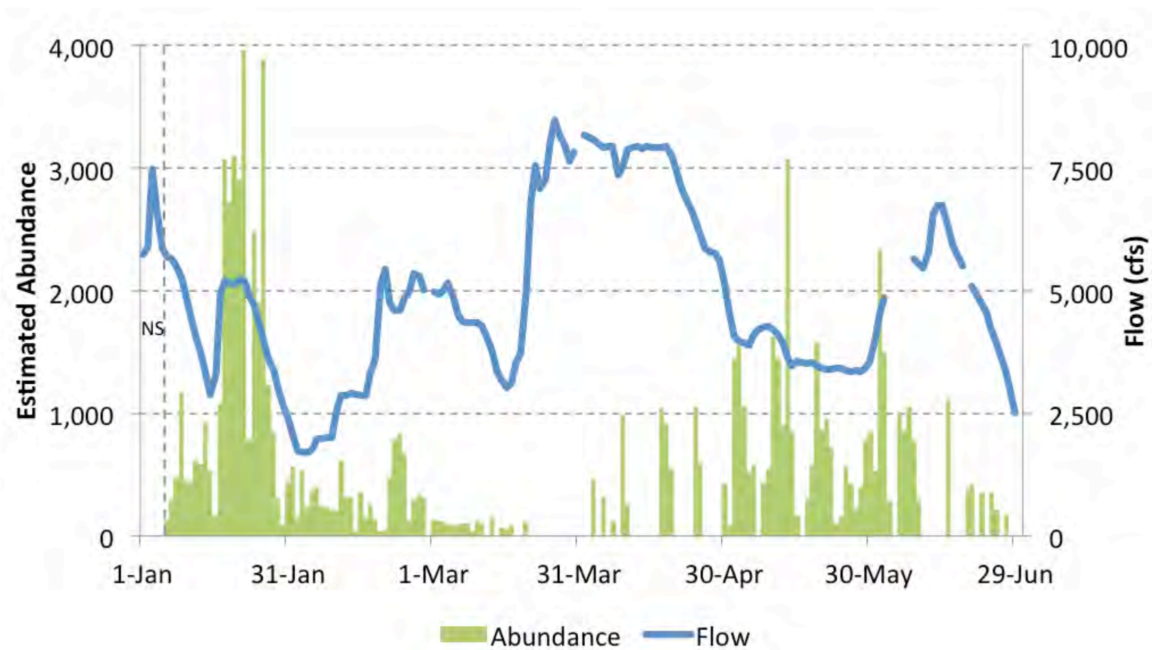

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2011.

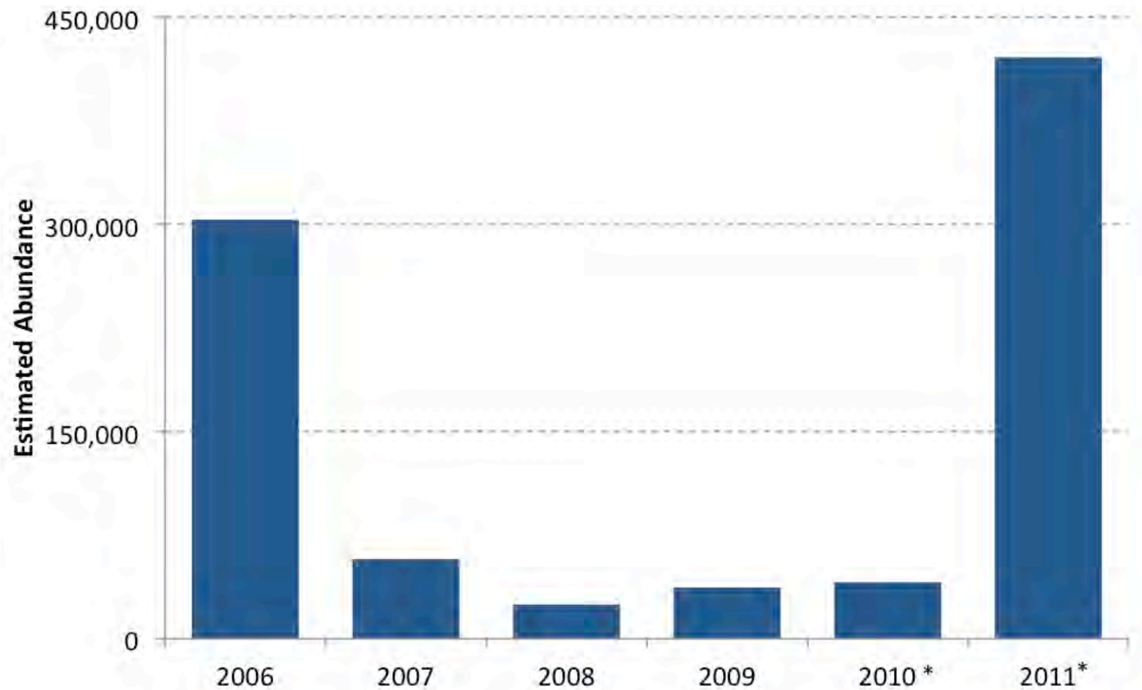

Figure 13.Total estimated Chinook passage at Waterford (2006-2011).

**Note that 2010-2011 estimates are based upon the median of historical trap efficiency.*

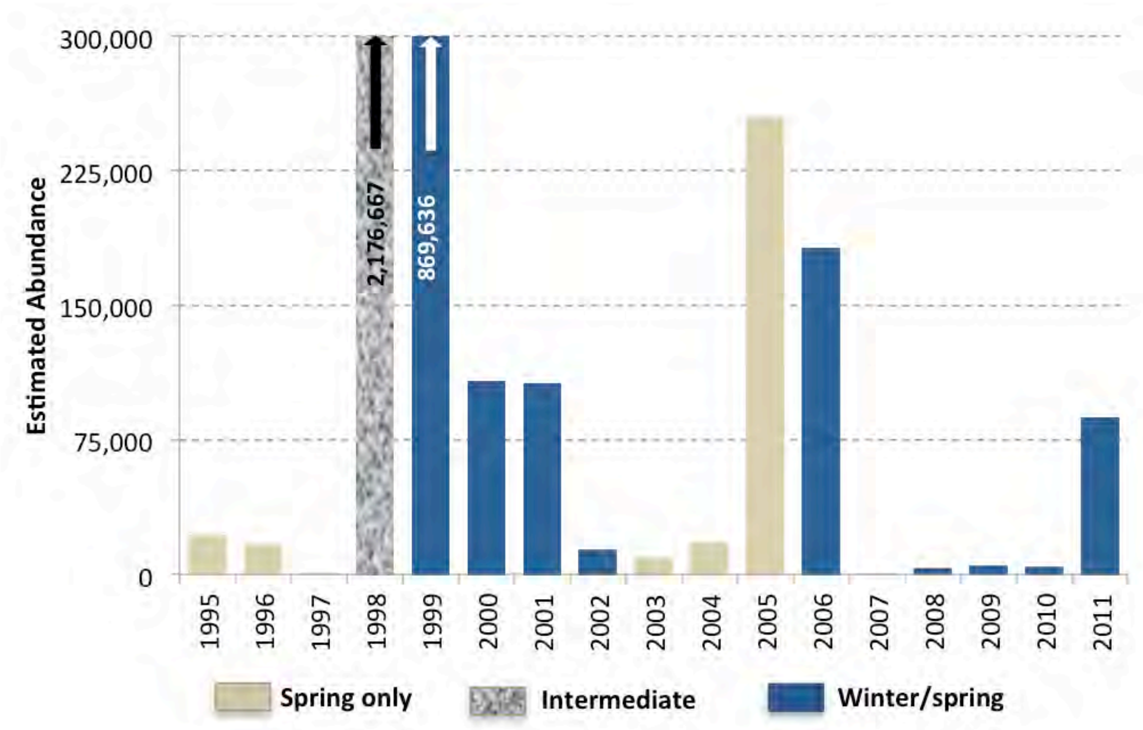

Figure 14. Total estimated Chinook passage at Shiloh and Grayson during 1995-2011. The color of the column defines the sampling period for that year.

Estimated Chinook Salmon Abundance and Environmental Factors

Peaks in salmon fry passage at Waterford in the winter were generally associated with changes in flow, rainfall and peaks in turbidity conditions. River releases were high, fluctuated during this period (January to mid-March) and ranged from 1,580 cfs to 5,350 cfs. River flow near Grayson during the winter period was even more variable as a result of storm run-off, particularly from Dry Creek entering at Modesto, and ranged from 1,697 cfs to 7,490 cfs. Fewer fish moved past the Waterford trap during the spring (mid-March through June) compared to the winter period (Figure 11) even though releases were increased to over 8,000 cfs. Smolt peaks were observed at the Grayson traps, however, and were generally higher when flows were decreasing (Figure 12).

During 2011 monitoring, daily average water temperatures ranged from 49.3°F to 56.1°F at the Waterford trap (Figure 15) and from 48.3°F to 59.5°F at the Grayson traps (Figure 16). Water temperatures generally increased through the outmigration season. Fry passage at Waterford increased as temperatures decreased in January (Figure 15), and smolt passage appeared to peak with slight fluctuations in temperature at Grayson during the spring (Figure 16).

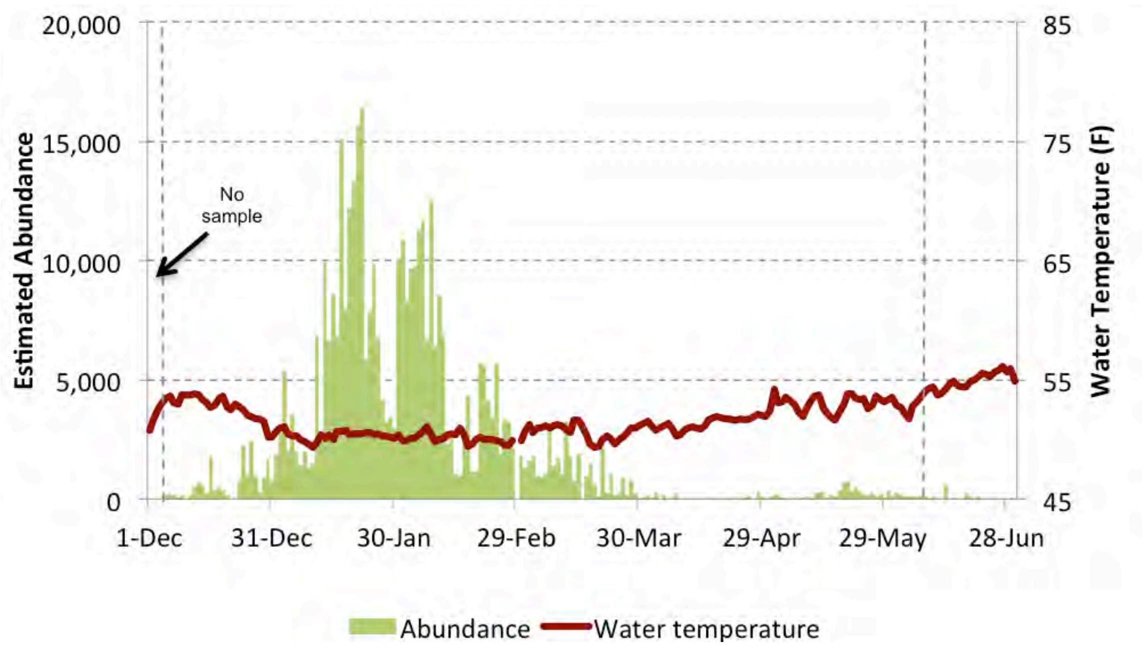

Figure 15. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Waterford trap during 2011. NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See Figure 9.

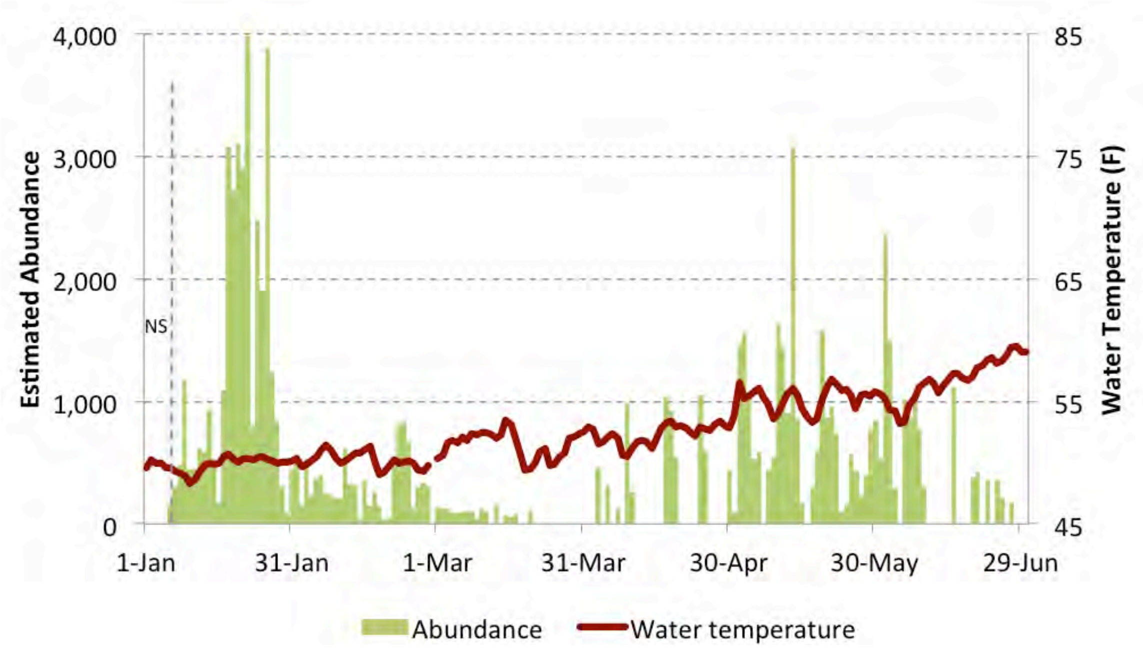

Figure 16. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Grayson trap during 2011.

Background turbidity was generally less than 4.5 NTU at Waterford (Figure 17) and less than 7 NTU at Grayson (Figure 18) during the 2011 monitoring period. During several storm events (Figure 19), increases in turbidity were observed but only ranged as high as 8 NTU at Waterford and 13 NTU at Grayson. Peaks in passage generally occurred one to several days after periods of elevated turbidity at both trapping sites.

The ratio of estimated total passage at Grayson relative to the estimated total passage at Waterford provides an index of survival through the river between the sites (24.6 miles) during years when the majority of the outmigration period is sampled. The survival index for 2011, 20.7%, should be interpreted with caution, since there is some uncertainty in the total passage estimate for Waterford. This value was calculated using the median estimated total passage for Waterford, and ranges from 20.4% to 21.0% based upon the range of estimated passages. Survival indices were also calculated for 2006 and 2008-2011 (Table 7). A survival index was not calculated for 2007 because sampling did not begin until mid-March. The survival index for 2010 was calculated similar to 2011 and should also be interpreted with caution.

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

Year	Survival Index
2006	10.4
2008	23.6
2009	13.2
2010	11.9
2011	20.7

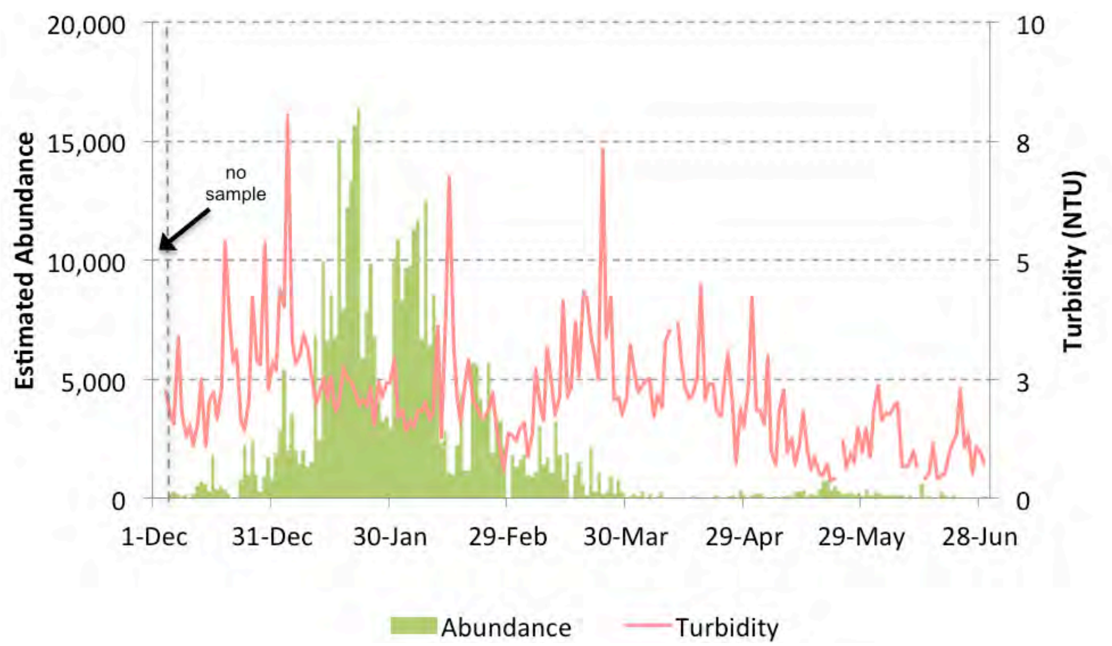

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2011. NOTE: From March 16-June 30 the graph depicts median daily passage estimates - See Figure 9.

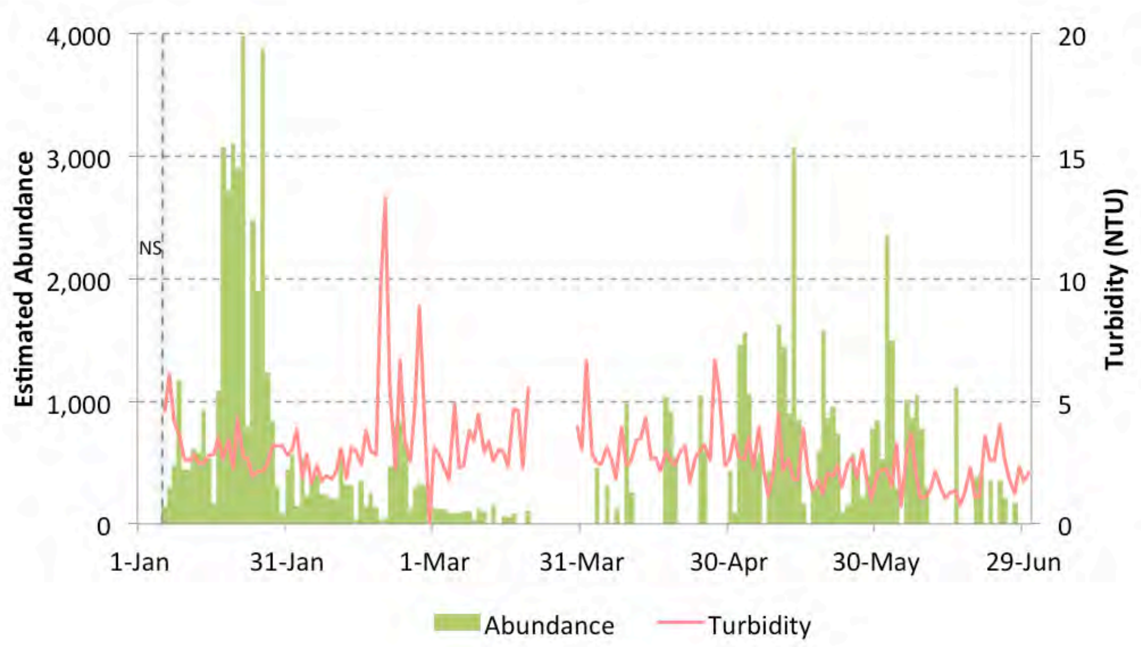

Figure 18. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2011.

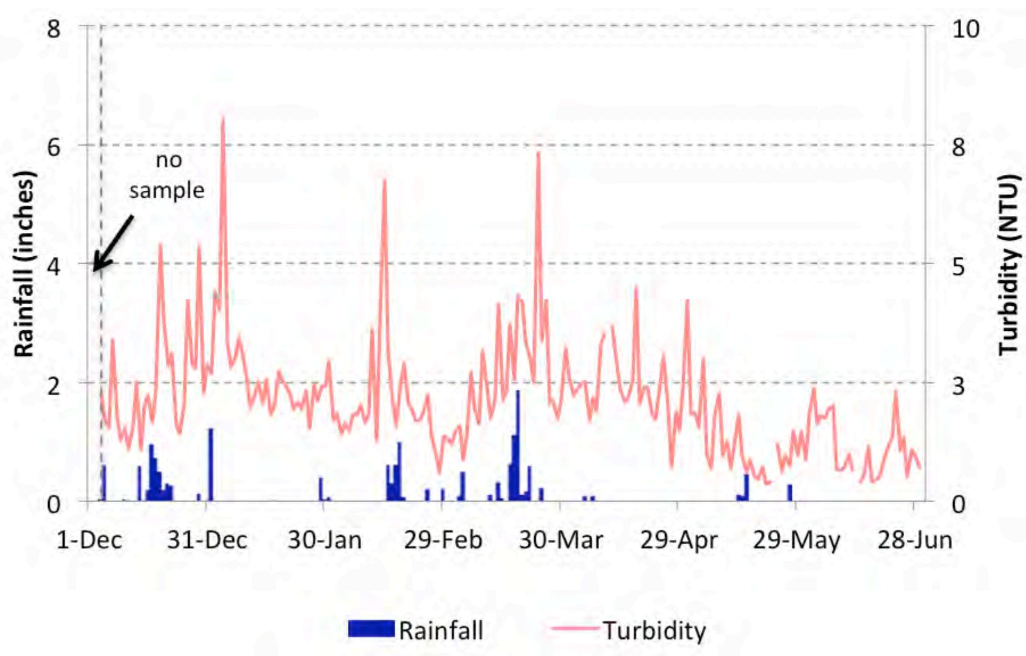

Figure 19. Daily rainfall measured at Don Pedro Reservoir and instantaneous turbidity at Waterford during 2011.

Chinook Salmon Length at Migration

Individual fork lengths of unmarked salmon captured at Waterford during 2011 ranged from 28 mm to 130 mm (Figure 20), and daily average length gradually increased from approximately 34 mm to over 90 mm during the course of the sampling period (Figure 21 and Figure 22). Most of the juvenile salmon passing Waterford during 2011 were fry measuring 30-39 mm (Figure 23). In total, it is estimated that 400,478 fry (<50 mm), 4,884 parr (50-69 mm), and 15,608 smolts (>70 mm) passed Waterford during 2011 (Table 5). Individual fork lengths of unmarked Chinook salmon captured at Grayson during 2011 ranged from 28 mm to 135 mm (Figure 24), and daily average length ranged between 32 mm and 115 mm during the sampling period (Figure 25 and Figure 26). More than 50% of the salmon estimated to have passed Grayson during 2011 were fry measuring 30-39 mm, followed by 41.5% passing as smolts measuring greater than 90 mm (Figure 26). In total, it is estimated that 45,781 fry (<50 mm), 1,654 parr (50-69 mm), and 39,737 smolts (>70 mm) passed Grayson during 2011 (Table 5).

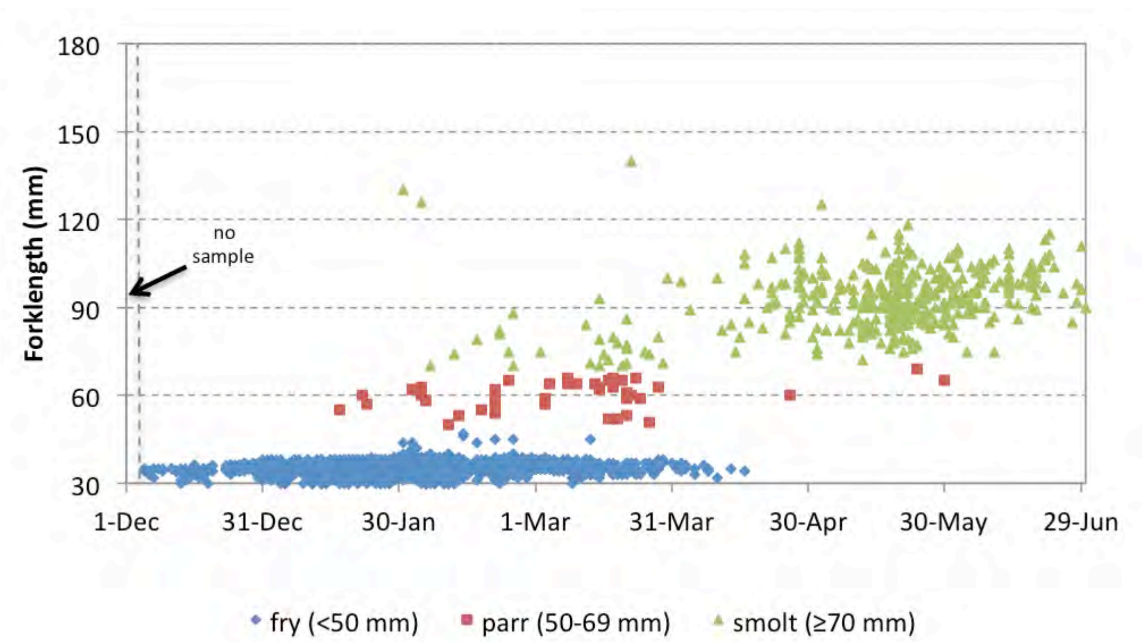

Figure 20. Individual fork lengths of juvenile salmon captured at Waterford during 2011.

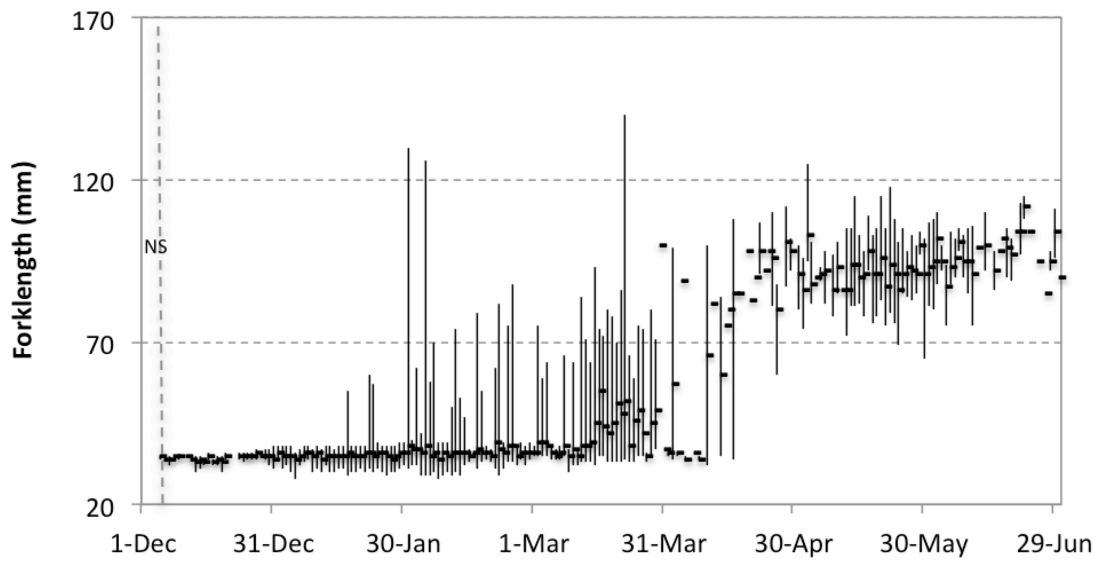

Figure 21. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2011.

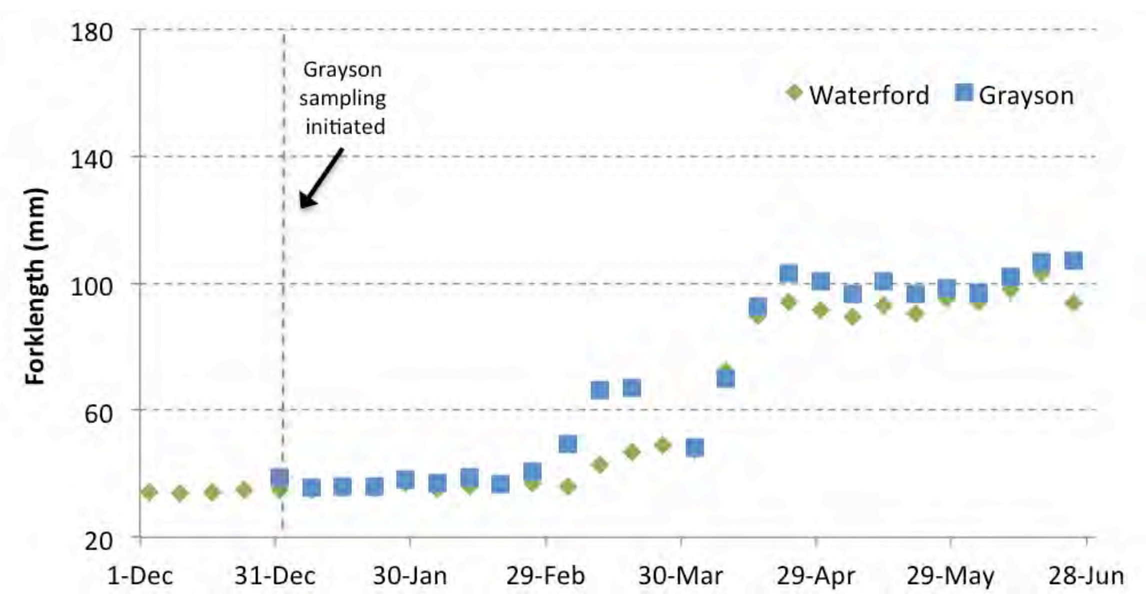

Figure 22. Average fork length of juvenile Chinook salmon captured at Waterford and Grayson by Julian week during 2011.

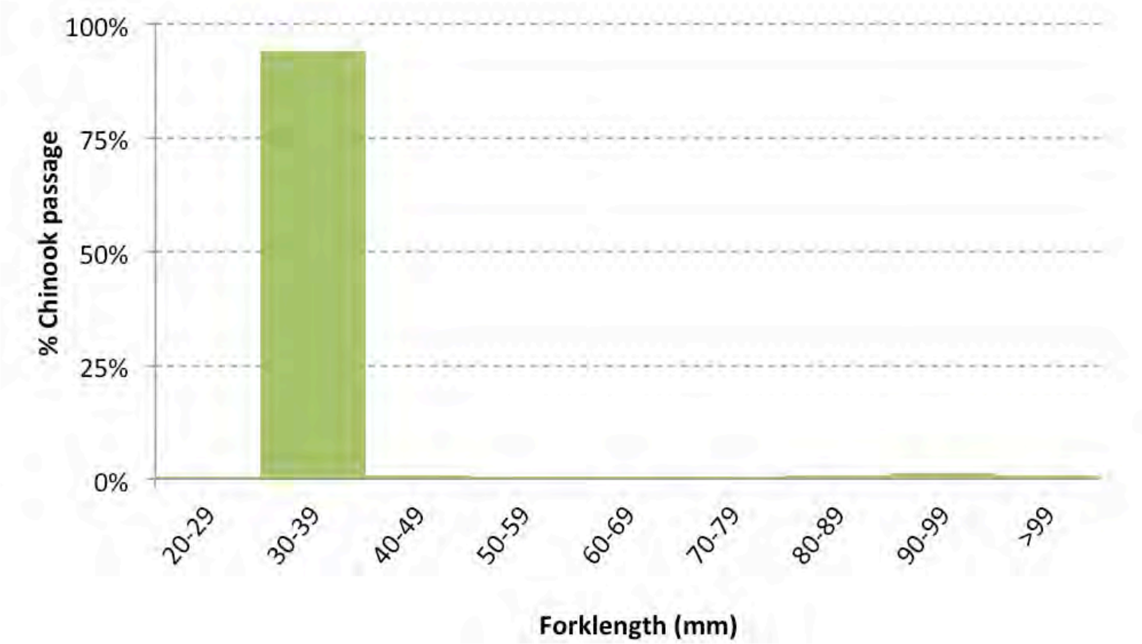

Figure 23. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Waterford during 2011.

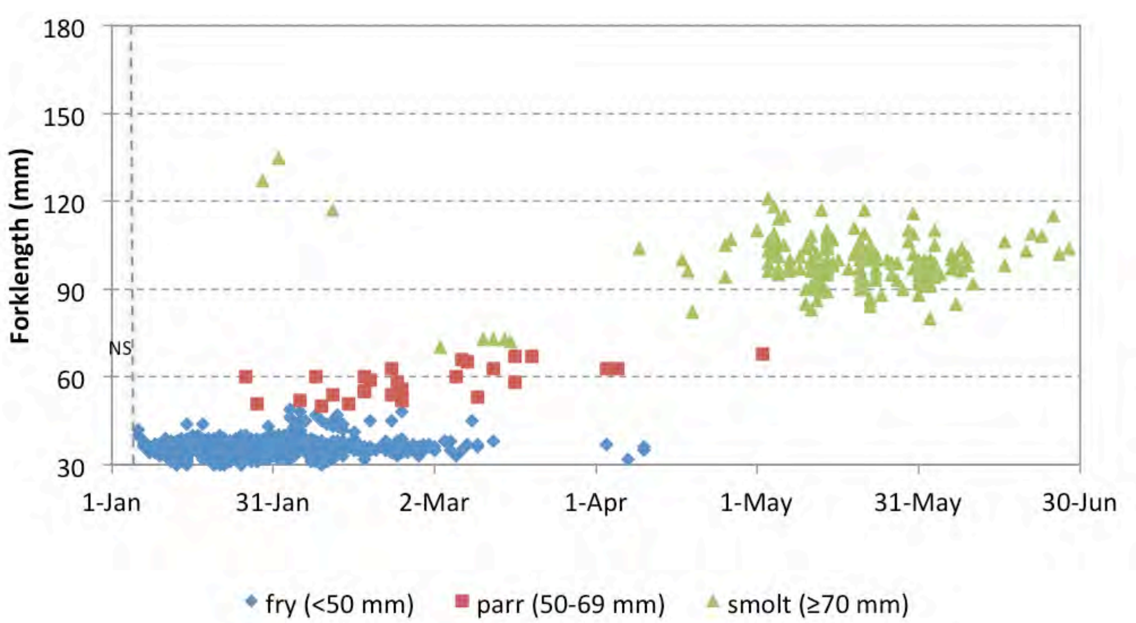

Figure 24. Individual fork lengths of juvenile salmon captured at Grayson during 2011.

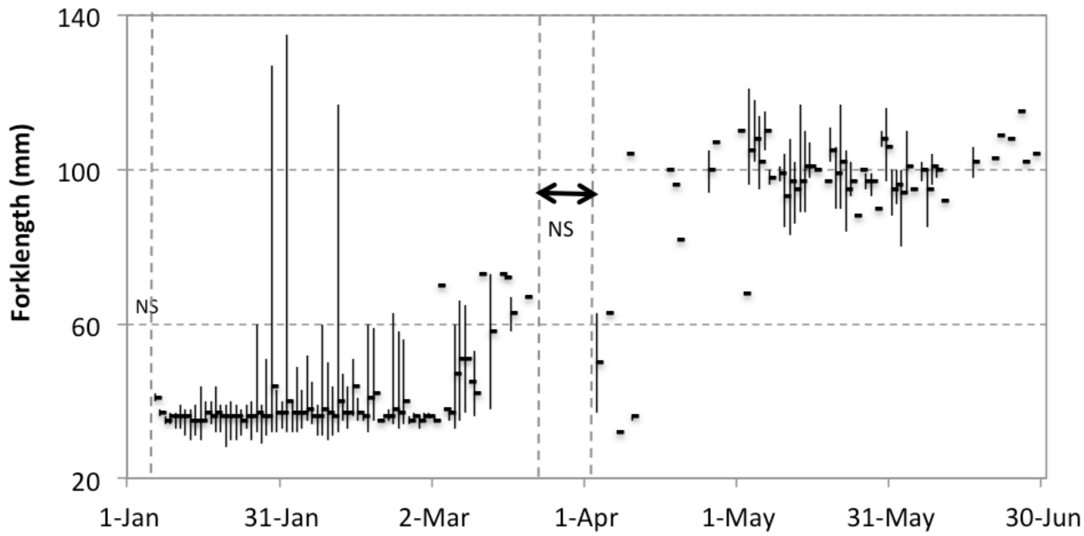

Figure 25. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2011.

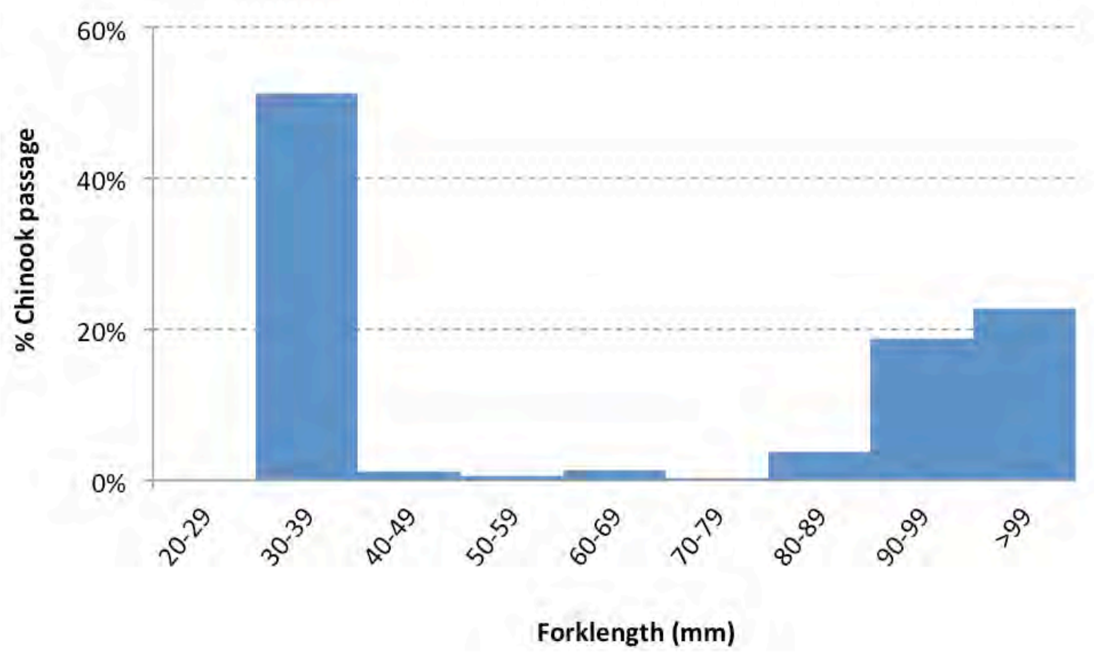

Figure 26. Length-frequency histogram of estimated Chinook passage (10 mm fork length bins) at Grayson during 2011.

Chinook Salmon Condition at Migration

Juveniles captured at both locations (Waterford and Grayson) during 2011 appeared healthy withoutvisually discernible signs of disease or stress. The length-weight relationship for individuals captured at both sites showed a very similar trend (Figure 27 and Figure 28).

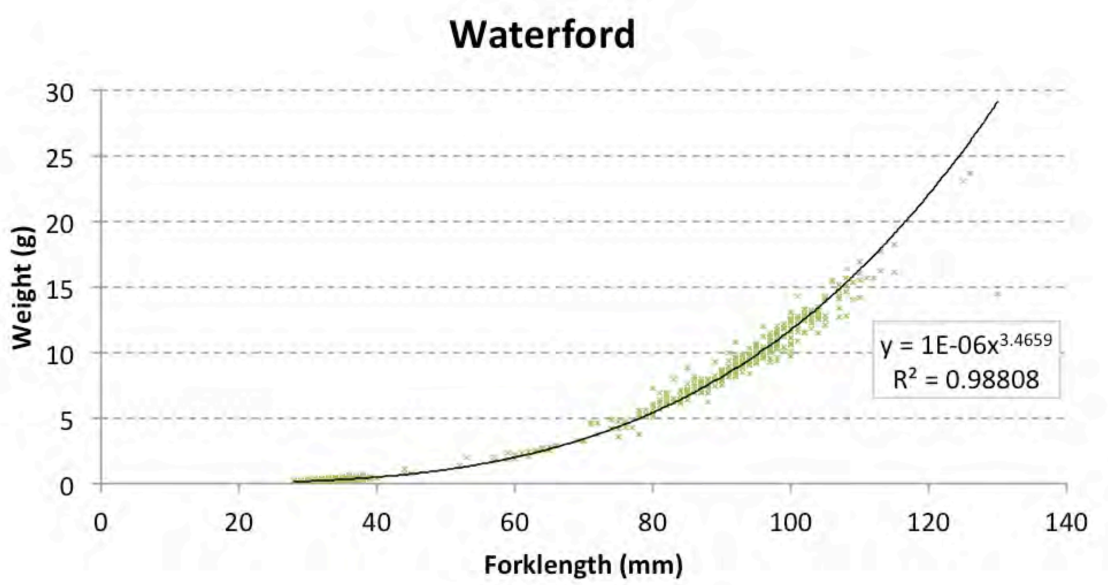

Figure 27. Length-weight relationship of fish measured at Waterford during 2011.

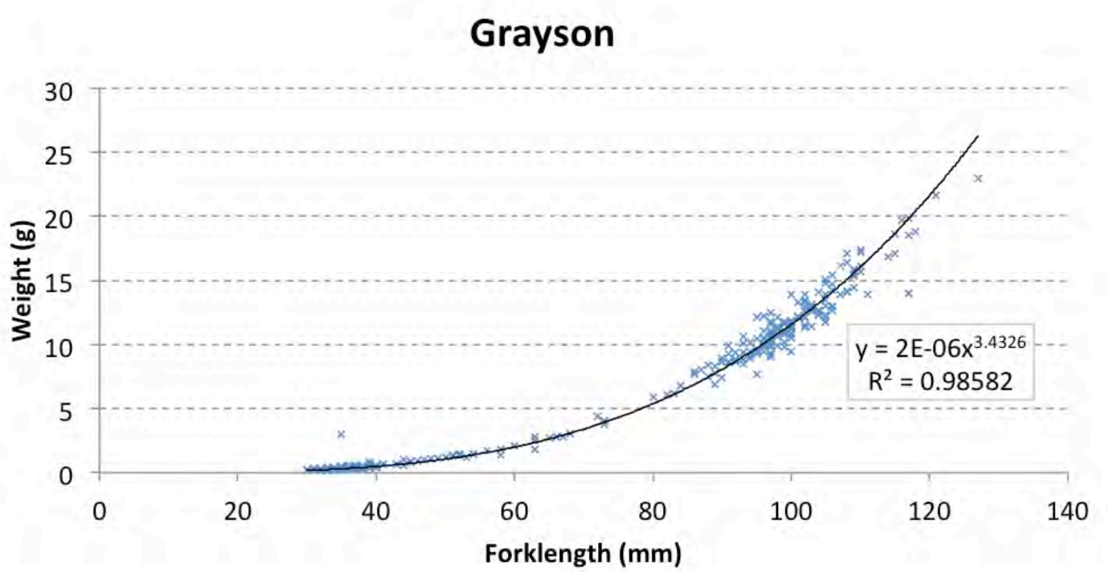

Figure 28. Length-weight relationship of fish measured at Grayson during 2011.

Oncorhynchus mykiss (Rainbow Trout/Steelhead)

No *O. mykiss* were captured at Waterford or Grayson in 2011.Total annual *O. mykiss* catch at the Grayson and Waterford traps between 2000 and 2011 ranged from 0 to 11 (Figure 29).

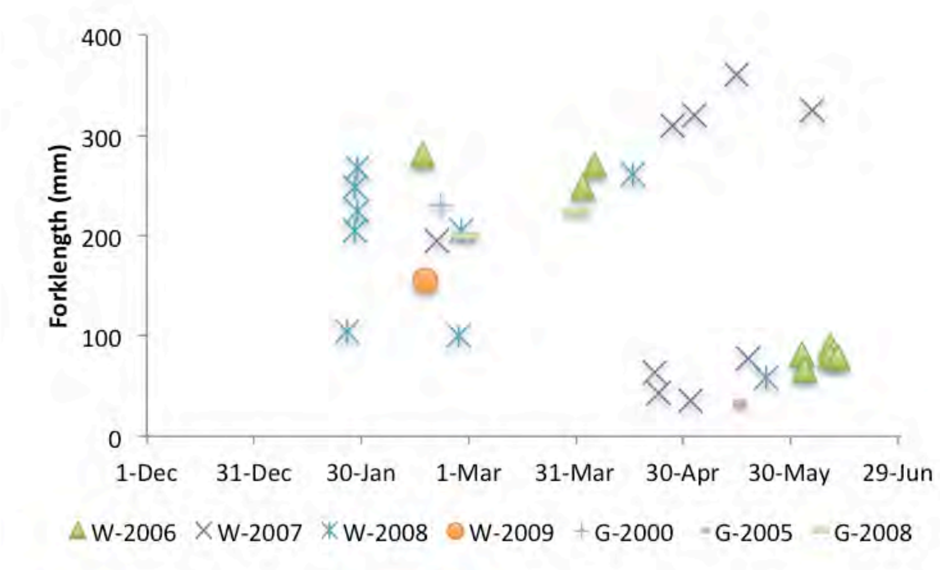

Figure 29. Date, size and location of *O. mykiss* captured at Waterford (W) and Grayson (G).

Other Fish Species Captured

A total of 49,265 non-salmonids representing at least 23 species (6 native, 17 introduced) were captured during operation of the Waterford and Grayson traps in 2011 (Table 8; Appendices C and D). Native species only comprised 1.7% of the total non-salmonid catch, consisting primarily of Sacramento pikeminnow (*n*=280). Most species captured at Waterford were also recorded at Grayson. Additional species only recorded at Waterford were green sunfish and threadfinshad. Species only recorded at Grayson were black bullhead, black crappie, carp, and inland silverside. Lampreys captured in the traps were primarily ammocoetes and were not identified to species or measured. No adult lamprey were captured at either trapping location.

Common Name	Scientific Name	Waterford Total Catch	Waterford Minimum Length (mm)	Waterford Average Length (mm)	Waterford Maximum Length (mm)	Grayson Total Catch	Grayson Minimum Length (mm)	Grayson Average Length (mm)	Grayson Maximum Length (mm)
Catfish Family									
Black bullhead	*Ameiurusmelas*	0	-	-	-	2	34	40	45
Brown bullhead	*Ameiurusnebulosus*	1	-	-	-	2	-	-	-
Channel catfish	*Ictaluruspunctatus*	1	50	50	50	16	33	45	60
White catfish	*Ictaluruscatus*	2	71	85	98	183	23	44	78
Herring Family									
Threadfin shad	*Dorosomapetenense*	1	41	41	41	0	-	-	-
Lamprey Family									
Lamprey - unidentified	Not applicable	143	-	-	-	19	-	-	-
Livebearer Family									
Mosquitofish	*Gambusiaaffinis*	30	18	41	30	54	16	28	47
Minnow Family									
Carp	*Cyprinuscarpio*	0	-	-	-	47,535	9	25	47
Golden shiner	*Notemigonuscrysoleucas*	2	55	83	110	24	23	50	132
Hardhead	*Mylopharodonconocephalus*	52	22	33	48	122	24	37	55
Hitch	*Laviniaexilicauda*	1	45	45	45	1	54	54	54
Red shiner	*Cyprinellalutrennsis*	4	30	41	63	35	19	40	59
Sacramento pikeminnow	*Ptychocheliusgrandis*	109	25	38	92	171	21	43	86
Sculpin Family									
Prickly Sculpin	*Cottusasper*	4	80	103	124	1	43	43	43
Silverside Family									
Inland silverside	*Menidiaberyllina*	0	-	-	-	1	40	40	40
Sucker Family									

Common Name	Scientific Name	Waterford Total Catch	Waterford Minimum Length (mm)	Waterford Average Length (mm)	Waterford Maximum Length (mm)	Grayson Total Catch	Grayson Minimum Length (mm)	Grayson Average Length (mm)	Grayson Maximum Length (mm)
Sacramento sucker	*Catostomusoccidentalis*	69	23	41	122	120	20	34	85
Sunfish Family									
Bluegill	*Lepomismacrochirus*	46	24	69	125	91	18	55	153
Black crappie	*Pomoxisannularis*	0	-	-	-	4	47	73	111
Green sunfish	*Lepomiscyanellus*	1	110	110	110	0	-	-	-
Largemouth bass	*Micropterussalmoides*	11	25	46	111	74	27	54	201
Redear sunfish	*Lepomismicrolophus*	15	30	79	133	20	31	76	200
Smallmouth bass	*Micropterusdolomieu*	3	28	52	82	20	21	72	227
Warmouth	*Lepomisgulosus*	4	31	84	122	14	30	55	80
Unidentified bass	Not applicable	12	25	30	46	44	12	27	130
Unidentified sunfish	Not applicable	1	-	-	-	2	22	25	27
Unidentified species	Not applicable	0	-	-	-	2	20	25	29

Total Species Captured = 23 (17 introduced, 6 native)

Total Native Individuals Captured = 812(378 at Waterford, 48,075 at Grayson)

Total Introduced Individuals Captured = 48,453 (121 at Waterford, 1,199 at Grayson)

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Appendix A. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Waterford and associated environmental data from 2011.

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
12/5/10	2	34	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	3890	2.8	53.4	1.73
12/6/10	3	33	34	34	0.0098	305	0	0	305	0.0098	305	0	0	305	305	3810	3.3	53.6	1.56
12/7/10	2	32	34	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	3000	3.4	53.0	3.41
12/8/10	1	35	35	35	0.0098	102	0	0	102	0.0098	102	0	0	102	102	2910	3.1	52.9	1.79
12/9/10	2	34	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	2900	2.6	53.7	1.29
12/10/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	2550	3.0	53.7	1.53
12/11/10	2	35	35	35	0.0098	203	0	0	203	0.0098	203	0	0	203	203	2130	2.5	53.7	1.11
12/12/10	5	34	34	34	0.0098	509	0	0	509	0.0098	509	0	0	509	509	1900	3.6	53.9	1.59
12/13/10	7	30	33	35	0.0098	712	0	0	712	0.0098	712	0	0	712	712	1890	3.6	53.7	2.50
12/14/10	6	31	34	35	0.0098	610	0	0	610	0.0098	610	0	0	610	610	2810	3.2	53.4	1.08
12/15/10	3	32	33	34	0.0098	305	0	0	305	0.0098	305	0	0	305	305	3810	3.4	53.1	2.01
12/16/10	18	34	35	36	0.0098	1831	0	0	1831	0.0098	1831	0	0	1831	1831	4590	4.6	52.7	2.23
12/17/10	4	32	33	34	0.0098	407	0	0	407	0.0098	407	0	0	407	407	5350	3.4	52.8	1.65
12/18/10	5	32	34	35	0.0098	509	0	0	509	0.0098	509	0	0	509	509	5330	3.0	53.5	2.33
12/19/10	4	30	33	35	0.0098	407	0	0	407	0.0098	407	0	0	407	407	5340	3.6	53.6	5.38
12/20/10	2	34	35	36	0.0098	203	0	0	203	0.0098	203	0	0	203	203	5320	1.8	52.7	3.78
12/21/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	5320	2.2	52.4	2.86
12/22/10	0	-	-	-	0.0098	0	0	0	0	0.0098	0	0	0	0	0	5340	3.9	52.9	3.10
12/23/10	8	34	35	36	0.0098	814	0	0	814	0.0098	814	0	0	814	814	5320	2.8	52.7	1.61
12/24/10	22	33	35	36	0.0098	2238	0	0	2238	0.0098	2238	0	0	2238	2238	5340	3.2	52.4	1.42
12/25/10	10	34	35	36	0.0098	1017	0	0	1017	0.0098	1017	0	0	1017	1017	5340	2.5	52.0	2.06
12/26/10	24	34	35	36	0.0098	2441	0	0	2441	0.0098	2441	0	0	2441	2441	5320	4.3	51.9	4.24
12/27/10	10	34	36	37	0.0098	1017	0	0	1017	0.0098	1017	0	0	1017	1017	5320	3.0	51.7	2.87
12/28/10	3	35	35	36	0.0098	305	0	0	305	0.0098	305	0	0	305	305	5310	3.3	51.7	2.81
12/29/10	9	34	35	37	0.0098	915	0	0	915	0.0098	915	0	0	915	915	4870	3.6	51.5	5.35
12/30/10	17	32	35	37	0.0098	1729	0	0	1729	0.0098	1729	0	0	1729	1729	5320	3.6	50.2	2.27
12/31/10	8	31	34	38	0.0098	814	0	0	814	0.0098	814	0	0	814	814	5320	3.2	50.2	2.88
1/1/11	19	33	36	38	0.0098	1933	0	0	1933	0.0098	1933	0	0	1933	1933	5330	3.1	50.7	2.68
1/2/11	28	31	35	38	0.0098	2848	0	0	2848	0.0098	2848	0	0	2848	2848	5060	2.3	51.0	4.41
1/3/11	53	32	35	38	0.0098	5391	0	0	5391	0.0098	5391	0	0	5391	5391	5330	2.6	51.1	4.01
1/4/11	20	30	35	38	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	5310	2.6	50.4	8.04
1/5/11	35	28	34	36	0.0098	3560	0	0	3560	0.0098	3560	0	0	3560	3560	5320	3.5	50.2	3.31
1/6/11	20	32	35	37	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	5350	3.1	50.2	2.82
1/7/11	14	33	36	38	0.0098	1424	0	0	1424	0.0098	1424	0	0	1424	1424	5260	3.7	50.0	3.01
1/8/11	20	34	36	38	0.0098	2034	0	0	2034	0.0098	2034	0	0	2034	2034	4920	3.0	49.8	3.45
1/9/11	13	30	35	37	0.0098	1322	0	0	1322	0.0098	1322	0	0	1322	1322	4390	3.6	49.6	3.12

	Unmarked Chinook Salmon																Environmental Conditions			
Date	Catch	Fork Length (mm) Min	Avg	Max	High Range Est. Efficiency	Estimated Passage - High Fry	Parr	Smolt	Total	Low Range Est. Efficiency	Estimated Passage - Low Fry	Parr	Smolt	Total	Median Passage	Flow (cfs) La Grange	Velocity (ft/s)	Temp at Trap	Turbidity (NTU)
1/10/11	15	31	36	38	0.0098	1526	0	0	1526	0.0098	1526	0	0	1526	1526	3810	2.8	49.3	2.55
1/11/11	68	30	34	37	0.0098	6917	0	0	6917	0.0098	6917	0	0	6917	6917	3340	3.1	49.8	1.96
1/12/11	24	32	35	38	0.0098	2441	0	0	2441	0.0098	2441	0	0	2441	2441	2940	2.9	50.3	2.23
1/13/11	98	30	35	38	0.0098	9968	0	0	9968	0.0098	9968	0	0	9968	9968	2530	4.0	50.0	2.52
1/14/11	65	30	35	37	0.0098	6611	0	0	6611	0.0098	6611	0	0	6611	6611	2160	3.5	50.4	2.07
1/15/11	85	31	35	38	0.0098	8623	23	0	8646	0.0098	8623	23	0	8646	8646	2150	3.6	50.0	2.57
1/16/11	67	31	35	38	0.0098	6797	18	0	6815	0.0098	6797	18	0	6815	6815	4730	3.2	50.7	1.82
1/17/11	148	29	36	55	0.0098	15014	40	0	15054	0.0098	15014	40	0	15054	15054	5000	2.7	50.7	1.99
1/18/11	78	30	35	38	0.0098	7913	21	0	7934	0.0098	7913	21	0	7934	7934	4930	3.0	50.7	2.73
1/19/11	120	30	35	38	0.0098	12174	32	0	12206	0.0098	12174	32	0	12206	12206	4860	2.7	50.4	2.53
1/20/11	131	31	35	38	0.0098	13290	35	0	13325	0.0098	13290	35	0	13325	13325	4960	3.0	50.5	2.45
1/21/11	154	30	36	38	0.0098	15623	41	0	15664	0.0098	15623	41	0	15664	15664	5130	3.3	50.4	2.24
1/22/11	161	31	36	60	0.0098	16280	96	0	16376	0.0098	16280	96	0	16376	16376	5120	4.0	50.4	1.95
1/23/11	58	30	35	57	0.0098	5865	35	0	5899	0.0098	5865	35	0	5899	5899	4770	3.8	50.5	2.08
1/24/11	77	31	36	39	0.0098	7786	46	0	7832	0.0098	7786	46	0	7832	7832	4270	3.3	50.5	1.95
1/25/11	97	30	36	38	0.0098	9808	58	0	9866	0.0098	9808	58	0	9866	9866	3810	3.5	50.3	2.33
1/26/11	67	29	35	38	0.0098	6775	40	0	6815	0.0098	6775	40	0	6815	6815	3420	2.5	50.4	1.54
1/27/11	41	30	34	38	0.0098	4146	25	0	4170	0.0098	4146	25	0	4170	4170	3200	2.9	50.2	2.45
1/28/11	32	30	35	38	0.0098	3236	19	0	3255	0.0098	3236	19	0	3255	3255	2820	3.0	50.3	2.11
1/29/11	34	31	36	39	0.0098	3397	41	21	3458	0.0098	3397	41	21	3458	3458	2520	3.6	50.1	2.43
1/30/11	29	32	36	39	0.0098	2897	35	18	2950	0.0098	2897	35	18	2950	2950	2210	2.9	50.1	2.43
1/31/11	99	31	38	130	0.0098	9890	120	60	10070	0.0098	9890	120	60	10070	10070	1910	3.8	50.4	2.94
2/1/11	107	32	37	40	0.0098	10689	130	65	10883	0.0098	10689	130	65	10883	10883	1610	3.5	49.9	1.71
2/2/11	82	32	37	62	0.0098	8192	99	50	8341	0.0098	8192	99	50	8341	8341	1580	3.7	49.9	1.84
2/3/11	95	29	36	42	0.0098	9490	115	58	9663	0.0098	9490	115	58	9663	9663	1590	3.6	50.0	1.42
2/4/11	96	29	38	126	0.0098	9590	116	58	9765	0.0098	9590	116	58	9765	9765	1660	3.5	50.1	1.62
2/5/11	111	29	35	58	0.0098	11170	60	60	11290	0.0098	11170	60	60	11290	11290	1880	3.9	50.3	1.49
2/6/11	115	30	36	70	0.0098	11572	62	62	11697	0.0098	11572	62	62	11697	11697	1880	3.6	50.7	1.83
2/7/11	66	28	34	39	0.0098	6642	36	36	6713	0.0098	6642	36	36	6713	6713	1900	3.6	51.0	1.82
2/8/11	123	29	36	39	0.0098	1237	67	67	1251	0.0098	1237	67	67	12511	12511	1900	3.6	50.4	2.00

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
						7			1		7								
2/9/11	63	30	35	39	0.0098	6340	34	34	6408	0.0098	6340	34	34	6408	6408	2450	3.6	49.8	1.66
2/10/11	84	29	36	50	0.0098	8453	46	46	8544	0.0098	8453	46	46	8544	8544	2770	4.0	50.0	1.83
2/11/11	68	30	36	74	0.0098	6843	37	37	6917	0.0098	6843	37	37	6917	6917	2780	4.0	50.1	3.61
2/12/11	23	29	36	53	0.0098	2292	31	16	2339	0.0098	2292	31	16	2339	2339	2810	4.5	50.4	1.27
2/13/11	28	32	36	47	0.0098	2791	38	19	2848	0.0098	2791	38	19	2848	2848	2800	4.5	50.5	3.87
2/14/11	11	33	35	37	0.0098	1096	15	8	1119	0.0098	1096	15	8	1119	1119	2790	4.2	50.4	6.74
2/15/11	10	35	36	36	0.0098	997	14	7	1017	0.0098	997	14	7	1017	1017	2790	3.8	50.9	3.15
2/16/11	22	31	37	79	0.0098	2193	30	15	2238	0.0098	2193	30	15	2238	2238	3170	nd	50.6	2.10
2/17/11	43	33	36	55	0.0098	4286	59	29	4374	0.0098	4286	59	29	4374	4374	3180	4.1	49.4	1.59
2/18/11	12	34	36	38	0.0098	1196	16	8	1221	0.0098	1196	16	8	1221	1221	4040	4.2	49.6	2.45
2/19/11	12	33	35	37	0.0098	1164	33	23	1221	0.0098	1164	33	23	1221	1221	4490	4.8	50.0	2.90
2/20/11	56	31	39	62	0.0098	5434	153	109	5696	0.0098	5434	153	109	5696	5696	4500	4.5	50.1	2.04
2/21/11	55	29	37	82	0.0098	5337	150	107	5594	0.0098	5337	150	107	5594	5594	4510	4.3	50.0	1.95
2/22/11	41	31	36	39	0.0098	3979	112	80	4170	0.0098	3979	112	80	4170	4170	4540	4.3	50.0	1.69
2/23/11	34	33	38	75	0.0098	3299	93	66	3458	0.0098	3299	93	66	3458	3458	4510	3.5	50.0	1.70
2/24/11	56	33	38	88	0.0098	5434	153	109	5696	0.0098	5434	153	109	5696	5696	4520	4.3	49.9	1.87
2/25/11	19	32	35	38	0.0098	1844	52	37	1933	0.0098	1844	52	37	1933	1933	4550	2.8	49.8	2.23
2/26/11	33	34	36	39	0.0098	3264	69	23	3357	0.0098	3264	69	23	3357	3357	4540	2.8	49.5	1.39
2/27/11	32	32	36	38	0.0098	3165	67	22	3255	0.0098	3165	67	22	3255	3255	4530	3.2	49.5	1.01
2/28/11	21	34	36	39	0.0098	2077	44	15	2136	0.0098	2077	44	15	2136	2136	4550	3.1	49.9	0.61
3/1/11	18	35	36	38	0.0098	1780	38	13	1831	0.0098	1780	38	13	1831	1831	4530	4.3	49.9	1.36
3/2/11	13	35	39	75	0.0098	1286	27	9	1322	0.0098	1286	27	9	1322	1322	4540	4.4	50.6	1.32
3/3/11	16	35	39	59	0.0098	1583	34	11	1627	0.0098	1583	34	11	1627	1627	5000	3.8	51.2	1.20
3/4/11	18	35	38	64	0.0098	1780	38	13	1831	0.0098	1780	38	13	1831	1831	4520	4.1	50.6	1.47
3/5/11	10	34	36	38	0.0098	987	30	0	1017	0.0098	987	30	0	1017	1017	3980	3.3	51.0	1.59
3/6/11	9	34	35	37	0.0098	889	27	0	915	0.0098	889	27	0	915	915	3780	3.4	51.0	0.9
3/7/11	11	34	36	38	0.0098	1086	33	0	1119	0.0098	1086	33	0	1119	1119	3780	3.4	51.1	1.35
3/8/11	30	35	38	66	0.0098	2962	90	0	3051	0.0098	2962	90	0	3051	3051	3770	3.8	51.0	2.71
3/9/11	14	30	35	37	0.0098	1382	42	0	1424	0.0098	1382	42	0	1424	1424	3790	3.5	51.1	1.94
3/10/11	17	32	37	64	0.0098	1678	51	0	1729	0.0098	1678	51	0	1729	1729	3780	4.2	51.3	1.63
3/11/11	11	32	35	37	0.0098	1086	33	0	1119	0.0098	1086	33	0	1119	1119	3660	3.8	51.1	3.17
3/12/11	32	33	38	84	0.0098	2785	219	250	3255	0.0098	2785	219	250	3255	3255	3280	3.4	50.9	2.39
3/13/11	18	33	38	71	0.0098	1567	123	141	1831	0.0098	1567	123	141	1831	1831	2870	3.4	50.6	1.75
3/14/11	8	33	39	64	0.0098	696	55	63	814	0.0098	696	55	63	814	814	2680	4.2	51.6	2.10
3/15/11	19	32	45	93	0.0098	1654	130	149	1933	0.0098	1654	130	149	1933	1933	2700	3.8	51.6	4.14
3/16/11	2	35	55	74	0.0560	86	7	8	100	0.0200	31	2	3	36	68	2830	4.0	51.2	2.14
3/17/11	10	35	44	72	0.0098	870	68	78	1017	0.0098	870	68	78	1017	1017	3320	4.2	50.4	2.30

	Unmarked Chinook Salmon																Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
3/18/11	15	33	42	80	0.0098	1306	103	117	1526	0.0098	1306	103	117	1526	1526	3500	4.2	49.6	3.72
3/19/11	6	33	45	78	0.0098	422	100	89	610	0.0098	422	100	89	610	610	4850	4.0	49.3	2.56
3/20/11	4	33	51	70	0.0560	138	33	29	200	0.0200	49	12	10	71	136	5260	4.2	49.4	4.4
3/21/11	21	33	48	86	0.0098	1476	350	311	2136	0.0098	1476	350	311	2136	2136	6380	4.8	50.0	4.19
3/22/11	8	34	52	140	0.0560	276	65	58	400	0.0200	99	23	21	143	271	7110	4.1	50.3	3.32
3/23/11	11	33	38	66	0.0098	773	183	163	1119	0.0098	773	183	163	1119	1119	7660	2.5	50.0	2.99
3/24/11	2	33	46	59	0.0098	141	33	30	203	0.0098	141	33	30	203	203	7260	2.7	49.6	2.49
3/25/11	3	35	49	75	0.0098	211	50	44	305	0.0098	211	50	44	305	305	7120	nd	50.0	7.33
3/26/11	9	35	42	74	0.0098	704	70	141	915	0.0098	704	70	141	915	915	7140	3.0	50.2	3.37
3/27/11	2	33	35	36	0.0098	156	16	31	203	0.0098	156	16	31	203	203	7510	3.6	50.5	4.24
3/28/11	8	35	45	80	0.0098	626	63	125	814	0.0098	626	63	125	814	814	7780	3.6	51.0	2.05
3/29/11	3	37	49	71	0.0098	235	23	47	305	0.0098	235	23	47	305	305	8110	3.9	51.0	2.10
3/30/11	1	100	100	100	0.0560	38	4	8	50	0.0200	14	1	3	18	34	8320	3.8	51.1	1.76
3/31/11	1	37	37	37	0.0098	78	8	16	102	0.0098	78	8	16	102	102	8310	3.8	51.4	2.11
4/1/11	2	35	36	36	0.0098	156	16	31	203	0.0098	156	16	31	203	203	8330	3.1	51.5	3.22
4/2/11	3	34	57	99	0.0560	127	0	23	150	0.0200	45	0	8	54	102	8360	3.6	51.2	2.62
4/3/11	3	35	36	36	0.0098	258	0	47	305	0.0098	258	0	47	305	305	8330	4.4	50.7	2.22
4/4/11	1	89	89	89	0.0560	42	0	8	50	0.0200	15	0	3	18	34	8310	4.4	50.9	2.35
4/5/11	2	33	34	35	0.0098	172	0	31	203	0.0098	172	0	31	203	203	8330	4.0	51.2	2.5
4/6/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8330	4.0	51.3	2.51
4/7/11	1	36	36	36	0.0098	86	0	16	102	0.0098	86	0	16	102	102	7570	4.7	50.9	1.71
4/8/11	3	34	34	35	0.0098	258	0	47	305	0.0098	258	0	47	305	305	7720	4.6	50.3	2.18
4/9/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8310	4.7	50.4	1.89
4/10/11	2	32	66	100	0.0560	29	0	71	100	0.0200	10	0	26	36	68	8320	4.2	50.8	3.30
4/11/11	1	82	82	82	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8320	3.5	51.0	3.53
4/12/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8290	nd	51.1	nd
4/13/11	2	35	60	84	0.0560	29	0	71	100	0.0200	10	0	26	36	68	8330	4.6	50.9	3.67
4/14/11	1	75	75	75	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8340	4.2	50.8	2.87
4/15/11	1	80	80	80	0.0560	14	0	36	50	0.0200	5	0	13	18	34	8320	4.4	51.2	2.34
4/16/11	5	34	85	108	0.0560	21	0	229	250	0.0200	7	0	82	89	170	8310	3.8	51.6	2.08
4/17/11	1	85	85	85	0.0560	4	0	46	50	0.0200	1	0	16	18	34	8340	4.6	51.8	2.19
4/18/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	8160	3.8	51.9	2.54
4/19/11	1	98	98	98	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7710	4.2	51.8	4.51
4/20/11	1	83	83	83	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7330	4.7	51.7	2.06
4/21/11	1	90	90	90	0.0560	4	0	46	50	0.0200	1	0	16	18	34	7040	4.1	51.7	2.40
4/22/11	4	91	98	107	0.0560	17	0	183	200	0.0200	6	0	65	71	136	6760	4.7	51.6	2.4
4/23/11	1	92	92	92	0.0560	0	2	48	50	0.0200	0	1	17	18	34	6430	3.7	51.6	1.81
4/24/11	2	98	98	98	0.0560	0	4	96	100	0.0200	0	2	34	36	68	6130	4.2	51.7	1.73

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
4/25/11	3	81	96	110	0.0560	0	7	143	150	0.0200	0	2	51	54	102	5780	2.6	51.6	2.44
4/26/11	4	60	80	88	0.0560	0	9	191	200	0.0200	0	3	68	71	136	5640	2.8	51.7	3.07
4/27/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	5630	3.1	51.9	1.97
4/28/11	10	87	101	112	0.0560	0	22	478	500	0.0200	0	8	171	179	339	5550	2.4	52.1	0.72
4/29/11	4	92	98	102	0.0560	0	9	191	200	0.0200	0	3	68	71	136	4890	3.1	52.0	1.9
4/30/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	4110	3.2	51.9	1.48
5/1/11	4	80	91	100	0.0560	0	0	200	200	0.0200	0	0	71	71	136	3470	3.1	52.4	2.37
5/2/11	6	74	86	96	0.0560	0	0	300	300	0.0200	0	0	107	107	204	3380	3.1	54.2	4.20
5/3/11	7	95	103	125	0.0560	0	0	350	350	0.0200	0	0	125	125	238	3370	2.8	53.0	1.85
5/4/11	3	82	88	101	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3360	3.4	53.1	1.84
5/5/11	1	90	90	90	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3550	3.4	53.5	1.55
5/6/11	2	89	91	93	0.0560	0	0	100	100	0.0200	0	0	36	36	68	3780	3.1	53.3	3.00
5/7/11	3	82	92	98	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3780	3.4	52.9	0.99
5/8/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	3780	3.6	52.3	0.70
5/9/11	3	78	86	97	0.0560	0	0	150	150	0.0200	0	0	54	54	102	3780	3.4	51.9	1.81
5/10/11	5	85	93	101	0.0560	0	0	250	250	0.0200	0	0	89	89	170	3720	2.9	52.5	2.28
5/11/11	1	86	86	86	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3550	3.0	53.3	0.95
5/12/11	8	72	86	105	0.0560	0	0	400	400	0.0200	0	0	143	143	271	3240	2.8	53.6	1.25
5/13/11	9	81	94	105	0.0560	0	0	450	450	0.0200	0	0	161	161	305	3000	3.6	53.7	0.69
5/14/11	10	81	94	115	0.0560	0	0	500	500	0.0200	0	0	179	179	339	2990	3.3	52.6	1.15
5/15/11	3	82	90	103	0.0560	0	0	150	150	0.0200	0	0	54	54	102	2980	3.6	52.1	1.81
5/16/11	6	78	91	98	0.0560	0	0	300	300	0.0200	0	0	107	107	204	2960	3.1	51.8	0.97
5/17/11	4	92	98	109	0.0560	0	0	200	200	0.0200	0	0	71	71	136	3000	3.5	51.6	0.61
5/18/11	12	76	91	103	0.0560	0	0	600	600	0.0200	0	0	214	214	407	3000	3.0	52.3	0.87
5/19/11	21	78	91	105	0.0560	0	0	1050	1050	0.0200	0	0	375	375	713	2970	3.1	53.0	0.52
5/20/11	23	83	96	115	0.0560	0	0	1150	1150	0.0200	0	0	411	411	780	2980	3.0	53.8	0.46
5/21/11	10	75	87	105	0.0560	0	8	492	500	0.0200	0	3	176	179	339	2980	3.3	53.8	0.71
5/22/11	16	79	94	118	0.0560	0	14	786	800	0.0200	0	5	281	286	543	3000	3.3	53.4	0.35
5/23/11	10	76	91	108	0.0560	0	8	492	500	0.0200	0	3	176	179	339	3010	3.5	53.3	0.41
5/24/11	6	69	86	101	0.0560	0	5	295	300	0.0200	0	2	105	107	204	2980	3.5	53.5	nd
5/25/11	6	85	91	105	0.0560	0	5	295	300	0.0200	0	2	105	107	204	2990	3.5	52.5	1.2
5/26/11	8	84	93	98	0.0560	0	7	393	400	0.0200	0	2	140	143	271	2990	3.5	52.9	0.63
5/27/11	4	83	92	103	0.0560	0	3	197	200	0.0200	0	1	70	71	136	2970	3.0	53.6	1.0
5/28/11	7	85	91	100	0.0560	0	8	342	350	0.0200	0	3	122	125	238	2980	3.0	53.3	0.75
5/29/11	3	97	100	104	0.0560	0	3	147	150	0.0200	0	1	52	54	102	3050	2.2	53.2	1.49
5/30/11	11	65	91	102	0.0560	0	12	538	550	0.0200	0	4	192	196	373	3550	3.4	53.3	0.97
5/31/11	5	81	93	107	0.0560	0	6	244	250	0.0200	0	2	87	89	170	4180	3.0	53.5	1.45
6/1/11	8	80	95	108	0.0560	0	9	391	400	0.0200	0	3	140	143	271	4730	2.9	52.9	0.86

	Unmarked Chinook Salmon																Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)		Temp	Turbidity
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	at Trap	(NTU)
6/2/11	7	88	102	110	0.0560	0	8	342	350	0.0200	0	3	122	125	238	4770	3.5	52.7	1.82
6/3/11	4	92	95	100	0.0560	0	4	196	200	0.0200	0	2	70	71	136	5240	2.5	52.2	2.36
6/4/11	4	75	87	94	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5520	2.9	51.7	1.6
6/5/11	5	88	93	104	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5520	2.9	52.8	1.80
6/6/11	5	90	96	102	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5520	4.0	53.1	1.75
6/7/11	4	98	101	105	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5530	2.8	53.7	1.94
6/8/11	5	90	95	103	0.0560	0	0	250	250	0.0200	0	0	89	89	170	5510	2.1	54.0	2.00
6/9/11	2	85	95	105	0.0560	0	0	100	100	0.0200	0	0	36	36	68	5420	2.5	54.3	0.68
6/10/11	4	75	91	106	0.0560	0	0	200	200	0.0200	0	0	71	71	136	5620	2.9	54.4	0.65
6/11/11	1	99	99	99	0.0560	0	0	50	50	0.0200	0	0	18	18	34	6910	2.7	53.7	0.71
6/12/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	7000	3.4	53.8	1.0
6/13/11	18	92	100	110	0.0560	0	0	900	900	0.0200	0	0	321	321	611	7020	nd	54.2	0.64
6/14/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	6600	nd	54.7	nd
6/15/11	3	86	92	98	0.0560	0	0	150	150	0.0200	0	0	54	54	102	6000	nd	54.9	0.42
6/16/11	1	98	98	98	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5730	3.0	54.5	0.53
6/17/11	1	102	102	102	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5480	2.5	54.4	1.15
6/18/11	9	90	99	105	0.0560	0	0	450	450	0.0200	0	0	161	161	305	5240	4.2	54.4	0.42
6/19/11	5	89	97	102	0.0560	0	0	250	250	0.0200	0	0	89	89	170	4970	3.8	54.9	0.46
6/20/11	1	104	104	104	0.0560	0	0	50	50	0.0200	0	0	18	18	34	4730	3.8	54.9	0.5
6/21/11	5	97	104	113	0.0560	0	0	250	250	0.0200	0	0	89	89	170	4470	3.4	55.2	0.92
6/22/11	2	108	112	115	0.0560	0	0	100	100	0.0200	0	0	36	36	68	4270	4.0	55.5	1.12
6/23/11	1	104	104	104	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3860	3.2	55.5	1.34
6/24/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	3580	4.0	55.2	2.30
6/25/11	1	95	95	95	0.0560	0	0	50	50	0.0200	0	0	18	18	34	3270	4.0	55.6	1.06
6/26/11	0	-	-	-	0.0560	0	0	0	0	0.0200	0	0	0	0	0	2980	3.8	55.8	1.34
6/27/11	1	85	85	85	0.0560	0	0	50	50	0.0200	0	0	18	18	34	2580	3.3	56.1	0.51
6/28/11	2	92	95	98	0.0560	0	0	100	100	0.0200	0	0	36	36	68	2190	3.1	55.6	1.1
6/29/11	3	96	104	111	0.0560	0	0	150	150	0.0200	0	0	54	54	102	2880	3.3	55.9	0.97
6/30/11	1	90	90	90	0.0560	0	0	50	50	0.0200	0	0	18	18	34	5450	3.5	54.9	0.73

Appendix B. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Grayson and associated environmental data from 2011.

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
1/6/11	2	40	41	42	0.014	139	0	0	139	5700	2.8	2.0	49.6	4.60
1/7/11	5	36	37	38	0.017	300	0	0	300	5640	2.9	1.9	49.3	6.09
1/8/11	9	34	35	36	0.019	484	0	0	484	5520	3.2	3.4	49.1	4.21
1/9/11	24	34	36	37	0.020	1172	0	0	1172	5260	3.2	3.1	48.9	3.59
1/10/11	11	33	36	37	0.024	450	0	0	450	4870	3.2	2.6	48.3	2.65
1/11/11	13	33	36	39	0.029	453	0	0	453	4460	2.6	2.7	48.7	2.58
1/12/11	21	31	36	38	0.034	618	0	0	618	4090	2.3	2.3	49.4	2.82
1/13/11	24	30	35	38	0.041	588	0	0	588	3690	3.0	2.3	49.8	2.50
1/14/11	45	31	35	39	0.048	935	0	0	935	3300	2.8	2.4	50.0	2.50
1/15/11	31	30	35	44	0.058	534	0	0	534	2890	2.5	2.3	49.8	2.80
1/16/11	8	35	37	40	0.047	172	0	0	172	3280	2.6	2.2	50.0	2.84
1/17/11	25	34	36	40	0.023	1085	0	0	1085	4960	3.4	3.0	50.6	3.52
1/18/11	63	32	37	44	0.020	3075	0	0	3075	5200	3.6	3.3	50.7	2.68
1/19/11	58	32	36	39	0.021	2725	0	0	2725	5160	3.4	2.9	50.2	3.43
1/20/11	66	28	36	39	0.021	3103	0	0	3103	5130	2.5	2.7	50.0	2.24
1/21/11	60	30	36	40	0.021	2906	0	0	2906	5230	3.4	3.3	50.3	4.28
1/22/11	83	30	36	39	0.021	3951	19	0	3969	5210	3.8	3.4	50.3	2.70
1/23/11	19	31	35	38	0.024	789	4	0	793	4940	3.8	3.4	50.3	2.68
1/24/11	65	33	36	39	0.026	2469	12	0	2480	4670	3.5	3.0	50.4	1.98
1/25/11	57	30	36	40	0.030	1896	9	0	1905	4330	3.6	2.8	50.5	2.13
1/26/11	132	32	37	60	0.034	3863	18	0	3881	3970	3.3	3.0	50.2	2.15
1/27/11	52	29	36	39	0.042	1231	6	0	1237	3600	3.2	3.0	50.2	2.45
1/28/11	39	31	36	51	0.046	844	4	0	848	3380	3.0	2.6	49.9	3.24
1/29/11	13	32	44	127	0.042	305	0	4	308	2990	2.8	2.5	50.0	3.17
1/30/11	6	32	36.5	43	0.060	98	0	1	100	2690	2.9	2.6	50.0	3.20
1/31/11	31	33	37	40	0.069	446	0	5	452	2350	2.6	2.2	50.1	2.80
2/1/11	41	32	40	135	0.072	560	0	6	567	2020	2.7	2.8	50.3	3.04
2/2/11	14	32	37	40	0.089	155	0	2	157	1740	2.3	2.2	49.7	3.85
2/3/11	49	32	37	49	0.092	528	0	6	534	1697	2.4	2.3	49.9	1.87
2/4/11	22	33	37	43	0.093	234	0	3	237	1699	2.3	2.3	50.1	2.85
2/5/11	33	35	38	52	0.088	365	9	2	376	1767	2.5	2.3	50.5	1.62
2/6/11	34	34	36	45	0.084	394	10	2	406	1988	2.6	2.4	51.1	2.38
2/7/11	21	31	36	39	0.084	242	6	1	249	1985	2.1	2.1	51.4	1.72
2/8/11	19	31	38	60	0.079	234	6	1	241	2002	2.5	2.3	51.0	1.96
2/9/11	18	30	37	50	0.081	215	5	1	222	2000	2.3	2.1	50.3	1.82
2/10/11	14	31	36	44	0.067	202	5	1	208	2549	nd	nd	50.0	2.17
2/11/11	32	32	40	117	0.052	598	14	4	616	2863	2.8	3.0	50.1	3.08
2/12/11	18	35	37	47	0.055	304	20	0	324	2876	2.5	3.0	50.4	1.88
2/13/11	18	33	37	44	0.056	303	20	0	323	2907	2.9	3.1	50.8	3.12
2/14/11	2	36	44	51	0.045	41	3	0	44	2889	3.0	2.9	50.8	3.00
2/15/11	20	35	37	41	0.056	332	22	0	354	2871	3.4	2.9	51.1	2.44
2/16/11	9	35	36	37	0.058	145	10	0	155	2871	2.9	2.8	51.3	3.83
2/17/11	10	32	41	60	0.038	244	16	0	261	3360	2.9	2.8	50.0	2.97
2/18/11	5	35	42	59	0.034	137	9	0	146	3590	3.1	3.3	49.1	2.78

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
2/19/11	1	35	35	35	0.022	42	4	0	45	5130	3.4	3.6	49.2	9.69
2/20/11	1	36	36	36	0.019	49	4	0	54	5430	3.8	3.6	49.8	13.30
2/21/11	12	35	36	38	0.025	442	40	0	481	4750	3.7	3.6	50.3	5.55
2/22/11	20	34	38	63	0.025	732	66	0	798	4610	3.4	2.9	50.0	2.25
2/23/11	22	33	37	58	0.026	772	69	0	841	4600	2.5	1.9	50.1	6.72
2/24/11	14	34	4	56	0.021	615	55	0	670	4860	3.3	2.9	50.1	3.47
2/25/11	3	34	35	36	0.024	117	10	0	127	4970	2.7	2.1	50.0	2.51
2/26/11	6	35	36	37	0.020	292	0	10	303	5340	3.4	2.5	49.4	4.73
2/27/11	7	33	35	36	0.021	329	0	12	340	5290	2.8	2.1	49.3	8.86
2/28/11	7	35	36	37	0.023	298	0	11	309	5020	3.3	2.9	49.8	3.77
3/1/11	3	36	36	37	0.023	128	0	5	133	4970	3.5	3.2	50.3	3.13
3/2/11	3	35	35	36	0.024	122	0	4	127	4940	3.5	3.4	50.6	2.74
3/3/11	1	70	70	70	0.008	124	0	4	129	4990	3.6	3.2	51.6	2.27
3/4/11	2	38	38	38	0.020	98	0	3	101	5160	3.2	2.7	51.8	1.78
3/5/11	2	35	37	38	0.024	52	26	7	85	4870	3.2	2.8	51.6	4.90
3/6/11	2	33	47	60	0.020	62	31	8	100	4520	3.3	2.6	52.1	2.29
3/7/11	2	35	51	66	0.019	66	33	8	108	4380	3.4	2.7	51.8	2.38
3/8/11	2	37	51	65	0.019	66	33	8	107	4340	3.1	2.8	52.3	3.81
3/9/11	1	45	45	45	0.022	27	14	3	45	4360	3.1	2.5	52.3	3.39
3/10/11	3	36	42	53	0.025	75	38	9	122	4350	3.1	2.5	52.5	4.46
3/11/11	1	73	73	73	0.010	64	32	8	104	4270	3.0	2.5	52.5	2.91
3/12/11	0	-	-	-	-	0	0	0	0	4080	2.8	2.5	52.2	3.38
3/13/11	3	38	58	73	0.019	23	68	68	158	3760	3.0	1.9	52.0	2.55
3/14/11	1	-	-	-	-	0	0	0	0	3380	2.8	2.3	52.3	3.04
3/15/11	1	73	73	73	0.015	9	28	28	66	3190	2.8	2.3	53.5	2.94
3/16/11	1	72	72	72	0.017	9	26	26	60	3030	3.0	2.4	53.1	2.34
3/17/11	2	58	63	67	0.022	13	39	39	92	3120	2.6	2.1	51.9	4.71
3/18/11	0	-	-	-	-	0	0	0	0	3530	3.0	2.7	50.7	4.59
3/19/11	0	-	-	-	-	0	0	0	0	3720	3.1	2.9	49.4	2.27
3/20/11	1	67	67	67	0.009	0	117	0	117	4970	3.4	2.1	49.5	5.55
3/21/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	6800	ns	ns	50.0	ns
3/22/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7540	ns	ns	50.9	ns
3/23/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7080	ns	ns	51.1	ns
3/24/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7260	ns	ns	49.8	ns
3/25/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8010	ns	ns	49.9	ns
3/26/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8480	ns	ns	50.4	ns
3/27/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	8200	ns	ns	50.8	ns
3/28/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7960	ns	ns	52.0	ns
3/29/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7640	ns	ns	52.1	ns
3/30/11	ns	ns	ns	ns	ns	ns	ns	ns	ns	7820	3.6	2.7	52.4	3.96
3/31/11	ns	ns	ns	ns	ns	0	0	0	ns	nd	ns	ns	52.6	3.03
4/1/11	ns	ns	ns	ns	ns	0	0	0	ns	8170	3.4	2.4	52.9	6.65
4/2/11	0	-	-	-	-	0	0	0	0	8130	3.0	2.1	52.7	2.84
4/3/11	2	37	50	63	0.004	230	230	0	459	8090	2.7	2.1	51.5	2.51
4/4/11	0	-	-	-	-	0	0	0	0	7990	2.9	2.0	51.8	2.41
4/5/11	1	63	63	63	0.003	161	161	0	323	7930	3.0	2.0	52.1	3.13
4/6/11	0	-	-	-	-	0	0	0	0	7940	2.8	2.1	52.4	2.64

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
4/7/11	1	32	32	32	0.008	61	61	0	122	7940	3.1	2.0	52.0	1.85
4/8/11	0	-	-	-	-	0	0	0	0	7360	2.3	1.7	50.6	3.95
4/9/11	1	104	104	104	0.001	660	0	330	990	7530	2.7	2.3	50.5	2.43
4/10/11	2	35	35.5	36	0.008	177	0	89	266	7870	2.7	2.3	51.2	2.51
4/11/11	0	-	-	-	-	0	0	0	0	7930	2.7	2.0	51.7	3.42
4/12/11	0	-	-	-	-	0	0	0	0	7940	2.8	2.0	51.9	3.49
4/13/11	0	-	-	-	-	0	0	0	0	7900	2.8	2.0	51.7	4.34
4/14/11	0	-	-	-	-	0	0	0	0	7940	2.9	2.1	51.1	2.67
4/15/11	0	-	-	-	-	0	0	0	0	7930	2.3	2.3	51.9	2.73
4/16/11	0	-	-	-	-	0	0	0	0	7930	2.2	1.6	52.8	2.14
4/17/11	1	100	100	100	0.001	0	0	1041	1041	7930	2.8	2.8	53.3	2.92
4/18/11	1	96	96	96	0.001	0	0	922	922	7940	2.8	1.8	53.4	2.59
4/19/11	1	82	82	82	0.002	0	0	551	551	7770	2.5	1.5	52.9	2.44
4/20/11	ns	ns	ns	ns	ns	0	0	0	ns	7460	2.7	1.9	53.0	2.99
4/21/11	0	-	-	-	-	0	0	0	0	7140	2.1	1.7	52.8	3.19
4/22/11	0	-	-	-	-	0	0	0	0	6890	2.6	1.4	52.5	1.68
4/23/11	0	-	-	-	-	0	0	0	0	6680	2.7	1.7	52.2	2.69
4/24/11	0	-	-	-	-	0	0	1053	1053	6410	2.5	1.5	52.9	3.00
4/25/11	2	94	100	105	0.002	0	0	601	601	6150	2.6	1.9	52.7	3.24
4/26/11	1	107	107	107	0.002	0	0	0	0	5870	2.4	1.8	52.7	2.63
4/27/11	0	-	-	-	-	0	0	0	0	5790	2.4	1.9	53.1	6.69
4/28/11	0	-	-	-	-	0	0	0	0	5770	2.1	1.6	53.4	5.37
4/29/11	0	-	-	-	-	0	0	0	0	5630	2.3	1.5	53.0	2.38
4/30/11	0	-	-	-	-	0	21	415	436	5100	1.9	1.5	52.8	2.62
5/1/11	1	110	110	110	0.002	0	4	88	92	4520	1.8	1.0	53.8	3.64
5/2/11	1	68	68	68	0.011	0	69	1386	1456	4070	1.7	0.9	56.5	2.75
5/3/11	6	96	105	121	0.004	0	74	1488	1562	3990	2.5	1.9	55.2	2.61
5/4/11	6	102	108	118	0.004	0	51	1013	1063	3930	2.4	1.9	55.5	3.52
5/5/11	5	95	102	114	0.005	0	25	504	529	3880	2.3	2.0	55.8	2.29
5/6/11	2	105	110	115	0.004	0	0	592	592	4090	2.3	1.7	56.1	3.95
5/7/11	3	96	98	100	0.005	0	0	0	0	4210	2.7	2.0	55.3	2.25
5/8/11	0	-	-	-	-	0	0	439	439	4260	2.5	1.9	54.8	1.15
5/9/11	2	97	99	101	0.005	0	0	549	549	4280	2.6	1.9	53.6	2.16
5/10/11	3	85	93	104	0.005	0	0	1631	1631	4210	2.8	2.7	54.1	4.53
5/11/11	8	83	97	108	0.005	0	0	1450	1450	4110	2.9	2.3	54.9	2.15
5/12/11	8	86	95	102	0.006	0	0	901	901	3930	2.8	2.6	55.6	2.67
5/13/11	5	89	97	117	0.006	0	0	3073	3073	3630	2.7	2.3	56.1	1.82
5/14/11	17	89	101	110	0.006	0	0	855	855	3470	2.5	2.2	55.6	1.79
5/15/11	5	98	101	107	0.006	0	0	170	170	3570	2.9	2.2	54.4	3.89
5/16/11	1	100	100	100	0.006	0	0	0	0	3540	2.6	2.3	53.7	2.10
5/17/11	0	-	-	-	-	0	0	305	305	3520	2.7	2.0	53.3	1.37
5/18/11	2	97	97	97	0.007	0	0	593	593	3540	2.8	2.3	53.5	1.80
5/19/11	3	102	105	111	0.005	0	0	1583	1583	3470	2.5	2.2	55.0	1.21
5/20/11	10	90	99	106	0.006	0	0	863	863	3420	2.7	2.2	56.2	2.06
5/21/11	5	90	102	117	0.006	0	0	959	959	3410	2.8	2.0	56.9	1.95
5/22/11	7	84	95	105	0.007	0	0	733	733	3400	2.6	2.2	56.4	2.38
5/23/11	5	93	97	102	0.007	0	0	110	110	3420	2.7	2.0	55.8	1.51

Date	Unmarked Chinook Salmon									Environmental Conditions				
	Catch	Fork Length (mm)			Est. Efficiency	Estimated Passage				Flow (cfs) Modesto Flow	Velocity (ft/s)		Temp at the traps	Turbidity (NTU)
		Min	Avg	Max		Fry	Parr	Smolt	Total		North	South		
5/24/11	1	88	88	88	0.009	0	0	161	161	3420	2.6	2.1	56.0	2.49
5/25/11	1	100	100	100	0.006	0	0	574	574	3370	2.6	2.1	55.5	2.71
5/26/11	4	95	97	99	0.007	0	0	430	430	3360	2.7	2.2	54.4	1.86
5/27/11	3	93	97	99	0.007	0	0	231	231	3380	2.6	2.2	55.5	3.04
5/28/11	2	90	90	90	0.009	0	0	406	406	3360	2.3	2.0	55.7	1.73
5/29/11	2	106	108	110	0.005	0	0	782	782	3430	1.9	1.8	55.4	0.98
5/30/11	4	97	106	116	0.005	0	0	852	852	3530	2.7	2.4	55.8	2.07
5/31/11	6	88	95	100	0.007	0	0	536	536	4010	3.0	2.4	55.6	2.18
6/1/11	3	91	96	100	0.006	0	0	2347	2347	4530	3.0	2.5	55.2	2.24
6/2/11	11	80	94	100	0.005	0	0	1495	1495	4870	3.1	2.5	54.3	1.57
6/3/11	5	94	101	110	0.003	0	0	291	291	nd	3.2	2.9	54.2	3.25
6/4/11	1	95	95	95	0.003	0	0	0	0	nd	1.8	1.2	53.2	0.71
6/5/11	0	-	-	-	-	0	0	1011	1011	nd	3.6	3.3	53.3	2.92
6/6/11	3	97	100	102	0.003	0	0	863	863	nd	3.4	3.2	54.7	3.68
6/7/11	3	85	95	100	0.003	0	0	1054	1054	nd	3.7	3.2	55.2	2.12
6/8/11	3	96	101	104	0.003	0	0	782	782	5640	3.4	3.0	56.1	1.06
6/9/11	2	98	100	101	0.003	0	0	298	298	5550	3.4	2.7	56.5	1.11
6/10/11	1	92	92	92	0.003	0	0	0	0	5460	2.9	2.8	56.8	1.43
6/11/11	0	-	-	-	-	0	0	0	0	5780	3.7	3.2	56.4	2.13
6/12/11	0	-	-	-	-	0	0	0	0	6560	3.4	3.2	55.7	1.45
6/13/11	0	-	-	-	-	0	0	0	0	6730	4.0	3.6	56.2	1.02
6/14/11	0	-	-	-	-	0	0	0	0	6740	3.8	3.6	56.8	1.29
6/15/11	0	-	-	-	-	0	0	1115	1115	6330	3.4	3.2	57.3	1.38
6/16/11	2	98	102	106	0.002	0	0	0	0	5940	3.2	3.0	57.3	0.78
6/17/11	0	-	-	-	-	0	0	0	0	5730	3.4	3.2	56.9	1.29
6/18/11	0	-	-	-	-	0	0	0	0	5520	3.6	3.2	56.8	2.30
6/19/11	0	-	-	-	-	0	0	383	383	nd	3.2	2.8	57.0	1.09
6/20/11	1	103	103	103	0.003	0	0	426	426	5100	3.6	3.2	57.8	1.15
6/21/11	1	109	109	109	0.002	0	0	0	0	4920	3.4	3.0	57.9	3.58
6/22/11	0	-	-	-	-	0	0	355	355	4710	3.0	3.0	58.4	2.63
6/23/11	1	108	108	108	0.003	0	0	0	0	4550	3.0	2.7	58.6	2.58
6/24/11	0	-	-	-	-	0	0	358	358	4200	2.7	2.2	58.1	4.05
6/25/11	1	115	115	115	0.003	0	0	216	216	3970	2.7	2.1	58.3	2.64
6/26/11	1	102	102	102	0.005	0	0	0	0	3640	2.7	2.3	58.8	1.87
6/27/11	0	-	-	-	-	0	0	179	179	3350	2.4	2.0	59.4	1.22
6/28/11	1	104	104	104	0.006	0	0	0	0	2940	2.0	1.9	59.5	2.34
6/29/11	0	-	-	-	-	0	0	0	0	2510	1.7	1.4	59.1	1.74
6/30/11	0	-	-	-	-	0	0	0	0	nd	2.3	2.2	59.1	2.11

Appendix C. Daily counts of non-salmonids captured at Waterford during 2011. See key below for species codes.

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
12/4/10		6						5			2		3					1	1		
12/5/10	1	2											1								
12/6/10		3						1		1	1		2								
12/7/10		1						2	1		3		1			1					
12/8/10		2								1	4		1								
12/9/10		1											3								
12/10/10		4									1										
12/11/10		12									2										
12/12/10								1													
12/13/10									1				1		1						
12/14/10	1							1	1	1			2								
12/15/10		1										1									
12/16/10		1									1										
12/17/10																					
12/18/10																					
12/19/10									1		2										
12/20/10									1							1					
12/21/10									1		1	1				1	1				
12/22/10																					
12/23/10																					
12/24/10																					
12/25/10																					
12/26/10																					
12/27/10									1												
12/28/10									1		1										
12/29/10		1							1												
12/30/10		1							1												
12/31/10									1												

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
1/1/11									1						1						
1/2/11																					
1/3/11									1											1	
1/4/11																					
1/5/11																1					
1/6/11																					
1/7/11																					
1/8/11																					
1/9/11															1						
1/10/11																					
1/11/11											1										
1/12/11									1	1	3										
1/13/11									1	1	1										
1/14/11								1			1										
1/15/11	1																			1	
1/16/11		1						1			1					1					
1/17/11										1											
1/18/11									1	1											
1/19/11		1																			
1/20/11																1					
1/21/11									1												
1/22/11																					
1/23/11																					
1/24/11																1					
1/25/11																					
1/26/11																					
1/27/11																					
1/28/11																					
1/29/11																					
1/30/11																					

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
1/31/11										1					1	1					
2/1/11		1														1					
2/2/11		1							1			1			1						1
2/3/11									1												
2/4/11																					
2/5/11																					
2/6/11									1												
2/7/11																					
2/8/11							1		1												
2/9/11																					
2/10/11									2												
2/11/11																					
2/12/11																					
2/13/11									1												
2/14/11						1															
2/15/11									1												
2/16/11		1																			
2/17/11								1	1												
2/18/11									1												
2/19/11									2												
2/20/11									1						1						
2/21/11									1		1										
2/22/11									1		1				1						
2/23/11																					
2/24/11																					
2/25/11																					
2/26/11																					
2/27/11									1												
2/28/11																					
3/1/11									1												

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
3/2/11																					
3/3/11																					
3/4/11																					
3/5/11																					
3/6/11						1										1					
3/7/11																					
3/8/11																					
3/9/11															1						
3/10/11									1												
3/11/11																					
3/12/11															1	1					
3/13/11																					
3/14/11																					
3/15/11																					
3/16/11																					
3/17/11													1								
3/18/11									1							1					
3/19/11																					
3/20/11									1												
3/21/11															1						
3/22/11		1													5	4					
3/23/11									1	1					2	4					
3/24/11									1						3	1					
3/25/11									2						1	1					
3/26/11								1						1	8	3	1				
3/27/11								1								1					
3/28/11															7						
3/29/11															8						1
3/30/11										1					7	1					
3/31/11															3						

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
4/1/11															7		1				
4/2/11															1						
4/3/11															2						
4/4/11														1							
4/5/11																1					
4/6/11															1						
4/7/11															2						
4/8/11								1								1					
4/9/11																1					
4/10/11															1						
4/11/11									1						1						
4/12/11															1						
4/13/11															3						
4/14/11															1						
4/15/11											1										
4/16/11															1						
4/17/11															2						
4/18/11		1																			
4/19/11																					
4/20/11															2						
4/21/11																1					
4/22/11																1					
4/23/11																					
4/24/11																					
4/25/11		1																			
4/26/11					1											1					
4/27/11																					
4/28/11															1						
4/29/11																					
4/30/11																					

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
5/1/11																1					
5/2/11								2								1					
5/3/11								3			1				1						
5/4/11																2					
5/5/11																					
5/6/11								2								1					
5/7/11																					
5/8/11								2							1	1					
5/9/11												1			1	1					
5/10/11																					
5/11/11																					
5/12/11																					
5/13/11																					
5/14/11																					
5/15/11								2													
5/16/11		1																			
5/17/11																					
5/18/11																					
5/19/11																					
5/20/11																					
5/21/11																					
5/22/11																					
5/23/11								1													
5/24/11																				1	
5/25/11	1							1								1					
5/26/11																					
5/27/11		1																			
5/28/11								1													
5/29/11																					
5/30/11								1								1					
5/31/11																1					

Date	BAS	BGS	BRB	CHC	GSF	GSN	HCH	HH	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	SNF	TFS	W	WHC
6/1/11																					
6/2/11								1								3					
6/3/11		1														3					
6/4/11															2						
6/5/11																1					
6/6/11	1																				
6/7/11															2						
6/8/11									1						1	1					
6/9/11															3	1				1	
6/10/11	1							1							1	4					
6/11/11															2						
6/12/11																					
6/13/11										1	1				7	1					
6/14/11																					
6/15/11	2														3	1					
6/16/11	1							2													
6/17/11																					
6/18/11																2					
6/19/11	1																				
6/20/11																					
6/21/11	1																				
6/22/11								1													
6/23/11																					
6/24/11	1		1					2								1					
6/25/11								1								3					
6/26/11				1				2							2						
6/27/11								1						2	1	2					
6/28/11								8							1	3					
6/29/11								1	1												
6/30/11								1	1						1						

Appendix D. Daily counts of non-salmonids captured at Grayson during 2011.See key in Appendix E for species codes

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
1/6/11		1										
1/7/11		3										
1/8/11												
1/9/11												
1/10/11		1										1
1/11/11		2										
1/12/11		2										1
1/13/11		1										
1/14/11		3										
1/15/11		1						1				2
1/16/11		3	1									4
1/17/11		4	1									4
1/18/11		1										2
1/19/11								1				
1/20/11												
1/21/11		1										
1/22/11												
1/23/11												
1/24/11												
1/25/11								1				
1/26/11		2										
1/27/11							1					1
1/28/11		2										
1/29/11		1		1								6
1/30/11		1										1
1/31/11		1										1
2/1/11		2										3
2/2/11		2										9
2/3/11		3					2					10
2/4/11		2										1
2/5/11		4		1								2
2/6/11		3									3	2
2/7/11		1		1			1					
2/8/11		2										6
2/9/11												2
2/10/11		3										
2/11/11		2										1
2/12/11	2	1		1								
2/13/11												1
2/14/11												

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
2/15/11		1									1	
2/16/11												
2/17/11							2					
2/18/11							1					
2/19/11											10	
2/20/11											4	
2/21/11												
2/22/11		1					1					
2/23/11		1								2		2
2/24/11												
2/25/11												
2/26/11												
2/27/11												
2/28/11		1										
3/1/11												
3/2/11		1										
3/3/11												
3/4/11							1					
3/5/11										1		1
3/6/11		1						1				
3/7/11												
3/8/11												
3/9/11												
3/10/11												
3/11/11								2				
3/12/11												
3/13/11								2				
3/14/11		1						1				
3/15/11		1						1				
3/16/11								1				
3/17/11								1				1
3/18/11		2						2				
3/19/11												
3/20/11												
4/2/11												
4/3/11										8		
4/4/11										5		
4/5/11										13		
4/6/11										5		
4/7/11								1				
4/8/11										5		
4/9/11												
4/10/11												

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
4/11/11										5		
4/12/11										4		
4/13/11										3		
4/14/11										2		
4/15/11												
4/16/11		1								1		
4/17/11												
4/18/11										1		
4/19/11										2		
4/21/11												
4/22/11										3		
4/23/11							1			4		
4/24/11								1		1		
4/25/11								5		1		
4/26/11						959				3		
4/27/11						832	1	1				
4/28/11						851						
4/29/11						525	1			3		
4/30/11		1				2170						
5/1/11						13544						1
5/2/11						6316				1		
5/3/11						5925				1		
5/4/11		1				4287						
5/5/11						4132						
5/6/11	2					1921						
5/7/11						976				4		
5/8/11						307		1		2		
5/9/11						690						
5/10/11	6	1				314				1		
5/11/11						275				2		1
5/12/11	1					202	1			3		
5/13/11	1					463						
5/14/11		1				422						
5/15/11	1	1				129						
5/16/11	1					88						1
5/17/11	4					110						
5/18/11	3	2				143				2	1	
5/19/11	2					163				2		
5/20/11		1			1	121				1		
5/21/11		1				137	1			1		1
5/22/11						168				4		
5/23/11						160						
5/24/11	1					205						

Date	BAS	BGS	BKB	BKS	BRB	C	CHC	GSN	HCH	HH	LAM	LMB
5/25/11	4					100						
5/26/11	3	2				113						
5/27/11						127				1		
5/28/11		1				96						
5/29/11	1					16				1		
5/30/11						52				1		
5/31/11						26						
6/1/11						15						1
6/2/11						41				1		
6/3/11						103				1		
6/4/11						82				1		
6/5/11						35						
6/6/11						11						
6/7/11						47				1		
6/8/11						25						
6/9/11					1	28						
6/10/11						27						1
6/11/11		1				8				1		
6/12/11												
6/13/11						8	2					
6/14/11						2						
6/15/11						4				6		
6/16/11						2				1		
6/17/11						4				5		
6/18/11		1				8				1		
6/19/11		1				4		1				
6/20/11	1											
6/21/11	1					2						1
6/22/11	1	1				1				2		
6/23/11	1	1				1				2		
6/24/11	2	1				1						
6/25/11	2	1				4						
6/26/11	3	1				6			1			
6/27/11	1	1										
6/28/11												3
6/29/11		1				1				1		
6/30/11		3										

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
1/6/11												
1/7/11												
1/8/11												
1/9/11												

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
1/10/11	1										1	
1/11/11	1					1						
1/12/11	3											
1/13/11	4			3	1	1		3				2
1/14/11	5			1	2			2				1
1/15/11	7			3	2							4
1/16/11						3	2					2
1/17/11	2											2
1/18/11					3							
1/19/11				1								1
1/20/11						1						
1/21/11												1
1/22/11						1						2
1/23/11												2
1/24/11	1			2								2
1/25/11	1											
1/26/11	1											
1/27/11	1											
1/28/11	1			1				1				3
1/29/11	3			2						1		1
1/30/11	2											1
1/31/11	2					1		1				5
2/1/11	1						1					3
2/2/11							1					2
2/3/11	1				3	1	1		2			16
2/4/11					2							4
2/5/11	1											
2/6/11	3											6
2/7/11	1											3
2/8/11				1								3
2/9/11	1					1						
2/10/11	3											1
2/11/11				1								3
2/12/11				1								1
2/13/11												1
2/14/11												2
2/15/11												2
2/16/11												
2/17/11												2
2/18/11												
2/19/11												
2/20/11												1
2/21/11											1	5

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
2/22/11											1	4
2/23/11												4
2/24/11						1						7
2/25/11												1
2/26/11												
2/27/11						1	1					3
2/28/11						1						
3/1/11								1				5
3/2/11						1						3
3/3/11						2						3
3/4/11												1
3/5/11												1
3/6/11	1											1
3/7/11										1		2
3/8/11	1											3
3/9/11						2						1
3/10/11							2	1				5
3/11/11							1					1
3/12/11						1						1
3/13/11												1
3/14/11						1						
3/15/11												1
3/16/11												
3/17/11	1											
3/18/11							1					3
3/19/11					1							
3/20/11												
4/2/11						4	2					
4/3/11						16	2					1
4/4/11												
4/5/11						4	2	1			1	
4/6/11						6						1
4/7/11						4						
4/8/11						2	2					1
4/9/11						6						
4/10/11						7						
4/11/11						5	2	1				
4/12/11						7						
4/13/11						3	1					1
4/14/11						3	3					
4/15/11						4						
4/16/11						1						
4/17/11						3	1					1

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
4/18/11					1							
4/19/11							1					1
4/21/11						4		1				
4/22/11							2					
4/23/11						1	1					
4/24/11						3	2					
4/25/11						3	1	1				1
4/26/11						1	3					
4/27/11						2	1					
4/28/11	1						5					
4/29/11					1	3	4					
4/30/11						1	10					
5/1/11						2						
5/2/11		1			1	4	1	1				
5/3/11					1							2
5/4/11					1							1
5/5/11				1	1							
5/6/11						1	1					1
5/7/11												1
5/8/11						3						1
5/9/11						2	1	1				
5/10/11						5	1					
5/11/11						2						1
5/12/11				1		1						
5/13/11					1	2						
5/14/11	1					2						1
5/15/11						4						
5/16/11						3	3					
5/17/11							1					
5/18/11							4					
5/19/11	1				1		5					1
5/20/11						1	5					1
5/21/11						2	4					1
5/22/11						1	1					
5/23/11						1	3	1				
5/24/11						2						2
5/25/11							1					
5/26/11												
5/27/11												1
5/28/11			1				1					1
5/29/11												
5/30/11						1	1					
5/31/11							1					1

Date	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	SNF	UNID	W	WHC
6/1/11												1
6/2/11						2	1					2
6/3/11							2					
6/4/11							6					
6/5/11						1	1					2
6/6/11												
6/7/11						1						4
6/8/11						2	3	1			2	2
6/9/11						2					1	2
6/10/11												1
6/11/11								1				1
6/12/11						1						1
6/13/11						2						
6/14/11						2						2
6/15/11							1					1
6/16/11												1
6/17/11						1	1					
6/18/11						1						1
6/19/11						1						
6/20/11					1			1				1
6/21/11	1					1						2
6/22/11					1						2	
6/23/11					1	1	2					
6/24/11					1		2					
6/25/11						1	3					1
6/26/11							5					
6/27/11	1				3							
6/28/11				1	2		2	1				
6/29/11				1	2						3	
6/30/11					2		2				2	

Appendix E. Key to species codes.

BAS	Unidentified bass
BGS	Bluegill
BKB	Black bullhead
BKS	Black crappie
BRB	Brown bullhead
C	Carp
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
RES	Redear sunfish
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SMB	Smallmouth bass
SNF	Unidentified sunfish
TFS	Threadfin shad
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	)	

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

<u>Report 2011-5</u>

2011 Snorkel Report and Summary Update

Prepared for

Turlock and Modesto Irrigation Districts

By

Stillwater Sciences
Berkeley, CA

March 2012

SUMMARY

In 2011, higher summer flows in June and July prevented safe river access for conducting the early summer Reference count survey within the 20-mile reach of the Tuolumne River below La Grange Dam. The 3-day survey was conducted on September 16th – 19th and again on November 1st – 3rd. Preliminary USGS flow at La Grange was about 336 cfs and water temperature ranged from 13.5°C (56.3 F) to 18.6°C (65.5 F) in September and flow was about 356 cfs with water temperatures from 12.7°C (54.9 °F) to 14.7°C (58.5 °F) in November. A total of 66 juvenile Chinook salmon and 1,179 rainbow trout were observed in various habitats in September and 25 Chinook salmon (including adults) and 148 rainbow trout were observed in November. Chinook salmon were observed downstream to Riffle 57 (River Mile [RM] 31.5) and rainbow trout downstream to Riffle 41A (RM 35.3) in September and Chinook salmon were observed to Riffle 31 (RM 38) and rainbow trout to Riffle 57 (RM 31.5) in November. Other native fish species observed were Sacramento sucker, Sacramento pikeminnow, hardhead, and riffle sculpin with the non-native species recorded being largemouth bass, smallmouth bass, and striped bass during the two surveys. 2011 represents the second consecutive year in which striped bass were observed in the lower Tuolumne River.

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.

Late summer surveys have been conducted in September of most years during the recent 2001–2011 period with the exception of 2008 and 2009. 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 Reference count surveys shifted beginning in the summer of 1996. In surveys from 1982–1996, warmwater 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 have 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 (*Oncorhynchus tshawytscha*) 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 and a comparable September snorkel survey was done in 2001–2007 and again in 2010–2011. In 2011 the survey was conducted in September and was repeated in November. The 2011 surveys were implemented as required studies under the FERC order issued 10 May 2010 regarding *O.mykiss.*

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 2011 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 twelve sites sampled are listed below. Riffle names are interchangeably designated with an “R” in this report (i.e. R21 = Riffle 21).

Site	Location	River Mile[a]
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

[a] derived from topographic maps as distance from confluence with the San Joaquin River

1.2 2011 SAMPLING CONDITIONS

The flow at La Grange during 16–19 September was approximately 336 cfs and approximately 356 cfs during the 01–03 November survey (Figure 2). Water temperature ranged from 13.5 °C (56.3 °F) at Riffle A7 on 16 September to 18.6 °C (65.5 °F) at Riffle 57 on 18 September and 12.7°C (54.9 °F) at Riffle 7 on 02 November to 14.7°C (58.5 °F) at Riffle 57 on 03 November. The higher flows sampled this year required some modification to the survey methods as noted in the methods section.

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 overall river section examined is limited to the reach with suitable underwater visibility, this generally being a 20-mile section below La Grange Dam downstream to Waterford. The snorkeling method provided an index of species abundance and these surveys can be referred to as “Reference count” surveys.

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 carefully surveyed. The only exceptions were the habitat areas that were too wide to effectively cover. 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. The 2011 surveys required more areas to be searched utilizing the downstream float method.

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 16–19 September and 01–03 November are summarized in Tables 1 and 2, respectively. 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 (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), and riffle sculpin (*Cottus gulosus*). The introduced (non-native) species observed were largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), redear sunfish (*Lepomis microlophus*), and striped bass (*Morone saxatilis*).

Chinook salmon were observed downstream to R57 (RM 31.5) and rainbow trout to R41A (RM 35.3) in September and Chinook salmon were observed to R31 (RM 38) and rainbow trout to R57 (RM 31.5) in November.

During the September surveys, there were 66 juvenile Chinook salmon observed in riffle, run, and run-pool habitats from RA7 (RM 50.7) near La Grange Dam downstream to R57 (RM 31.5), ranging in size from 70–140 mm total length (TL). There were 1,179 rainbow trout observed ranging in size from 70–520 mm TL and seen in riffle, run, and run-pool habitats. A total of 836 juvenile (<150 mm TL) and 343 adult rainbow trout were observed between RA7 (RM 50.7) and R41A (RM 35.3). Fish were observed in riffle, run, and run-pool habitats. Water temperature at those locations ranged from 13.5 ºC (56.3 F) to 18.0 ºC (64.4 F). Sacramento sucker, along with Sacramento pikeminnow and hardhead were often co-occurring, while riffle sculpin were observed at 3 locations in low numbers usually hidden under cobble/boulder substrate. Striped bass were observed at R2 (RM 49.9), R21 (R42.9), and R31 (RM 38.0) for only the second time during the Reference count surveys. The other year when striped bass were observed was in 2010.

During the November surveys, there were 25 Chinook salmon including 14 adult spawners observed in riffle, run and pool habitats from RA7 (RM 50.7) to R31 (RM 38.0) ranging in size from 60–90 mm TL for the juveniles and 320–650 mm TL for the adult spawners. The 148 rainbow trout observed ranged in size from 70–500 mm FL and were also observed in the similar combinations of riffle, run and pool habitats as the salmon. A total of 34 juvenile (<150 mm TL) and 114 adult rainbow trout were observed between RA7 (RM 50.7) and R57 (RM 31.5). Water temperature ranged from 12.7°C (54.9 °F) to 14.7°C (58.5 °F) at those locations. In comparison to other fish species observed in September, no striped bass were observed in November and only one hardhead was seen.

4 COMPARISON WITH OTHER YEARS

4.1 Rainbow trout and Chinook salmon: 1982-2011

Tables 3 and 4 summarize rainbow trout and Chinook salmon observations for all snorkel surveys conducted between 1982 and 2011. 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 regularly observed at locations downstream to RM 42.9 or RM 42.3. For the 1982–2011 period, Chinook salmon were recorded in all years except 1991 and 1992 although in some years there counts were very low after May. Chinook salmon were also commonly seen downstream to about RM 42.9. Figures 3 and 4 graphically represent Tables 3 and 4 for the

June-September period, only. Dates and locations where rainbow trout and Chinook salmon were observed for the 2001-2011 period are in Figures 5 and 6.

4.2 Recent surveys: 2001-2011

Since the early summer snorkel survey could not be completed due to high flows in some years (2005, 2006, 2010, 2011), the comparative discussion will focus on the late summer (September) surveys. The number of rainbow trout and Chinook salmon observed for the 2001 to 2011 period were graphed by location for the September surveys (Figures 7 and 8). Rainbow trout were commonly observed in the upper 10 miles of river below the La Grange Dam. This is similar to the distribution of Chinook salmon although Chinook were occasionally seen as far downstream as Hickman Bridge (RM 31.5).

The locations sampled since 2001 were the same each year and these surveys were the most comparable showing presence or absence along the lower Tuolumne River by year and generally indicating abundance from observed counts. September surveys show Rainbow trout counts increased from 2001 to 2005 and were much higher beginning in 2006 (Figure 9). 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 (Figure 10) in September were comparatively low.

In both 2010 and 2011, an additional Reference count survey was also conducted in November pursuant to the May 2010 FERC Order. Although observations of *O. mykiss* were generally similar in both November surveys (Table 3), the November 2011 observations represented an apparent reduction from the September 2011 counts. This pattern was not seen in the 2010 data and was possibly due to density dependent factors following the reduction in flows in September 2011. The density indices for the 2010 and 2011 surveys are shown in Figure 11.

4.3 Other species observed: 1986-2011

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 5). 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 addition to *O. mykiss* and Chinook salmon, other native fish species observed in 2011 were Sacramento sucker, Sacramento pikeminnow, hardhead, and riffle sculpin with the non-native species recorded being largemouth bass, smallmouth bass, and striped bass. The observance of striped bass at R2, R21, and R31 during the September surveys was somewhat unusual. The only other year when striped bass were observed was 2010.

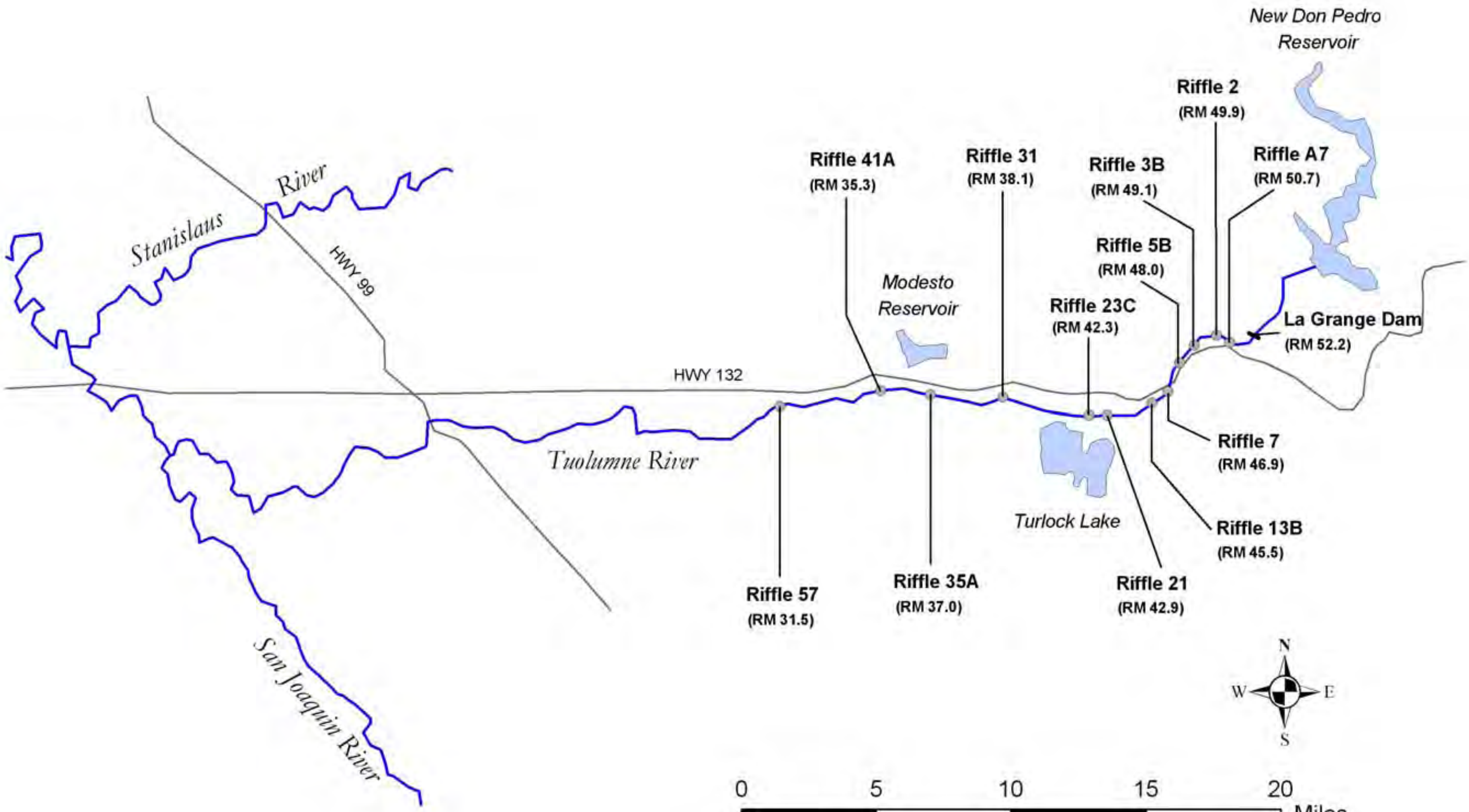

Figure 1. Locations of snorkel survey sites on the lower Tuolumne River, 2011.

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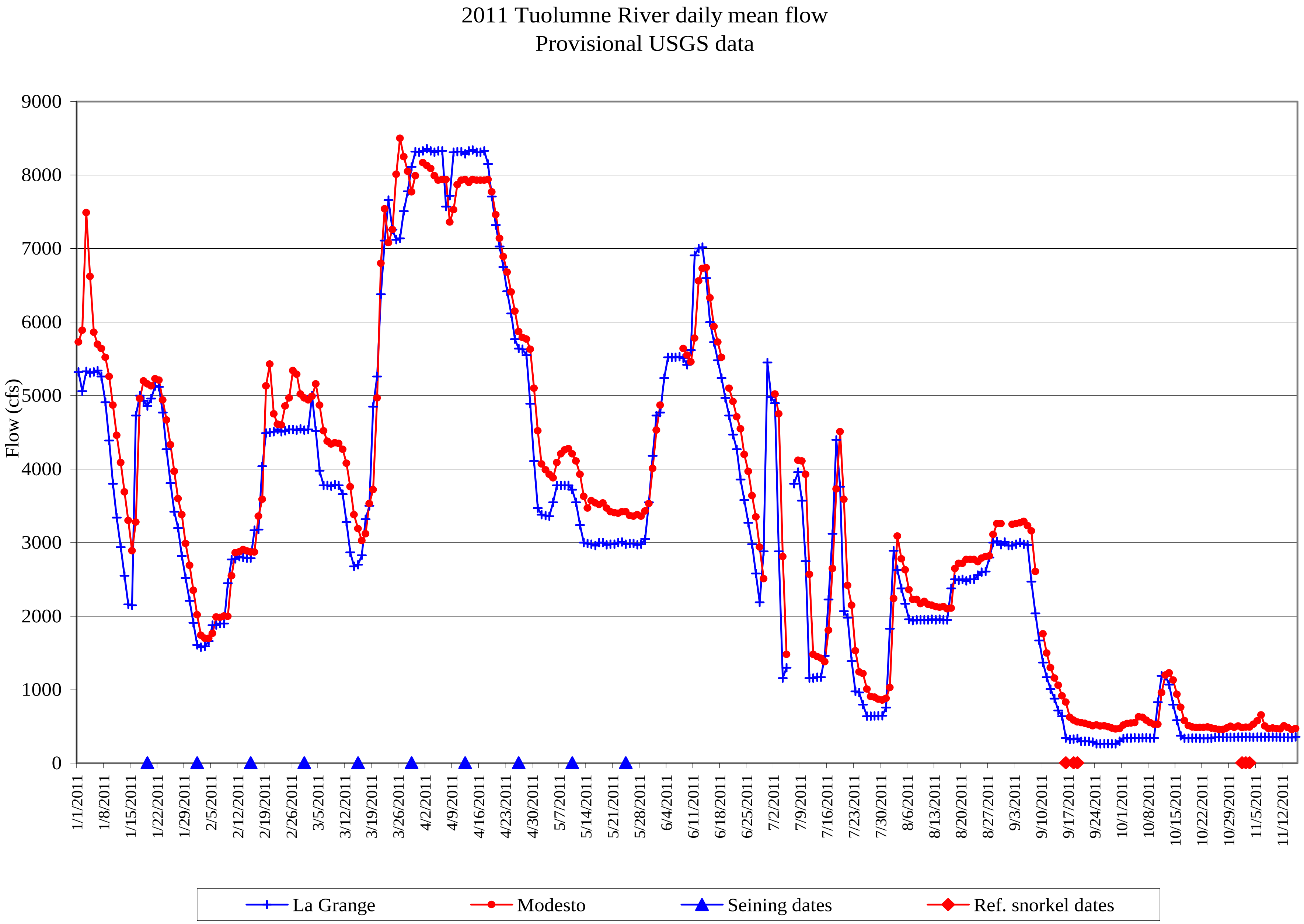

Figure 2. 2011 Tuolumne River flows at La Grange and Modesto

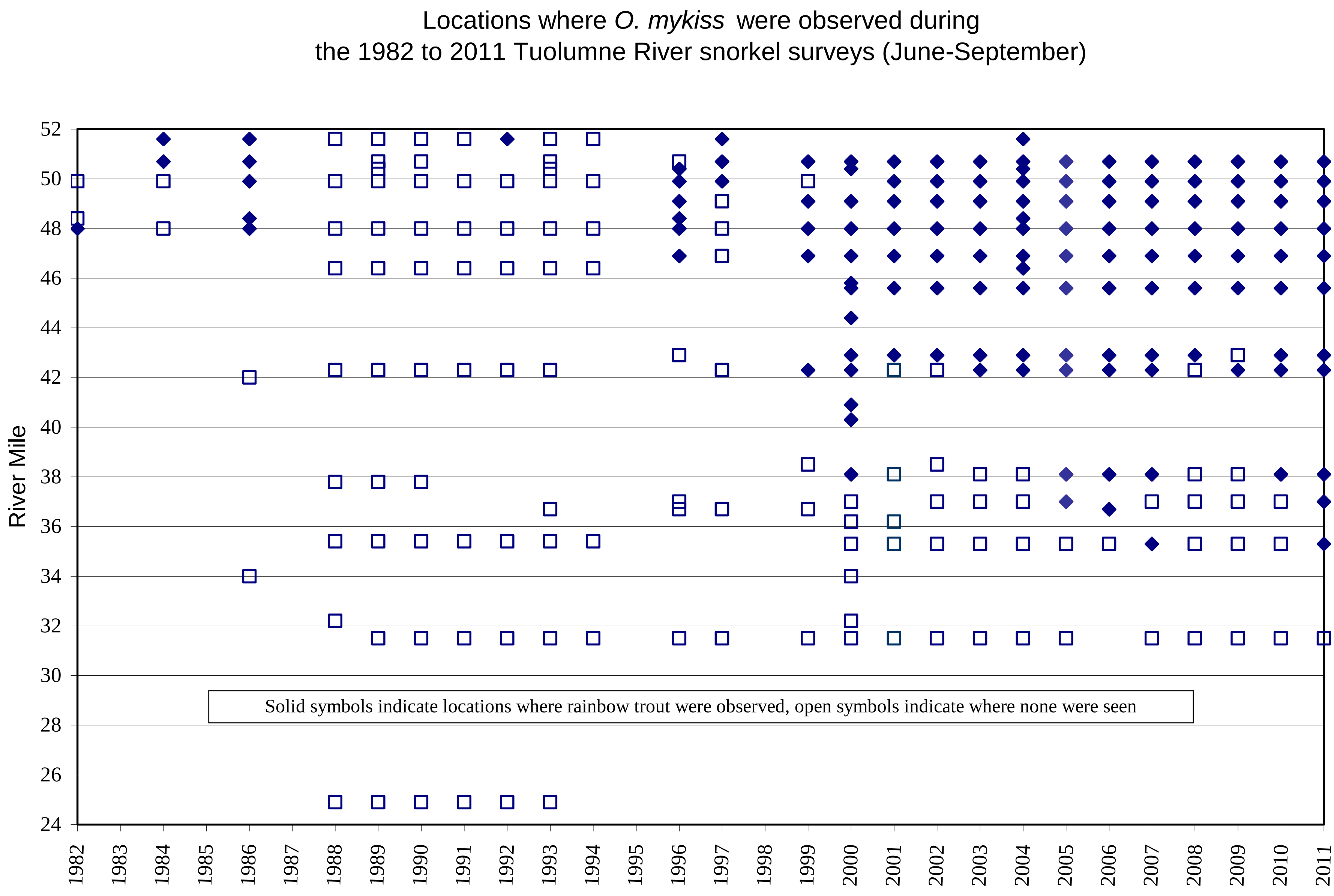

Figure 3. Locations where *O. mykiss* were observed

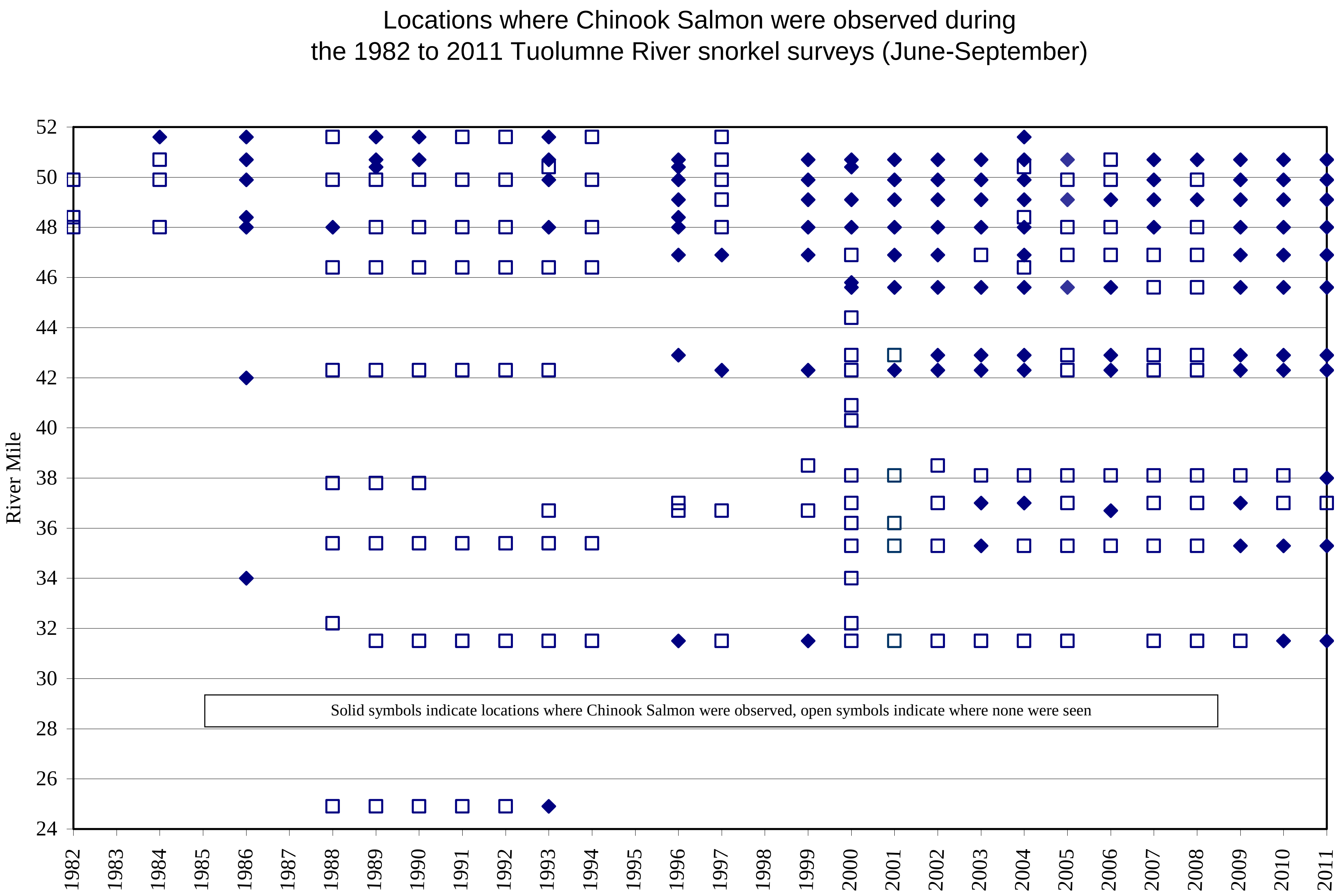

Figure 4. Locations where Chinook salmon were observed

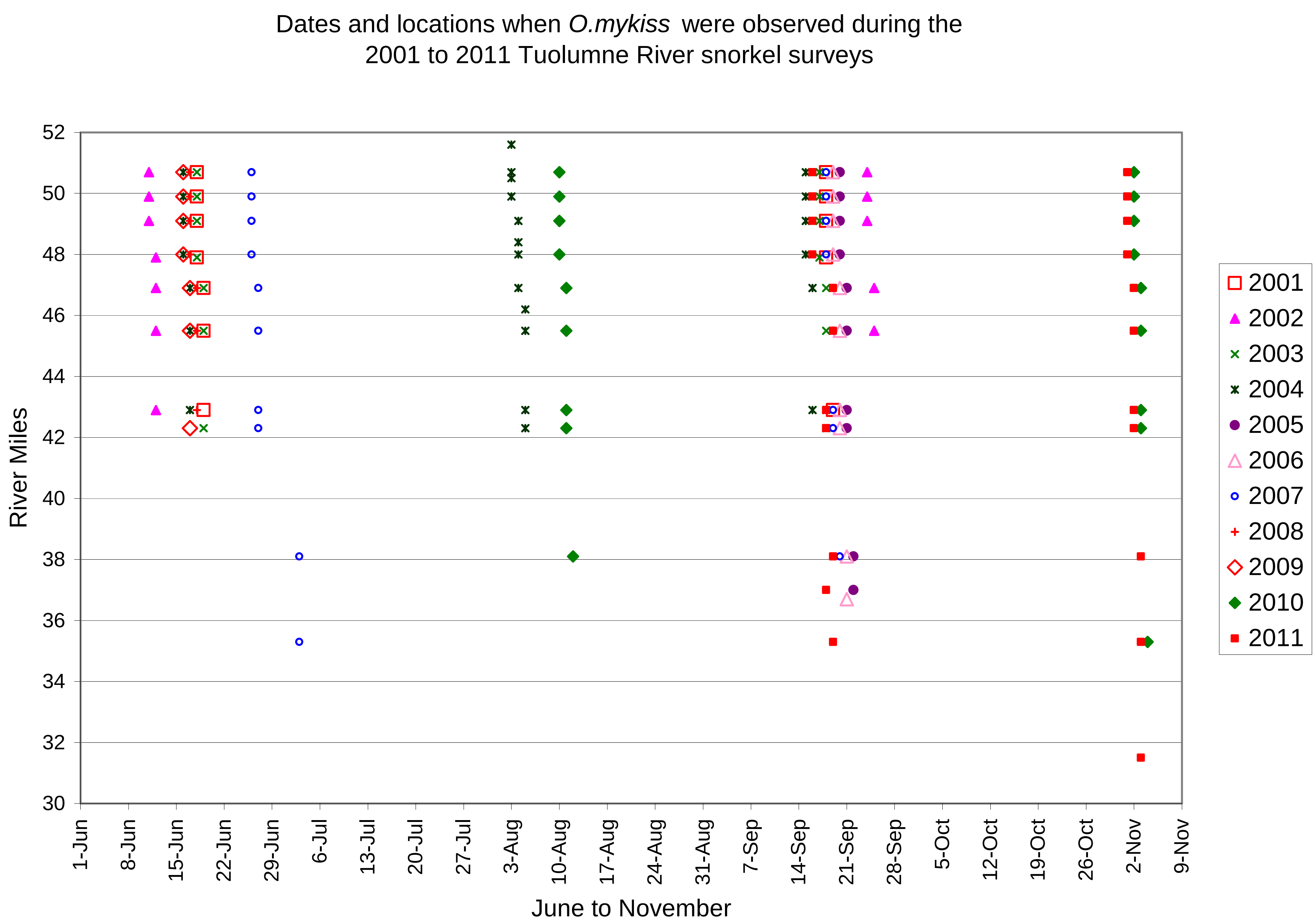

Figure 5. Dates and locations where *O. mykiss* were observed during the snorkel surveys

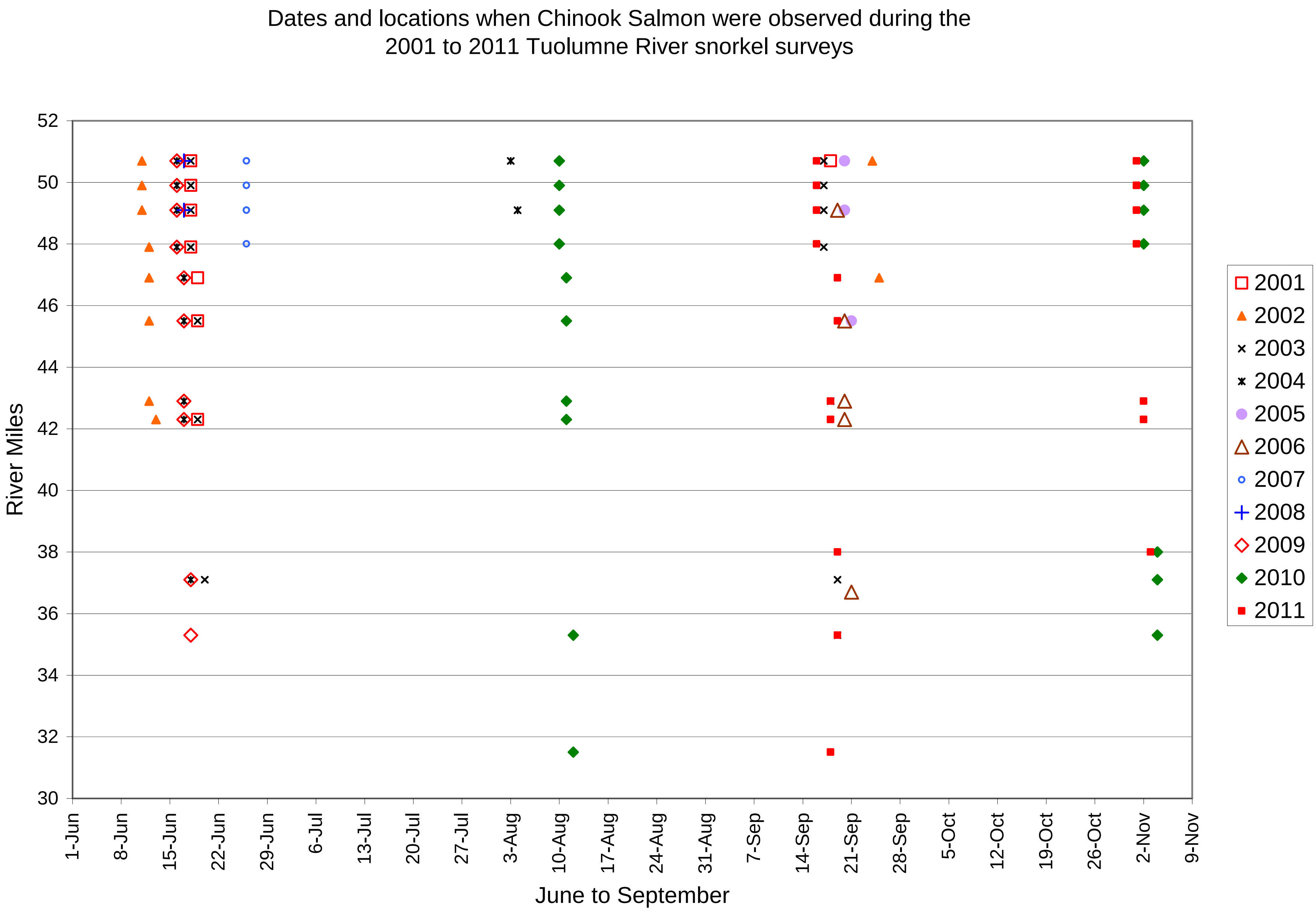

Figure 6. Dates and locations where Chinook Salmon were observed during the snorkel surveys.

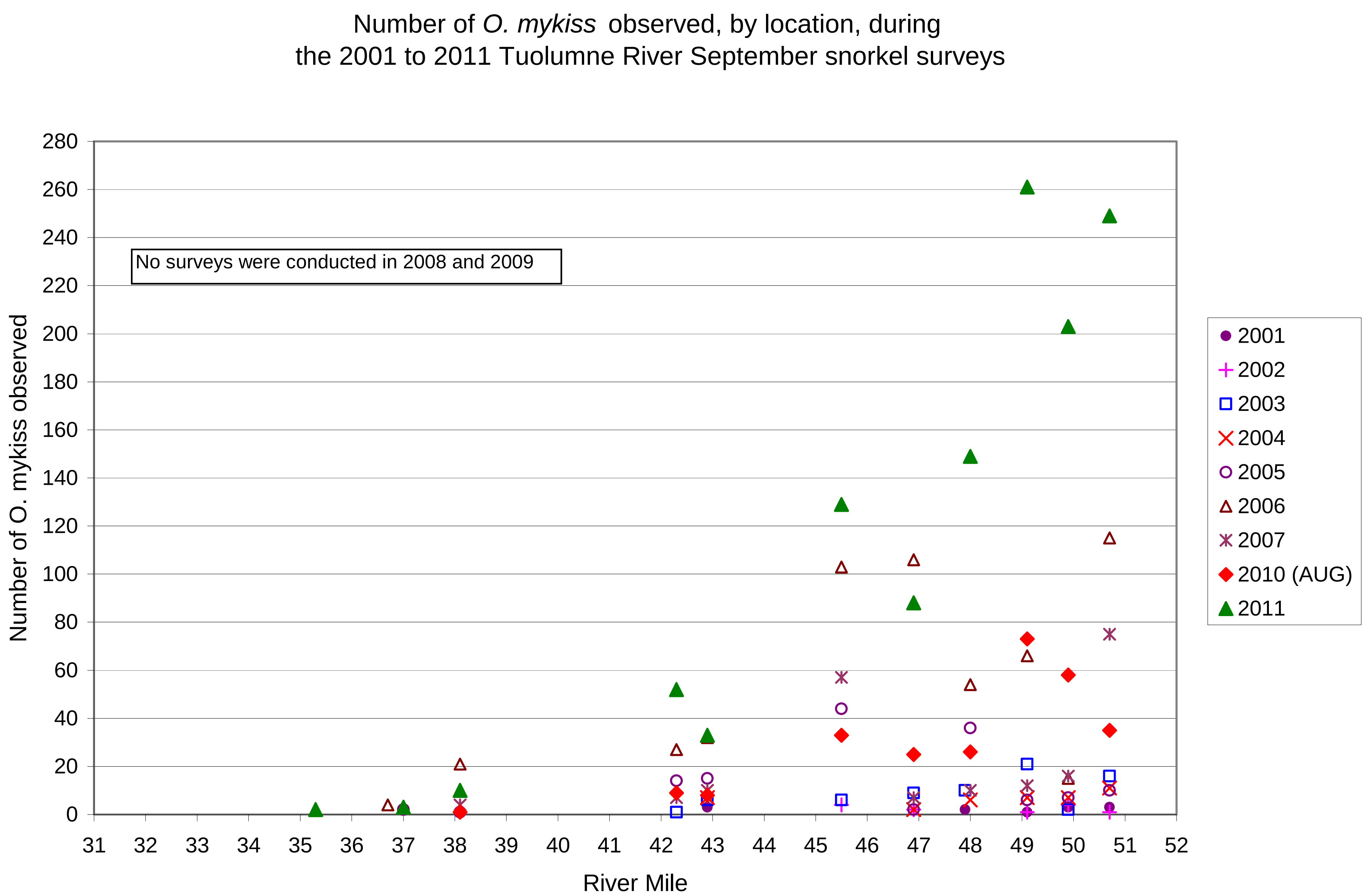

Figure 7. O. mykiss observations during the September snorkel surveys

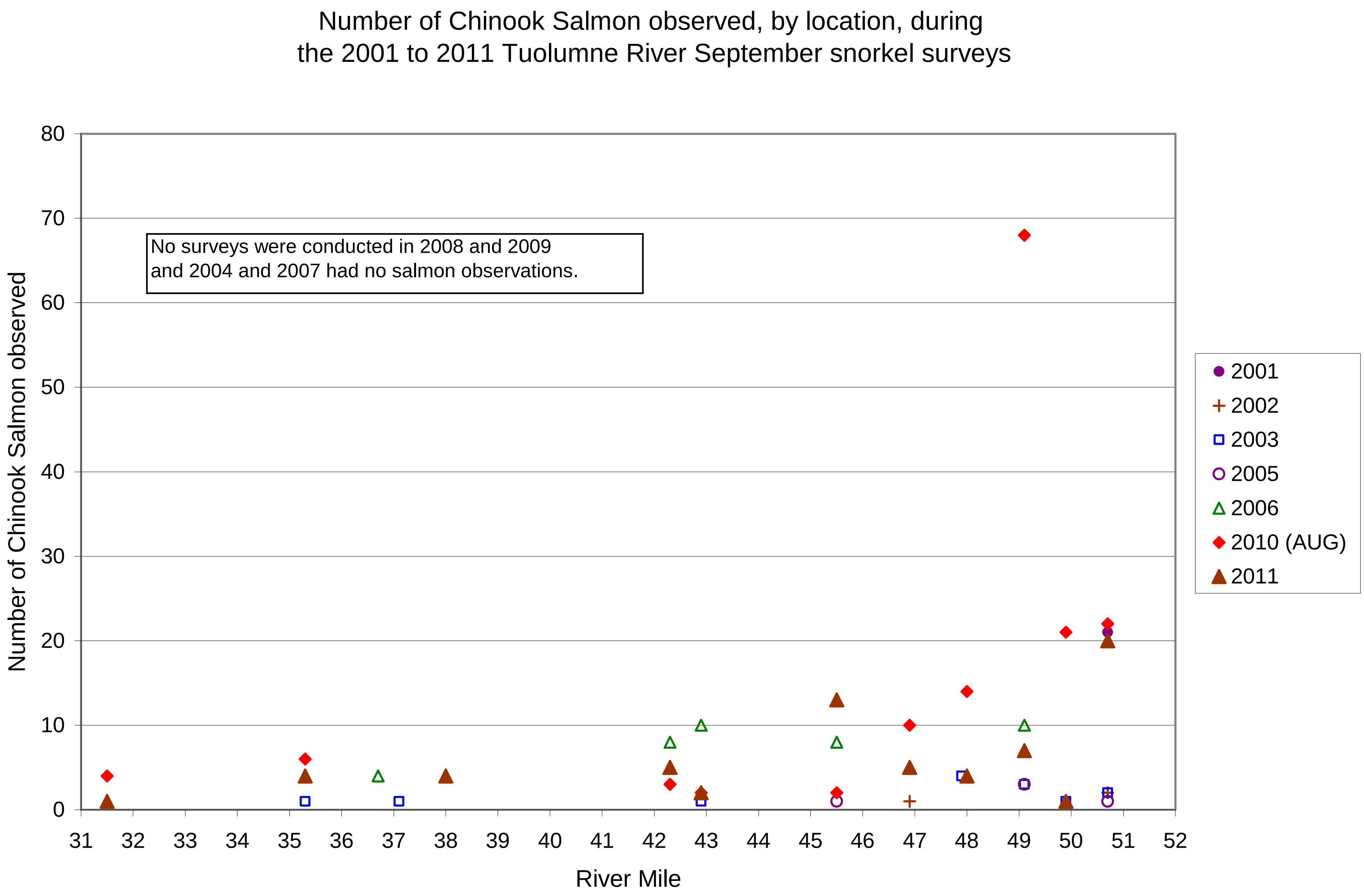

Figure 8. Chinook salmon observations during the September snorkel surveys

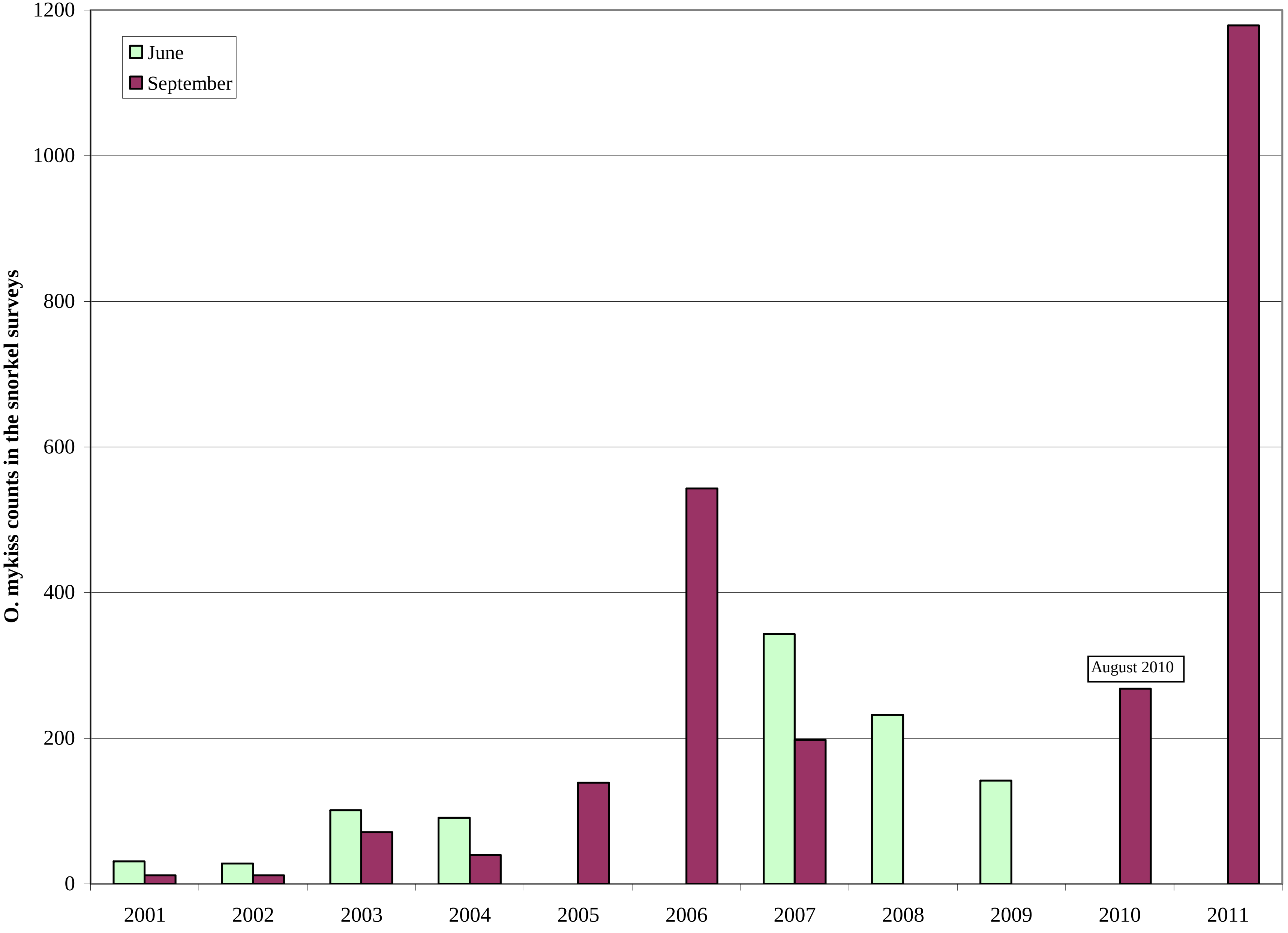

Figure 9. *O. mykiss* counts during the June and September snorkel surveys

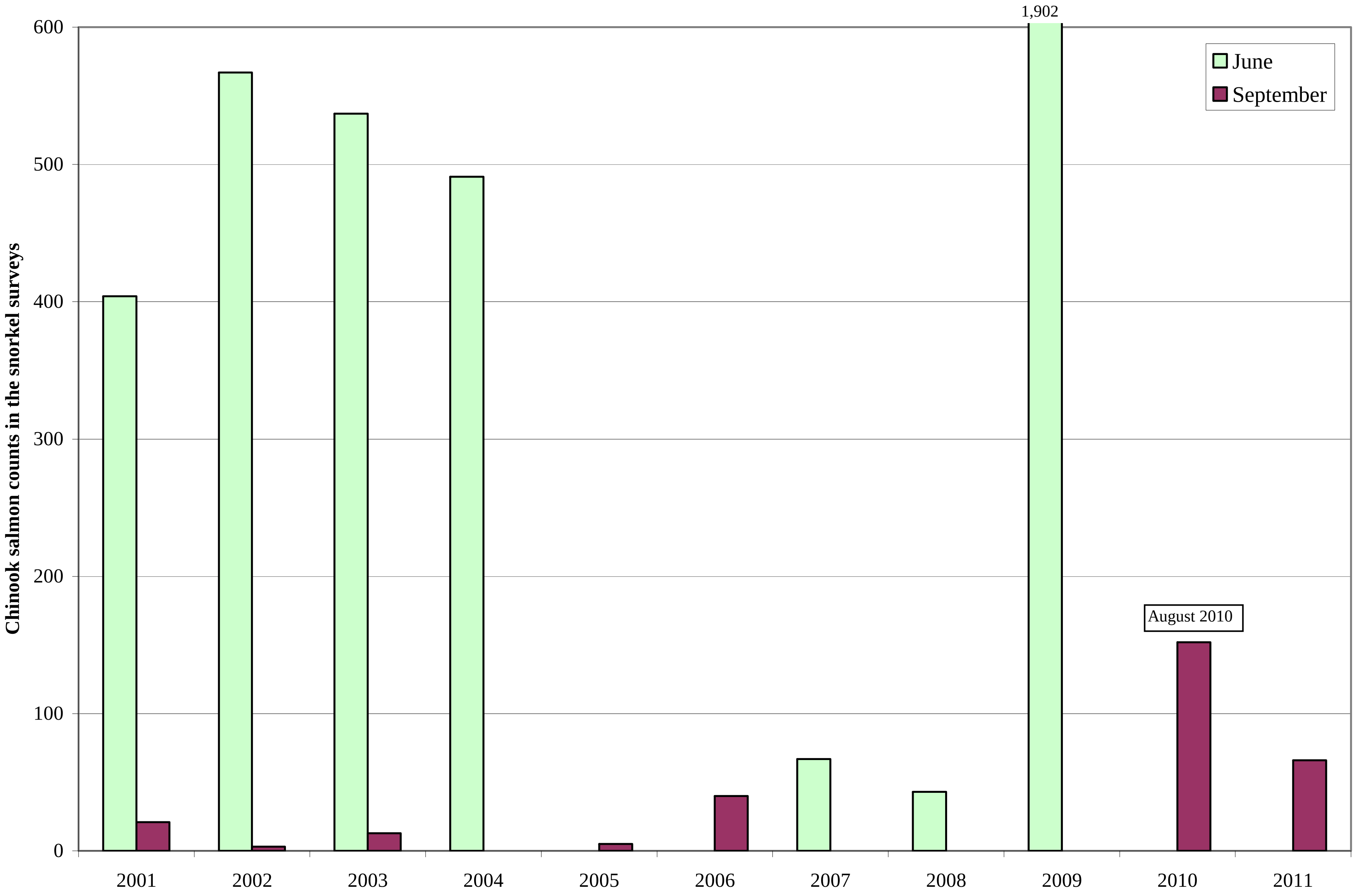

Figure 10. Chinook salmon counts during the June and September snorkel surveys

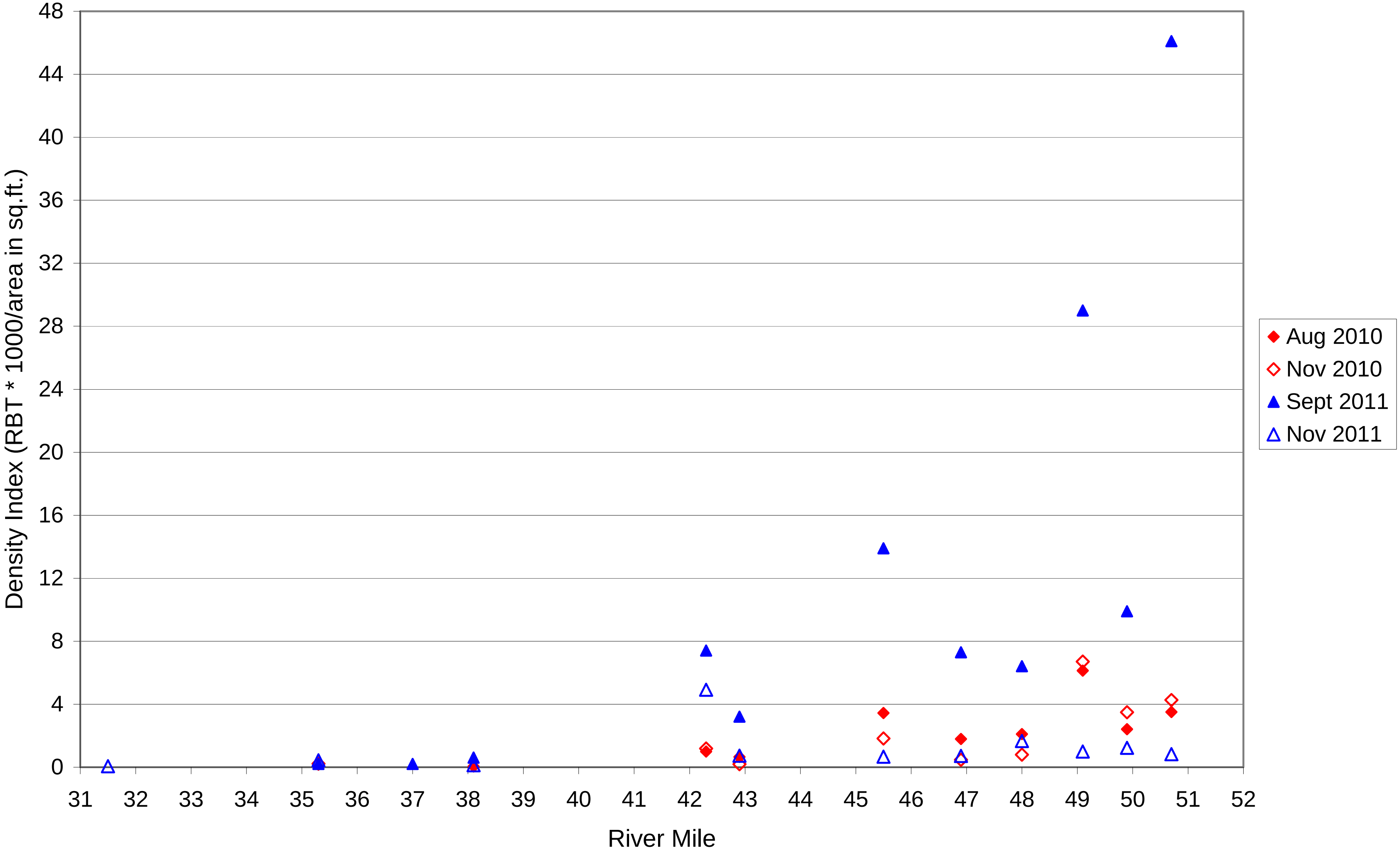

Figure 11. *O. mykiss* density indices for 2010 and 2011 snorkel surveys.

TABLE 1. 2011 TUOLUMNE RIVER SNORKEL SUMMARY (TID/MID)

															NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM									
DATE	START TIME	LOCATION	RIVER MILE	SITE	AREA (Sq. Ft.)	AVG. DEPTH (FEET)	TIME (Min.)	HABITAT	SUBSTRATE	WATER TEMP. (C)	DO (mg/l)	EC	TURB. (NTU)	HORIZ. VISIB. (FEET)	CHINOOK count/est.	CHINOOK size	RAINBOW count/est.	RAINBOW size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	RIFFLE SCULPIN	LARGEMOUTH BASS	SMALLMOUTH BASS	STRIPED BASS
16SEP	1023	Riffle A7	50.7	1	3,000	3.3	13.0	Riffle-Run	cobble,boulder,bedrock	13.5	12.5	20	0.9	23.0	10	(70-100)	50	(70-140)			(80)			
																	110	(160-400)						
	1027			2	2,400	3.5	22.0	Run	gravel,cobble,sand						10	(90-110)	82	(70-140)						
																	7	(200-320)						
16SEP	1148	Riffle 2	49.9	1	6,000	1.5	20.0	Riffle	cobble,gravel,boulder	15.0	11.0	25	0.9	18.0	1	(110)	44	(80-140)			(50,60,70)			
																	10	(160-240)						
	1203			2	4,500	7.0	18.0	Pool-Run	bedrock,cobble,boulder								52	(80-140)						(400)
																	7	(280-500)						
	1205			3	10,000	5.0	17.0	Run-Pool	cobble,gravel,bedrock								57	(70-140)						
																	33	(160-450)						
16SEP	1400	Riffle 3B	49.1	1	4,000	2.2	15.0	Riffle	cobble,gravel,sand	15.8	9.9	20	0.9	20.0			81	(80-140)						
																	13	(160-425)						
	1358			2	5,000	2.4	13.0	Run-Riffle	cobble,gravel,boulder						7	(70-130)	110	(70-140)						
																	57	(160-380)						
16SEP	1505	Riffle 5B	47.9	1	2,000	2.5	12.0	Riffle	cobble,gravel,sand	16.2	9.8	24	0.8	18.0			12	(80-140)						
																	6	(160-425)						
	1524			2	11,250	4.5	32.0	Run	cobble,bedrock,gravel						4	100-110)	59	(90-140)						
																	20	(160-460)						
	1500			3	10,000	4.5	15.0	Run-Pool	cobble,bedrock,boulder								35	(70-140)		(420,440)				
																	17	(160-380)						
					58,150		177.0			**Subtotal**					**32**		**862**			**2**	**4**			**1**
19SEP	1420	Riffle 7	46.9	1	5,000	1.5	20.0	Riffle	cobble,gravel,sand	15.5	9.6	21	1.0	18.0			40	(100-140)						
																	4	(360-420)						
	1425			2	7,000	5.5	18.0	Run	bedrock,cobble,sand						5	(90-110)	26	(110-140)	(80)	(500)				
																	18	(150-520)						
19SEP	1318	Riffle 13B	45.5	1	5,250	3.0	16.0	Run	cobble,gravel,sand	14.9	9.2	24	1.0	20.0	3	80-100)	60	(70-140)						
																	7	(160-240)						
	1323			2	4,000	2.5	16.0	Riffle	gravel,cobble,sand						10	(80-110)	62	(80-140)	(80)					
18SEP	1059	Riffle 21	42.9	1	4,375	2.5	18.0	Riffle	cobble,gravel,boulder	14.8	8.8	28	1.2	15.0	2	(80,80)	13	(110-140)						
																	8	(160-200)						
	1105			2	6,000	6.0	17.0	Run-Pool	cobble,gravel,sand								6	(100-140)	(450)					(500)
																	6	(160-520)						
18SEP	0950	Riffle 23C	42.3	1	3,000	2.5	13.0	Run-Riffle	cobble,gravel,bedrock	15.0	9.7	24	1.3	14.0	2	(80,90)	23	(100-140)						
																	12	(160-460)						
	0949			2	4,000	2.0	14.0	Riffle	cobble,gravel,bedrock						3	(80-100)	14	(90-140)						
																	3	(160,180,340)						
					38,625		132.0			**Subtotal**					**25**		**302**		**3**	**1**				**1**
19SEP	0916	Riffle 31	38.0	1	6,000	1.8	18.0	Riffle	cobble,gravel,boulder	16.3	8.8	34	1.2	16.0	1	(100)	2	(120,320)	(700)					
	0918			2	12,000	4.0	17.0	Run-Pool	cobble,gravel,sand						3	(90,90,100)	6	(110-140)	65(400-800)			(140)		(480)
																	2	(240,260)						
18SEP	1316	Riffle 35A	37.1	1	4,500	1.8	18.0	Riffle	cobble,gravel,sand	18.0	8.0	34	2.4	14.0			2	(130,400)		7(70-80)	(70,80)			
	1317			2	11,250	3.0	18.0	Run	cobble,gravel,sand								1	(180)	9(60-100)	7(60-100),(240,260,280)				
19SEP	1106	Riffle 41A	35.3	1	3,000	2.0	17.0	Run-Riffle	cobble,gravel,sand	17.1	9.0	35	1.1	13.0	1	(140)	2	(120,140)		5(60-90)				
	1106			2	2,500	4.5	7.0	Run-Pool	sand,gravel,bedrock						3	(100-120)							(160)	
	1113			3	6,000	2.0	13.0	Riffle	cobble,gravel,sand										12(80-110)	32(60-90)				
18SEP	1432	Riffle 57	31.5	1	13,125	1.8	18.0	Riffle	cobble,gravel,boulder	18.6	9.2	37	1.5	13.0					25(360-500)			(140)	(160)	
	1434			2	7,000	2.8	16.0	Run	cobble,gravel,bedrock						1	(110)			(600)	(360,450)			6(160-280)	
					65,375		142.0			**Subtotal**					**9**		**15**		**113**	**56**	**2**	**2**	**8**	**1**
										TOTAL#					**66**		**1179**		**116**	**59**	**6**	**2**	**8**	**3**

TABLE 2. 2011 TUOLUMNE RIVER SNORKEL SUMMARY (TID/MID)

DATE	START TIME	LOCATION	RIVER MILE	SITE	AREA (Sq. Ft.)	AVG. DEPTH (FEET)	TIME (Min.)	HABITAT	SUBSTRATE	WATER TEMP. (C)	DO (mg/l)	EC	TURB. (NTU)	HORIZ. VISIB. (FEET)	NUMBER COUNTED (ESTIMATED TOTAL LENGTH OR SIZE RANGE IN MM) CHINOOK count/est.	CHINOOK size	RAINBOW count/est.	RAINBOW size	SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	RIFFLE SCULPIN	HARDHEAD
01NOV	1006	Riffle A7	50.7	1	5,000	3.3	23.0	Riffle-Run	cobble,boulder,gravel	13.0	12.6	20	0.9	22.0	4	(380-550)						
	1008			2	2,250	3.5	20.0	Run	gravel,cobble,sand						2	(500,600)	6	(160-340)			(70,80)	
01NOV	1132	Riffle 2	49.9	1	6,000	1.5	20.0	Riffle	cobble,gravel,boulder	13.7	12.3	26	1.1	16.0	No fish observed							
	1147			2	6,000	7.0	20.0	Pool-Run	bedrock,cobble,boulder						2	(320,360)	4	(300-360)		(420)		
	1150			3	10,000	5.0	16.0	Run-Pool	cobble,gravel,bedrock						1	(480)	23	(220-350)				
01NOV	1336	Riffle 3B	49.1	1	3,000	2.2	14.0	Riffle	cobble,gravel,sand	14.2	10.7	31	1.0	15.0			5	(160-360)			(30)	
	1338			2	5,000	2.4	17.0	Run-Riffle	cobble,gravel,boulder						2	(470,490)	3	(240,240,320)				
01NOV	1447	Riffle 5B	47.9	1	2,000	2.5	11.0	Riffle	cobble,gravel,sand	14.5	10.7	21	0.8	15.0			2	(360,380)				
	1515			2	12,000	4.5	26.0	Run	cobble,bedrock,gravel						2	(490,500)	4	(380-500)				
	1445			3	10,500	4.5	16.0	Run-Pool	cobble,bedrock,boulder								2	(130,140)				
																	33	(160-350)				
					61,750		183.0			Subtotal					13		82			1	3	
02NOV	1004	Riffle 7	46.9	1	5,000	1.5	15.0	Riffle	cobble,gravel,sand	12.7	12.7	25	1.0	18.0			1	(280)				
	1002			2	7,500	5.5	16.0	Run	bedrock,cobble,sand								8	(300-480)		(380,420)		
02NOV	1108	Riffle 13B	45.5	1	7,000	2.5	18.0	Run	cobble,gravel,sand	13.0	9.8	24	0.9	18.0			1	(140)				
																	7	(160-210)				
	1102			2	5,000	2.5	15.0	Riffle	gravel,cobble,sand						No fish observed							
02NOV	1253	Riffle 21	42.9	1	7,000	2.5	20.0	Riffle	cobble,gravel,sand	13.4	10.9	27	0.9	15.0			7	(130-140)				
*	1300			2	4,000	7.0	11.0	Pool	cobble,gravel,sand						1	(70)	1	(120)	(70,70,80)			
02NOV	1428	Riffle 23C	42.3	1	2,500	2.0	17.0	Run-Riffle	cobble,gravel,bedrock	14.2	N.A.	25	1.1	14.0	8	(60-80)	11	(100-140)				
																	10	(150-230)				
	1430			2	4,000	2.0	15.0	Riffle	cobble,gravel,bedrock						2	(80,90)	10	(70-140)				
																	1	(150)				
					42,000		127.0			Subtotal					11		57		3	2		
03NOV	0938	Riffle 31	38.0	1	6,000	2.5	16.0	Riffle	cobble,gravel,boulder	13.3	11.6	34	1.6	14.0	1	(650)	1	(140)				
	0940			2	10,000	4.0	18.0	Run-Pool	cobble,gravel,sand								1	(330)				
03NOV	1052	Riffle 35A	37.1	1	4,000	1.5	17.0	Riffle	cobble,gravel,sand	14.1	10.7	31	1.3	14.0					60(50-90)	70(50-80)		
	1050			2	8,750	3.3	16.0	Run	cobble,gravel,sand											(70), 6(300-350)		
03NOV	1245	Riffle 41A	35.3	1	3,000	2.0	15.0	Run-Riffle	cobble,gravel,sand	14.2	10.9	32	1.3	14.0			4	(180-420)				
	1243			2	2,500	4.5	7.0	Run-Pool	sand,gravel,bedrock								2	(130,280)				
	1250			3	8,000	2.0	10.0	Riffle	cobble,gravel,sand						No fish observed							
03NOV	1352	Riffle 57	31.5	1	7,500	2.0	14.0	Riffle	cobble,gravel,boulder	14.7	10.6	38	1.3	12.0					20(400-600)	(380)		
	1353			2	7,000	2.8	15.0	Run	cobble,gravel,bedrock								1	(280)	40(300-550)	4(180-280)		(300)
					56,750		128.0			Subtotal					1		9		120	82		1
										TOTAL#					25		148		123	85	3	1

Table 3. Tuolumne River snorkel survey locations (1982-2010) with number of O. mykiss observed, otherwise none were seen.

	1982	1984		1985	1986		1987			1988					1989				1990				1991		1992	
	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
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
Riffle A7 (RM 50.7)			26			13			X						X	X		X	X		X					
Riffle 1A (RM 50.4)								X									X									
Riffle 2 (RM 49.9)	X		X			25	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																				
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
Riffle 7 (RM 46.9)																										
Riffle 9 (RM 46.4)										X				X	X			X		X		X	X	X	X	X
Riffle 12 (RM 45.8)																										
Riffle 13A-B (RM 45.6)																										
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
Riffle 24 (RM 42.0)					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)																										
Riffle 37 (RM 36.2)								X																		
Riffle 39-40 (RM 35.4)										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
Charles (RM 24.9)										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

Table 3 (cont). Tuolumne River snorkel survey locations (1982-2010) with number of O. mykiss observed, otherwise none were seen.

	1993				1994			1995	1996	1997	1999	2000	2001		2002		2003		2004			2005	2006	2007		2008	2009	2010		2011	
	MAY	JUN	JUL	OCT	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
LOCATIONS																															
Riffle A3/A4 (RM 51.6)	X	X	X	X		X	X	X		4										5											
Riffle A7 (RM 50.7)	X	X	X	X	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
Riffle 1A (RM 50.4)	X	X		X					**51**			3								4											
Riffle 2 (RM 49.9)	X	X		X		X	X		**91**	2	X		3	3	1	4	8	2	23	2	7	7	15	34	16	9	12	58	67	203	27
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
Riffle 4B (RM 48.4)	X								**55**											8											
Riffle 5B (RM 48.0)	X		X		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
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
Riffle 9 (RM 46.4)	X	X		X		X	X													3											
Riffle 12 (RM 45.8)												5																			
Riffle 13A-B (RM 45.6)	X											20	3	X	2	4	1	6	5	13	X	46	103	15	57	24	4	33	14	129	8
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
Riffle 23B-C (RM 42.3)			X		X					X	9	4	X	X	X	X	1	1	X	1	X	14	27	5	7	X	2	9	10	52	32
Riffle 24 (RM 42.0)	X							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
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
Riffle 36A (RM 36.7)	X		X		X				X	X	X												4								
Riffle 37 (RM 36.2)												X	X	X																	
Riffle 39-40 (RM 35.4)		X		X		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
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	X	X	X	1
Charles (RM 24.9)		X		X			X																								
Total O.mykiss	0	0	0	0	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

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

Table 4. Tuolumne River snorkel survey locations (1982-2010) with number of Chinook Salmon observed, otherwise none were seen.

	1982	1984		1985	1986				1987	1988					1989				1990				1991		1992	
	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
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
Riffle A7 (RM 50.7)			X			20			X						X	11		X	144		3					
Riffle 1A (RM 50.4)								150		22							25									
Riffle 2 (RM 49.9)	?		X			50	100+	100+		1				X	X			X	11	X		X	X	X	X	X
Riffle 3B (RM 49.1)										1																
Riffle 4B (RM 48.4)	?	?		60	30	25				1																
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
Riffle 7 (RM 46.9)																										
Riffle 9 (RM 46.4)										3				X	X			X		X		X	X	X	X	X
Riffle 12 (RM 45.8)																										
Riffle 13A-B (RM 45.6)																										
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
Riffle 24 (RM 42.0)					10																					
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)																										
Riffle 37 (RM 36.2)								40																		
Riffle 39-40 (RM 35.4)										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
Charles (RM 24.9)										X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	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

Table 4 (cont). Tuolumne River snorkel survey locations (1982-2010) with number of Chinook Salmon observed, otherwise none were seen.

	1993				1994			1995	1996	1997	1999	2000	2001		2002		2003		2004			2005	2006	2007		2008	2009	2010		2011	
	MAY	JUN	JUL	OCT	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
LOCATIONS																															
Riffle A3/A4 (RM 51.6)	9	35	X	10		X	X	2		X										X											
Riffle A7 (RM 50.7)	54	X	2	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
Riffle 1A (RM 50.4)	14	X		7					**29**			47								X											
Riffle 2 (RM 49.9)	6	2		11		X	X		**16**	X	3		4	X	10	X	72	1	16	X	X	X	X	18	X	X	43	21	32	1	3
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
Riffle 4B (RM 48.4)	5								**43**											X											
Riffle 5B (RM 48.0)	33		3	3	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
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
Riffle 9 (RM 46.4)	3	X		7		X	X													X											
Riffle 12 (RM 45.8)												6																			
Riffle 13A-B (RM 45.6)	X	X		X								5	6	X	10	X	9	X	3	X	X	1	8	X	X	X	2	2	X	13	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
Riffle 23B-C (RM 42.3)			X	X	2			1		2	1	X	1	X	2	X	8	X	1	X	X	X	8	X	X	X	12	3	X	5	10
Riffle 24 (RM 42.0)	X	X						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
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
Riffle 36A (RM 36.7)	8		X	X	X				X	X	X												4								
Riffle 37 (RM 36.2)												X	X	X																	
Riffle 39-40 (RM 35.4)		X		X		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
Riffle 46 (RM 34.0)												X																			
Riffle 52B (RM 32.2)												X																			
Riffle 57-58 (RM 31.5)	X	X		X	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
Charles (RM 24.9)		1		X			X																								
Total Chinook Salmon	132	38	5	45	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

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

Table 5. 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 2010, 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
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
Salmonidae	rainbow trout	N	RT	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	
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
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
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															
Centrarchidae	bluegill		BG	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	
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
Centrarchidae	smallmouth bass		SMB	X	X	X	X	X	X	X	X					X	X	X	X	X		X	X	X	X	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
Moronidae	striped bass		SB																						X	X

(List includes all species observed during 1986-2010 snorkel studies)

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-6

September 2011 *Oncorhynchus mykiss* Population Estimate Report

Prepared by

Stillwater Sciences
Berkeley, CA

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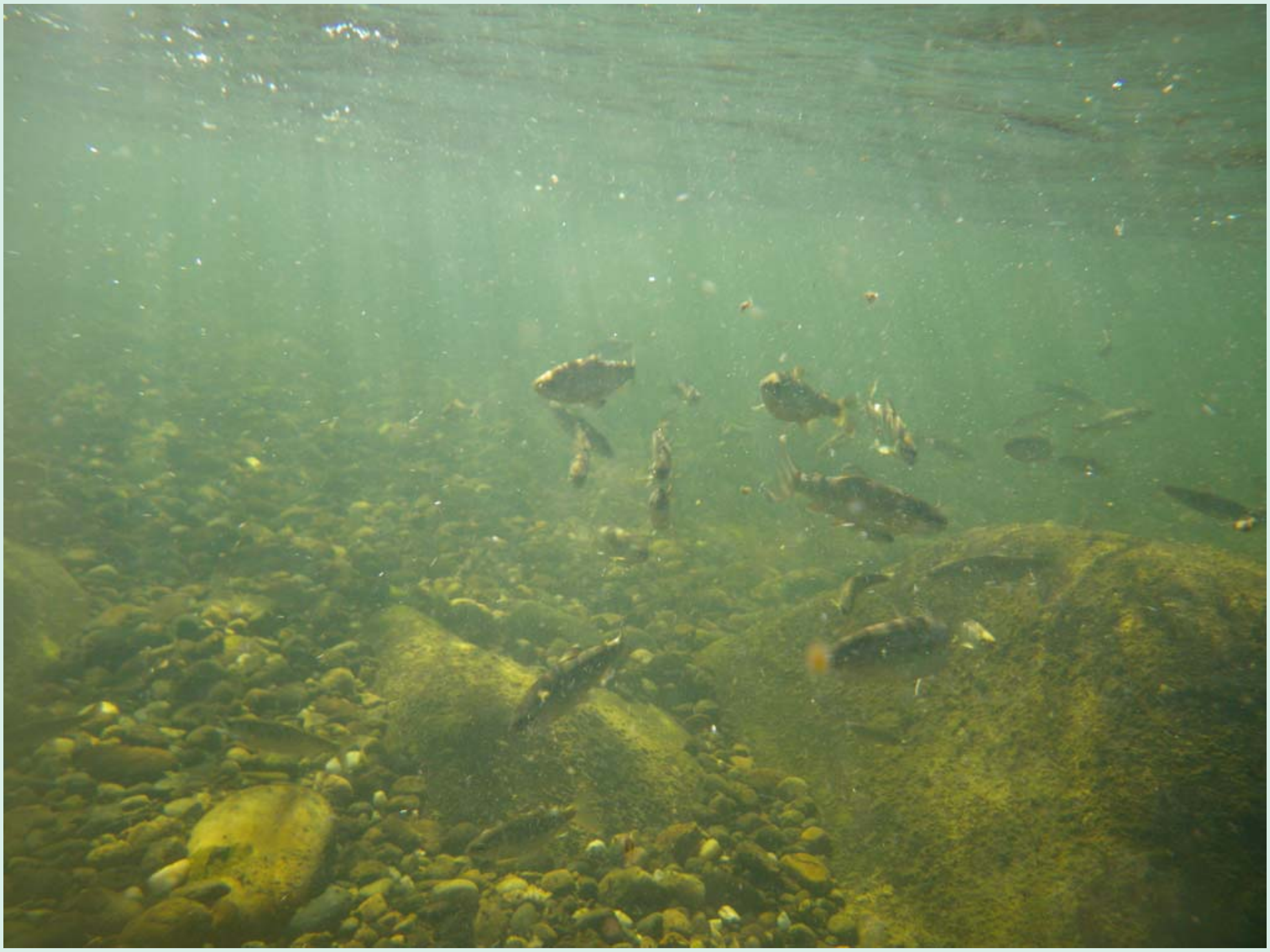
FINAL REPORT ◦ MARCH 2012

September 2011 Population Size Estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River



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Stillwater Sciences. 2012. September 2011 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Draft. Prepared by Stillwater Sciences, Berkeley, California for the Turlock Irrigation District and the Modesto Irrigation Districts, California. March

SUMMARY

In September 2011, the final population size estimate of *Oncorhynchus mykiss* was developed in the lower Tuolumne River in accordance with the 3 April 2008 Delegated Order issued by the Federal Energy Regulatory Commission (FERC) implementing elements of a study plan previously developed in coordination with California Dept. of Fish and Game (CDFG), National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) biologists, and submitted to FERC on 16 July 2007.

Snorkel surveys were conducted during daylight hours from 20 to 24 September 2011 to estimate *O. mykiss* population size within the Tuolumne River. In addition to snorkel survey observations of *O. mykiss*, data for Chinook salmon (*O. tshawytscha*) and other species was also collected. Snorkel surveys were conducted using a two-phase survey design to sample five different habitat strata (i.e., riffle, run head, run body/tail, pool head, and pool body/tail) found downstream of La Grange Dam at river mile (RM) 51.8 using habitat typing from surveys performed in June 2008 (ending at RM 39.5) and March 2009 (from RM 39.5 down to RM 29.0). The study reach extended from RM 51.8 to RM 35.0, approximately 4.9 miles downstream of Robert's Ferry Bridge. A total of 32 of 245 sampling units in the study reach upstream of RM 35.0 were selected for either single pass or multi-pass snorkel surveys in September 2011.

O. mykiss Population Estimates

Based upon the maximum count obtained over all dive passes in each sampled unit, a total of 4,913 young-of-the-year/juvenile (<150 mm total length [TL]) and 813 larger (≥150 mm TL) *O. mykiss* were observed in September 2011. Using a bounded counts population estimator (BCE) for the September 2011 survey period, a total of approximately 47,432 juvenile and 9,541 larger *O. mykiss* were present within the study reach (RM 51.8–35). The population estimates for both juveniles and larger fish exceeded estimates from all previous years (2008–2010) during which these surveys have been conducted.

Chinook Salmon Population Estimates

For Chinook salmon encountered during the September 2011 snorkel surveys, a maximum count of 2,576 juveniles (<150 mm TL) were observed within all habitat types along the study reach. This corresponded to bounded counts population estimates of 24,299 juvenile Chinook salmon, which exceeded the population estimates from all previous years (2008–2010). There were also 157 larger (≥150 mm TL) Chinook salmon observed in September 2011.

Other Species

A combination of native minnows (hardhead and Sacramento pikeminnow), along with native Sacramento sucker accounted for approximately 96% of non-salmonid fish observed for both the September sampling period, with very low counts of non-native centrarchid species (largemouth bass, smallmouth bass) observed. Striped bass were found in low numbers in pool habitat throughout the reach. Native minnows and suckers were found in the highest densities downstream of RM 40.

Relationship between Temperature and *O. mykiss* Habitat Use

To test the hypothesis that the summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature, water temperature data from thermographs deployed in the Tuolumne River were compared to juvenile and adult *O. mykiss* density from the September 2011 survey along the study reach. The data show that temperatures increased in the downstream direction, from 12.7ºC (54.8°F) to 16.8ºC (62.2°F) (maximum weekly average temperature [MWAT]), and that *O. mykiss* density of both larger fish and juveniles generally decreased along this same gradient. Although this pattern is similar to what was observed in all previous years (2008–2010), suitable temperatures below 18.7°C were maintained throughout the study reach (RM 51.8–35.0) suggesting additional factors may be restricting the distribution of *O. mykiss* downstream of RM 44.0.

O. Mykiss Habitat Use at Restoration Sites

A second hypothesis that habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurred at the same density in both restored and nearby reference sites was tested based on observed densities of *O. mykiss* juveniles and larger fish in habitat types (riffle, run head, and pool head) common to both groups in the September survey. For juveniles, this comparison showed riffle habitat use at upstream restoration sites was greater than that of other riffle habitats. Juvenile habitat use within run head habitats was similar or reduced at the restoration sites in comparison to reference sites, with low use of pool head habitat. For larger fish, this comparison showed a potential increase of habitat use of riffle habitat at restoration sites, with diminished use of run head habitat, and insufficient data for a comparison of pool head habitat use at restoration sites.

Comparison with September 2011 Reference Count Survey Results

A comparison was made of *O. mykiss* and juvenile Chinook data collected during the September 2011 BCE survey to the reference count snorkel survey data collected in September 2011. The comparison shows a similar longitudinal trend, with overall densities decreasing in the downstream direction for both species, although densities in the upstream portion of the reach varied between surveys, especially for Chinook juveniles. Along the study reach common to both surveys, a total of 836 *O. mykiss* “juveniles” (< 150 mm) and 343 larger fish (>150 mm) were observed in the September reference count snorkel survey, while 4,587 juveniles and 742 larger fish were observed in the September BCE survey. A total of 66 juvenile (< 150 mm) Chinook were seen in the September reference survey with 2,413 seen in the September 2011 BCE survey.

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Appendices

1 INTRODUCTION

Routine fisheries monitoring surveys for the Don Pedro Project (FERC Project No. 2299) by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) have long documented the presence of *Oncorhynchus mykiss* in the lower Tuolumne River (TID/MID 2005). Summer snorkel surveys, conducted in most years since 1988, have documented an increased *O. mykiss* presence and relative abundance that is associated with the more consistent and higher summer flows provided since 1997 (TID/MID 2008).

On 19 March 1998, the National Marine Fisheries Service (NMFS) first listed the Central Valley steelhead as threatened under the Endangered Species Act (ESA). After several court challenges, NMFS issued a new final rule relisting the Central Valley steelhead on 5 January 2006 (71 FR 834). In a separate process resulting from terms of the 1996 FERC license amendment for the Project, NMFS staff provided input to a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al. 2007) and included recommendations for developing abundance estimates, habitat use surveys, and anadromy determination of resident *O. mykiss*. These recommendations were conceptually used to develop the Districts' FERC Study Plan (TID/MID 2007), which was the subject of a 3 April 2008 FERC Order. As part of the Order, the Districts were required to conduct population estimate surveys in winter (February/March) and summer (June/July), with the first surveys starting in summer 2008 to determine *O. mykiss* population abundance by habitat type.

The Districts first submitted a detailed *O. mykiss* population estimate study plan (Stillwater Sciences 2008a) to FERC on 3 July 2008 to provide information on the abundance and habitat requirements within the lower Tuolumne River. A report on the July 2008 population size estimate (Stillwater Sciences 2008b) was submitted as part of the Districts' 2008 annual report to FERC (TID/MID 2009). An updated study plan (Stillwater Sciences 2009) was prepared in 2009 for the population estimate surveys and is attached to this report as Appendix A. In addition to providing data to develop population size estimates under current conditions, the study plan examined the following hypotheses:

- Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
- Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

The *O. mykiss* snorkel surveys employed a two-phase sampling approach for the development of a reach-wide population estimate (Hankin and Mohr 2001) in the lower Tuolumne River. Survey sites were selected using a stratified random sampling approach, where the strata were major habitat types. In September 2011, the overall sampling "universe" from which sampling strata were delineated extended from near La Grange Dam at river mile (RM) 51.8 to RM 35.0, approximately 4.9 miles downstream of Robert's Ferry Bridge (Figure 1). This reach coincides with the downstream areas where *O. mykiss* were observed (Riffle 41A at RM 35.3) during the September 2011 reference count snorkel surveys (TID/MID 2012).

The two-phase stratified sampling design involved snorkeling pre-selected sampling units (e.g., riffle, run, pool, etc.) multiple times in order to quantify the variance associated with density and subsequent population estimates. As in a typical Phase I sampling approach, primary snorkel surveys (Edmundson et al. 1968, Hankin and Reeves 1988, McCain 1992, Dolloff et al. 1996) were conducted across a subset of the all sampling units. In Phase II, approximately 20–70% of each habitat type sampled was randomly selected for replicated surveys by repeated dive counts.

The methods presented by Stillwater Sciences (2009) discussed using a combined approach of both repeated dive counts and electrofishing. Current ESA permit restrictions for NMFS Section 10(a)(1)(A) permit No. 1282 (Stillwater Sciences) did not allow sufficient incidental take to conduct the second-phase surveys using electrofishing. Consequently, the surveys used only snorkel surveys, as provided for in the 2007 study plan and identified in letters provided by the Districts to FERC dated 3 July 2008 and 31 March 2009.

2 METHODS

2.1 Habitat Characterization

2.1.1 Habitat mapping

Habitat maps were compiled from an analysis of past habitat surveys, historical and more recent aerial photographs, and field surveys conducted in 2008, with results superimposed within a geographic information system (GIS). Field maps for the September 2011 BCE snorkel surveys were created using an orthorectified aerial photo and accompanying Light Detection and Ranging (LiDAR) topographic data from 21 September 2005 recorded at river flows of 321 cfs. Preliminary sampling unit boundaries of common habitat features (pools, riffles, and runs) were estimated from the LiDAR and bathymetric data between RM 52–38 within GIS by calculating locations corresponding to major water depth transitions (Table 2-1).

Table 2-1. Coarse-scale habitat types used during snorkel surveys.

Habitat type	Description[a]	Approximate depth
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).	0–4 ft
Run	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).	4–10 ft
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.	>10 ft

[a] Major habitat types determined based upon observed hydraulic conditions (McCain 1992, Thomas and Bovee 1993, Cannon and Kennedy 2003)

As an initial validation of these coarse scale habitat types, we compared the habitat types mapped in July 2008 (Appendix B) with previous habitat type maps (Appendix C) developed by McBain and Trush (2004) between 1999–2001 on a base-layer map corresponding to a wetted perimeter of 622 cfs flown on 20 May 1991. Appendix C shows major habitat types (i.e., riffle, run, pool) encountered during the 1999–2001 surveys along with past and planned gravel introduction locations included in the *Tuolumne River Coarse Sediment Management Plan* (McBain and Trush 2004).

In general, habitat typing shown by McBain and Trush (Appendix C) indicates larger proportions of "pool" habitat types than those determined during this effort (Appendix B), which reserved the pool habitat designation for water depths greater than 10 ft. Additionally, because *O. mykiss* tend to congregate at transitions between habitat types, Appendix B shows a further division of pool and run body habitats into smaller, transitional habitat sampling units (pool head, pool tail, run head, and run tail) based upon location of slope channel slope break at the upstream and downstream end of the unit. For the September 2011 surveys, pool tail and run tail habitats were consolidated into corresponding upstream pool body or run body habitat. This action was based on low use of the pool tail and run tail habitats as discrete sampling units in prior surveys (July 2008 and March 2009) and results in a reduced number of sampling units having low potential for use by salmonids available for habitat selection, thereby increasing the number of sampling units having a higher potential use, while not eliminating them from the area surveyed (see Section 2.2.1 for a complete description of sampling unit selection).

2.1.2 Habitat data collection

Float surveys were conducted in July 2008 and February 2009 to further refine and validate the preliminary habitat maps (Appendix B) described above at flows of approximately 106 cfs and 168 cfs, respectively. In addition to refining the locations and sizes of potential habitat sampling units, we collected habitat data (Table 2-2) at several locations within each sampling unit. Starting at upstream end of the study reach just downstream of La Grange Dam (Figure 1), habitat units were assigned a natural sequence order (NSO), a number, beginning with NSO 001, and incremented this identifier at each habitat transition (e.g., NSO 001 pool head, NSO 002 pool body, etc). The upstream and downstream end of each unit was located and marked on field maps, the location recorded with a handheld GPS unit, and labeled with flagging indicating the date, unit number, and habitat type.

Table 2-2. Habitat data collected at each unit.

Parameter	Method	Metric/Descriptor	Method reporting limit
Natural Sequence Order (NSO—Habitat unit #)	N/A	NSO-1, NSO-2, NSO-3, …	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Habitat type	Visual estimation	See Table 2-1	N/A
Average unit width	Horizontal distance	Meters (feet) (measured at multiple transects)	0.01 m (0.1 ft)
Average unit length	Horizontal distance	Meters (feet)	0.01 m (0.1 ft)
Maximum/minimum depth	Vertical distance	Meters (feet)	0.15 m (0.5 ft)
Bed substrate composition	Visual estimation	Bedrock, boulder, cobble, gravel, organic, sand, silt	10%
Cover type	Visual estimation	None, boulder, cobble, IWM, bedrock ledges, overhead vegetation, aquatic vegetation	10%

Note that although the wetted perimeter of the 2009 habitat maps corresponds to a 2005 air photo at flows of 321 cfs, in order to provide a more accurate channel edge boundary for the September 2011 surveys, the channel edge of the habitat unit boundaries shown in Appendix B correspond to a wetted perimeter of 230 cfs previously digitized from air photos taken in 1986–1987 and later refined to adjust for channel migration. The average daily flow during the September 2011 sampling was 308 cfs. Because the estimated wetted perimeter of the habitat unit boundaries did not vary more than a few feet in most cases at these two flows, the channel edge boundary for 230 cfs was used for both the September 2011 surveys. For each habitat unit shown, habitat unit length and width were subsequently determined in GIS. Appendix D shows accompanying field habitat data collected in all habitat units mapped, including maximum depth and average width (usually at 1/3 and 2/3 of the unit's length), bed substrate composition, and instream cover type.

2.2 Snorkel Surveys

2.2.1 Study design and survey unit selection

After habitat typing and collecting habitat data in all units, a subset of units of each habitat strata was selected for single-pass snorkel surveys. The survey units were selected to balance the habitat sampling unit replication, total available number of units to draw from, coverage of at least 10% of the total length of a given habitat type, as well as sampling effort. The selection process involved random selection of one of the most upstream units of each habitat type, followed by a systematic uniform sampling of the remaining units in the study reach. After the first dive pass was completed, a tab was then pulled to determine if the unit was included in the second phase of sampling.

For the September 2011 surveys, a subset of 6–7 units were selected for each of the 5 habitat types were selected (Table 2-3).

Table 2-3. Sample unit selection and survey count for September 2011.

Habitat	Phase I dives		Phase II survey	
	Initial units	Passes	Repeat units	Passes
Riffle	7	1	3	2
Pool head	6	1	3	2
Pool body /tail	6	1	3	2
Run head	6	1	3	2
Run body /tail	7	1	3	2
Total	**32**		**30**	

2.2.2 Snorkel data collection

Snorkel surveys were conducted during daylight hours from 20 to 24 September 2011. A two-phase survey design was used to survey the various riffle, run, and pool strata. For the first phase, single-pass dive surveys were conducted by a four-person team. Sampling units were sampled from downstream to upstream in dive lanes using a zigzag pattern, passing fish and allowing them to escape downstream of the diver. If fish were observed to escape upstream, the diver took care to avoid counting these individuals twice. Divers recorded the type, length, and number of fish

(Table 2-4). Total lengths were estimated in 50 mm size ranges (called "bins") using markings on dive slates to correct for underwater size distortion.

Table 2-4. Fish data collected within each unit during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method reporting limit
Date; start and end time	N/A	Day/month/year; hour/minute	N/A
Number of individuals	Visual estimation	Number	1
Fish length	Visual estimation	Millimeter	50-mm bins

The second phase of sampling required the collection of repeat dive counts and fish size data during each of two subsequent passes through the selected habitat units. These data were later used to statistically expand the dive counts to total population estimates for each habitat type. The Phase 2 dive pass replication was established at 2 passes in 2009 surveys to reduce sampling effort within particular sampling units while increasing the overall sample unit coverage (Stillwater Sciences 2010). Lastly, the occurrence of other non-salmonid native and non-native fish species was recorded as presence/absence and abundance.

2.3 Water Quality and Flow

At fish sampling locations, in addition to noting the type, length, and number of fish (Section 2.2), we collected spot measurements of *in situ* water quality data (temperature, dissolved oxygen, and conductivity) using a pre-calibrated multi-probe (YSI 85, Yellow Springs Instruments, Yellow Springs, OH) (Table 2-5). Dissolved oxygen (DO) probes were recalibrated each day and checked for accuracy in the laboratory against DO concentrations measured in aerated tap water. Changes in underwater visibility were monitored horizontally using a Secchi disk oriented both toward and away from the sun. Daily average flow data for each day were obtained from the stream gage below the La Grange powerhouse at RM 51.8 (USGS No. 11289650).

Table 2-5. Water quality data collected during snorkel surveys.

Parameter	Method	Metric/Descriptor	Method reporting limit
Temperature	EPA 170.1	°C	0.1 °C
Dissolved oxygen	SM 4500-O	mg/L	0.01 mg/L
Conductivity	SM 2510A	umhos/cm	1.0 umhos/cm
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)

2.4 Water and Air Temperatures

From spring 1987 to present, TID/MID has collected water temperature data from various locations in the lower Tuolumne River using recording thermographs (Hobo Pro V2 thermographs, OnSet Computer Corporation, Bourne, MA). The thermographs measured and stored water temperature data at one-hour intervals, with data downloads occurring at least twice a year.

Water temperature data collection during September 2011 also included spot measurements taken during snorkel surveys. The measurements were recorded over the course of the day as divers moved further downstream; as such, it was anticipated that these water temperatures would not be as representative as hourly thermograph recordings. The data do provide a general description of relative temperature conditions during dive surveys, however.

Regional air temperature data were obtained from the National Weather Service (NWS) station at Modesto Airport near RM 18. Water and air temperature data for the August through September 2011 period is presented in this report (Figure 2).

2.5 Data analysis

2.5.1 Bounded counts population estimate

Water quality and fish observation counts were summarized by habitat unit type with initial density estimates calculated based upon the area searched within each habitat unit sampled. In addition to comparisons of fish density between habitat types, the density estimates and uncertainties were propagated across the unsampled areas for an overall reach-wide population estimate.

Population estimates were made for each stratum and size class using the general methods of Hankin and Mohr (2001). For units receiving multiple dives, the bounded counts formulae are used to produce an estimate of the unit population and an estimate of the variance of this estimate. Specifically, when there are r passes, and the counts of these are sorted in increasing order as $m_1 \le m_2 \le \ldots \le m_r$, the population is estimated as

$$\tilde{y}_B = m_r + (m_r - m_{r-1}),$$

and the mean squared error of this is estimated as

$$\tilde{\mathrm{MSE}}(\tilde{y}_B) = (m_r - m_{r-1})^2 .$$

The total population of multiply dived units is estimated as the sum of the bounded-counts estimates for the individual units. The total population of the survey region is estimated by expanding this, first to *all* dived units (singly or multiply dived) on the basis of mean dive counts, and then to all units (dived or undived) on the basis of area. An estimator of the variance of this is constructed from estimates of the mean-squared errors of the bounded-counts estimates for the multiply dived individual units, and the variance of the bounded-counts estimates around their common mean. The final formulae are included in Hankin and Mohr (2001). A nominal confidence interval for each stratum and size class was calculated formally as

$\hat{Y} \pm 1.96\sqrt{\hat{V}}$, where $\hat{Y}$ and $\hat{V}$ are the mean and variance estimates, *except* that the lower bound of this interval was "trimmed" to the number of fish actually observed.

2.5.2 Comparisons with September 2011 reference count snorkel surveys

Data collected during the September 2011 snorkel surveys (20–24 September) were compared to reference count snorkel survey data collected during 16–19 September 2011 (TID/MID 2012). Although the sampled areas of these surveys differ, these data were collected only a few days prior to the data collected for this report, allowing for a general comparison of presence/absence and the relative proportions of larger and smaller size classes of *O. mykiss* and Chinook salmon in sampling units sampled during both surveys. Further, although TID/MID has sampled the same reference locations since 2001, the comparison is limited to the September 2011 data as these are the most directly comparable.

3 RESULTS

3.1 Habitat Characterization

For the total reach surveyed in September 2011 (RM 51.8–35.0), “run body/tail” habitat type occupied the greatest length of channel along the study reach, followed by pool body/tail and riffles (Table 3-1). The “pool body/tail” habitat type, while less abundant than other habitat types (e.g., run head), occupied the third greatest length of channel. Other transitional habitat types (e.g., run head and pool head) accounted for only 7.2% of the total reach length. Habitat maps and data for the entire study reach are shown in Appendices B and D. The longitudinal distribution of the area of each of the major habitat types within bins of 2 river miles is shown in Figure 3. The distribution of each of the major habitat types sampled in September 2011 is presented in Figure 4.

Table 3-1. Summary of habitat types from RM 51.8 to 35.0, September 2011.

Habitat type	Count	% by count	Total length (ft)	Total length (mi)	% reach length	Area (ft^2)
Riffle	53	21.6	18,408	3.49	20.7	1,557,614
Pool head	13	5.3	1,330	0.25	1.5	107,495
Pool body/tail	32	13.1	14,580	2.76	16.4	1,564,680
Run head	49	20.0	4,169	0.79	4.7	376,205
Run body/tail	98	40.0	50,247	9.52	56.6	5,053,173
Total	**245**	**100.0**	**88,733**	**16.81**	**100.0**	**8,659,167**

3.2 Water Quality and Flow

As water quality data were collected exclusively within units chosen for snorkel survey, data are presented by river mile, rather than by sampling unit, or summarized for the entire reach (Table 3-2). Water quality data for sampling units selected for snorkel surveys are shown in Appendix E.

Because of the influence of ambient air temperatures (Sullivan et al. 1990), temperatures of water released from the cold water pool of Don Pedro Reservoir increase in a downstream direction for the spot measurements (Table 3-2) and in the continuous thermograph record during the September survey period (Appendix F). Note that the water temperature ranges shown in Table 3-2 represent changes over the course of the sampling day, and do not include nighttime temperatures or lows that are shown at representative thermograph locations in Appendix F.

Daily average flow during the September 2011 survey period was 308 cfs as recorded at the USGS station near the La Grange powerhouse (No. 11289650). No dissolved oxygen readings were recorded due to instrument malfunction. Horizontal visibility was reduced at the most downstream locations due to local turbidity sources.

Table 3-2. Range of water quality data collected at snorkel sites during fish surveys in September 2011.

River miles	Sample date	Flow (cfs)[a]	Water temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
49.2−48.0	20 September	318	13.9–15.5 [57.0–59.9]	--	28–26	25.7–27.3
51.6−50.1	21 September	319	12.6–14.7 [54.7–58.5]	--	30–26	25.3–25.7
45.9−38.0	22 September	315	14.1–16.7 [57.4–62.1]	--	21–15	27.7–37.4
49.7−36.2	23 September	305	15.1–18.0 [59.2–64.4]	--	26–11	25.7–38.5
45.3−44.8	24 September	281	14.2 [57.6]	--	18	28.9

[a] Daily average flow data are measured from the stream gauge below La Grange powerhouse at RM 51.8 (USGS No. 11289650).

3.3 Water and Air Temperature

The daily average water temperature for all thermographs and the daily minimum, maximum, and average air temperature (from the NWS station at the Modesto Airport) are shown in Appendix F. The range of daily averages, instantaneous maximum temperature, maximum weekly average temperature (MWAT), and the seven-day average of daily maximum temperature (7dayMAX) for the 20–24 September study period was determined, and all three metrics for both periods showed a similar trend of increasing in the downstream direction. The MWAT is the seven-day rolling average of average daily temperatures, and describes ambient water temperature conditions over the previous week. It is a standard used in water quality studies and total maximum daily load (TMDL) estimations of allowable temperature. The 7dayMAX is the seven-day rolling average of the daily maximum temperatures, and is a potentially more accurate indicator of conditions affecting survival and growth of salmonids (Sullivan et al. 2000, Stillwater Sciences 2002).

During the September 2011 survey period, water temperature data collected by thermographs followed similar trends to instantaneous temperature data collected during snorkel surveys, showing an increase in the downstream direction (Table 3-3). Along the study reach, the MWAT increased from 12.7°C (54.8°F) at Riffle A7 to 16.8°C (58.0°F) at the Ruddy Gravel site (Table 3-3). The 7dayMAX temperature ranged from 13.7°C (56.7°F) at the Riffle A7 location to 18.4°C (65.2°F) at the Ruddy Gravel site. The hourly, mean weekly average (MWAT), and 7dayMAX water temperatures for Riffle A7 (RM 50.8), Riffle 13B (RM 45.5), Roberts Ferry Bridge (RM 39.6), and Ruddy Gravel (RM 36.5) from 1 August to 30 September 2011 are presented graphically in Appendix F.

Table 3-3. Maximum weekly average temperature, seven-day average of daily maximum temperatures, and instantaneous maximum temperatures recorded by thermographs in the survey reach of the lower Tuolumne River during September 2011.

Monitoring location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	12.7 [54.8] (24 Sept)	13.7 [56.7] (24 Sept)	13.8 [56.9] (21 Sept)
Riffle 13B	45.5	14.4 [58.0] (24 Sept)	16.0 [60.8] (24 Sept)	16.2 [61.1] (20 Sept)
Roberts Ferry Bridge[a]	39.6	15.9 [60.6] (24 Sept)	16.7 [62.0] (24 Sept)	17.1 [62.7] (24 Sept)
Ruddy Gravel	36.5	16.8 [62.2] (24 Sept)	18.4 [65.2] (24 Sept)	18.7 [65.6] (22 Sept)

Note: Thermographs used have a reported error of ±0.2°C.
[a] Thermograph located approximately 0.75 miles upstream of bridge.

The average daily Modesto Airport air temperatures over the study period ranged from 25.0 to 26.78 ºC (77.0 to 80.0 °F) with a high temperature of 37.2 °C (99.0 °F) (

Table 3-4). The warmest day of September occurred before the study period on 10 September with an average daily temperature of 28.9 °C (84.0 °F) (Figure 2) and a daily high temperature of 37.8 °C (100.0 °F).

Table 3-4. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the September 2011 snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
20 September 2011	26.1 [79]	15.6 [60]	36.7 [98]
21 September 2011	26.7 [80]	16.1 [61]	37.2 [99]
22 September 2011	26.7 [80]	16.7 [62]	36.7 [98]
23 September 2011	27.8 [82]	17.8 [64]	37.2 [99]
24 September 2011	25.0 [77]	16.1 [61]	33.3 [92]

Hourly water temperature for several monitoring stations along the length of the study reach and daily air temperature from the Modesto Airport station was compared (Figure 2). With flow being stable throughout period, Figure 2 shows that at the upstream-most monitoring station, water and air temperature are more independent of each other than at thermographs located farther downstream. That is, water temperature becomes more influenced by air temperature in the downstream direction, with water and air temperature peaks and troughs occurring at the same times of day at the downstream monitoring site at Ruddy Gravel (RM 39.6).

3.4 Snorkel Surveys

3.4.1 *O. mykiss* observations

During the September 2011 survey period, divers observed 5,929 *O. mykiss* ranging from 0–500 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (Table 3-5, Table 3-6 and Figure 5). These included 5,065 fish classified as a juvenile in the <150 mm size categories, with the other 864 observed in the larger (≥150 mm) size classes (Table 3-5 and Table 3-6). The *O. mykiss* were observed all but two of the sampling units from RM 51.6 to RM 36.2. The *O. mykiss* were observed in all habitat types, with the highest numbers seen in a riffle habitat unit at RM 50.6 (Table 3-5 and Table 3-6). Complete fish observation data by sampling unit and dive pass is presented in Appendix G.

The *O. mykiss* were observed in 28 different sampling units from RM 51.8 to RM 36.3 and in all habitat types (Table 3-5). Habitat use for both juvenile and larger *O. mykiss*, based on the maximum count from dive passes, was highest in riffle and run body/tail habitats (Figure 6a). Fish densities (Figure 6b) for juvenile size classes (<150 mm) highest in riffle and run head habitats. Juvenile size classes were also observed in each of the other habitat types, with lowest density in pool body habitats (Figure 6b). Larger size classes (>150 mm) were observed in highest density in run head habitats, with lower densities found in each of the other habitat types (Figure 6b).

Habitat use for *O. mykiss* was concentrated at upstream sampling units (above RM 44.0) and primarily occurred at transitional run head and riffle habitats (Figure 7 and Figure 8).

Table 3-5. Maximum count of *O. mykiss* by sampling unit, September 2011 (data are divided into 50 mm total length size classes).

RM	Sampling Unit	Habitat	Multiple pass survey (Y/N)	0–49 mm	50–99 mm	100–149 mm	150–199 mm	200–249 mm	250–299 mm	300–349 mm	350–399 mm	400–449 mm	450–499 mm
51.6	4	Pool head	Y						4	4	1		
50.9	11	Pool body	Y		1				2	15	6	3	
50.6	14	Riffle	N	2	1,192	528	75	8	5	16	1		
50.3	19	Run head	Y	7	58	28	5	3	4	9	12	2	
50.1	20/21	Run body/tail	Y	166	316	224	29	22	9	8			
49.7	27	Pool head	Y	1	99	27	3	2	1				
49.6	28/29	Pool body/tail	Y	9	179	101	20	6	3	18	5		
49.3	31/32	Run body/tail	N	3	20	232	128	8	12	17	24	1	3
49.2	33	Riffle	Y	3	391	242	58	18	2	4	4	2	1
49.1	38	Run head	Y		18	46	6			1			
48.7	43/44	Run body/tail	Y	10	94	151	59	24	15	4	5	3	
48.0	53	Riffle	N		28	16	1						
48.0	54	Pool head	Y		45	22	4	1		4	2		
45.9	70	Riffle	Y	1	240	125	27	6	3	6			
45.9	71	Run head	N		27	31	18	9	6	6	4		
45.8	72/73	Run body/tail	Y	10	82	41	18	11	6	2			
45.3	81	Pool body	Y		31	16	3	2		4	2		
44.8	90	Run head	N		25	5							
44.8	91/92	Run body/tail	N		132	34	3	3		1			
39.4	161	Run head	Y			2	3						
39.3	162/163	Run body/tail	N								1		

RM	Sampling Unit	Habitat	Multiple pass survey (Y/N)	0–49 mm	50–99 mm	100–149 mm	150–199 mm	200–249 mm	250–299 mm	300–349 mm	350–399 mm	400–449 mm	450–499 mm
39.2	164	Riffle	N										
39.2	165	Pool head	N			1							
38.3	182/183	Pool body/tail	N			1							
38.1	192	Pool head	N										
38.0	193/194	Pool body/tail	N							1			
36.8	217	Riffle	N		1			1					
36.8	218	Run head	N				1						
36.7	219/220	Run body/tail	N					1					
36.3	225	Riffle	Y			1	2	1		1			
36.2	230	Pool head	N										
36.2	231/232	Pool body/tail	Y										
Total (maximum unit count of all passes)				**212**	**2,979**	**1,874**	**463**	**126**	**72**	**121**	**67**	**11**	**4**

Table 3-6. Maximum count of *O. mykiss* by habitat type, September 2011 (data are divided into 50 mm total length size classes).

Habitat	0–49 mm	50–99 mm	100–149 mm	150–199 mm	200–249 mm	250–299 mm	300–349 mm	350–399 mm	400–449 mm	450–499 mm	Total (max. unit count of all passes)
Pool body/tail	9	211	118	23	8	5	38	13	3		428
Pool head	1	144	50	7	3	5	8	3			221
Riffle	6	1,852	912	163	34	10	27	5	2	1	3,012
Run body/tail	189	644	682	237	69	42	32	30	4	3	1,932
Run head	7	128	112	33	12	10	16	16	2		336
Totals by size class	212	2,979	1,874	463	126	72	121	67	11	4	5,929

3.4.2 *O. mykiss* population estimate

Table 3-7 shows the September 2011 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for young-of-year/juvenile and ≥150 mm for larger fish) and habitat type using the method of bounded counts (Hankin and Mohr 2001) for the study reach from RM 51.8 to RM 35.0. From an observed 4,913 smaller *O. mykiss* in September 2011, an estimated population of 47,432 smaller fish (with a 95% CI of 36,334–58,530) was determined (Table 3-7). From an observed 813 larger *O. mykiss* in September 2011, an estimated population of 9,541 larger fish (with a 95% CI of 7,188–11,895) was determined (Table 3-7). The population estimates for both juveniles and larger fish exceeded estimates from all previous years (2008–2010) during which these surveys have been conducted (Stillwater Sciences 2012). Both size classes of *O. mykiss* were observed in all habitat types, with the highest observations of smaller fish in riffle habitat and the highest observations of larger fish in run body/tail habitat.

Table 3-7. *O. mykiss* September 2011 bounded counts population estimates between RM 51.8 and 35.0 by fish length and habitat type.

Habitat	*O. mykiss* < 150 mm				*O. mykiss* ≥ 150 mm			
	Obs.[a]	Est.	St. dev.	95% CI[b]	Obs.	Est.	St. dev.	95% CI[b]
Pool head	192	416	250.3	192–207	22	53	12.7	28–78
Pool body/tail	332	2,951	2,775.5	332–8,391	81	742	461.1	81–1,646
Riffle	2,739	26,371	4,431.8	17,684–35,057	224	2,570	616.8	1,361–3,779
Run head	243	3422	1,249.3	974–5,871	80	980	245.5	499–1,461
Run body/tail	1,407	14,271	1,758.6	10,825–17,718	406	5,196	888.0	3,456–6,937
Total	**4,913**	**47,432**	**5,662.2**	**36,334–58,530**	**813**	**9,541**	**1200.9**	**7,188–11,895**

[a] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins yields may overestimate total fish observed.
[b] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.3 Chinook salmon observations

Table 3-8 and Table 3-9 show the number of juvenile (<150 mm) Chinook salmon observed within the study reach during the September 2011 surveys, based on the maximum count by pass, resulting in a total of 2,665 observations. These salmon were seen in 21 different sampling units ranging from RM 51.6 to RM 36.3 (Table 3-8) and all habitat types (Table 3-9).

Table 3-8. Maximum counts of juvenile Chinook salmon by size class and sampling unit, September 2011.

River mile	Sampling unit	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm	100–149 mm
51.6	4	Pool head	Y			2
50.9	11	Pool body	Y			
50.6	14	Riffle	N		142	114
50.3	19	Run head	Y		21	20
50.1	20/21	Run body/tail	Y		111	86
49.7	27	Pool head	Y		92	45
49.6	28/29	Pool body/tail	Y		206	106
49.3	31/32	Run body/tail	N		260	93

River mile	Sampling unit	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm	100–149 mm
49.2	33	Riffle	Y		247	188
49.1	38	Run head	Y		34	20
48.7	43/44	Run body/tail	Y	2	140	370
48.0	53	Riffle	N		1	2
48.0	54	Pool head	Y		4	8
45.9	70	Riffle	Y		82	48
45.9	71	Run head	N		14	9
45.8	72/73	Run body/tail	Y		28	23
45.3	81	Pool body	Y		53	8
44.8	90	Run head	N			5
44.8	91/92	Run body/tail	N		46	26
39.4	161	Run head	Y			2
39.3	162/163	Run body/tail	N			
39.2	164	Riffle	N			
39.2	165	Pool head	N			
38.3	182/183	Pool body/tail	N			
38.1	192	Pool head	N			
38.0	193/194	Pool body/tail	N			
36.8	217	Riffle	N		1	2
36.8	218	Run head	N			
36.7	219/220	Run body/tail	N			
36.3	225	Riffle	Y		4	
36.2	230	Pool head	N			
36.2	231/232	Pool body/tail	Y			
Total (max. unit count of all passes)				**2**	**1,486**	**1,177**

Table 3-9. Maximum counts of juvenile Chinook salmon by size class and habitat type, September 2011.

Habitat	0–49 mm	50–99 mm	100–149 mm	Total (maximum unit count of all passes)
Pool body/tail		259	114	373
Pool head		96	55	151
Riffle		477	354	831
Run body/tail	2	585	598	1,185
Run head		69	56	125
Totals by size class	**2**	**1,486**	**1,177**	**2,665**

There were an additional 160 observations of larger Chinook salmon (≥150 mm) with the majority (n=141) in the 150–200 mm size range. The complete Chinook salmon observation data by pass are shown in Appendix G.

3.4.4 Chinook salmon population estimate

Table **3-10** shows the September 2011 Chinook salmon population estimate for the lower Tuolumne River by length (<150 mm for juvenile; >150 mm for larger fish) and habitat type using the method of bounded counts (Hankin and Mohr 2001). From an observed 2,576 juvenile salmon in September 2011, an estimated population of 24,299 juveniles (with a 95% CI of 10,674–37,950) was determined (Table 3-10). From an observed 157 larger salmon in September 2011, an estimated population of 2,015 larger fish (with a 95% CI of 833–3,197) was determined (Table 3-10). The population estimates for both juveniles and larger fish exceeded estimates from all previous years (2008–2010) during which these surveys have been conducted (Stillwater Sciences 2012). Both size classes of Chinook salmon were observed in all habitat types, with the exception of the run head habitat where no larger fish were observed.

Table 3-10. Chinook salmon September 2011 bounded count population estimates between RM 51.8 and 35.0 by fish length and habitat type.

Habitat	Chinook salmon < 150 mm				Chinook salmon ≥ 150 mm			
	Obs.[a]	Est.	St. dev.	95% CI[b]	Obs.[a]	Est.	St. dev.	95% CI[b]
Pool head	151	321	290.0	151–890	3	6	6.1	3–18
Pool body/tail	373	3,500	3,114.2	373–9,604	7	71	59.8	7–188
Riffle	755	6,316	1,495.7	3,384–9,248	77	1,039	300.4	451–1,628
Run head	125	1,802	869.2	125–3,506	0	--	--	--
Run body/tail	1,172	12,360	5,978.2	1,172–24,077	70	899	519.5	151–890
Total	**2,576**	**24,299**	**6,965.2**	**10,647–37,950**	**157**	**2,015**	**603.1**	**833–3,197**

[a] Largest numbers seen in any single dive pass for each unit, summed over units. Note that because of the potential for the same fish to be assigned to different size classes on subsequent passes, summation of the largest numbers assigned to individual (50 mm) size bins yields may overestimate total fish observed.
[b] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.5 Non-salmon observations

Several other fish species were observed and counted during the September 2011 survey period (Table 3-11). Most other fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families, with the highest concentrations downstream of RM 40. A combination of hardhead and Sacramento pikeminnow, along with Sacramento sucker accounted for 95.7%. The complete non-salmonid fish observation data are in Appendix G.

Table 3-11. Maximum counts of non-salmonid species by sampling unit, September 2011.

RM	Sampling unit	Habitat	BG	CP	GAM	HH/PM	LMB	SB	SC	SMB	SS
50.9	11	Pool body							1		
49.6	28/29	Pool body/tail						1			
49.3	31/32	Run body/tail				4					
49.2	33	Riffle							17		1
49.1	38	Run head							1		1
48.7	43/44	Run body/tail							1		
48.0	53	Riffle							2		1
48.0	54	Pool head				1	1				1
45.9	70	Riffle									8

RM	Sampling unit	Habitat	BG	CP	GAM	HH/PM	LMB	SB	SC	SMB	SS
45.9	71	Run head							2		5
45.8	72/73	Run body/tail				2			6		2
45.3	81	Pool body				1					
44.8	90	Run head									1
39.4	161	Run head				12					80
39.3	162/163	Run body/tail				1					1,000
39.2	164	Riffle			10	51			1		100
38.3	182/183	Pool body/tail				50		1		2	151
38.1	192	Pool head				20					50
38.0	193/194	Pool body/tail	1			1					30
36.8	218	Run head		5		200					300
36.7	219/220	Run body/tail		42		16	1			1	22
36.3	225	Riffle		3		70			1		105
36.2	230	Pool head						1			
36.2	231/232	Pool body/tail						1		2	20
Total (all sampled units)			**1**	**50**	**10**	**429**	**2**	**4**	**32**	**5**	**1,878**

BG=bluegill; CP=common carp; GAM=gambusia species; HH/PM=hardhead/Sacramento pikeminnow; LMB=largemouth bass; SB=striped bass; SC=sculpin; SMB=smallmouth bass; species; SS=Sacramento sucker.

4 DISCUSSION

4.1 Bounded Counts Study Assumptions

It should be noted that the bounded counts method was developed for use in smaller stream systems (Hankin and Mohr 2001) and applying the methodology to a larger system such as the Tuolumne River is only feasible provided key assumptions are satisfied. One critical assumption of the bounded counts approach is that all individuals have an equal probability of being observed. This assumption may be challenged in locations with large numbers of juvenile fish, low visibility conditions in deeper pool habitats, or low visibility due to light and background turbidity variations within the river from upstream to downstream. For these reasons, the resulting population estimates may be low-biased and misidentification of salmonid species in large schools may result in over- or under-estimates of the true population size.

A second assumption of the bounded counts method is that observation efficiency is not 100%, so the number of fish seen in any single dive pass is, in general, an underestimate of the true number of fish present. For a closed population where fish do not migrate into or out of the unit between dives, the maximum number of fish seen over multiple passes is a low-biased estimator of the true population. Although complete dive coverage of all sampled units in 2011 was achieved, because larger habitat units were subsampled in prior years (i.e., run habitats in 2008), the resulting density expansions may have introduced a high-biased estimate of the true population size since fish are able to migrate freely into and out of the searched area.

4.2 Variations in *O. mykiss* Population Estimates

The September 2011 population estimates for both juvenile and larger fish were substantially higher than in previous years. Most fish were observed within the upper seven miles of the reach (upstream of RM 44.8), with extremely high numbers of juveniles (<150 mm) observed at the upstream riffle location near RM 50.6. The high number of observations of larger fish (≥ 150 mm) was dominated by fish in the 150–200-mm size class (54% of all observations). As is more typically seen, very few juvenile or larger fish were observed downstream of RM 40.0 (near Robert's Ferry Bridge), even though suitable water temperatures (<18.7° C) were present.

Although favorable conditions as the result flood control releases extending from January into September may have allowed for significantly higher recruitment, survival, and growth of juveniles, there is no clear indication as to why the downstream portion of the survey reach did not see similar increases in observed fish. Considering that fish in the 150–200 mm size range would not be part of the 2011 year class suggests the origin of these fish may be related to upstream flood control releases. The larger sized fish (>250 mm) may have arrived from upstream, or by migration from downstream locations in the Tuolumne River or San Joaquin Basin.

4.3 *O. mykiss* Distribution in Relation to Water Temperature

During the September 2011 snorkel surveys, maximum water temperatures remained below 18.7°C throughout the study reach, with daily average temperatures exceeding 17.0°C only at the lowest thermograph site (RM 36.5) on 24 September 2011 (Appendix F). These temperature conditions are not thought to particularly affect the distribution of *O. mykiss* and it is likely that some other factor may also explain the decreasing *O. mykiss* density with distance downstream of La Grange Dam. All *O. mykiss* observed were found at or upstream of RM 36.3, similar to previous surveys.

To test Hypothesis #1 that summer/fall distribution of observed life stages of *O. mykiss* across suitable habitat is related to ambient river water temperature, a comparison was made of water temperature data taken from thermographs to fish density in the sampled units. The data show that temperatures increase in the downstream direction (Section 3.3, Figure 9) and that the density of all *O. mykiss* is lower downstream of RM 44 (Section 3.3, Figure 9), suggesting a covariation of observed density and water temperature. However, although sampling units downstream of RM 44 showed low *O. mykiss* density, water temperatures were below 18.7°C throughout the study reach. Among sampling units where fish were seen upstream of RM 44, densities of *O. mykiss* showed no discernable pattern relative to water temperatures (Figure 9). The consistent pattern of reduced densities downstream of RM 44, despite suitable water temperatures in 2011 suggests that additional factors may be restricting the distribution of *O. mykiss* downstream of RM 44.

Results from a counting weir deployed at RM 24 show no detections of *O. mykiss* during the operational period from September 9, 2010 through December 1, 2010 (TID/MID 2011) and the weir was re-deployed on September 16, 2011. Although high flows necessitate removal of the counting weir, the operational period is intended to extend from September through March to capture the period of peak adult upstream migration for anadromous (non-resident) *O. mykiss* and is also used as an indication of both the presence/absence of *O. mykiss* in the downstream portion of the river and the potential recruitment of fry and juveniles. Since beginning operations in 2009, only one *O. mykiss* has been detected in November 2009 (Stillwater Sciences 2012).

4.4 Habitat Associations of *O. mykiss* and Chinook Salmon Observations

Table 4-1 and Table 4-2 show the range of cover and substrate components observed during habitat mapping for each habitat type where *O. mykiss* and Chinook salmon were present during the September 2011 surveys. Variations of cover types and amounts were limited in all sampling units, with higher percentages of sampling units with no cover found throughout the reach (Appendix D). Therefore cover results do not provide a meaningful basis for establishing a relationship with habitat use by juveniles or adults of either species. Nevertheless, *O. mykiss* and Chinook salmon were observed primarily in riffle and run body/tail habitats where higher percentages of cobble were reported relative to other substrates associated with those habitat types (Table 4-1 and Table 4-2).

Table 4-1. Cover and substrate type found in sampling units with *O. mykiss* present during the September 2011 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	10–10	10–10	5–10	0–0	0–0
Wood	5–5	0–0	0–0	5–5	5–5
Ledge	0–0	0–0	10–10	0–0	0–0
Overhang	5–5	5–5	5–10	5–10	5–5
Aquatic vegetation	20–50	0–0	0–0	0–0	0–10
No cover	40–85	85–100	80–100	90–100	90–100
Substrate type range (% covering channel bed)					
Bedrock	20–30	20–50	0–0	0–0	0–0
Boulder	5–20	10–20	10–10	10–40	10–20
Cobble	20–50	30–60	20–70	20–60	30–70
Gravel	10–30	5–60	20–70	20–40	20–50
Sand	10–30	5–10	10–10	10–40	10–30
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

Table 4-2. Cover and substrate type found in sampling units with Chinook salmon present during the September 2011 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	10–10	10–10	5–10	0–0	0–0
Wood	5–5	0–0	0–0	5–5	5–5
Ledge	0–0	0–0	10–10	0–0	0–0
Overhang	5–5	5–5	5–10	5–10	5–5
Aquatic vegetation	50–50	0–0	0–0	0–0	10–10
No cover	40–100	85–100	80–100	90–100	90–95
Substrate type range (% covering channel bed)					
Bedrock	20–30	20–50	0–0	0–0	0–0
Boulder	20–20	10–20	10–10	10–40	10–20
Cobble	20–40	30–60	20–70	40–60	30–70
Gravel	10–60	5–10	20–70	20–40	20–50
Sand	10–30	5–10	10–10	20–20	10–30
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

4.5 Habitat Use at Restored Sites by *O. mykiss* and Chinook salmon

Hypothesis #2 states that the density of *O. mykiss* juveniles and adults is the same in restored sites as in nearby reference sites in the Tuolumne River. This hypothesis was originally formulated with the intention of testing habitat use at planned gravel augmentation sites (TID/MID 2007). However, only three gravel addition projects have been completed over the past 10 years. Two have been constructed near Old La Grange Bridge by CDFG (2001–2003). An additional project at Bobcat Flat (RM 43) was initiated in two phases by the Friends of the Tuolumne (now Tuolumne River Conservancy) in 2005 and completed in the weeks leading up to the September 2011 surveys. Due to concerns regarding low visibility due to turbidity from newly placed gravels, no sampling was conducted along a one-mile reach between approximately RM 42.5 and RM 43.5 where Phase II of the Bobcat Flat project was being completed. The habitat types within this reach will be remapped following completion of the project as part of 2012 spawning gravel and *O. mykiss* studies for the Don Pedro Relicensing. The limited number of gravel augmentation projects completed during the 2008–2011 period has, in turn, limited the sampling replication and statistical power to detect any differences between restored and reference sites. Nevertheless, as s a means to evaluate habitat use at completed restoration sites, observed densities of *O. mykiss* juveniles and adults were compared at the three habitat types that were sampled within the restoration sites to the same habitat types surveyed elsewhere in September 2011.

Figure 10 shows the *O. mykiss* density of juveniles and adults at pool head, riffle, and run head habitats types sampled in September 2011 from sampling units found at both the restoration sites and from all similar sample units within the study reaches upstream of RM 36.0. For juvenile *O. mykiss* the densities show a relatively high use of riffle habitat at restoration sites when compared with other riffle sampling units; with relatively similar use of run head habitat at the upstream restoration sites; and diminished density in pool head habitats (Figure 10). For larger fish, this comparison showed a potential increase of riffle habitat use at restoration sites, with slightly diminished use of run head habitat, and insufficient data for a comparison of pool head habitats. Sampling sites downstream of RM 40 show very low or zero density of both juvenile and larger *O. mykiss*.

A similar evaluation was done using juvenile Chinook salmon. Figure 11 shows juvenile Chinook densities as sampled in September 2011 for the same three habitat types. In September 2011, juvenile Chinook densities at the restoration sites were similar in riffle habitat types and run head habitat types when compared to the reference sampling units (Figure 11), with insufficient data to describe pool head habitats. Similar to *O. mykiss*, there were very low or density of Chinook downstream of RM 40.

Considering the similar habitat preferences for juvenile *O. mykiss* and juvenile Chinook salmon, it appears that salmonid use of restoration sites is similar, or possibly enhanced within riffle habitats, when compared with nearby reference sites. Additional replication through either an increased number of gravel augmentation sites, or an increased number of survey events would be needed to improve the statistical power enough to detect whether significant differences in habitat use exist.

4.6 Comparison to September 2011 Reference Count Snorkel Surveys

Results from the September 2011 snorkel data were compared to observations made during the September 2011 reference count snorkel survey (TID/MID 2012) for the sampled reach common to both surveys and within sampling units surveyed during both sampling events (Table 4-3 and Table 4-4). The September 2011 BCE data are observations from the first pass of the multiple pass bounded count estimation method to allow for a more direct comparison to September 2011 reference survey, which came from single pass snorkel surveys that employ catch-per-unit-effort (CPUE) methodology.

Table 4-3. Salmonid observations in September reference count (single pass) and September BCE (first pass) surveys in 2011 within the reach sampled during both studies.

September 2011 reference count snorkel survey					September 2011 BCE snorkel survey				
Location	RM	<150 mm *O. mykiss* count	≥150 mm *O. mykiss* count	<150 mm *O. tshawytscha* count	Sampling units	RM	<150 mm *O. mykiss* count	≥150 mm *O. mykiss* count	<150 mm *O. tshawytscha* count
Riffle A7—R41A	50.7–35.3	836	343	66	1–245	51.8–35.0	4,587	742	2,413

Table 4-4. Salmonid counts and estimated densities in September reference count (single pass) and September BCE (first pass) surveys in 2011 for units snorkeled during both dates.

Location	RM	September 2011 reference count snorkel survey									September 2011 BCE snorkel surveys								
		Site	Habitat type	Area (ft^2)	<150 mm *O. mykiss*		≥150 mm *O. mykiss*		<150 mm *O. tshawytscha*		Sample Unit	Habitat type	Area (ft^2)	<150 mm *O. mykiss*		≥150 mm *O. mykiss*		<150 mm *O. tshawytscha*	
					#	#/ft^2	#	#/ft^2	#	#/ft^2				#	#/ft^2	#	#/ft^2	#	#/ft^2
Riffle A7	50.6	1	Riffle	3,000	50	0.017	110	0.037	10	0.186	14	Riffle	45,697	1,722	0.038	105	0.002	256	0.006
Riffle 2	49.9	2	Pool-Run	4,500	52	0.012	7	0.002	0	0.000	28,29	Pool body/tail	23,848	251	0.011	38	0.002	312	0.013
Riffle 2	49.9	3	Run-Pool	10,000	57	0.006	33	0.003	0	0.000	31	Run body/tail	184,289	255	0.001	193	0.001	353	0.002
Riffle 3B	49.1	1	Riffle	4,000	81	0.020	13	0.003	0	0.000	33	Riffle	69,547	509	0.007	74	0.001	366	0.005
Riffle 5B	46.9	3	Run-Pool	10,000	35	0.004	17	0.002	0	0.000	54	Pool head	14,381	64	0.004	8	0.001	8	0.001

4.6.1 *O. mykiss* observations

A total of 836 juvenile (<150 mm) and 343 larger (≥150 mm) *O. mykiss* were observed in the September 2011 reference count survey, while 4,587 juveniles and 742 larger fish were observed in the September 2011 BCE survey (Table 4-3). With the exception of the upstream riffle location near RM 50.6, where a significantly larger number of juveniles were observed during the BCE survey, the between-site comparison shows a generally similar observation trend for juveniles (Table 4-4). There are no discernable trends in the distribution of larger fish (Table 4-4). It should be noted that the September 2011 reference count survey data were collected from sites established in past years and targeted based on prior years' data as likely areas of relatively high *O. mykiss* abundance. The area surveyed during the September BCE surveys was greater (by an order of magnitude in most cases) than in the reference count surveys (Table 4-4).

The reference count snorkel survey reoccupies the same sampling units and areas on an annual basis, produces a yearly index with which to evaluate yearly trends, assuming reoccupied sampling units and areas are representative of the entire reach. The BCE methodology (Hankin and Mohr 2001) produces a population estimate, with appropriate confidence intervals, that, due to the incorporation of multiple passes in each unit and greater area searched in each unit and along the reach, can be used to evaluate habitat- and reach-wide distribution patterns.

4.6.2 Chinook salmon observations

A total of 66 Chinook salmon juveniles were observed during the September 2011 reference survey, while a total of 2,413 juveniles were observed during the September BCE survey (Table 4-3). Although Chinook salmon juveniles were observed in low numbers throughout the survey reach during the September 2011 reference count snorkel surveys (TID/MID 2012), the between-site comparison with the BCE surveys shows juvenile salmon absent at all but the upstream riffle location near RM 50.6. The BCE survey shows juvenile salmon in relatively large numbers downstream to near RM 49.1 (Table 4-4).

Although a stream-type life history strategy is not believed to be common for Chinook salmon in the Tuolumne River, the presence of juveniles in September indicates that conditions (e.g., water temperature, food availability) in summer 2011 were suitable for over-summering in upper portions of the reach.

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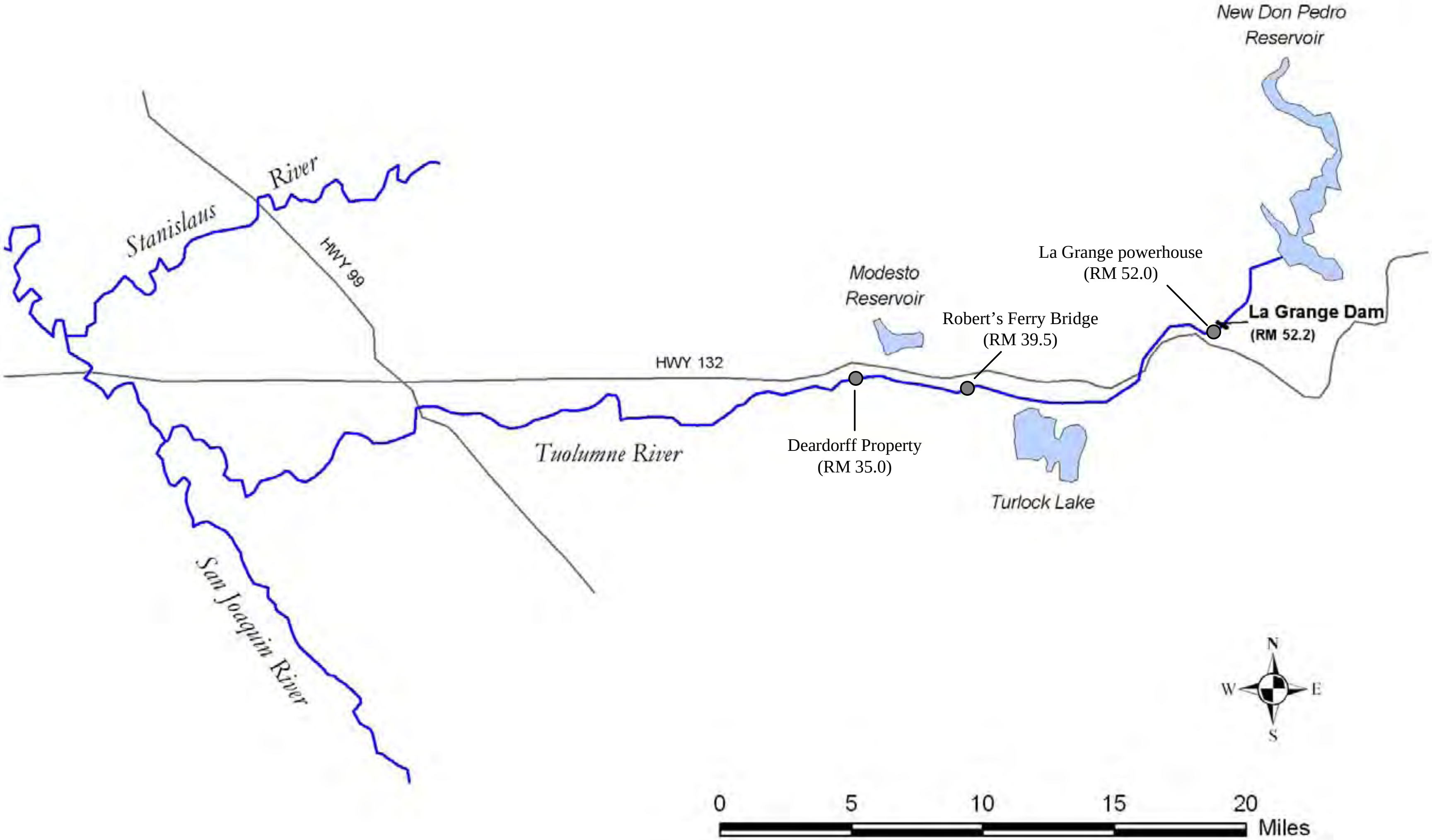


Figure 1. BCE study reach on the lower Tuolumne River, September 2011.

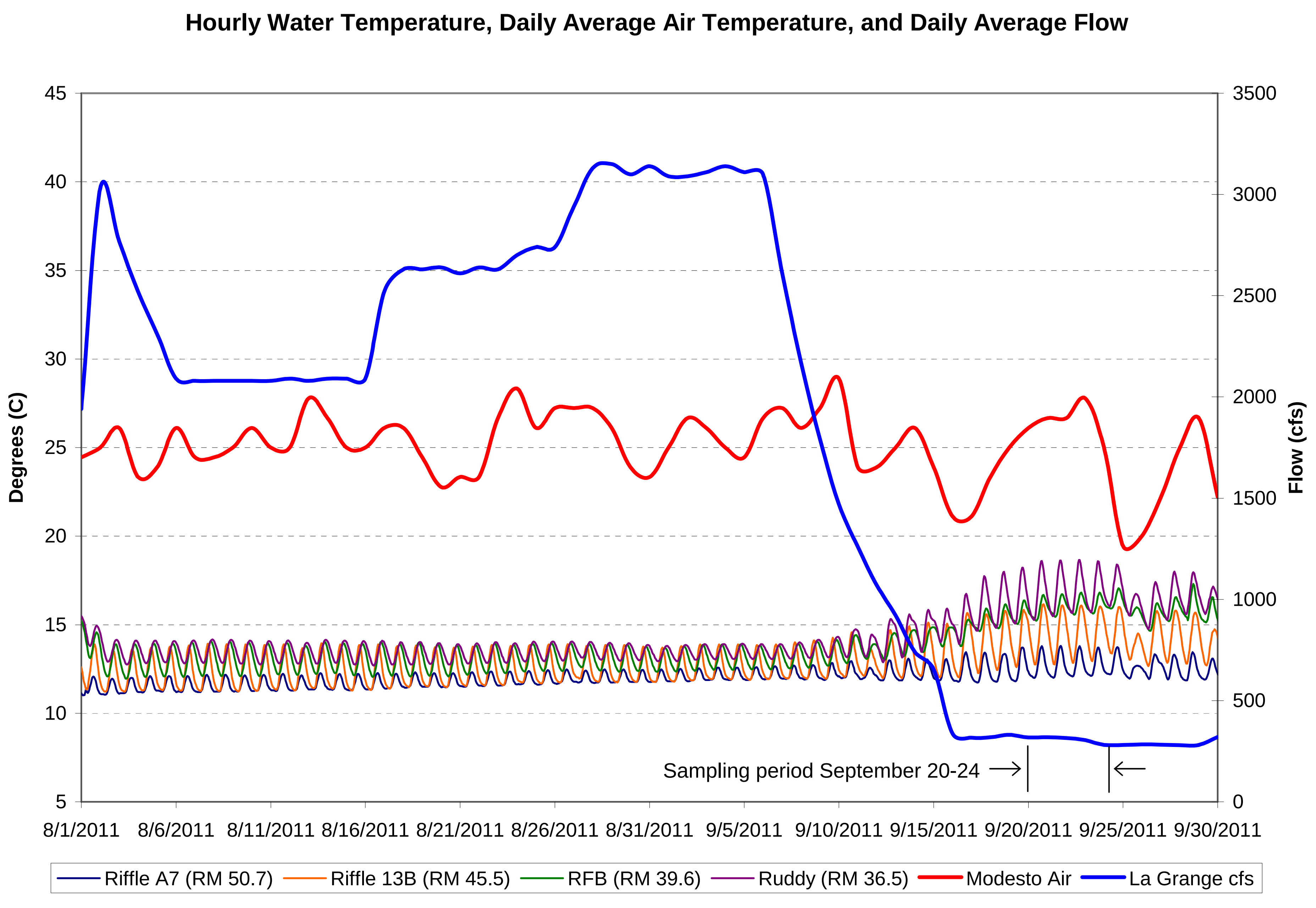


Figure 2. Hourly water temperature, daily average air temperature, and daily average flow for the study reach from 1 August to 30 September 2011.

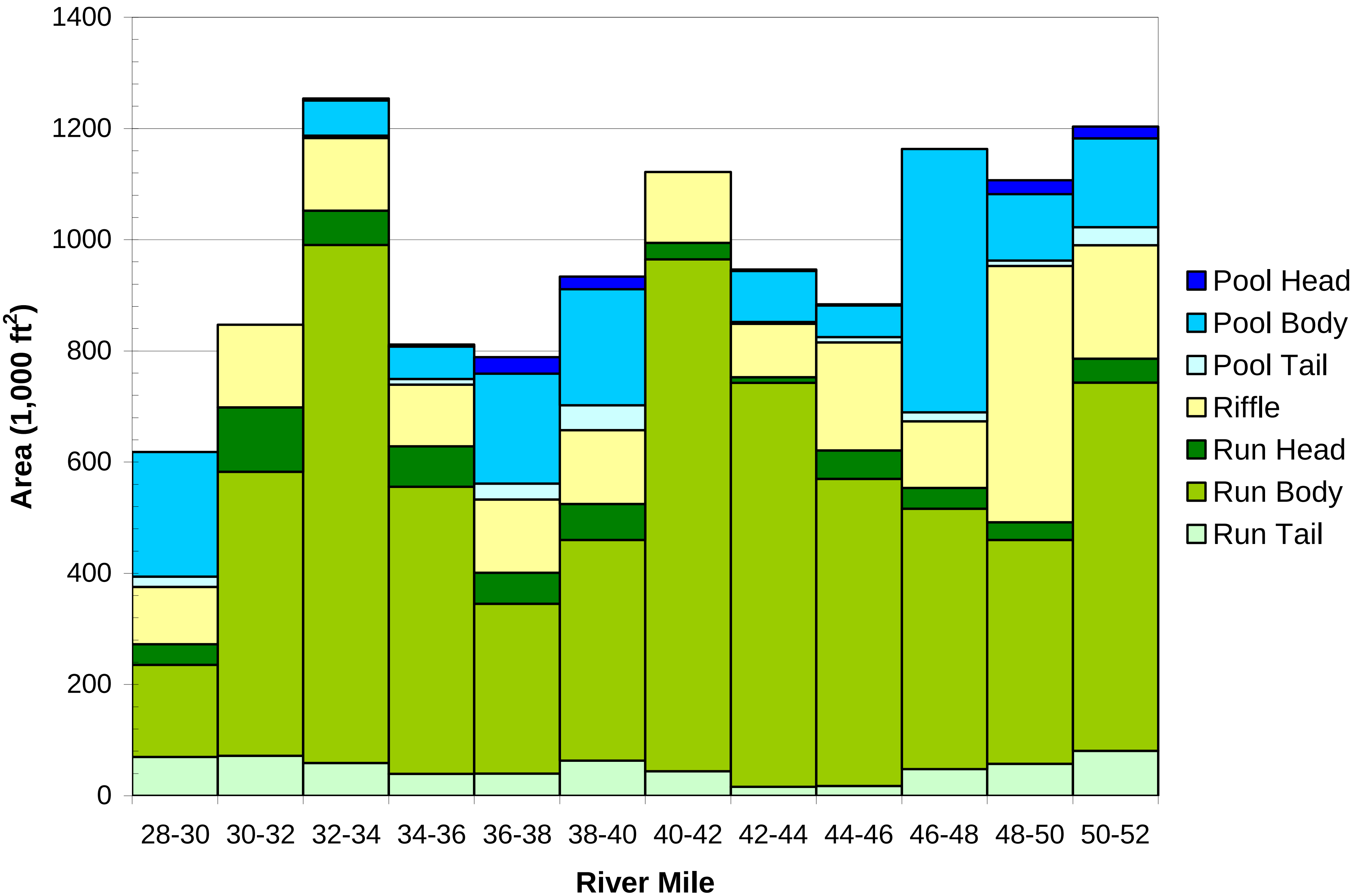


Figure 3. Longitudinal distribution of major habitat type areas by river mile in the lower Tuolumne River (RM 52–30) for September 2011 survey.

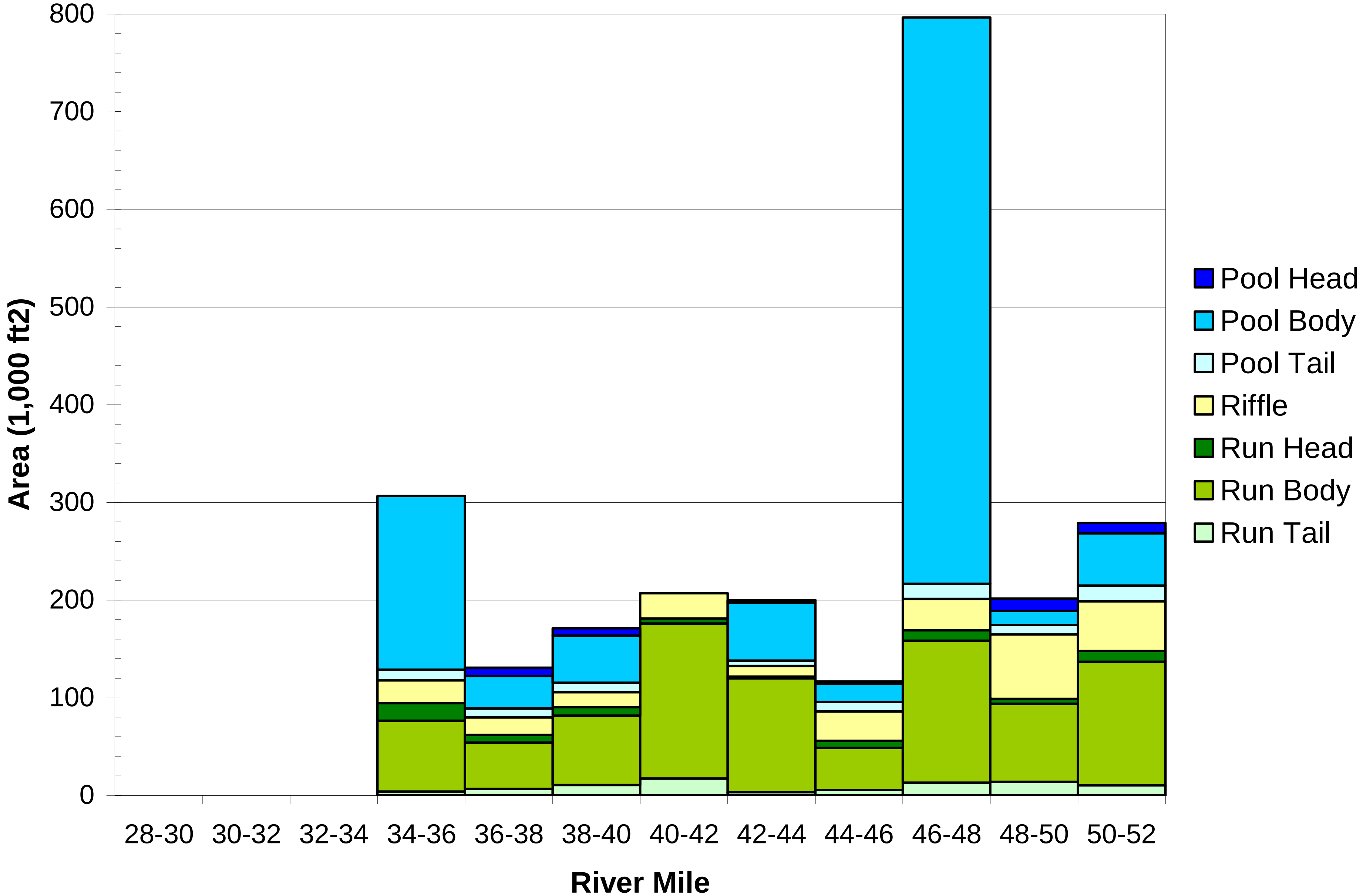


Figure 4. Longitudinal distribution of major habitat type areas sampled by river mile in the lower Tuolumne River (RM 52–38) for September 2011 survey.

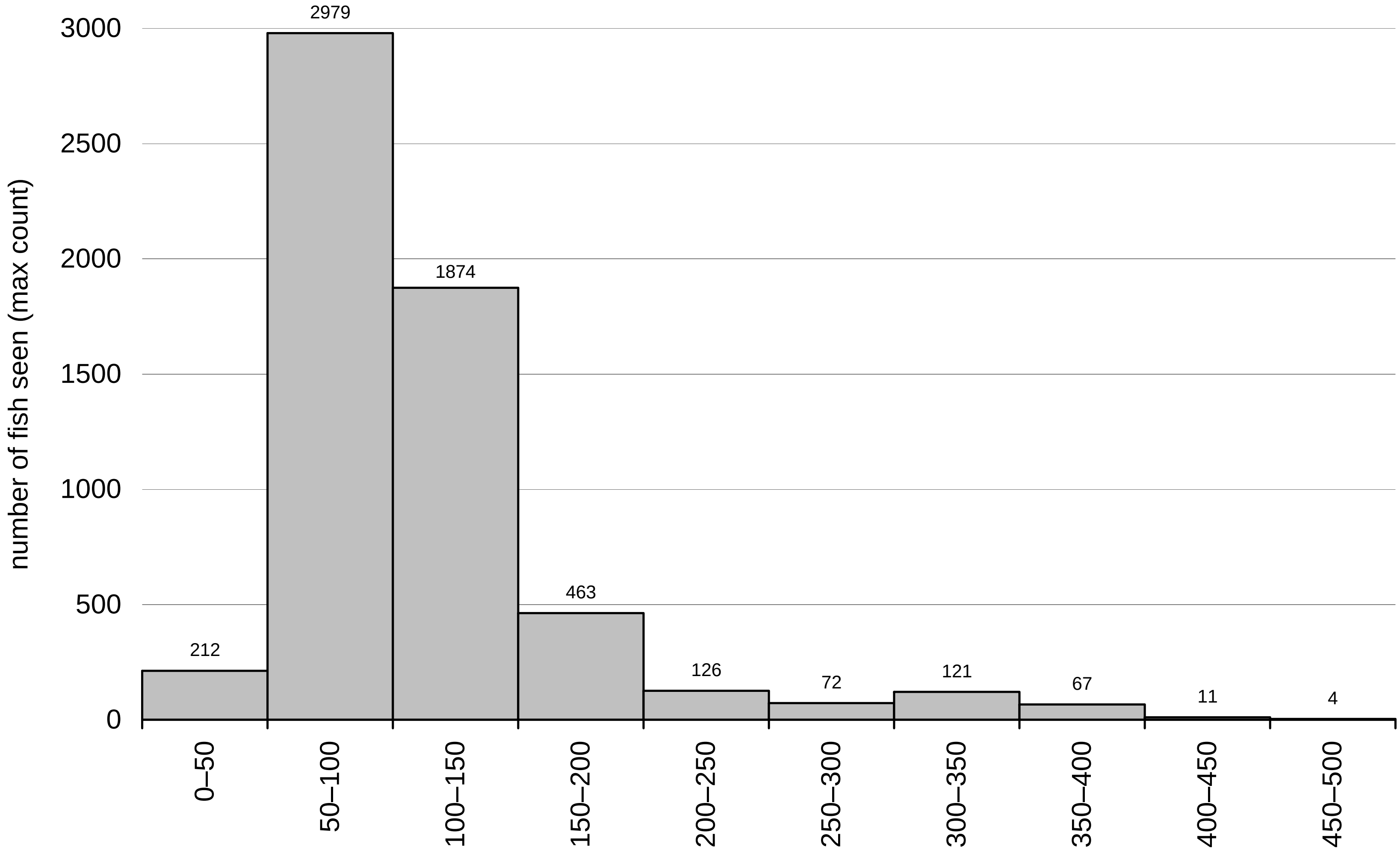


Figure 5. Size distribution of *O. mykiss* observed in Tuolumne River snorkel surveys, September 2011. For units receiving multiple passes, the count is from the pass with the largest count for that size class.

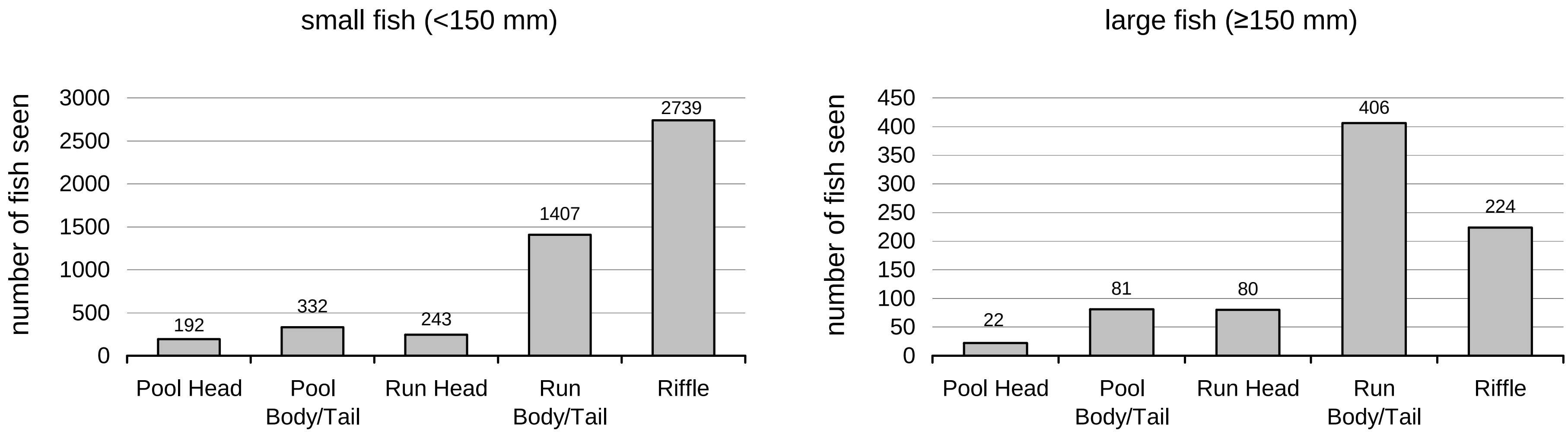


Figure 6a. Distribution of observed *O. mykiss* counts among habitat types, by size class in September 2011. For units receiving multiple passes, the count is from the pass with the largest count.

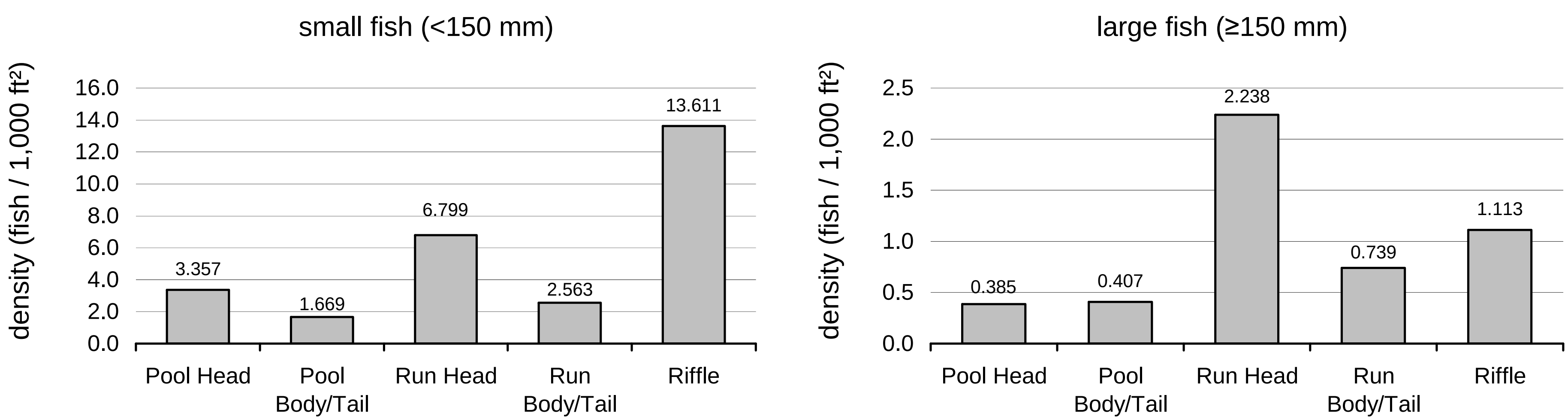


Figure 6b. Distribution of observed *O. mykiss* density based on maximum count among habitat types, by size class in September 2011.

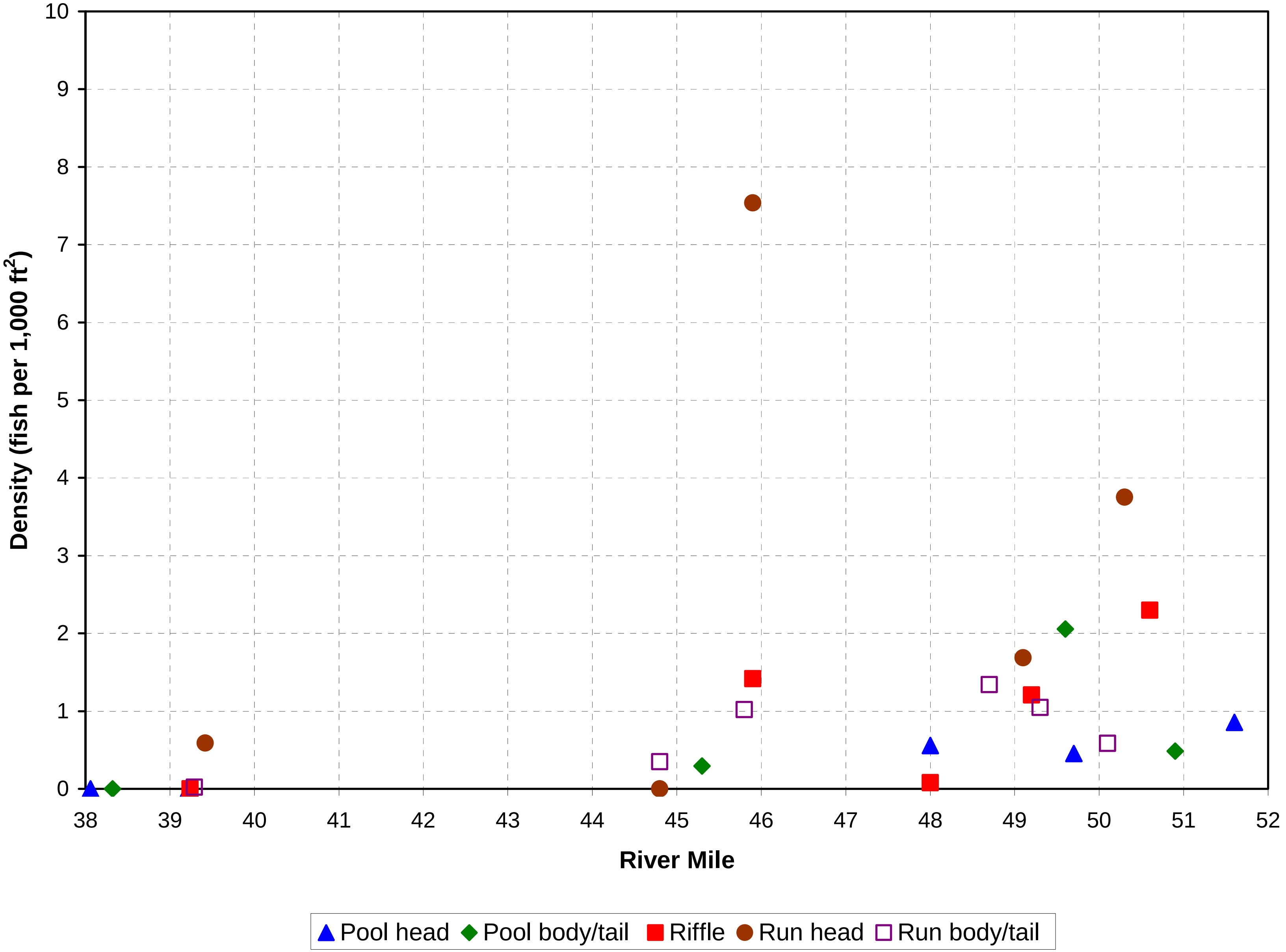


Figure 7. September 2011 adult *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.

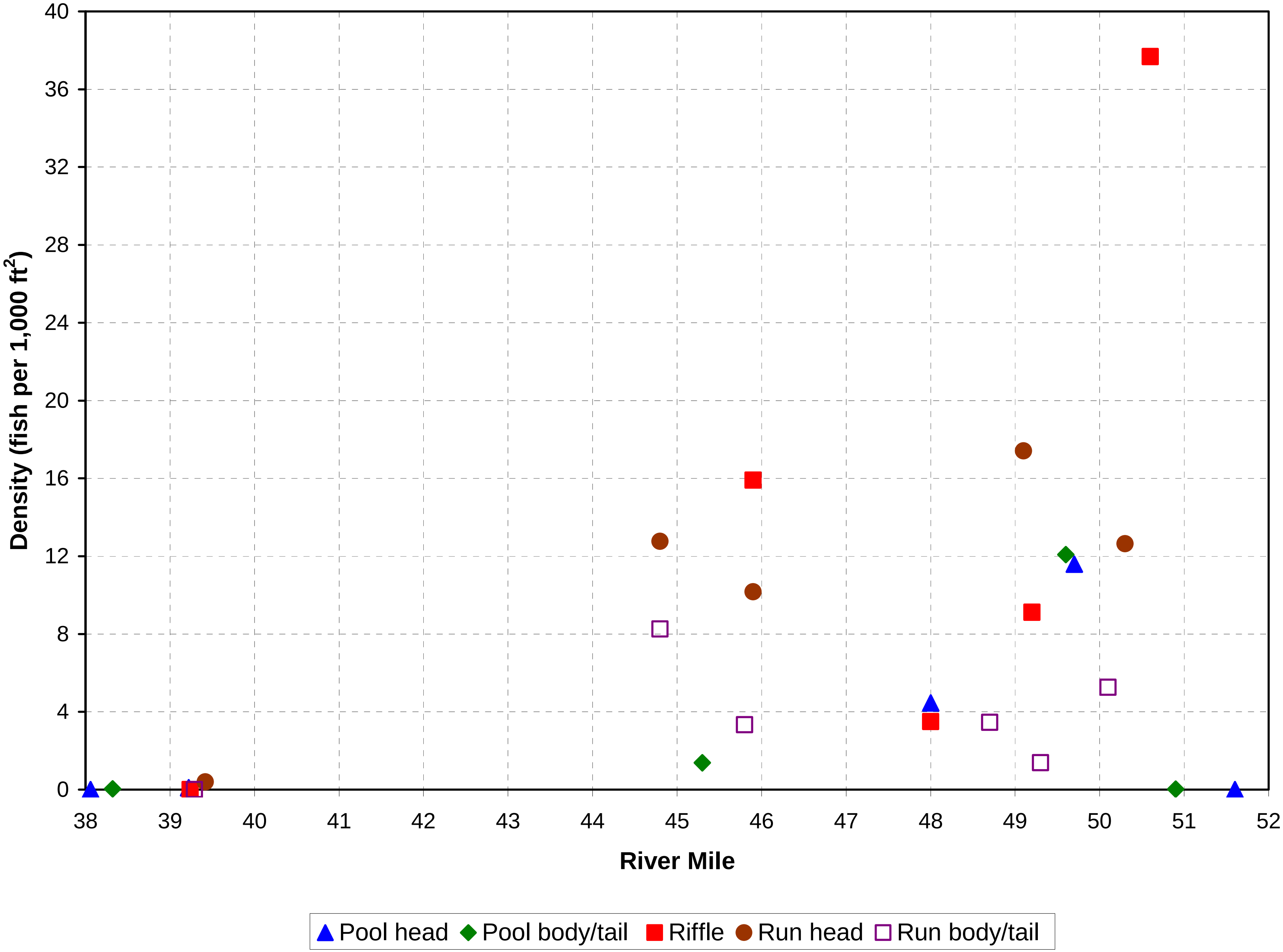
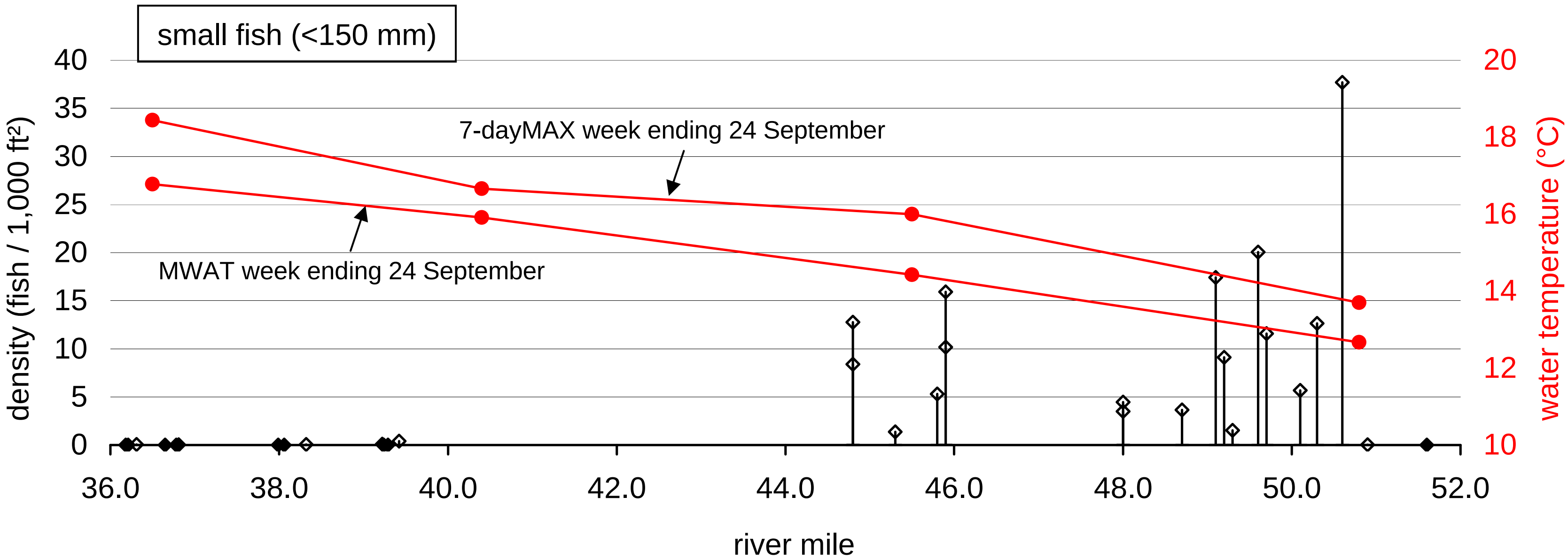


Figure 8. September 2011 juvenile *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.



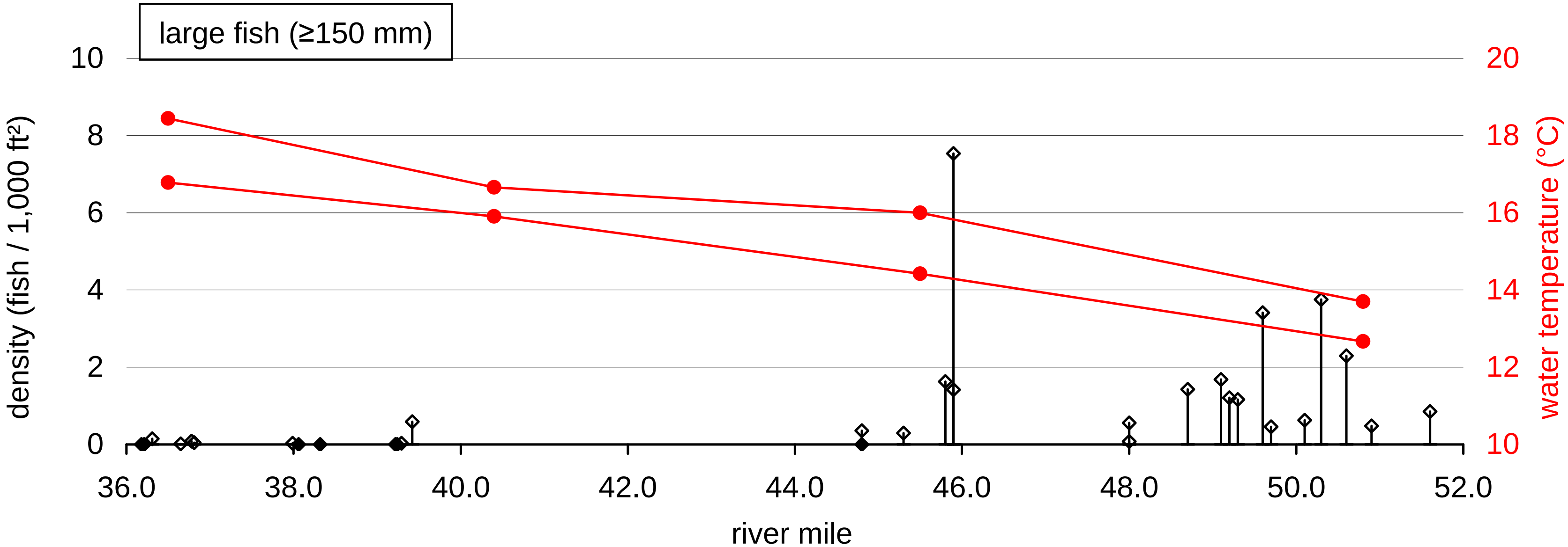


Figure 9. Longitudinal distribution of observed *O. mykiss* and water temperature in the lower Tuolumne River, September 2011. Solid diamonds are observed zeros, open diamonds are observed non-zero values.

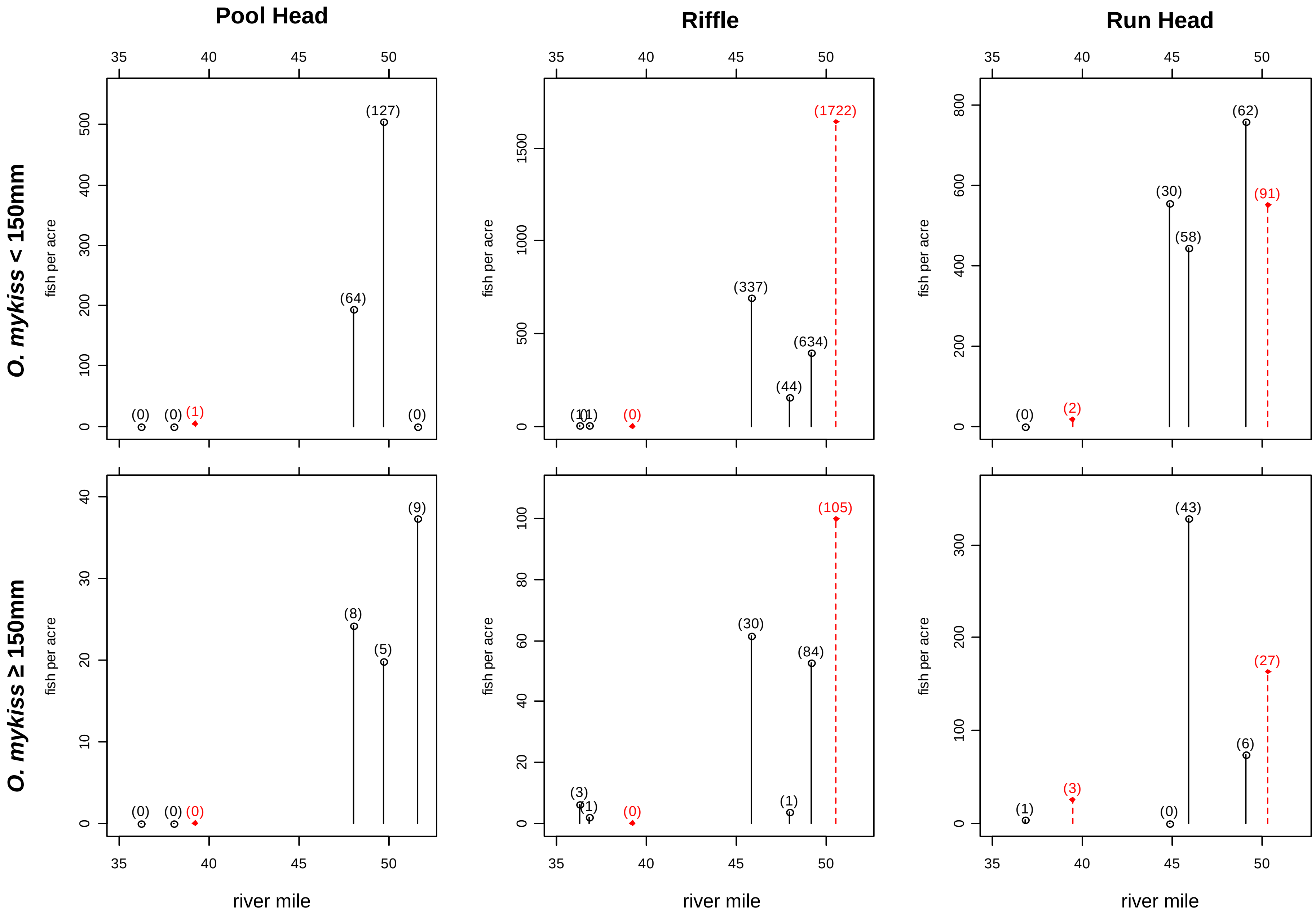


Figure 10. Observed densities of *O. mykiss* in individual sampling units in the September 2011 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (7-11 [RM 39.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

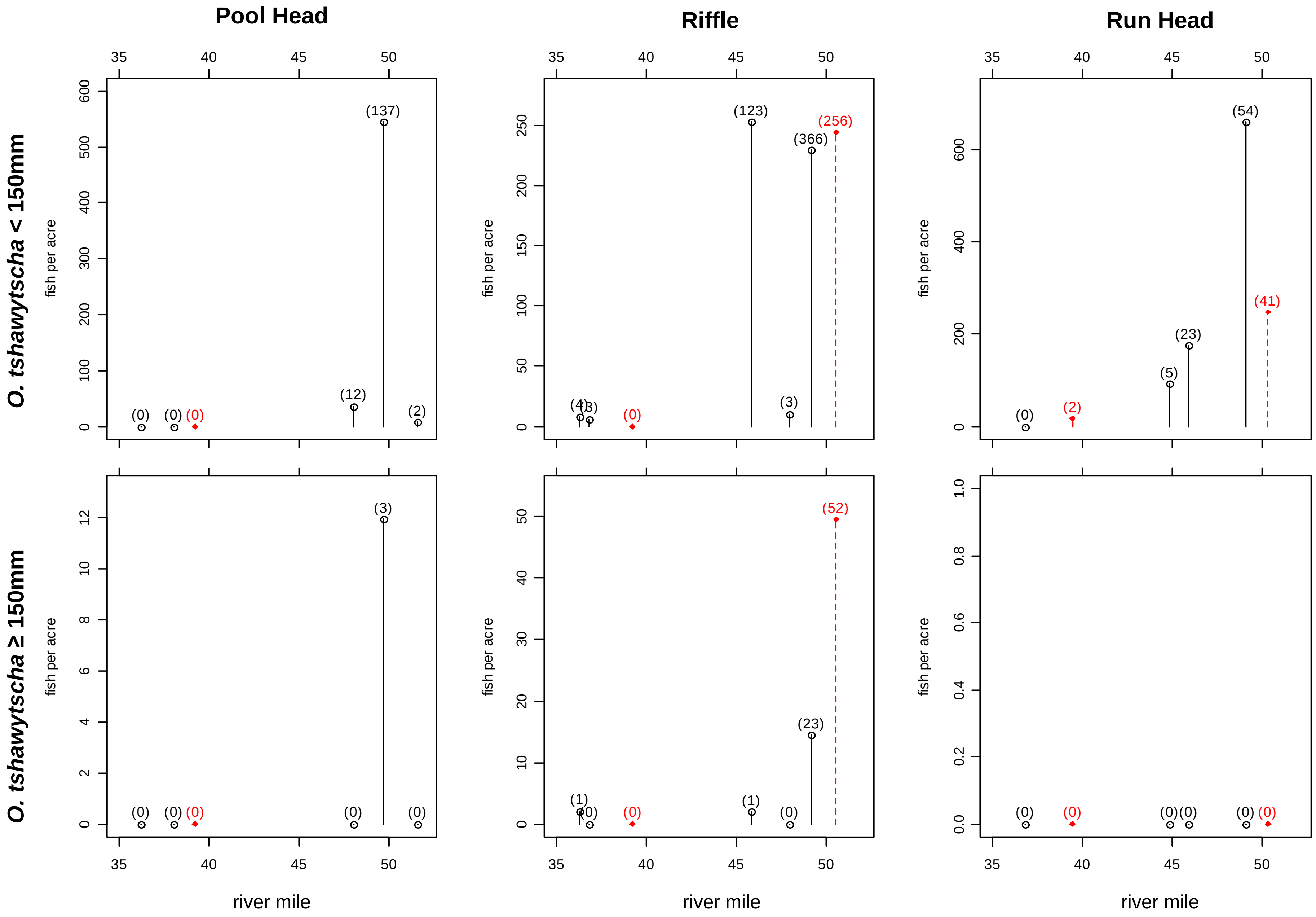


Figure 11. Observed densities of *O. tshawytscha* in individual sampling units in the September 2011 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (7-11 [RM39.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

Appendices

Appendix A: Study Plan (2009)

Study Plan for Population Size Estimates of *O. mykiss* in the lower Tuolumne River

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Appendices

1 BACKGROUND AND PURPOSE

Fisheries monitoring for the Don Pedro Project (FERC Project No. 2299) by the Turlock Irrigation District (TID) and Modesto Irrigation District (MID) has long documented the presence of *Oncorhynchus mykiss (O. mykiss)* in the lower Tuolumne River (TID/MID 2005). On March 19, 1998 the National Marine Fisheries Service (NMFS) first listed the Central Valley steelhead as threatened under the Endangered Species Act (ESA). After several court challenges, NMFS issued a new final rule relisting the Central Valley steelhead on January 5, 2006 (71 FR 834). In a separate process regarding terms of the 1996 FERC license amendments for the Project, NMFS staff provided input to a draft limiting factors analysis for Tuolumne River salmonids (Mesick et al 2007) and included recommendations for developing abundance estimates, habitat use surveys and anadromy determination of resident *O. mykiss*. These recommendations were conceptually used to develop the Districts FERC Study Plan (TID/MID 2007) which was the subject of an April 3, 2008 FERC Order. As part of the Order, the Districts are required to conduct population estimate surveys in summer (June/July) and winter (February/March), starting in summer 2008 to determine *O. mykiss* population abundance by habitat type.

The purpose of the proposed *O. mykiss* population surveys is to provide population size estimates over several sampling seasons of differing environmental conditions to determine habitat use and needs within the lower Tuolumne River. The surveys will be used to examine the following hypotheses:

> <u>Hypothesis 1</u>: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> <u>Hypothesis 2</u>: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

As recommended by Stillwater Sciences (Stillwater), the surveys will employ a two-phase sampling approach of potential *O. mykiss* habitat using snorkel surveys for the development of a "bounded count" population estimate (Hankin and Mohr 2001). Although the methodology presented below discusses both repeated dive counts and calibration by depletion electrofishing, current ESA permit restrictions for both NMFS Section 10(a)(1)(A) permit No's 1280 (TID) and 1282 (Stillwater) do not allow sufficient incidental take to conduct the second phase surveys at this time using electrofishing. Discussions with NMFS permitting staff and Stillwater have occurred since submittal of the 2007 FERC Study Plan, resulting in a pending formal request to NMFS by Stillwater for modification of Permit 1282 (see Section 6 below). The Section 10 Permit 1280 issued to TID in 2005 authorized only up to 5 juvenile *O. mykiss* annually by electrofishing that was further restricted to River Mile 25–30 during September to November. Thus that permit is not applicable or adequate to the season, location, and fish numbers needed to conduct the electrofishing for this population estimate study. Consequently, the July 2008 survey was conducted using snorkel surveys only as provided for in the 2007 study plan. It is not anticipated that the pending permit amendment request will be resolved prior to the winter 2009 survey, as such this will be conducted using snorkel surveys. If the pending amendment request is resolved prior to July 2008, then summer 2009 surveys will be conducted using the combined method presented below.

2 FIELD SAMPLING AND DATA COLLECTION

The two-phase stratified sampling design involves snorkeling pre-selected habitat units (e.g., riffle, run, pool, etc.) multiple times in order to quantify the variance associated with density and subsequent population estimates. Habitat units are selected using stratified random sampling where the habitat types possess a pre-determined probability of occurrence within areas where *O. mykiss* have been frequently observed during the summer in the lower Tuolumne River, extending from approximately river mile (RM) 52–40 during summers and potentially extending to near the city of Waterford (RM 30) during colder winter conditions.

In a typical Phase 1 sampling approach, primary snorkel surveys (Edmundson et al. 1968, Hankin and Reeves 1998, McCain 1992, Dolloff et al. 1996) will be conducted across a subset of all habitat units. In Phase 2, approximately 20–70% of each habitat type sampled will be randomly selected for replicated surveys by either repeated dive counts or depletion electrofishing (Reynolds 1996). Although the bounded counts methodology was developed for use in smaller stream systems (Hankin and Mohr 2001), applying the methodology to a larger system such as the Tuolumne River is feasible provided key assumptions are satisfied. A critical assumption of the bounded counts approach is that all individuals have a chance of being observed. This may not be practically attainable due to the depths of some of the in-channel mining pits and also potentially due to low visibility conditions occurring at downstream locations or due to winter-time sediment inputs during rain events. Hankin and Mohr (2001) found that their survey designs were suitable for coho salmon (*O. kisutch*), but they were less confident about applying the methodology to *O. mykiss* juveniles because the fish's furtive nature may violate the assumption that all fish have an observation probability >0. Sampling sites and methods may be modified following initial surveys because local conditions cannot be anticipated and may dictate the use of other schedules, locations, or techniques. Stillwater Sciences will notify TID, FERC, and permitting authorities if substantive changes in the study design, methods or schedule are anticipated.

2.1 Habitat Typing

On-the-ground mapping of potential habitat for *O. mykiss* will be delineated on digital ortho-rectified aerial photographs and information from previous habitat mapping efforts. Appendices A and B shows preliminary habitat units from RM 52–30 based upon habitat mapping conducted by Stillwater Sciences (2008) between La Grange Dam (RM 52) and Roberts Ferry Bridge (RM 40) (Appendix A) as well as preliminary habitat units from RM 40 to Waterford (RM 30) based upon mapping conducted by McBain & Trush (2004) and EA Engineering (1997) shown in Appendix B. The Appendix B habitat maps will be updated for flow and morphological characteristics in the field in late February and late June in each year. The final habitat maps will delineate all potential *O. mykiss* habitats according to the major types listed in Table 1, as well as transitional habitats that may be preferentially used by various size classes (i.e., pool heads, pool bodies, pool tails, run heads, run bodies, run tails, and riffles).

Table 1. Coarse scale habitat types to be used during snorkel surveys

Habitat Type	Description[a]	Approximate Depth
Riffle	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble or boulder. Gradient moderate (less than 4%).	0–4 ft
Run	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).	4–10 ft
Pool	Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.	>10 ft

[a]Major habitat types determined based upon observed hydraulic conditions (McCain 1992, Thomas and Bovee 1993, Cannon and Kennedy 2003)

A Geographic Information System (GIS) will be used to update and refine habitat maps prior to thorough field verification of flow, depth, and habitat conditions in the river. Within each reach, individual habitat units will be digitized as two-dimensional features of varying shapes, or polygons, where each unit is a discrete functional habitat, as defined above. This approach is consistent with the general techniques of McCain (1992), Thomas and Bovee (1993), and Cannon and Kennedy (2003) and allows a flexible approach to evaluating habitat and habitat use patterns at a scale that can be easily delineated given available data, readily depicted, and is ecologically meaningful for aquatic species.

Habitat units will be assigned a natural sequence order (NSO), starting at one which is the first unit at the upstream end of the site, and a habitat type unit number (1…N pools, runs and riffles). The maximum depth, length and width (usually at 1/3 and 2/3 of the units length) will be recorded and flagging tied at both upstream and downstream ends of units to be surveyed. Pertinent information such as date, unit number, and type is included on the flag. Lastly, the upper and lower end of each unit will be located by GPS and mapping from previous efforts will be verified or updated.

2.2 Sample Site Selection

After all potential habitat units are typed and all pertinent information recorded, a subset of each habitat unit type will be selected for single-pass snorkel surveys. Although additional units may be selected at gravel augmentation and other in-channel restoration sites (See Hypothesis 2), selection for sampling proceeds by random selection of the starting sampling unit in the upper survey section, followed by a systematic uniform sampling of the remaining units in the survey reach. For example, every 3^{rd}, 4^{th} or larger selection interval will be used to distribute the selected units uniformly across the survey reach.

Because the total length of river sampled affects the confidence bounds of the resulting *O. mykiss* population estimates, at least 10% of the total length of a given habitat type and a minimum of 5 units of each type will be sampled. Based upon preliminary habitat mapping and median unit lengths of various habitat types, Table 2 shows that 63 sampling units for the winter surveys will be selected from representative locations between RM 52–30 to meet the minimums above. This estimate further assumes that, since detailed habitat type mapping has not been conducted from RM 40–30, habitat type distribution and median length from RM 40–30 are similar to RM 52–40, as determined by summer 2008 habitat type mapping (Stillwater Sciences 2008). The exact number sampled will be determined after random selection of the habitat units prior to study implementation.

During summer, an estimated 35 units will be selected for single-pass snorkel survey from representative locations between RM 52–40 (Table 2). For both winter and summer surveys, the number and location of habitat units may be adjusted if initial systematic sampling does not allow the study to adequately to test Hypothesis 2.

Table 2. Estimated number of sampling units that will meet study design assumption of sampling at least 10% of the total length of a given habitat type.

Habitat Type	Total length (ft) RM 52-40[a]	Estimated total length (ft) RM 40-30[b]	Estimated total length (ft) RM 52-30	Median length (ft)[c]	# of units to be sampled Winter 2009 RM 52-30[d]	Estimated sampled Length Winter 2009	# of units to be sampled Summer 2009 RM 52-40[d]	Estimated sampled Length Summer 2009
Riffle	14,320	13,590	27,910	322	9	10%	5	11%
Pool head	619	618	1,237	106	9	77%	5	86%
Pool body	6,741	6,795	13,536	393	9	26%	5	29%
Pool tail	781	618	1,399	124	9	80%	5	79%
Run head	2,067	1,853	3,920	51	9	12%	5	12%
Run body	37,350	35,829	73,179	843	9	10%	5	11%
Run tail	2,393	2,471	4,864	54	9	10%	5	11%
Total	**64,271**	**61,775[e]**	**126,046**		**63**		**35**	

[a]From Stillwater Sciences (2008)
[b]Assumes same proportion of habitat types as from RM 52-40
[c]Assumes median habitat unit lengths from RM52-40 are proportional to median lengths along RM 40-30.
[d]Assumes at least 10% of the total length of each habitat type will be sampled; Estimates based upon 10% of the total length of a habitat type by median habitat unit length to determine a minimum number of units
[e]Actual river length from RM 40-30

2.3 Sampling Period

Winter sampling will begin in late February with systematic random selection of habitat units from RM 52-30, based upon summer 2008 maps (Appendix A) and previous habitat typing between RM 40–30 (Appendix B). Following habitat selection, Stillwater will use single-pass snorkel surveys and second phase calibration surveys within units of each type to develop uncertainty and bias estimates. Second phase sampling will be conducted using multi-pass snorkel surveys and/or depletion electrofishing methods as allowed under applicable permits (See Section 6).

Summer sampling will use habitat maps from RM 52–40 developed in summer 2008 (Appendix A). Although no additional habitat mapping is anticipated following winter 2009 surveys, habitat unit flagging will be established in advance of each snorkel survey effort and seasonal changes in habitat distribution may force revision of habitat type maps, specifically the upper and lower boundaries of habitat units and/or channel margins, prior to summer 2009 surveys.

2.4 Measurement Parameters and Sampling Methods

Multiple parameters will be measured in order to meet the objectives for this study (Table 3). Photos and GPS locations will be taken at each site, and site locations identified on GIS maps corresponding to mapped aquatic habitat units. General site information recorded at fish sampling locations will include site name, GPS coordinates, time, date, and crew member names. *In situ* water quality parameters (Temperature, dissolved oxygen, and conductivity) will be collected using a pre-calibrated multi-probe (YSI 85, Yellow Springs Instruments, Yellow Springs, OH). Underwater visibility will also be estimated into the sun and away from the sun using a Secchi disk to monitor any changes in visibility. Dissolved oxygen probes will be recalibrated at each site and checked for accuracy against concentrations measured in Winkler titrations (Grasshoff et al 1983) at the beginning and end of the sampling effort using a dissolved oxygen test kit.

Table 3. Measurement parameters and methods for snorkel surveys

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Habitat Typing Attributes			
Natural sequence order (Reach ID – Habitat unit #)	N/A	A-1, A-2, A-3, …	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Habitat type	Visual estimation	See Table 1	N/A
Average unit width	Horizontal distance	meters (feet) (measured at multiple transects)	3 ft (1 m)
Average unit length	Horizontal distance	meters (feet)	3 ft (1 m)
Maximum/minimum depth	Vertical distance	meters (feet)	1 ft (0.3 m)
Bed substrate composition	Visual estimation	bedrock, boulder, cobble, gravel, organic, sand, silt	10%
Cover type	Visual estimation	none, boulder, cobble, IWM, bedrock ledges, overhead vegetation, aquatic vegetation	10%
Field Data During Snorkel Surveys			
Temperature	EPA 170.1	°C	0.1 °C
Dissolved Oxygen	SM 4500-O	mg/L	0.0 mg/L
Conductivity	SM 2510A	umhos/cm	1.0 umhos/cm
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)
Date/Start time/End time	N/A	Day/month/year	N/A
Number of Individuals	Visual estimation	Number	1
Fish length – snorkeling	Visual estimation	millimeter	50 mm
Fish length – electrofishing	Fork length	millimeter	1 mm
Weight - electrofishing	Electronic balance	gram	0.1 g

2.4.1 Snorkel Surveys

Snorkel surveys will be conducted during daylight hours (7:00am–5:00pm winter; 6:00am–8:00pm summer). A two phase survey design will be used to survey the seven different strata (Table 4). At the first phase, single-pass dive surveys will be conducted by a four to five person crew depending upon river flows and underwater visibility. Sampling units will generally be sampled from downstream to upstream in dive lanes using a zigzag pattern, passing fish and allowing them to escape downstream of the diver. If fish are observed to escape upstream, the diver will take care to avoid counting these fish twice. Divers will record their observations of pertinent attributes (Table 3) and numbers of *O. mykiss* and Chinook salmon (*O. tshawtscha*) observed; with fish lengths to be estimated in 50 mm size ranges using a scale model or markings on the slates to correct for underwater size distortion. After the first dive pass is completed a tab is then pulled to determine if the unit is included in the second phase of sampling.

Table 4. Preliminary sample unit selection and survey count.

	Winter 2009				Summer 2009			
	Phase I Dives		Phase II Survey		Phase I Dives		Phase II Survey	
Habitat	Initial Units	Passes	Repeat Units	Passes	Initial Units	Passes	Repeat Units	Passes
Riffle	9	1	2	2	5	1	2	2
Pool head	9	1	2	2	5	1	2	2
Pool body	9	1	2	2	5	1	2	2
Pool tail	9	1	2	2	5	1	2	2
Run head	9	1	2	2	5	1	2	2
Run body	9	1	2	2	5	1	2	2
Run tail	9	1	2	2	5	1	2	2
	Total	63	Total	28	Total	35	Total	28

The second phase of sampling collects data that will later be used to extrapolate dive counts to total population estimates by three passes of either repeated dive counts or depletion electrofishing. Ideally, if the count of *O. mykiss* from the Phase 1 snorkel survey is less than or equal to 20 individuals then three additional dive passes are made. If electrofishing is permitted, all units with a count of juvenile *O. mykiss* counts greater than 20 individuals will be surveyed by electrofishing. Lastly, occurrence of other native and non-native fish species will be recorded as presence/absence.

2.4.2 Electrofishing at Riverine Sites

If employed during the summer 2009 survey, electrofishing will be conducted by a 4 person crew during the daylight hours (6:00am-8pm) following the dive surveys. Ideally, 3-pass electrofishing will be used on all second phase dive units where the first dive pass exceeded 20 *O. mykiss*. Dive units that require electrofishing for dive calibration will be completed as soon as possible after the dive survey.

Shallow water habitat may be sampled using back pack electrofishing units while deep water habitat may be sampled using a boat electrofishing unit. Back pack electrofishing in shallow waters less than 3–4 ft depth will be conducted using two or more Smith-Root back pack electrofishers (Model LR-24 or Model 12 with 11-inch anode rings and standard “rat-tail” cathodes). Boat electrofishing may be used in deeper riverine habitats using a boat mounted Smith Root 1.5 KVA electrofishing unit. To ensure the health of all fish captured during electrofishing, all electrofishing will be conducted in accordance with NMFS (2000) electrofishing guidelines and an electrofishing logbook will be maintained and updated at each sampling site.

Depending upon river flows and depth, electrofishing will use block nets placed at the upstream and downstream ends of the unit to be fished, taking care to avoid disturbance of the unit during net set-up. Block nets will be set up where possible to prevent fish from moving out of the unit. If block nets are not feasible, then a snorkeler may be stationed at the upstream end of a unit to observe any fish moving out of the unit.

First pass electrofishing will proceed slowly and deliberately upstream from the downstream end of the unit; members of an electrofishing crew will move to the top and back down to the bottom working closely together. To maintain equal effort on subsequent passes, electrofishing time (seconds) will be recorded to allow for any adjustments in sampling effort. A fourth pass will be conducted if one of the following applies:

1. The number of *O. mykiss* caught on the 2nd pass exceeds the number of *O. mykiss* caught on the 1st pass.
2. The number of *O. mykiss* caught on the 3rd pass is greater than or equal to 25 percent of number caught on the 2nd pass.

The procedure may be modified in riffle habitats to facilitate capture of shocked fish in fast water. In the riffle strata, a pass consists of a sweep from the top to the bottom of the unit. Depending on the water velocity, block nets may or may not be set at the upstream end of riffle units.

2.4.3 Fish Handling Protocols

Any fish captured during electrofishing surveys will be processed, and information collected regarding species identification, fork length (FL, mm), weight (g), and, if applicable, notes on general condition. All fish will be rapidly retrieved using dip nets and placed immediately into aerated live wells or buckets with water. Large fish will be kept separate from juvenile fish to avoid confinement predation. Fish will be identified to species and origin (hatchery or wild stock) where possible. Fish that are weighed and measured will be anesthetized using clove oil to minimize handling stress. After all fish are identified, counted, and measured, fish will be held for approximately 10 minutes, until they show signs of "normal" swimming patterns and behavior.

2.5 Hypothesis Testing

The purpose of the proposed *O. mykiss* population surveys is to provide population size estimates over several sampling seasons of differing environmental conditions to determine habitat use and needs within the lower Tuolumne River. The surveys will be used to examine the following hypotheses:

> Hypothesis 1: Summertime distribution of suitable habitat by observed life stages of *O. mykiss* is related to ambient river water temperature.
>
> Hypothesis 2: Habitat use by *O. mykiss* juveniles and adults observed in the Tuolumne River occurs at the same density in both restored and nearby reference sites.

While the selection for sampling proceeds by random selection of the starting sampling unit in the upper survey section, followed by a systematic uniform sampling of the remaining units in the survey reach, additional units adjacent to or near restoration sites may be non-randomly selected to provide treatment and control locations to test Hypothesis 2, especially during winter 2009 surveys when low ambient river water temperatures obviate the need to test Hypothesis 1.

2.6 Field Work Notification

To ensure field staff safety and to satisfy scientific collecting permit requirements, the parties listed in Table 5 will be notified in advance of the proposed sampling in as required to confirm sampling dates.

Table 5. Field Work Notification

Contact	Affiliation	Address	Phone and Email
Tim Ford	TID	333 East Canal Dr. Turlock, CA 95380	209.883.8275 tjford@tid.org
Tim Heyne	CDFG	P.O. Box 10 La Grange, CA 95329	209.853.2533 x1# theyne@dfg.ca.gov
Jeffery Jahn	NMFS	777 Sonoma Ave. Rm 325 Santa Rosa, CA 95404	707.575.6097 Jeffrey.Jahn@noaa.gov

Prior to mobilization, planned river operations by the Districts will be checked to determine if fish sampling would be safe under the anticipated flow and all parties will be notified of any delay or modification to the sampling schedule.

3 QUALITY ASSURANCE

The objective of data collection for this Project is to produce data that represent as closely as possible, *in situ* conditions of the Tuolumne River with respect to river flow conditions, water quality, abundance and habitat use by *O. mykiss*. To meet this objective, field sampling, sample preparation, and analysis will follow general guidelines outlined in USEPA (2002) by ensuring that:

- the project's objectives, hypotheses and data quality objectives are identified and agreed upon,
- the intended measurements and methods are consistent with project objectives,
- the assessment procedures are sufficient for determining if data of the type and quality needed and expected are obtained, and
- any potential limitations on the use of the data can be identified and documented.

Aquatic environments are inherently variable, but management decisions must be based on a data from a limited number of locations and often collected in short time periods. How well the information collected represent the reach or river-wide fish population depends upon a systematic approach to quality assurance.

3.1 Data Quality Objectives for Measurement Data

The data quality parameters used to assess the acceptability of the data are precision, accuracy, representativeness, comparability, and completeness. Precision measures the reproducibility of measurements under a given set of conditions. Analytical precision is limited to water quality and physical habitat characteristics (Table 6). Accuracy is an expression of the degree to which a measured or computed value represents the true value. Field accuracy is controlled by adherence to sample collection procedures.

Table 6. Data quality objectives for field parameters

Parameter	Units	Accuracy	Precision	Completeness
Dissolved Oxygen	mg/L	± 0.5	10%	90%
Temperature	^{o}C	± 0.5	5%	90%
Conductivity	umhos/cm	± 5%	± 5%	90%
Depth	meters	± 0.2	N/A	N/A
Visibility (Secchi)	meters	± 0.05	N/A	N/A

- Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. For this study, monitoring site selection will be conducted based on physical habitat attributes. Additionally, specific measurement parameters have been identified as relevant based on numerous studies indicating factors associated with species distribution.

- Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this biological assessment, comparability of data will be established through the use of standard analytical methodologies and reporting formats.

- The project goal for completeness, a measure of the amount of data that is determined to be valid in proportion to the amount of data collected, will be 90% for analytical water quality parameters. The data quality objective for completeness for all components of this study is 90%.

3.2 Training Requirements/Certification

Specialized training is required for the proposed sampling activities, however none of the sampling activities require outside certification from an agency or another entity. Required permits for biological sampling are discussed in Section 5. Field crews will be staffed by a variety of qualified personnel, which due to the nature of extended field activities, will necessarily be rotated in and out of the field.

3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

To ensure proper equipment performance in the field, maintenance and operational procedures, including preventative maintenance, will be performed on all YSI multiprobes (temperature, dissolved oxygen, and conductivity). YSI maintenance will be recorded in a logbook with the date the maintenance was performed and the initials of the technician. When the instruments are not deployed, the calibration or storage cup will be used to protect sensors from damage and desiccation.

3.4 Instrument Calibration and Frequency

Field probes used for field sampling will be calibrated prior to use, midway through each sampling event, and at the end of each sampling event. Measurement devices for conductivity will be checked against a standard whose source is different than that selected for calibration. Dissolved oxygen will be checked against aerated water whose oxygen content is established by the Winkler method (Grashoff et al 1983). Temperature does not require calibration because of the unvarying nature of the temperature sensor and its conditioning circuitry.

3.5 Reconciliation with Data Quality Objectives

If data do not meet the project's specifications, the following actions will be taken. First, the task leaders working with the field crew leaders (in some cases they will be the same person) will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. They will suggest corrective action. If the problem cannot be corrected by training, revision of techniques, or replacement of supplies/equipment, then the task leaders will review the data quality objectives (DQOs) and determine if the DQOs are feasible. If the specific DQOs are not achievable, they will determine whether the specific DQO can be relaxed, or if the parameter should be eliminated from the monitoring program.

3.6 Data Management

All field data will be amassed in a quality-checked database and summarized. QA checks will be applied to all data before data entry and data will be stored on Stillwater Sciences servers. Full backup of data from all offices is done on a weekly basis, while differential backup (files that have changed since the last full backup) is done on a nightly basis. The backup process is accomplished with a Fast Tape Library and backup processes are completed during off-peak hours. Two sets of tapes are taken offsite by two Information Technology (IT) staff members on a weekly basis to ensure recovery in case of failure or catastrophe.

4 DATA ANALYSIS

Data analysis will be conducted to summarize *in situ* water quality and fish counts in each sampling strata. Bounded counts or depletion estimators will be used to determine populations and linear density for each sampled unit, together with estimates of uncertainty. In addition to comparisons of fish density between sampling strata, the density estimates and uncertainties will be propagated across the unsampled areas for an overall population estimate. Exploratory multiple regression analysis will also be used to determine relationships between fish density and recorded habitat variables.

5 REPORTING

A data report will be prepared for use with permitting authorities that includes: date, time, and location of sampling activities; species and number of species collected; and a copy of field data sheets. Results of the winter 2009 surveys will be transmitted to TID electronically within three weeks of the survey completion (April/May 2009). A client review draft of the technical report covering the results of both winter and summer 2009 surveys will be submitted to TID by August 24, 2009. Assuming an internal and Agency review comments are received within one and three weeks of issuance of the client review and Agency review drafts, respectively, the Agency review draft will be available by September 8, 2009 and final report will be complete by October 16, 2009.

6 PERMITTING REQUIREMENTS

Stillwater Sciences will maintain the following permits to sample fish populations that may be present:

- NMFS Section 10(a)(1)(A) permit 1282
- California Department of Fish and Game individual Scientific Collection Permits.

A NMFS Section 10(a)(1)(A) permit 1282 has been obtained and all NMFS guidelines (e.g., notification, data gathering, preservation) will be followed if any Central Valley steelhead are captured. Under that existing NMFS permit, electrofishing is limited to an authorized incidental take of 40 juvenile *O. mykiss* and the <5% unintentional mortality limit, and no adults. An amendment to the sampling description was submitted to NMFS on June 2, 2008 with increased take limits for handling electrofishing of 100 adults and 200 juveniles at an unintentional mortality rate of <10%. Mr. Jeffrey Jahn of NMFS will be notified at least two weeks prior to applicable sampling to confirm sampling dates and locations. Electrofishing under an amended permit will be suspended in the event that the authorized incidental take limits were exceeded and all subsequent calibration surveys would be made by repeat dive surveys. Annual reporting will be provided to Mr. Jeffrey Jahn of NMFS by March 1, of each year.

CDFG Scientific Collecting Permits (SCPs) will be maintained for species potentially present in the project area. CDFG guidelines (e.g., notification, data gathering, and preservation) will be followed if special-status species are captured and the CDFG 24-hr dispatch (916.446.0045) will be notified should unrelated events result in fish kills.

No intentional mortality or removal of special-status species from the wild is included in this study plan. In the event unintentional mortality occurs beyond the take permit limits, NMFS staff will be contacted within 24 hrs and a fin-clip will be provided to the Salmonid Genetic Repository. CDFG will also be contacted to determine the disposition of the individual specimen and whether the individual may be retained for otolith analysis.

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Appendix B: 2008 Habitat Maps

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 01

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 02

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 03

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 04

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 05

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 06

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 07

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 08

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 09

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 10

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 11

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 12

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 13

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 14

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 15

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 16

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 17

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 18

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 19

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 20

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs | Riffles | Pools

Tile Boundary (shown white on the map)

River Miles

METADATA

Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)

Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 21

0 125 250 500 Feet

Stillwater Sciences
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Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 22

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 23

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 24

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 25

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 26

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 27

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 28

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 29

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 30

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
River Miles

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 31

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 32

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
River Miles

Stillwater Sciences
www.stillwatersci.com

0 125 250 500 Feet

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 33

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

Tile 34

Tuolumne River - O. mykiss BCE Surveys, 2008-2011

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
River Miles

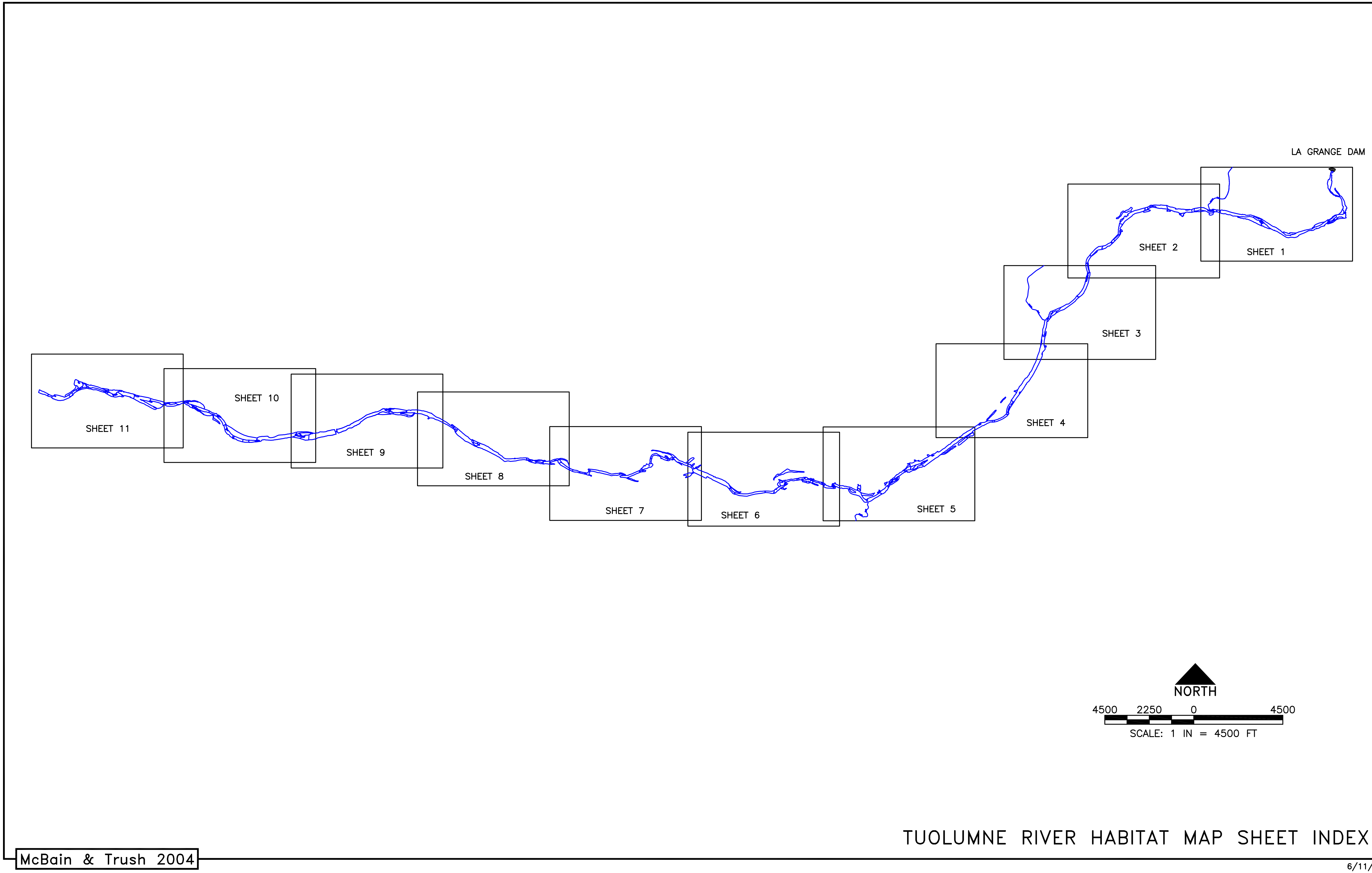
Stillwater Sciences
www.stillwatersci.com

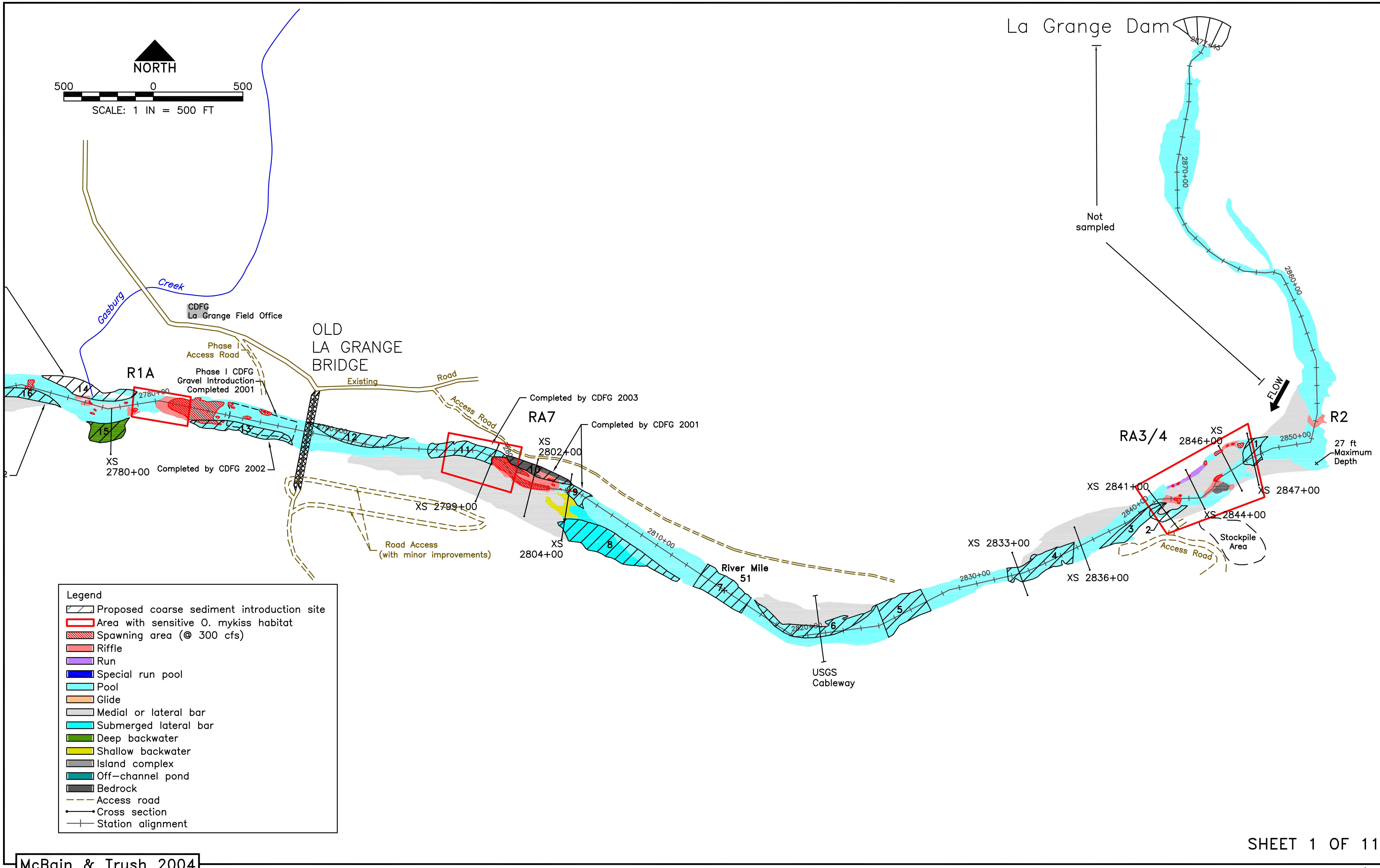
0 125 250 500 Feet

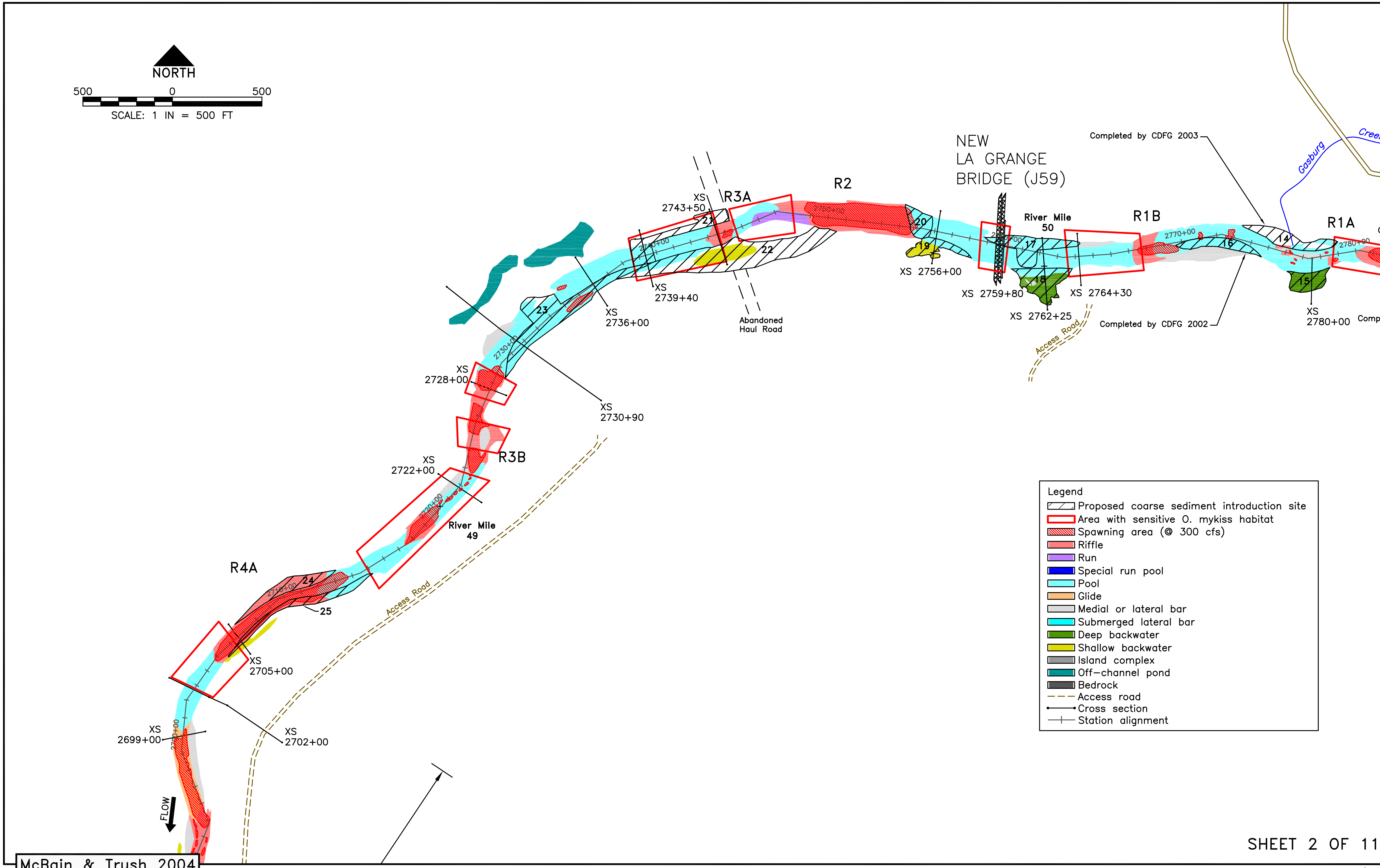
METADATA
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)
Wetted perimeter were first based on EA_mapping data (1986-87) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

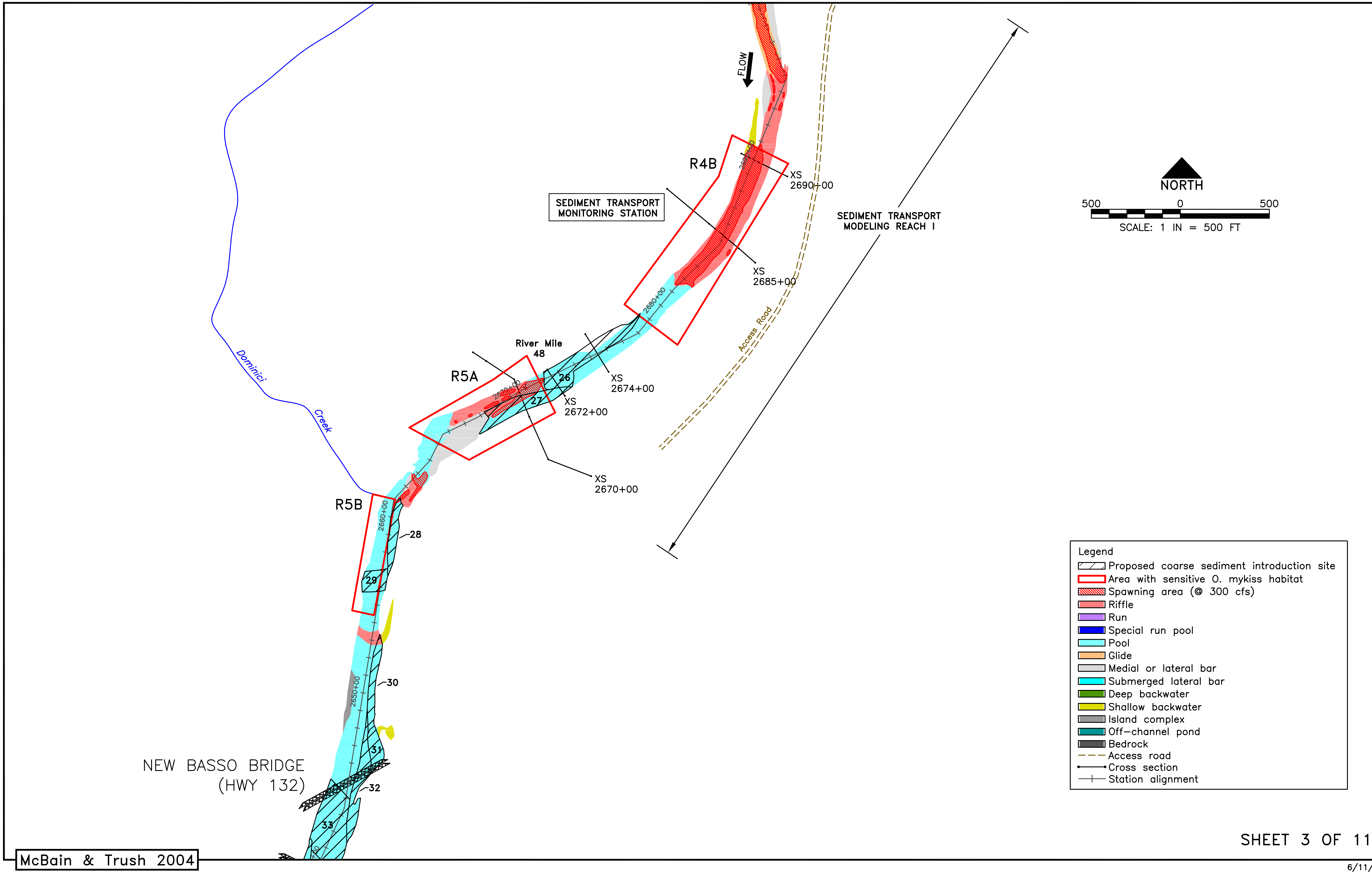
Tile 35

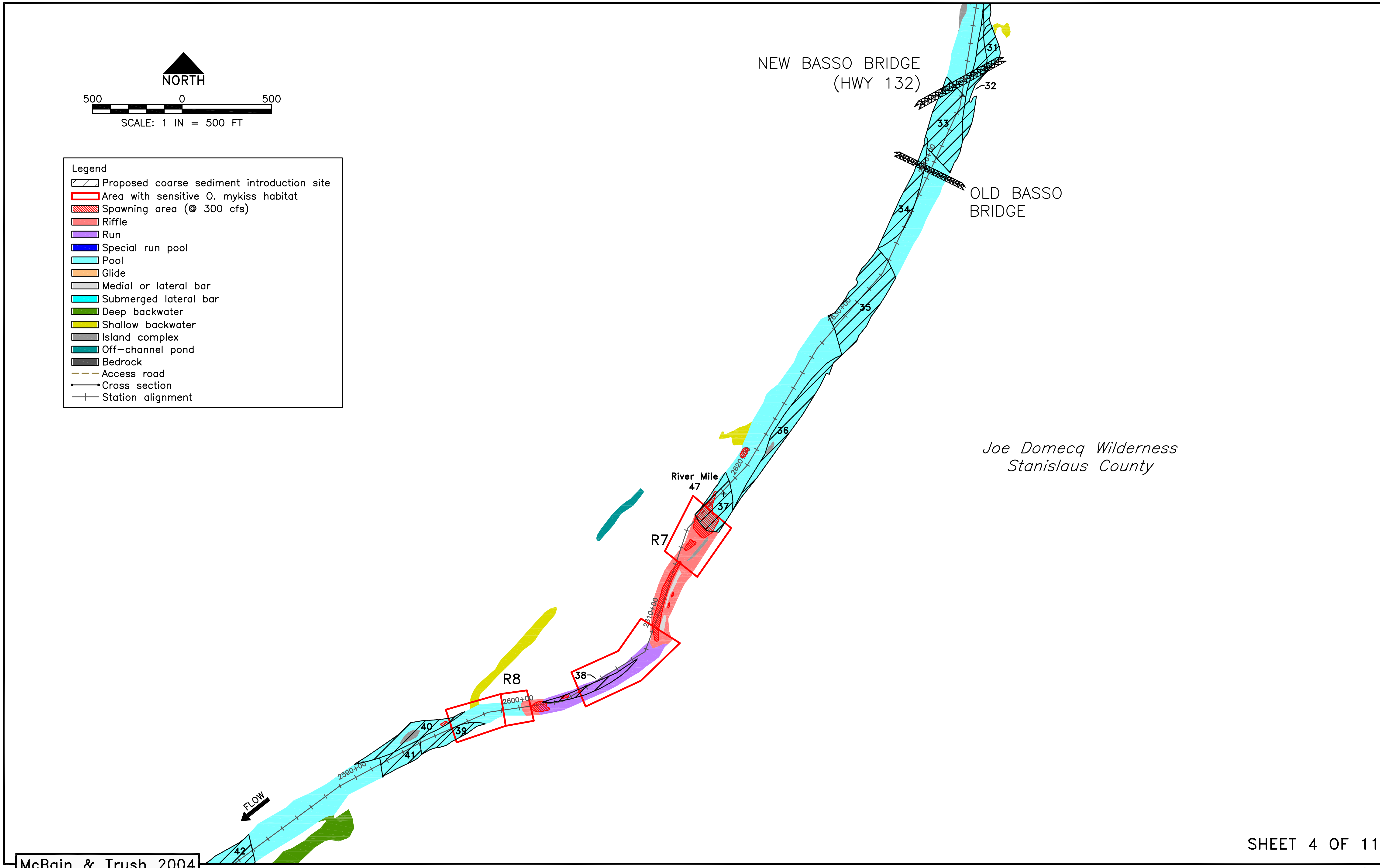
Appendix C: 2004 Habitat Maps


LA GRANGE DAM
SHEET 1
SHEET 2
SHEET 3
SHEET 4
SHEET 5
SHEET 6
SHEET 7
SHEET 8
SHEET 9
SHEET 10
SHEET 11
NORTH
4500 2250 0 4500
SCALE: 1 IN = 4500 FT
TUOLUMNE RIVER HABITAT MAP SHEET INDEX
McBain & Trush 2004
6/11/04

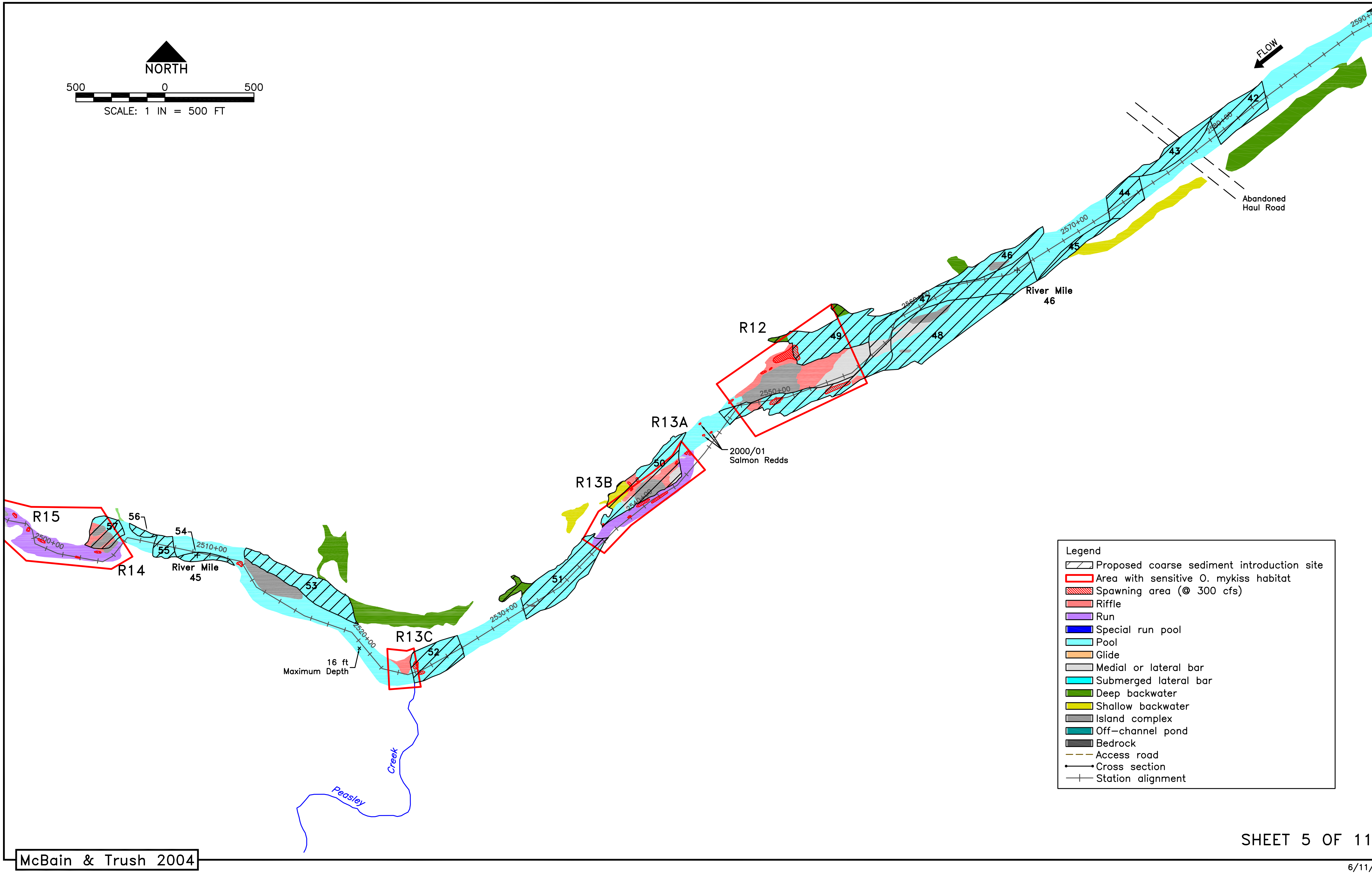

NORTH
500 0 500
SCALE: 1 IN = 500 FT
La Grange Dam
Not sampled
FLOW
R2
27 ft Maximum Depth
RA3/4
XS 2846+00
XS 2847+00
XS 2841+00
XS 2844+00
Stockpile Area
Access Road
XS 2833+00
XS 2836+00
River Mile 51
USGS Cableway
RA7
Completed by CDFG 2003
Completed by CDFG 2001
XS 2802+00
XS 2799+00
XS 2804+00
Road Access (with minor improvements)
OLD LA GRANGE BRIDGE
Existing Road
Access Road
CDFG La Grange Field Office
Gasburg Creek
Phase I Access Road
Phase I CDFG Gravel Introduction Completed 2001
R1A
XS 2780+00
Completed by CDFG 2002
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 1 OF 11
McBain & Trush 2004
6/11/04


NORTH
500
0
500
SCALE: 1 IN = 500 FT
NEW
LA GRANGE
BRIDGE (J59)
R1A
R1B
R2
R3A
R3B
R4A
River Mile
50
River Mile
49
Completed by CDFG 2003
Completed by CDFG 2002
Abandoned
Haul Road
Access Road
Gasburg
Creek
XS 2743+50
XS 2739+40
XS 2736+00
XS 2730+90
XS 2728+00
XS 2722+00
XS 2705+00
XS 2702+00
XS 2699+00
XS 2756+00
XS 2759+80
XS 2762+25
XS 2764+30
XS 2780+00
FLOW
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 2 OF 11
McBain & Trush 2004
6/11/04


FLOW
R4B
XS
2690+00
SEDIMENT TRANSPORT
MONITORING STATION
XS
2685+00
SEDIMENT TRANSPORT
MODELING REACH I
NORTH
500
0
500
SCALE: 1 IN = 500 FT
Access Road
2680+00
River Mile
48
R5A
26
27
XS
2674+00
XS
2672+00
XS
2670+00
Dominici
Creek
R5B
2660+00
28
29
30
2650+00
31
32
33
NEW BASSO BRIDGE
(HWY 132)
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 3 OF 11
McBain & Trush 2004
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
NEW BASSO BRIDGE
(HWY 132)
OLD BASSO
BRIDGE
Joe Domecq Wilderness
Stanislaus County
River Mile
47
R7
R8
2630+00
2620+00
2610+00
2600+00
2590+00
31
32
33
34
35
36
37
38
39
40
41
42
FLOW
SHEET 4 OF 11
McBain & Trush 2004

6/11/04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FLOW
Abandoned Haul Road
River Mile 46
R12
R13A
2000/01 Salmon Redds
R13B
R15
R14
River Mile 45
R13C
16 ft Maximum Depth
Peasley Creek
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
2590+00
2570+00
2550+00
2530+00
2520+00
2510+00
2500+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 5 OF 11
McBain & Trush 2004
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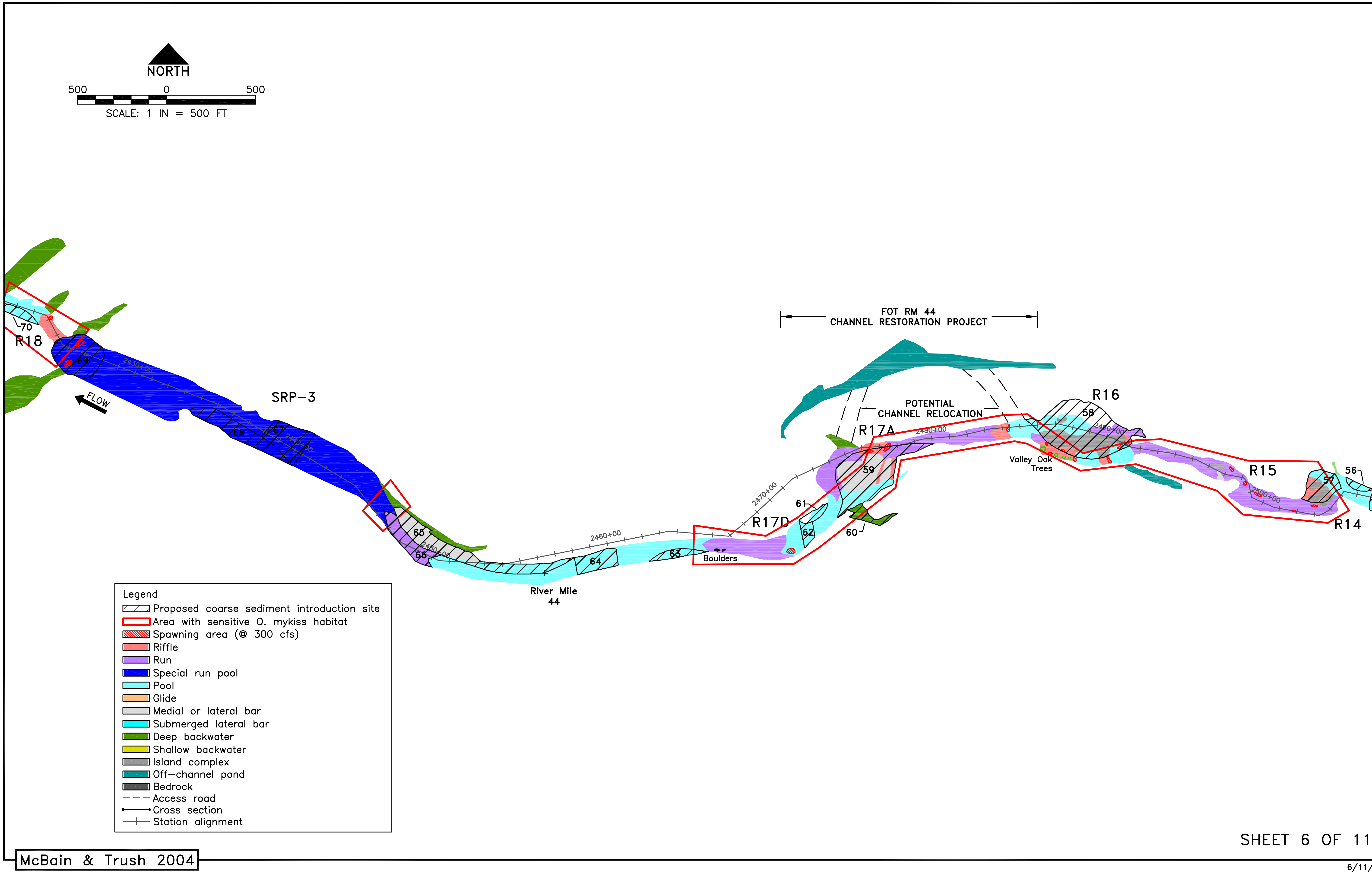
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FOT RM 44
CHANNEL RESTORATION PROJECT
POTENTIAL
CHANNEL RELOCATION
R18
R17A
R17D
R16
R15
R14
SRP-3
FLOW
Valley Oak
Trees
Boulders
River Mile
44
2430+00
2460+00
2470+00
2480+00
2490+00
2500+00
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 6 OF 11
McBain & Trush 2004
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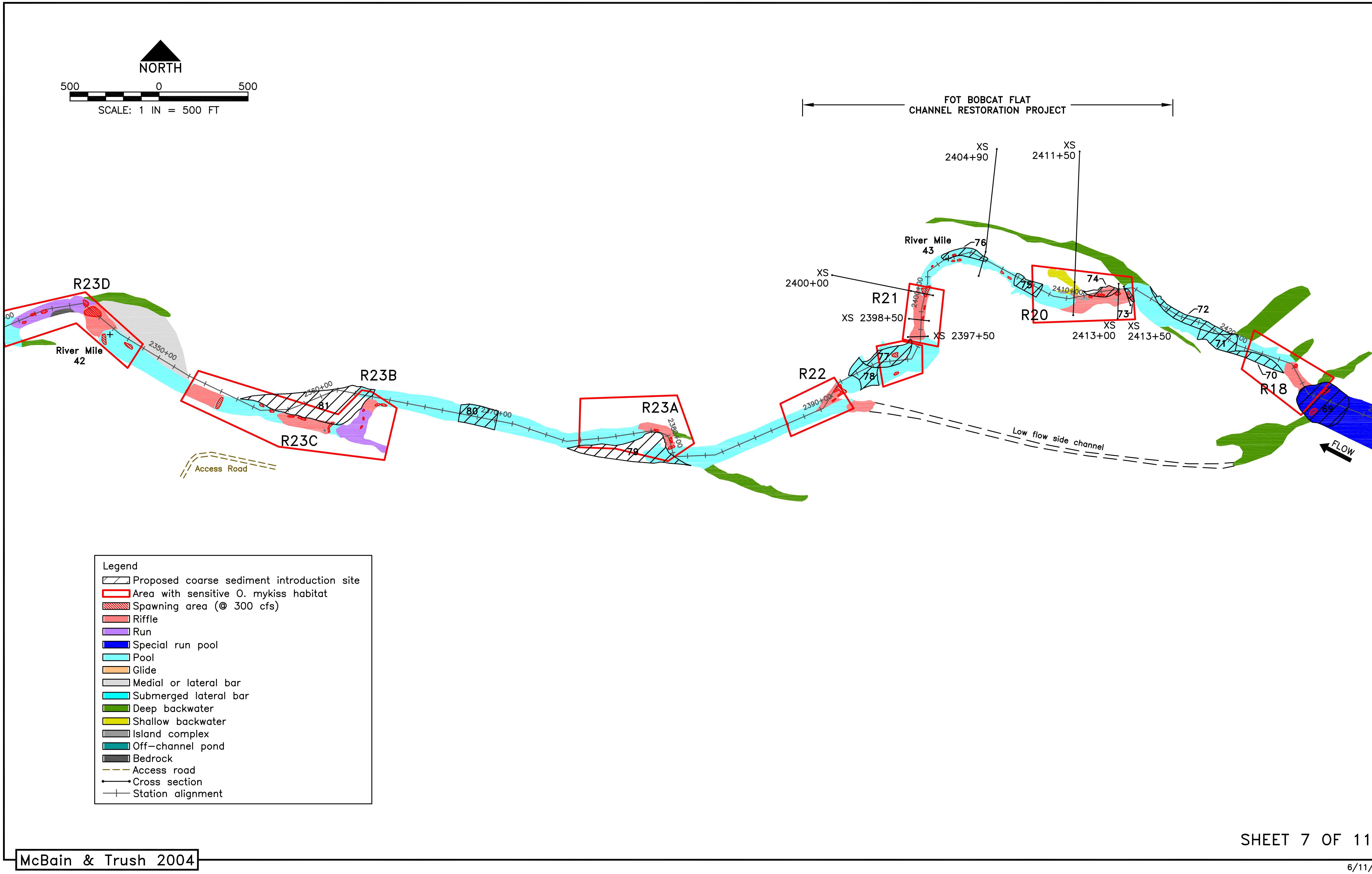
NORTH
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FOT BOBCAT FLAT
CHANNEL RESTORATION PROJECT
XS 2404+90
XS 2411+50
River Mile 43
XS 2400+00
R21
XS 2398+50
XS 2397+50
R20
XS 2413+00
XS 2413+50
R23D
River Mile 42
2350+00
R23B
R23C
Access Road
R23A
R22
Low flow side channel
R18
FLOW
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 7 OF 11
McBain & Trush 2004
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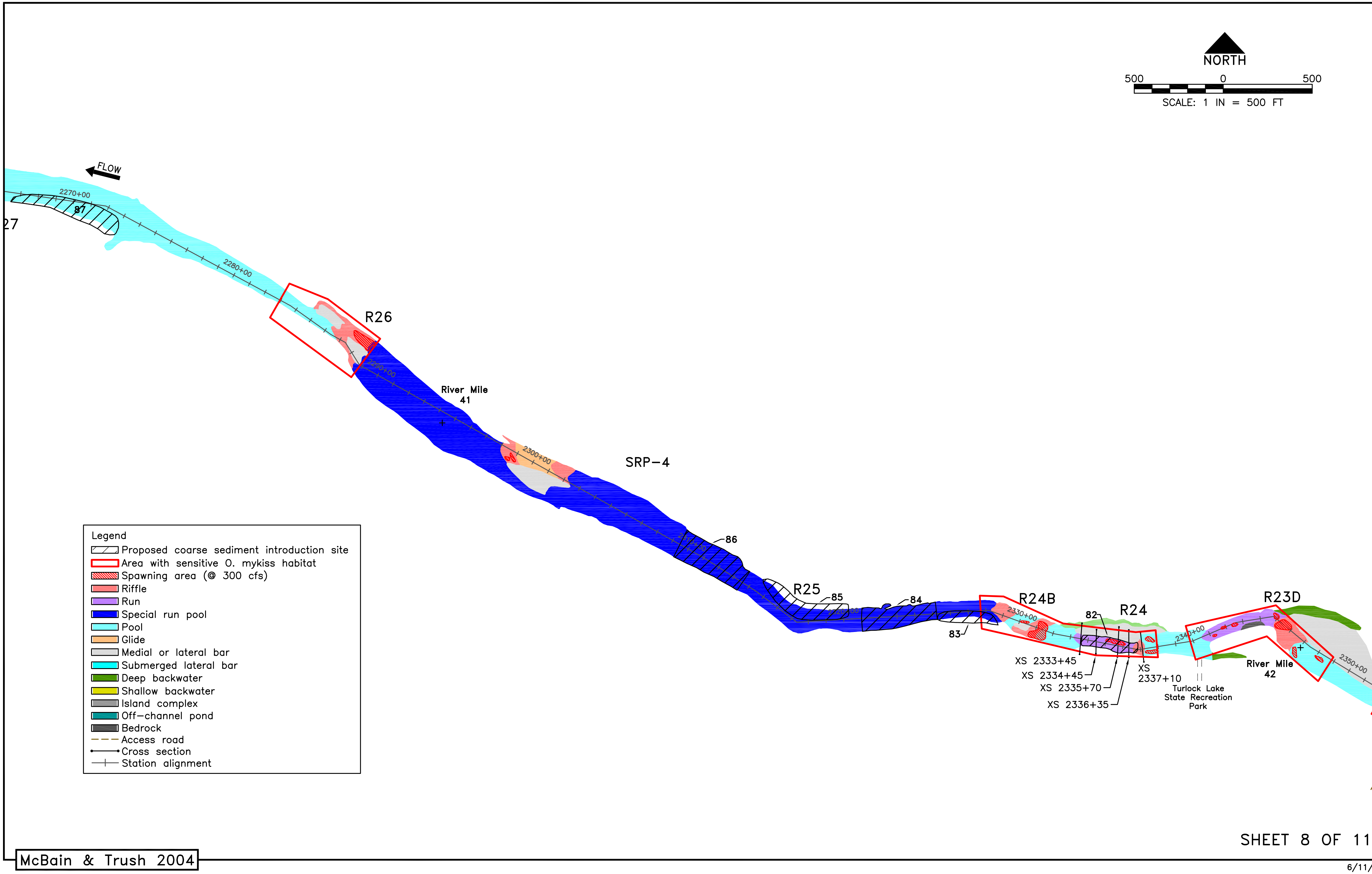
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SCALE: 1 IN = 500 FT
FLOW
27
87
R26
River Mile 41
SRP-4
86
R25
85
84
83
R24B
82
R24
R23D
XS 2333+45
XS 2334+45
XS 2335+70
XS 2336+35
XS 2337+10
Turlock Lake State Recreation Park
River Mile 42
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off-channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 8 OF 11
McBain & Trush 2004
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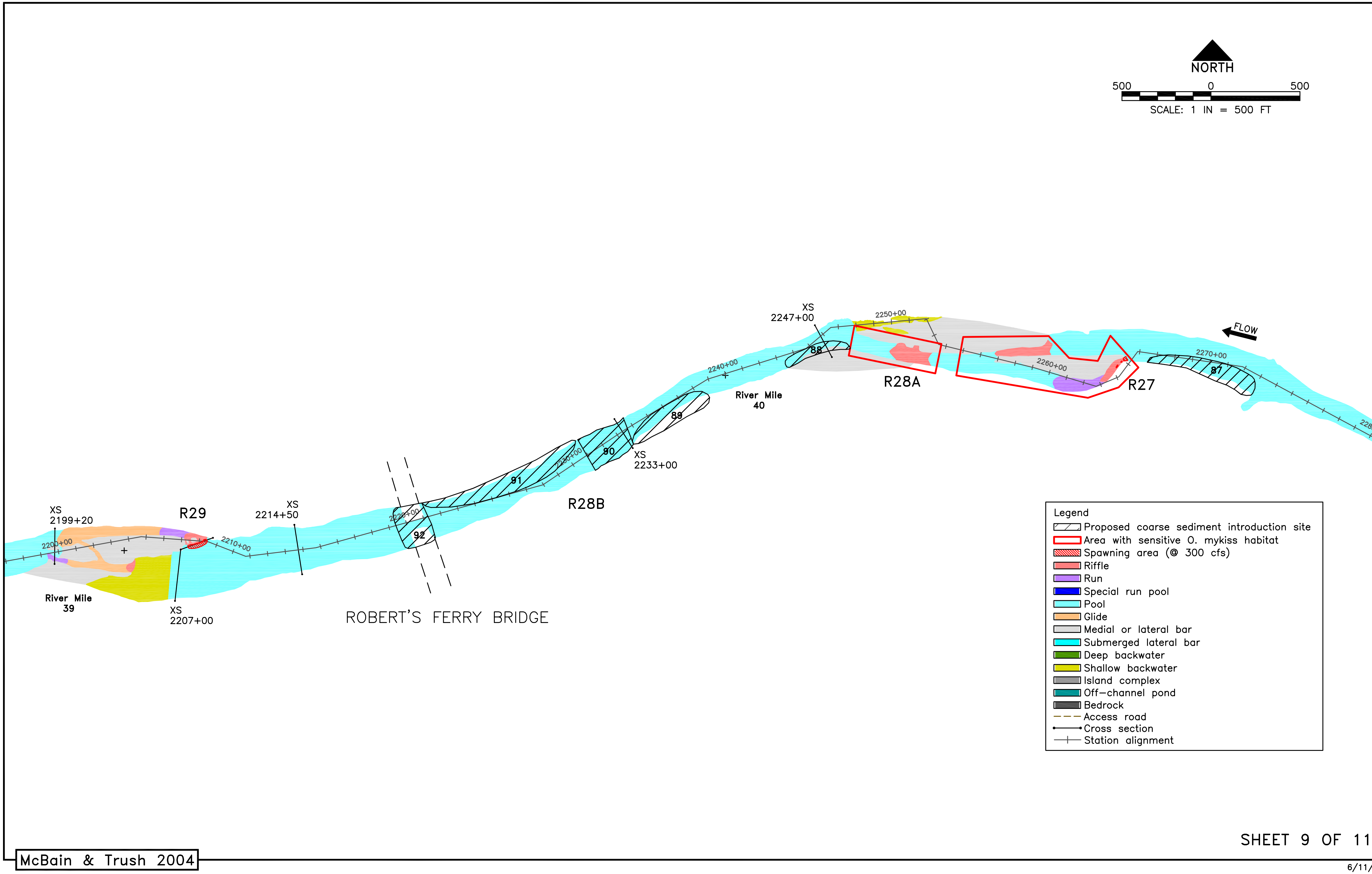
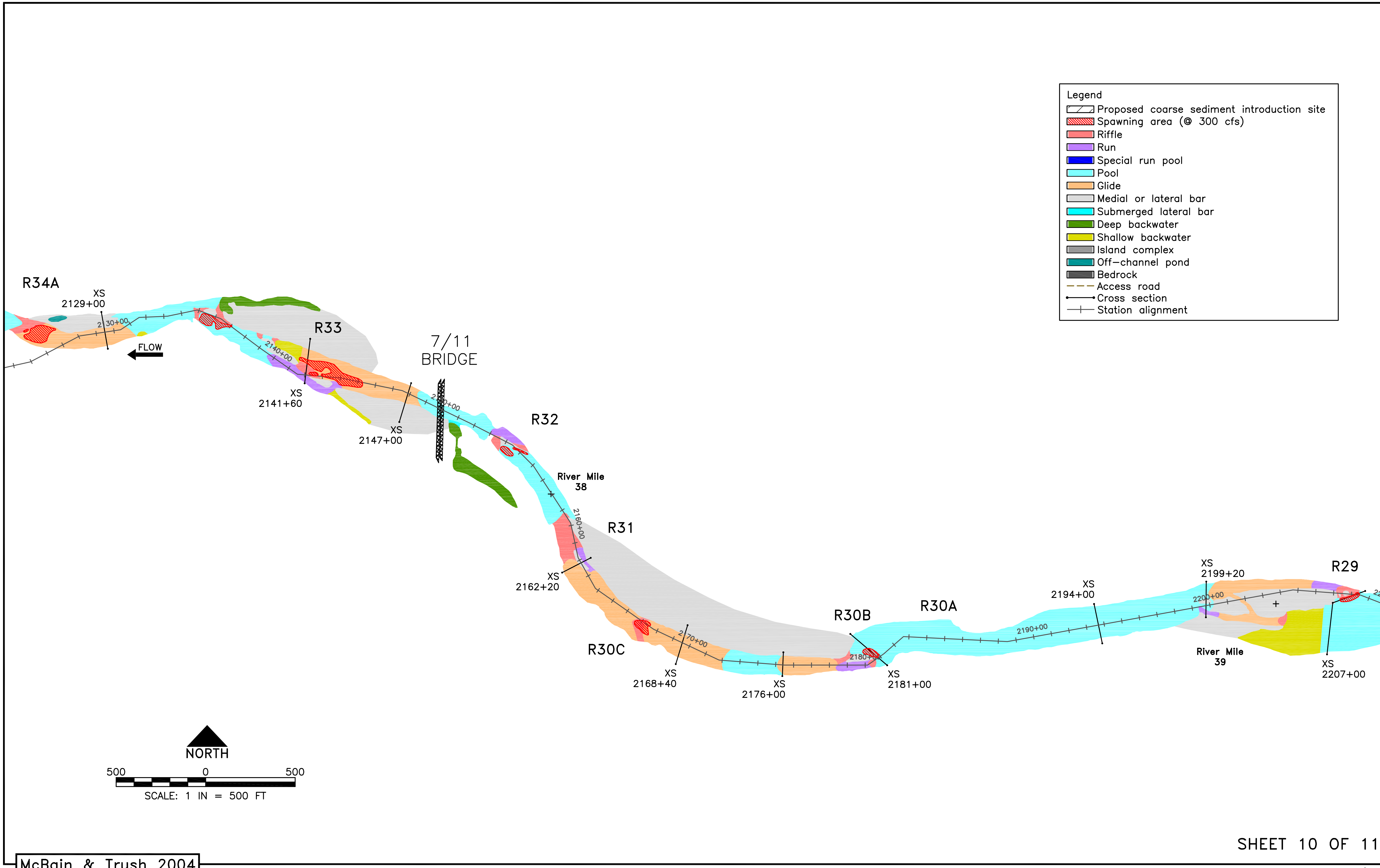
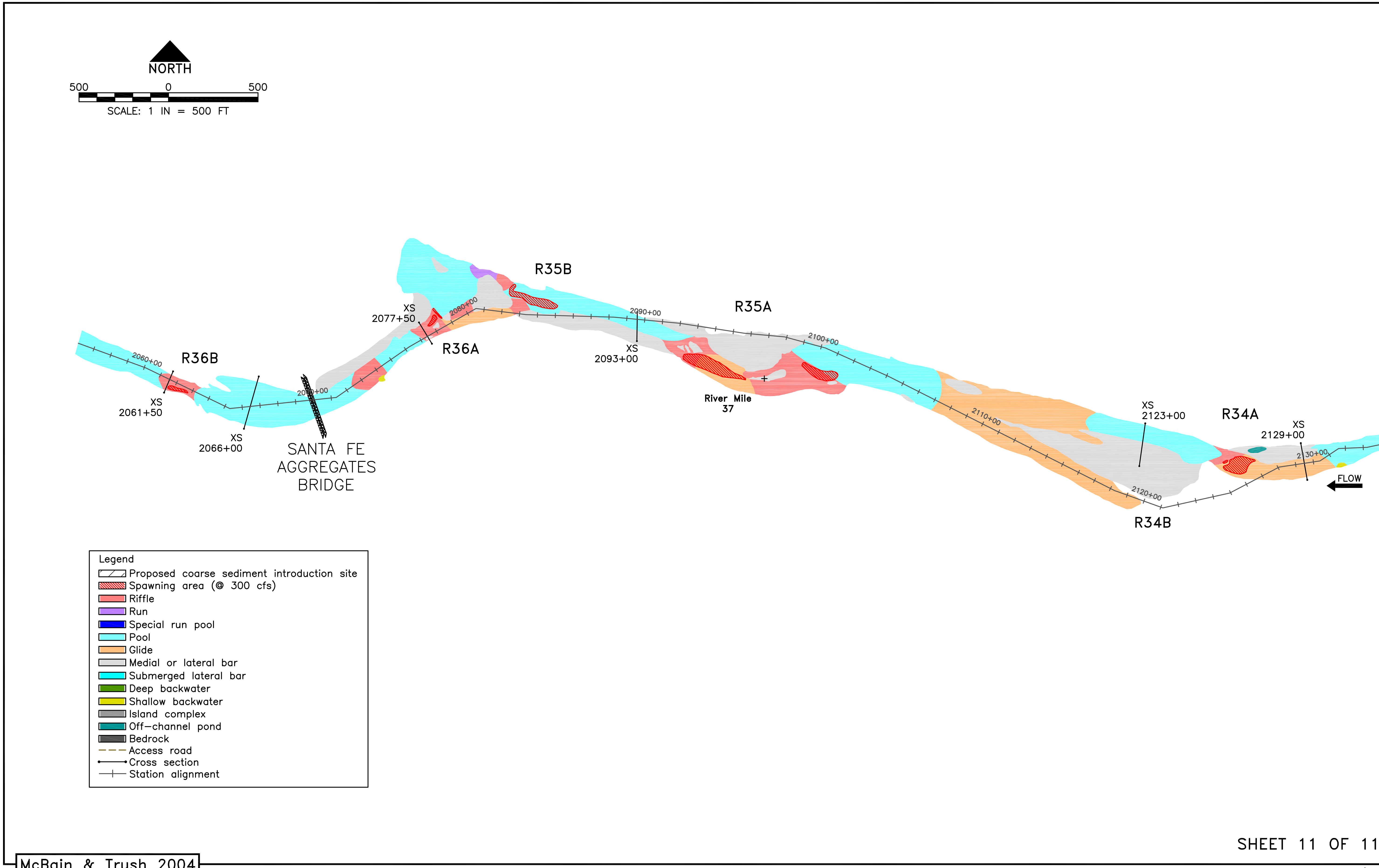

NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
XS 2199+20
R29
XS 2214+50
XS 2207+00
River Mile 39
ROBERT'S FERRY BRIDGE
R28B
XS 2233+00
River Mile 40
XS 2247+00
R28A
R27
92
91
90
89
88
87
2200+00
2210+00
2220+00
2230+00
2240+00
2250+00
2260+00
2270+00
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 9 OF 11
McBain & Trush 2004
6/11/04


Legend
Proposed coarse sediment introduction site
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off−channel pond
Bedrock
Access road
Cross section
Station alignment
R34A
XS 2129+00
R33
FLOW
7/11 BRIDGE
XS 2141+60
XS 2147+00
R32
River Mile 38
R31
XS 2162+20
R30C
XS 2168+40
XS 2176+00
R30B
R30A
XS 2181+00
XS 2194+00
XS 2199+20
R29
River Mile 39
XS 2207+00
NORTH
500 0 500
SCALE: 1 IN = 500 FT
SHEET 10 OF 11
McBain & Trush 2004
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
R36B
R36A
R35B
R35A
R34A
R34B
XS 2061+50
XS 2066+00
XS 2077+50
XS 2093+00
XS 2123+00
XS 2129+00
2060+00
2070+00
2080+00
2090+00
2100+00
2110+00
2120+00
2130+00
SANTA FE AGGREGATES BRIDGE
River Mile 37
FLOW
Legend
Proposed coarse sediment introduction site
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
SHEET 11 OF 11
McBain & Trush 2004
6/11/04

Appendix D: Habitat Data

Table D-1. Physical habitat types and dimensions of surveyed areas in the lower Tuolumne River (RM 51.8–29.0).

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
1	51.8		140	75	10,537	5.0	8.0	Pool head
2	51.7		450	143	64,161	18.0	28.0	Pool body
3	51.7		157	61	9,600	1.5	3.0	Pool tail
4	51.6	Yes	85	124	10,506	3.0	5.0	Pool head
5	51.6		393	129	50,702	18.0	25.0	Pool body
6	51.5		250	89	22,309	4.0	6.0	Pool tail
7	51.5		292	68	19,851	3.0	6.0	Riffle
8	51.4		117	82	9,562	5.0	6.0	Run head
9	51.1		2047	97	199,103	6.0	8.0	Run body
10	51.0		182	86	15,733	3.5	4.5	Run tail
11	50.9	Yes	457	99	45,397	10.0	16.0	Pool body
12	50.8		843	128	107,699	4.0	7.0	Run body
13	50.8		93	86	7,988	1.5	3.0	Run tail
14	50.6	Yes	708	65	45,670	1.5		Riffle
15	50.6		161	85	13,760	6.0	7.0	Run head
16	50.5		704	132	92,609	5.0	8.0	Run body
17	50.4		59	146	8,600	2.5	3.0	Run tail
18	50.3		941	130	121,948	1.5	2.0	Riffle
19	50.3	Yes	59	109	7,193	4.0	8.0	Run head
20	50.1	Yes	848	151	107,630	3.0	4.0	Run body
21	50.1		70	119	8,333	1.5	2.0	Run tail
22	50.1		132	127	16,750	1.0	1.5	Riffle
23	50.0		93	133	12,379	4.0	6.0	Run head
24	49.9		1007	199	200,462	4.0	8.0	Run body
25	49.8		274	154	42,115	2.0	4.0	Run tail
26	49.7		527	139	72,991	1.5	2.0	Riffle
27	49.7	Yes	127	86	10,955	4.0	6.0	Pool head
28	49.6	Yes	161	89	14,345	6.0	9.0	Pool body
29	49.6		112	85	9,490	1.5	2.5	Pool tail
30	49.6		50	110	5,520	3.0	5.0	Run head
31	49.3	Yes	1440	115	166,115	2.5	3.5	Run body
32	49.3		132	137	18,071	2.0	2.5	Run tail
33	49.2	Yes	552	126	69,509	1.5	2.5	Riffle
34	49.2		112	65	7,283	2.0	3.0	Run head
35	49.1		321	82	26,475	3.0	5.0	Run body
36	49.1		44	103	4,532	1.5	2.0	Run tail
37	49.1		78	97	7,594	1.5	2.0	Riffle
38	49.1	Yes	43	83	3,559	2.0	3.5	Run head
39	49.1		240	81	19,424	2.5	4.0	Run body
40	49.0		23	95	2,180	2.5	3.0	Run tail
41	48.8		1080	114	122,953	1.5	3.0	Riffle

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
42	48.8		36	97	3,505	1.5	2.0	Run head
43	48.7	Yes	749	93	69,528	2.5	4.0	Run body
44	48.7		39	110	4,304	2.0	3.0	Run tail
45	48.4		1275	117	149,495	1.5	2.0	Riffle
46	48.4		92	102	9,378	1.5	2.0	Run head
47	48.3		915	111	101,397	3.5	5.0	Run body
48	48.2		153	127	19,368	1.5	2.0	Run tail
49	48.2		346	75	25,887	1.5	2.0	Riffle
50	48.2		40	60	2,392	2.0	2.0	Run head
51	48.1		380	53	20,027	5.0	8.0	Run body
52	48.1		114	56	6,430	3.0	3.5	Run tail
53	48.0	Yes	234	54	12,554	1.5	2.0	Riffle
54	48.0	Yes	164	89	14,569	5.0	7.0	Pool head
55	47.2		4036	143	579,150	7.0	15.0	Pool body
56	47.2		136	115	15,575	1.5	2.5	Pool tail
57	47.1		740	80	58,852	1.5	2.0	Riffle
58	47.0		136	85	11,535	2.0	3.0	Run head
59	46.9		472	76	36,067	4.0	6.0	Run body
60	46.9		137	86	11,760	1.5	2.5	Run tail
61	46.9		318	81	25,666	1.0	2.0	Riffle
62	46.9		64	85	5,428	1.5	2.0	Run head
63	46.8		188	90	16,848	2.0	3.0	Run body
64	46.8		126	131	16,480	1.0	2.5	Run tail
65	46.8		100	123	12,268	0.8	1.5	Riffle
66	46.8		153	96	14,675	1.5	2.0	Run head
67	46.0		3829	97	370,148	4.0	6.0	Run body
68	46.0		89	133	11,835	1.5	2.0	Run tail
69	45.9		234	95	22,286	4.0	7.0	Run body
70	45.9	Yes	277	76	21,181	1.5	2.0	Riffle
71	45.9	Yes	61	93	5,701	2.0		Run head
72	45.8	Yes	243	94	22,751	2.5	3.5	Run body
73	45.8		125	64	7,976	1.5	2.0	Run tail
74	45.7		243	40	9,820	0.8	1.8	Riffle
75	45.7		90	35	3,141	1.5	2.0	Run head
76	45.7		88	50	4,433	1.5	4.0	Run body
77	45.7		32	99	3,153	1.5	2.0	Run tail
78	45.6		675	109	73,797	1.5	2.0	Riffle
79	45.6		85	178	15,127	1.5	2.0	Run head
80	45.4		1040	120	124,357	3.5	5.0	Run body
81	45.3	Yes	301	101	30,519	7.0	11.0	Pool body
82	45.3		126	220	27,658	2.0	3.0	Run head
83	45.1		1182	97	114,144	4.0	6.0	Run body
84	45.1		94	113	10,640	1.5	5.0	Run tail
85	45.0		394	52	20,673	1.5	2.0	Riffle

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
86	45.0		53	41	2,181	2.0	3.0	Pool head
87	44.9		101	71	7,213	5.0	8.0	Pool body
88	44.9		80	121	9,661	3.0	4.0	Pool tail
89	44.8		734	59	43,114	1.5	2.5	Riffle
90	44.8	Yes	22	107	2,350	0.8	1.5	Run head
91	44.8	Yes	318	62	19,745	1.5	2.5	Run body
92	44.8		15	25	368	1.0	1.5	Run tail
93	44.7		100	30	3,032	1.5	2.0	Riffle
94	44.7		47	26	1,217	1.0	1.5	Run head
95	44.7		248	67	16,708	4.0	8.0	Run body
96	44.7		34	87	2,950	1.5	2.0	Run tail
97	44.6		417	52	21,741	1.5	2.5	Riffle
98	44.6		20	49	984	2.0	2.5	Run head
99	44.6		203	53	10,740	3.0	4.0	Run body
100	44.5		20	59	1,182	1.0	1.5	Run tail
101	44.5		472	59	27,744	1.5	2.0	Riffle
102	44.5		10	68	681	2.0	2.5	Run head
103	43.9		3209	82	261,993	3.0	3.0	Run body
104	43.7		683	144	98,065	6.0	15.0	Pool body
105	43.3		2173	146	316,376	4.0	6.0	Run body
106	43.3		50	110	5,487	1.5	2.0	Run tail
107	43.2		326	81	26,534	1.5	2.0	Riffle
108	43.2		41	74	3,020	1.0	2.0	Run head
109	43.1		906	62	56,464	2.5	6.0	Run body
110	43.1		36	49	1,771	2.0	2.5	Run tail
111	43.0		238	42	10,077	0.8	1.2	Riffle
112	43.0		50	48	2,392	1.5	2.5	Pool head
113	43.0		159	166	26,397	5.0	7.0	Pool body
114	43.0		46	169	7,767	1.5	5.0	Pool tail
115	43.0		33	154	5,097	2.0	3.0	Run head
116	42.9		309	124	38,258	4.0	10.0	Run body
117	42.9		18	84	1,518	1.0	1.5	Run tail
118	42.9		77	57	4,403	1.0	2.0	Riffle
119	42.9		31	45	1,395	2.0	2.5	Run head
120	42.7		978	87	84,726	1.0	8.0	Run body
121	42.7		12	78	932	1.5	2.5	Run tail
122	42.7		89	48	4,288	1.0	3.0	Riffle
123	42.7		18	55	991	2.5	3.0	Run head
124	42.4		1571	77	120,609	2.0	5.0	Run body
125	42.4		69	96	6,600	1.5	2.0	Run body
126	42.3		227	55	12,478	1.0	3.0	Riffle
127	42.3		84	23	1,953	1.5	4.0	Run body
128	42.3		265	32	8,417	1.5	2.3	Riffle
129	42.2		25	28	699	1.5	3.0	Run head

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
130	42.1		1066	62	65,871	2.0	4.0	Run body
131	42.0		53	60	3,196	1.0	1.5	Run tail
132	41.9		521	64	33,202	1.0	1.5	Riffle
133	41.9		41	46	1,877	2.0	2.5	Run head
134	41.8		940	82	77,063	2.0	4.0	Run body
135	41.8		47	96	4,525	0.8	1.5	Run tail
136	41.7		300	90	27,080	0.8	1.5	Riffle
137	41.7		59	70	4,133	1.5	2.0	Run head
138	41.2		2512	123	308,848	3.0	6.0	Run body
139	41.2		125	151	18,858	1.0	1.3	Run tail
140	41.1		312	107	33,422	1.0	1.5	Riffle
141	41.1		102	163	16,604	1.5	2.0	Run head
142	41.0		666	185	122,933	2.0	4.5	Run body
143	41.0		83	182	15,121	0.8	1.3	Run tail
144	40.9		189	32	6,116	0.8	1.5	Riffle
145	40.9		62	39	2,425	1.5	2.0	Run head
146	40.5		2207	101	223,893	5.0	9.0	Run body
147	40.5		54	53	2,861	1.5	2.0	Run tail
148	40.4		638	53	33,978	1.5	2.5	Riffle
149	40.4		37	83	3,076	1.5	2.0	Run head
150	40.3		502	94	47,268	2.5	4.0	Run body
151	40.3		34	81	2,767	1.0	1.5	Run tail
152	40.2		503	53	26,860	0.8	1.5	Riffle
153	40.2		51	68	3,462	1.5	2.0	Run head
154	39.7		2569	123	317,216	3.0	7.0	Run body
155	39.7		26	142	3,699	1.5		Run tail
156	39.7		219	91	19,859	0.8	1.0	Riffle
157	39.6		86	62	5,294	3.0	4.0	Run head
158	39.5		857	97	82,763	6.0	6.6	Run body
159	39.5		98	81	7,993	2.5	3.0	Run tail
160	39.4		84	62	5,246	1.0	1.5	Riffle
161	39.4	Yes	123	41	5,102	3.5	4.5	Run head
162	39.3	Yes	713	50	35,662	5.0	7.5	Run body
163	39.3		151	80	12,041	3.5	5.0	Run tail
164	39.2	Yes	104	98	10,131	1.0	1.5	Riffle
165	39.2	Yes	93	117	10,818	3.5	4.0	Pool head
166	38.9		1496	90	134,259	6.5	9.9	Pool body
167	38.9		99	91	9,033	3.0	4.0	Pool tail
168	38.9		73	92	6,682	1.5	3.0	Riffle
169	38.9		76	108	8,227	4.0	5.0	Run head
170	38.8		498	77	38,331	5.5	7.2	Run body
171	38.8		121	83	10,096	7.0	10.5	Pool body
172	38.8		87	98	8,506	3.0	4.0	Run head
173	38.7		324	85	27,545	4.0	5.0	Run body

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
174	38.7		99	100	9,935	3.0	4.0	Run tail
175	38.7		61	118	7,163	1.5	2.3	Riffle
176	38.6		148	105	15,607	2.5	3.5	Run head
177	38.6		219	91	19,976	4.0	4.8	Run body
178	38.6		115	57	6,513	2.0	2.5	Run tail
179	38.5		412	55	22,840	1.2	2.0	Riffle
180	38.5		75	68	5,113	4.0	6.0	Run head
181	38.4		657	39	25,600	4.0	5.0	Run body
182	38.3	Yes	205	68	13,869	8.5	10.5	Pool body
183	38.3		183	66	12,189	4.5	10.5	Pool tail
184	38.3		129	102	13,154	2.5	6.0	Run head
185	38.2		137	139	18,966	2.0	2.5	Run body
186	38.2		134	149	19,976	2.0	2.0	Run tail
187	38.2		285	143	40,886	1.0	1.5	Riffle
188	38.1		86	93	7,964	2.5	4.0	Pool head
189	38.1		235	81	19,027	6.0	10.0	Pool body
190	38.1		55	145	7,947	2.5	4.0	Pool tail
191	38.1		89	115	10,283	1.0	2.0	Riffle
192	38.1	Yes	46	89	4,147	4.0	6.0	Pool head
193	38.0	Yes	378	83	31,490	8.0	13.0	Pool body
194	38.0		81	91	7,365	2.0	3.5	Pool tail
195	38.0		63	64	4,010	3.0	3.5	Run head
196	37.9		271	72	19,591	4.0	5.5	Run body
197	37.9		84	92	7,736	3.0	3.5	Run tail
198	37.8		227	75	17,099	2.0	2.5	Riffle
199	37.8		115	42	4,779	4.0	4.5	Pool head
200	37.7		926	78	72,513	4.0	6.6	Pool body
201	37.6		114	117	13,311	3.0	4.0	Pool tail
202	37.6		163	97	15,857	0.8	1.5	Riffle
203	37.6		130	88	11,423	2.0	3.0	Run head
204	37.5		618	91	55,953	2.5	3.5	Run body
205	37.4		102	77	7,851	2.0	3.0	Run tail
206	37.3		769	50	38,658	1.7	2.5	Riffle
207	37.3		99	58	5,710	2.5	4.0	Run head
208	37.1		916	57	51,803	3.5	4.5	Run body
209	37.1		58	52	3,054	2.0	3.0	Run tail
210	37.0		266	40	10,767	1.5	2.0	Riffle
211	37.0		127	36	4,530	5.0	7.0	Run head
212	36.9		370	80	29,741	5.5	7.6	Run body
213	36.9		85	98	8,321	2.0	3.0	Run tail
214	36.9		70	83	5,779	3.0	5.0	Pool head
215	36.9		126	58	7,330	7.0	10.5	Pool body
216	36.9		94	48	4,471	4.0	5.0	Pool tail
217	36.8	Yes	357	60	21,436	1.5	2.0	Riffle

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
218	36.8	Yes	157	75	11,815	3.0	4.0	Run head
219	36.6	Yes	675	97	65,353	3.0	6.0	Run body
220	36.6		62	86	5,313	3.0	4.0	Run tail
221	36.6		178	74	13,173	1.0	1.5	Riffle
222	36.6		181	71	12,919	3.0	5.0	Run head
223	36.4		1047	90	94,576	6.5	8.3	Run body
224	36.3		115	97	11,107	3.0	3.5	Run tail
225	36.3	Yes	224	92	20,644	1.5	2.0	Riffle
226	36.3		69	79	5,484	2.0	2.5	Run head
227	36.3		213	65	13,878	2.0	2.5	Run body
228	36.2		70	58	4,092	1.5	2.0	Run tail
229	36.2		74	54	4,022	1.2	2.0	Riffle
230	36.2	Yes	89	72	6,363	4.0	9.8	Pool head
231	36.2	Yes	175	131	22,846	6.0	12.3	Pool body
232	36.2		106	107	11,336	4.0	6.0	Pool tail
233	36.1		211	78	16,529	2.0	3.0	Pool head
234	35.7		2458	72	177,862	9.0	13.4	Pool body
235	35.6		210	53	11,010	3.0	3.5	Pool tail
236	35.5		353	97	34,136	1.0	1.5	Riffle
237	35.5		368	126	46,431	2.0	3.0	Run head
238	35.2		1394	100	139,804	3.5	7.0	Run body
239	35.2		48	84	4,006	3.0	4.0	Run tail
240	35.2		81	79	6,351	2.0	3.0	Riffle
241	35.2		70	60	4,157	3.0	4.0	Run head
242	35.2		74	68	5,054	4.5	5.8	Run body
243	35.1		62	65	3,996	1.5	2.0	Run tail
244	35.1		501	54	27,305	2.0	3.0	Riffle
245	35.0		79	82	6,466	1.5	2.5	Run head
246	35.0		302	65	19,636	2.0	3.0	Run body
247	35.0		114	31	3,548	1.5	2.0	Run tail
248	34.9		62	50	3,125	1.5	2.0	Riffle
249	34.9		151	50	7,602	3.0	4.0	Run head
250	34.7		1255	62	78,340	3.5	7.0	Run body
251	34.6		351	66	23,058	6.5	10.5	Pool body
252	34.6		119	82	9,791	3.0	4.0	Pool tail
253	34.5		293	77	22,628	1.0	2.0	Riffle
254	34.5		61	63	3,879	8.0	12.0	Pool head
255	34.4		445	79	35,344	4.0	8.0	Pool body
256	34.1		1722	91	157,333	3.0	4.0	Run body
257	34.1		137	81	11,136	1.5	2.0	Run tail
258	34.1		130	70	9,152	1.0	1.5	Riffle
259	34.0		103	79	8,137	2.0	2.5	Run head
260	34.0		452	59	26,907	2.5	3.5	Run body
261	33.9		142	38	5,468	1.5	2.0	Run tail

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
262	33.8		505	32	16,314	1.0	1.5	Riffle
263	33.8		86	53	4,509	2.0	2.5	Run head
264	33.8		265	52	13,757	3.0	3.5	Run body
265	33.8		59	57	3,342	2.0	2.5	Run tail
266	33.7		524	43	22,663	2.0	4.0	Riffle
267	33.6		241	67	16,237	3.0	4.0	Run head
268	33.5		690	116	79,804	2.5	5.0	Run body
269	33.4		231	79	18,336	1.0	2.0	Run tail
270	33.4		163	63	10,208	1.0	1.5	Riffle
271	33.4		49	74	3,588	6.0	7.5	Pool head
272	33.2		898	71	63,477	9.0	12.0	Pool body
273	33.2		102	39	3,988	2.0	3.0	Pool tail
274	33.2		190	55	10,514	1.0	1.5	Riffle
275	33.2		103	71	7,311	1.5	2.5	Run head
276	33.1		343	105	35,908	2.0	2.5	Run body
277	33.1		136	118	16,054	1.5	2.0	Run tail
278	33.0		312	62	19,368	1.0	1.5	Riffle
279	33.0		209	35	7,298	3.5	6.0	Run head
280	32.1		4454	174	776,561	5.5	9.2	Run body
281	32.1		143	124	17,763	4.0	5.5	Run tail
282	32.0		293	100	29,228	1.0	1.5	Riffle
283	32.0		163	107	17,489	2.5	3.0	Run head
284	32.0		294	86	25,244	3.5	4.0	Run body
285	31.9		41	86	3,565	2.0	3.7	Run tail
286	31.9		290	87	25,317	1.0	2.0	Riffle
287	31.9		157	43	6,710	2.5	3.0	Run head
288	31.7		838	55	45,952	3.5	5.0	Run body
289	31.7		112	85	9,543	2.5	3.0	Run tail
290	31.6		181	100	18,051	1.0	2.0	Riffle
291	31.6		148	108	15,990	4.0	5.5	Run head
292	31.5		475	89	42,320	5.0	6.0	Run body
293	31.5		154	62	9,597	1.5	2.5	Run tail
294	31.5		175	74	13,012	1.0	1.5	Riffle
295	31.4		210	100	21,058	3.0	4.5	Run head
296	31.3		567	87	49,612	4.0	5.5	Run body
297	31.3		139	54	7,465	2.5	4.0	Run tail
298	31.2		538	44	23,863	1.5	2.5	Riffle
299	31.2		122	70	8,583	3.5	4.5	Run head
300	31.1		240	61	14,568	3.5	5.0	Run body
301	31.1		41	72	2,974	2.0	3.0	Run tail
302	31.1		206	66	13,664	1.3	2.0	Riffle
303	31.1		98	75	7,324	3.0	4.0	Run head
304	30.7		1892	85	160,847	4.0	5.5	Run body
305	30.7		200	102	20,508	1.5	2.5	Run tail

Sampling Unit	RM	September 2011 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
306	30.6		113	83	9,452	1.2	2.0	Riffle
307	30.6		113	69	7,775	2.0	3.5	Run head
308	30.5		513	74	37,874	3.5	6.5	Run body
309	30.5		157	95	14,947	2.5	3.5	Run tail
310	30.4		259	37	9,478	1.0	2.0	Riffle
311	30.4		71	40	2,836	2.5	3.0	Run head
312	30.4		188	47	8,790	2.5	3.0	Run body
313	30.4		59	49	2,887	1.5	3.0	Run tail
314	30.2		946	43	40,519	1.2	2.0	Riffle
315	30.2		263	49	12,952	2.5	3.0	Run head
316	30.1		123	60	7,371	2.5	5.0	Run body
317	30.1		52	71	3,674	2.0	3.0	Run tail
318	30.1		189	298	56,219	1.5	2.0	Riffle
319	30.0		329	171	56,219	2.0	3.0	Run head
320	29.7		1444	155	224,395	5.0	8.0	Run body
321	29.7		68	59	3,978	3.0	4.0	Run tail
322	29.6		681	329	223,763	11.0	15.7	Pool body
323	29.6		222	84	18,626	3.0	7.0	Pool tail
324	29.5		109	38	4,188	1.0	2.0	Riffle
325	29.5		110	55	6,041	4.0	5.0	Run head
326	29.5		190	51	9,726	3.0	4.0	Run body
327	29.5		52	63	3,270	2.0	3.0	Run tail
328	29.5		70	58	4,066	1.2	2.0	Riffle
329	29.4		88	40	3,575	3.5	4.0	Run head
330	29.4		301	53	15,958	3.5	4.5	Run body
331	29.4		169	79	13,387	1.5	2.5	Run tail
332	29.3		192	168	32,257	1.2	2.0	Riffle
333	29.3		131	139	18,145	2.0	3.8	Run head
334	29.2		402	110	44,240	3.0	5.0	Run body
335	29.2		51	135	6,896	2.0	3.5	Run tail
336	29.2		247	92	22,792	1.0	1.5	Riffle
337	29.1		103	88	9,057	2.5	3.0	Run head
338	29.1		168	89	14,954	3.5	4.5	Run body
339	29.0		331	127	42,219	2.0	2.5	Run tail
340	29.0		447	90	40,119	1.5	2.0	Riffle

Table D-2. Percent cover and type for habitat units within the study area.

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
51.8	1	Pool head	7/8/2008	90	5			5	
51.7	2	Pool body	7/8/2008	80					20
51.7	3	Pool tail	7/8/2008	100					
51.6	4	Pool head	7/8/2008	100					
51.6	5	Pool body	7/8/2008	90					10
51.5	6	Pool tail	7/8/2008	100					
51.5	7	Riffle	7/8/2008	90	5			5	
51.4	8	Run head	7/8/2008	85				5	10
51.1	9	Run body	7/8/2008	60	10				30
51.0	10	Run tail	7/8/2008	90					10
50.9	11	Pool body	7/8/2008	50					50
50.8	12	Run body	7/8/2008	45	5				50
50.8	13	Run tail	7/8/2008	90				10	
50.6	14	Riffle	7/8/2008	80	10		10		
50.6	15	Run head	7/8/2008	90	10				
50.5	16	Run body	7/8/2008	95				5	
50.4	17	Run tail	7/8/2008	90				5	
50.3	18	Riffle	7/8/2008	90	5				5
50.3	19	Run head	7/8/2008	90					10
50.1	20	Run body	7/8/2008	95				5	
50.1	21	Run tail	7/8/2008	90	5			5	
50.1	22	Riffle	7/8/2008	95					5
50.0	23	Run head	7/8/2008	95				5	
49.9	24	Run body	7/8/2008	95				5	
49.8	25	Run tail	7/8/2008	95				5	
49.7	26	Riffle	7/8/2008	90	5			5	
49.7	27	Pool head	7/8/2008	85	10			5	
49.6	28	Pool body	7/8/2008	85	10			5	
49.6	29	Pool tail	7/8/2008	85	10			5	
49.6	30	Run head	7/8/2008	100					
49.3	31	Run body	7/8/2008	95		5			
49.3	32	Run tail	7/8/2008	95				5	
49.2	33	Riffle	7/8/2008	90	5			5	
49.2	34	Run head	7/8/2008	85	5			10	
49.1	35	Run body	7/8/2008	85	5			10	
49.1	36	Run tail	7/8/2008	95				5	
49.1	37	Riffle	7/8/2008	95				5	
49.1	38	Run head	7/8/2008	90		5		5	
49.1	39	Run body	7/8/2008	90	5			5	
49.0	40	Run tail	7/8/2008	95				5	
48.8	41	Riffle	7/8/2008	95				5	
48.8	42	Run head	7/8/2008	75				5	20
48.7	43	Run body	7/8/2008	90				10	

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
48.7	44	Run tail	7/8/2008	95				5	
48.4	45	Riffle	7/8/2008	90				10	
48.4	46	Run head	7/8/2008	90				10	
48.3	47	Run body	7/8/2008	90				10	
48.2	48	Run tail	7/8/2008	90				10	
48.2	49	Riffle	7/8/2008	90				10	
48.2	50	Run head	7/8/2008	90		5		5	
48.1	51	Run body	7/8/2008	95	5				
48.1	52	Run tail	7/8/2008	95	5				
48.0	53	Riffle	7/8/2008	95				5	
48.0	54	Pool head	7/8/2008	85	10			5	
47.2	55	Pool body	7/8/2008	85	10			5	
47.2	56	Pool tail	7/8/2008	95				5	
47.1	57	Riffle	7/8/2008	100					
47.0	58	Run head	7/8/2008	100					
46.9	59	Run body	7/8/2008	95				5	
46.9	60	Run tail	7/8/2008	90				10	
46.9	61	Riffle	7/8/2008	95				5	
46.9	62	Run head	7/8/2008	90				10	
46.8	63	Run body	7/8/2008	95				5	
46.8	64	Run tail	7/8/2008	95				5	
46.8	65	Riffle	7/8/2008	95				5	
46.8	66	Run head	7/8/2008	100					
46.0	67	Run body	7/8/2008	95				5	
46.0	68	Run tail	7/8/2008	95				5	
45.9	69	Run body	7/8/2008	100					
45.9	70	Riffle	7/8/2008	90				10	
45.9	71	Run head	7/8/2008	95				5	
45.8	72	Run body	7/8/2008	95				5	
45.8	73	Run tail	7/8/2008	100					
45.7	74	Riffle	7/8/2008	95				5	
45.7	75	Run head	7/9/2008	90				10	
45.7	76	Run body	7/9/2008	90				10	
45.7	77	Run tail	7/9/2008	100					
45.6	78	Riffle	7/9/2008	95				5	
45.6	79	Run head	7/9/2008	85				5	10
45.4	80	Run body	7/9/2008	80	15			5	
45.3	81	Pool body	7/9/2008	40		5		5	50
45.3	82	Run head	7/9/2008	45				5	50
45.1	83	Run body	7/9/2008	35		5		10	50
45.1	84	Run tail	7/9/2008	75		5		20	
45.0	85	Riffle	7/9/2008	70		5		25	
45.0	86	Pool head	7/9/2008	85		5		10	
44.9	87	Pool body	7/9/2008	90		5		5	
44.9	88	Pool tail	7/9/2008	95					5

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
44.8	89	Riffle	7/9/2008	90				10	
44.8	90	Run head	7/9/2008	90		5		5	
44.8	91	Run body	7/9/2008	100					
44.8	92	Run tail	7/9/2008	85				15	
44.7	93	Riffle	7/9/2008	80				20	
44.7	94	Run head	7/9/2008	90				10	
44.7	95	Run body	7/9/2008	100					
44.7	96	Run tail	7/9/2008	95				5	
44.6	97	Riffle	7/9/2008	90				10	
44.6	98	Run head	7/9/2008	95				5	
44.6	99	Run body	7/9/2008	95				5	
44.5	100	Run tail	7/9/2008	95				5	
44.5	101	Riffle	7/9/2008	95				5	
44.5	102	Run head	7/9/2008	100					
43.9	103	Run body	7/9/2008	90				10	
43.7	104	Pool body	7/9/2008	65				5	30
43.3	105	Run body	7/9/2008	65				5	30
43.3	106	Run tail	7/9/2008	90				5	5
43.2	107	Riffle	7/9/2008	85		5		10	
43.2	108	Run head	7/9/2008	95				5	
43.1	109	Run body	7/9/2008	95				5	
43.1	110	Run tail	7/9/2008	90				10	
43.0	111	Riffle	7/9/2008	95				5	
43.0	112	Pool head	7/9/2008	65		5			30
43.0	113	Pool body	7/9/2008	60		10			30
43.0	114	Pool tail	7/9/2008	70		25		5	
43.0	115	Run head	7/9/2008	70		20		10	
42.9	116	Run body	7/9/2008	100					
42.9	117	Run tail	7/9/2008	95				5	
42.9	118	Riffle	7/9/2008	95				5	
42.9	119	Run head	7/9/2008	95				5	
42.7	120	Run body	7/9/2008	95				5	
42.7	121	Run tail	7/9/2008	95				5	
42.7	122	Riffle	7/9/2008	90				5	5
42.7	123	Run head	7/9/2008	95				5	
42.4	124	Run body	7/9/2008	95				5	
42.4	125	Run body	7/9/2008	95				5	
42.3	126	Riffle	7/9/2008	80				20	
42.3	127	Run body	7/9/2008	100					
42.3	128	Riffle	7/9/2008	75	5	5		15	
42.2	129	Run head	7/9/2008	90				10	
42.1	130	Run body	7/9/2008	90				10	
42.0	131	Run tail	7/9/2008	95				5	
41.9	132	Riffle	7/9/2008	95				5	
41.9	133	Run head	7/9/2008	95				5	

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
41.8	134	Run body	7/9/2008	95				5	
41.8	135	Run tail	7/9/2008	95				5	
41.7	136	Riffle	7/9/2008	95				5	
41.7	137	Run head	7/9/2008	90				10	
41.2	138	Run body	7/9/2008	100					
41.2	139	Run tail	7/9/2008	95				5	
41.1	140	Riffle	7/9/2008	95				5	
41.1	141	Run head	7/9/2008	80					20
41.0	142	Run body	7/9/2008	95				5	
41.0	143	Run tail	7/9/2008	95				5	
40.9	144	Riffle	7/9/2008	95				5	
40.9	145	Run head	7/9/2008	100					
40.5	146	Run body	7/9/2008	65				10	25
40.5	147	Run tail	7/9/2008	85				15	
40.4	148	Riffle	7/9/2008	70				30	
40.4	149	Run head	7/9/2008	75				5	20
40.3	150	Run body	7/9/2008	100					
40.3	151	Run tail	7/9/2008	100					
40.2	152	Riffle	7/9/2008	95				5	
40.2	153	Run head	7/9/2008	100					
39.7	154	Run body	7/9/2008	95				5	
39.7	155	Run tail	7/9/2008	95				5	
39.7	156	Riffle	2/10/2009	95					5
39.6	157	Run head	2/10/2009	100					
39.5	158	Run body	2/10/2009	80					20
39.5	159	Run tail	2/10/2009	80					20
39.4	160	Riffle	2/10/2009	95					5
39.4	161	Run head	2/10/2009	95					
39.3	162	Run body	2/10/2009	95				5	
39.3	163	Run tail	2/10/2009	95				5	
39.2	164	Riffle	2/10/2009	95					5
39.2	165	Pool head	2/10/2009	100					
38.9	166	Pool body	2/10/2009	90					10
38.9	167	Pool tail	2/10/2009	100					
38.9	168	Riffle	2/10/2009	100					
38.9	169	Run head	2/10/2009	100					
38.8	170	Run body	2/10/2009	100					
38.8	171	Pool body	2/10/2009	90				5	5
38.8	172	Run head	2/10/2009	95				5	
38.7	173	Run body	2/10/2009	95				5	
38.7	174	Run tail	2/10/2009	100					
38.7	175	Riffle	2/10/2009	100					
38.6	176	Run head	2/10/2009	100					
38.6	177	Run body	2/10/2009	100					
38.6	178	Run tail	2/10/2009	100					

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
38.5	179	Riffle	2/10/2009	100					
38.5	180	Run head	2/10/2009	90					10
38.4	181	Run body	2/10/2009	100					
38.3	182	Pool body	2/10/2009	80					20
38.3	183	Pool tail	2/10/2009	90				5	5
38.3	184	Run head	2/10/2009	100					
38.2	185	Run body	2/10/2009	100					
38.2	186	Run tail	2/10/2009	100					
38.2	187	Riffle	2/10/2009	95				5	
38.1	188	Pool head	2/10/2009	95				5	
38.1	189	Pool body	2/11/2009	90					10
38.1	190	Pool tail	2/11/2009	100					
38.1	191	Riffle	2/11/2009	100					
38.1	192	Pool head	2/11/2009	90					10
38.0	193	Pool body	2/11/2009	70					30
38.0	194	Pool tail	2/11/2009	100					
38.0	195	Run head	2/11/2009	100					
37.9	196	Run body	2/11/2009	100					
37.9	197	Run tail	2/11/2009	100					
37.8	198	Riffle	2/11/2009	100					
37.8	199	Pool head	2/11/2009	85		15			
37.7	200	Pool body	2/11/2009	100					
37.6	201	Pool tail	2/11/2009	100					
37.6	202	Riffle	2/11/2009	100					
37.6	203	Run head	2/11/2009	100					
37.5	204	Run body	2/11/2009	100					
37.4	205	Run tail	2/11/2009	100					
37.3	206	Riffle	2/11/2009	100					
37.3	207	Run head	2/11/2009	100					
37.1	208	Run body	2/11/2009	100					
37.1	209	Run tail	2/11/2009	100					
37.0	210	Riffle	2/11/2009	100					
37.0	211	Run head	2/11/2009	100					
36.9	212	Run body	2/11/2009	100					
36.9	213	Run tail	2/11/2009	100					
36.9	214	Pool head	2/11/2009	100					
36.9	215	Pool body	2/11/2009	100					
36.9	216	Pool tail	2/11/2009	100					
36.8	217	Riffle	2/11/2009	100					
36.8	218	Run head	2/11/2009	100					
36.6	219	Run body	2/11/2009	100					
36.6	220	Run tail	2/11/2009	100					
36.6	221	Riffle	2/11/2009	100					
36.6	222	Run head	2/11/2009	100					
36.4	223	Run body	2/11/2009	100					

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
36.3	224	Run tail	2/11/2009	100					
36.3	225	Riffle	2/11/2009	100					
36.3	226	Run head	2/11/2009	100					
36.3	227	Run body	2/11/2009	100					
36.2	228	Run tail	2/11/2009	100					
36.2	229	Riffle	2/11/2009	100					
36.2	230	Pool head	2/11/2009	100					
36.2	231	Pool body	2/11/2009	100					
36.2	232	Pool tail	2/11/2009	100					
36.1	233	Pool head	2/11/2009	100					
35.7	234	Pool body	2/11/2009	100					
35.6	235	Pool tail	2/11/2009	100					
35.5	236	Riffle	2/11/2009	100					
35.5	237	Run head	2/11/2009	100					
35.2	238	Run body	2/11/2009	100					
35.2	239	Run tail	2/12/2009	95				5	
35.2	240	Riffle	2/12/2009	100					
35.2	241	Run head	2/12/2009	100					
35.2	242	Run body	2/12/2009	100					
35.1	243	Run tail	2/12/2009	100					
35.1	244	Riffle	2/12/2009	100					
35.0	245	Run head	2/12/2009	95				5	
35.0	246	Run body	2/12/2009	95				5	
35.0	247	Run tail	2/12/2009	100					
34.9	248	Riffle	2/12/2009	100					
34.9	249	Run head	2/12/2009	95		5			
34.7	250	Run body	2/12/2009	100					
34.6	251	Pool body	2/12/2009	75				5	20
34.6	252	Pool tail	2/12/2009	100					
34.5	253	Riffle	2/12/2009	95				5	
34.5	254	Pool head	2/12/2009	100					
34.4	255	Pool body	2/12/2009	100					
34.1	256	Run body	2/12/2009	100					
34.1	257	Run tail	2/12/2009	95				5	
34.1	258	Riffle	2/12/2009	100					
34.0	259	Run head	2/12/2009	100					
34.0	260	Run body	2/12/2009	100					
33.9	261	Run tail	2/12/2009	100					
33.8	262	Riffle	2/12/2009	100					
33.8	263	Run head	2/12/2009	100					
33.8	264	Run body	2/12/2009	100					
33.8	265	Run tail	2/12/2009	100					
33.7	266	Riffle	2/12/2009	100					
33.6	267	Run head	2/12/2009	100					
33.5	268	Run body	2/12/2009	100					

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
33.4	269	Run tail	2/12/2009	100					
33.4	270	Riffle	2/12/2009	100					
33.4	271	Pool head	2/12/2009	100					
33.2	272	Pool body	2/12/2009	70					30
33.2	273	Pool tail	2/12/2009	100					
33.2	274	Riffle	2/12/2009	100					
33.2	275	Run head	2/12/2009	100					
33.1	276	Run body	2/12/2009	95					5
33.1	277	Run tail	2/12/2009	100					
33.0	278	Riffle	2/12/2009	100					
33.0	279	Run head	2/12/2009	100					
32.1	280	Run body	2/12/2009	60					40
32.1	281	Run tail	2/12/2009						
32.0	282	Riffle	2/12/2009						
32.0	283	Run head	2/12/2009						
32.0	284	Run body	2/12/2009						
31.9	285	Run tail	2/12/2009						
31.9	286	Riffle	2/12/2009						
31.9	287	Run head	2/12/2009						
31.7	288	Run body	2/12/2009						
31.7	289	Run tail	2/12/2009						
31.6	290	Riffle	2/12/2009						
31.6	291	Run head	2/12/2009						
31.5	292	Run body	2/12/2009						
31.5	293	Run tail	2/12/2009						
31.5	294	Riffle	2/12/2009	100					
31.4	295	Run head	2/12/2009	100					
31.3	296	Run body	2/12/2009	100					
31.3	297	Run tail	2/12/2009	100					
31.2	298	Riffle	2/12/2009	100					
31.2	299	Run head	2/13/2009	100					
31.1	300	Run body	2/13/2009	100					
31.1	301	Run tail	2/13/2009	100					
31.1	302	Riffle	2/13/2009	100					
31.1	303	Run head	2/13/2009	100					
30.7	304	Run body	2/13/2009	100					
30.7	305	Run tail	2/13/2009	90					10
30.6	306	Riffle	2/13/2009	100					
30.6	307	Run head	2/13/2009	100					
30.5	308	Run body	2/13/2009	100					
30.5	309	Run tail	2/13/2009	100					
30.4	310	Riffle	2/13/2009	85				15	
30.4	311	Run head	2/13/2009	100					
30.4	312	Run body	2/13/2009	100					
30.4	313	Run tail	2/13/2009	100					

River mile	Sampling unit	Habitat type	Habitat survey date	No cover (%)	Boulder (%)	Wood (%)	Ledge (%)	Overhang (%)	Aquatic vegetation (%)
30.2	314	Riffle	2/13/2009	90				10	
30.2	315	Run head	2/13/2009	100					
30.1	316	Run body	2/13/2009	100					
30.1	317	Run tail	2/13/2009	100					
30.1	318	Riffle	2/13/2009	100					
30.0	319	Run head	2/13/2009	100					
29.7	320	Run body	2/13/2009	70					30
29.7	321	Run tail	2/13/2009	90					10
29.6	322	Pool body	2/13/2009	100					
29.6	323	Pool tail	2/13/2009	100					
29.5	324	Riffle	2/13/2009	100					
29.5	325	Run head	2/13/2009	95	5				
29.5	326	Run body	2/13/2009	85					15
29.5	327	Run tail	2/13/2009	100					
29.5	328	Riffle	2/13/2009	100					
29.4	329	Run head	2/13/2009	100					
29.4	330	Run body	2/13/2009	100					
29.4	331	Run tail	2/13/2009	100					
29.3	332	Riffle	2/13/2009	90				10	
29.3	333	Run head	2/13/2009	100					
29.2	334	Run body	2/13/2009	100					
29.2	335	Run tail	2/13/2009	100					
29.2	336	Riffle	2/13/2009	100					
29.1	337	Run head	2/13/2009	100					
29.1	338	Run body	2/13/2009	90					10
29.0	339	Run tail	2/13/2009	100					
29.0	340	Riffle	2/13/2009	100					

Table D-3. Substrate types for sampling units within the study area.

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
51.8	1	Pool head	7/8/2008	10	50	40				
51.7	2	Pool body	7/8/2008	50	40	10				
51.7	3	Pool tail	7/8/2008	20	30	50				
51.6	4	Pool head	7/8/2008	50	20	30				
51.6	5	Pool body	7/8/2008	50	20	25		5		
51.5	6	Pool tail	7/8/2008	40	30	30				
51.5	7	Riffle	7/8/2008		30	60	10			
51.4	8	Run head	7/8/2008		20	60	10	10		
51.1	9	Run body	7/8/2008	15	15	60	10			
51.0	10	Run tail	7/8/2008			60	30	10		
50.9	11	Pool body	7/8/2008	20	10	50		20		
50.8	12	Run body	7/8/2008	20	10	50		20		
50.8	13	Run tail	7/8/2008			60	30	10		
50.6	14	Riffle	7/8/2008			60	30	10		
50.6	15	Run head	7/8/2008		10	50	40			
50.5	16	Run body	7/8/2008	10	10	60	20			
50.4	17	Run tail	7/8/2008		20	60	20			
50.3	18	Riffle	7/8/2008		20	60	20			
50.3	19	Run head	7/8/2008		20	60	20			
50.1	20	Run body	7/8/2008		20	60	20			
50.1	21	Run tail	7/8/2008		20	60	20			
50.1	22	Riffle	7/8/2008		20	60	20			
50.0	23	Run head	7/8/2008		20	60	20			
49.9	24	Run body	7/8/2008		60	20	20			
49.8	25	Run tail	7/8/2008		40	40	20			
49.7	26	Riffle	7/8/2008		20	60	20			
49.7	27	Pool head	7/8/2008	20	20	40	10	10		
49.6	28	Pool body	7/8/2008	20	20	40	10	10		
49.6	29	Pool tail	7/8/2008	10	20	60	10			
49.6	30	Run head	7/8/2008		20	60	20			
49.3	31	Run body	7/8/2008		20	60	20			
49.3	32	Run tail	7/8/2008		10	70	20			
49.2	33	Riffle	7/8/2008		10	70	20			
49.2	34	Run head	7/8/2008		10	70	20			
49.1	35	Run body	7/8/2008		10	70	20			
49.1	36	Run tail	7/8/2008		10	70	20			
49.1	37	Riffle	7/8/2008		10	70	20			
49.1	38	Run head	7/8/2008		10	70	20			
49.1	39	Run body	7/8/2008		10	70	20			
49.0	40	Run tail	7/8/2008		10	70	20			
48.8	41	Riffle	7/8/2008		10	70	20			
48.8	42	Run head	7/8/2008		10	70	20			
48.7	43	Run body	7/8/2008		40	40	20			

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
48.7	44	Run tail	7/8/2008		40	40	20			
48.4	45	Riffle	7/8/2008		20	60	20			
48.4	46	Run head	7/8/2008		10	40	50			
48.3	47	Run body	7/8/2008		10	50	40			
48.2	48	Run tail	7/8/2008		10	70	20			
48.2	49	Riffle	7/8/2008		10	70	20			
48.2	50	Run head	7/8/2008		10	70	20			
48.1	51	Run body	7/8/2008	20	10	50	20			
48.1	52	Run tail	7/8/2008	20	10	50	20			
48.0	53	Riffle	7/8/2008		10	70	20			
48.0	54	Pool head	7/8/2008	20	10	60	5	5		
47.2	55	Pool body	7/8/2008	20	10	60	5	5		
47.2	56	Pool tail	7/8/2008		10	70	20			
47.1	57	Riffle	7/8/2008		10	70	20			
47.0	58	Run head	7/8/2008		10	70	20			
46.9	59	Run body	7/8/2008	20	10	50	20			
46.9	60	Run tail	7/8/2008		20	60	20			
46.9	61	Riffle	7/8/2008		10	70	20			
46.9	62	Run head	7/8/2008		10	70	20			
46.8	63	Run body	7/8/2008		10	70	20			
46.8	64	Run tail	7/8/2008		10	60	30			
46.8	65	Riffle	7/8/2008		10	60	30			
46.8	66	Run head	7/8/2008		10	50	30	10		
46.0	67	Run body	7/8/2008		20	50	20	10		
46.0	68	Run tail	7/8/2008		10	70	20			
45.9	69	Run body	7/8/2008		10	70	20			
45.9	70	Riffle	7/8/2008			20	70	10		
45.9	71	Run head	7/8/2008			30	40	30		
45.8	72	Run body	7/8/2008			40	40	20		
45.8	73	Run tail	7/8/2008			40	50	10		
45.7	74	Riffle	7/8/2008			40	50	10		
45.7	75	Run head	7/9/2008		10	60	20	10		
45.7	76	Run body	7/9/2008		10	60	20	10		
45.7	77	Run tail	7/9/2008		10	60	20	10		
45.6	78	Riffle	7/9/2008			70	20	10		
45.6	79	Run head	7/9/2008		10	10	30	50		
45.4	80	Run body	7/9/2008	20	20	30		30		
45.3	81	Pool body	7/9/2008	30	20	20		30		
45.3	82	Run head	7/9/2008			10	30	50	10	
45.1	83	Run body	7/9/2008	10	20	50	10	10		
45.1	84	Run tail	7/9/2008		10	70	20			
45.0	85	Riffle	7/9/2008		10	60	30			
45.0	86	Pool head	7/9/2008		10	60	30			
44.9	87	Pool body	7/9/2008			60	20	20		
44.9	88	Pool tail	7/9/2008			60	20	20		

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
44.8	89	Riffle	7/9/2008		20	60	20			
44.8	90	Run head	7/9/2008			40	50	10		
44.8	91	Run body	7/9/2008		10	60	30			
44.8	92	Run tail	7/9/2008		10	60	30			
44.7	93	Riffle	7/9/2008			60	30	10		
44.7	94	Run head	7/9/2008			60	30	10		
44.7	95	Run body	7/9/2008							
44.7	96	Run tail	7/9/2008			40	10	50		
44.6	97	Riffle	7/9/2008		10	50	40			
44.6	98	Run head	7/9/2008		10	50	40			
44.6	99	Run body	7/9/2008		10	40	40	10		
44.5	100	Run tail	7/9/2008		10	40	40	10		
44.5	101	Riffle	7/9/2008	10	10	50	30			
44.5	102	Run head	7/9/2008		10	50	30	10		
43.9	103	Run body	7/9/2008	40	10	30	10	10		
43.7	104	Pool body	7/9/2008	20	10	20		50		
43.3	105	Run body	7/9/2008	20	10	20		50		
43.3	106	Run tail	7/9/2008		10	60	20	10		
43.2	107	Riffle	7/9/2008		10	60	30			
43.2	108	Run head	7/9/2008		10	60	20	10		
43.1	109	Run body	7/9/2008		10	60	30			
43.1	110	Run tail	7/9/2008		10	60	30			
43.0	111	Riffle	7/9/2008		10	60	30			
43.0	112	Pool head	7/9/2008		10	50	30	10		
43.0	113	Pool body	7/9/2008		10	50	30	10		
43.0	114	Pool tail	7/9/2008		10	50	30	10		
43.0	115	Run head	7/9/2008		10	50	30	10		
42.9	116	Run body	7/9/2008		10	60	30			
42.9	117	Run tail	7/9/2008		10	60	30			
42.9	118	Riffle	7/9/2008		10	60	30			
42.9	119	Run head	7/9/2008		20	50	30			
42.7	120	Run body	7/9/2008		20	50	30			
42.7	121	Run tail	7/9/2008		10	60	30			
42.7	122	Riffle	7/9/2008		10	50	40			
42.7	123	Run head	7/9/2008		10	50	40			
42.4	124	Run body	7/9/2008		10	50	40			
42.4	125	Run body	7/9/2008		10	50	40			
42.3	126	Riffle	7/9/2008		10	50	40			
42.3	127	Run body	7/9/2008	50		40	10			
42.3	128	Riffle	7/9/2008	15	10	50	20	5		
42.2	129	Run head	7/9/2008	15	10	50	20	5		
42.1	130	Run body	7/9/2008		10	60	30			
42.0	131	Run tail	7/9/2008		10	50	40			
41.9	132	Riffle	7/9/2008		15	50	35			
41.9	133	Run head	7/9/2008	15	15	45	25			

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
41.8	134	Run body	7/9/2008	15	15	40	20	10		
41.8	135	Run tail	7/9/2008		10	60	30			
41.7	136	Riffle	7/9/2008		10	60	30			
41.7	137	Run head	7/9/2008	15	10	50	25			
41.2	138	Run body	7/9/2008	15	10	50	25			
41.2	139	Run tail	7/9/2008		10	60	20	10		
41.1	140	Riffle	7/9/2008		10	50	30	10		
41.1	141	Run head	7/9/2008		10	50	30	10		
41.0	142	Run body	7/9/2008		10	50	30	10		
41.0	143	Run tail	7/9/2008		10	60	20	10		
40.9	144	Riffle	7/9/2008		10	60	20	10		
40.9	145	Run head	7/9/2008		10	50	40			
40.5	146	Run body	7/9/2008		50	20		30		
40.5	147	Run tail	7/9/2008		10	60	30			
40.4	148	Riffle	7/9/2008		10	50	40			
40.4	149	Run head	7/9/2008		10	50	30	10		
40.3	150	Run body	7/9/2008							
40.3	151	Run tail	7/9/2008		20	50	30			
40.2	152	Riffle	7/9/2008		20	50	30			
40.2	153	Run head	7/9/2008		20	50	30			
39.7	154	Run body	7/9/2008	20	10	50	10	10		
39.7	155	Run tail	7/9/2008		10	50	40			
39.7	156	Riffle	2/10/2009			50	40	10		
39.6	157	Run head	2/10/2009			30	20	50		
39.5	158	Run body	2/10/2009			30	20	50		
39.5	159	Run tail	2/10/2009			30	20	50		
39.4	160	Riffle	2/10/2009			50	40	10		
39.4	161	Run head	2/10/2009		10	50	30	10		
39.3	162	Run body	2/10/2009		10	50	30	10		
39.3	163	Run tail	2/10/2009	5		55	30	10		
39.2	164	Riffle	2/10/2009			50	40	10		
39.2	165	Pool head	2/10/2009			30	60	10		
38.9	166	Pool body	2/10/2009			20	50	30		
38.9	167	Pool tail	2/10/2009			50	40	10		
38.9	168	Riffle	2/10/2009			50	40	10		
38.9	169	Run head	2/10/2009			60	25	15		
38.8	170	Run body	2/10/2009			30	40	30		
38.8	171	Pool body	2/10/2009		5	60	20	15		
38.8	172	Run head	2/10/2009			60	30	10		
38.7	173	Run body	2/10/2009			60	30	10		
38.7	174	Run tail	2/10/2009			60	30	10		
38.7	175	Riffle	2/10/2009			60	30	10		
38.6	176	Run head	2/10/2009			60	30	10		
38.6	177	Run body	2/10/2009			60	30	10		
38.6	178	Run tail	2/10/2009			60	30	10		

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
38.5	179	Riffle	2/10/2009			60	30	10		
38.5	180	Run head	2/10/2009			50	20	30		
38.4	181	Run body	2/10/2009			60	30	10		
38.3	182	Pool body	2/10/2009		5	45	20	30		
38.3	183	Pool tail	2/10/2009		5	60	20	15		
38.3	184	Run head	2/10/2009			60	30	10		
38.2	185	Run body	2/10/2009			70	20	10		
38.2	186	Run tail	2/10/2009			60	30	10		
38.2	187	Riffle	2/10/2009			70	20	10		
38.1	188	Pool head	2/10/2009			60	30	10		
38.1	189	Pool body	2/11/2009		5	60	25	10		
38.1	190	Pool tail	2/11/2009			60	20	10	10	
38.1	191	Riffle	2/11/2009			70	20	10		
38.1	192	Pool head	2/11/2009			50	20	20	10	
38.0	193	Pool body	2/11/2009	20		20	30	30		
38.0	194	Pool tail	2/11/2009			40	40	20		
38.0	195	Run head	2/11/2009			50	40	10		
37.9	196	Run body	2/11/2009			60	30	10		
37.9	197	Run tail	2/11/2009			60	30	5	5	
37.8	198	Riffle	2/11/2009			60	30	10		
37.8	199	Pool head	2/11/2009			60	30	10		
37.7	200	Pool body	2/11/2009	10			60	30		
37.6	201	Pool tail	2/11/2009			5	75	20		
37.6	202	Riffle	2/11/2009	5		5	80	10		
37.6	203	Run head	2/11/2009			10	60	20	10	
37.5	204	Run body	2/11/2009			30	60	10		
37.4	205	Run tail	2/11/2009			40	60			
37.3	206	Riffle	2/11/2009			40	60			
37.3	207	Run head	2/11/2009			50	40	10		
37.1	208	Run body	2/11/2009			50	40	10		
37.1	209	Run tail	2/11/2009			50	50			
37.0	210	Riffle	2/11/2009			60	40			
37.0	211	Run head	2/11/2009			50	40	10		
36.9	212	Run body	2/11/2009			10	60	30		
36.9	213	Run tail	2/11/2009			20	70	10		
36.9	214	Pool head	2/11/2009			20	70	10		
36.9	215	Pool body	2/11/2009			20	50	30		
36.9	216	Pool tail	2/11/2009			10	60	30		
36.8	217	Riffle	2/11/2009			30	60	10		
36.8	218	Run head	2/11/2009			40	50	10		
36.6	219	Run body	2/11/2009			20	40	40		
36.6	220	Run tail	2/11/2009			20	60	20		
36.6	221	Riffle	2/11/2009			30	60	10		
36.6	222	Run head	2/11/2009			40	60			
36.4	223	Run body	2/11/2009			20	60	20		

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
36.3	224	Run tail	2/11/2009			30	60	10		
36.3	225	Riffle	2/11/2009			30	60	10		
36.3	226	Run head	2/11/2009			30	60	10		
36.3	227	Run body	2/11/2009			30	60	10		
36.2	228	Run tail	2/11/2009			30	60	10		
36.2	229	Riffle	2/11/2009			30	60	10		
36.2	230	Pool head	2/11/2009			30	60	10		
36.2	231	Pool body	2/11/2009			30	60	10		
36.2	232	Pool tail	2/11/2009			20	60	20		
36.1	233	Pool head	2/11/2009				80	20		
35.7	234	Pool body	2/11/2009	25		20	40	15		
35.6	235	Pool tail	2/11/2009			30	60	10		
35.5	236	Riffle	2/11/2009			30	60	10		
35.5	237	Run head	2/11/2009			30	60	10		
35.2	238	Run body	2/11/2009		5	15	20	60		
35.2	239	Run tail	2/12/2009			30	60	5	5	
35.2	240	Riffle	2/12/2009			35	60	5		
35.2	241	Run head	2/12/2009			35	60	5		
35.2	242	Run body	2/12/2009			30	65	5		
35.1	243	Run tail	2/12/2009			20	80			
35.1	244	Riffle	2/12/2009			20	60	20		
35.0	245	Run head	2/12/2009			20	70	10		
35.0	246	Run body	2/12/2009			40	50	10		
35.0	247	Run tail	2/12/2009			20	70	10		
34.9	248	Riffle	2/12/2009			10	80	10		
34.9	249	Run head	2/12/2009			20	70	10		
34.7	250	Run body	2/12/2009	5		25	60	10		
34.6	251	Pool body	2/12/2009	40		20	20	20		
34.6	252	Pool tail	2/12/2009	30		30	20	20		
34.5	253	Riffle	2/12/2009	5		30	65			
34.5	254	Pool head	2/12/2009	40		10	20	30		
34.4	255	Pool body	2/12/2009			30	50	20		
34.1	256	Run body	2/12/2009			30	60	10		
34.1	257	Run tail	2/12/2009			40	60			
34.1	258	Riffle	2/12/2009			30	60	10		
34.0	259	Run head	2/12/2009			40	50	10		
34.0	260	Run body	2/12/2009			30	40	30		
33.9	261	Run tail	2/12/2009			30	50	20		
33.8	262	Riffle	2/12/2009			30	60	10		
33.8	263	Run head	2/12/2009			40	60			
33.8	264	Run body	2/12/2009			40	50	10		
33.8	265	Run tail	2/12/2009			40	60			
33.7	266	Riffle	2/12/2009			40	50	10		
33.6	267	Run head	2/12/2009			10	70	20		
33.5	268	Run body	2/12/2009			20	40	40		

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
33.4	269	Run tail	2/12/2009			20	50	30		
33.4	270	Riffle	2/12/2009			30	60	10		
33.4	271	Pool head	2/12/2009			40	40	20		
33.2	272	Pool body	2/12/2009	10		20	30	30	10	
33.2	273	Pool tail	2/12/2009			40	50	10		
33.2	274	Riffle	2/12/2009			40	50	10		
33.2	275	Run head	2/12/2009			50	40	10		
33.1	276	Run body	2/12/2009			25	60	5	10	
33.1	277	Run tail	2/12/2009			40	50	10		
33.0	278	Riffle	2/12/2009			20	70	10		
33.0	279	Run head	2/12/2009			20	40	40		
32.1	280	Run body	2/12/2009				50	50		
32.1	281	Run tail	2/12/2009	No data collected						
32.0	282	Riffle	2/12/2009	No data collected						
32.0	283	Run head	2/12/2009	No data collected						
32.0	284	Run body	2/12/2009	No data collected						
31.9	285	Run tail	2/12/2009	No data collected						
31.9	286	Riffle	2/12/2009	No data collected						
31.9	287	Run head	2/12/2009	No data collected						
31.7	288	Run body	2/12/2009	No data collected						
31.7	289	Run tail	2/12/2009	No data collected						
31.6	290	Riffle	2/12/2009	No data collected						
31.6	291	Run head	2/12/2009	No data collected						
31.5	292	Run body	2/12/2009	No data collected						
31.5	293	Run tail	2/12/2009	No data collected						
31.5	294	Riffle	2/12/2009			40	50		10	
31.4	295	Run head	2/12/2009			20	70	10		
31.3	296	Run body	2/12/2009			10	60	30		
31.3	297	Run tail	2/12/2009			10	60	30		
31.2	298	Riffle	2/12/2009			30	60	10		
31.2	299	Run head	2/13/2009			40	50	10		
31.1	300	Run body	2/13/2009			30	40	30		
31.1	301	Run tail	2/13/2009			30	60	10		
31.1	302	Riffle	2/13/2009			30	60	10		
31.1	303	Run head	2/13/2009	10		40	40	10		
30.7	304	Run body	2/13/2009	10		40	40	10		
30.7	305	Run tail	2/13/2009			40	40	20		
30.6	306	Riffle	2/13/2009			40	50	10		
30.6	307	Run head	2/13/2009			40	50	10		
30.5	308	Run body	2/13/2009			40	50	10		
30.5	309	Run tail	2/13/2009			40	50	10		
30.4	310	Riffle	2/13/2009			30	50	20		
30.4	311	Run head	2/13/2009			30	60	10		
30.4	312	Run body	2/13/2009			40	50	10		
30.4	313	Run tail	2/13/2009		5	35	50	10		

River mile	Unit	Habitat type	Habitat survey date	Bedrock (%)	Boulder (%)	Cobble (%)	Gravel (%)	Sand (%)	Silt (%)	Organic (%)
30.2	314	Riffle	2/13/2009			30	60	10		
30.2	315	Run head	2/13/2009			30	60	10		
30.1	316	Run body	2/13/2009			30	60	10		
30.1	317	Run tail	2/13/2009			30	60	10		
30.1	318	Riffle	2/13/2009			40	50	10		
30.0	319	Run head	2/13/2009			5	15	80		
29.7	320	Run body	2/13/2009				30	70		
29.7	321	Run tail	2/13/2009				30	70		
29.6	322	Pool body	2/13/2009				20	80		
29.6	323	Pool tail	2/13/2009				30	70		
29.5	324	Riffle	2/13/2009			30	60	10		
29.5	325	Run head	2/13/2009			40	60			
29.5	326	Run body	2/13/2009				20	80		
29.5	327	Run tail	2/13/2009				60	40		
29.5	328	Riffle	2/13/2009			30	70			
29.4	329	Run head	2/13/2009			20	60	10	10	
29.4	330	Run body	2/13/2009			10	70	20		
29.4	331	Run tail	2/13/2009			10	70	20		
29.3	332	Riffle	2/13/2009			10	80	10		
29.3	333	Run head	2/13/2009			10	70	20		
29.2	334	Run body	2/13/2009			20	70	10		
29.2	335	Run tail	2/13/2009			10	70	20		
29.2	336	Riffle	2/13/2009			10	80	10		
29.1	337	Run head	2/13/2009			10	60	30		
29.1	338	Run body	2/13/2009	15		30	30	25		
29.0	339	Run tail	2/13/2009	40		20	20	20		
29.0	340	Riffle	2/13/2009	20		10	60	10		

Appendix E: Water Quality Data

Table E-1. Water quality data for the sampling units selected for snorkel sampling, September 2011.

RM	Unit	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
51.6	4	Pool Head	21-Sep	10:20	12.6		25.5	29.5	8.0	6.0	8.0
50.9	11	Pool Body	21-Sep	12:45	13.7		25.5	27.5	16.0	8.0	16.0
50.6	14	Riffle	21-Sep	11:30	13.7		25.3	27.5	4.0	1.5	4.0
50.3	19	Run Head	21-Sep	14:15	14.7		25.3	26.0	9.0	5.0	9.0
50.1	20	Run Body	21-Sep	14:50	14.7		25.3	26.0	10.0	6.0	10.0
49.7	27	Pool Head	23-Sep	15:45	15.1		25.7	26.3	6.0	3.0	6.0
49.6	28	Pool Body	23-Sep	14:50	15.1		25.7	26.3	20.0	5.0	20.0
49.3	31	Run Body	23-Sep	14:10	15.1		25.7	26.3	8.0	4.0	8.0
49.2	33	Riffle	20-Sep	14:40	15.1		25.7	26.3	4.0	1.5	4.0
49.1	38	Run Head	20-Sep	13:05	13.9		27.3	27.0	4.5	2.5	4.5
48.7	43	Run Body	20-Sep	10:45	13.9		27.3	27.0	5.0	2.5	5.0
48.0	53	Riffle	20-Sep	17:05	15.5		26.6	28.0	4.0	1.3	4.0
48.0	54	Pool Head	20-Sep	17:20	15.5		26.6	28.0	10.0	6.0	10.0
45.9	70	Riffle	22-Sep	15:10	14.1		27.7	21.0	3.0	1.5	3.0
45.9	71	Run Head	22-Sep	14:05	14.1		27.7	21.0	4.0	2.0	4.0
45.8	72	Run Body	22-Sep	14:15	14.1		27.7	21.0	4.0	2.0	4.0
45.3	81	Pool Body	24-Sep	10:15	14.2		28.9	17.5	15.0	10.0	15.0
44.8	90	Run Head	24-Sep	9:15	14.2		28.9	17.5	3.0	1.5	3.0
44.8	91	Run Body	24-Sep	9:25	14.2		28.9	17.5	4.0	2.0	4.0
39.4	161	Run Head	22-Sep	9:15	15.9		35.9	15.5		2.5	4.0
39.3	162	Run Body	22-Sep	9:30	15.9		35.9	15.5		4.0	9.0
39.2	164	Riffle	22-Sep	10:10	15.9		35.9	15.5		1.5	3.5
39.2	165	Pool Head	22-Sep	10:25	15.9		35.9	15.5	3.5	2.0	3.5
38.3	182	Pool Body	22-Sep	12:05	16.7		37.4	15.0	12.0	4.0	12.0
38.1	192	Pool Head	22-Sep	11:00	16.7		37.4	15.0	7.0	2.5	7.0
38.0	193	Pool Body	22-Sep	11:10	16.7		37.4	15.0	12.0	8.0	12.0
36.8	217	Riffle	23-Sep	11:00	18.0		38.5	13.0	4.0	1.5	4.0

RM	Unit	Habitat type	Sample date	Start time	Water temperature (C)	DO (ppm)	Specific conductivity (mS)	Horizontal visability (ft)	Vertical visability (ft)	Average depth (ft)	Maximum depth (ft)
36.8	218	Run Head	23-Sep	11:25	18.0		38.5	13.0		4.0	6.0
36.7	219	Run Body	23-Sep	11:35	18.0		38.5	13.0		7.0	18.0
36.3	225	Riffle	23-Sep	10:20	18.0		38.5	13.0	6.0	3.0	6.0
36.2	230	Pool Head	23-Sep	9:45	16.6		37.9	10.5	8.0	3.0	8.0
36.2	231	Pool Body	23-Sep	10:00	16.6		37.9	10.5	14.0	6.0	14.0

Appendix F: Water Temperature Data

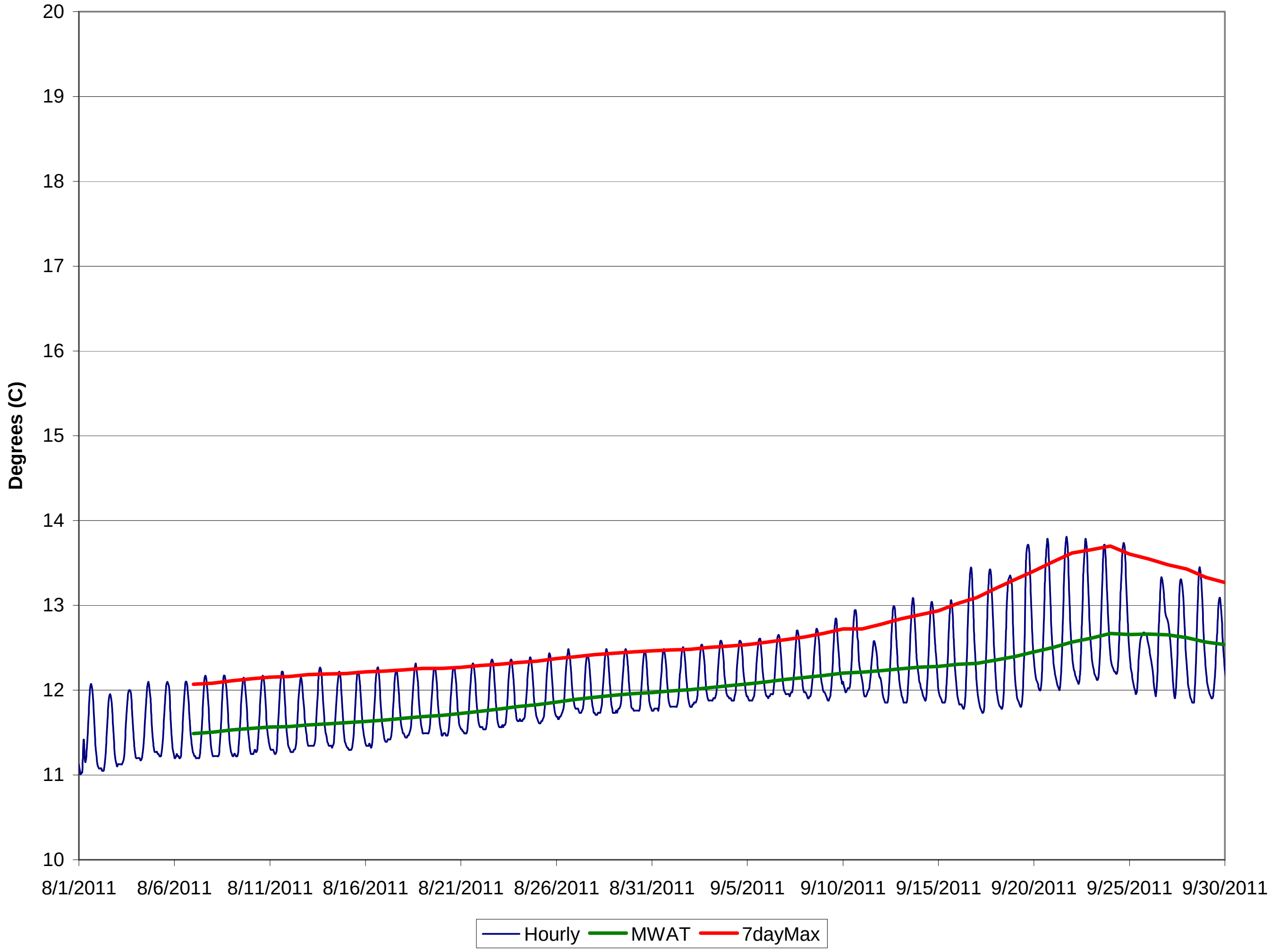


Figure F-1. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle A7 (RM 50.8), August-September 2011.

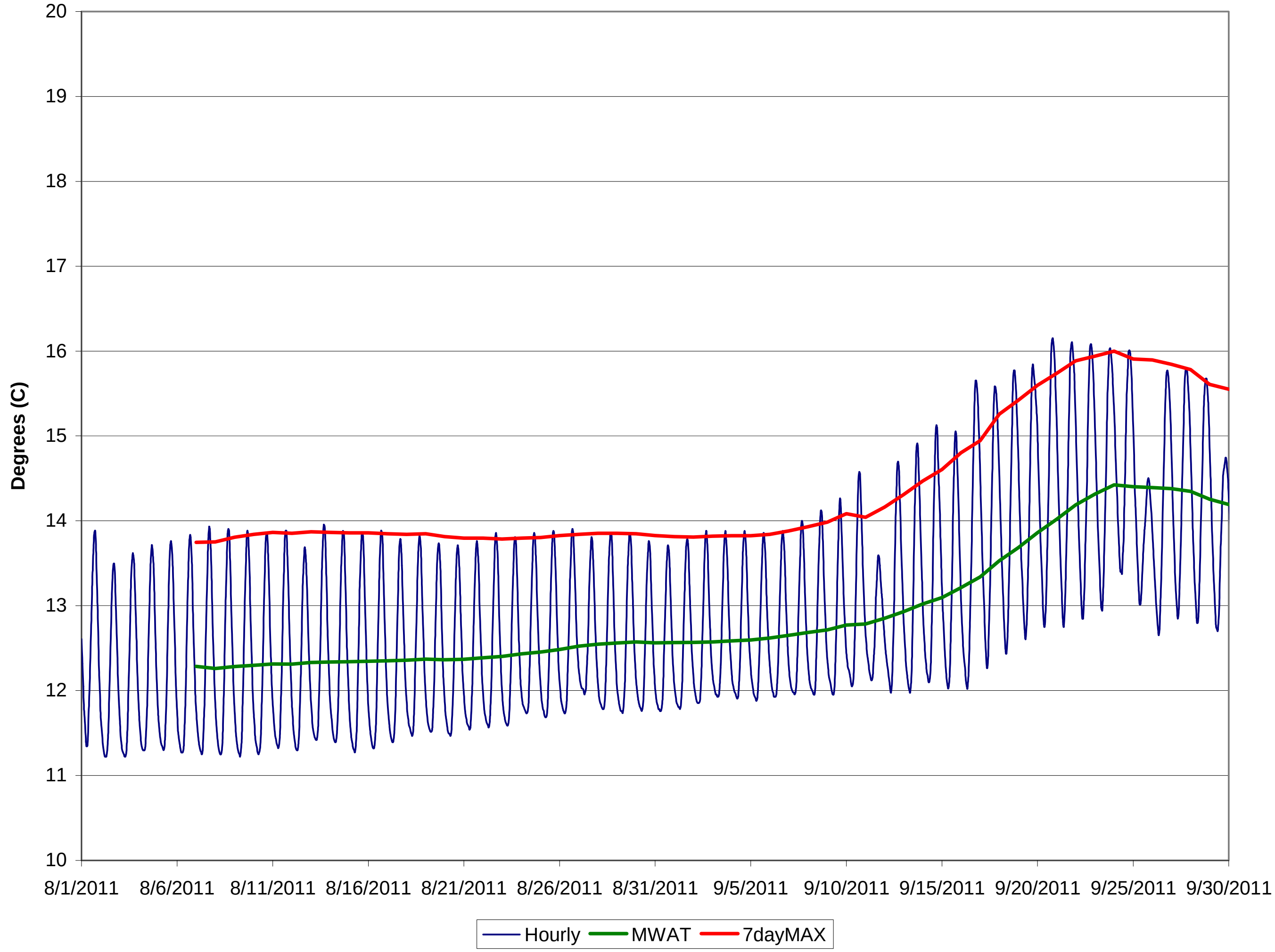


Figure F-2. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 13B (RM 45.5), August-September 2011.

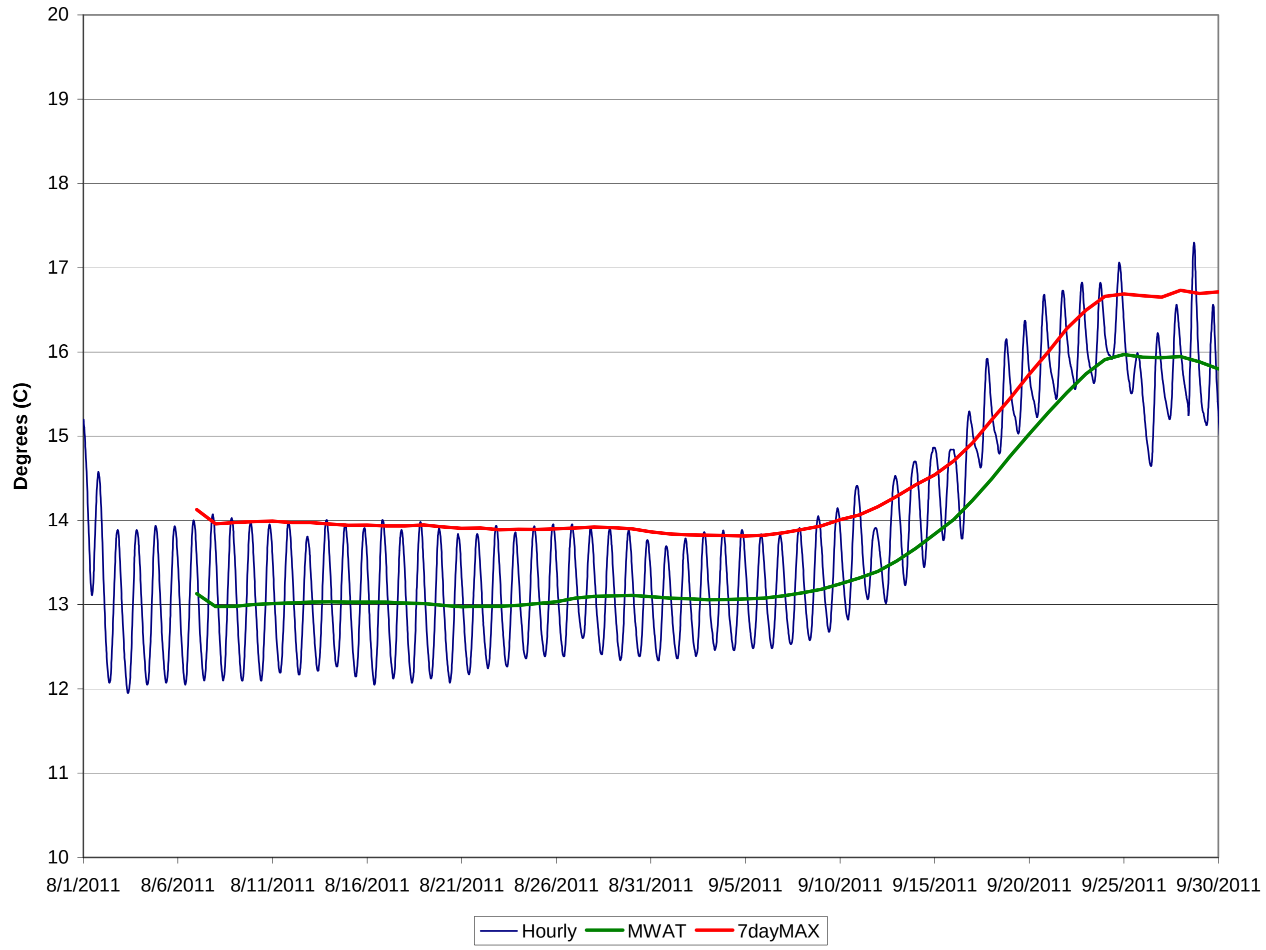


Figure F-3. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Roberts Ferry Bridge (RM 39.6), August-September 2011.

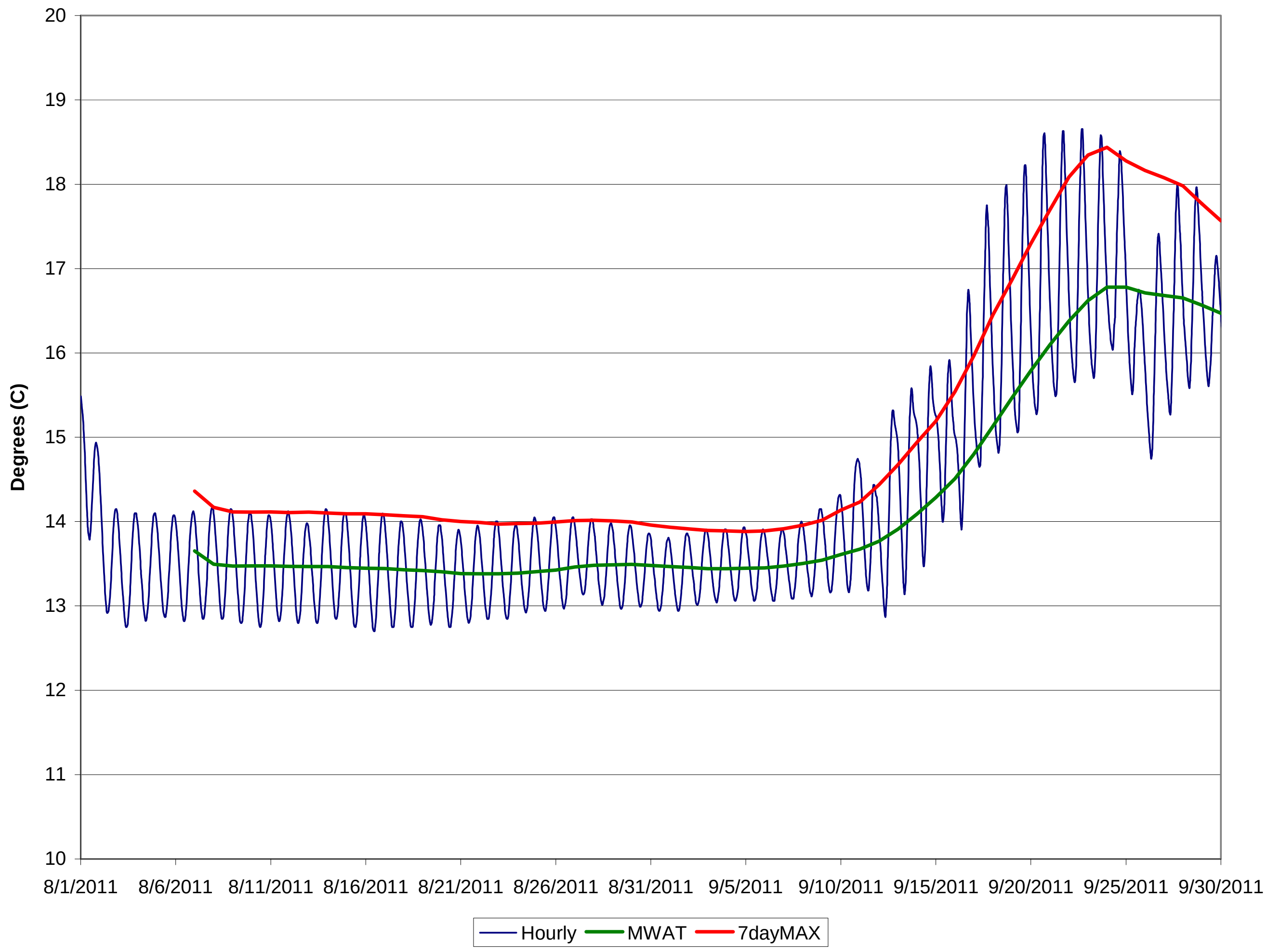


Figure F-4. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Ruddy Gravel (RM 36.5), August-September 2011.

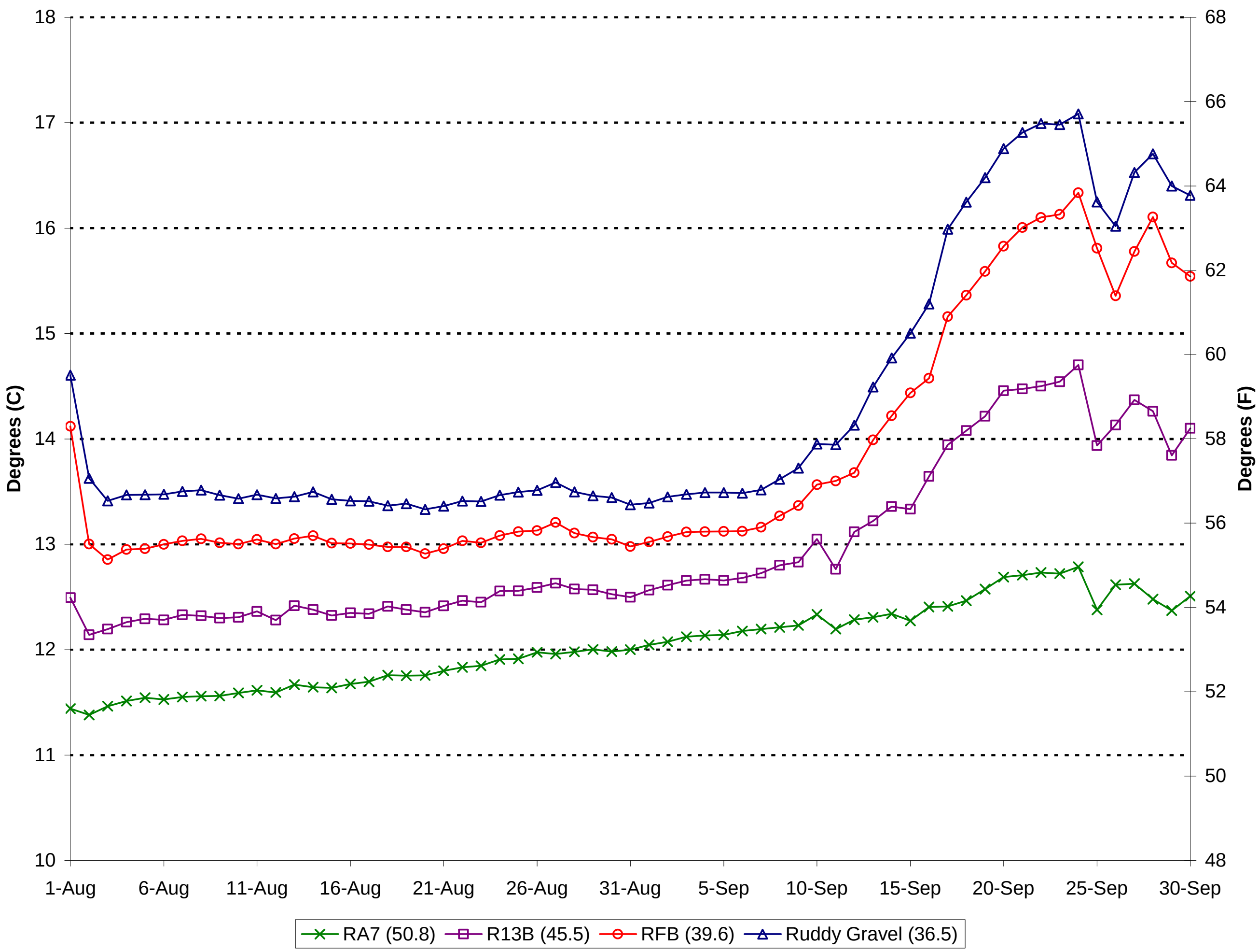


Figure F-5. Average daily water temperature from thermographs, August-September 2011.

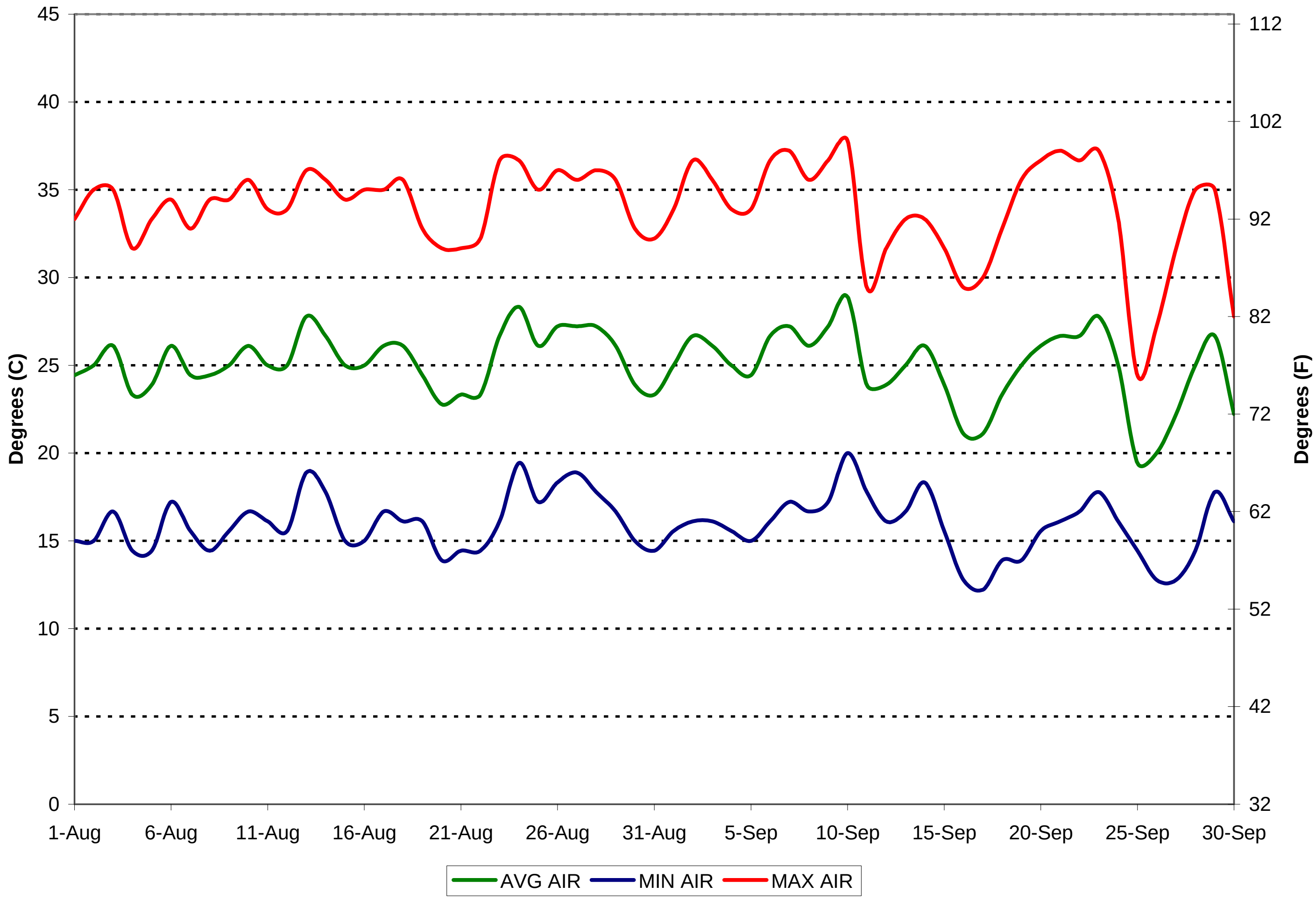


Figure F-6. Daily average, minimum, and maximum air temperature at the Modesto Airport, August-September 2011.

Appendix G: Fish Observation Data

Table G-1. *O. mykiss* observation data for the sampling units, September 2011.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool Head	M	1	4	250-300
51.6	4	Pool Head	M	1	4	300-350
51.6	4	Pool Head	M	1	1	350-400
51.6	4	Pool Head	M	2	4	250-300
51.6	4	Pool Head	M	2	2	300-350
51.6	4	Pool Head	M	3	4	250-300
51.6	4	Pool Head	M	3	1	300-350
51.6	4	Pool Head	M	3	1	350-400
50.9	11	Pool Body	M	1	1	50-100
50.9	11	Pool Body	M	1	2	250-300
50.9	11	Pool Body	M	1	12	300-350
50.9	11	Pool Body	M	1	5	350-400
50.9	11	Pool Body	M	1	2	400-450
50.9	11	Pool Body	M	2	15	300-350
50.9	11	Pool Body	M	2	4	350-400
50.9	11	Pool Body	M	2	3	400-450
50.9	11	Pool Body	M	3	2	250-300
50.9	11	Pool Body	M	3	12	300-350
50.9	11	Pool Body	M	3	6	350-400
50.9	11	Pool Body	M	3	1	400-450
50.6	14	Riffle	S	1	2	0-50
50.6	14	Riffle	S	1	1192	50-100
50.6	14	Riffle	S	1	528	100-150
50.6	14	Riffle	S	1	75	150-200
50.6	14	Riffle	S	1	8	200-250
50.6	14	Riffle	S	1	5	250-300
50.6	14	Riffle	S	1	16	300-350
50.6	14	Riffle	S	1	1	350-400
50.3	19	Run Head	M	1	6	0-50
50.3	19	Run Head	M	1	57	50-100
50.3	19	Run Head	M	1	28	100-150
50.3	19	Run Head	M	1	5	150-200
50.3	19	Run Head	M	1	3	200-250
50.3	19	Run Head	M	1	3	250-300
50.3	19	Run Head	M	1	7	300-350
50.3	19	Run Head	M	1	7	350-400
50.3	19	Run Head	M	1	1	400-450
50.3	19	Run Head	M	2	5	0-50
50.3	19	Run Head	M	2	58	50-100

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
50.3	19	Run Head	M	2	14	100-150
50.3	19	Run Head	M	2	3	150-200
50.3	19	Run Head	M	2	1	200-250
50.3	19	Run Head	M	2	9	300-350
50.3	19	Run Head	M	2	12	350-400
50.3	19	Run Head	M	2	2	400-450
50.3	19	Run Head	M	3	7	0-50
50.3	19	Run Head	M	3	40	50-100
50.3	19	Run Head	M	3	8	100-150
50.3	19	Run Head	M	3	2	150-200
50.3	19	Run Head	M	3	4	250-300
50.3	19	Run Head	M	3	6	300-350
50.3	19	Run Head	M	3	5	350-400
50.1	20	Run Body	M	1	166	0-50
50.1	20	Run Body	M	1	208	50-100
50.1	20	Run Body	M	1	135	100-150
50.1	20	Run Body	M	1	8	150-200
50.1	20	Run Body	M	1	8	200-250
50.1	20	Run Body	M	1	7	250-300
50.1	20	Run Body	M	1	8	300-350
50.1	20	Run Body	M	2	105	0-50
50.1	20	Run Body	M	2	286	50-100
50.1	20	Run Body	M	2	205	100-150
50.1	20	Run Body	M	2	29	150-200
50.1	20	Run Body	M	2	22	200-250
50.1	20	Run Body	M	2	9	250-300
50.1	20	Run Body	M	2	8	300-350
50.1	20	Run Body	M	3	70	0-50
50.1	20	Run Body	M	3	316	50-100
50.1	20	Run Body	M	3	224	100-150
50.1	20	Run Body	M	3	10	150-200
50.1	20	Run Body	M	3	8	200-250
50.1	20	Run Body	M	3	8	250-300
50.1	20	Run Body	M	3	8	300-350
49.7	27	Pool Head	M	1	82	50-100
49.7	27	Pool Head	M	1	25	100-150
49.7	27	Pool Head	M	1	2	150-200
49.7	27	Pool Head	M	1	2	200-250
49.7	27	Pool Head	M	1	1	250-300
49.7	27	Pool Head	M	2	76	50-100
49.7	27	Pool Head	M	2	27	100-150

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
49.7	27	Pool Head	M	2	2	150-200
49.7	27	Pool Head	M	3	1	0-50
49.7	27	Pool Head	M	3	99	50-100
49.7	27	Pool Head	M	3	27	100-150
49.7	27	Pool Head	M	3	3	150-200
49.6	28	Pool Body	M	1	9	0-50
49.6	28	Pool Body	M	1	156	50-100
49.6	28	Pool Body	M	1	86	100-150
49.6	28	Pool Body	M	1	15	150-200
49.6	28	Pool Body	M	1	6	200-250
49.6	28	Pool Body	M	1	2	250-300
49.6	28	Pool Body	M	1	13	300-350
49.6	28	Pool Body	M	1	2	350-400
49.6	28	Pool Body	M	2	8	0-50
49.6	28	Pool Body	M	2	179	50-100
49.6	28	Pool Body	M	2	101	100-150
49.6	28	Pool Body	M	2	20	150-200
49.6	28	Pool Body	M	2	5	200-250
49.6	28	Pool Body	M	2	3	250-300
49.6	28	Pool Body	M	2	18	300-350
49.6	28	Pool Body	M	2	3	350-400
49.6	28	Pool Body	M	3	1	0-50
49.6	28	Pool Body	M	3	172	50-100
49.6	28	Pool Body	M	3	75	100-150
49.6	28	Pool Body	M	3	16	150-200
49.6	28	Pool Body	M	3	1	200-250
49.6	28	Pool Body	M	3	2	250-300
49.6	28	Pool Body	M	3	15	300-350
49.6	28	Pool Body	M	3	5	350-400
49.3	31	Run Body	S	1	3	0-50
49.3	31	Run Body	S	1	20	50-100
49.3	31	Run Body	S	1	232	100-150
49.3	31	Run Body	S	1	128	150-200
49.3	31	Run Body	S	1	8	200-250
49.3	31	Run Body	S	1	12	250-300
49.3	31	Run Body	S	1	17	300-350
49.3	31	Run Body	S	1	24	350-400
49.3	31	Run Body	S	1	1	400-450
49.3	31	Run Body	S	1	3	450-500
49.2	33	Riffle	M	1	3	0-50
49.2	33	Riffle	M	1	377	50-100

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
49.2	33	Riffle	M	1	129	100-150
49.2	33	Riffle	M	1	58	150-200
49.2	33	Riffle	M	1	18	200-250
49.2	33	Riffle	M	1	2	300-350
49.2	33	Riffle	M	1	4	350-400
49.2	33	Riffle	M	1	2	400-450
49.2	33	Riffle	M	2	1	0-50
49.2	33	Riffle	M	2	391	50-100
49.2	33	Riffle	M	2	242	100-150
49.2	33	Riffle	M	2	37	150-200
49.2	33	Riffle	M	2	8	200-250
49.2	33	Riffle	M	2	2	250-300
49.2	33	Riffle	M	2	4	300-350
49.2	33	Riffle	M	2	4	350-400
49.2	33	Riffle	M	2	1	400-450
49.2	33	Riffle	M	3	369	50-100
49.2	33	Riffle	M	3	102	100-150
49.2	33	Riffle	M	3	12	150-200
49.2	33	Riffle	M	3	1	200-250
49.2	33	Riffle	M	3	3	300-350
49.2	33	Riffle	M	3	4	350-400
49.2	33	Riffle	M	3	1	450-500
49.1	38	Run Head	M	1	16	50-100
49.1	38	Run Head	M	1	46	100-150
49.1	38	Run Head	M	1	4	150-200
49.1	38	Run Head	M	1	1	300-350
49.1	38	Run Head	M	2	18	50-100
49.1	38	Run Head	M	2	27	100-150
49.1	38	Run Head	M	2	2	150-200
49.1	38	Run Head	M	3	16	50-100
49.1	38	Run Head	M	3	14	100-150
49.1	38	Run Head	M	3	6	150-200
48.7	43	Run Body	M	1	10	0-50
48.7	43	Run Body	M	1	94	50-100
48.7	43	Run Body	M	1	151	100-150
48.7	43	Run Body	M	1	48	150-200
48.7	43	Run Body	M	1	20	200-250
48.7	43	Run Body	M	1	10	250-300
48.7	43	Run Body	M	1	1	300-350
48.7	43	Run Body	M	1	5	350-400
48.7	43	Run Body	M	1	3	400-450

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
48.7	43	Run Body	M	2	2	0-50
48.7	43	Run Body	M	2	88	50-100
48.7	43	Run Body	M	2	114	100-150
48.7	43	Run Body	M	2	47	150-200
48.7	43	Run Body	M	2	24	200-250
48.7	43	Run Body	M	2	15	250-300
48.7	43	Run Body	M	2	1	300-350
48.7	43	Run Body	M	2	4	350-400
48.7	43	Run Body	M	2	3	400-450
48.7	43	Run Body	M	3	3	0-50
48.7	43	Run Body	M	3	52	50-100
48.7	43	Run Body	M	3	110	100-150
48.7	43	Run Body	M	3	59	150-200
48.7	43	Run Body	M	3	22	200-250
48.7	43	Run Body	M	3	10	250-300
48.7	43	Run Body	M	3	4	300-350
48.7	43	Run Body	M	3	4	350-400
48.0	53	Riffle	S	1	28	50-100
48.0	53	Riffle	S	1	16	100-150
48.0	53	Riffle	S	1	1	150-200
48.0	54	Pool Head	M	1	42	50-100
48.0	54	Pool Head	M	1	22	100-150
48.0	54	Pool Head	M	1	4	150-200
48.0	54	Pool Head	M	1	2	300-350
48.0	54	Pool Head	M	1	2	350-400
48.0	54	Pool Head	M	2	45	50-100
48.0	54	Pool Head	M	2	10	100-150
48.0	54	Pool Head	M	2	3	150-200
48.0	54	Pool Head	M	2	4	300-350
48.0	54	Pool Head	M	3	34	50-100
48.0	54	Pool Head	M	3	21	100-150
48.0	54	Pool Head	M	3	3	150-200
48.0	54	Pool Head	M	3	1	200-250
48.0	54	Pool Head	M	3	3	300-350
45.9	70	Riffle	M	1	1	0-50
45.9	70	Riffle	M	1	229	50-100
45.9	70	Riffle	M	1	77	100-150
45.9	70	Riffle	M	1	17	150-200
45.9	70	Riffle	M	1	6	200-250
45.9	70	Riffle	M	1	3	250-300
45.9	70	Riffle	M	1	2	300-350

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
45.9	70	Riffle	M	2	212	50-100
45.9	70	Riffle	M	2	125	100-150
45.9	70	Riffle	M	2	19	150-200
45.9	70	Riffle	M	2	5	200-250
45.9	70	Riffle	M	2	6	300-350
45.9	70	Riffle	M	3	240	50-100
45.9	70	Riffle	M	3	80	100-150
45.9	70	Riffle	M	3	27	150-200
45.9	70	Riffle	M	3	2	200-250
45.9	71	Run Head	S	1	27	50-100
45.9	71	Run Head	S	1	31	100-150
45.9	71	Run Head	S	1	18	150-200
45.9	71	Run Head	S	1	9	200-250
45.9	71	Run Head	S	1	6	250-300
45.9	71	Run Head	S	1	6	300-350
45.9	71	Run Head	S	1	4	350-400
45.8	72	Run Body	M	1	10	0-50
45.8	72	Run Body	M	1	60	50-100
45.8	72	Run Body	M	1	41	100-150
45.8	72	Run Body	M	1	18	150-200
45.8	72	Run Body	M	1	11	200-250
45.8	72	Run Body	M	1	6	250-300
45.8	72	Run Body	M	1	2	300-350
45.8	72	Run Body	M	2	80	50-100
45.8	72	Run Body	M	2	37	100-150
45.8	72	Run Body	M	2	18	150-200
45.8	72	Run Body	M	2	7	200-250
45.8	72	Run Body	M	2	2	300-350
45.8	72	Run Body	M	3	82	50-100
45.8	72	Run Body	M	3	39	100-150
45.8	72	Run Body	M	3	11	150-200
45.8	72	Run Body	M	3	3	200-250
45.8	72	Run Body	M	3	1	300-350
45.3	81	Pool Body	M	1	31	50-100
45.3	81	Pool Body	M	1	11	100-150
45.3	81	Pool Body	M	1	2	150-200
45.3	81	Pool Body	M	1	3	300-350
45.3	81	Pool Body	M	2	21	50-100
45.3	81	Pool Body	M	2	16	100-150
45.3	81	Pool Body	M	2	2	150-200
45.3	81	Pool Body	M	2	2	200-250

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
45.3	81	Pool Body	M	2	1	300-350
45.3	81	Pool Body	M	2	2	350-400
45.3	81	Pool Body	M	3	15	50-100
45.3	81	Pool Body	M	3	10	100-150
45.3	81	Pool Body	M	3	3	150-200
45.3	81	Pool Body	M	3	1	200-250
45.3	81	Pool Body	M	3	4	300-350
45.3	81	Pool Body	M	3	1	350-400
44.8	90	Run Head	S	1	25	50-100
44.8	90	Run Head	S	1	5	100-150
44.8	91	Run Body	S	1	132	50-100
44.8	91	Run Body	S	1	34	100-150
44.8	91	Run Body	S	1	3	150-200
44.8	91	Run Body	S	1	3	200-250
44.8	91	Run Body	S	1	1	300-350
39.4	161	Run Head	M	1	2	150-200
39.4	161	Run Head	M	2	3	150-200
39.4	161	Run Head	M	3	2	100-150
39.4	161	Run Head	M	3	3	150-200
39.3	162	Run Body	S	1	1	350-400
39.2	164	Riffle	S	1	0	--
39.2	165	Pool Head	S	1	1	100-150
38.3	182	Pool Body	S	1	1	100-150
38.1	192	Pool Head	S	1	0	--
38.0	193	Pool Body	S	1	1	300-350
36.8	217	Riffle	S	1	1	50-100
36.8	217	Riffle	S	1	1	200-250
36.8	218	Run Head	S	1	1	150-200
36.7	219	Run Body	S	1	1	200-250
36.3	225	Riffle	M	1	2	150-200
36.3	225	Riffle	M	2	2	150-200
36.3	225	Riffle	M	2	1	300-350
36.3	225	Riffle	M	3	1	100-150
36.3	225	Riffle	M	3	1	150-200
36.3	225	Riffle	M	3	1	200-250
36.2	230	Pool Head	S	1	0	--
36.2	231	Pool Body	S	1	0	--

Table G-2. *O. tshawyschta* observation data for the sampling units, September 2011.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool Head	M	1	0	
51.6	4	Pool Head	M	2	0	
51.6	4	Pool Head	M	3	2	100-150
50.9	11	Pool Body	M	1	0	
50.9	11	Pool Body	M	2	0	
50.9	11	Pool Body	M	3	0	
50.6	14	Riffle	S	1	142	50-100
50.6	14	Riffle	S	1	114	100-150
50.6	14	Riffle	S	1	50	150-200
50.6	14	Riffle	S	1	2	200-250
50.3	19	Run Head	M	1	21	50-100
50.3	19	Run Head	M	1	20	100-150
50.3	19	Run Head	M	2	18	50-100
50.3	19	Run Head	M	2	7	100-150
50.3	19	Run Head	M	3	15	50-100
50.3	19	Run Head	M	3	11	100-150
50.1	20	Run Body	M	1	111	50-100
50.1	20	Run Body	M	1	59	100-150
50.1	20	Run Body	M	1	9	150-200
50.1	20	Run Body	M	2	109	50-100
50.1	20	Run Body	M	2	77	100-150
50.1	20	Run Body	M	3	84	50-100
50.1	20	Run Body	M	3	86	100-150
49.7	27	Pool Head	M	1	77	50-100
49.7	27	Pool Head	M	1	34	100-150
49.7	27	Pool Head	M	1	3	150-200
49.7	27	Pool Head	M	2	92	50-100
49.7	27	Pool Head	M	2	45	100-150
49.7	27	Pool Head	M	2	3	150-200
49.7	27	Pool Head	M	3	88	50-100
49.7	27	Pool Head	M	3	35	100-150
49.7	27	Pool Head	M	3	2	150-200
49.6	28	Pool Body	M	1	206	50-100
49.6	28	Pool Body	M	1	106	100-150
49.6	28	Pool Body	M	1	5	150-200
49.6	28	Pool Body	M	1	1	400-450
49.6	28	Pool Body	M	2	180	50-100
49.6	28	Pool Body	M	2	81	100-150
49.6	28	Pool Body	M	2	3	150-200

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
49.6	28	Pool Body	M	2	1	400-450
49.6	28	Pool Body	M	2	1	550-600
49.6	28	Pool Body	M	3	158	50-100
49.6	28	Pool Body	M	3	93	100-150
49.6	28	Pool Body	M	3	3	150-200
49.3	31	Run Body	S	1	260	50-100
49.3	31	Run Body	S	1	93	100-150
49.3	31	Run Body	S	1	6	150-200
49.3	31	Run Body	S	1	1	350-400
49.3	31	Run Body	S	1	4	550-600
49.2	33	Riffle	M	1	178	50-100
49.2	33	Riffle	M	1	188	100-150
49.2	33	Riffle	M	1	16	150-200
49.2	33	Riffle	M	1	5	200-250
49.2	33	Riffle	M	1	2	500-550
49.2	33	Riffle	M	2	174	50-100
49.2	33	Riffle	M	2	156	100-150
49.2	33	Riffle	M	2	10	150-200
49.2	33	Riffle	M	2	3	200-250
49.2	33	Riffle	M	2	1	350-400
49.2	33	Riffle	M	3	247	50-100
49.2	33	Riffle	M	3	103	100-150
49.2	33	Riffle	M	3	13	150-200
49.2	33	Riffle	M	3	1	200-250
49.1	38	Run Head	M	1	34	50-100
49.1	38	Run Head	M	1	20	100-150
49.1	38	Run Head	M	2	34	50-100
49.1	38	Run Head	M	2	13	100-150
49.1	38	Run Head	M	3	0	--
48.7	43	Run Body	M	1	119	50-100
48.7	43	Run Body	M	1	339	100-150
48.7	43	Run Body	M	1	31	150-200
48.7	43	Run Body	M	1	1	450-500
48.7	43	Run Body	M	2	140	50-100
48.7	43	Run Body	M	2	370	100-150
48.7	43	Run Body	M	2	42	150-200
48.7	43	Run Body	M	3	2	0-50
48.7	43	Run Body	M	3	97	50-100
48.7	43	Run Body	M	3	362	100-150
48.7	43	Run Body	M	3	36	150-200
48.0	53	Riffle	S	1	1	50-100

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
48.0	53	Riffle	S	1	2	100-150
48.0	54	Pool Head	M	1	2	50-100
48.0	54	Pool Head	M	1	6	100-150
48.0	54	Pool Head	M	2	4	50-100
48.0	54	Pool Head	M	2	8	100-150
48.0	54	Pool Head	M	3	1	50-100
48.0	54	Pool Head	M	3	6	100-150
45.9	70	Riffle	M	1	51	50-100
45.9	70	Riffle	M	1	41	100-150
45.9	70	Riffle	M	1	1	150-200
45.9	70	Riffle	M	2	68	50-100
45.9	70	Riffle	M	2	48	100-150
45.9	70	Riffle	M	2	1	150-200
45.9	70	Riffle	M	3	82	50-100
45.9	70	Riffle	M	3	41	100-150
45.9	70	Riffle	M	3	1	150-200
45.9	71	Run Head	S	1	14	50-100
45.9	71	Run Head	S	1	9	100-150
45.8	72	Run Body	M	1	5	50-100
45.8	72	Run Body	M	1	19	100-150
45.8	72	Run Body	M	1	2	150-200
45.8	72	Run Body	M	2	28	50-100
45.8	72	Run Body	M	2	23	100-150
45.8	72	Run Body	M	2	1	150-200
45.8	72	Run Body	M	3	11	50-100
45.8	72	Run Body	M	3	22	100-150
45.8	72	Run Body	M	3	4	150-200
45.3	81	Pool Body	M	1	53	50-100
45.3	81	Pool Body	M	1	8	100-150
45.3	81	Pool Body	M	2	11	50-100
45.3	81	Pool Body	M	2	5	100-150
45.3	81	Pool Body	M	3	35	50-100
45.3	81	Pool Body	M	3	5	100-150
44.8	90	Run Head	S	1	5	100-150
44.8	91	Run Body	S	1	46	50-100
44.8	91	Run Body	S	1	26	100-150
44.8	91	Run Body	S	1	4	150-200
39.4	161	Run Head	M	1	1	100-150
39.4	161	Run Head	M	2	1	100-150
39.4	161	Run Head	M	3	2	100-150
39.3	162	Run Body	S	1	0	--

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
39.2	164	Riffle	S	1	0	--
39.2	165	Pool Head	S	1	0	--
38.3	182	Pool Body	S	1	0	--
38.1	192	Pool Head	S	1	0	--
38.0	193	Pool Body	S	1	0	--
36.8	217	Riffle	S	1	1	50-100
36.8	217	Riffle	S	1	2	100-150
36.8	218	Run Head	S	1	0	--
36.7	219	Run Body	S	1	0	--
36.3	225	Riffle	M	1	0	--
36.3	225	Riffle	M	2	0	--
36.3	225	Riffle	M	3	4	50-100
36.3	225	Riffle	M	3	1	150-200
36.2	230	Pool Head	S	1	0	--
36.2	231	Pool Body	S	1	1	450-500

Table G-3. Non-salmonid fish observation data for the sampling units, September 2011.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
50.9	11	Pool Body	M	3	Sculpin sp.	1	0-50
49.6	28	Pool Body	M	1	Striped bass	1	350-400
49.3	31	Run Body	S	1	Pikeminnow/Hardhead	4	450-500
49.2	33	Riffle	M	1	Sculpin sp.	8	50-100
49.2	33	Riffle	M	2	Sculpin sp.	5	50-100
49.2	33	Riffle	M	2	Sacramento sucker	1	0-50
49.2	33	Riffle	M	3	Sculpin sp.	1	100-150
49.2	33	Riffle	M	3	Sculpin sp.	17	50-100
49.1	38	Run Head	M	1	Sculpin sp.	1	50-100
49.1	38	Run Head	M	3	Sacramento sucker	1	50-100
48.7	43	Run Body	M	2	Sculpin sp.	1	50-100
48.0	53	Riffle	S	1	Sculpin sp.	1	0-50
48.0	53	Riffle	S	1	Sculpin sp.	2	50-100
48.0	53	Riffle	S	1	Sacramento sucker	1	50-100
48.0	54	Pool Head	M	1	Largemouth bass	1	200-250
48.0	54	Pool Head	M	1	Sacramento sucker	1	250-300
48.0	54	Pool Head	M	1	Sacramento sucker	1	350-400
48.0	54	Pool Head	M	2	Largemouth bass	1	200-250
48.0	54	Pool Head	M	2	Pikeminnow/Hardhead	1	400-450
48.0	54	Pool Head	M	2	Sacramento sucker	1	350-400
48.0	54	Pool Head	M	3	Largemouth bass	1	50-100
48.0	54	Pool Head	M	3	Sacramento sucker	1	250-300
45.9	70	Riffle	M	1	Sacramento sucker	8	0-50
45.9	71	Run Head	S	1	Sculpin sp.	2	50-100
45.9	71	Run Head	S	1	Sacramento sucker	5	0-50
45.8	72	Run Body	M	1	Sculpin sp.	6	50-100
45.8	72	Run Body	M	2	Sacramento sucker	2	0-50
45.8	72	Run Body	M	3	Pikeminnow/Hardhead	2	250-300
45.8	72	Run Body	M	3	Sculpin sp.	1	50-100
45.8	72	Run Body	M	3	Sacramento sucker	1	0-50
45.3	81	Pool Body	M	1	Pikeminnow/Hardhead	1	300-350
44.8	90	Run Head	S	1	Sacramento sucker	1	300-350
39.4	161	Run Head	M	1	Pikeminnow/Hardhead	2	200-250
39.4	161	Run Head	M	1	Pikeminnow/Hardhead	12	250-300
39.4	161	Run Head	M	1	Pikeminnow/Hardhead	10	300-350
39.4	161	Run Head	M	1	Sacramento sucker	50	0-50
39.4	161	Run Head	M	2	Pikeminnow/Hardhead	11	250-300
39.4	161	Run Head	M	2	Pikeminnow/Hardhead	4	350-400
39.4	161	Run Head	M	2	Sacramento sucker	32	0-50

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
39.4	161	Run Head	M	3	Pikeminnow/Hardhead	1	100-150
39.4	161	Run Head	M	3	Pikeminnow/Hardhead	9	250-300
39.4	161	Run Head	M	3	Pikeminnow/Hardhead	1	350-400
39.4	161	Run Head	M	3	Sacramento sucker	80	0-50
39.3	162	Run Body	S	1	Pikeminnow/Hardhead	1	250-300
39.3	162	Run Body	S	1	Sacramento sucker	1000	0-50
39.3	162	Run Body	S	1	Sacramento sucker	3	200-250
39.2	164	Riffle	S	1	Gambusia sp.	10	0-50
39.2	164	Riffle	S	1	Pikeminnow/Hardhead	51	0-50
39.2	164	Riffle	S	1	Sculpin sp.	1	0-50
39.2	164	Riffle	S	1	Sacramento sucker	100	0-50
38.3	182	Pool Body	S	1	Pikeminnow/Hardhead	50	0-50
38.3	182	Pool Body	S	1	Pikeminnow/Hardhead	2	150-200
38.3	182	Pool Body	S	1	Pikeminnow/Hardhead	5	200-250
38.3	182	Pool Body	S	1	Pikeminnow/Hardhead	2	250-300
38.3	182	Pool Body	S	1	Pikeminnow/Hardhead	7	350-400
38.3	182	Pool Body	S	1	Striped bass	1	400-450
38.3	182	Pool Body	S	1	Smallmouth bass	2	200-250
38.3	182	Pool Body	S	1	Sacramento sucker	151	0-50
38.3	182	Pool Body	S	1	Sacramento sucker	6	250-300
38.3	182	Pool Body	S	1	Sacramento sucker	1	300-350
38.1	192	Pool Head	S	1	Pikeminnow/Hardhead	20	0-50
38.1	192	Pool Head	S	1	Sacramento sucker	50	0-50
38.0	193	Pool Body	S	1	Bluegill	1	0-50
38.0	193	Pool Body	S	1	Pikeminnow/Hardhead	1	250-300
38.0	193	Pool Body	S	1	Pikeminnow/Hardhead	1	400-450
38.0	193	Pool Body	S	1	Sacramento sucker	30	0-50
38.0	193	Pool Body	S	1	Sacramento sucker	4	400-450
36.8	218	Run Head	S	1	Common carp	5	300-350
36.8	218	Run Head	S	1	Pikeminnow/Hardhead	200	0-50
36.8	218	Run Head	S	1	Sacramento sucker	300	0-50
36.7	219	Run Body	S	1	Common carp	10	300-350
36.7	219	Run Body	S	1	Common carp	36	350-400
36.7	219	Run Body	S	1	Common carp	2	400-450
36.7	219	Run Body	S	1	Common carp	42	450-500
36.7	219	Run Body	S	1	Largemouth bass	1	150-200
36.7	219	Run Body	S	1	Pikeminnow/Hardhead	2	150-200
36.7	219	Run Body	S	1	Pikeminnow/Hardhead	5	200-250
36.7	219	Run Body	S	1	Pikeminnow/Hardhead	16	250-300
36.7	219	Run Body	S	1	Pikeminnow/Hardhead	11	300-350

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
36.7	219	Run Body	S	1	Pikeminnow/Hardhead	5	350-400
36.7	219	Run Body	S	1	Smallmouth bass	1	150-200
36.7	219	Run Body	S	1	Sacramento sucker	2	200-250
36.7	219	Run Body	S	1	Sacramento sucker	22	350-400
36.7	219	Run Body	S	1	Sacramento sucker	10	400-450
36.3	225	Riffle	M	1	Common carp	2	500-550
36.3	225	Riffle	M	1	Pikeminnow/Hardhead	15	0-50
36.3	225	Riffle	M	1	Pikeminnow/Hardhead	2	100-150
36.3	225	Riffle	M	1	Pikeminnow/Hardhead	1	150-200
36.3	225	Riffle	M	1	Pikeminnow/Hardhead	16	250-300
36.3	225	Riffle	M	1	Sacramento sucker	100	0-50
36.3	225	Riffle	M	1	Sacramento sucker	8	450-500
36.3	225	Riffle	M	2	Common carp	1	200-250
36.3	225	Riffle	M	2	Common carp	2	450-500
36.3	225	Riffle	M	2	Pikeminnow/Hardhead	60	0-50
36.3	225	Riffle	M	2	Pikeminnow/Hardhead	1	100-150
36.3	225	Riffle	M	2	Pikeminnow/Hardhead	1	150-200
36.3	225	Riffle	M	2	Pikeminnow/Hardhead	1	200-250
36.3	225	Riffle	M	2	Pikeminnow/Hardhead	7	250-300
36.3	225	Riffle	M	2	Sacramento sucker	9	0-50
36.3	225	Riffle	M	3	Common carp	1	150-200
36.3	225	Riffle	M	3	Common carp	3	500-550
36.3	225	Riffle	M	3	Pikeminnow/Hardhead	70	0-50
36.3	225	Riffle	M	3	Pikeminnow/Hardhead	1	100-150
36.3	225	Riffle	M	3	Pikeminnow/Hardhead	4	150-200
36.3	225	Riffle	M	3	Pikeminnow/Hardhead	8	250-300
36.3	225	Riffle	M	3	Sculpin sp.	1	0-50
36.3	225	Riffle	M	3	Sacramento sucker	105	0-50
36.3	225	Riffle	M	3	Sacramento sucker	1	400-450
36.2	230	Pool Head	S	1	Striped bass	1	350-400
36.2	231	Pool Body	S	1	Striped bass	1	400-450
36.2	231	Pool Body	S	1	Smallmouth bass	2	150-200
36.2	231	Pool Body	S	1	Smallmouth bass	1	200-250
36.2	231	Pool Body	S	1	Smallmouth bass	1	300-350
36.2	231	Pool Body	S	1	Sacramento sucker	11	350-400
36.2	231	Pool Body	S	1	Sacramento sucker	20	400-450
36.2	231	Pool Body	S	1	Sacramento sucker	10	450-500

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-7

Tuolumne River *O. mykiss* Acoustic Tracking Study
2011 Technical Report

Prepared by

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and
Andrea N. Fuller

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Tuolumne River *O. mykiss* Acoustic Tracking Study 2011 Technical Report

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Turlock Irrigation District
Modesto Irrigation District

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March 2012

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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, originating in the central Sierra Nevada in Yosemite National Park and flowing 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 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 fish migration since at least 1871.

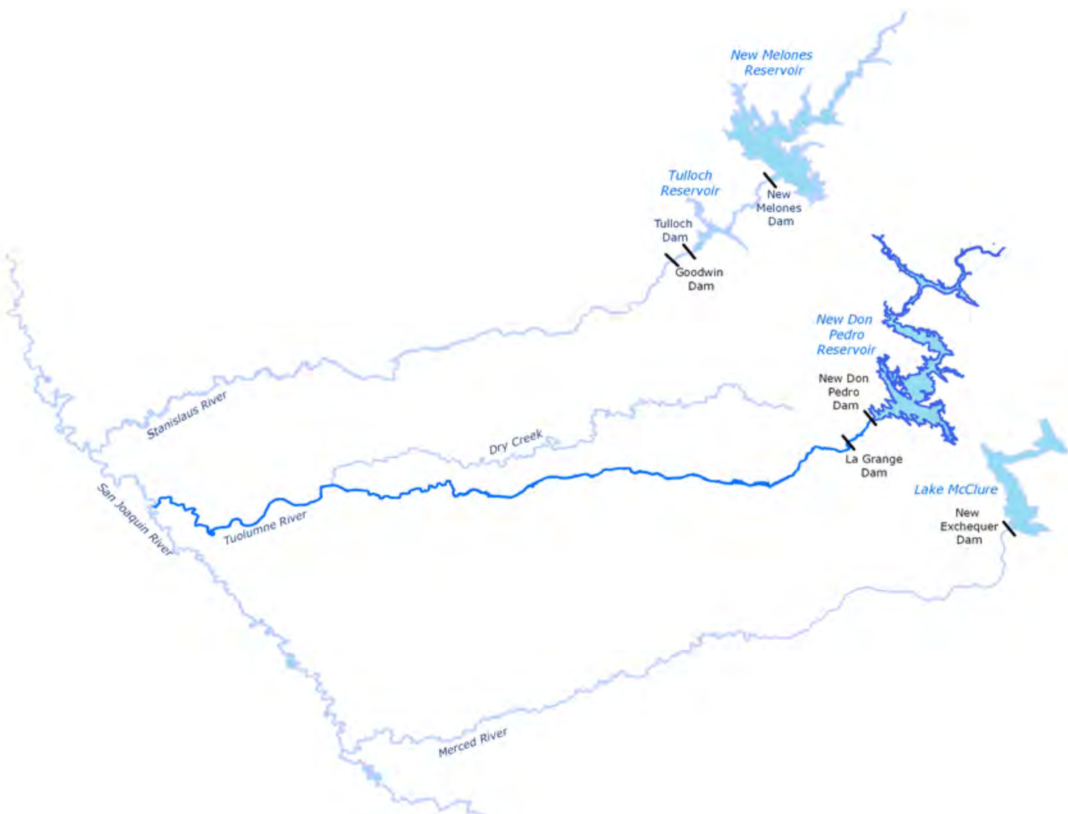

Figure 1. Location map of the Tuolumne River within the San Joaquin River Basin.

Purpose and history of study

Turlock Irrigation District and Modesto Irrigation District (Districts) have been required to conduct fisheries studies and monitoring under the Don Pedro Project Federal Energy Regulatory Commission (FERC) license starting in 1971. A required "Ten Year Summary Report" (TID/MID 2005) presenting results of these efforts was filed by the Districts with FERC in March 2005. FERC solicited input on the Report and held a public meeting during 2005-2006 which led to a December 20, 2006, request from FERC for a new Tuolumne River Fisheries Study Plan (Study Plan) to be prepared by the Districts and submitted by March 20, 2007. The Study Plan was intended to address information needs under Article 58 of the Project license that were identified during the review of the Report and in subsequent discussions. The primary goals of the Study Plan were to provide continued long-term trend monitoring and to undertake studies that clarify major factors that affect and potentially limit the Chinook salmon (*Oncorhynchus tshawytscha*) and *Oncorhynchus mykiss* (*O. mykiss*) populations in the Tuolumne River. The Study Plan was also expected to specifically include tasks on "Steelhead Presence/Protection."

The Districts distributed a proposed Study Plan for review on February 2, 2007, and revised Study Plans that included a requested winter (January-March) adult *O. mykiss* tracking study were submitted by the Districts on March 20, 2007 and July 13, 2007. An Order issued by FERC on April 3, 2008, directed the Districts to conduct all of the O. mykiss studies identified in the Study Plan, including the adult tracking study beginning in January 2009. That task was intended to better determine habitat associations and potential spawning locations, including habitat use by *O. mykiss* adults in restored and nearby reference sites. While routine fisheries monitoring conducted by the Districts has long documented the presence of *O. mykiss* in the Lower Tuolumne River (TID/MID 2005), little is known about life history strategies of *O. mykiss* in the Tuolumne River (i.e.; habitat use, in-river migration patterns, and spawning location and timing).

Objectives of the adult *O. mykiss* acoustic tracking study include:

1. Determine spawning locations of tagged adult *O. mykiss*.
2. Document migration patterns of tagged adult *O. mykiss*.
3. Determine potential habitat use of restored river reaches and nearby reference sites by tagged adult *O. mykiss*.

This study was to begin in January 2009, and timely preparations were made by the Districts to implement the study on schedule including budgeting, contracting, equipment purchase, and requesting necessary permits and authorizations. However, necessary Endangered Species Act (ESA) take authorizations were not issued by the Agencies to permit moving forward with the study in 2009, and the study was delayed until March 2010. This report covers the tagging of all *O. mykiss* in 2010, the acoustic tracking conducted in 2011, and a summary of all acoustic tracking over the 2 years of the study.

Methods

Capturing study fish

Adult *O. mykiss* were targeted by hook and line sampling conducted between La Grange Dam (RM 52.2) and Turlock Lake State Recreation Area (TLSRA) (RM 42.6) during March, April, and October 2010 (**Error! Reference source not found.**). Artificial, barbless lures or flies were used to minimize potential injury or mortality. All fish captured were placed in 38-53 L perforated containers in the river while equipment was prepared to collect biological data and for tagging if the fish was of suitable size. Prior to collection of biological data, all fish were anesthetized in a separate 53 L container using a solution of 80-90 mg/L tricane methanesulfonate in water buffered with an equal concentration of sodium bicarbonate.

Once anesthetized, fish were identified to species, fork length was measured to the nearest millimeter and weight was measured to the nearest gram. Non-biological data recorded for each fish included time and location (GPS coordinates) of capture, habitat type at capture site, photos, and other general conditions (i.e., weather conditions, substrate type, water temperature, turbidity, conductivity, and dissolved oxygen). Habitat unit designations were based on mapping conducted by Stillwater Sciences (2009) for the 2009 *O. mykiss* population surveys. Fish not selected for tagging were released immediately after necessary data was collected and they had recovered from anesthesia.

Tagging O. mykiss

HTI X-type acoustic transmitters were used for this study. These tags operate at 307 kHz and were programmed with tag periods ranging from 7000 to 7300 milliseconds using an HTI model 490-LP tag programmer. The separation between tag codes was 14 milliseconds. Healthy adult *O. mykiss* of suitable size were immediately tagged. The maximum permitted tag weight to body weight ratio of 3.5% was generally expected to correspond to adult *O. mykiss* greater than approximately 350 mm (14 in). However, in consultation with CDFG, the maximum tag weight to body weight ratio was increased to 4% after the first two days of sampling which corresponded to adult *O. mykiss* greater than approximately 300 mm (12 in). All fish were tagged at a mobile tagging station, which allowed all tagging to be completed near the original capture location.

Figure 2. Location map of study area on the Tuolumne River.

Fish were surgically implanted with acoustic transmitters according to implantation procedures outlined in Adams et al. 1998 and Martinelli et al. 1998. A ventral incision approximately 20 mm long was made anterior to the apex of the pelvic girdle. The tag was inserted into the peritoneal cavity and the incision was closed with three interrupted sutures. Typical surgery times were less than four minutes. Fish were then placed into perforated holding containers in the river to recover from anesthesia. Fish were allowed to recover for 10-15 minutes before the container was turned on its side allowing for volitional release. Function of the tag was confirmed using an HTI model 492 acoustic tag detector prior to tag insertion and again during the recovery period.

Tracking O. mykiss

Fixed station acoustic arrays were installed near Basso Bridge (RM 47.5), the Waterford Rotary Screw Trap site (RM 29.8), and the Grayson Rotary Screw Trap site (RM 5.2) (Figure 2). Each array consisted of an acoustic tag datalogger (HTI Model 295G) attached to an omnidirectional hydrophone (HTI Model 590). The system was powered by a 12-volt deep cycle battery charged by a 3 ft by 5 ft solar panel (216 watt, 36 volt). These arrays were installed prior to the release of tagged fish, and were operational by February 18, 2010. A beacon tag was deployed at each site to continually document that the array was functioning properly and could detect passing tags. Data were downloaded and reviewed once per week, at minimum, to confirm proper function of the arrays, and to limit potential data loss in case of equipment failure or vandalism.

Mobile tracking was conducted by a raft outfitted with an HTI Model 295G datalogger with GPS tracking capabilities. Mobile tracking surveys consisted of actively searching for tagged fish to determine their specific locations, including macro or micro-habitat usage. The timing, frequency and location of mobile surveys were dependent on environmental conditions and detection data from fixed stations and mobile tracking. Mobile tracking surveys were also conducted within 10 days of each tagging event to confirm the location and proper function of each tagged fish.

Data recorded for each fish detected during mobile tracking included, tag code, time of detection, location of detection (GPS coordinates), surface water temperature at the hydrophone, and macro habitat unit type. Micro-habitat usage (e.g. depth, substrate, association with features such as undercut bank, woody debris, large boulder, etc.) was also evaluated by using signal strength to more precisely estimate the location of each fish. In some cases, after the general location of tagged fish was determined, snorkel and underwater video techniques were used to document fish location within the habitat unit, general behavior (spawning activity), and condition.

River conditions

Provisional daily average flow data for the Tuolumne River at La Grange was obtained from USGS at http://waterdata.usgs.gov/ca/nwis/uv/?site_no=11289650&agency_cd=USGS. Water temperature data were also obtained from hourly recording Hobo Pro v2 water temperature data loggers (Onset Computer Corporation) maintained by the Districts at 5 sites from below La Grange Dam (RM 51.8) to Roberts Ferry Bridge (RM 39.4).

Results

Capturing study fish

During the spring period, FISHBIO staff conducted hook-and-line sampling on five days between March 23 and April 7, 2010 from La Grange (RM 50.5) to TLSRA (RM 42.6). Flows during this period ranged between 225 cfs and 650 cfs. A total of 17 *O. mykiss* were captured, with fork lengths ranging from 225-505 mm and weights ranging from 135->600 g (Table A-1).

The fall sampling period occurred over five days from October 15 to 28, 2010. Flows during this period ranged between 350 cfs and 550 cfs. A total of 25 O. mykiss were captured, forklengths ranged between 190 mm and 540 mm and weights ranging from 77-1619 g (Table A-1).

Of the 42 *O. mykiss* captured, 19 did not meet minimum size requirements and two were rejected for other reasons. One of the rejected fish had an old hook lodged deep in its throat, and the other had previously been tagged (code 7012.8). None of the captured *O. mykiss* during the 2010 sampling period were adipose fin clipped.

During the fall sampling period, five Chinook salmon smolts were incidentally captured, with fork lengths ranging from 116-170 mm. Chinook salmon were not captured during the spring sampling. Non-salmonid species incidentally captured during hook and line sampling included hardhead and striped bass (Table 1).

Table 1. Number of O. mykiss captured and tagged, and incidental species captured during 2010 sampling.

Survey Date	Reach	*O. mykiss* captured	*O. mykiss* tagged	Incidental capture		
				CHN	HH	STB
3/23	La Grange	3	3			
3/24	Basso	7	0			
3/29	Basso	3	3		1	
4/6	La Grange	0	0			
4/7	Basso	4	0			
10/15	La Grange	4	1	3		
10/19	Basso	9	4	2		1
10/20	La Grange	5	3			
10/27	Basso	3	2			
10/28	La Grange	4	4			

Species codes: CHN- Chinook salmon, HH- Hardhead, STB- Striped bass

Tagging O. mykiss

A total of 20 adult *O. mykiss* were successfully implanted with HTI X-type tags over two discrete periods during the spring and fall 2010 (Table 2). Tagged fish body weight ranged from 313 to 1,619 g (314 - 540 mm forklength). Average tag weight was 12.58 g (11.95 g to 13.35 g), and the average tag to body weight ratio was 2.2% (0.74% to 3.8%). The average surgery time (time that fish were removed from anesthesia until returned to fresh water) was 3 minutes 28 seconds, and average recovery time was 10.62 minutes (8.5 to 13.8 minutes). After recovery all fish were released in good condition at their original point of capture. One fish did not properly recover from tagging and, in compliance with permitting requirements, was sacrificed and provided to CDFG La Grange.

Table 2. Date, location, and biological data for all *O. mykiss* tagged during 2010.

Capture Date	Rivermile	Length (mm)	Weight (g)	Sex	Tag Code	Tag/Body Ratio	Habitat Unit	Habitat Type
3/23	50.0	425	>600	M	7054.8	<2.3%	023	Run Head
3/23	50.0	450	>600	M	7068.8	<2.2%	023	Run Head
3/23	49.2	505	>600	F	7012.8	<2.2%	033	Riffle
3/29	47.0	368	479	F	7110.8	2.8%	058	Run Head
3/29	45.0	360	395	F	7194.8	3.2%	086	Pool Head
3/29	45.0	353	396	F	7124.8	3.3%	086	Pool Head
10/15	51.6	314	313	unknown	7138.8	3.8%	005	Pool
10/19	47.0	463	1128	F	7026.8	1.2%	058	Run Head
10/19	46.0	370	508	unknown	7222.8	2.4%	067	Run
10/19	45.0	360	552	unknown	7208.8	2.2%	086	Pool
10/19	44.2	382	650	F	7166.8	1.9%	103	Run
10/20	52.1	350	520	unknown	7236.8	2.3%	--	Run
10/20	50.0	400	908	F	7040.8	1.4%	023	Run Head
10/20	49.3	360	492	unknown	7250.8	2.5%	031	Run
10/27	46.8	320	420	M	7264.8	2.8%	066	Run Head
10/27	46.8	350	477	F	7320.8	2.5%	066	Run Head
10/28	52.1	502	1207	M	7292.8	1.1%	--	Run
10/28	51.4	450	887	M	7152.8	1.4%	008	Run Head
10/28	49.2	380	690	F	7180.8	1.7%	033	Riffle
10/28	49.2	540	1619	F	7278.8	0.7%	033	Riffle

On March 23, two males (425 and 450 mm), and a post-spawn female (505 mm) were tagged between La Grange and Basso (Figure 3). On March 29, three female fish (353 -368 mm) were tagged between Basso and TLSRA (Figure 4). During the fall period, eight tagged fish (314 – 502 mm) were captured between La Grange and Basso (Figure 3), and six (320 – 463 mm) were captured between Basso and TLSRA (Figure 4).

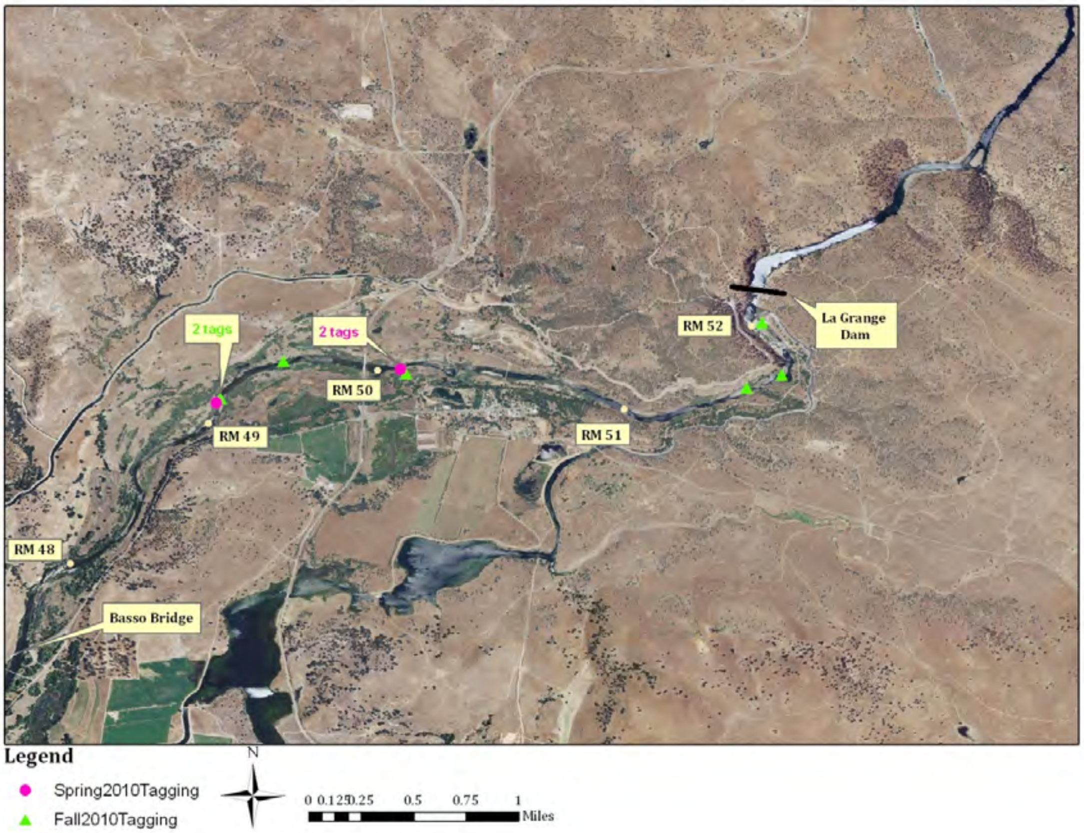

Figure 3. Release locations of tagged *O. mykiss* between La Grange Dam and Basso Bridge.

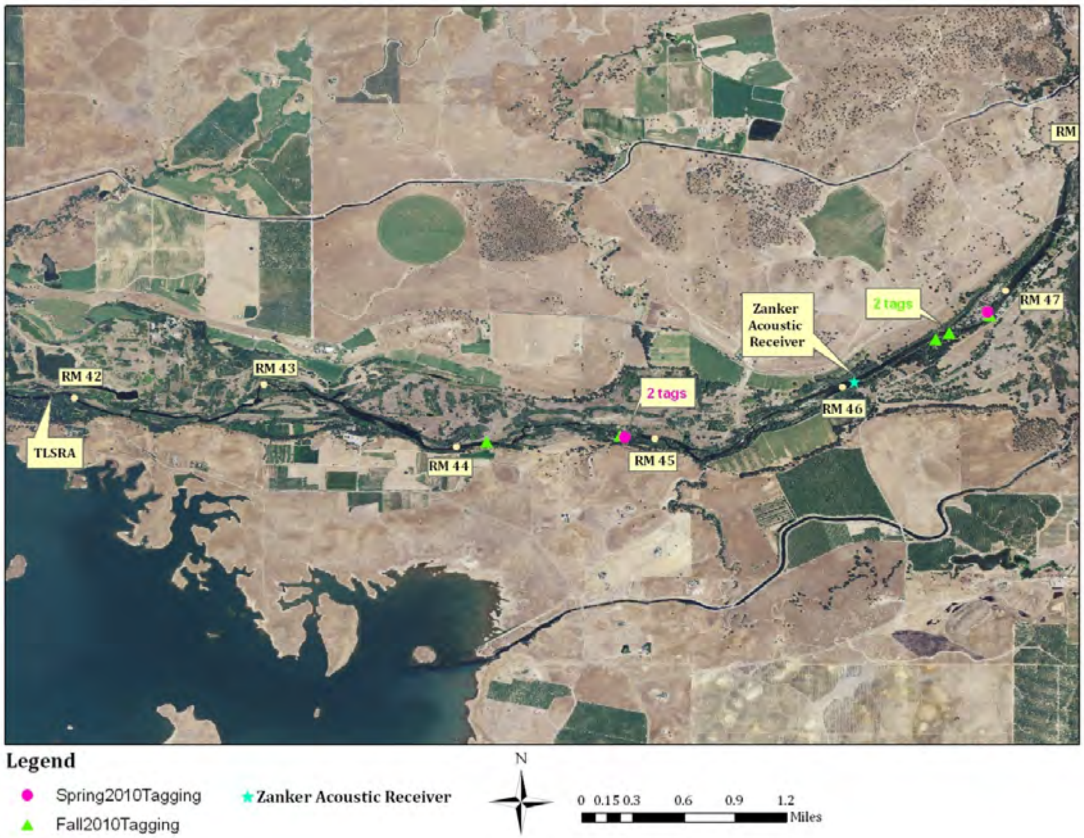

Figure 4. Release locations of tagged *O. mykiss* from Basso Bridge to Turlock Lake State Recreation Area.

Fixed station monitoring

The Zanker fixed station array was actively recording data during 77.8% of the entire study period (3/23/10- 7/1/11). The receiver was inactive for a total of 2,315 hours. These outages were due to the solar array not charging during extended periods with limited sunlight, datalogger malfunction, or high flows covering the hydrophone with debris. The Waterford array was actively recording data during 82.5% of the period, and was inactive for 1,812 hours. Outages at this site were also due to charging issues, datalogger malfunction, high flow debris, as well as some vandalism issues. The Grayson array was actively recording during 82.1% of the period, and was inactive for 1,987 hours. Outages at this site were due to charging issues or datalogger malfunction.

Seven acoustically tagged fish were detected at the Zanker fixed station array (RM 47.5) between August 18, 2010 and March 20, 2011 (Table 3). A total of 1,575 detections were recorded at this location. These detections do not all represent a fish moving past the receiver, but rather a tagged fish that is holding within the detection range of the receiver. A new acoustic file is saved hourly, so it is possible to have multiple detections within a day. For example, tag 7320.08 recorded 1,163 detections on 71 out of 76 consecutive days with a range of 2 to 25 detections per day. A similar detection pattern was recorded with tags 7110.08 and 7222.08.

Table 3. Detection history for the Zanker fixed station array.

Tag Code	First Detection Date	Last Detection Date	Total Days Detected	Total Number of Detections
7110.08	8/18/10	9/10/10	18	125
7138.08	11/28/10	2/18/10	20	31
7166.08	11/29/10	12/24/10	4	6
7222.08	10/27/10	12/29/10	22	245
7250.08	11/8/10	11/24/10	2	2
7264.08	3/20/11		1	3
7320.08	12/18/10	3/5/11	71	1163

The other acoustically tagged fish detected by a fixed station array were not associated with this study. A total of 13 tags were detected at the Grayson receiver (RM 5.2) between June 16 and August 4, 2011 (Table 4). These tags were implanted in yearling steelhead from the Mokelumne River Hatchery, and were released downstream in the San Joaquin River at Durham Ferry (RM 66) between March 22 and June 18 as part of the USBR RPA studies. At the time of release, these fish ranged from 221 to 318 mm and weighed 114.3 to 363.0 g.

Table 4. Detection history for the Grayson fixed station array of tagged *O. mykiss* that were released at Durham Ferry.

Tag Code	First Detection Date	Last Detection Date	# of Detection Events	Release Date	Length (mm)	Weight (g)
5438.26	6/29/11	7/6/11	10	6/15/11	275	214.8
5920.04	7/1/11		1	5/7/11	313	345.0
5977.26	6/28/11	7/5/11	4	6/16/11	280	218.4
6249.04	6/16/11	7/28/11	3	5/20/11	294	252.6
6732.04	6/26/11		2	5/18/11	242	164.7
8265.04	7/25/11	7/27/11	4	5/5/11	318	363.0
8812.26	7/29/11	7/31/11	4	5/25/11	317	307.9
9420.04	6/29/11	8/4/11	3	5/6/11	286	241.2
9568.26	7/1/11		1	5/23/11	221	114.3
10057.04	6/26/11	8/4/11	7	5/5/11	253	141.0
10149.26	8/4/11		1	5/21/11	252	150.6
10646.26	6/30/11	7/7/11	4	5/23/11	273	244.2
10771.04	7/7/11		1	5/6/11	257	151.7

Mobile tracking

A total of 11 mobile tracking surveys were conducted between November 1, 2010 and July 31, 2011 (Table 5). During the initial surveys after tagging events the location of all 14 fish from the fall tagging period was confirmed. Mobile tracking was limited to the reach between La Grange Dam (RM 52.0) and Roberts Ferry Bridge (RM 39.4), as no fish tagged for this study were detected moving past the Waterford or Grayson fixed receivers. A single survey was conducted between Roberts Ferry Bridge and the Waterford receiver (RM 29.8) on March 31, however no tags were detected in this reach. Flows during this period ranged between 357 cfs and 8,353 cfs (Figure 5). Average daily water temperature near La Grange Dam (RM 51.8) ranged from 9.4-11.9o C, while the temperature near Roberts Ferry Bridge ranged from 9.5- 14.9 o C during the study period (Figure 6).

Tag 7166.8 was implanted in a female *O. mykiss* captured in habitat unit NSO 103 (Stillwater habitat maps) at RM 44.2 on October 19. During subsequent mobile tracking surveys on October 27 and November 1, this tag was detected within 45 meters of the original release location. This tag was detected passing the Zanker fixed receiver (RM 47.5) on November 29, before again being detected on December 1 through mobile tracking at NSO 014 (CDFG gravel introduction site, riffle A7) 10,315 m upstream of the release location. Between December 22 and 24, this tag was again detected downstream at the Zanker receiver. On January 19 and February 2 mobile surveys, this tag was detected back upstream at NSO 014. The next detection of this tag was back downstream in the same habitat unit where it was originally captured (NSO 103), where it was detected 3 times between May 6 and July 8.

Table 5. Distance between mobile tracking detections by survey date (upstream [+], downstream [-], not detected [ND]).

Tag ID	Distance Between Detections (m)									
	1-Nov	1-Dec	9-Dec	23-Dec	19-Jan	2-Feb	24-Mar	30-Mar	6-May	13-May	8-Jul
7026.8	+60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7040.8	-55	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7138.8	0	-5785	+5715	ND	-10940	ND	ND	ND	ND	ND	ND
7152.8	-20	ND	+80	ND	ND	ND	ND	ND	-40	-90	ND
7166.8	+45	+10270	ND	ND	-20	+45	ND	ND	-10225	+55	-130
7180.8	-215	+395	-315	ND	ND	ND	ND	ND	ND	ND	ND
7208.8	-100	-70	+175	+30	+10	-20	ND	ND	ND	ND	ND
7222.8	-540	+290	-105	ND	ND	ND	ND	ND	ND	ND	ND
7236.8	-40	ND	-60	ND	ND	ND	ND	ND	ND	ND	ND
7250.8	-6030	+730	ND	ND	ND	ND	ND	ND	ND	ND	ND
7264.8	0	+2615	+1370	ND	ND	ND	ND	ND	ND	ND	ND
7278.8	+20	+100	+45	ND	ND	ND	ND	ND	ND	ND	ND
7292.8	-20	ND	-415	ND	ND	ND	ND	ND	ND	ND	ND
7320.8	0	-65	ND	-785	0	ND	ND	ND	ND	ND	ND

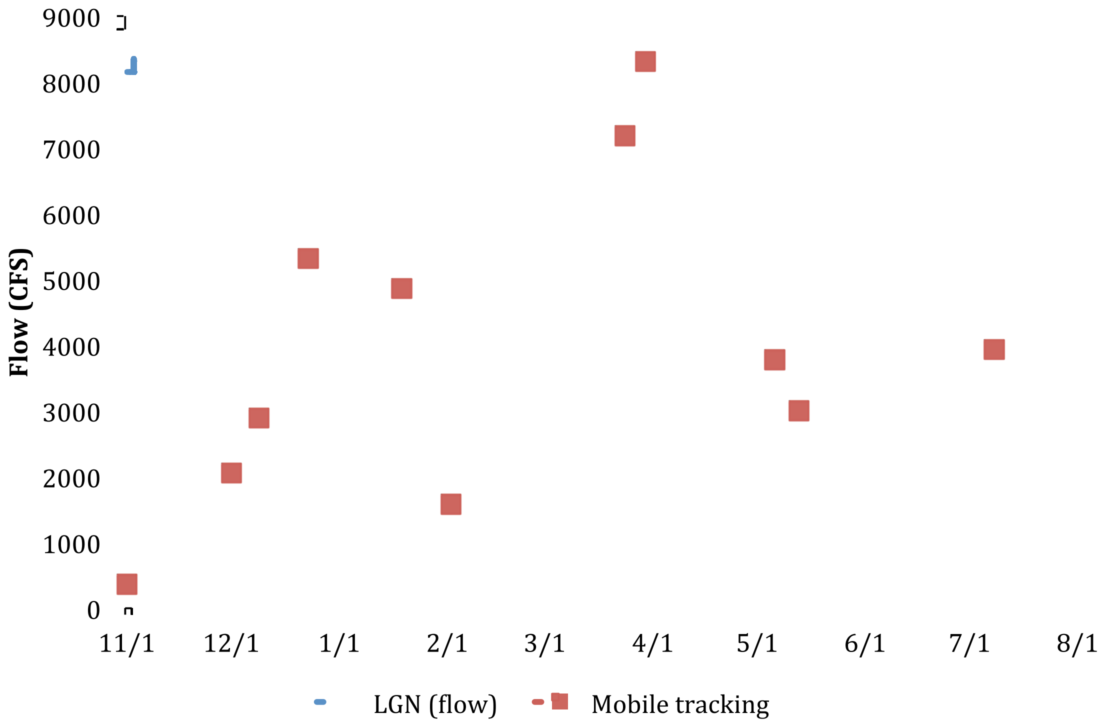

Figure 5. Tuolumne River flow at La Grange (LGN) and dates of mobile tracking surveys.

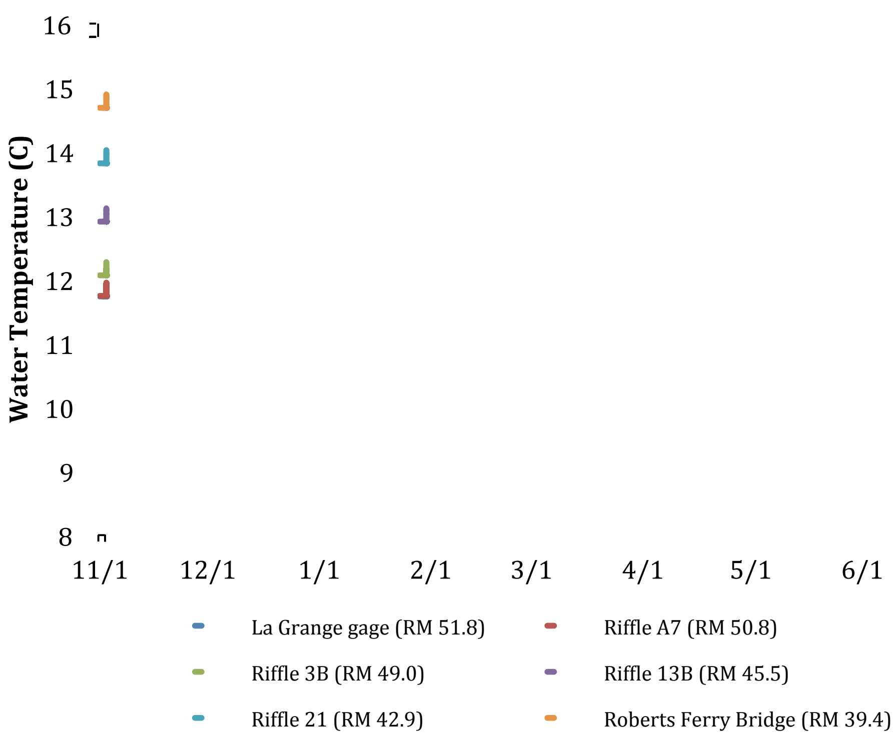

Figure 6. Tuolumne River daily average water temperature data.

On October 27, a male *O. mykiss* was tagged (tag code 7264.8) at RM 46.8 (NSO 066). This tag was detected near the release location on November 1. During the December 1 mobile survey, this tag was detected 2,615 m upstream of the release location. On December 9, it was detected an additional 1,370 m upstream at NSO 33. Although this fish was not detected again though mobile surveys, it was detected at the Zanker fixed receiver on March 20.

Tag code 7138.8 was captured and released on October 15 at RM 51.6 (NSO 005). On November 1, this tag was detected near the same location it was released. On November 28 and 30, this tag was detected passing the Zanker receiver. During the December 1 mobile survey, this tag was detected 2,725 m upstream of the Zanker receiver at NSO 054. On the following survey, December 9, it was detected an additional 5,715 m upstream near the original release location. Between January 1 through 16, this tag was again detected at the Zanker receiver. On the January 19 mobile survey, it was detected 11,010 m downstream from the original release location at NSO 095.

Tag code 7208.8 was captured and tagged at RM 45.0 (NSO 086) on October 19. This individual was detected 7 times between October 27 and February 2, with all detections within 220 m of the original release location.

Tag code 7152.8 was implanted into a male O. mykiss captured in NSO 008 at RM 51.4 on October 28. This individual was detected 4 four times between November 1 and May 13, with all detections within 70 m of the original release location.

The remaining nine tag codes (7026.8, 7040.8, 7180.8, 7222.8, 7236.8, 7250.8, 7278.8, 7292.8, and 7320.8) had limited detections during the mobile surveys, ranging from one to three detections during the November 1 –December 23 period. None of these tags were detected through mobile surveys after December 23. However, two of the tags (7222.8 and 7320.8) had multiple detections at the Zanker fixed receiver. Tag code 7222.8 was detected 245 times between October 27 and December 29, and tag code 7250.8 was detected 1,163 times between December 18 and March 5.

Discussion

Spawning locations of tagged adult O. mykiss

The ability to determine the spawning locations of adult *O. mykiss* was limited in 2011 due to a number of factors associated with the high river flows. These factors included increased background noise reducing detection efficiencies, inability to observe fish though snorkeling, and possibility of tagged fish moving into off-channel habitats that were not sampled.

Two acoustically tagged fish made large upstream movements in late fall/early winter, and moved back downstream near the original release locations. While spawning activity was not observed due to high flows, it is likely that these fish were spawning. Tag code 7166.8, implanted in a female, was detected on four occasions at NSO 014 (riffle A7, CDFG gravel introduction site) between December 1 and February 2.

Similarly, tag code 7264.8 was detected 3,985 m upstream of the original release location at NSO 033. Although this fish was not detected in any subsequent mobile surveys, it was detected at the Zanker receiver on March 20. Habitat unit NSO 033 is the same location that a post-spawn female *O. mykiss* was captured during 2010 sampling.

The capture and detection histories of these 3 individuals supports the thought that *O. mykiss* spawning occurs during the December through March period. There is limited data available on the spawn timing of *O. mykiss* in the San Joaquin basin, however it is believed to occur primarily from January through March (McEwan 2001).

Use of restored river reaches by tagged adult O. mykiss

Three fish were captured and tagged (tags 7040.8, 7054.8, and 7068.8) just downstream of the CDFG gravel introduction riffle 1A/1B (NSO 018-022) in a unit identified as sensitive *O. mykiss* habitat (McBain & Trush 2004). While these fish were not detected within the restoration reach, they were repeatedly detected in the same location and may have been attracted to this area by features associated with the restored habitat such as increased invertebrate production. No other *O. mykiss* were captured or detected within restored reaches of the Tuolumne River.

Seventeen of the 20 tagged fish were captured in eight habitat units that were identified as sensitive *O. mykiss* habitat (McBain & Trush 2004). The 2004 mapping surveys identified a total of 47 sites as sensitive *O. mykiss* habitat between La Grange Dam and Roberts Ferry Bridge, with 43 sites occurring above TLSRA.

Migration patterns of tagged adult O. mykiss

Operation of fixed acoustic arrays also provided information about straying of hatchery produced *O. mykiss* into the Tuolumne River. A total of 2209 hatchery produced yearling *O. mykiss* implanted with acoustic tags were released into the San Joaquin River at Durham Ferry (RM 66), approximately 23 miles downstream of the Grayson receiver, between March 22 and June 18, as part of USBR's six-year RPA studies. Thirteen of these tags were detected in the Tuolumne River at Grayson between June 26 and August 4. The time from release to initial detection at the Grayson receiver ranged from 14 to 81 days (mean- 47 days). It is unknown whether the tagged fish were still alive, or had been consumed by predators that were migrating upstream. However, the acoustic signals from some of these tags and there detections over extended periods were similar to those of known tagged predators from other studies. This is the second consecutive spring that tagged fish from South Delta studies have been detected entering the Tuolumne River. Straying of hatchery-produced yearling *O. mykiss* has also been documented at the Stanislaus River Weir (Ryan Cuthbert, FISHBIO, personal communication).

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Appendix A.

Table A-1. Date, location, and biological data for all *O. mykiss* captured during 2010.

Capture Date	Reach	Length (mm)	Weight (grams)	Sex	Tagged (Y/N)	Tag Code	Tag/Body Ratio
3/23	La Grange	425	>600	M	Y	7054.8	< 2.3%
3/23	La Grange	450	>600	M	Y	7068.8	<2.2%
3/23	La Grange	505	>600	F	Y	7012.8	<2.2%
3/24	Basso	293	306.4	unknown	N		
3/24	Basso	272	249.0	unknown	N		
3/24	Basso	271	222.8	unknown	N		
3/24	Basso	310	335.0	unknown	N		
3/24	Basso	282	263.0	unknown	N		
3/24	Basso	225	134.6	unknown	N		
3/24	Basso	293	--	unknown	N		
3/29	Basso	368	479.0	F	Y	7110.8	2.8%
3/29	Basso	360	395.0	F	Y	7194.8	3.2%
3/29	Basso	353	395.7	F	Y	7124.8	3.3%
4/7	Basso	310	215.2	unknown	N		
4/7	Basso	307	216.0	unknown	N		
4/7	Basso	283	--	unknown	N		
4/7	Basso	290	--	unknown	N		
10/15	La Grange	257	194.5	unknown	N		
10/15	La Grange	314	313.0	unknown	Y	7138.8	3.8%
10/15	La Grange	230	140	unknown	N		
10/15	La Grange	218	99.6	unknown	N		
10/19	Basso	463	1128.0	F	Y	7026.8	1.2%
10/19[a]	Basso	375	553.0	unknown	N		
10/19	Basso	370	508.0	unknown	Y	7222.8	2.4%
10/19	Basso	190	77.1	unknown	N		
10/19	Basso	360	552.0	unknown	Y	7208.8	2.2%
10/19	Basso	382	650.0	F	Y	7166.8	1.9%
10/19	Basso	210	101.4	unknown	N		
10/19	Basso	195	79.4	unknown	N		
10/19	Basso	200	87.8	unknown	N		
10/20	La Grange	350	520.0	unknown	Y	7236.8	2.3%
10/20	La Grange	400	908.0	F	Y	7040.8	1.4%
10/20	La Grange	360	492.0	unknown	Y	7250.8	2.5%
10/20[b]	La Grange	497	1224.0	F	N		
10/20	La Grange	390	716.0	unknown	N		
10/27	Basso	320	420.0	M	Y	7264.8	2.8%
10/27	Basso	350	477.0	F	Y	7320.8	2.5%
10/27	Basso	210	109	unknown	N		
10/28	La Grange	502	1207	M	Y	7292.8	1.1%
10/28	La Grange	450	887	M	Y	7152.8	1.4%
10/28	La Grange	380	690	F	Y	7180.8	1.7%
10/28	La Grange	540	1619	F	Y	7278.8	0.7%

[a]Fish did not recover from surgery, sacrificed and given to CDFG.

[b]Recapture of tag code 7012.8, tag was no longer active.

UNITED STATES OF AMERICA
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FEDERAL ENERGY REGULATORY COMMISSION

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

2011 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2011-8

Fall/Winter Migration Monitoring at the Tuolumne River Weir
2011 Annual Report

Prepared by

Ryan Cuthbert
Chris Becker
and
Andrea Fuller

FISHBIO Environmental, LLC
Oakdale, CA

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Fall/Winter Migration Monitoring at the Tuolumne River Weir

2011 Annual Report

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

Prepared By:
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March 2012

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Introduction

The California Department of Fish and Game (CDFG) has reported salmon escapement estimates on the Tuolumne River since 1940 (Fry 1961). Estimates of adult fall-run Chinook salmon escapement have varied from about 100 to 130,000 from 1940 to 1997 (mean: 18,300; median: 7,100) (Ford and Brown 2001). Over the last decade, estimates of adult fall-run Chinook salmon have ranged from a high of 17,873 in 2000 (Vasques 2001) to a low of 211 in 2007 (Blakeman 2008). Most, estimates of fall-run population size were obtained using carcass surveys (some weir counts were made at Modesto in the 1940's). While carcass surveys provide essential data to document the 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 provide direct counts that are not subject to the same biases. Weirs also provide precise migration timing information, while carcass surveys provide essential data to document the timing and distribution of spawning. Resistance board weirs have been widely used in Alaska to estimate salmonid escapement since the early 1990's (Tobin 1994), and a weir has been operated successfully on the nearby Stanislaus River since 2003.

The Tuolumne River weir project was initiated during fall 2009, and the Turlock Irrigation District (TID), Modesto Irrigation District (MID), and the City and County of San Francisco jointly supported this effort. The objectives of the Tuolumne River Weir Project include:

- Determine escapement of fall-run Chinook salmon and steelhead to the Tuolumne River through direct counts.
- Document migration timing of adult fall-run Chinook salmon and steelhead in the Tuolumne River and evaluate potential relationships withenvironmental factors.
- Determine size and gender composition of returning adult salmon population.
- Estimate hatchery contribution to spawning population
- Document passage of non-salmonids

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 – the largest impoundment is Don Pedro Reservoir. 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 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 below the typical downstream boundary of the CDFG spawning surveys. Site selection was also based on operational criteria that include water velocity, channel width, bank slope, channel gradient, channel uniformity, and substrate type.

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 16, 2011, monitoring continued throughout the remainder of the fall-run Chinook salmon migration period.

Weir and Vaki components were inspected and cleaned daily or more frequently when debris loads were heavy. The boat passage portion of the weir was briefly over-topped (submerged) on six occasions due to debris, and half of the weir was briefly over-topped on December 1, 2011 (Table 1). Maintenance procedures generally followed guidelines found in Tobin (1994) and Stewart (2002, 2003), although slight adjustments were made to accommodate site-specific attributes of the Tuolumne River Weir. For example, sealed plastic barrels were used for additional floatation during periods of high flows (Figure 2).

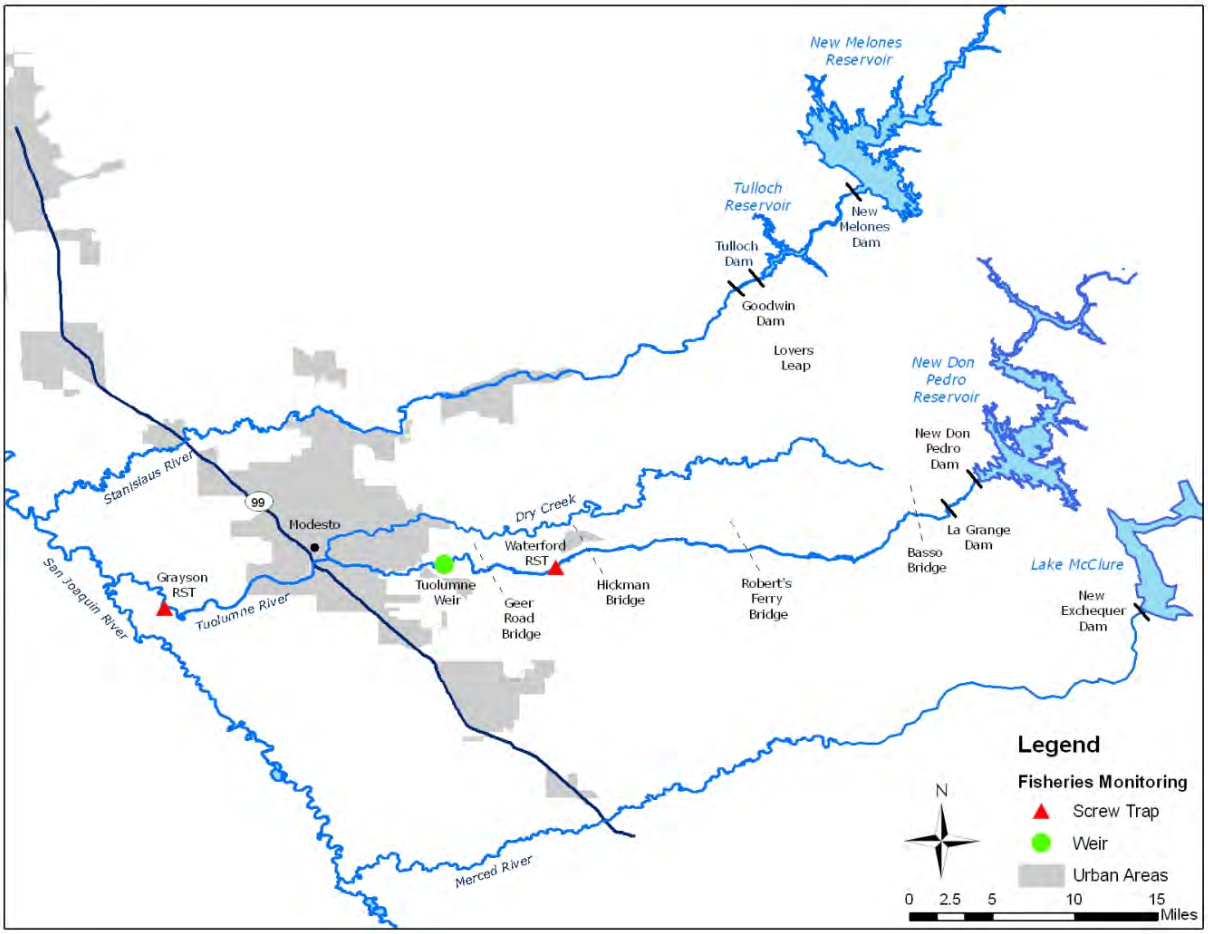

Figure 1. Map of the Tuolumne River displaying the location of the Tuolumne River Weir and other key points of interest.

Table 1. Date, time, and flow of weir over-topping occasions.

Date	Time (hhmm)	Average Daily Flow (cfs)
Sept. 19	0900	331
Sept. 21	1300	319
Sept. 23	0845	305
Oct. 11	0800	1,290
Nov. 6	1230	365
Dec. 1	0800	363

Figure 2. Photograph of the flotation barrels lining the underneath of the resistance weir.

In conjunction with the weir, a Vaki Riverwatcher fish counting system (Vaki system) was used during the majority of 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 3).

Figure 3. Left: Photograph of the Vaki Riverwatcher infrared scanner looking from upstream to downstream at the upstream side of the scanner plates. Center: Example of the riverwatcher camera and lights. Right: Tuolumne Weir Vaki Riverwatcher computer system and job box.

The Vaki infrared scanner was attached to a fyke at an opening in the weir, and data was relayed to a computer system that generated infrared silhouettes and video clips of passing objects (Figure 4). The system also recorded the time, speed, and direction of passage, as well as the depth of the passing object.

The Riverwatcher estimates length based on the depth (body depth) of the fish. A user-defined coefficient was derived from a body depth to total length ratio from measurements of trapped fish and carcasses. The user-defined coefficient is applied to the Riverwatcher measured depth to estimate total length. The coefficient is derived by 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. Total length is estimated by the following equation:

$$L = D \times l$$

where, *L* is the estimated total length, *D* is the body depth measured by the Riverwatcher, and *l* is the length coefficient. Only trapped fish were used for Chinook salmon ratio measurements.

Data from the Vaki computer was downloaded and reviewed daily during the peak migration periods. Infrared silhouettes were used in conjunction with digital video to identify passing objects (Figure 5). Video aids in the determination of gender, total length, presence/absence of adipose fin, distinguishing salmonids to species, and provides the only evidence of the condition of the fish.

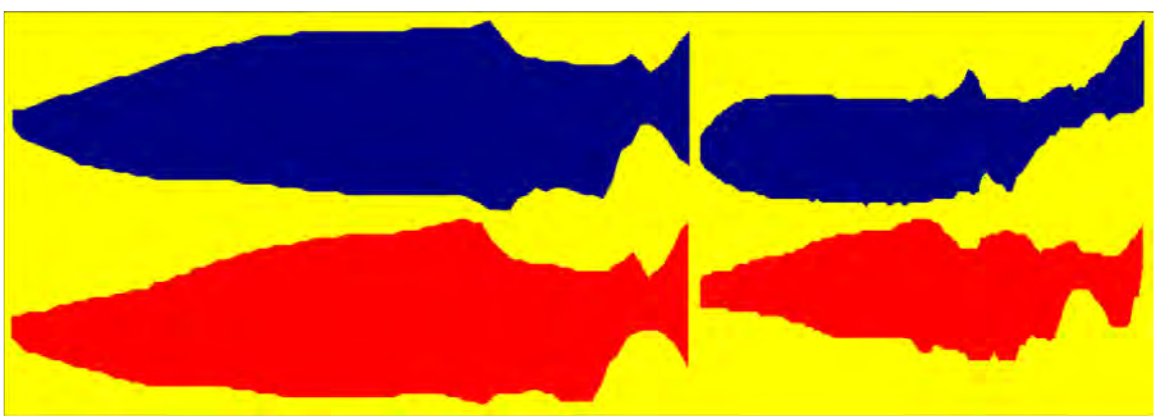

Figure 4. Example of silhouette images produced from both sets of scanner diodes (one image from one set of diodes is displayed in blue and the other is displayed in red). The left set of images is an example of a typical salmonid silhouette and the right set of images is an example of a poor salmonid silhouette.

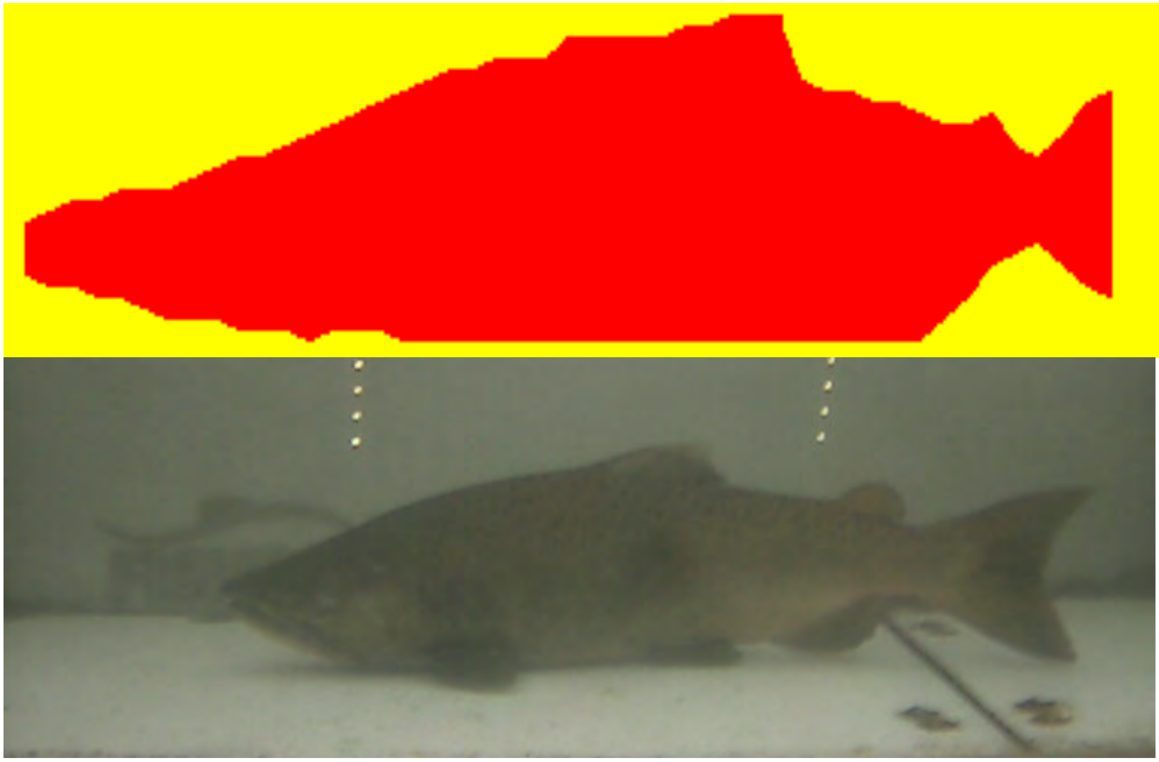

Figure 5. Top image is an example of a typical salmonid silhouette and the bottom image is a screen capture from a video clip of the same fish that is displayed in the top image. Note: Video clips are a higher quality image than the screen capture.

After each passage was identified to species, data were exported into an excel spreadsheet. The daily passage counts consisted of net upstream passages (upstream passages – downstream passages). Other information obtained from video clips was recorded including whether the presence/absence of an adipose fin (ad-clipped; Figure 6), fish condition, and gender.

Video clips provide the only means by which Chinook salmon and O. mykiss may be distinguished, and the identity of many species is uncertain based on infrared silhouettes alone. The quality of video is reduced when turbidity increases and can preclude identification of fish to species.

Physical data collected during each weir check included water temperature (°F), dissolved oxygen (mg/L), conductivity (µ), turbidity (NTU), stream gauge (ft), weather conditions (RAN = rain, CLD = cloudy, CLR = clear, FOG = fog), and water velocity (ft/s) measurements at the opening of the Riverwatcher scanner. Instantaneous water temperature and dissolved oxygen were recorded using an ExStik II model DO600

Dissolved Oxygen Meter 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 model 2020e Turbidimeter (LaMotte Co.), and water velocity was measured using a digital Flow Probe model FP-101 (Global Water Instrumentation, Inc.). Tuolumne River flow was also downloaded from the United States Geological Survey (USGS).

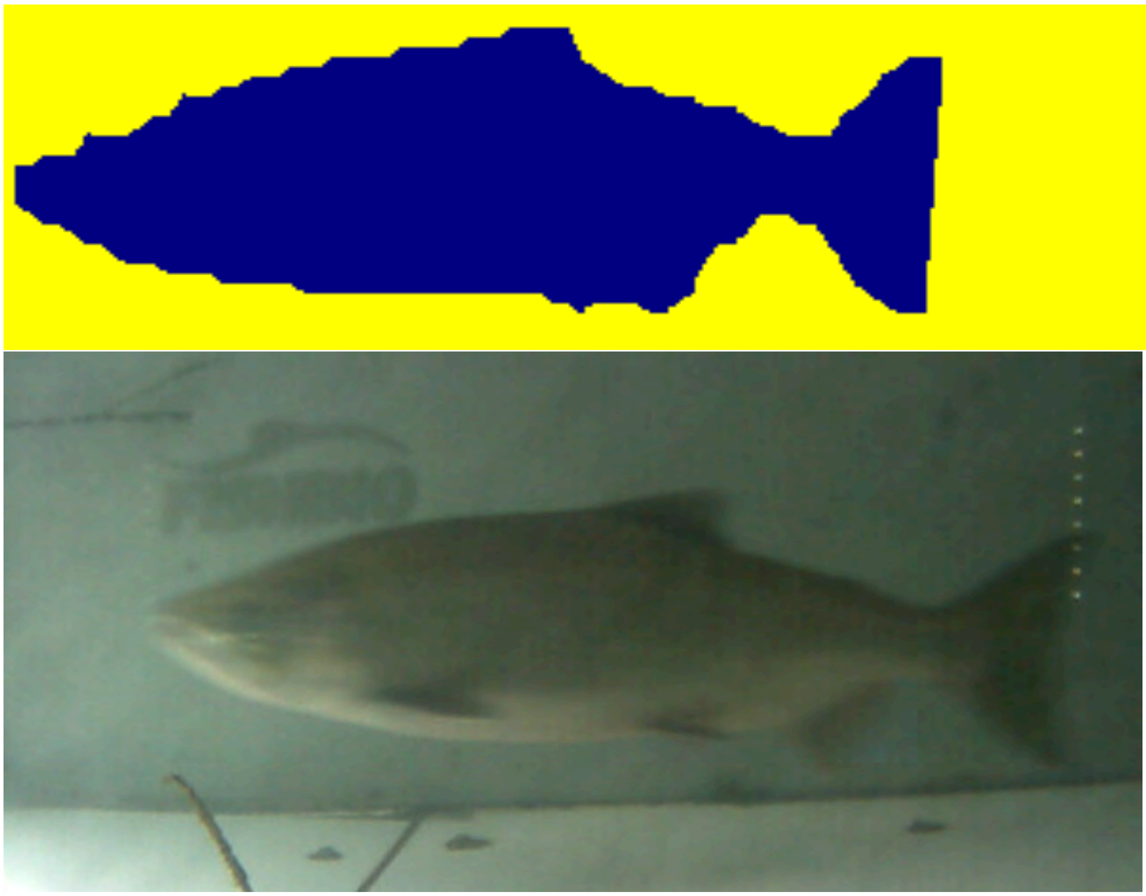

Figure 6. Example of a silhouette image and screen capture from a video clip of the same Chinook salmon that has a clipped adipose fin (ad-clip). Note: Video clips are a higher quality image than the screen capture.

Visual assessments in a half-mile reach upstream and downstream of the weir were conducted to monitor potential migration delay or digging activity. Boat surveys were conducted on Monday, Wednesday and Friday of each week during September and daily from October 1 through December 15. After December 15 boat surveys were conducted Monday, Wednesday and Friday for the remainder of the season. A “stacking ratio" was calculated using the number of salmon observed downstream of the weir and the number of salmon recorded by the Riverwatcher passing the weir during a three-day period to identify potential migration delays and if the ratio exceeded 1.15, three panels would be removed from the weir until CDFG allowed normal operations to resume. Five fish were observed downstream and fourteen fish were observed upstream of the weir during visual assessments from a boat, resulting in a maximum stacking ratio of 0.02 for the season, which is substantially less than the 1.15 threshold.

Results

Chinook salmon abundance and migration timing

Between September 16, 2011 and December 31, 2011, the Riverwatcher detected 2,817 adult fall-run Chinook salmon as they passed upstream of the weir. Daily passage ranged between 1 and 125 Chinook (Figure 7). Although Diel Chinook salmon passage was not signicantly different between dusk (1600-2159 hours), night (2200-0359 hours), dawn (0400-0959 hours), and day (1000-1559 hours) time-blocks (ANOVA: $F = 6.42$, $P = 0.3E\text{-}3$), it appears the majority of Chinook salmon passage occured between dusk and dawn with a substantial decrease in passage during the day (1000 hours – 1559 hours; Figure 8).

Chinook salmon gender and size

Total fall-run Chinook salmon passage was composed of 67% male (n = 1,892), 25% female (n = 712), and 8% unknown (n = 213). Mean total length for Chinook salmon upstream passages were: 583 mm (n = 2,801) for male, 614 mm (n = 892) for female, 562 mm (n = 270) for unknown; and 589 mm for all Chinook combined (Figutre 9). Mean lengths for male and female salmon differed slightly between size groups, but the length frequency distributions for males and females were predominately the 550 – 600 mm size class (Figure 9).

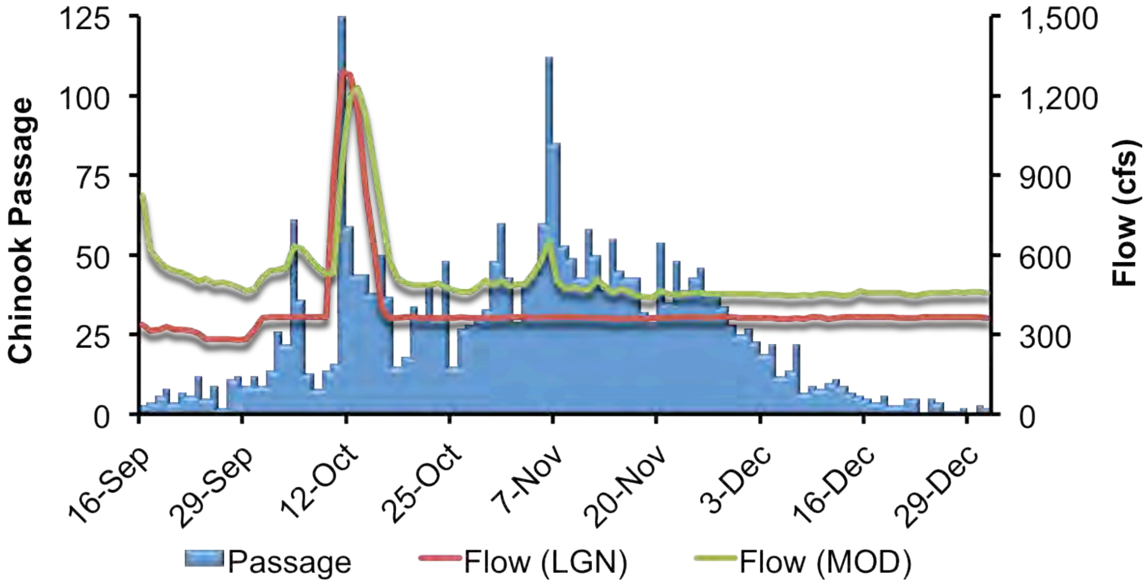

Figure 7. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to daily average flows (cfs) recorded in the Tuolumne River at La Grange (LGN) and Modesto (MOD) between September 16, 2011 and December 31, 2011 [Data source: CDEC].

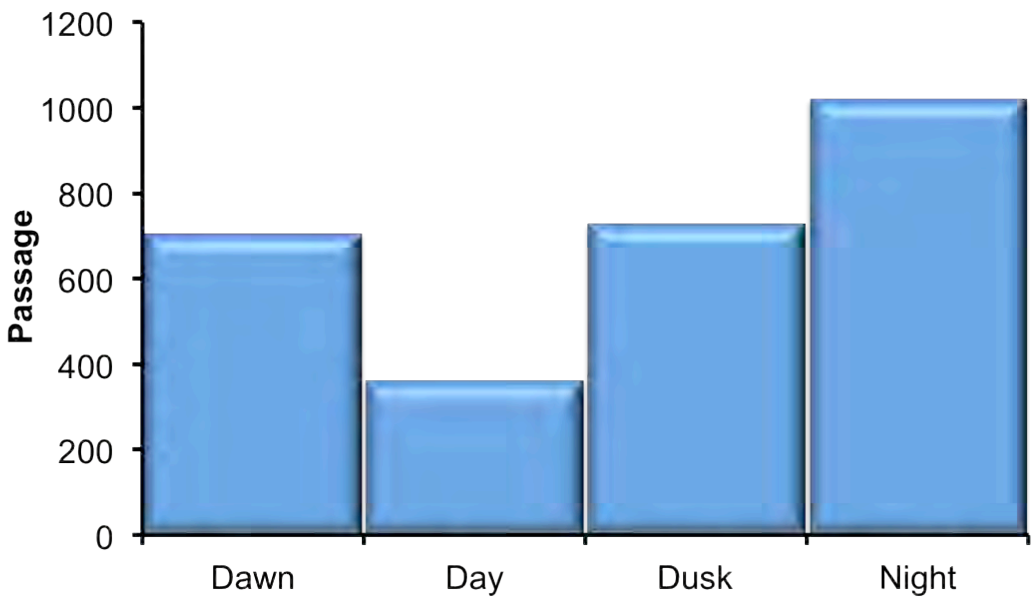

Figure 8. Chinook salmon passage in 6-hour time blocks. Diel Chinook salmon passage was not significant among the different time periods (ANOVA: *$F = 6.42$, $P = 0.3E\text{-}3$*).

Origin of Chinook salmon production

Chinook with adipose fin clips (ad-clips), suggesting hatchery origin, were observed in 55% (n=1,442) of Chinook that could be positively identified for presence/absence of adipose fin at the Tuolumne River weir during 2011. Although releases of hatchery origin Chinook have not been made in the Tuolumne River in recent years, straying from other basins is common as evidenced by the recovery of coded wire tags during annual carcass surveys.

Table 2. Fall-run Chinook salmon upstream passage data from September 16, 2011 through December 31, 2011 (upstream passage counts only, data are not directly comparable to net passage). Parenthesis indicates range.

Sex – Adipose fin clip	Mean TL (mm)	95% CI (mm)	n
Male – No	589 (201 - 1,017)	589 ± 6	1,165
Male – Yes	580 (234 – 1,037)	580 ± 4	1,604
Male – Unknown	542 (205 - 873)	542 ± 42	32
Female – No	635 (386 - 952)	635 ± 11	404
Female – Yes	598 (347 - 944)	598 ± 8	486
Female – Unknown	511 (476 - 545)	511 ± 67	2
Unknown – No	571 (502 - 773)	571 ± 22	24
Unknown – Yes	484 (251 - 669)	484 ± 176	4
Unknown – Unknown	563 (272 - 823)	563 ± 10	242
Combined	589 (201 - 1,037)	589 ± 3	3,963

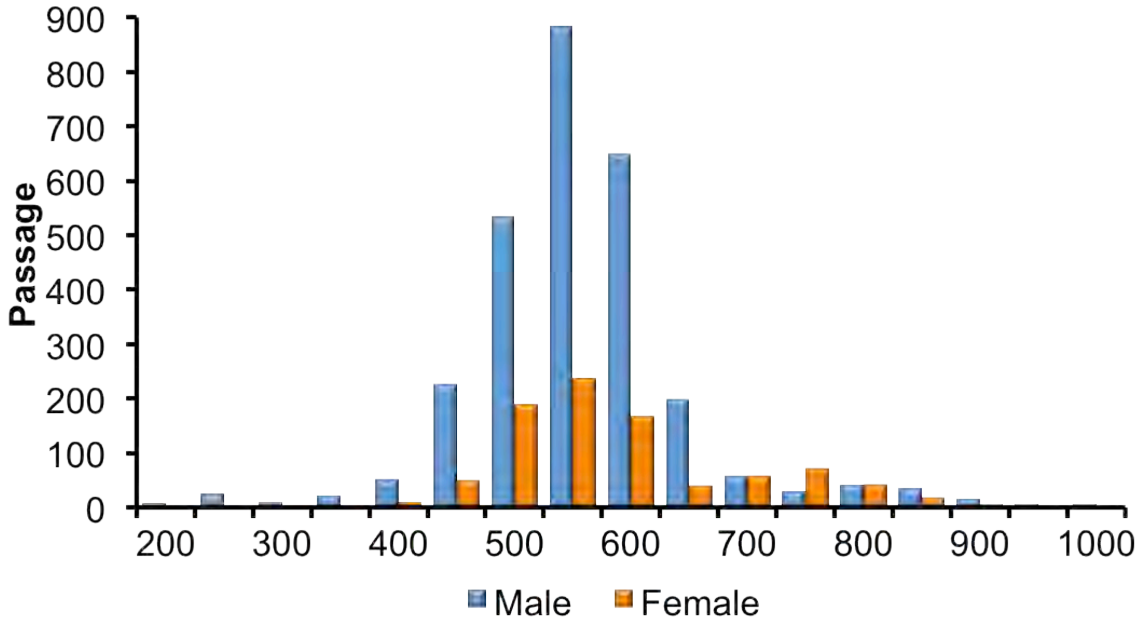

Figure 9. Length frequency of male and female fall-run Chinook salmon passage (upstream passage counts only, data are not directly comparable to net passage).

O. mykiss

Four *O. mykiss* were recorded passing through the weir between September 16, 2011 and December 31, 2011 (Table 3). One *O. mykiss* was recorded as an ad-clip and gender was not determinable for all *O. mykiss*, either due to fish size or quality of video.

Table 3. *O. mykiss* passages observed at the Tuolumne River weir between September 16, 2011 and December 31, 2011.

Species	Date	TL (mm)	Adipose Fin Clip
O. mykiss	9/20/11	384	No
O. mykiss	9/20/11	418	No
O. mykiss	9/23/11	360	No
O. mykiss	11/15/11	384	Yes

Non-salmonids

There were 12 other species identified passing the weir including bluegill sunfish (*Lepomis macrochirus*), common carp (*Cyprinuscarpio*), channel catfish (*Ictaluruspunctatus*), goldfish (*Carassiusauratus*), hardhead (*Mylopharodon conocephalus*), largemouth bass (*Micropterussalmoides*), Sacramento blackfish (*Orthodonmicrolepidotus*), Sacramento pikeminnow (*Ptychocheilusgrandis*), Sacramento sucker (*Catostomusoccidentalis*), smallmouth bass (*Micropterusdolomieu*), striped bass (*Moronesaxatilis*), white catfish (*Ictaluruscatus*); as well as unknown species of black bass (*Micropterus spp.*), catfish (*Ameiurus spp. and Ictalurus spp.*), and sunfish (Lepomis spp.) (Table 4). There were 11 net upstream passages that were identified as fish, but could not be identified to species.

Table 4. Incidental species passage data from September 16, 2011 through December 31, 2011. Only upstream passages were used for Total Length measurements (TL). Parenthesis indicates range.

Native Species	Mean TL (mm)	Date Range	Total Passage
Hardhead	291 (208 – 624)	9/18/11 – 12/31/11	489
Sacramento blackfish	419 (234 – 530)	9/20/11 – 12/21/11	44
Sacramento pikeminnow	325 (208 – 546)	9/18/11 – 12/31/11	94
Sacramento sucker	410 (224 – 784)	9/16/11 – 12/31/11	1,531
Non-native Species	Mean TL (mm)	Date Range	Total Passage
Bluegill sunfish	124	10/21/11	1
Common carp	518 (318 – 744)	9/16/11 – 12/7/11	354
Channel catfish	441 (284 – 611)	9/19/11 – 12/17/11	43
Goldfish	331 (246 – 375)	9/20/11 – 10/12/11	6
Largemouth bass	313 (174 – 426)	9/23/11 – 12/20/11	50
Smallmouth bass	285 (204 – 407)	9/17/11 – 12/30/11	53
Striped bass	434 (203 – 707)	9/21/11 – 11/20/11	14
White catfish	347 (180 – 572)	9/17/11 – 12/31/11	209
Unknown – black bass	274 (185 – 407)	9/21/11 – 12/2/11	25
Unknown – catfish	329 (180 – 509)	9/18/11 – 11/2/11	24
Unknown Species	Mean TL (mm)	Date Range	Total Passage
Unknown – sunfish	134	9/21/11 – 9/21/11	2
Unknown	511 (270 – 996)	9/18/11 – 12/20/11	11

Environmental Conditions

Between September 16, 2011 and December 31, 2011 daily average flow at La Grange (LGN; RM 51.8) ranged between 280 cfs and 1,290 cfs (393 cfs season average). Daily average flow at Modesto (MOD; RM 17) ranged between 440 cfs and 1,230 cfs (520 cfs season average) during weir monitoring (Figure 7).

Instantaneous water temperatures measured at the weir ranged between 47.5˚F and 69.6˚F (56.6˚F season average; Figure 10). Instantaneous turbidity ranged between 0.17 NTU and 2.42 NTU (0.87 NTU season average; Figure 11), and instantaneous dissolved oxygen ranged between 8.29 mg/L and 12.79 mg/L (10.60 mg/L season average; Figure 12).

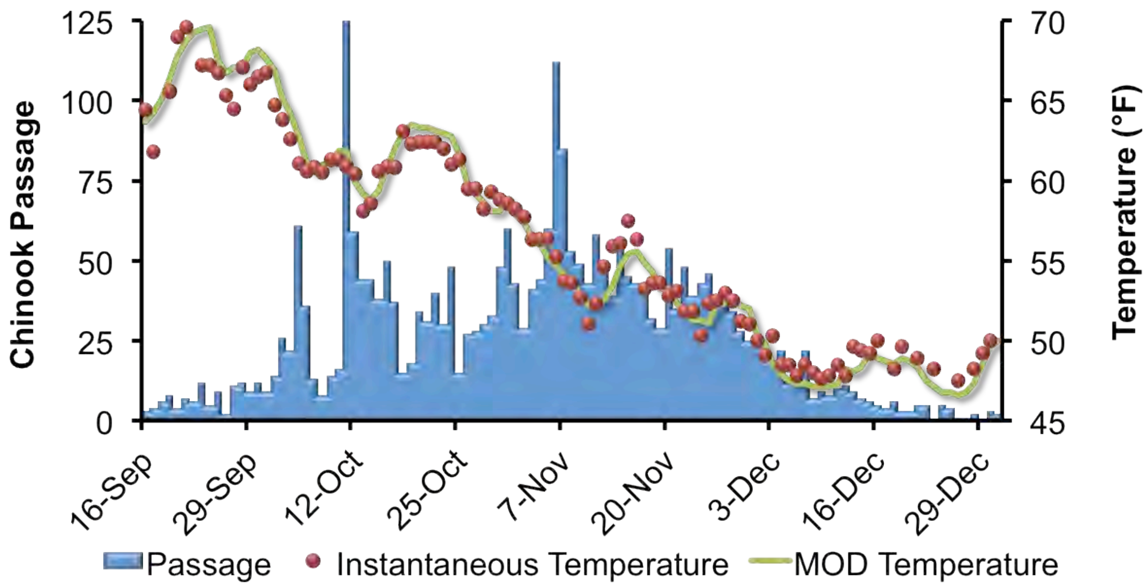

Figure 10. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous water temperature (°F) at the weir and daily average water temperature (°F) at Modesto (MOD) between September 16, 2011 and December 31, 2011 [Data source: CDEC – http://cdec.water.ca.gov].

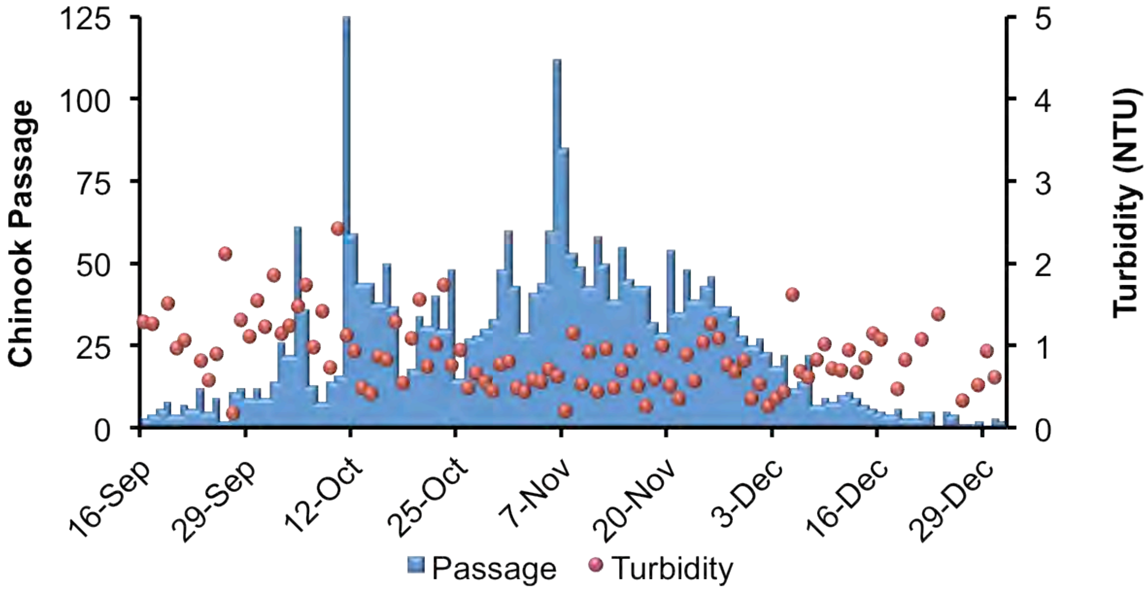

Figure 11. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous turbidity (NTU) between September 16, 2011 and December 31, 2011.

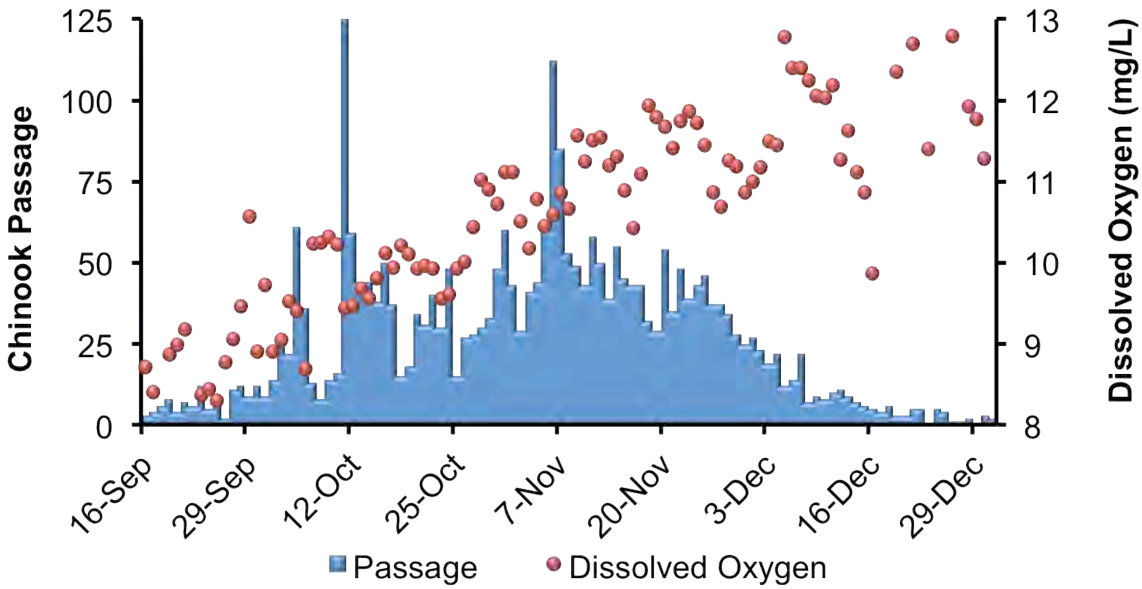

Figure 12. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous dissolved oxygen (mg/L) between September 16, 2011 and December 31, 2011.

Discussion

The Vaki Riverwatcher detected 2,817 fall-run Chinook salmon during 2011, which represents a substantial increase over the previous two years (Table 5). Although there were no apparent relationships between migration timing and turbidity or dissolved oxygen during 2010; there appeared to be an increase in passage once temperature decreased below 60°F which coincided with a small increase in flow due to managed pulse flow releases for fall-run Chinook salmon migration attraction. There also appeared to be an increase in passage in relation to very small peaks (i.e. fluctuations) in flow. For example, small peaks in daily average flow (<100 cfs) appear to coincide with substantial inscreases in daily passage; thereby, suggesting that the magnitude of the peak flow does not influence daily passage rather it is simply the fluctuation, however small the magnitude might be, in flow that possibly triggers an increase in migratory response.

Table 5. Annual adult Chinook salmon passage counts by run-type and range of dates that adult Chinook salmon passed the Tuolumne River Weir.

Year	Run Type	Passage Date Range	Total Passage Count
2011	Fall	September 16 – December 31	2,817
	Unknown	January 1 – Present	-
2010	Fall	September 9 – December 1	785
	Unknown	No sample	-
2009	Fall	September 22 – December 31	264
	Unknown	January 1 –February 10	31

Approximately 64% of the Chinook salmon observed at the Tuolumne River weir were two-year-old fish (≤ 600 mm TL), and the majority (74%) of these were males. Two-year-old males are commonly known as jacks and these fish may contribute up to 67% of the run 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, the large increase in the number of jacks in the Sacramento and San Joaquin Basin have forced the Pacific Fishery Management Council to modify the prediction model and declare the Chinook salmon overfished (Tracy et. al. 2012).

The Tuolumne River Chinook salmon population is not supplemented with hatchery fish however, the 2011 fall-run was comprised of 55% ad-clipped Chinook (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 quite a few un-clipped hatchery fish also entered this river in 2011. 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) and may be found to be even greater once analysis of CWT data for the most recent years are completed.

Escapement estimates from carcass survey counts were not available at the time that this report was prepared. However, escapement estimates from weir counts and carcass surveys differed greatly during the previous two years (2009 and 2010) of monitoring, whereby, the carcass survey estimate was substantially underestimated in comparison to the weir estimate.

In addition to providing information on migrating adult fall run Chinook salmon, the weir also provided information on the movement and sizes of 12 non-salmonid species observed passing the weir. Many (30%) of the non-salmonid species were non-native, and many of the non-native species are known to prey on juvenile Chinook salmon (e.g. largemouth bass, smallmouth, striped bass, and catfish) (Tabor et. al. 2007). Year-round monitoring could provide more insight into Chinook salmon run dynamics on the Tuolumne River as well as abundance indicators for predatory fishes.

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