March 31, 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 2010.

Please find the enclosed 2010 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 *O. mykiss* population estimates and acoustic tracking study results required 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	TURLOCK IRRIGATION DISTRICT
Greg Dias	Robert M. Nees
Project Manager	AGM Civil Engineering and Water Resources

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

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: 2009 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

- FERC PROJECT NO. 2299 –

2010 ANNUAL SUMMARY REPORT

Turlock and Modesto Irrigation Districts

Introduction

This is the Districts' 15th 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 2010 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 2005-2010. 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, 2011 for studies conducted in calendar year 2010.

1 - Fishery Monitoring

1.1. Fall-run Salmon Counts and Estimates

The two-year ban on commercial and sport ocean harvest was partially lifted and the Central Valley fall Chinook runs, which have been the lowest on record, showed substantial improvement. 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. 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 contained here for 2010 were obtained indirectly through an online CDFG "GrandTab" compilation that was updated on March 9, 2010.

The counting weir operation initiated in 2009, was continued in both the Tuolumne and Stanislaus rivers, with counting operations beginning 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. Due to high flows in the Tuolumne River, weir operation was ended earlier than in 2009, and as such, likely under estimates the total run, which typically can continue through the end of December. The 2010 fall run weir count for the Tuolumne was 766 adult Chinook salmon (through November 30, 2010) and 1,379 salmon at the Stanislaus weirs (through January 2, 2011). These counts represents an increase from the 2009 counts of 280 salmon in the Tuolumne river and 1,250 salmon in the Stanislaus river.

In contrast to those actual weir counts, the CDFG float surveys, using the customary carcass survey method by boat, resulted in preliminary 2010 fall-run Chinook population estimates (from GrandTab spreadsheet summary) of 540 salmon for the Tuolumne River and 1,086 for the Stanislaus River. It is not clear at this time if those estimates are inclusive of all river reaches or what the survey period was in 2010. As was the case in 2009, these estimates are lower than the weir counts in both rivers. The 2010 GrandTab numbers for the Merced River run are 651 (river) and 146 (hatchery) for a total of 797. These tributary counts/estimates of 797 (Merced), 766 (Tuolumne), and 1,379 (Stanislaus) total 2,942 salmon for the basin and are graphed in Exhibit 1. Summary details for these surveys, dating back to 1973 can be found in Report 2010-2, while specific details for any given year are in the annual survey reports.

A draft CDFG Tuolumne River fall spawning survey report for 2009 in included here as Report 2010-1. A CDFG report for the 2010 fall run has not yet been provided. Consequently, Report 2010-2 only contains an abbreviated update for 2010, but does include tributary estimates for prior years. Report 2010-8 has a detailed review of the Tuolumne weir operation in 2010.

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) were much higher in 2010 with a preliminary GrandTab estimate of 163,181 (including 51,726 in hatcheries), greater than the 53,129 total in 2009 and the highest since 2006 total of 292,875. The estimate of adult fall-run in the Sacramento basin was 152,831 (PFMC 2010a), up from the prior low of 49,573 in 2009 and within the PFMC lower management target of 122,000 to 180,000 hatchery and natural area adults for the Sacramento River system. However, it was less than the PFMC preseason forecast of 245,483 (PFMC 2010b). A partial ban on the commercial and sport salmon fishery was implemented for California during 2010, following two years of a total ban during 2008-2009.

The total number of estimated 2-year olds in the Sacramento basin was 27,483, an indication that the cohort of 3-year olds (year class from 2008 runs) in 2011 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 2011 Sacramento basin is 729,893 adults (95% CI = 231,671–1,228,114), so some ocean harvest is being considered for 2011. Exhibits 1 and 2 contain graphs of historical harvest and abundance data through 2010.

1.2. Seine Sampling

Report 2010-3 reviews the routine seine monitoring conducted in eleven surveys during January-June 2010 at eight Tuolumne River sites from RM 50.5-3.4 and two San Joaquin River locations. A total of 386 natural Chinook salmon were caught in the Tuolumne River and none in the San Joaquin River. This was the 7th lowest number of salmon caught during the 1986-2010 period. Salmon were captured from RM 50.5-24.9 (La Grange to Charles Road).

Density of fry (≤ 50 mm) peaked on 17 February, similar in timing to other years of the 2005-2010 period. The density of juveniles (> 50 mm) peaked on 30 March, which was also similar to other years in the period. Fork length (FL) ranged from 29-101 mm, fry were caught throughout the sampling season. A comparative review with other years is in Report 2010-3. The seine report classifies "juvenile" salmon as >50 mm, whereas the screw trap report distinguishes parr (50–69 mm) and smolt (≥ 70 mm) size ranges.

A total of 29 *O. mykiss* (21-51 mm FL) were caught in the Tuolumne River from February17-May 11. A total of 15 fish species were recorded in the Tuolumne River and 10 species in the San Joaquin River during the season.

1.3. Screw Trapping

Report 2010-4 reviews the screw trap monitoring conducted near Waterford (RM 29.8) from January 5–June 11 and near Grayson (RM 5.2) from January 6-June 17 and includes a comparison with other years. Total salmon catches were 2,281 at the Waterford screw trap and 52 at the Grayson screw trap.

Fry (< 50 mm) capture at the Waterford screw trap occurred from January 19 through mid-May with an estimated passage of 10,735 for that life stage (13,399 in 2009); estimated peak passage was in late January associated with storm events and elevated turbidity. Grayson had an estimated passage of 183 fry (145 in 2009).

Waterford had a passage estimate of 1,030 parr (50-69 mm) and 29,728 smolts (≥ 70 mm), less than the 2009 estimates of 4,562 parr and more than the 19,213 smolts in 2009. The Grayson passage estimates showed no parr passage in 2010, compared with an estimate of 200 in 2009 and a passage estimate of 4,260 smolts in 2010, compared with 4,332 in 2009. The peak smolt passage was in mid May and was associated with higher release flows at La Grange Dam. The survival index for 2010 of 10.4%, should be interpreted with caution, since there is substantial uncertainty in the total passage estimate for Waterford. Survival indices of 23.6%, 13.2% and 11.9% were calculated for 2006, 2008 and 2009, respectively. 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 2010. There were 22 other fish species captured in the screw traps in 2010.

1.4. Reference Count Snorkeling

Report 2010-5 reviews the snorkel surveys that were conducted on August 10-12 and November 2-4, 2010 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 August survey was conducted at a flow of approximately 315 cfs with water temperature ranging from 11.1 °C (52.0 °F) to 20.1 °C (68.2 °F). A total of 152 juvenile Chinook salmon and 268 rainbow trout (*O. mykiss*) were recorded in the August survey. The November survey was conducted at a flow of approximately 360 cfs with water temperature ranging from 11.7 °C (53.1 °F) to 14.3 °C (57.7 °F). A total of 170 Chinook salmon (including adult spawners) and 288 rainbow trout (*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 31 (RM 38.0) in August. Chinook salmon and *O. mykiss* were both observed downstream to Riffle 41A (RM 35.3) 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, redear sunfish, and striped bass. Report 2010-5 also contains a comparison with other years, dating back to 1982.

1.5. *O. mykiss* Population Estimate Surveys

This snorkeling study pursuant to the 2008 FERC Order was first done in July 2008. There were surveys conducted in March and July of 2009 and the 2009 report was submitted to FERC on January 15, 2010. In 2010, surveys were conducted in March and April, with the 2010 report submitted to FERC on January 15, 2011. Two separately required *O. mykiss* annual monitoring reports were also submitted in January 2010 and January 2011 along with the population estimate reports which summarized, among other monitoring results, the outcome of the population estimate surveys.

Report 2010-6 presents the population estimates for O. mykiss and Chinook salmon based on surveys conducted in 2010 and provides a comparison of these results with those from previous surveys. The population estimates are based on babitat 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*

Both the March and August 2010 surveys extended from RM 51.8 to RM 38.4. In March, *O. mykiss* were observed down to RM 38.5 and in August to RM 39.7. The August 2010 juvenile O. mykiss population estimate was lower than the July 2009 estimate and similar to the July 2008 estimate juveniles. The summer population estimates are within the 95% CI for juvenile *O. mykiss* in all three years (2008-2010). The August 2010 adult *O. mykiss* population estimate was higher than both the July 2009 estimate and the July 2008 estimate. The March 2010 adult estimate was similar to March 2009.

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

As in previous years, most of the salmon in the surveys were in the 50-99 mm range. The 2010 estimate of juvenile salmon in March was much lower than the March 2009 estimate, with the August 2010 estimate higher than in July 2008 but lower than in July 2009. There were also 14 adult Chinook salmon (>150 mm FL) observed from RM 50.6-48.1 in August 2010.

1.6. *O. mykiss* Acoustic Tag and Tracking

This tracking study pursuant to the May 2010 FERC Order was initiated by FISHBIO in March 2010 after permits required to initiate the adult *O. mykiss* tracking study were obtained. The initial study was conducted from March through November 2010. Report 2010-7 presents results from the 2010 study and shows little movement of tagged fish beyond approximately 500 meters (0.31 miles) of their release location, with no tagged fish from the study detected downstream of RM 44. The study is scheduled to include continuation of tracking fish tagged in the fall of 2010 through spring of 2011, with recommendations for an additional tagging effort in fall of 2011 and subsequent tracking through spring of 2012.

1.7. Counting Weir

The year 2010 represents the second 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 2010-8 provides detailed results and sampling conditions for the Tuolumne River weir during the 2010 Fall/Winter monitoring season, which totaled 766 adult Chinook salmon counted for the lower Tuolumne River. The weir was deployed at RM 24.5 from September 9 through November 30 when flood management releases necessitated removal of the weir. The 2010 monitoring period thus represents an underestimate of the total escapement,

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

which typically continues through December. As discussed in report 2010-1, the weir count does not include fish spawning downstream of RM 24.5. Lastly, the high flows in December 2010 also prevented CDFG spawner surveys and these results (not yet published) will also represent an underestimate of the actual spawner population for 2010.

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 2010 compared with 2009 for the Mossdale trawl catch and remained similar 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 varies considerably from year to year and the understanding of that environment has increased in recent years. The Northwest Fisheries Science Center (NWFSC) reported "extremely mixed" signals of ocean ecosystem indicators, with a cooling trend interrupted in by warming from fall 2009 through spring 2010. However, in May 2010 the cooling trend resumed and ocean conditions have remained cold since the summer 2010, suggesting that ocean conditions for salmon in 2011 may be "among the best of the past 15 years" (details 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.

NOAA fisheries reported results from the first phase of a Chinook salmon ocean distribution mapping study (http://swfsc.noaa.gov/news.aspx?ParentMenuId=54&Division=FED&id=16373) that suggested Central Valley salmon stocks may still be depressed based on initial counts in Oregon and California. An additional NOAA fisheries report on genetic stock identification of Chinook salmon from the Monterey Bay recreational fishery in 2010 estimated that "94% of the

catch was Central Valley Fall Run Chinook, which is similar to the proportion in 2006, when this stock was relatively abundant, and substantially higher than in 2007, which was the first year of the stock "collapse"".
(http://swfsc.noaa.gov/news.aspx?ParentMenuId=54&Division=FED&id=16266)

3.2. Delta Issues

3.2.1. Salmon salvage and losses at Delta water export facilities

Exhibit 4 contains 2010 State Water Project (SWP) and Federal Central Valley Project (CVP) delta water export facility salmon salvage and loss information. Additional review will be available in SJRGA (*In Progress*). Natural/unmarked salmon salvage for January-June at the facilities was higher in 2010 with combined facility estimates of 9,325 salmon salvaged compared with 7,115 in 2009. The number of salmon losses at the facilities was similar in 2010 compared with 2009 (14,203 and 14,295, respectively). 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-March, but there was a dominant salvage of larger juveniles/smolts (75-110 mm) from late March through late May. Weekly density (combined salvage and loss/1000 AF of export) was during April and May 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.

During WY 2010, flows of 3,000 cfs at Vernalis were targeted for acoustic tracking studies during April 1–24 and May 26–31 (the D-1641 requirement for Vernalis flows during these periods is expected to range from 1,420 to 2,280 cfs). For the April 25-May 25 test period, flows of 3,200 cfs were targeted at Vernalis and the daily combined CVP and SWP export rates were limited to no more than 1,500 cfs from April 1 through May 31. Actual flows at Vernalis during the VAMP test were approximately 5,900 cfs. Flows in the Tuolumne River exceeded the

VAMP requirement during this time period due to flood management releases (See Attachment A3).

The 2010 VAMP smolt tracking study used a total of 1,004 hatchery smolts with implanted acoustic transmitters, representing the 5th year that acoustic technology was used to estimate juvenile salmon survival through the southern Sacramento-San Joaquin Delta (VAMP 2010). There were 7 releases made in 2010 of about 72 smolts each during April and May at Durham Ferry on the San Joaquin River, with other release locations near Stockton, CA and in Old River. Tracking 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. Similar to 2009, a non-physical barrier at the Head of Old River was tested in 2010, incorporating some design and deployment modifications. No study results for the 2010 study are available at this time. However, preliminary indications are that receiver performance at the monitoring stations improved in 2010 and that survival estimates should be available for all release groups. Mortality of smolts was also noted as being lower in 2010 from Durham Ferry to the upper Old River junction than in 2009 (VAMP 2011). The VAMP tagging study is planned to continue in 2011 with some proposed changes in the timing and release numbers made at Durham Ferry (VAMP 2011).

3.2.3. Other Delta issues

A National Research Council (NRC) panel studying sustainable water and environmental management in the California Bay-Delta held a series of meetings in 2010 at the request of Congress and the Departments of the Interior and Commerce. The panel will focus on whether there are conservation actions other than those in the biological opinions that would protect species while using less water, and to account for potential conflict between the needs of NMFS and USFWS species. More information can be found at the following websites. http://swfsc.noaa.gov/news.aspx?ParentMenuId=54&Division=FED&id=15970 and http://www8.nationalacademies.org/cp/projectview.aspx?key=49175 .

4 – Hydrology, Flow Schedules, and River Operations

The 2010 calendar year included part of the 2010 and 2011 water years (WY) from October 1st through September 30th. The WY2010 Tuolumne River preliminary computed natural runoff was 97% of the long-term average (http://cdec.water.ca.gov/cgi-progs/reports/FLOWOUT.201009). The 2010 San Joaquin Basin 60-20-20 Water Supply Index was 3,687,196 – an "Intermediate BN-AN" 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 2010 and 2011 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 2010 included Article 37 minimum flow and pulse flow requirements spanning the 2009 and 2010 FFYs. Part 3 of Attachment A contains the primary flow schedule correspondence. The initial volume used in the April 2010 scheduling process was 300,923 AF representing the maximum requirement due to above average runoff conditions and an increase from the 151,222 AF scheduled in 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 generally exceeding 2,000 cfs occurred from mid-April through early-July due to above average runoff conditions. Base flows of at least 300 cfs occurred in August through October. A fall pulse volume of 5,950 AF occurred during October 6-16 and was scheduled to provide a peak of 800 cfs. Flood management flows exceeding 2,000 cfs resumed in December and continued through January 2011.

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 catagories (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 restoration project activity is occurring.

6 – Tuolumne River Technical Advisory Committee (TRTAC)

Four quarterly TRTAC meetings were held in 2010: March, June, September, and December; the fishery agencies attended none of the meetings in 2010. Attachment B contains the 2010 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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Pacific Fishery Management Council (PFMC) 2011b. Preseason Report 1: stock abundance analysis for 2011 ocean salmon fisheries. Portland, OR Available at: http://www.pcouncil.org/wp-content/uploads/Preseason_Report_I_2011.pdf

San Joaquin River Group Authority (SJRGA). *(In Progress*) 2010 Annual Technical Report: On implementation and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. Prepared for California State Water Resources Control Board in Compliance with D-1641. Available when completed at http://www.sjrg.org/

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

Vernalis Adaptive Management Plan (VAMP) 2010. Proposal for the 2010 VAMP Study. VAMP Biology Team. March 12, 2010.

VAMP 2011. Study Proposal for the 2011 Vernalis Adaptive Management Plan (VAMP) Fish Monitoring and Evaluation Program. Prepared for the Biology subcommittee of the San Joaquin River Technical Committee. March 15, 2011.

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 1992-2010 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

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

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

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

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

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 2010 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 2010 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

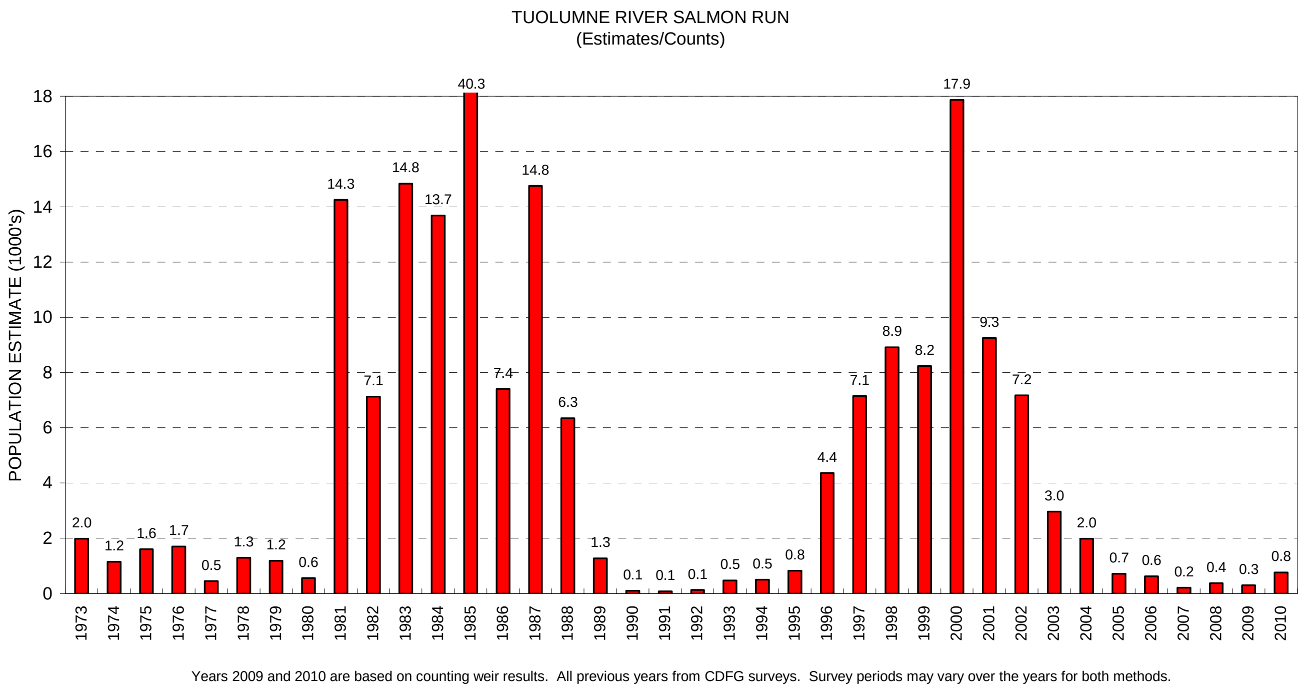


Exhibit 1A

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

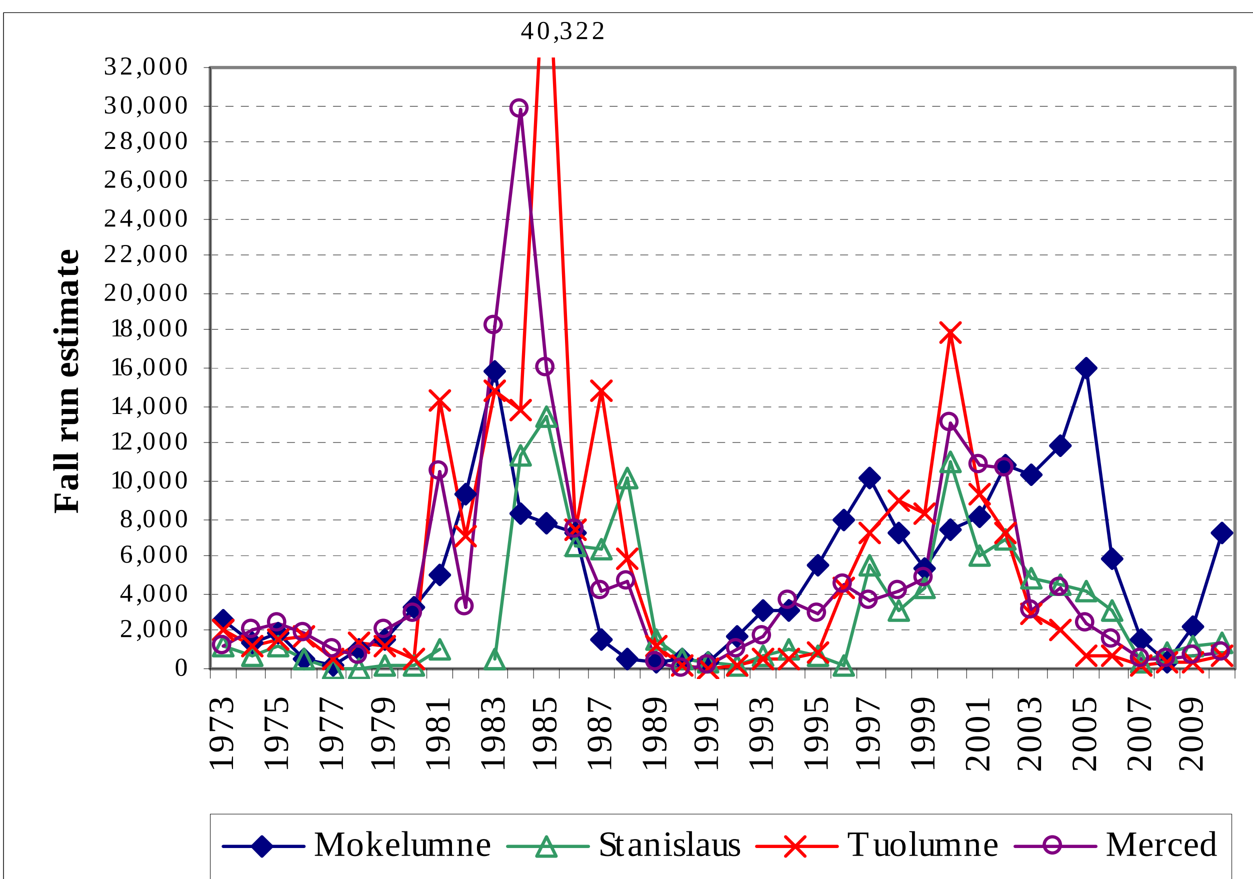


Exhibit 1B

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

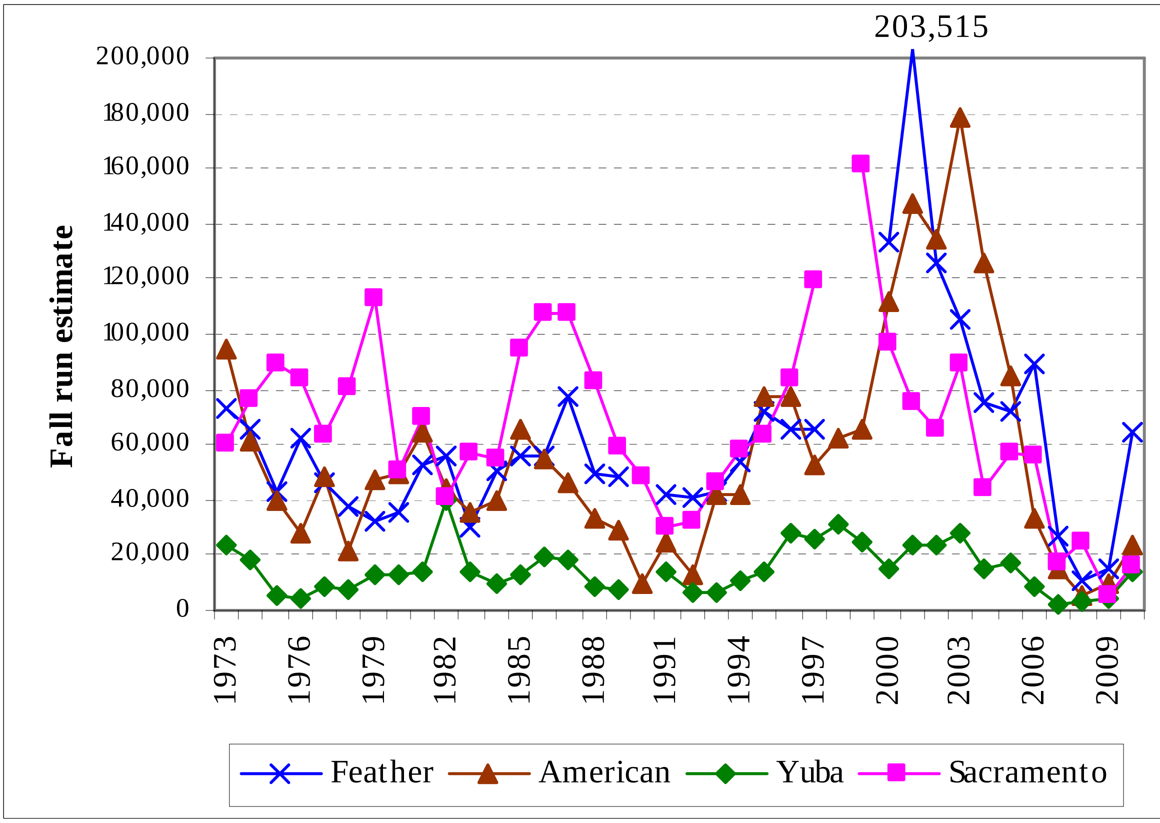


Exhibit 1C

Combined Natural Spawning and Hatchery Fall-run Total Since 1973

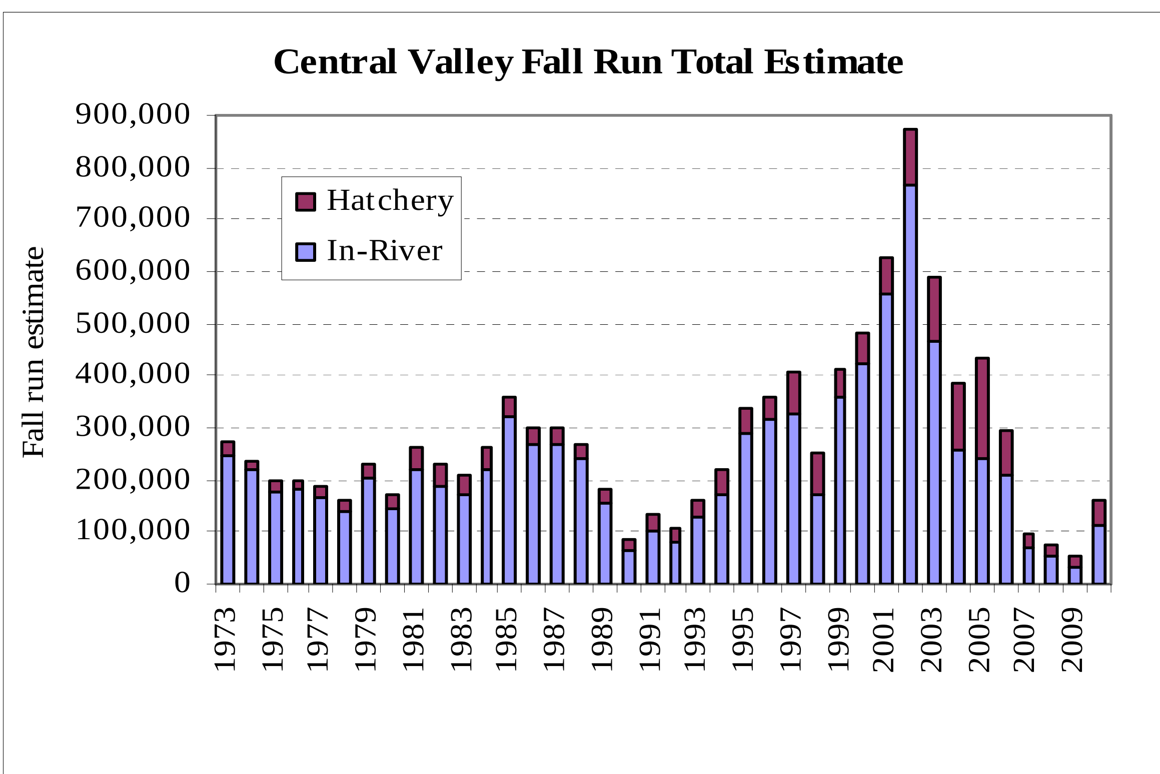


Exhibit 1D

Exhibit 2 – Salmon harvest and Sacramento abundance data

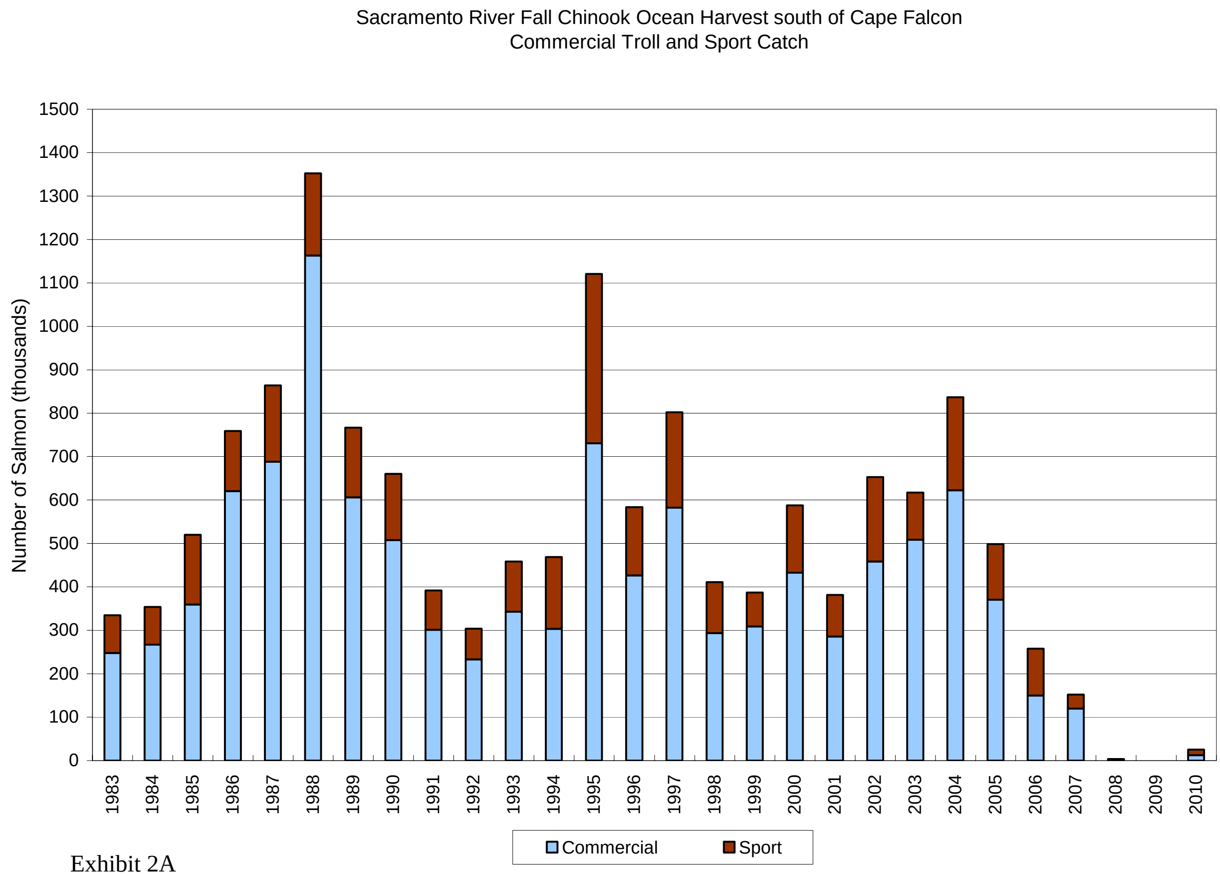


Exhibit 2A

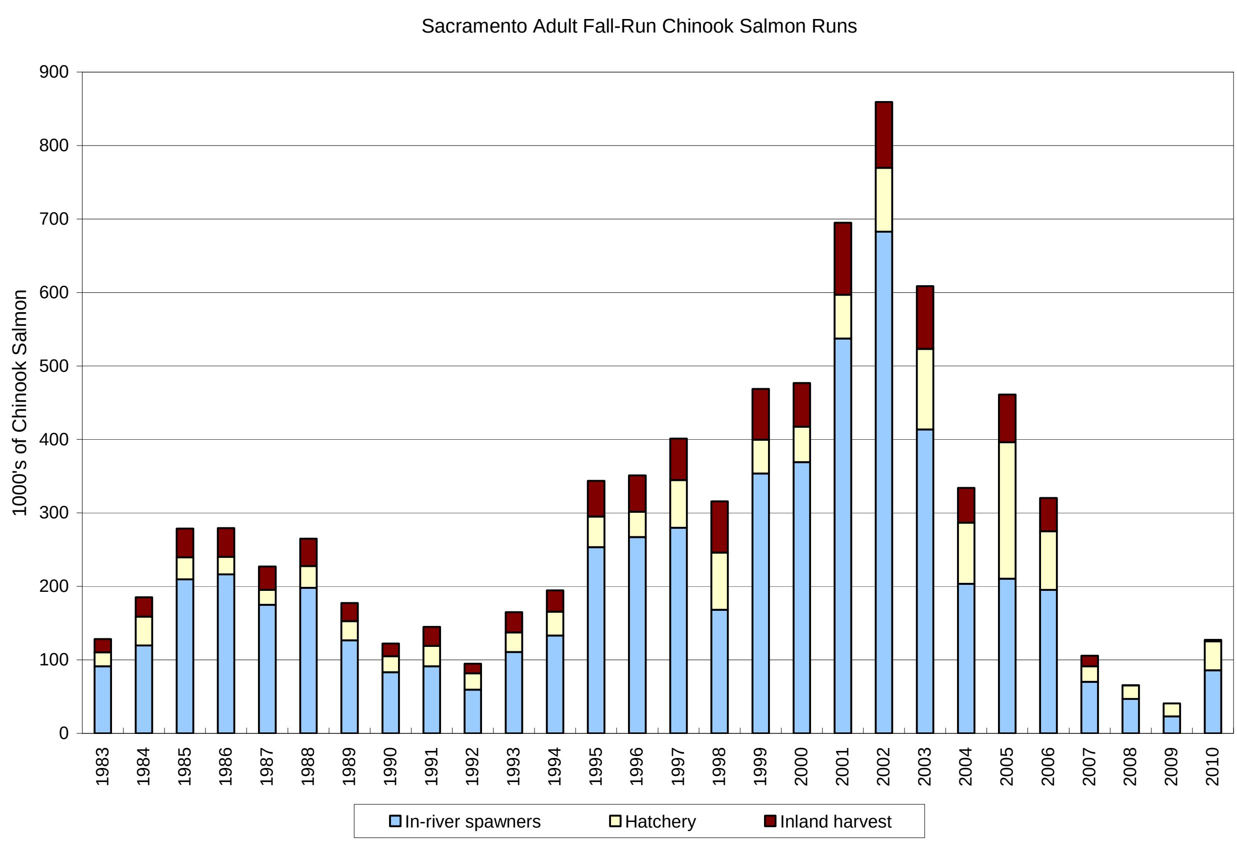


Exhibit 2B

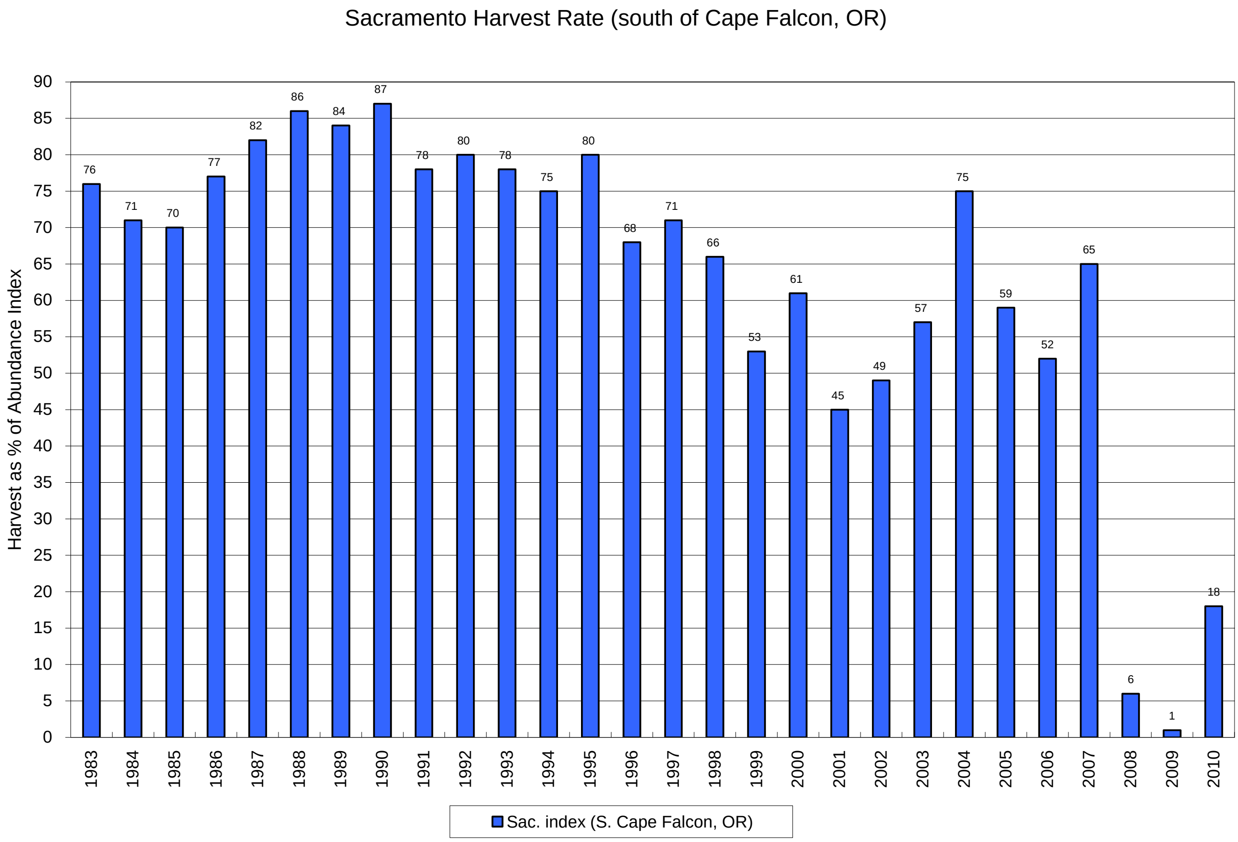


Exhibit 2C

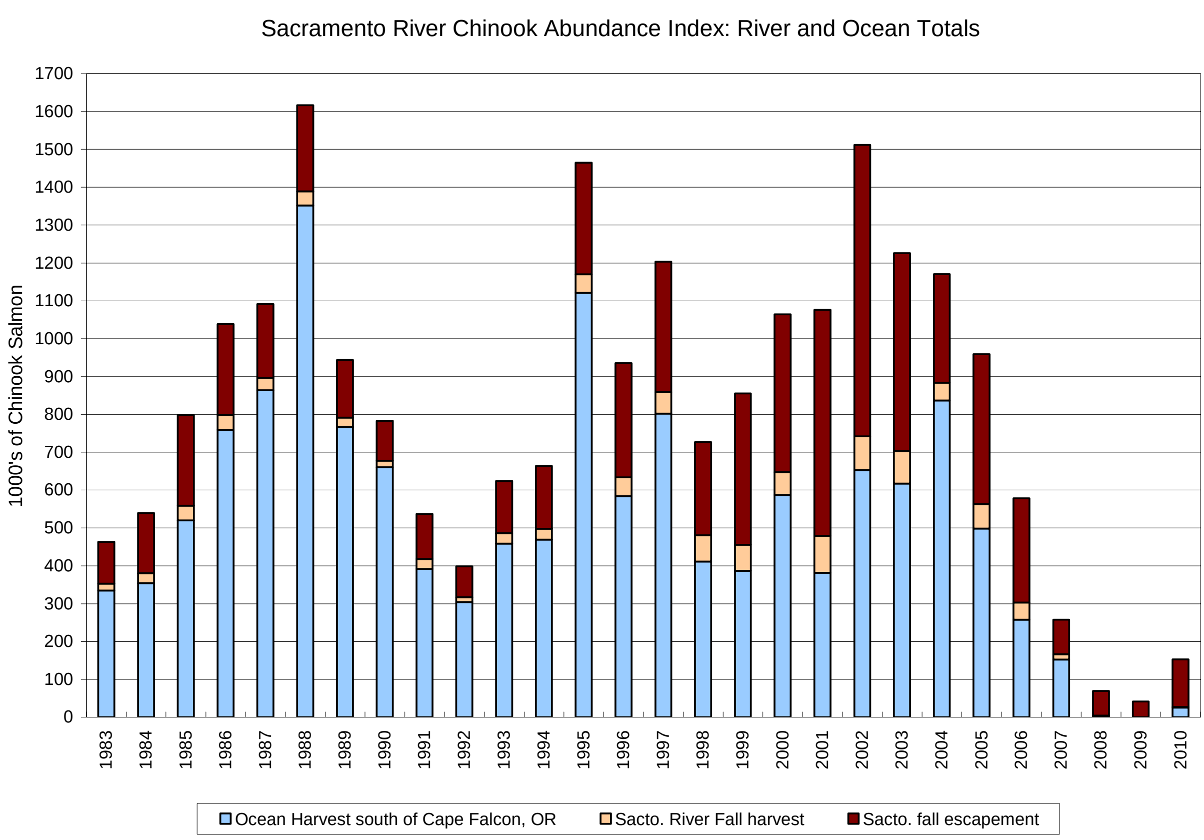


Exhibit 2D

Exhibit 3 – January-June 2010 Basin salmon rearing/outmigration data

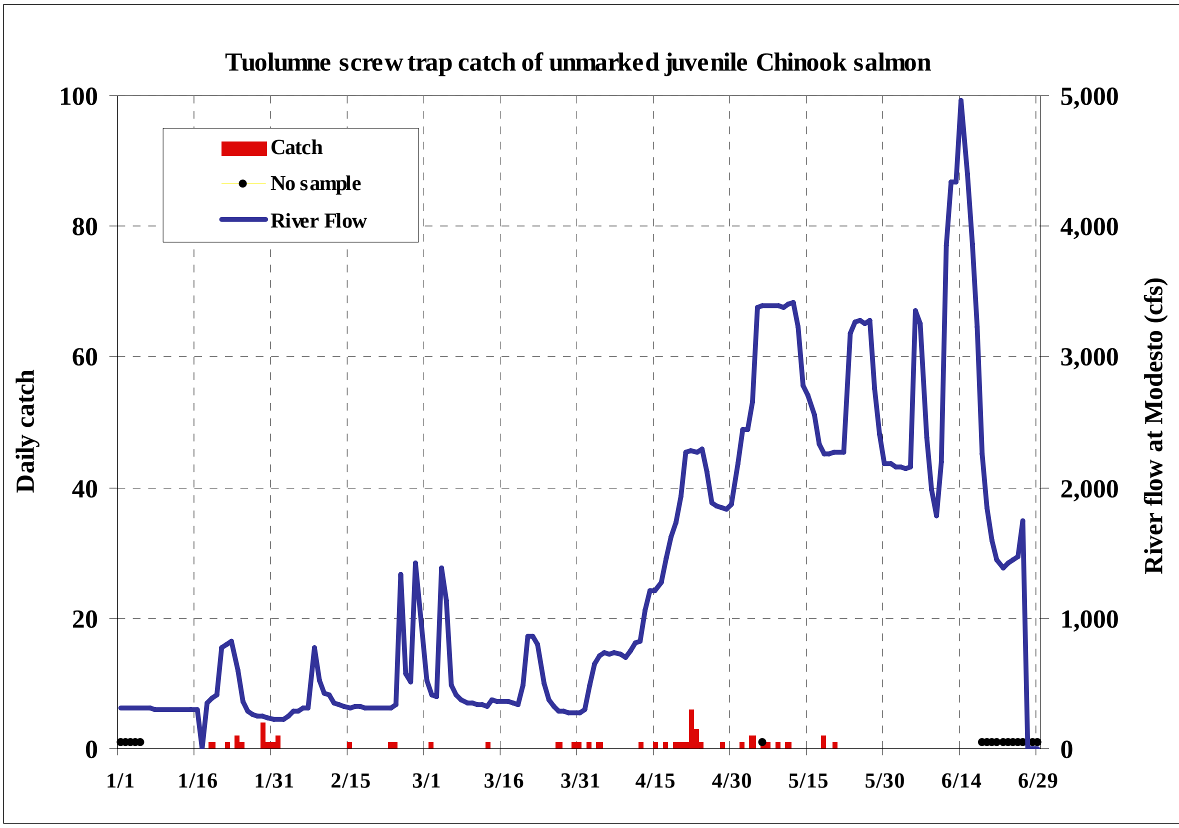


Exhibit 3A

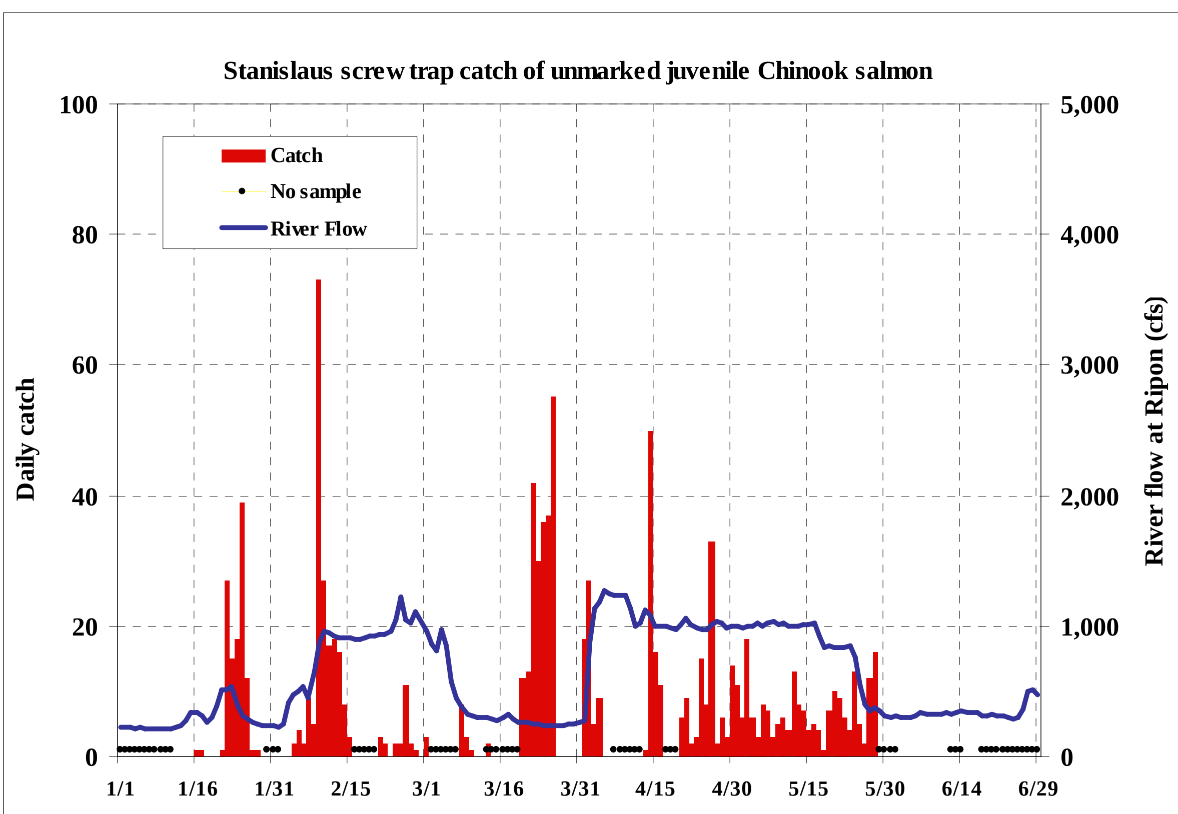
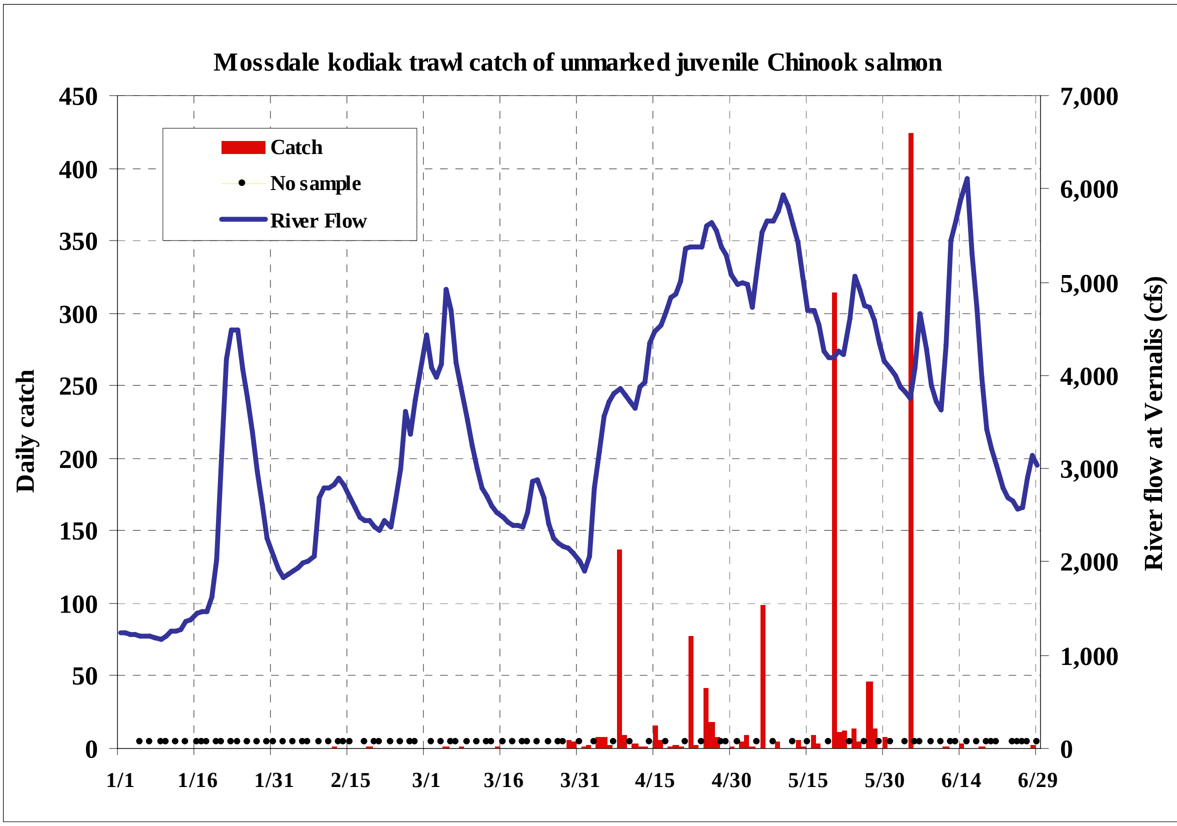


Exhibit 3B



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
7,000
6,000
5,000
4,000
3,000
2,000
1,000
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

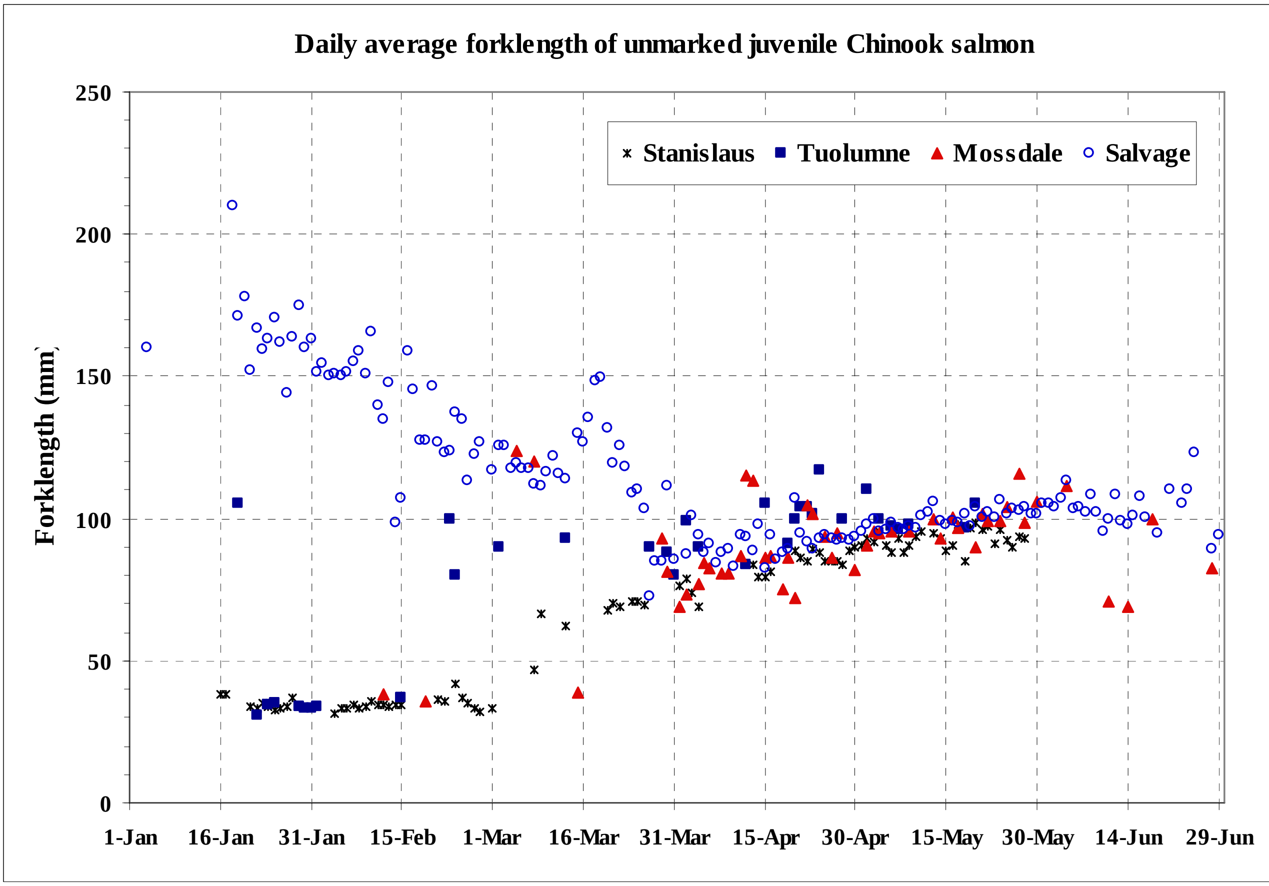


Exhibit 3D

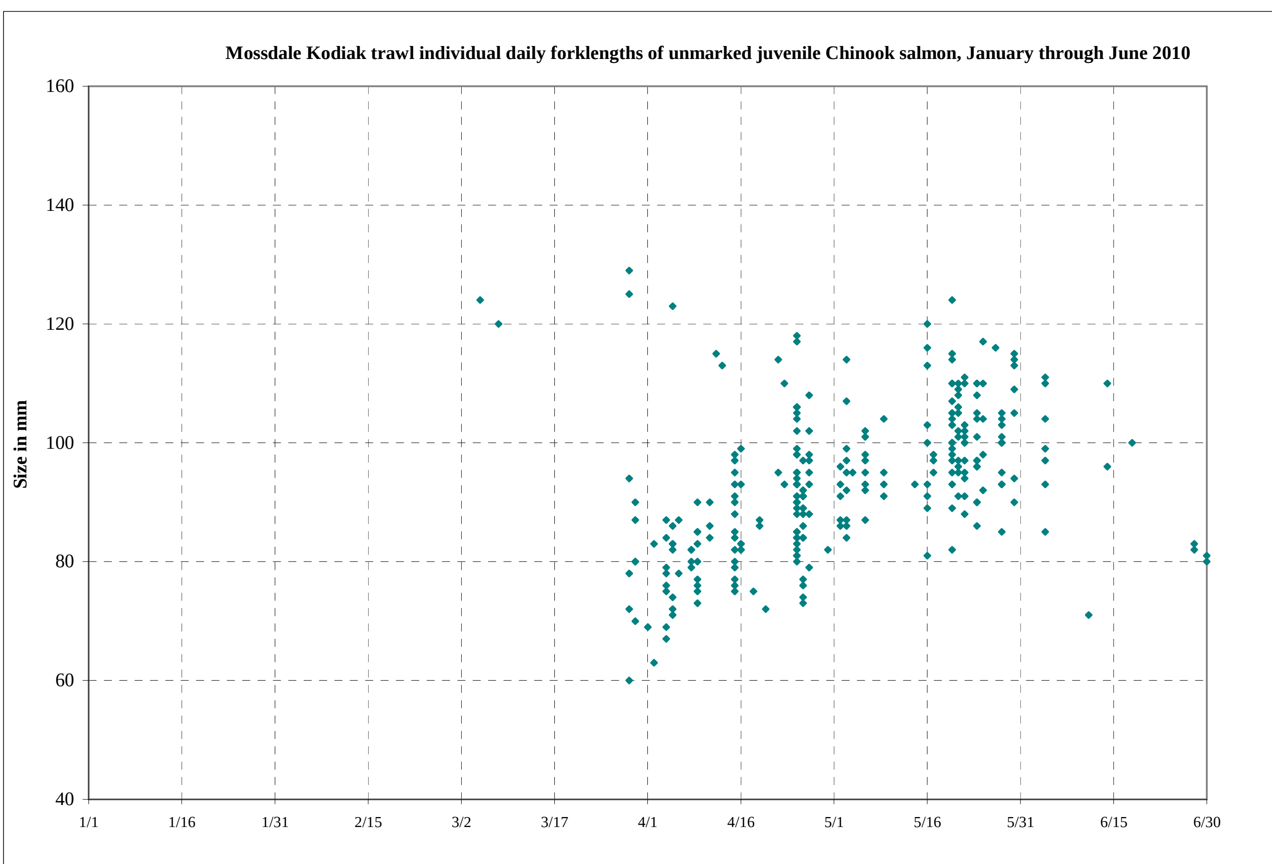


Exhibit 3E

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Exhibit 4 – January-June 2010 Delta salmon salvage data, water exports and basin flows

STATE WATER PROJECT							SWP	SWP	CVP&SWP
							Expanded	Combined	average
week ending	Total chinook salvage			Combined	Ave. cfs	Acre ft.	salvage /	salvage & loss	export rate
date	Observed	Exp.Salvage	Est. Loss	salvage & loss	Export	Export	1000 ac.ft.	per 1000 ac.ft.	(cfs)
7-Jan				0	3642	50,555	0.0	0.0	4,647
14-Jan				0	3708	51,477	0.0	0.0	4,712
21-Jan				0	5005	69,470	0.0	0.0	6,095
28-Jan	54	156	681.79	837.79	3399	47,185	3.3	17.8	5,975
4-Feb	56	157	684.54	841.54	4297	59,643	2.6	14.1	7,684
11-Feb	41	129	551	680	2977	41,330	3.1	16.5	6,940
18-Feb	9	26	113.18	139	2482	34,457	0.8	4.0	6,027
25-Feb	11	31	134.74	166	3135	43,521	0.7	3.8	7,066
4-Mar	14	42	181.99	224	3551	49,285	0.9	4.5	7,458
11-Mar	34	99	433.87	533	4234	58,778	1.7	9.1	8,267
18-Mar	4	10	43.6	54	2712	37,641	0.3	1.4	5,616
25-Mar	15	39	166.62	206	3667	50,898	0.8	4.0	6,859
1-Apr	24	68	284.69	353	3356	46,589	1.5	7.6	5,749
8-Apr	7	24	101.53	126	698	9,687	2.5	13.0	1,520
15-Apr	34	97	416.48	513	724	10,048	9.7	51.1	1,466
22-Apr	8	26	111.78	138	661	9,175	2.8	15.0	1,493
29-Apr	27	96	410.9	507	661	9,175	10.5	55.2	1,513
6-May	51	166	717.62	884	662	9,185	18.1	96.2	1,490
13-May	116	278	1186.16	1,464	538	7,462	37.3	196.2	1,361
20-May				0	0	0	0.0	0.0	1,103
27-May	39	155	714.12	869	1227	17,036	9.1	51.0	2,462
3-Jun	77	214	1050.14	1,264	3391	47,072	4.5	26.9	6,266
10-Jun	12	39	186.62	226	3888	53,969	0.7	4.2	7,401
17-Jun	7	22	107.14	129	3139	43,578	0.5	3.0	6,005
24-Jun				0	3318	46,061	0.0	0.0	6,596
1-Jul				0	3119	43,301	0.0	0.0	6,072
Tot&avg	**640**	**1,874**	**8,279**	**10,153**		**946,579**	**4.3**	**22.9**	
VAMP	194	540	2,315	2,855	465	25,823	16	87	1,367

CENTRAL VALLEY PROJECT							CVP	CVP	
							Expanded	Combined	Vernalis
week ending	Total chinook salvage			Combined	Ave. cfs	Acre ft.	salvage/	salvage & loss	flow
date	Observed	Expanded	Est. Loss	salvage & loss	Export	Export	1000 ac.ft.	per 1000 ac.ft.	(cfs)
7-Jan	1	4	3.88	7.88	1005	13,956	0.3	0.6	1219
14-Jan				0	1004	13,935	0.0	0.0	1247
21-Jan	7	28	26.08	54.08	1091	15,140	1.8	3.6	1789
28-Jan	50	185	147.22	332.22	2575	35,748	5.2	9.3	3904
4-Feb	53	207	149.76	356.76	3388	47,025	4.4	7.6	2066
11-Feb	86	338	226.78	564.78	3963	55,006	6.1	10.3	2325
18-Feb	31	117.5	80.8	198.3	3544	49,198	2.4	4.0	2677
25-Feb	29	112.5	77.97	190.47	3930	54,558	2.1	3.5	2521
4-Mar	62	246	169.86	415.86	3907	54,239	4.5	7.7	3903
11-Mar	51	199.5	128.33	327.83	4032	55,972	3.6	5.9	3916
18-Mar	21	71	54.22	125.22	2904	40,316	1.8	3.1	2562
25-Mar	60	239	171.95	410.95	3192	44,306	5.4	9.3	2589
1-Apr	34	135	95.73	230.73	2393	33,217	4.1	6.9	2112
8-Apr	105	415	346.57	761.57	822	11,410	36.4	66.7	3280
15-Apr	59	236	196.59	432.59	742	10,298	22.9	42.0	3969
22-Apr	96	384	323.67	707.67	832	11,543	33.3	61.3	4952
29-Apr	188	748	624.26	1372.26	852	11,827	63.2	116.0	5459
6-May	112	446.5	383.1	829.6	828	11,497	38.8	72.2	5064
13-May	142	564	489.45	1053.45	823	11,428	49.4	92.2	5694
20-May	166	657	559.17	1216.17	1103	15,305	42.9	79.5	4518
27-May	242	967	816.82	1783.82	1234	17,135	56.4	104.1	4649
3-Jun	216	840	630.16	1470.16	2875	39,910	21.0	36.8	4120
10-Jun	48	187	130.57	317.57	3513	48,768	3.8	6.5	4002
17-Jun	25	97	71.57	168.57	2866	39,783	2.4	4.2	5348
24-Jun	2	8	5.42	13.42	3277	45,492	0.2	0.3	3117
1-Jul	5	18.8	13.86	32.66	2953	40,985	0.5	0.8	3112
Tot&avg	**1,891**	**7,451**	**5,924**	**13,375**	**2,294**	**827,998**	**15.9**	**29.0**	**3,466**
VAMP	662	2,635	2,249	4,471	902	50,057	49	90	5,184

Exhibit 4A

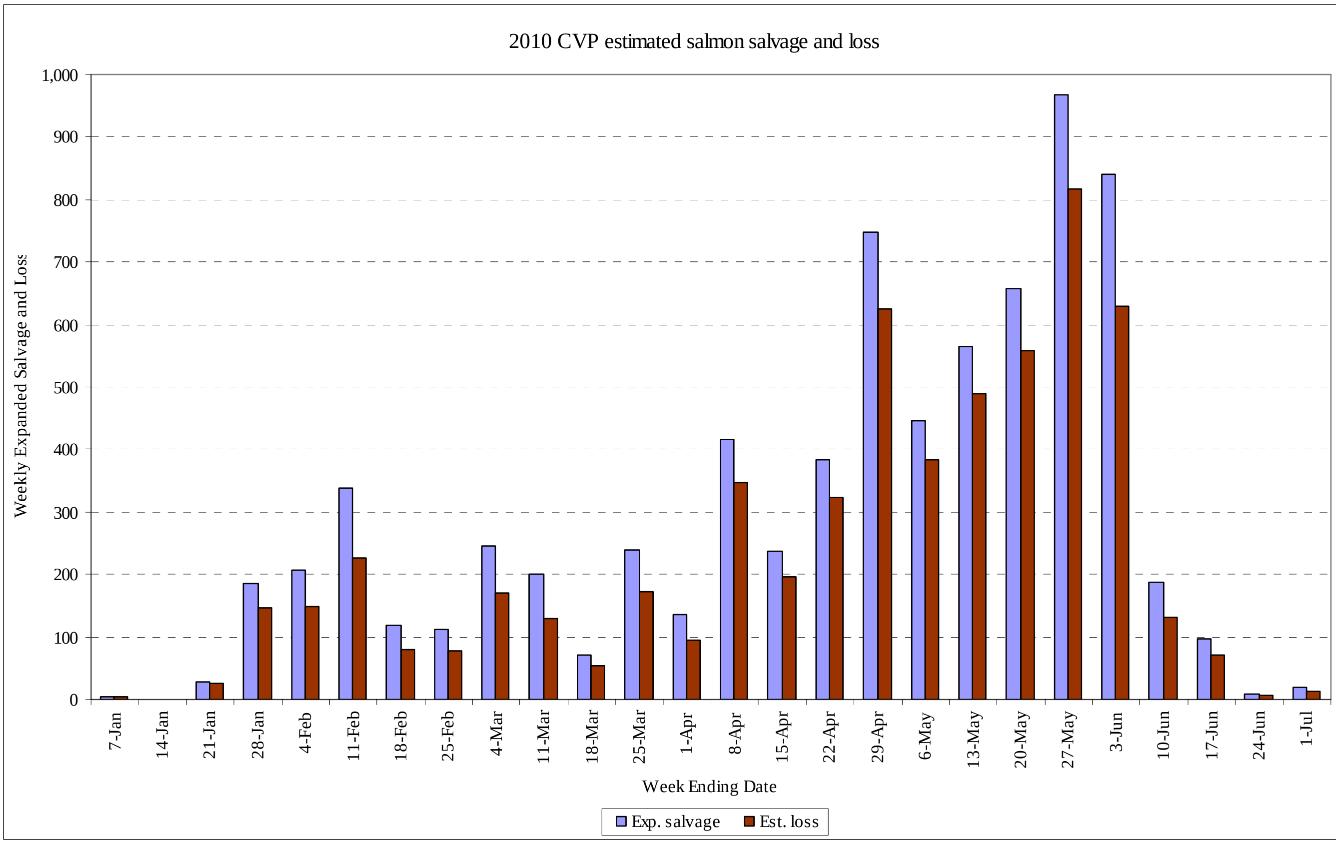


Exhibit 4B

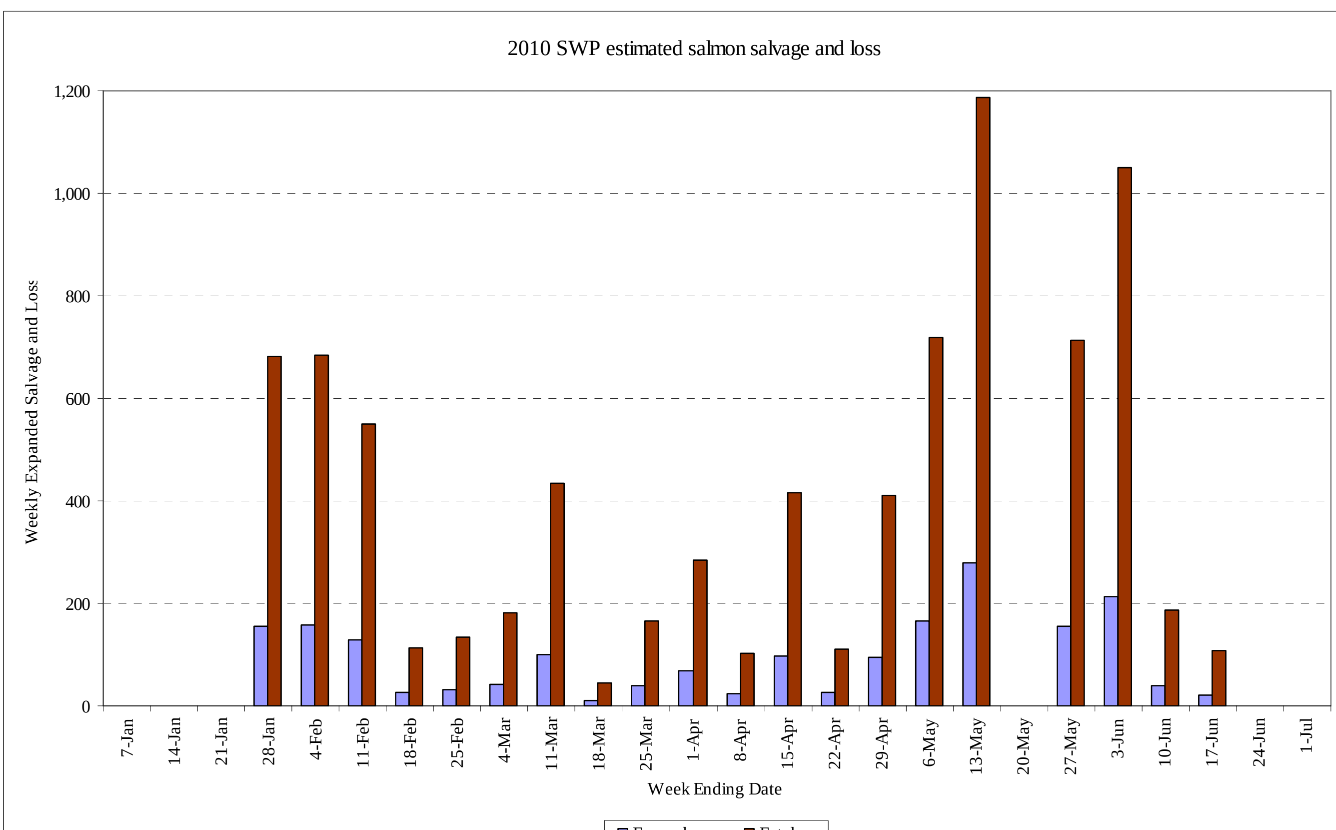


Exhibit 4C

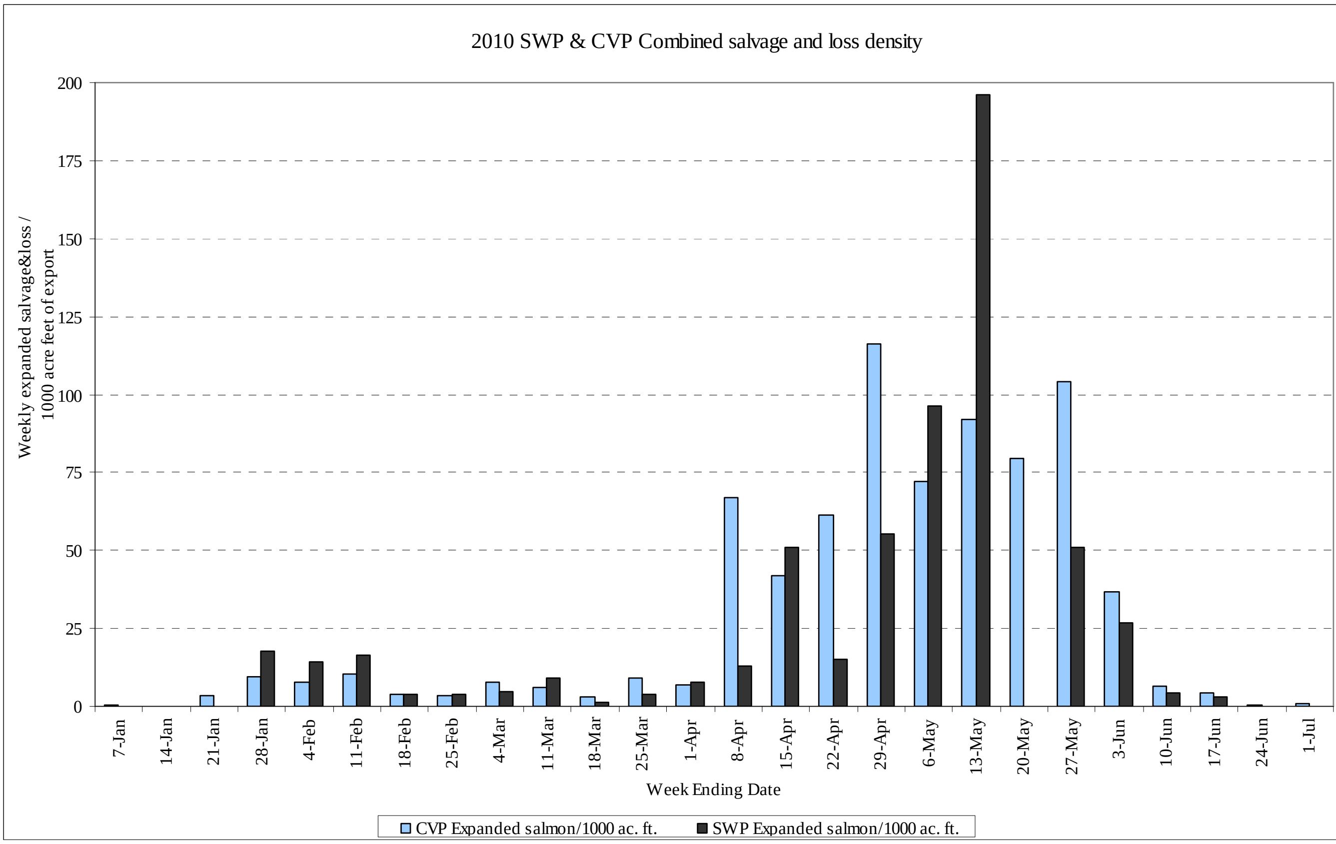


Exhibit 4D

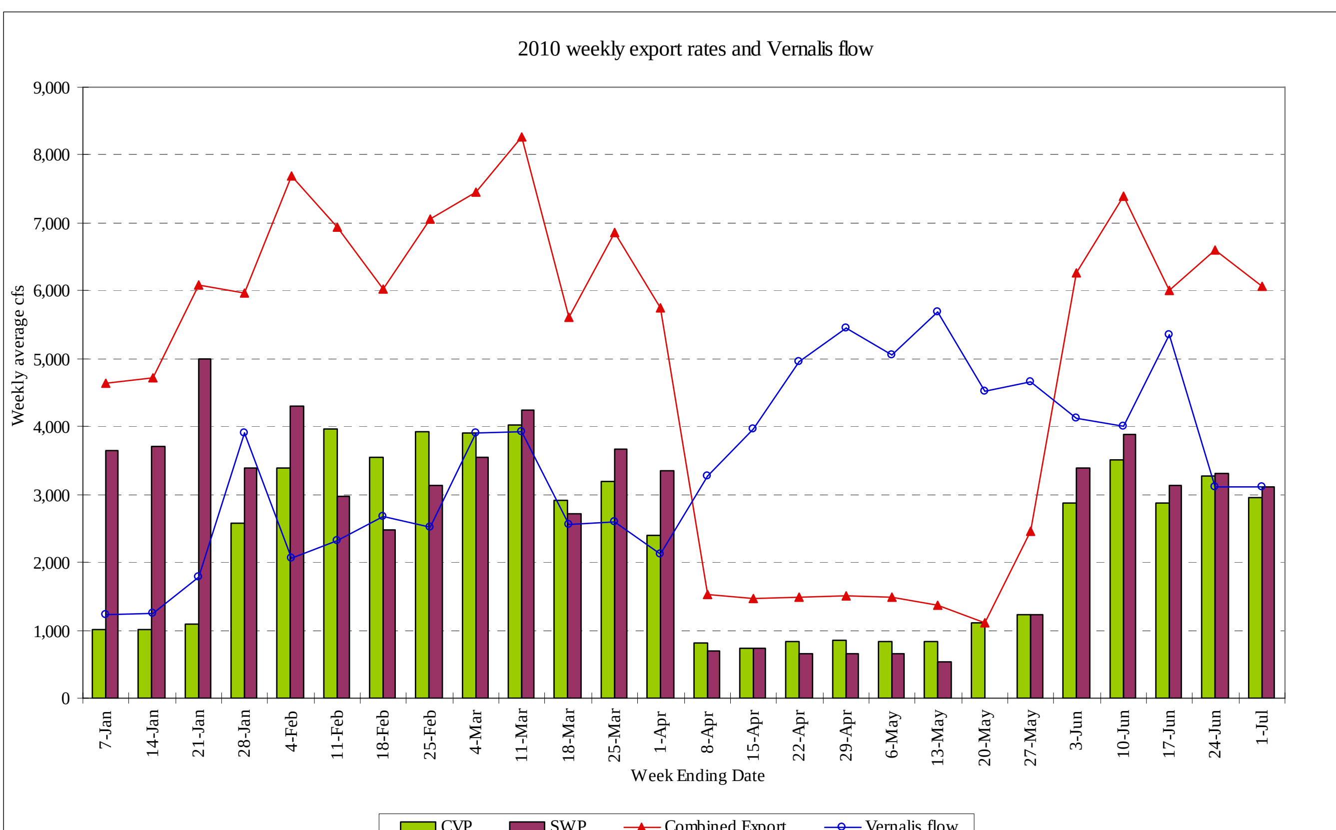


Exhibit 4E

Exhibit 4F

OBSERVED CHINOOK SALVAGE AT THE SWP & CVP DELTA FISH FACILITIES 08/01/2009 THROUGH 07/31/2010

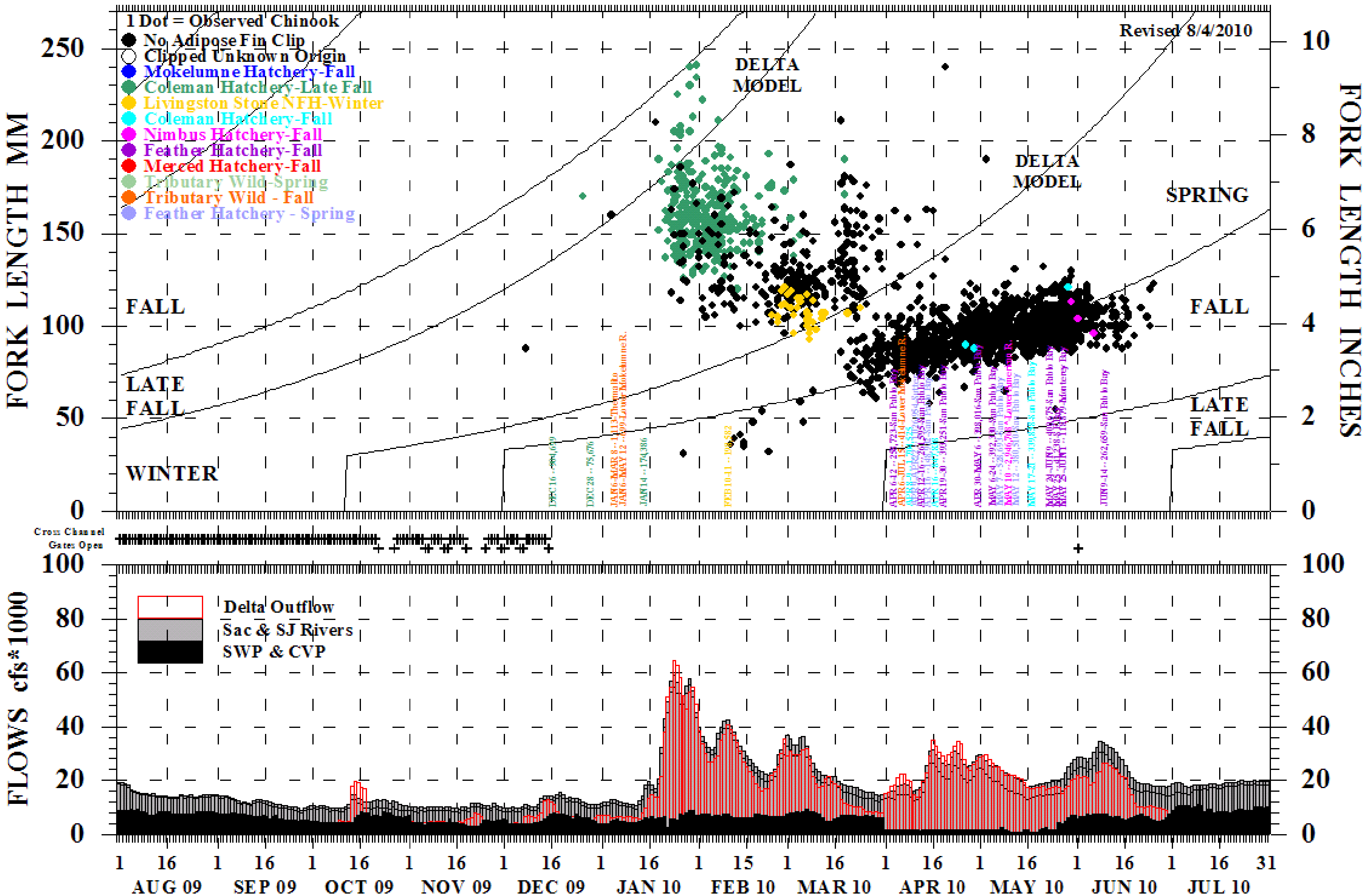
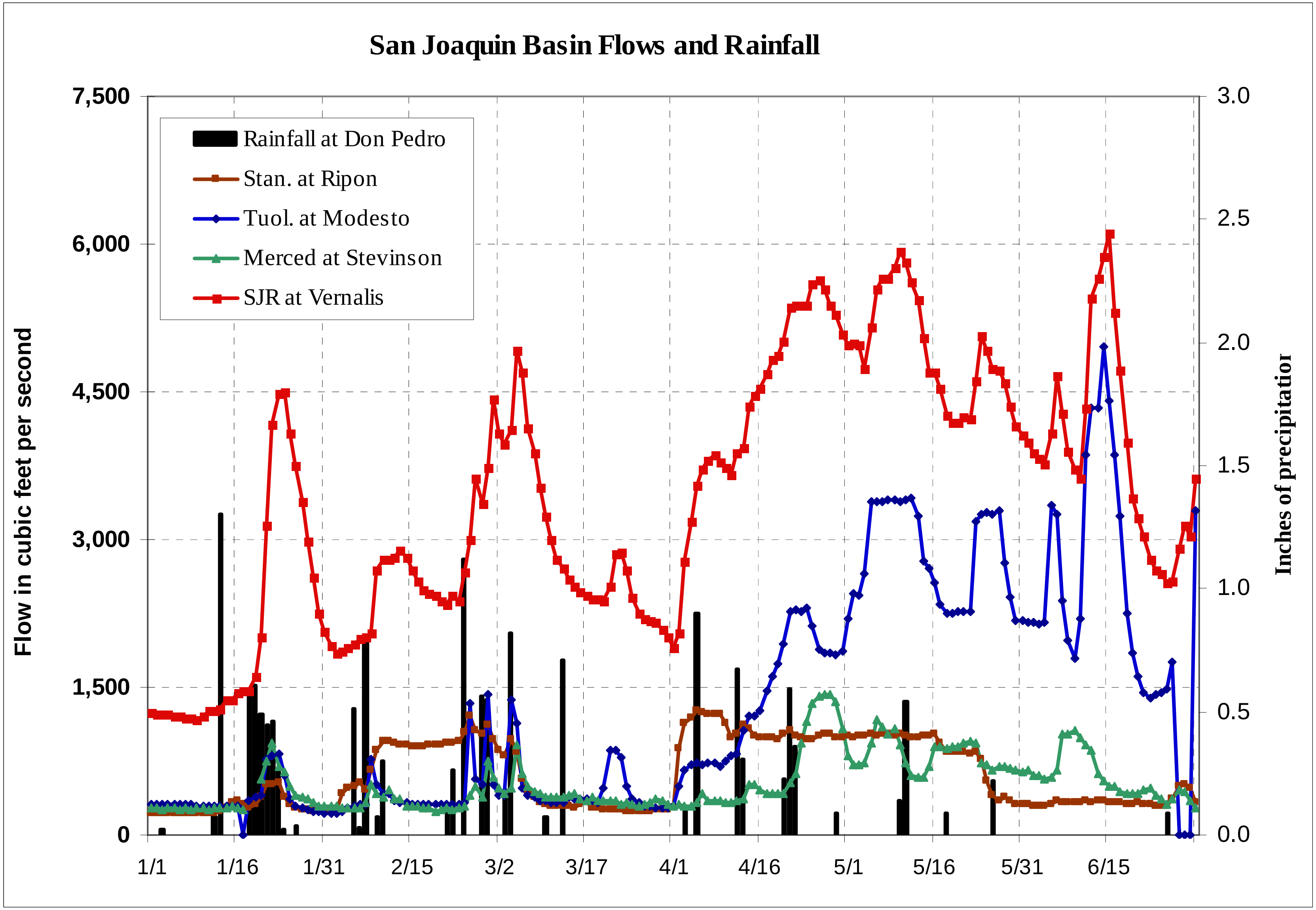


Exhibit 4G


San Joaquin Basin Flows and Rainfall
Rainfall at Don Pedro
Stan. at Ripon
Tuol. at Modesto
Merced at Stevinson
SJR at Vernalis
Flow in cubic feet per second
Inches of precipitation
7,500
6,000
4,500
3,000
1,500
0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/1
1/16
1/31
2/15
3/2
3/17
4/1
4/16
5/1
5/16
5/31
6/15

Attachment -A-

Water, Flows, Temperature, and Flow Schedule Correspondence

1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data
    1.1. 2010/2011 Water Years (Oct-Sep) daily average computed natural flow, actual flow, and FERC flow schedule at La Grange
    1.2. 2010/2011 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. 2010/2011 Water Years Don Pedro Reservoir storage
    1.5. 2010/2011 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 2010 daily average water temperature for Tuolumne and San Joaquin Rivers
    2.2. Modesto air temperature for Water Year 2010
3. Flow schedule correspondence for 2010
    3.1. Mar 25 – Flow schedule for 2009-2010 and 2010-2011 fish flow years
    3.2. Apr 2 – Final flow schedule for 2009-2010
    3.3. Apr 22 – Minimum flow schedule for 2010-2011

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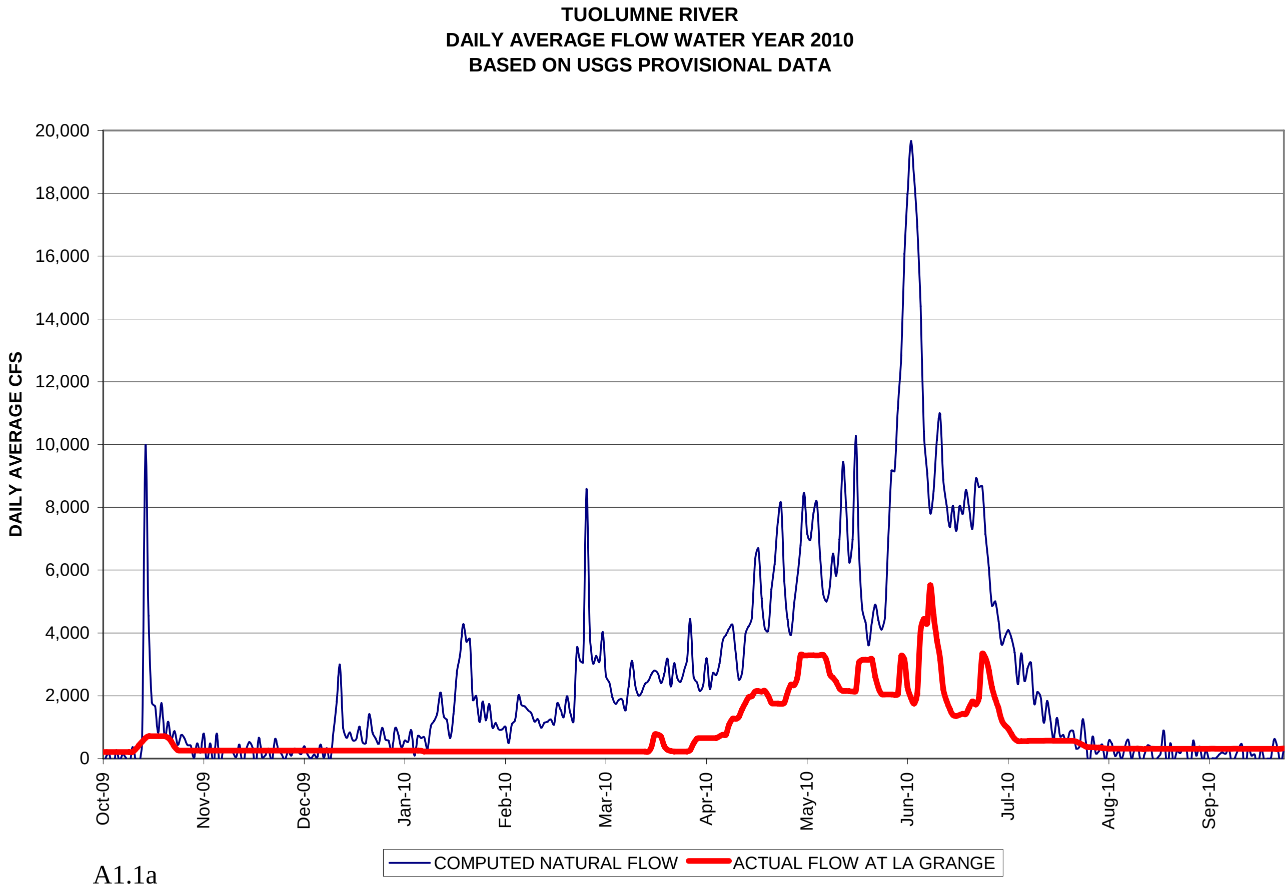
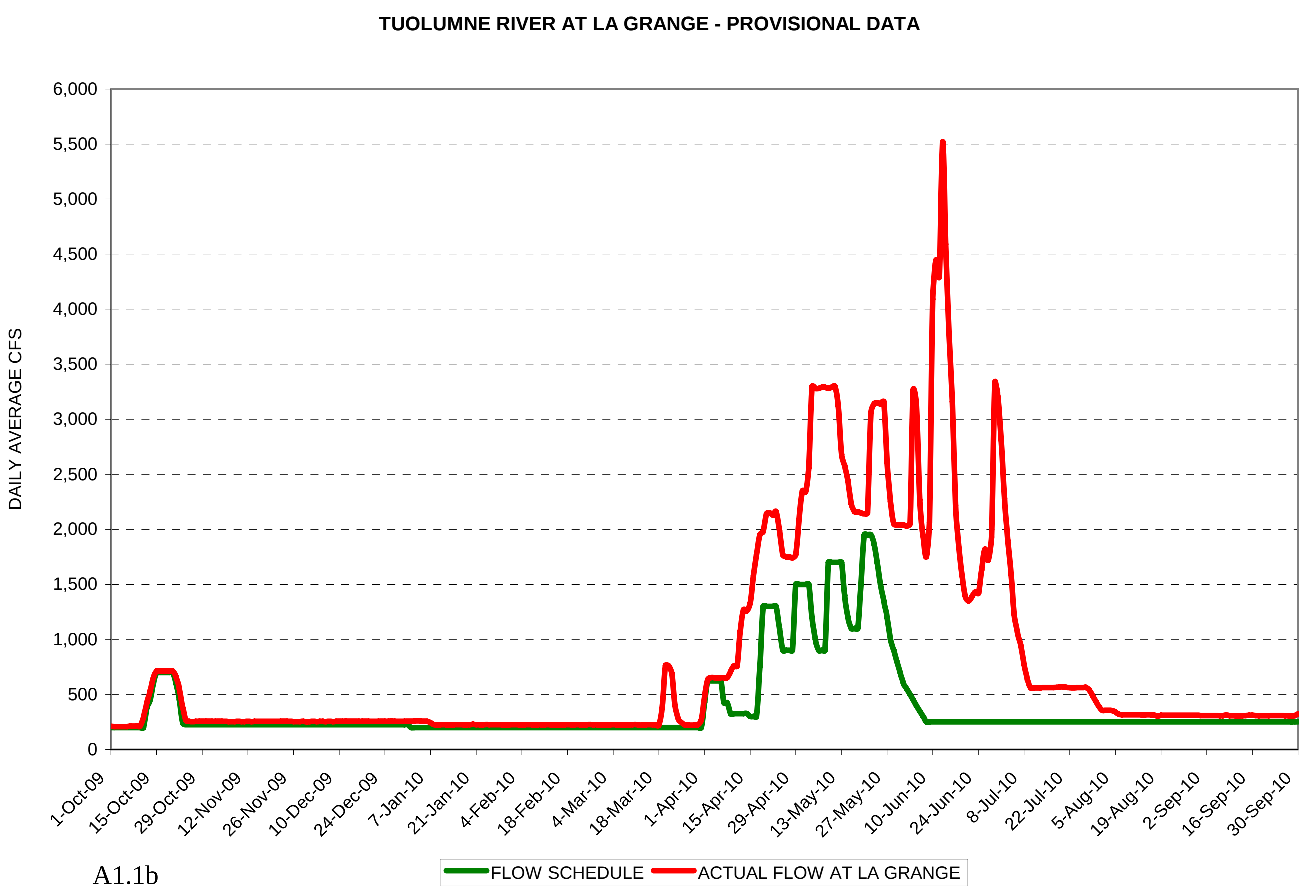
1. Graphs of flows, FERC flow schedule, reservoir status, and precipitation data

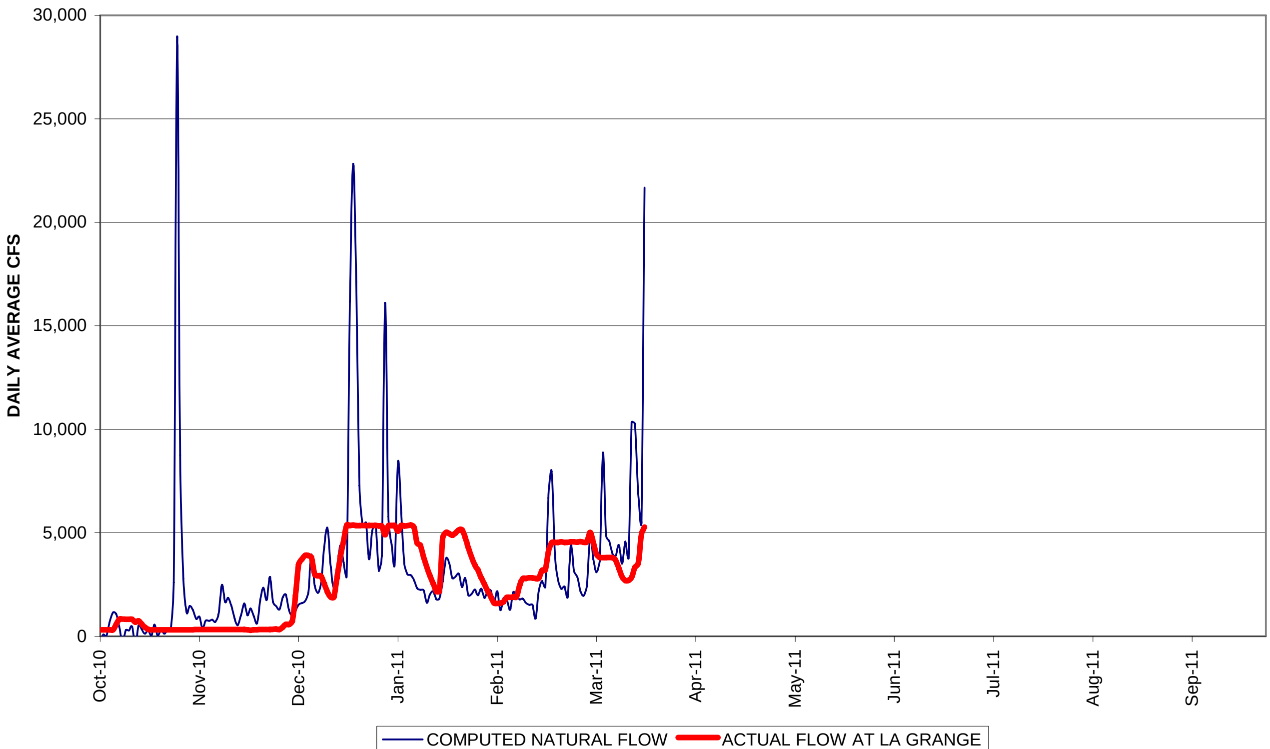


A1.1a



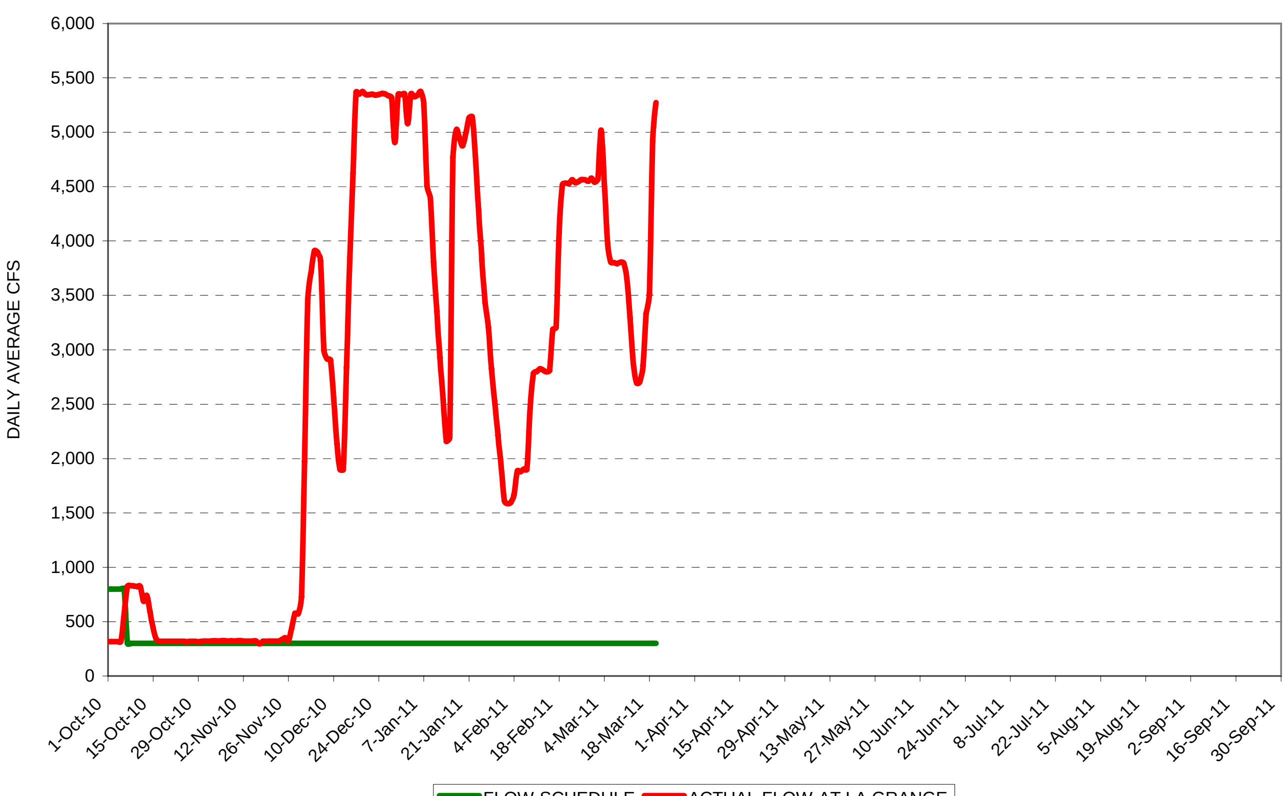
A1.1b

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



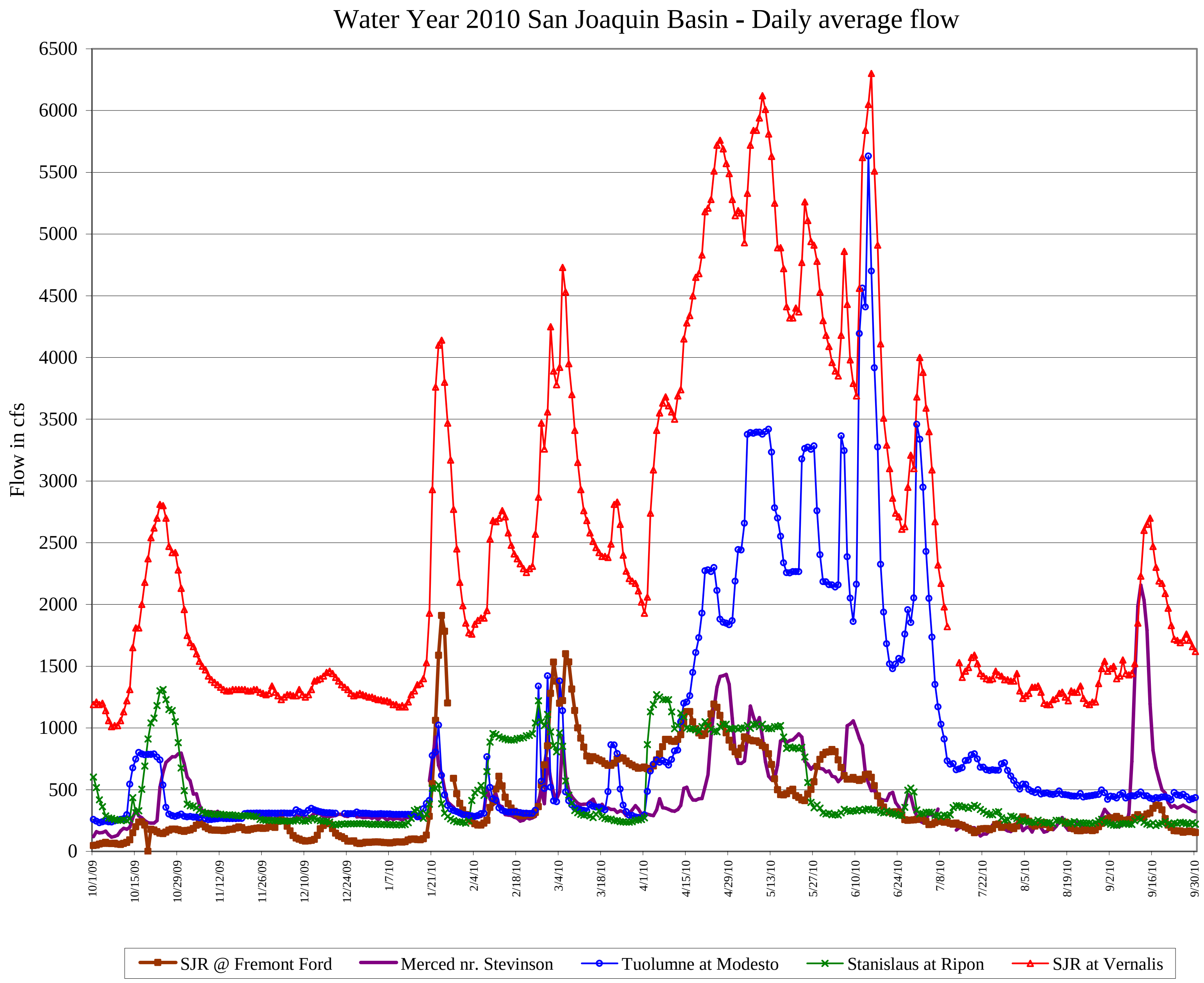
A1.1c

TUOLUMNE RIVER AT LA GRANGE - PROVISIONAL DATA



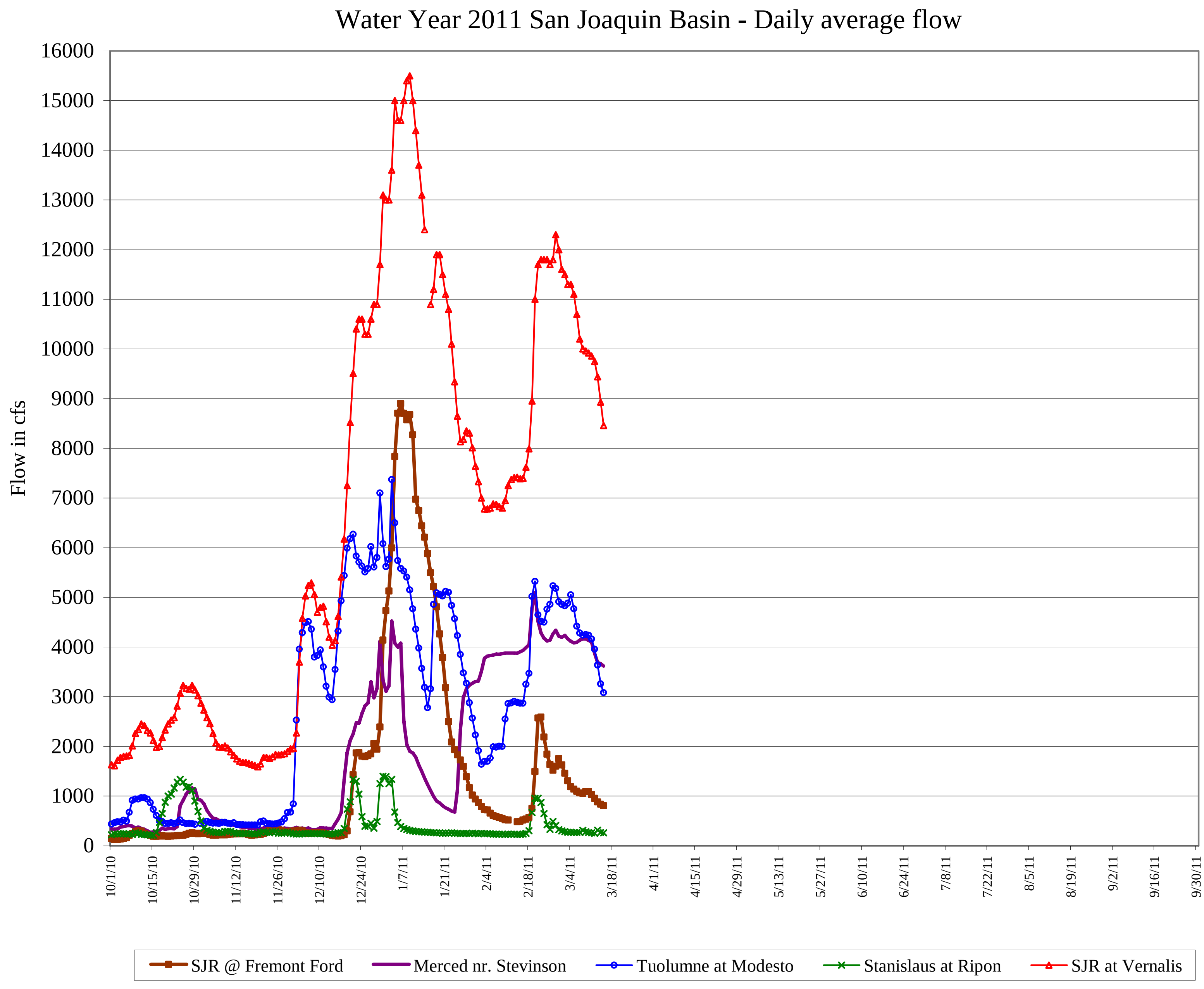
A1.1d

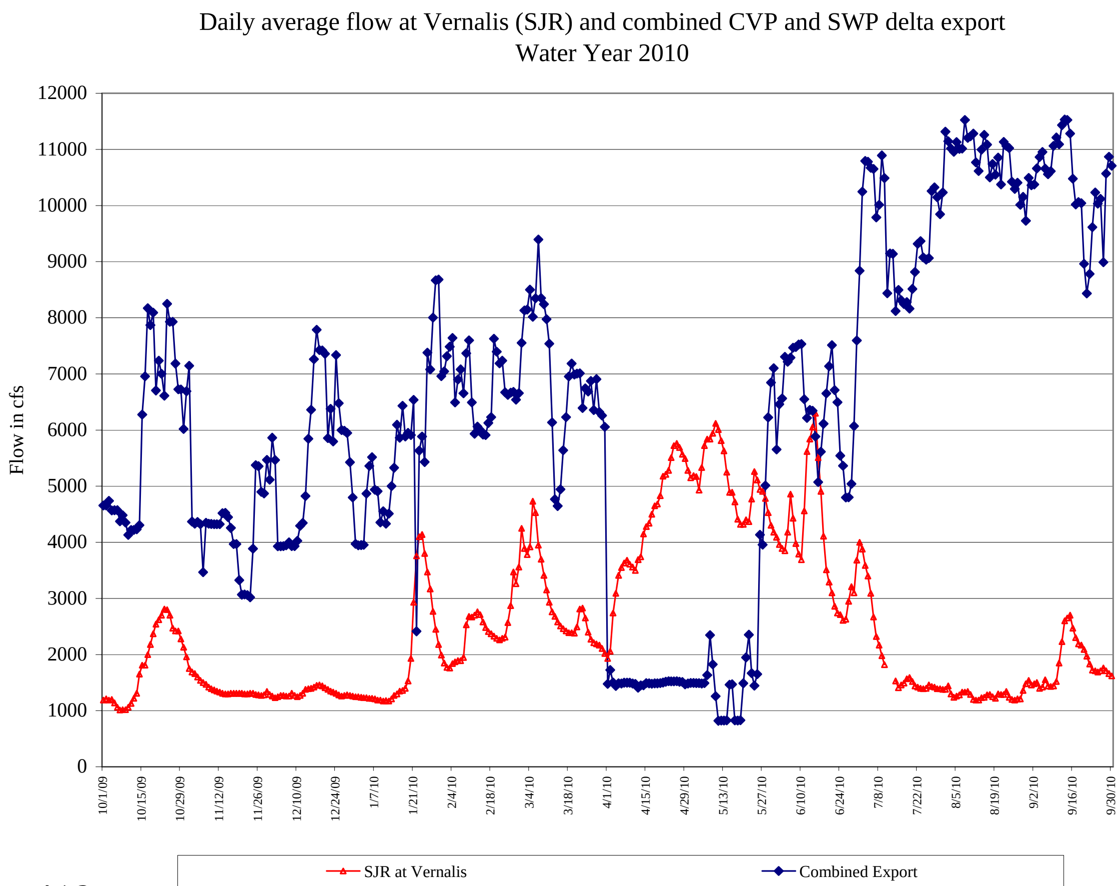
A1.2a



Water Year 2010 San Joaquin Basin - Daily average flow
Flow in cfs
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1/09
10/15/09
10/29/09
11/12/09
11/26/09
12/10/09
12/24/09
1/7/10
1/21/10
2/4/10
2/18/10
3/4/10
3/18/10
4/1/10
4/15/10
4/29/10
5/13/10
5/27/10
6/10/10
6/24/10
7/8/10
7/22/10
8/5/10
8/19/10
9/2/10
9/16/10
9/30/10
SJR @ Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis

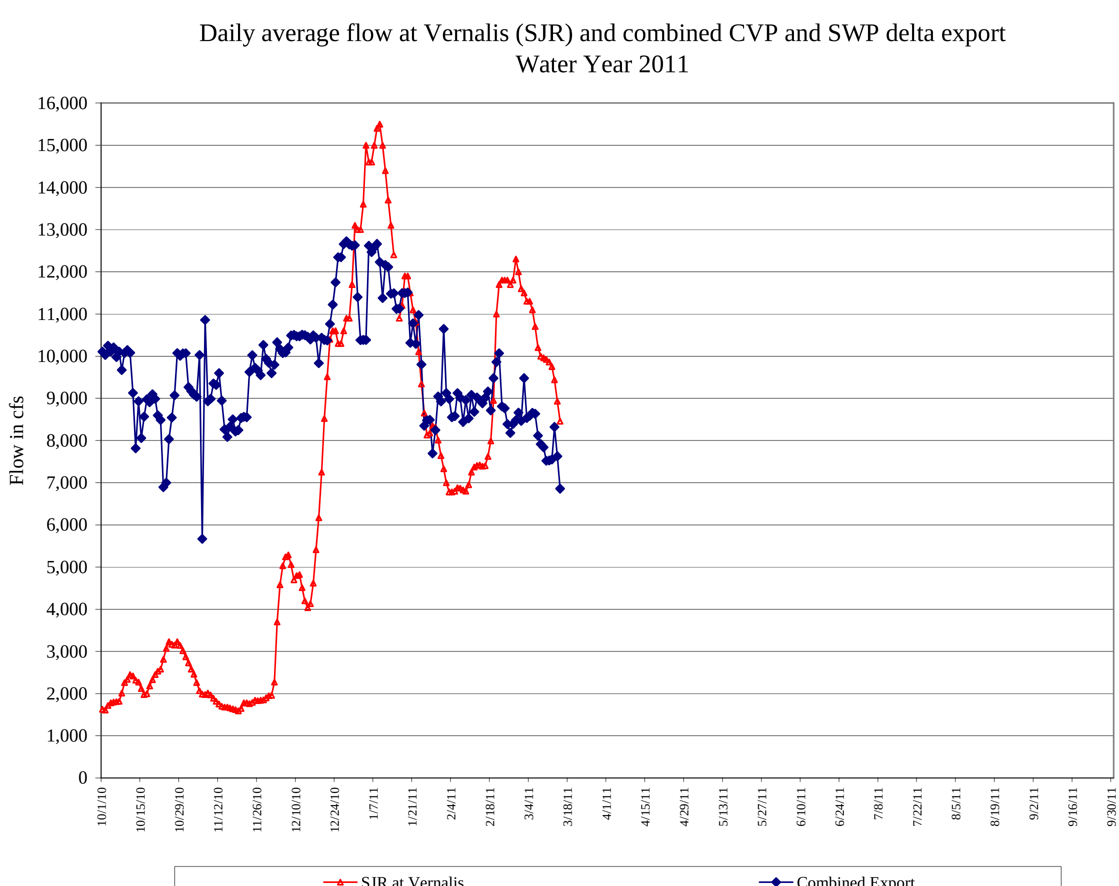
A1.2b


Water Year 2011 San Joaquin Basin - Daily average flow
Flow in cfs
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
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 @ Fremont Ford
Merced nr. Stevinson
Tuolumne at Modesto
Stanislaus at Ripon
SJR at Vernalis



Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2010
Flow in cfs
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10/1/09
10/15/09
10/29/09
11/12/09
11/26/09
12/10/09
12/24/09
1/7/10
1/21/10
2/4/10
2/18/10
3/4/10
3/18/10
4/1/10
4/15/10
4/29/10
5/13/10
5/27/10
6/10/10
6/24/10
7/8/10
7/22/10
8/5/10
8/19/10
9/2/10
9/16/10
9/30/10
SJR at Vernalis
Combined Export

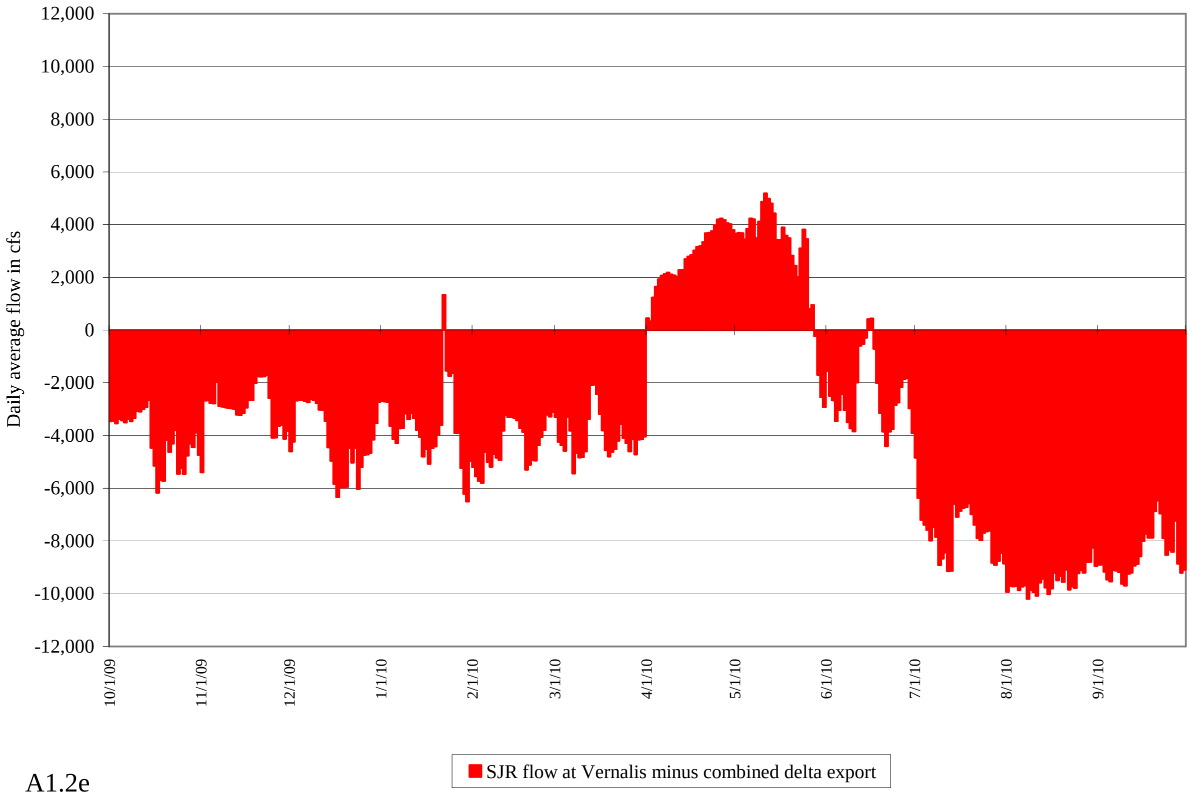
A1.2c



Daily average flow at Vernalis (SJR) and combined CVP and SWP delta export
Water Year 2011
Flow in cfs
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
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

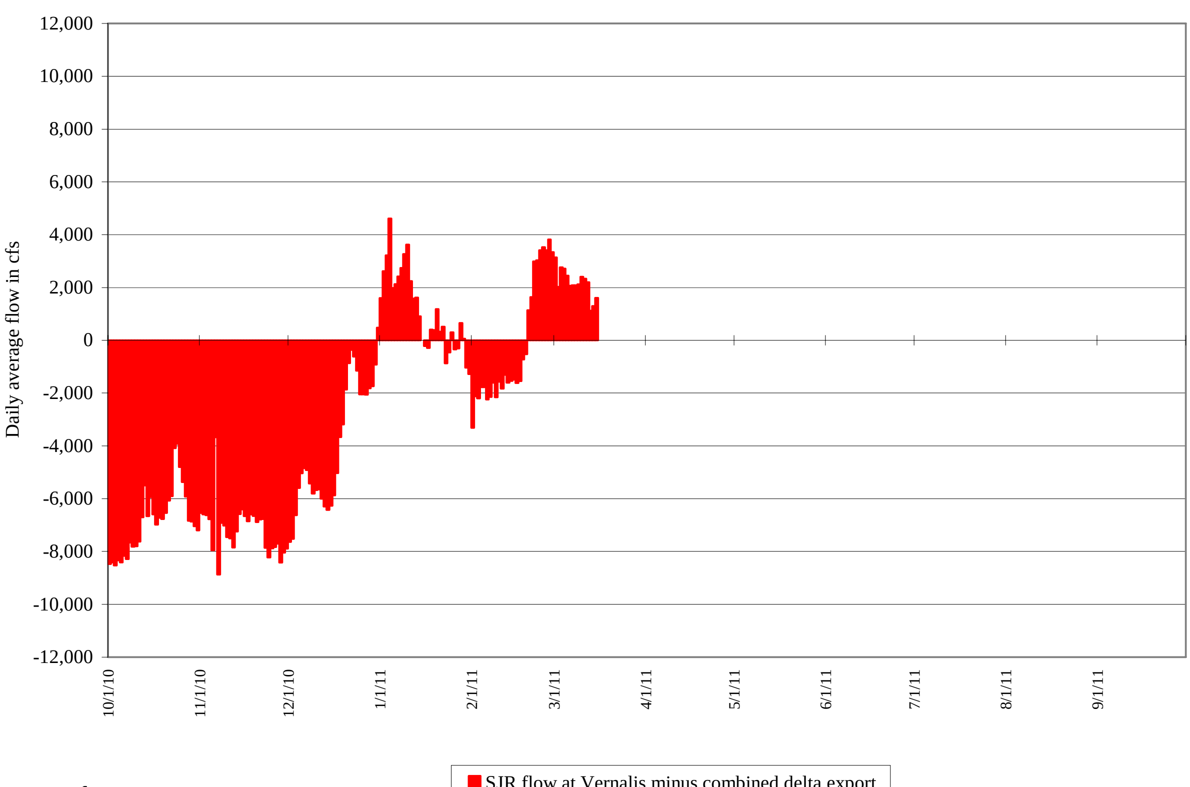
A1.2d

Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2010

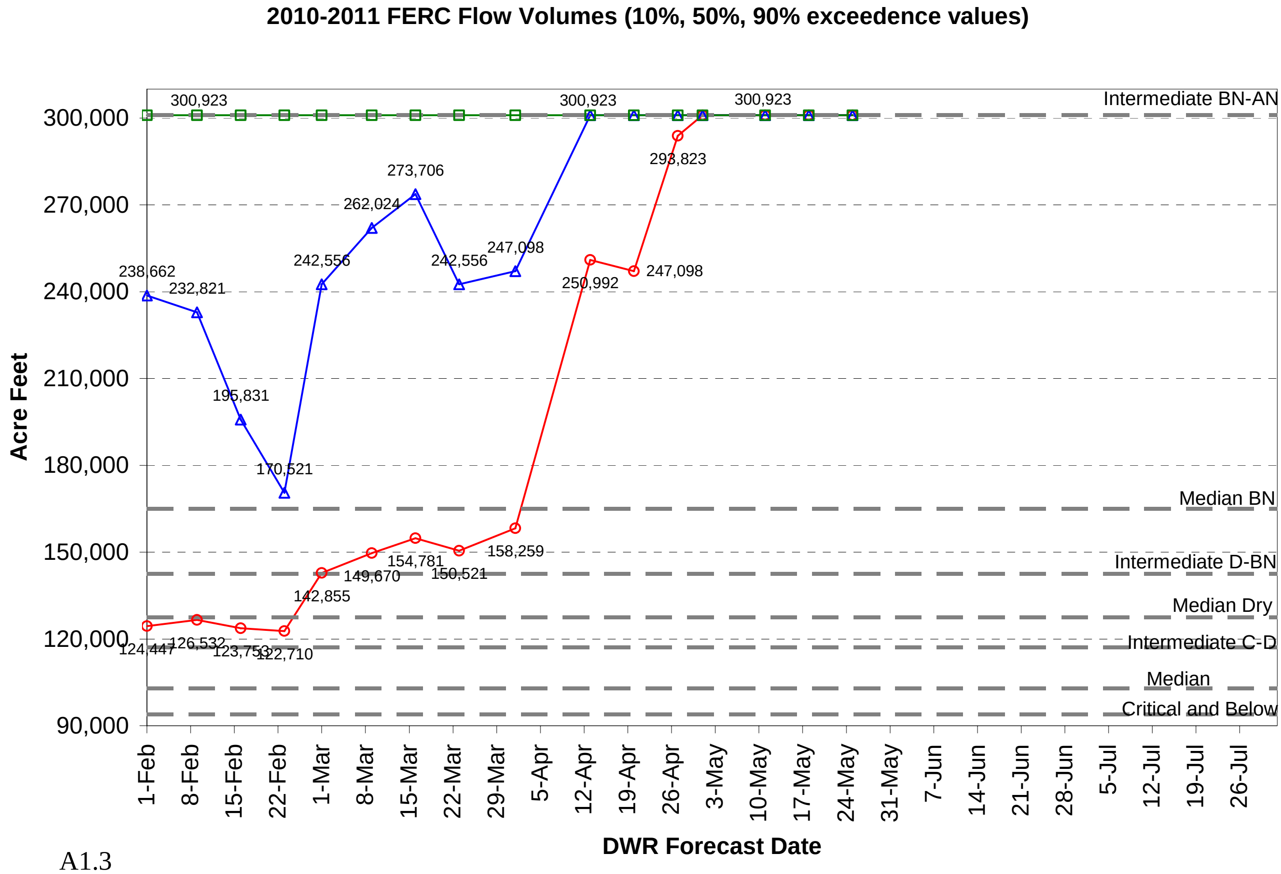


A1.2e

Daily average flow at Vernalis (SJR) minus combined CVP and SWP delta export
Water Year 2011

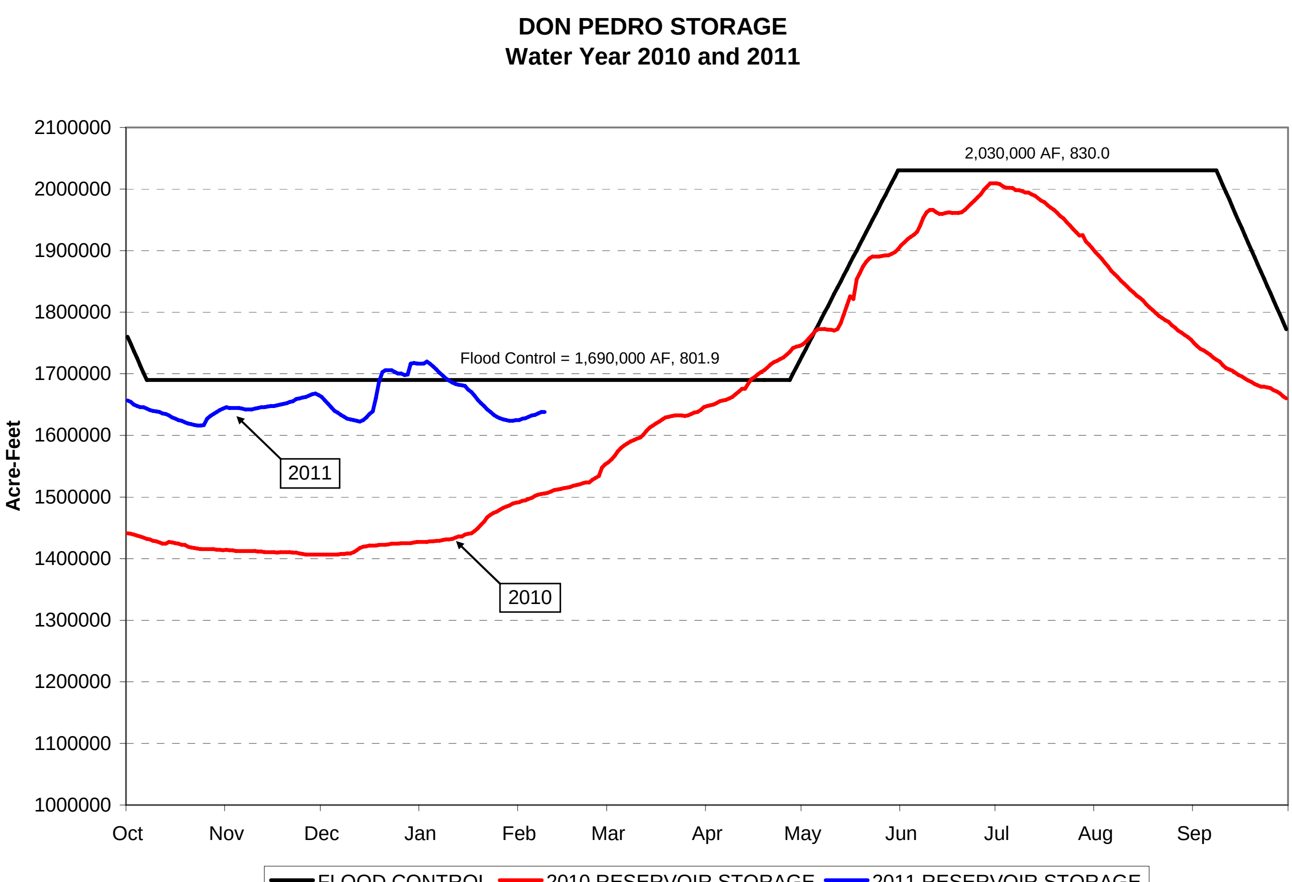


A1.2f



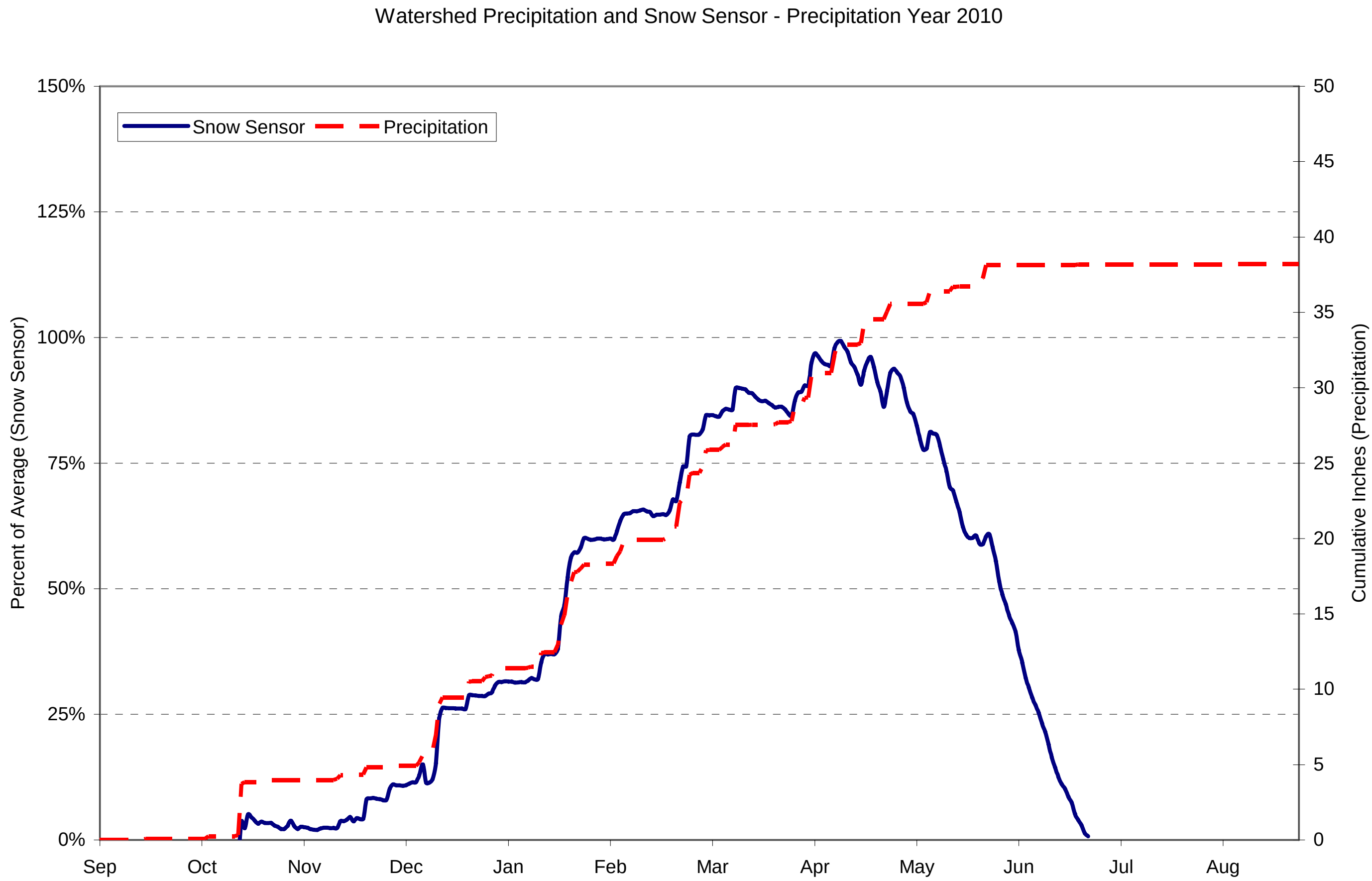
2010-2011 FERC Flow Volumes (10%, 50%, 90% exceedence values)
Acre Feet
DWR Forecast Date
Intermediate BN-AN
Median BN
Intermediate D-BN
Median Dry
Intermediate C-D
Median
Critical and Below
300,923
238,662
232,821
195,831
170,521
242,556
262,024
273,706
242,556
247,098
293,823
250,992
247,098
158,259
154,781
150,521
149,670
142,855
124,447
126,532
123,753
122,710

A1.3



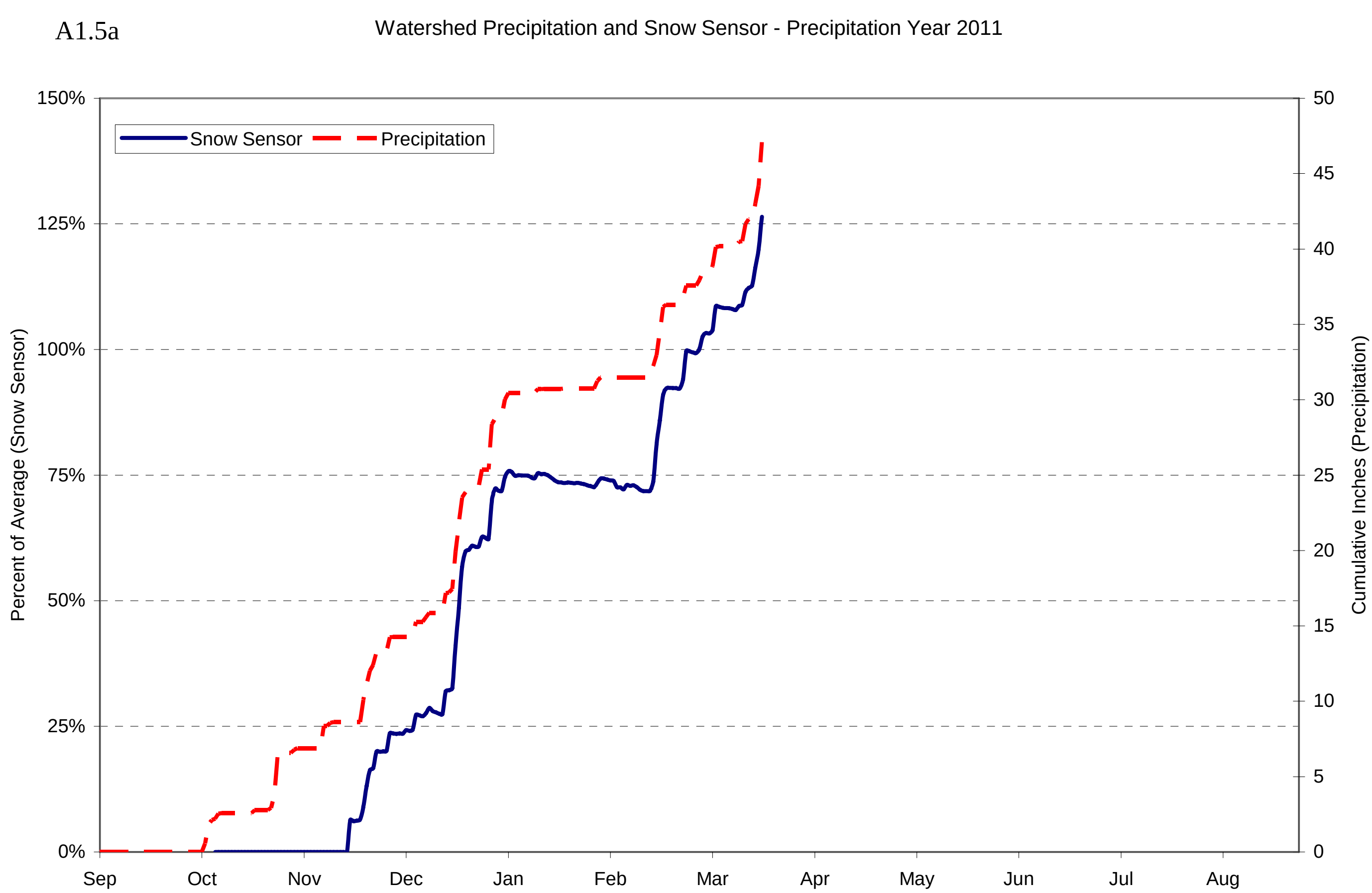
DON PEDRO STORAGE
Water Year 2010 and 2011
Acre-Feet
2,030,000 AF, 830.0
Flood Control = 1,690,000 AF, 801.9
2011
2010
FLOOD CONTROL
2010 RESERVOIR STORAGE
2011 RESERVOIR STORAGE

A1.4



Watershed Precipitation and Snow Sensor - Precipitation Year 2010
Snow Sensor
Precipitation
Percent of Average (Snow Sensor)
Cumulative Inches (Precipitation)
150%
125%
100%
75%
50%
25%
0%
50
45
40
35
30
25
20
15
10
5
0
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

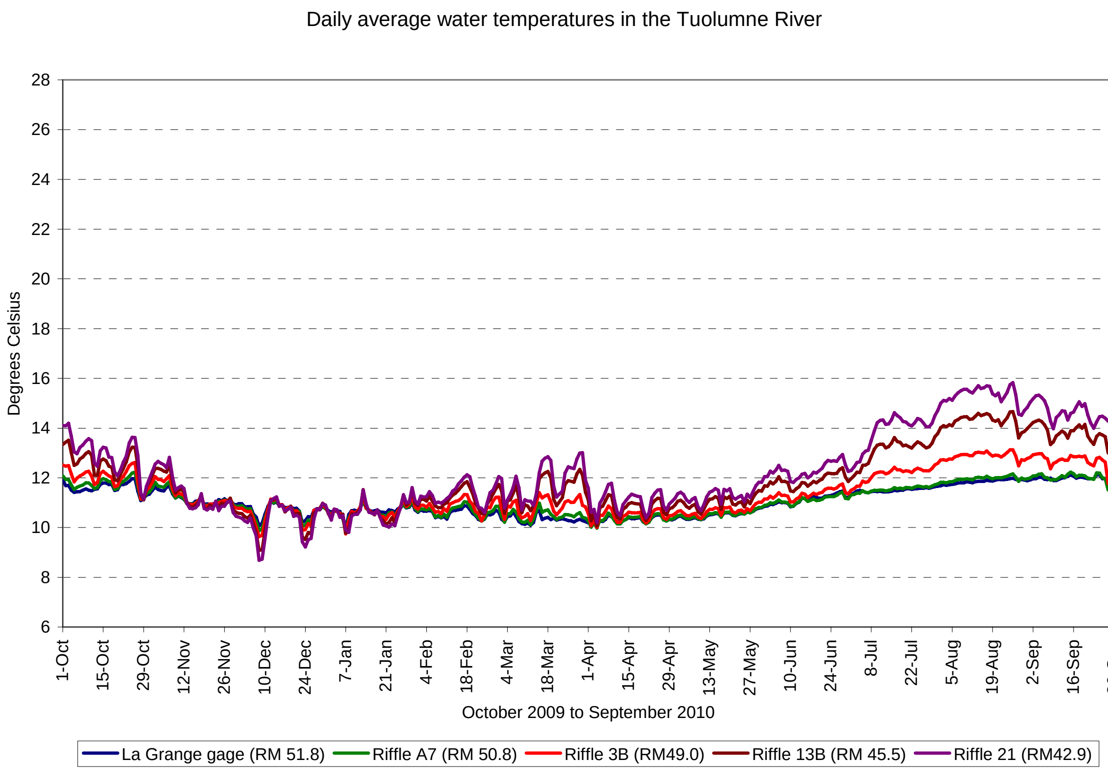
A1.5a



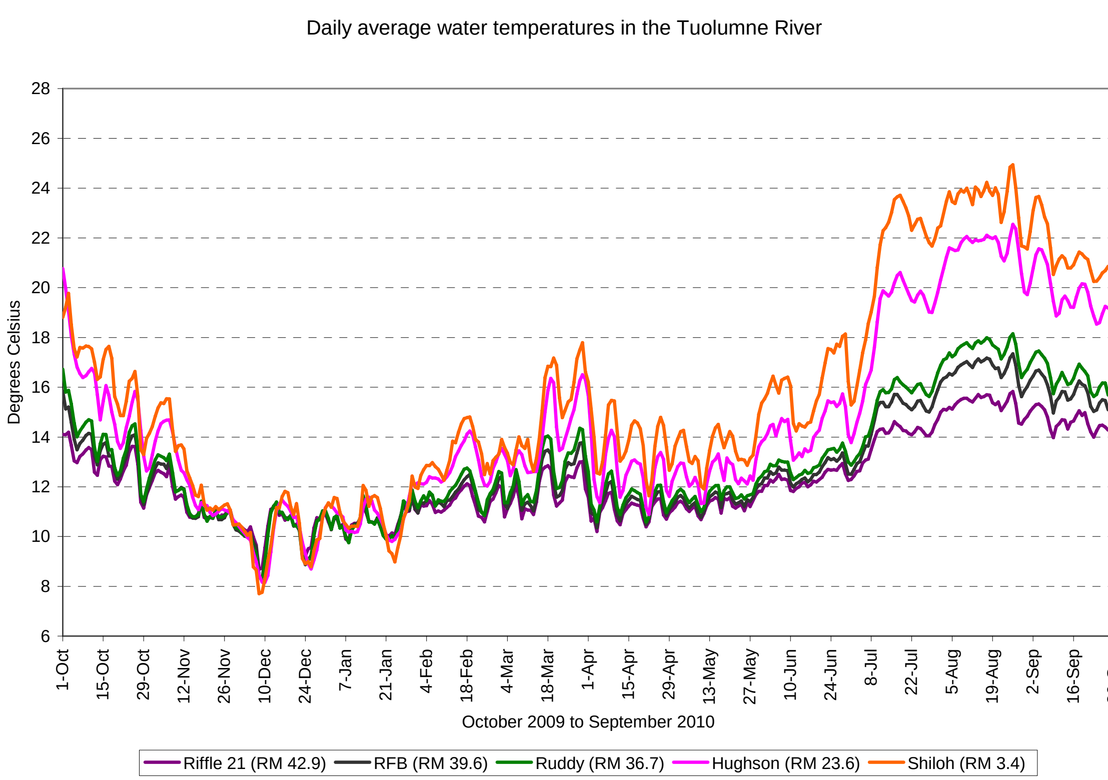
Watershed Precipitation and Snow Sensor - Precipitation Year 2011
Snow Sensor
Precipitation
Percent of Average (Snow Sensor)
Cumulative Inches (Precipitation)
150%
125%
100%
75%
50%
25%
0%
50
45
40
35
30
25
20
15
10
5
0
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug

A1.5b

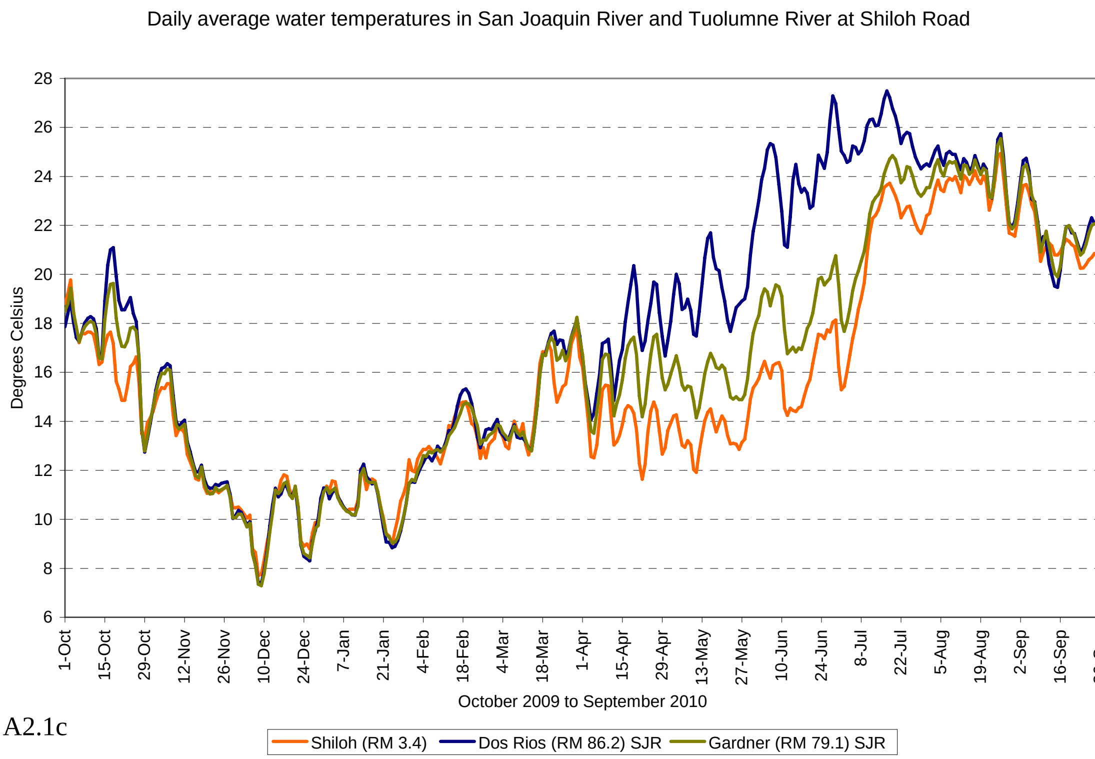
2. Graphs of water temperature and air temperature



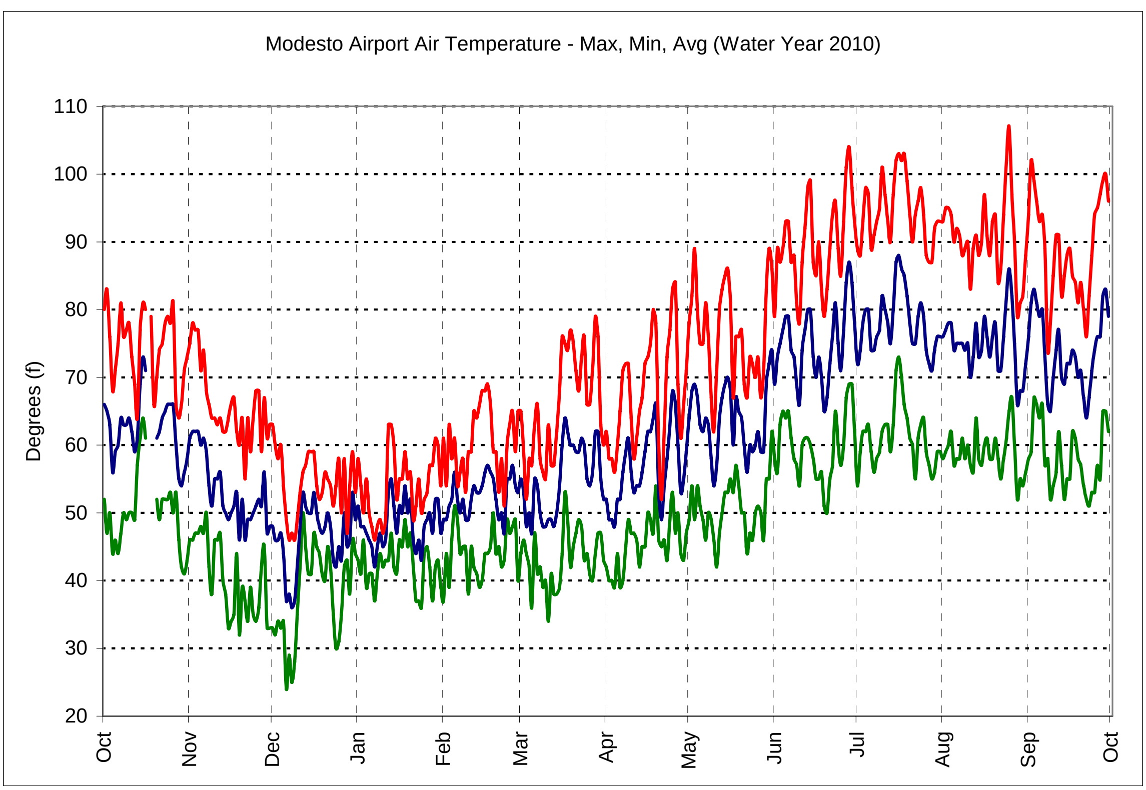
A2.1a



A2.1b


Daily average water temperatures in San Joaquin River and Tuolumne River at Shiloh Road
Degrees Celsius
28
26
24
22
20
18
16
14
12
10
8
6
1-Oct
15-Oct
29-Oct
12-Nov
26-Nov
10-Dec
24-Dec
7-Jan
21-Jan
4-Feb
18-Feb
4-Mar
18-Mar
1-Apr
15-Apr
29-Apr
13-May
27-May
10-Jun
24-Jun
8-Jul
22-Jul
5-Aug
19-Aug
2-Sep
16-Sep
30-Sep
October 2009 to September 2010
Shiloh (RM 3.4)
Dos Rios (RM 86.2) SJR
Gardner (RM 79.1) SJR

A2.1c


Modesto Airport Air Temperature - Max, Min, Avg (Water Year 2010)
Degrees (f)
110
100
90
80
70
60
50
40
30
20
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct

A2.2

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

Don Pedro Dam and Powerhouse

March 25, 2010

VIA E-MAIL

Tim Heyne
California Dept. of Fish and Game
P.O. Box 10
La Grange, CA 95329

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

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

RE: Project 2299 – Flow Schedule for 2009-2010 and 2010-2011 Fish Flow Years

Dear Fishery Agency Representatives:

This letter pertains to aspects of Articles 37 & 38 of the Don Pedro Project license regarding Tuolumne River flows. It contains a review of the fall 2009 flows and flow schedule information for the 2009-2010 Fish Flow Year ending April 14, 2010 and the 2010-2011 Fish Flow Year starting April 15, 2010.

Review of Article 38 45-Day Period and Fall Pulse Flow Requirement

The Article 38 '45-Day Period' in fall 2009 began October 17 and ended November 30, as has been the default period for many years. In accordance with Article 38, reduction in river height between the end of the 45-day period and March 31 shall not exceed four inches (0.33 feet) below the average height established during the 45-day period (based on the rating table for the discontinued USGS Old La Grange Bridge streamflow gage).

Using provisional daily flow data from the USGS gage below La Grange Dam, the calculated average flow was 314 cfs for the 2009 45-day period, which corresponds to a river height of 170.03 feet at the Old La Grange Bridge based on the USGS 1996 rating table. A gage elevation of 169.70 feet is 4 inches below that average and corresponds to 202 cfs as shown in Table 1. The flow schedule requirement has been 200 cfs or more since December 1, 2009. Flow releases have exceeded 202 cfs, so the flow requirement this season after the 45-day period related to Article 38 has been met to date; the Article 38 period ends on March 31.

The Article 37 fall pulse flow allocation was 9,352 AF during the 12 days of October 12-23 and the provisional measured flows below La Grange Dam in that period totaled 14,143 AF.

Flow Schedule for the 2009-2010 Fish Flow Year ending April 14, 2010

The most recent flow schedule letter sent to you on October 19, 2009 contained the current schedule for the Article 37 2009-2010 Fish Flow Year starting April 15, 2009 and the total annual requirement of 175,791 AF. Provisional USGS flow data (and estimated values since January 19) indicate that volume had already been released to the Tuolumne River below La Grange Dam by about March 15, 2010. Identified in the letter of October 19, 2009, there remained an unscheduled volume of 7,049 AF for the current Fish Flow Year. Several proposals and discussions have occurred among the District and the Fishery Agencies over the past three months about scheduling the 7,049 AF remainder. A default allocation was established, shown in Table 2, which schedules that volume during the April 2-14 period, resulting in a flow of 474 cfs over 13 days to finish out the schedule for the current Fish Flow Year.

The flow schedule discussions have also considered a potential carryover to the next Fish Flow Year of 5,000 AF of the 7,049 AF remainder to the summer (June through September) period of 2010. The District received a letter from the Fishery Agencies e-mailed on March 12, 2010, which contained, among other issues, a recommendation to carry over 5,000 AF. The District sent an e-mail reply to the Fishery Agencies that same day with several identified concerns, stating that resolution of those issues was needed. To date there has been no resolution of those items, so the schedule in Table 2 will be followed and there will be no carryover unless mutual agreement is reached by April 1.

Flow Schedule for the 2010-2011 Fish Flow Year starting April 15, 2010

The 1996 FERC Order, Amended Article 37, contained a Water Year Classification Index for determining the annual 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 and updated Index thresholds for determining the year type classification were contained in the letter provided to you on October 19, 2009.

TID has again been tracking the Index forecasts and providing your agencies with corresponding flow volume information in e-mails this season. Table 3 contains the Department of Water Resources (DWR) monthly forecasts and updates of those forecasts to date. The forecasts are similar to last year at this time in that there has been a wide range in potential FERC flow volume requirements at the 90% and 50% exceedence levels. In addition, there has been an extended dry period, so the potential flow volumes are expected to continue to be variable going into the 2010-2011 Fish Flow Year.

There will again be the need to coordinate the basin spring pulse flow schedule for the Vernalis Adaptive Management Program (VAMP) in 2010. TID has supplied your agencies with initial preliminary spring daily schedules for potential dry, average, and wet conditions in a March 8 e-mail and to the VAMP Hydrology Coordinator for the March 17 VAMP technical meeting. At that meeting, the initial selection of the 2010 31-day VAMP period was from April 25 - May 25. The corresponding start of that period at La Grange would be April 23, 2008 using the customary 2-day lead time for flow to arrive at Vernalis on the San Joaquin River. As a result, consideration of Tuolumne flows for the preceding April 15-22 period will be needed in the initial flow schedule.

Based on applying the current DWR April-July runoff forecast of March 23 to update the DWR March 1 60-20-20 Basin Index, the annual minimum Article 37 flow requirements presently are 160,065 AF (Intermediate Dry-Below Normal) in the 90% Exceedence case and 300,923 AF (Intermediate Below Normal-Above Normal) in the 50% Exceedence case; these values are also shown on Table 3 with the respective Basin Index. Due to the dry trend, the 90% and 50% levels are considered at present.

Based on the above, two provisional daily schedules for April 15 – June 19 consistent with the draft schedules already provided on March 8 are presented as examples (Table 4); the 2009 schedule is included for comparison. The schedules have the following features:

1) The base flow/pulse flow amounts are those specified for the year types in Article 37.
2) The overall timing of the spring pulse flow incorporates the proposed VAMP period.
3) The pulse flow pattern with multiple peaks generally corresponds to various coordinated schedules utilized in past years.
4) Rampdown (transition) flows are included.

We will need rapid consensus and approval as in prior years to (1) establish and implement the initial FERC flow schedule starting April 15 and for the VAMP scheduling process, and (2) for all subsequent schedule adjustments so that any flow modifications can be conducted in a timely manner, including adequate advance notice for the Districts to implement such operations. It is again expected that some short-term adjustments might be made within the designated VAMP period as may be necessary and feasible in accordance with the VAMP flow coordination effort. Such adjustments would preferentially be made first to any applicable VAMP supplemental flows and secondarily to the FERC pulse flows.

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

Sincerely,

Robert M. Nees
Director of Water Resources and Regulatory Affairs

Cc: Larry Weis - TID
Allen Short – MID
Michael Carlin - CCSF
FERC Secretary

TURLOCK IRRIGATION DISTRICT

October 17 - November 30, 2008 Average Flow

Tuolumne River Below La Grange Dam Near La Grange

ACTUAL FLOWS (Provisional USGS Numbers)

DATE	FLOW CFS	DATE	FLOW CFS
17-Oct	715	08-Nov	254
18-Oct	715	09-Nov	255
19-Oct	712	10-Nov	254
20-Oct	713	11-Nov	254
21-Oct	660	12-Nov	255
22-Oct	548	13-Nov	254
23-Oct	379	14-Nov	255
24-Oct	263	15-Nov	255
25-Oct	255	16-Nov	255
26-Oct	254	17-Nov	256
27-Oct	255	18-Nov	256
28-Oct	256	19-Nov	255
29-Oct	258	20-Nov	256
30-Oct	255	21-Nov	256
31-Oct	257	22-Nov	255
01-Nov	255	23-Nov	257
02-Nov	256	24-Nov	255
03-Nov	257	25-Nov	255
04-Nov	255	26-Nov	254
05-Nov	256	27-Nov	254
06-Nov	254	28-Nov	254
07-Nov	254	29-Nov	255
		30-Nov	252
		TOTAL RELEASE=	14,143

45 day average =	314 cfs =	170.03	ft elevation *
Less 4 inches		-0.33	
Minimum Flow =	202 CFS =	169.70	ft elevation *

* From U.S.G.S. table 22; for old La Grange Bridge (station not in use)

TABLE 2

Tuolumne River Flow Schedule

SCHEDULE FOR 2009 - 20010 Fish Flow Year

DATE		Number of	Flow for Average: Base Flow			Pulse Flows			Interpolation Flow			Other Adjusted Flow			Total FERC Flow	
From:	To:	DAYS	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM. A.F.
15-Apr-2009	15-Apr-2009	1	180	357	357	0	0	0	0	0	0	0	0	0	180	357
16-Apr-2009	16-Apr-2009	1	180	357	714	10	20	20	0	0	0	0	0	0	190	734
17-Apr-2009	17-Apr-2009	1	180	357	1,071	80	159	179	0	0	0	0	0	0	260	1,250
18-Apr-2009	18-Apr-2009	1	180	357	1,428	210	417	595	0	0	0	0	0	0	390	2,023
19-Apr-2009	19-Apr-2009	1	180	357	1,785	350	694	1,289	100	198	198	0	0	0	630	3,273
20-Apr-2009	20-Apr-2009	1	180	357	2,142	360	714	2,003	100	198	397	0	0	0	640	4,542
21-Apr-2009	21-Apr-2009	1	180	357	2,499	360	714	2,717	100	198	595	0	0	0	640	5,812
22-Apr-2009	22-Apr-2009	1	180	357	2,856	360	714	3,431	100	198	793	0	0	0	640	7,081
23-Apr-2009	23-Apr-2009	1	180	357	3,213	360	714	4,145	100	198	992	0	0	0	640	8,350
24-Apr-2009	24-Apr-2009	1	180	357	3,570	360	714	4,860	100	198	1190	0	0	0	640	9,620
25-Apr-2009	25-Apr-2009	1	180	357	3,927	360	714	5,574	100	198	1388	0	0	0	640	10,889
26-Apr-2009	26-Apr-2009	1	180	357	4,284	360	714	6,288	100	198	1587	0	0	0	640	12,159
27-Apr-2009	27-Apr-2009	1	180	357	4,641	360	714	7,002	100	198	1785	0	0	0	640	13,428
28-Apr-2009	28-Apr-2009	1	180	357	4,998	180	357	7,359	100	198	1983	0	0	0	460	14,340
29-Apr-2009	29-Apr-2009	1	180	357	5,355	180	357	7,716	100	198	2182	0	0	0	460	15,253
30-Apr-2009	30-Apr-2009	1	180	357	5,712	180	357	8,073	100	198	2380	0	0	0	460	16,165
01-May-2009	01-May-2009	1	180	357	6,069	180	357	8,430	100	198	2579	0	0	0	460	17,078
02-May-2009	02-May-2009	1	180	357	6,426	180	357	8,787	100	198	2777	0	0	0	460	17,990
03-May-2009	03-May-2009	1	180	357	6,783	180	357	9,144	100	198	2975	0	0	0	460	18,902
04-May-2009	04-May-2009	1	180	357	7,140	180	357	9,501	100	198	3174	0	0	0	460	19,815
05-May-2009	05-May-2009	1	180	357	7,498	300	595	10,096	100	198	3372	0	0	0	580	20,965
06-May-2009	06-May-2009	1	180	357	7,855	500	992	11,088	100	198	3570	0	0	0	780	22,512
07-May-2009	07-May-2009	1	180	357	8,212	700	1,388	12,476	0	0	3570	0	0	0	880	24,258
08-May-2009	08-May-2009	1	180	357	8,569	700	1,388	13,864	0	0	3570	0	0	0	880	26,003
09-May-2009	09-May-2009	1	180	357	8,926	750	1,488	15,352	0	0	3570	0	0	0	930	27,848
10-May-2009	10-May-2009	1	180	357	9,283	750	1,488	16,840	0	0	3570	0	0	0	930	29,693
11-May-2009	11-May-2009	1	180	357	9,640	750	1,488	18,327	0	0	3570	0	0	0	930	31,537
12-May-2009	12-May-2009	1	180	357	9,997	750	1,488	19,815	0	0	3570	0	0	0	930	33,382
13-May-2009	13-May-2009	1	180	357	10,354	750	1,488	21,302	0	0	3570	0	0	0	930	35,226
14-May-2009	14-May-2009	1	180	357	10,711	750	1,488	22,790	0	0	3570	0	0	0	930	37,071
15-May-2009	15-May-2009	1	180	357	11,068	750	1,488	24,278	0	0	3570	0	0	0	930	38,916
16-May-2009	16-May-2009	1	180	357	11,425	750	1,488	25,765	0	0	3570	0	0	0	930	40,760
17-May-2009	17-May-2009	1	180	357	11,782	750	1,488	27,253	0	0	3570	0	0	0	930	42,605
18-May-2009	18-May-2009	1	180	357	12,139	700	1,388	28,641	0	0	3570	0	0	0	880	44,350
19-May-2009	19-May-2009	1	180	357	12,496	700	1,388	30,030	0	0	3570	0	0	0	880	46,096
20-May-2009	20-May-2009	1	180	357	12,853	650	1,289	31,319	0	0	3570	0	0	0	830	47,742
21-May-2009	21-May-2009	1	180	357	13,210	500	992	32,311	0	0	3570	0	0	0	680	49,091
22-May-2009	22-May-2009	1	180	357	13,567	400	793	33,104	0	0	3570	0	0	0	580	50,241
23-May-2009	23-May-2009	1	180	357	13,924	300	595	33,699	0	0	3570	0	0	0	480	51,193
24-May-2009	24-May-2009	1	180	357	14,281	300	595	34,294	0	0	3570	0	0	0	480	52,145
25-May-2009	25-May-2009	1	180	357	14,638	200	397	34,691	0	0	3570	0	0	0	380	52,899
26-May-2009	26-May-2009	1	180	357	14,995	200	397	35,088	0	0	3570	0	0	0	380	53,653
27-May-2009	27-May-2009	1	180	357	15,352	200	397	35,484	0	0	3570	0	0	0	380	54,407
28-May-2009	28-May-2009	1	180	357	15,709	125	248	35,732	0	0	3570	0	0	0	305	55,012
29-May-2009	29-May-2009	1	180	357	16,066	125	248	35,980	0	0	3570	0	0	0	305	55,617
30-May-2009	30-May-2009	1	180	357	16,423	85	169	36,149	0	0	3570	0	0	0	265	56,142
31-May-2009	31-May-2009	1	180	357	16,780	85	169	36,317	0	0	3570	0	0	0	265	56,668
01-Jun-2009	01-Jun-2009	1	75	149	16,929	0	0	36,317	190	377	3947	0	0	0	265	57,193
02-Jun-2009	02-Jun-2009	1	75	149	17,078	0	0	36,317	190	377	4324	0	0	0	265	57,719
03-Jun-2009	07-Jun-2009	5	75	744	17,821	0	0	36,317	135	1,339	5663	0	0	0	210	59,802
08-Jun-2009	15-Jun-2009	8	75	1,190	19,012	0	0	36,317	30	476	6139	0	0	0	105	61,468
16-Jun-2009	30-Jun-2009	15	75	2,231	21,243	0	0	36,317	0	0	6139	0	0	0	75	63,699
01-Jul-2009	31-Jul-2009	31	75	4,612	25,855	0	0	36,317	0	0	6139	0	0	0	75	68,311
01-Aug-2009	31-Aug-2009	31	75	4,612	30,466	0	0	36,317	0	0	6139	0	0	0	75	72,922
01-Sep-2009	10-Sep-2009	10	75	1,488	31,954	0	0	36,317	20	397	6536	0	0	0	95	74,807
11-Sep-2009	13-Sep-2009	3	75	446	32,400	0	0	36,317	20	119	6655	0	0	0	95	75,372
14-Sep-2009	30-Sep-2009	17	75	2,529	34,929	0	0	36,317	20	674	7329	0	0	0	95	78,575
01-Oct-2009	11-Oct-2009	11	200	4,364	39,293	0	0	36,317		0	7329	0	0	0	200	82,939
12-Oct-2009	12-Oct-2009	1	200	397	39,689	175	347	36,664		0	7329	0	0	0	375	83,683
13-Oct-2009	13-Oct-2009	1	200	397	40,086	250	496	37,160		0	7329	0	0	0	450	84,575
14-Oct-2009	14-Oct-2009	1	200	397	40,483	400	793	37,954		0	7329	0	0	0	600	85,765
15-Oct-2009	15-Oct-2009	1	200	397	40,879	500	992	38,945		0	7329	0	0	0	700	87,154
16-Oct-2009	20-Oct-2009	5	175	1,736	42,615	525	5,207	44,152		0	7329	0	0	0	700	94,096
21-Oct-2009	21-Oct-2009	1	175	347	42,962	425	843	44,995		0	7329	0	0	0	600	95,286
22-Oct-2009	22-Oct-2009	1	175	347	43,309	275	545	45,540		0	7329	0	0	0	450	96,179
23-Oct-2009	23-Oct-2009	1	175	347	43,656	65	129	45,669		0	7329	0	0	0	240	96,655
24-Oct-2009	31-Oct-2009	8	175	2,777	46,433	0	0	45,669	25	401	7730	25	397	397	225	100,229
01-Nov-2009	16-Nov-2009	16	175	5,554	51,987	0	0	45,669	25	802	8532	25	793	1,190	225	107,378
17-Nov-2009	30-Nov-2009	14	175	4,860	56,846	0	0	45,669	25	702	9234	25	694	1,884	225	113,634
01-Dec-2009	31-Dec-2009	31	175	10,760	67,607	0	0	45,669	25	1,554	10788	25	1,537	3,421	225	127,486
01-Jan-2010	31-Jan-2010	31	175	10,760	78,367	0	0	45,669		0	10788	25	1,537	4,959	200	139,783
01-Feb-2010	28-Feb-2010	28	175	9,719	88,086	0	0	45,669		0	10788	25	1,388	6,347	200	150,890
01-Mar-2010	31-Mar-2010	31	175	10,760	98,846	0	0	45,669		0	10788	25	1,537	7,884	200	163,188
01-Apr-2010	01-Apr-2010	1	175	347	99,193	0	0	45,669		0	10788	25	50	7,934	200	163,585
02-Apr-2010	14-Apr-2010	13	175	4,512	103,706	0	0	45,669		0	10788	298	7,694	15,628	473	175,791
No. of days		365	(April 15 through April 14)													

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index

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

Table 3

SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION

602020 INDEX

YEAR	APRIL-JULY RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	OCTOBER-MARCH RUNOFF (AF) STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	602020 INDEX	TUOLUMNE RIVER MINIMUM FLOW REQUIREMENT	San Joaquin Index (not the FERC Index) RANKING
Feb 1 Forecast													
Dry	400,000	760,000	400,000	900,000	2,460,000	220,000	405,000	235,000	350,000	1,210,000	2,264,639	133,064	Dry
Average	650,000	1,170,000	600,000	1,270,000	3,690,000	315,000	535,000	305,000	450,000	1,605,000	3,081,639	300,923	Below Normal
Wet	1,110,000	1,960,000	1,060,000	2,090,000	6,220,000	470,000	785,000	465,000	660,000	2,380,000	4,754,639	300,923	Wet
Feb 09 Update													
Dry	410,000	780,000	410,000	920,000	2,520,000	220,000	405,000	235,000	350,000	1,210,000	2,300,639	135,516	Dry
Average	640,000	1,150,000	600,000	1,270,000	3,660,000	315,000	535,000	305,000	450,000	1,605,000	3,063,639	294,919	Below Normal
Wet	1,080,000	1,890,000	1,030,000	2,020,000	6,020,000	470,000	785,000	465,000	660,000	2,380,000	4,634,639	300,923	Wet
Feb 16 Update													
Dry	400,000	750,000	400,000	890,000	2,440,000	220,000	405,000	235,000	350,000	1,210,000	2,252,639	132,247	Dry
Average	610,000	1,080,000	570,000	1,210,000	3,470,000	315,000	535,000	305,000	450,000	1,605,000	2,949,639	251,796	Below Normal
Wet	1,030,000	1,780,000	970,000	1,910,000	5,690,000	470,000	785,000	465,000	660,000	2,380,000	4,436,639	300,923	Wet
Feb 23 Update													
Dry	400,000	750,000	390,000	870,000	2,410,000	220,000	405,000	235,000	350,000	1,210,000	2,234,639	131,021	Dry
Average	580,000	1,040,000	550,000	1,170,000	3,340,000	315,000	535,000	305,000	450,000	1,605,000	2,871,639	222,292	Below Normal
Wet	990,000	1,700,000	920,000	1,810,000	5,420,000	470,000	785,000	465,000	660,000	2,380,000	4,274,639	300,923	Wet
Mar 1 Forecast													
Dry	460,000	910,000	500,000	1,050,000	2,920,000	220,000	430,000	235,000	335,000	1,220,000	2,542,639	152,399	
Average	630,000	1,170,000	640,000	1,330,000	3,770,000	270,000	460,000	270,000	425,000	1,425,000	3,093,639	300,923	Below Normal
Wet	1,020,000	1,790,000	990,000	1,920,000	5,720,000	380,000	560,000	325,000	515,000	1,780,000	4,334,639	300,923	Wet
Mar 09 Update													
Dry	490,000	960,000	530,000	1,100,000	3,080,000	220,000	430,000	235,000	335,000	1,220,000	2,638,639	159,214	Below Normal
Average	650,000	1,200,000	660,000	1,360,000	3,870,000	270,000	460,000	270,000	425,000	1,425,000	3,153,639	300,923	Above Normal
Wet	1,000,000	1,760,000	980,000	1,890,000	5,630,000	380,000	560,000	325,000	515,000	1,780,000	4,280,639	300,923	Wet
Mar 16 Update													
Dry	510,000	1,000,000	550,000	1,140,000	3,200,000	220,000	430,000	235,000	335,000	1,220,000	2,710,639	164,325	Below Normal
Average	660,000	1,220,000	670,000	1,380,000	3,930,000	270,000	460,000	270,000	425,000	1,425,000	3,189,639	300,923	Above Normal
Wet	980,000	1,730,000	970,000	1,850,000	5,530,000	380,000	560,000	325,000	515,000	1,780,000	4,220,639	300,923	Wet
Mar 23 Update													
Dry	500,000	960,000	530,000	1,110,000	3,100,000	220,000	430,000	235,000	335,000	1,220,000	2,650,639	160,065	Below Normal
Average	640,000	1,160,000	640,000	1,330,000	3,770,000	270,000	460,000	270,000	425,000	1,425,000	3,093,639	300,923	Below Normal
Wet	930,000	1,620,000	910,000	1,740,000	5,200,000	380,000	560,000	325,000	515,000	1,780,000	4,022,639	300,923	Wet

TABLE 4

Tuolumne FERC flows

DWR SJ Basin Index Forecast

VAMP period of Apr25-May25 at Vernalis
(23Apr-May23 at La Grange)

23-Mar-10	**Interm. D-BN (90% Index)** **Annual Vol. = 160,065** **Spring pulse vol. = 35,920**				**(50% Index)** **Annual Vol. = 300,923** **Spring pulse vol. = 89,882**				2009 schedule
	base flow	pulse flow	pulse AF	Total flow	base flow	pulse flow	pulse AF	Total flow	
15-Apr-10	180	120	238	300	300	0	0	300	180
16-Apr-10	180	120	238	300	300	0	0	300	190
17-Apr-10	180	120	238	300	300	0	0	300	260
18-Apr-10	180	120	238	300	300	450	893	750	390
19-Apr-10	180	120	238	300	300	1,000	1,983	1,300	630
20-Apr-10	180	120	238	300	300	1,000	1,983	1,300	640
21-Apr-10	180	120	238	300	300	1,000	1,983	1,300	640
22-Apr-10	180	280	555	460	300	1,000	1,983	1,300	640
23-Apr-10	180	720	1,428	900	300	1,000	1,983	1,300	640
24-Apr-10	180	720	1,428	900	300	800	1,587	1,100	640
25-Apr-10	180	720	1,428	900	300	600	1,190	900	640
26-Apr-10	180	720	1,428	900	300	600	1,190	900	640
27-Apr-10	180	720	1,428	900	300	600	1,190	900	640
28-Apr-10	180	650	1,289	830	300	600	1,190	900	460
29-Apr-10	180	450	893	630	300	1,200	2,380	1,500	460
30-Apr-10	180	300	595	480	300	1,200	2,380	1,500	460
1-May-10	180	300	595	480	300	1,200	2,380	1,500	460
2-May-10	180	300	595	480	300	1,200	2,380	1,500	460
3-May-10	180	720	1,428	900	300	1,200	2,380	1,500	460
4-May-10	180	720	1,428	900	300	900	1,785	1,200	460
5-May-10	180	720	1,428	900	300	700	1,388	1,000	580
6-May-10	180	720	1,428	900	300	600	1,190	900	780
7-May-10	180	720	1,428	900	300	600	1,190	900	880
8-May-10	180	650	1,289	830	300	600	1,190	900	880
9-May-10	180	450	893	630	300	1,400	2,777	1,700	930
10-May-10	180	300	595	480	300	1,400	2,777	1,700	930
11-May-10	180	300	595	480	300	1,400	2,777	1,700	930
12-May-10	180	300	595	480	300	1,400	2,777	1,700	930
13-May-10	180	720	1,428	900	300	1,400	2,777	1,700	930
14-May-10	180	720	1,428	900	300	1,100	2,182	1,400	930
15-May-10	180	720	1,428	900	300	900	1,785	1,200	930
16-May-10	180	720	1,428	900	300	800	1,587	1,100	930
17-May-10	180	720	1,428	900	300	800	1,587	1,100	930
18-May-10	180	600	1,190	780	300	800	1,587	1,100	880
19-May-10	180	500	992	680	300	1,200	2,380	1,500	880
20-May-10	180	400	793	580	300	1,650	3,273	1,950	830
21-May-10	180	300	595	480	300	1,650	3,273	1,950	680
22-May-10	180	200	397	380	300	1,650	3,273	1,950	580
23-May-10	180	120	238	300	300	1,565	3,104	1,865	480
24-May-10	180	70	139	250	300	1,400	2,777	1,700	480
25-May-10	180	0	0	180	300	1,200	2,380	1,500	380
26-May-10	180			180	300	1,050	2,083	1,350	380
27-May-10	180			180	300	900	1,785	1,200	380
28-May-10	180			180	300	700	1,388	1,000	305
29-May-10	180			180	300	600	1,190	900	305
30-May-10	180			180	300	500	992	800	265
31-May-10	135			135	300	400	793	700	265
1-Jun-10	100			100	250	350	694	600	265
2-Jun-10	75			75	250	300	595	550	265
3-Jun-10	75			75	250	250	496	500	210
4-Jun-10	75			75	250	200	397	450	210
5-Jun-10	75			75	250	150	298	400	210
6-Jun-10	75			75	250	100	198	350	210
7-Jun-10	75			75	250	50	99	300	210
8-Jun-10	75			75	250		0	250	105
9-Jun-10	75			75	250		0	250	105
10-Jun-10	75			75	250		0	250	105
11-Jun-10	75			75	250		0	250	105
12-Jun-10	75			75	250		0	250	105
13-Jun-10	75			75	250		0	250	105
14-Jun-10	75			75	250		0	250	105
15-Jun-10	75			75	250		0	250	105
16-Jun-10	75			75	250		0	250	75
17-Jun-10	75			75	250		0	250	75
18-Jun-10	75			75	250		0	250	75
19-Jun-10	75			75	250		0	250	75
			Total pulse 35,921	VAMP avg. 726			Total pulse 89,881	VAMP avg. 1,355	VAMP avg 681

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

Don Pedro Dam and Powerhouse

April 2, 2010

VIA E-MAIL

Tim Heyne
California Dept. of Fish and Game
P.O. Box 10
La Grange, CA 95329

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

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

RE: Project 2299 – Final Flow Schedule for 2009-2010 Fish Flow Year under Article 37

Dear Fishery Agency Representatives:

The Fishery Agencies requested by e-mail on March 31, 2010 a modification to the schedule contained in the letter of March 25, 2010 for the remainder of the 2009-2010 Fish Flow Year ending April 14, 2010. Specifically, the scheduled flow increase was proposed to begin a day earlier on April 1, 2010 and the pattern of higher flows for the April 2-14 period was proposed to be adjusted. Your agencies were notified by e-mail that same day (1) that this schedule modification could be accommodated on short notice in this case and (2) of the specific flow schedule adjustments to meet the total annual volume. The attached table includes the final flow schedule for the 2009-2010 Fish Flow Year ending April 14, 2010.

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

Sincerely,

Robert M. Nees
Director of Water Resources and Regulatory Affairs

C: Larry Weis - TID
Allen Short – MID
Michael Carlin - CCSF
FERC Secretary

TABLE 1

Tuolumne River Flow Schedule

SCHEDULE FOR 2009 - 20010 Fish Flow Year

			Flow for Average													
DATE		Number of	Base Flow			Pulse Flows			Interpolation Flow			Other Adjusted Flow			Total FERC Flow	
From:	To:	DAYS	CFS	AF	ACCUM A.F.	CFS	AF	ACCUM A.F.	CFS	AF	ACCUM. A.F.	CFS	AF	ACCUM. A.F.	CFS	ACCUM A.F.
15-Apr-2009	15-Apr-2009	1	180	357	357	0	0	0	0	0	0	0	0	0	180	357
16-Apr-2009	16-Apr-2009	1	180	357	714	10	20	20	0	0	0	0	0	0	190	734
17-Apr-2009	17-Apr-2009	1	180	357	1,071	80	159	179	0	0	0	0	0	0	260	1,250
18-Apr-2009	18-Apr-2009	1	180	357	1,428	210	417	595	0	0	0	0	0	0	390	2,023
19-Apr-2009	19-Apr-2009	1	180	357	1,785	350	694	1,289	100	198	198	0	0	0	630	3,273
20-Apr-2009	20-Apr-2009	1	180	357	2,142	360	714	2,003	100	198	397	0	0	0	640	4,542
21-Apr-2009	21-Apr-2009	1	180	357	2,499	360	714	2,717	100	198	595	0	0	0	640	5,812
22-Apr-2009	22-Apr-2009	1	180	357	2,856	360	714	3,431	100	198	793	0	0	0	640	7,081
23-Apr-2009	23-Apr-2009	1	180	357	3,213	360	714	4,145	100	198	992	0	0	0	640	8,350
24-Apr-2009	24-Apr-2009	1	180	357	3,570	360	714	4,860	100	198	1190	0	0	0	640	9,620
25-Apr-2009	25-Apr-2009	1	180	357	3,927	360	714	5,574	100	198	1388	0	0	0	640	10,889
26-Apr-2009	26-Apr-2009	1	180	357	4,284	360	714	6,288	100	198	1587	0	0	0	640	12,159
27-Apr-2009	27-Apr-2009	1	180	357	4,641	360	714	7,002	100	198	1785	0	0	0	640	13,428
28-Apr-2009	28-Apr-2009	1	180	357	4,998	180	357	7,359	100	198	1983	0	0	0	460	14,340
29-Apr-2009	29-Apr-2009	1	180	357	5,355	180	357	7,716	100	198	2182	0	0	0	460	15,253
30-Apr-2009	30-Apr-2009	1	180	357	5,712	180	357	8,073	100	198	2380	0	0	0	460	16,165
01-May-2009	01-May-2009	1	180	357	6,069	180	357	8,430	100	198	2579	0	0	0	460	17,078
02-May-2009	02-May-2009	1	180	357	6,426	180	357	8,787	100	198	2777	0	0	0	460	17,990
03-May-2009	03-May-2009	1	180	357	6,783	180	357	9,144	100	198	2975	0	0	0	460	18,902
04-May-2009	04-May-2009	1	180	357	7,140	180	357	9,501	100	198	3174	0	0	0	460	19,815
05-May-2009	05-May-2009	1	180	357	7,498	300	595	10,096	100	198	3372	0	0	0	580	20,965
06-May-2009	06-May-2009	1	180	357	7,855	500	992	11,088	100	198	3570	0	0	0	780	22,512
07-May-2009	07-May-2009	1	180	357	8,212	700	1,388	12,476	0	0	3570	0	0	0	880	24,258
08-May-2009	08-May-2009	1	180	357	8,569	700	1,388	13,864	0	0	3570	0	0	0	880	26,003
09-May-2009	09-May-2009	1	180	357	8,926	750	1,488	15,352	0	0	3570	0	0	0	930	27,848
10-May-2009	10-May-2009	1	180	357	9,283	750	1,488	16,840	0	0	3570	0	0	0	930	29,693
11-May-2009	11-May-2009	1	180	357	9,640	750	1,488	18,327	0	0	3570	0	0	0	930	31,537
12-May-2009	12-May-2009	1	180	357	9,997	750	1,488	19,815	0	0	3570	0	0	0	930	33,382
13-May-2009	13-May-2009	1	180	357	10,354	750	1,488	21,302	0	0	3570	0	0	0	930	35,226
14-May-2009	14-May-2009	1	180	357	10,711	750	1,488	22,790	0	0	3570	0	0	0	930	37,071
15-May-2009	15-May-2009	1	180	357	11,068	750	1,488	24,278	0	0	3570	0	0	0	930	38,916
16-May-2009	16-May-2009	1	180	357	11,425	750	1,488	25,765	0	0	3570	0	0	0	930	40,760
17-May-2009	17-May-2009	1	180	357	11,782	750	1,488	27,253	0	0	3570	0	0	0	930	42,605
18-May-2009	18-May-2009	1	180	357	12,139	700	1,388	28,641	0	0	3570	0	0	0	880	44,350
19-May-2009	19-May-2009	1	180	357	12,496	700	1,388	30,030	0	0	3570	0	0	0	880	46,096
20-May-2009	20-May-2009	1	180	357	12,853	650	1,289	31,319	0	0	3570	0	0	0	830	47,742
21-May-2009	21-May-2009	1	180	357	13,210	500	992	32,311	0	0	3570	0	0	0	680	49,091
22-May-2009	22-May-2009	1	180	357	13,567	400	793	33,104	0	0	3570	0	0	0	580	50,241
23-May-2009	23-May-2009	1	180	357	13,924	300	595	33,699	0	0	3570	0	0	0	480	51,193
24-May-2009	24-May-2009	1	180	357	14,281	300	595	34,294	0	0	3570	0	0	0	480	52,145
25-May-2009	25-May-2009	1	180	357	14,638	200	397	34,691	0	0	3570	0	0	0	380	52,899
26-May-2009	26-May-2009	1	180	357	14,995	200	397	35,088	0	0	3570	0	0	0	380	53,653
27-May-2009	27-May-2009	1	180	357	15,352	200	397	35,484	0	0	3570	0	0	0	380	54,407
28-May-2009	28-May-2009	1	180	357	15,709	125	248	35,732	0	0	3570	0	0	0	305	55,012
29-May-2009	29-May-2009	1	180	357	16,066	125	248	35,980	0	0	3570	0	0	0	305	55,617
30-May-2009	30-May-2009	1	180	357	16,423	85	169	36,149	0	0	3570	0	0	0	265	56,142
31-May-2009	31-May-2009	1	180	357	16,780	85	169	36,317	0	0	3570	0	0	0	265	56,668
01-Jun-2009	01-Jun-2009	1	75	149	16,929	0	0	36,317	190	377	3947	0	0	0	265	57,193
02-Jun-2009	02-Jun-2009	1	75	149	17,078	0	0	36,317	190	377	4324	0	0	0	265	57,719
03-Jun-2009	07-Jun-2009	5	75	744	17,821	0	0	36,317	135	1,339	5663	0	0	0	210	59,802
08-Jun-2009	15-Jun-2009	8	75	1,190	19,012	0	0	36,317	30	476	6139	0	0	0	105	61,468
16-Jun-2009	30-Jun-2009	15	75	2,231	21,243	0	0	36,317	0	0	6139	0	0	0	75	63,699
01-Jul-2009	31-Jul-2009	31	75	4,612	25,855	0	0	36,317	0	0	6139	0	0	0	75	68,311
01-Aug-2009	31-Aug-2009	31	75	4,612	30,466	0	0	36,317	0	0	6139	0	0	0	75	72,922
01-Sep-2009	10-Sep-2009	10	75	1,488	31,954	0	0	36,317	20	397	6536	0	0	0	95	74,807
11-Sep-2009	13-Sep-2009	3	75	446	32,400	0	0	36,317	20	119	6655	0	0	0	95	75,372
14-Sep-2009	30-Sep-2009	17	75	2,529	34,929	0	0	36,317	20	674	7329	0	0	0	95	78,575
01-Oct-2009	11-Oct-2009	11	200	4,364	39,293	0	0	36,317		0	7329		0	0	200	82,939
12-Oct-2009	12-Oct-2009	1	200	397	39,689	73	145	36,462	102	202	7531		0	0	375	83,683
13-Oct-2009	13-Oct-2009	1	200	397	40,086	73	145	36,607	177	351	7883		0	0	450	84,575
14-Oct-2009	14-Oct-2009	1	200	397	40,483	73	145	36,751	327	649	8531		0	0	600	85,765
15-Oct-2009	15-Oct-2009	1	200	397	40,879	73	145	36,896	427	847	9378		0	0	700	87,154
16-Oct-2009	20-Oct-2009	5	175	1,736	42,615	73	723	37,619	452	4,483	13862		0	0	700	94,096
21-Oct-2009	21-Oct-2009	1	175	347	42,962	73	145	37,764	352	698	14560		0	0	600	95,286
22-Oct-2009	22-Oct-2009	1	175	347	43,309	73	145	37,909	195	387	14947	8	15	15	450	96,179
23-Oct-2009	23-Oct-2009	1	175	347	43,656	73	145	38,053		0	14947	-8	(15)	(0)	240	96,656
24-Oct-2009	31-Oct-2009	8	175	2,777	46,433	0	0	38,053	50	798	15744		0	(0)	225	100,231
01-Nov-2009	16-Nov-2009	16	175	5,554	51,987	0	0	38,053	50	1,595	17340		0	(0)	225	107,380
17-Nov-2009	30-Nov-2009	14	175	4,860	56,846	0	0	38,053	50	1,396	18736		0	(0)	225	113,635
01-Dec-2009	31-Dec-2009	31	175	10,760	67,607	0	0	38,053	50	3,091	21827		0	(0)	225	127,487
01-Jan-2010	31-Jan-2010	31	175	10,760	78,367	0	0	38,053	25	1,537	23364		0	(0)	200	139,785
01-Feb-2010	28-Feb-2010	28	175	9,719	88,086	0	0	38,053	25	1,388	24753		0	(0)	200	150,892
01-Mar-2010	31-Mar-2010	31	175	10,760	98,846	0	0	38,053	25	1,537	26290		0	(0)	200	163,190
01-Apr-2010	01-Apr-2010	1	175	347	99,193	0	0	38,053	254	504	26794		0	(0)	429	164,040
02-Apr-2010	02-Apr-2010	1	175	347	99,540	0	0	38,053	450	893	27686		0	(0)	625	165,280
03-Apr-2010	03-Apr-2010	1	175	347	99,888	0	0	38,053	450	893	28579		0	(0)	625	166,520
04-Apr-2010	04-Apr-2010	1	175	347	100,235	0	0	38,053	450	893	29472		0	(0)	625	167,759
05-Apr-2010	05-Apr-2010	1	175	347	100,582	0	0	38,053	450	893	30364		0	(0)	625	168,999
06-Apr-2010	06-Apr-2010	1	175	347	100,929	0	0	38,053	450	893	31257		0	(0)	625	170,239
07-Apr-2010	07-Apr-2010	1	175	347	101,276	0	0	38,053	250	496	31753		0	(0)	425	171,082
08-Apr-2010	08-Apr-2010	1	175	347	101,623	0	0	38,053	250	496	32248		0	(0)	425	171,925
09-Apr-2010	09-Apr-2010	1	175	347	101,970	0	0	38,053	150	298	32546		0	(0)	325	172,569
10-Apr-2010	14-Apr-2010	5	175	1,736	103,706	0	0	38,053	150	1,486	34032		0	(0)	325	175,791
No. of days		365	(April 15 through April 14)													

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index

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

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

Don Pedro Dam and Powerhouse

April 22, 2010

VIA E-MAIL

Tim Heyne
California Dept. of Fish and Game
P.O. Box 10
La Grange, CA 95329

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

Maria Rea
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814-4708

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

Dear Fishery Agency representatives:

Based on applying the current DWR April-July runoff forecast update of April 13 to the DWR April 1 60-20-20 basin index, the annual minimum flow requirement is 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.

Table 2 has the same daily Article 37 schedule previously provided in the March 25 letter for the 50% exceedence condition. At the present time, substantially higher flows ranging from about 1,700-2,500 cfs in a similar pattern are initially projected to continue into at least late May. Those higher total flows have been incorporated into the VAMP operational schedule for the April 23 – May 23 period.

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

Sincerely,

Robert M. Nees
Director of Water Resources and Regulatory Affairs

C: Larry Weis - TID
Allen Short – MID
Michael Carlin - CCSF
FERC Secretary

TID

Table 1

SAN JOAQUIN VALLEY WATER YEAR HYDROLOGIC CLASSIFICATION

602020 INDEX

	APRIL-JULY RUNOFF (AF)					OCTOBER-MARCH RUNOFF (AF)					602020	TUOLUMNE RIVER	San Joaquin Index (not the FERC Index)
YEAR	STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	STANISLAUS	TUOLUMNE	MERCED	FRIANT	TOTAL	INDEX	MINIMUM FLOW REQUIREMENT	RANKING
Feb 1 Forecast													
Dry	400,000	760,000	400,000	900,000	2,460,000	220,000	405,000	235,000	350,000	1,210,000	2,264,639	133,064	Dry
Average	650,000	1,170,000	600,000	1,270,000	3,690,000	315,000	535,000	305,000	450,000	1,605,000	3,081,639	300,923	Below Normal
Wet	1,110,000	1,960,000	1,060,000	2,090,000	6,220,000	470,000	785,000	465,000	660,000	2,380,000	4,754,639	300,923	Wet
Feb 09 Update													
Dry	410,000	780,000	410,000	920,000	2,520,000	220,000	405,000	235,000	350,000	1,210,000	2,300,639	135,516	Dry
Average	640,000	1,150,000	600,000	1,270,000	3,660,000	315,000	535,000	305,000	450,000	1,605,000	3,063,639	294,919	Below Normal
Wet	1,080,000	1,890,000	1,030,000	2,020,000	6,020,000	470,000	785,000	465,000	660,000	2,380,000	4,634,639	300,923	Wet
Feb 16 Update													
Dry	400,000	750,000	400,000	890,000	2,440,000	220,000	405,000	235,000	350,000	1,210,000	2,252,639	132,247	Dry
Average	610,000	1,080,000	570,000	1,210,000	3,470,000	315,000	535,000	305,000	450,000	1,605,000	2,949,639	251,796	Below Normal
Wet	1,030,000	1,780,000	970,000	1,910,000	5,690,000	470,000	785,000	465,000	660,000	2,380,000	4,436,639	300,923	Wet
Feb 23 Update													
Dry	400,000	750,000	390,000	870,000	2,410,000	220,000	405,000	235,000	350,000	1,210,000	2,234,639	131,021	Dry
Average	580,000	1,040,000	550,000	1,170,000	3,340,000	315,000	535,000	305,000	450,000	1,605,000	2,871,639	222,292	Below Normal
Wet	990,000	1,700,000	920,000	1,810,000	5,420,000	470,000	785,000	465,000	660,000	2,380,000	4,274,639	300,923	Wet
Mar 1 Forecast													
Dry	460,000	910,000	500,000	1,050,000	2,920,000	220,000	430,000	235,000	335,000	1,220,000	2,542,639	152,399	
Average	630,000	1,170,000	640,000	1,330,000	3,770,000	270,000	460,000	270,000	425,000	1,425,000	3,093,639	300,923	Below Normal
Wet	1,020,000	1,790,000	990,000	1,920,000	5,720,000	380,000	560,000	325,000	515,000	1,780,000	4,334,639	300,923	Wet
Mar 09 Update													
Dry	490,000	960,000	530,000	1,100,000	3,080,000	220,000	430,000	235,000	335,000	1,220,000	2,638,639	159,214	Below Normal
Average	650,000	1,200,000	660,000	1,360,000	3,870,000	270,000	460,000	270,000	425,000	1,425,000	3,153,639	300,923	Above Normal
Wet	1,000,000	1,760,000	980,000	1,890,000	5,630,000	380,000	560,000	325,000	515,000	1,780,000	4,280,639	300,923	Wet
Mar 16 Update													
Dry	510,000	1,000,000	550,000	1,140,000	3,200,000	220,000	430,000	235,000	335,000	1,220,000	2,710,639	164,325	Below Normal
Average	660,000	1,220,000	670,000	1,380,000	3,930,000	270,000	460,000	270,000	425,000	1,425,000	3,189,639	300,923	Above Normal
Wet	980,000	1,730,000	970,000	1,850,000	5,530,000	380,000	560,000	325,000	515,000	1,780,000	4,220,639	300,923	Wet
Mar 23 Update													
Dry	500,000	960,000	530,000	1,110,000	3,100,000	220,000	430,000	235,000	335,000	1,220,000	2,650,639	160,065	Below Normal
Average	640,000	1,160,000	640,000	1,330,000	3,770,000	270,000	460,000	270,000	425,000	1,425,000	3,093,639	300,923	Below Normal
Wet	930,000	1,620,000	910,000	1,740,000	5,200,000	380,000	560,000	325,000	515,000	1,780,000	4,022,639	300,923	Wet
Apr 1 Forecast													
Dry	530,000	990,000	540,000	1,150,000	3,210,000	270,000	460,000	275,000	430,000	1,435,000	2,759,639	179,926	
Average	650,000	1,160,000	640,000	1,340,000	3,790,000	270,000	460,000	275,000	430,000	1,435,000	3,107,639	300,923	Above Normal
Wet	900,000	1,550,000	880,000	1,680,000	5,010,000	270,000	460,000	275,000	430,000	1,435,000	3,839,639	300,923	Wet
Apr 13 Update													
Dry	620,000	1,150,000	670,000	1,370,000	3,810,000	270,000	460,000	275,000	430,000	1,435,000	3,119,639	300,923	Above Normal
Average	730,000	1,290,000	750,000	1,540,000	4,310,000	270,000	460,000	275,000	430,000	1,435,000	3,419,639	300,923	Above Normal
Wet	920,000	1,590,000	940,000	1,810,000	5,260,000	270,000	460,000	275,000	430,000	1,435,000	3,989,639	300,923	Wet

TABLE 2
Tuolumne River Flow Schedule
SCHEDULE FOR 2010 - 2011 Fish Flow Year

DATE From:	DATE To:	Number of DAYS	Base Flow CFS	Base Flow AF	Base Flow ACCUM. A.F.	Pulse Flows CFS	Pulse Flows AF	Pulse Flows ACCUM. A.F.	Flow for Average Interpolation Flow CFS	Flow for Average Interpolation Flow AF	Flow for Average Interpolation Flow ACCUM. A.F.	Other Adjusted Flow CFS	Other Adjusted Flow AF	Other Adjusted Flow ACCUM. A.F.	Total FERC Flow CFS	Total FERC Flow ACCUM. A.F.
15-Apr-2010	15-Apr-2010	1	300	595	595	0	0	0	0	0	0	0	0	0	300	595
16-Apr-2010	16-Apr-2010	1	300	595	1,190	0	0	0	0	0	0	0	0	0	300	1,190
17-Apr-2010	17-Apr-2010	1	300	595	1,785	0	0	0	0	0	0	0	0	0	300	1,785
18-Apr-2010	18-Apr-2010	1	300	595	2,380	450	893	893	0	0	0	0	0	0	750	3,273
19-Apr-2010	19-Apr-2010	1	300	595	2,975	1000	1,983	2,876	0	0	0	0	0	0	1,300	5,851
20-Apr-2010	20-Apr-2010	1	300	595	3,570	1000	1,983	4,860	0	0	0	0	0	0	1,300	8,430
21-Apr-2010	21-Apr-2010	1	300	595	4,165	1000	1,983	6,843	0	0	0	0	0	0	1,300	11,008
22-Apr-2010	22-Apr-2010	1	300	595	4,760	1000	1,983	8,826	0	0	0	0	0	0	1,300	13,587
23-Apr-2010	23-Apr-2010	1	300	595	5,355	1000	1,983	10,810	0	0	0	0	0	0	1,300	16,165
24-Apr-2010	24-Apr-2010	1	300	595	5,950	800	1,587	12,397	0	0	0	0	0	0	1,100	18,347
25-Apr-2010	25-Apr-2010	1	300	595	6,545	600	1,190	13,587	0	0	0	0	0	0	900	20,132
26-Apr-2010	26-Apr-2010	1	300	595	7,140	600	1,190	14,777	0	0	0	0	0	0	900	21,917
27-Apr-2010	27-Apr-2010	1	300	595	7,736	600	1,190	15,967	0	0	0	0	0	0	900	23,702
28-Apr-2010	28-Apr-2010	1	300	595	8,331	600	1,190	17,157	0	0	0	0	0	0	900	25,488
29-Apr-2010	29-Apr-2010	1	300	595	8,926	1200	2,380	19,537	0	0	0	0	0	0	1,500	28,463
30-Apr-2010	30-Apr-2010	1	300	595	9,521	1200	2,380	21,917	0	0	0	0	0	0	1,500	31,438
01-May-2010	01-May-2010	1	300	595	10,116	1200	2,380	24,298	0	0	0	0	0	0	1,500	34,413
02-May-2010	02-May-2010	1	300	595	10,711	1200	2,380	26,678	0	0	0	0	0	0	1,500	37,388
03-May-2010	03-May-2010	1	300	595	11,306	1200	2,380	29,058	0	0	0	0	0	0	1,500	40,364
04-May-2010	04-May-2010	1	300	595	11,901	900	1,785	30,843	0	0	0	0	0	0	1,200	42,744
05-May-2010	05-May-2010	1	300	595	12,496	700	1,388	32,231	0	0	0	0	0	0	1,000	44,727
06-May-2010	06-May-2010	1	300	595	13,091	600	1,190	33,421	0	0	0	0	0	0	900	46,512
07-May-2010	07-May-2010	1	300	595	13,686	600	1,190	34,612	0	0	0	0	0	0	900	48,298
08-May-2010	08-May-2010	1	300	595	14,281	600	1,190	35,802	0	0	0	0	0	0	900	50,083
09-May-2010	09-May-2010	1	300	595	14,876	1400	2,777	38,579	0	0	0	0	0	0	1,700	53,455
10-May-2010	10-May-2010	1	300	595	15,471	1400	2,777	41,355	0	0	0	0	0	0	1,700	56,826
11-May-2010	11-May-2010	1	300	595	16,066	1400	2,777	44,132	0	0	0	0	0	0	1,700	60,198
12-May-2010	12-May-2010	1	300	595	16,661	1400	2,777	46,909	0	0	0	0	0	0	1,700	63,570
13-May-2010	13-May-2010	1	300	595	17,256	1400	2,777	49,686	0	0	0	0	0	0	1,700	66,942
14-May-2010	14-May-2010	1	300	595	17,851	1100	2,182	51,868	0	0	0	0	0	0	1,400	69,719
15-May-2010	15-May-2010	1	300	595	18,446	900	1,785	53,653	0	0	0	0	0	0	1,200	72,099
16-May-2010	16-May-2010	1	300	595	19,041	800	1,587	55,240	0	0	0	0	0	0	1,100	74,281
17-May-2010	17-May-2010	1	300	595	19,636	800	1,587	56,826	0	0	0	0	0	0	1,100	76,463
18-May-2010	18-May-2010	1	300	595	20,231	800	1,587	58,413	0	0	0	0	0	0	1,100	78,645
19-May-2010	19-May-2010	1	300	595	20,826	1200	2,380	60,793	0	0	0	0	0	0	1,500	81,620
20-May-2010	20-May-2010	1	300	595	21,421	1650	3,273	64,066	0	0	0	0	0	0	1,950	85,488
21-May-2010	21-May-2010	1	300	595	22,017	1650	3,273	67,339	0	0	0	0	0	0	1,950	89,355
22-May-2010	22-May-2010	1	300	595	22,612	1650	3,273	70,612	0	0	0	0	0	0	1,950	93,223
23-May-2010	23-May-2010	1	300	595	23,207	1565	3,104	73,716	0	0	0	0	0	0	1,865	96,922
24-May-2010	24-May-2010	1	300	595	23,802	1400	2,777	76,493	0	0	0	0	0	0	1,700	100,294
25-May-2010	25-May-2010	1	300	595	24,397	1200	2,380	78,873	0	0	0	0	0	0	1,500	103,269
26-May-2010	26-May-2010	1	300	595	24,992	1050	2,083	80,955	0	0	0	0	0	0	1,350	105,947
27-May-2010	27-May-2010	1	300	595	25,587	900	1,785	82,740	0	0	0	0	0	0	1,200	108,327
28-May-2010	28-May-2010	1	300	595	26,182	700	1,388	84,129	0	0	0	0	0	0	1,000	110,311
29-May-2010	29-May-2010	1	300	595	26,777	600	1,190	85,319	0	0	0	0	0	0	900	112,096
30-May-2010	30-May-2010	1	300	595	27,372	500	992	86,311	0	0	0	0	0	0	800	113,683
31-May-2010	31-May-2010	1	300	595	27,967	400	793	87,104	0	0	0	0	0	0	700	115,071
01-Jun-2010	01-Jun-2010	1	250	496	28,463	350	694	87,798	0	0	0	0	0	0	600	116,261
02-Jun-2010	02-Jun-2010	1	250	496	28,959	300	595	88,393	0	0	0	0	0	0	550	117,352
03-Jun-2010	03-Jun-2010	1	250	496	29,455	250	496	88,889	0	0	0	0	0	0	500	118,344
04-Jun-2010	04-Jun-2010	1	250	496	29,950	200	397	89,286	0	0	0	0	0	0	450	119,236
05-Jun-2010	05-Jun-2010	1	250	496	30,446	150	298	89,583	0	0	0	0	0	0	400	120,030
06-Jun-2010	06-Jun-2010	1	250	496	30,942	100	198	89,782	0	0	0	0	0	0	350	120,724
07-Jun-2010	07-Jun-2010	1	250	496	31,438	50	99	89,881	0	0	0	0	0	0	300	121,319
08-Jun-2010	08-Jun-2010	1	250	496	31,934	0	0	89,881	0	0	0	0	0	0	250	121,815
09-Jun-2010	09-Jun-2010	1	250	496	32,430	0	0	89,881	0	0	0	0	0	0	250	122,311
10-Jun-2010	10-Jun-2010	1	250	496	32,926	0	0	89,881	0	0	0	0	0	0	250	122,807
11-Jun-2010	30-Jun-2010	20	250	9,917	42,843	0	0	89,881	0	0	0	0	0	0	250	132,724
01-Jul-2010	31-Jul-2010	31	250	15,372	58,215	0	0	89,881	0	0	0	0	0	0	250	148,096
01-Aug-2010	31-Aug-2010	31	250	15,372	73,587	0	0	89,881	0	0	0	0	0	0	250	163,468
01-Sep-2010	30-Sep-2010	30	250	14,876	88,463	0	0	89,881	0	0	0	0	0	0	250	178,344
01-Oct-2010	06-Oct-2010	6	300	3,570	92,033	500	5,950	95,831	0	0	0	0	0	0	800	187,864
07-Oct-2010	22-Oct-2010	16	300	9,521	101,554	0	0	95,831	0	0	0	0	0	0	300	197,385
23-Oct-2010	23-Oct-2010	1	300	595	102,149	0	0	95,831	0	0	0	0	0	0	300	197,980
24-Oct-2010	24-Oct-2010	1	300	595	102,744	0	0	95,831	0	0	0	0	0	0	300	198,575
25-Oct-2010	25-Oct-2010	1	300	595	103,339	0	0	95,831	0	0	0	0	0	0	300	199,170
26-Oct-2010	31-Oct-2010	6	300	3,570	106,909	0	0	95,831	0	0	0	0	0	0	300	202,740
01-Nov-2010	16-Nov-2010	16	300	9,521	116,430	0	0	95,831	0	0	0	0	0	0	300	212,261
17-Nov-2010	30-Nov-2010	14	300	8,331	124,760	0	0	95,831	0	0	0	0	0	0	300	220,591
01-Dec-2010	31-Dec-2010	31	300	18,446	143,207	0	0	95,831	0	0	0	0	0	0	300	239,038
01-Jan-2011	31-Jan-2011	31	300	18,446	161,653	0	0	95,831	0	0	0	0	0	0	300	257,484
01-Feb-2011	28-Feb-2011	28	300	16,661	178,314	0	0	95,831	0	0	0	0	0	0	300	274,145
01-Mar-2011	31-Mar-2011	31	300	18,446	196,760	0	0	95,831	0	0	0	0	0	0	300	292,591
01-Apr-2011	01-Apr-2011	1	300	595	197,355	0	0	95,831	0	0	0	0	0	0	300	293,186
02-Apr-2011	02-Apr-2011	1	300	595	197,950	0	0	95,831	0	0	0	0	0	0	300	293,781
03-Apr-2011	03-Apr-2011	1	300	595	198,545	0	0	95,831	0	0	0	0	0	0	300	294,376
04-Apr-2011	04-Apr-2011	1	300	595	199,140	0	0	95,831	0	0	0	0	0	0	300	294,971
05-Apr-2011	05-Apr-2011	1	300	595	199,736	0	0	95,831	0	0	0	0	0	0	300	295,567
06-Apr-2011	06-Apr-2011	1	300	595	200,331	0	0	95,831	0	0	0	0	0	0	300	296,162
07-Apr-2011	07-Apr-2011	1	300	595	200,926	0	0	95,831	0	0	0	0	0	0	300	296,757
08-Apr-2011	08-Apr-2011	1	300	595	201,521	0	0	95,831	0	0	0	0	0	0	300	297,352
09-Apr-2011	09-Apr-2011	1	300	595	202,116	0	0	95,831	0	0	0	0	0	0	300	297,947
10-Apr-2011	14-Apr-2011	5	300	2,975	205,091	0	0	95,831	0	0	0	0	0	0	300	300,922
No. of days		365 (April 15 through April 14)														

1 cfs day = 1.983471 acre-feet (af)

Notes: 1. Based on 60-20-20 Index

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

Attachment -B-

2010 Tuolumne River
Technical Advisory Committee Materials:

- List of 2010 TRTAC Activities/Materials

- March Meeting

- June Meeting

- September Meeting

- December Meeting

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

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

333 East Canal Drive
Turlock, CA 95381-0949
Phone: (209) 883-8275
Fax: (209) 656-2180
Email: tjford@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

March 18, 2010 at 9:30 AM

Turlock Irrigation District, Lunch Room (2nd floor)

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from Dec 2009 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Fall run information – weir; river surveys
   - Ongoing monitoring – seine, screw trap, weir, winter snorkel survey
   - 2009 annual FERC report
   - Other planned studies for 2010

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 10, SEPTEMBER 9, DECEMBER 9

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

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TECHNICAL ADVISORY COMMITTEE MEETING

18 March 2010 at 9:30 AM

Turlock Irrigation District, Lunch Room (2nd floor)

Summary

1. INTRODUCTION AND ANNOUNCEMENTS
   - No fishery agencies were present.
   - Jesse Roseman attended from TRT.

2. ADMINISTRATIVE ITEMS:
   - Review/Revise agenda – No changes
   - Review notes from 11DEC – Approved
   - Items produced since last meeting – reviewed the handout listing material posted at http://tuolumnerivertac.com/ Those included:
     - Prior meeting agenda, summary, and handouts
     - Correspondences regarding the January 15 *O. mykiss* monitoring report
     - January 15, 2010 report on O. mykiss pursuant to ordering paragraph (C)(5) of the April 3, 2008 FERC Order
     - Several technical reports for the annual FERC report
     - Counting weir data, seine data, and updates to the basin monitoring newsletter.

3. MONITORING/REPORTS:
   - Salmon run data. Ford discussed salmon run estimates for the Tuolumne, Merced and Stanislaus Rivers and stated he was waiting for a 2009 spawning survey report from CDFG. Although CDFG reported 124 for the Tuolumne in GrandTab (excluding spawners below Fox Grove?), counting weir numbers were 280 by mid-January, and reached 300 by the week of March 15. By comparison, CDFG reported a GrandTab Stanislaus estimate of 595 while the weir count there was 1250 by mid-January; a handout of the daily weir counts was reviewed. Other GrandTab numbers were: Merced River with 604 (358:246 for River:Hatchery) and Mokelumne River with 2,229 (680:1549 for River:Hatchery).
   - Counting weir. The weir will continue operation into April and May as flows allow (upper limit may be about 1500 cfs).
   - Seine/Screw Trapping. Handouts of size and abundance of RST salmon catch were reviewed. At Waterford, the early fry peaks were associated with storm events, but catch was low at Grayson overall. Many larger juveniles (80-120 mm) were also caught at Waterford in January – those were not from fall 2009 run. The fall 2009 cohort catch began to include parr and smolts (50-80 mm) mainly in March at Waterford.

- *O. mykiss* Studies. Hume indicated that the March 2009 population estimate was complete. Ford reported that the adult *O. mykiss* tracking study had been approved and that the project would be initiated within the week.

4. FLOW OPERATIONS:
   - Reviewed water year forecasting based on 1 MAR 10%, 50% and 90% exceedance estimates (see handouts). Still a wide range between the 50% and 90% levels. VAMP flows were planned from April 25 to May 25 (at Vernalis)
   - Discussions with the fishery agencies about the use of 7000 AF for pulse flows, base flow, or carryover storage were ongoing at the time of the meeting.

5. AGENCY/NGO UPDATES
   - TRT
     - Roseman discussed a Jeff Jardine article in the Modesto Bee about the removal of the Dennett Dam and pursuing funding sources.
     - Roseman discussed a Farmwater Toolbox forum on Thursday March 25, 2010 at the UC Cooperative Extension in Merced. Details and other resources can be found at: http://agwaterstewards.org/txp/Home/
     - Roseman discussed the second TRT "Paddle to the Sea" event from May 7 to June 5.

6. ADDITIONAL ITEMS
   - None.

7. NEXT MEETING DATES – JUNE 10, SEPTEMBER 9, DECEMBER 9

TRTAC Meeting Attendees

	Name	Organization
1.	Tim Ford	TID/MID
2.	Noah Hume	Stillwater
3.	Galileo Morales	TID
4.	Robert Nees	TID
5.	Jesse Roseman	TRT
6.	Walter Ward	MID

2010 TRTAC Materials/Postings to Website

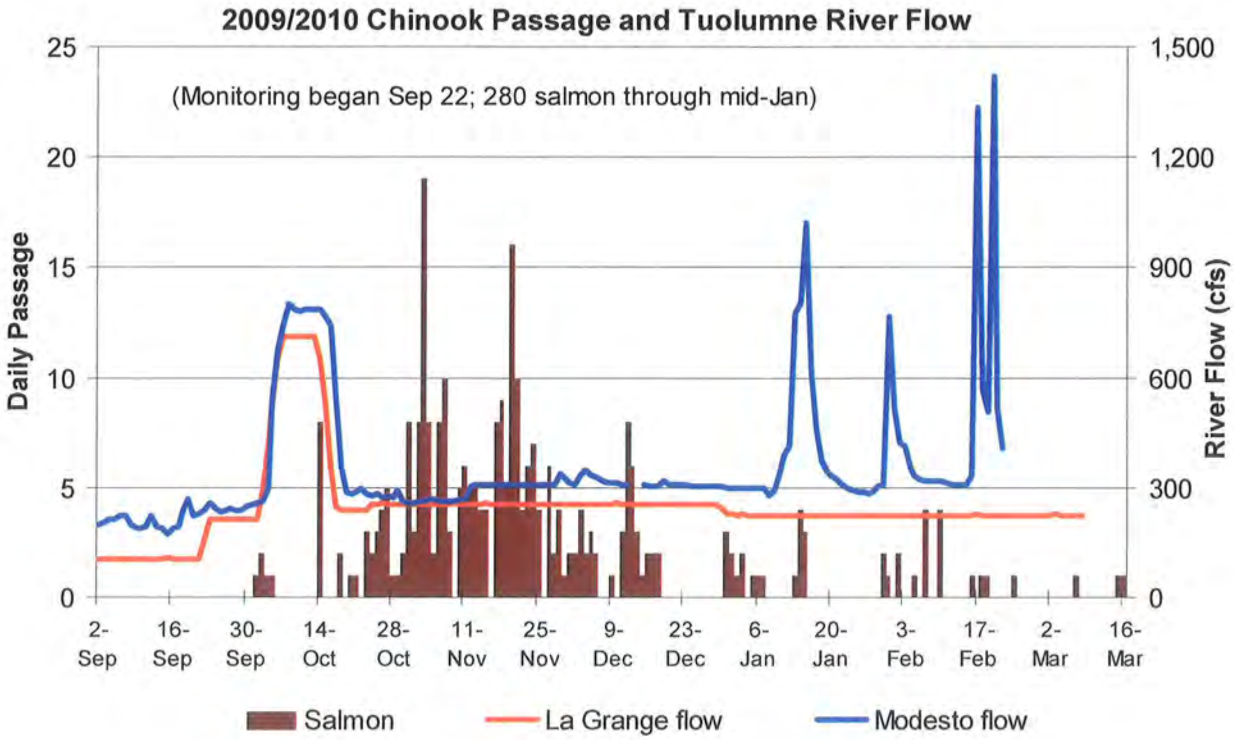
2009Dec11-2010Mar18 Postings to TRTAC website http://tuolumnerivertac.com/

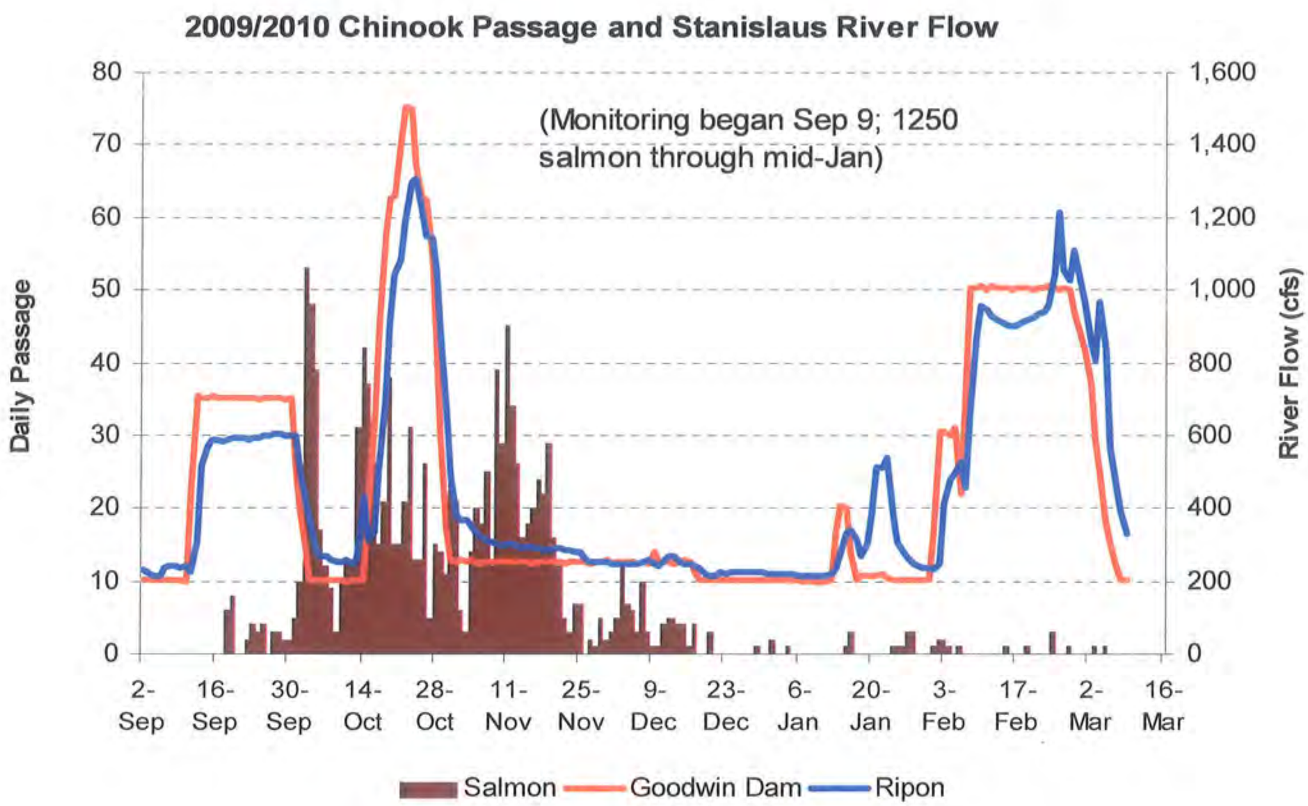
- Meetings
    - December 2009 TRTAC meeting summary and handouts
    - March 2010 TRTAC meeting agenda

- Correspondence
    - Districts' letter to FERC re: submittal of the O. mykiss monitoring report dated January 15, 2010.
    - CDFG letter to TID re: comments to O. mykiss monitoring report dated January 5, 2010
    - NMFS letter to FERC re: request for extension to provide comments to O. mykiss monitoring report dated December xx, 2009 (filed Dec24)

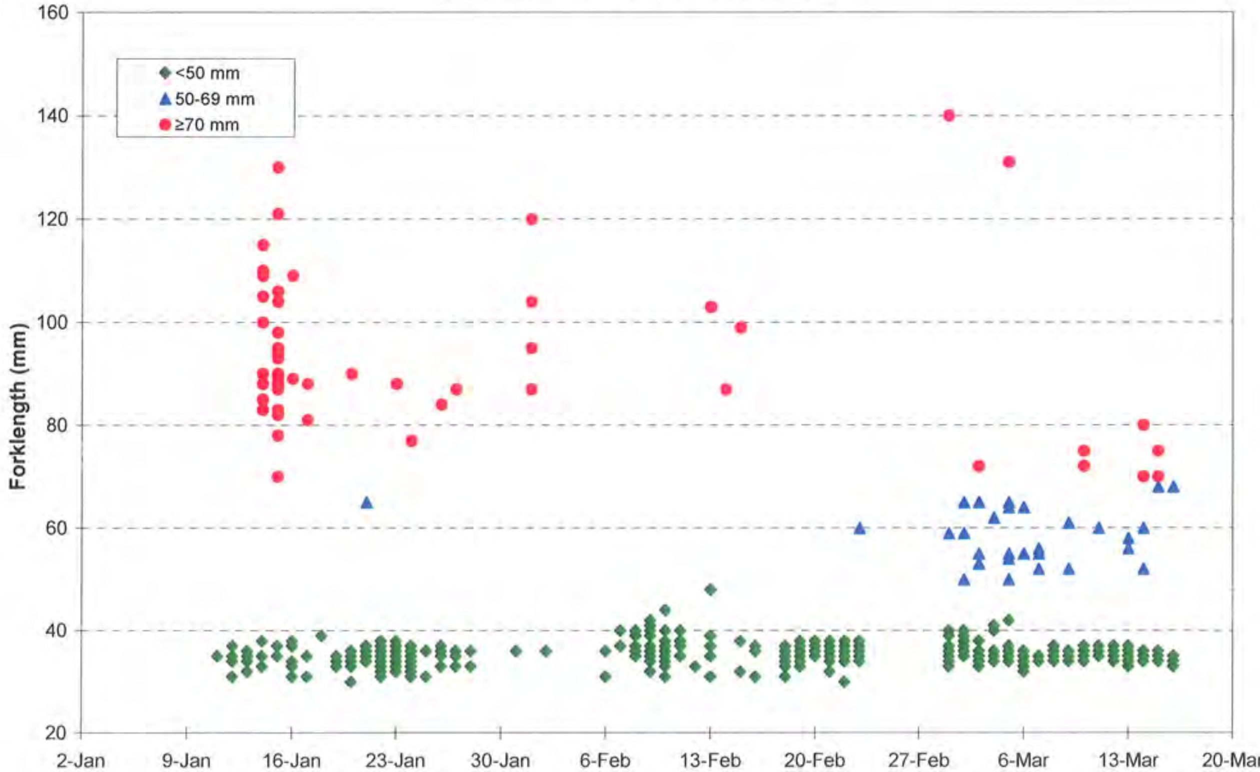
- Documents
    - 2009 Aquatic Invertebrate Monitoring and Summary Update
    - 2009 Review of Summer Flow Operations
    - 2009 Rotary Screw Trap Report
    - January 2010 Final Tuolumne River O. mykiss Monitoring Report
    - January 20, 2010 - The Districts' Answer to the Statement of the Resource Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
    - January 5, 2010 - Statement of the Resources Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
    - TID and MID report on O. mykiss pursuant to ordering paragraph (C)(5) of the April 3, 2008 FERC Order

- Data/Monitoring
    - 2010 seine data
    - Updates of basin monitoring newsletter (includes 2010 RST monitoring)
    - 2009-10 Counting weir data

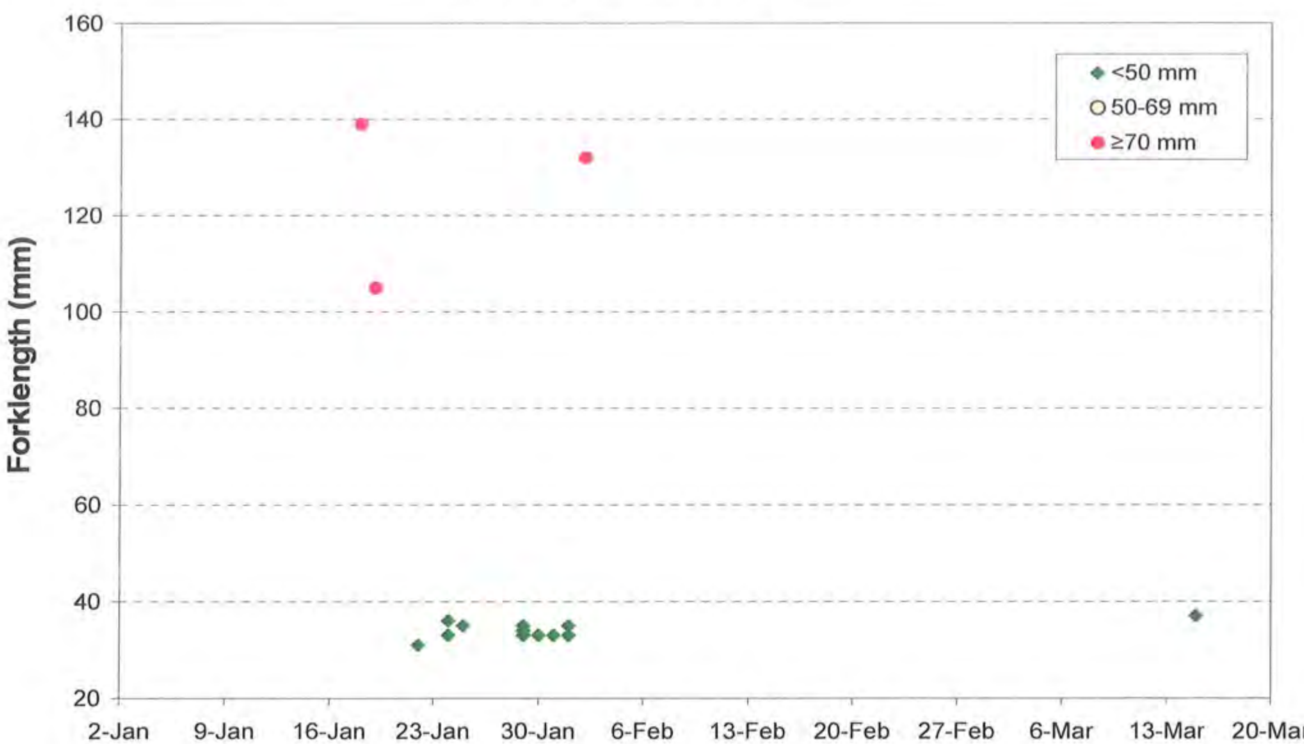

2009/2010 Chinook Passage and Tuolumne River Flow
(Monitoring began Sep 22; 280 salmon through mid-Jan)
Daily Passage
River Flow (cfs)
25
20
15
10
5
0
1,500
1,200
900
600
300
0
2-Sep
16-Sep
30-Sep
14-Oct
28-Oct
11-Nov
25-Nov
9-Dec
23-Dec
6-Jan
20-Jan
3-Feb
17-Feb
2-Mar
16-Mar
Salmon
La Grange flow
Modesto flow


2009/2010 Chinook Passage and Stanislaus River Flow
(Monitoring began Sep 9; 1250 salmon through mid-Jan)
Daily Passage
River Flow (cfs)
80
70
60
50
40
30
20
10
0
1,600
1,400
1,200
1,000
800
600
400
200
0
2-Sep
16-Sep
30-Sep
14-Oct
28-Oct
11-Nov
25-Nov
9-Dec
23-Dec
6-Jan
20-Jan
3-Feb
17-Feb
2-Mar
16-Mar
Salmon
Goodwin Dam
Ripon

2010 Waterford screw trap salmon

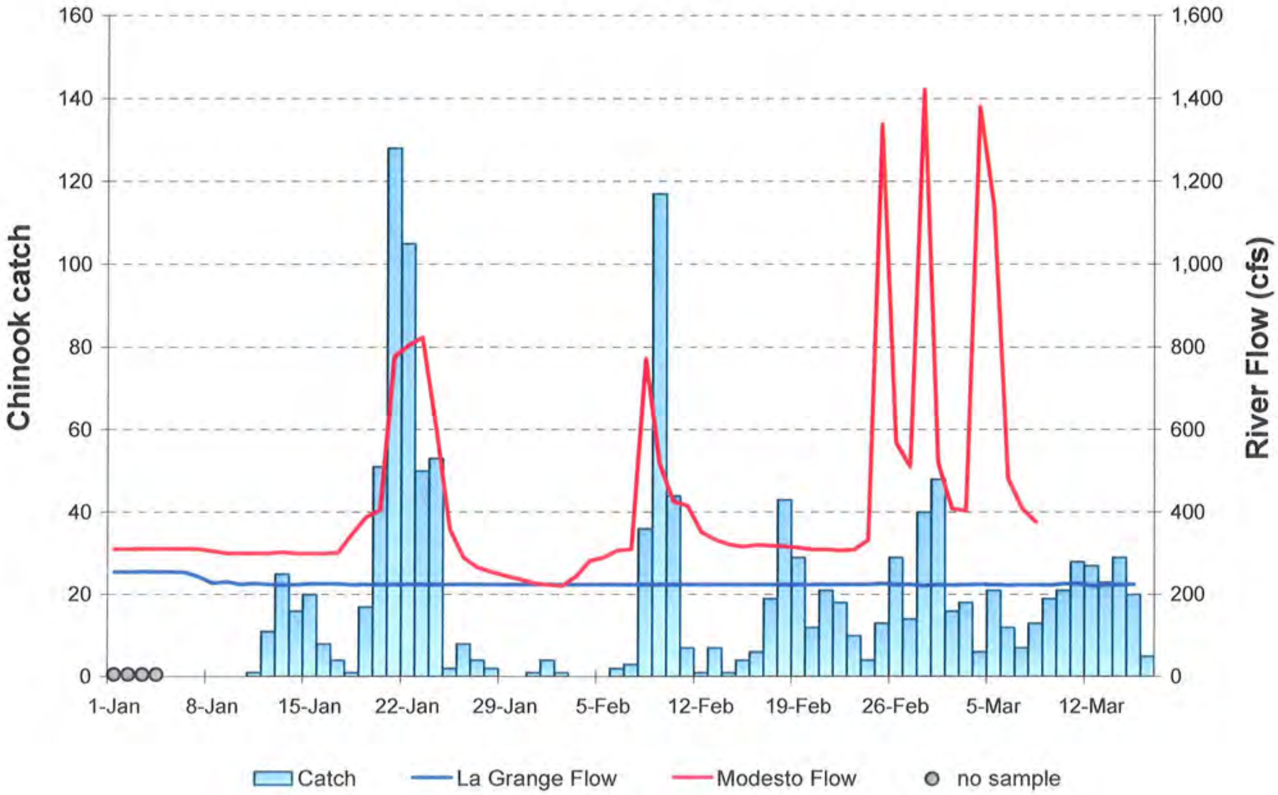


2010 Grayson screw trap salmon

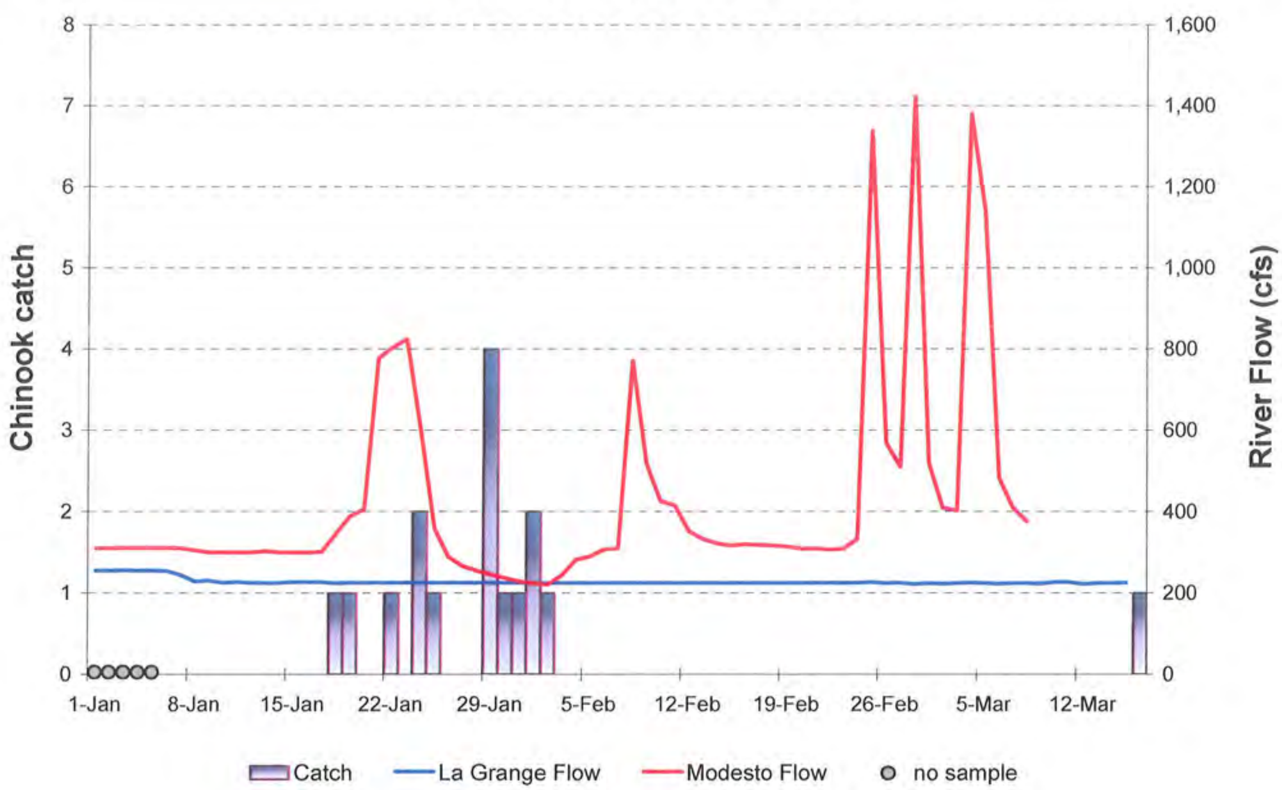


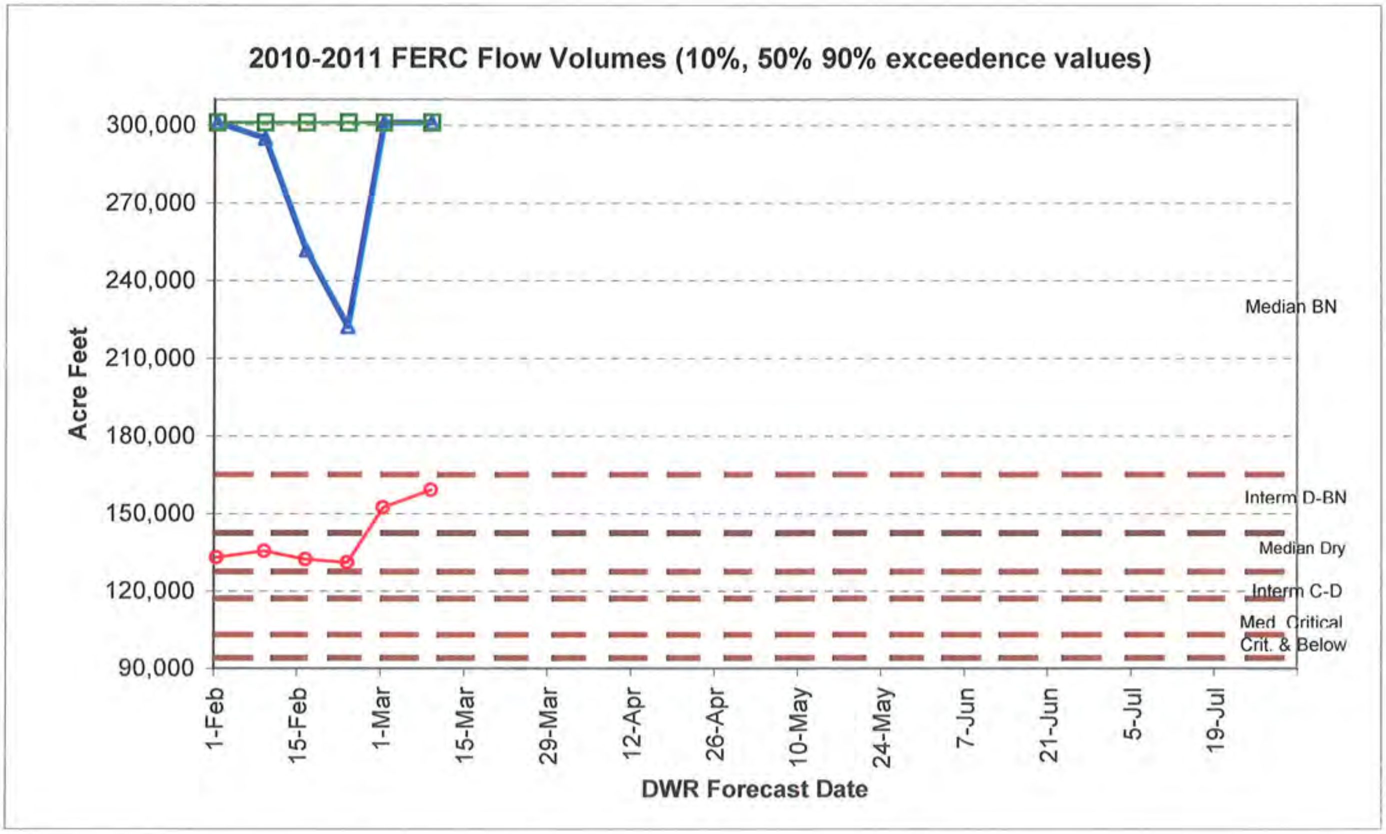
DRAFT

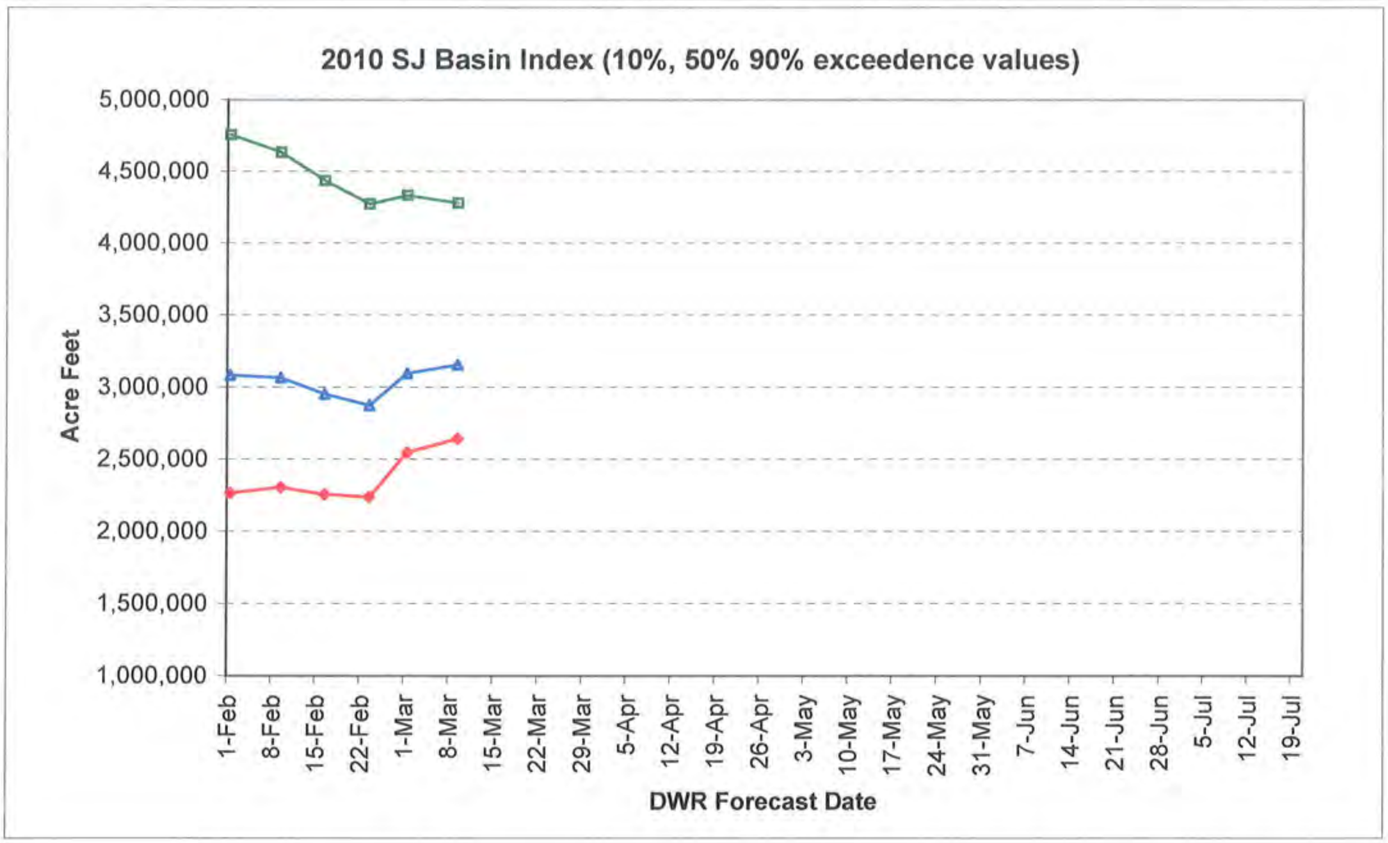
2010 Waterford screw trap salmon



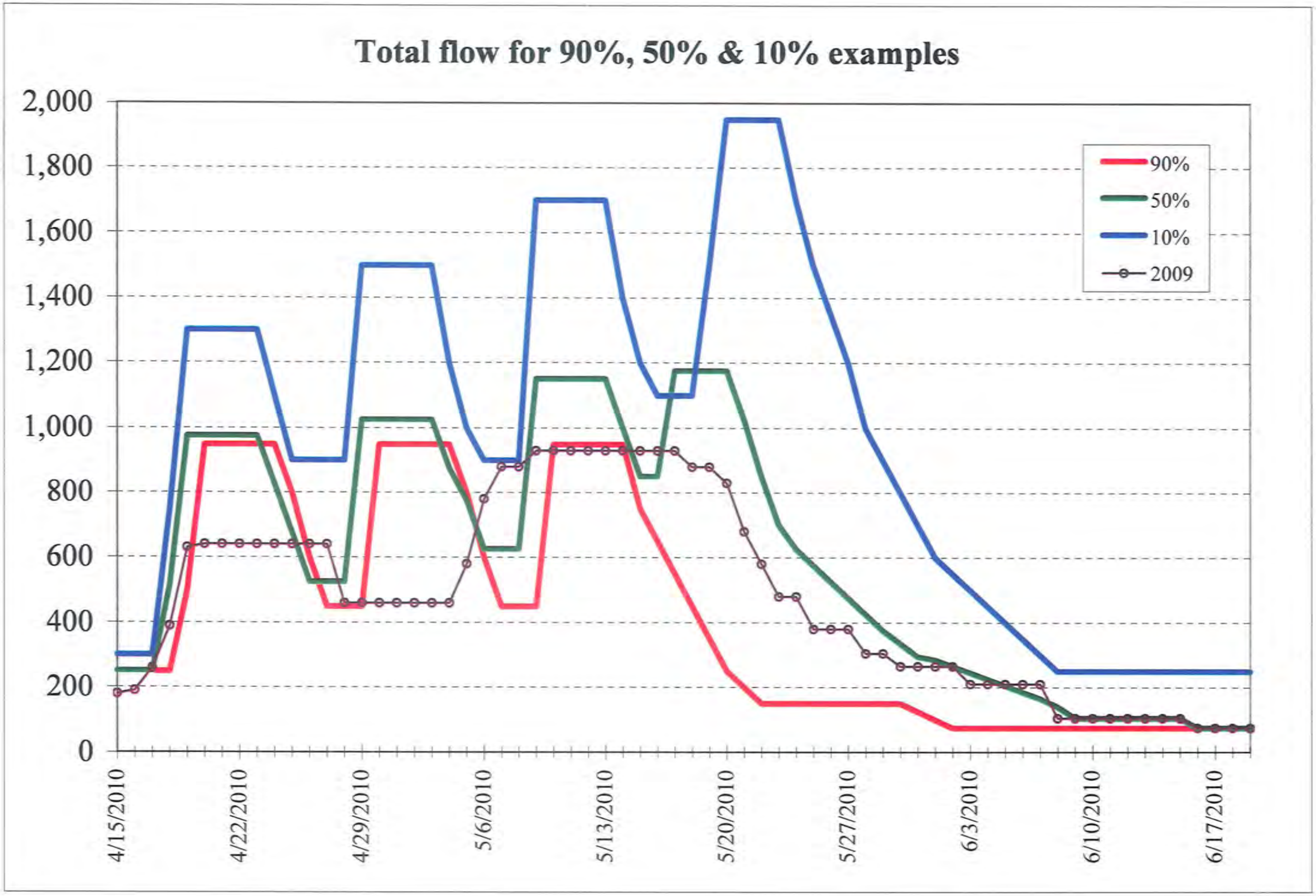
2010 Grayson screw trap salmon




2010-2011 FERC Flow Volumes (10%, 50% 90% exceedence values)
Acre Feet
300,000
270,000
240,000
210,000
180,000
150,000
120,000
90,000
Median BN
Interm D-BN
Median Dry
Interm C-D
Med. Critical
Crit. & Below
1-Feb
15-Feb
1-Mar
15-Mar
29-Mar
12-Apr
26-Apr
10-May
24-May
7-Jun
21-Jun
5-Jul
19-Jul
DWR Forecast Date


2010 SJ Basin Index (10%, 50% 90% exceedence values)
Acre Feet
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
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
5-Jul
12-Jul
19-Jul
DWR Forecast Date

DRAFT


Total flow for 90%, 50% & 10% examples
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
90%
50%
10%
2009
4/15/2010
4/22/2010
4/29/2010
5/6/2010
5/13/2010
5/20/2010
5/27/2010
6/3/2010
6/10/2010
6/17/2010

Paddle-a-thon

Paddle. Donate. Participate

Register:

Via phone: 1-888-994-3344
Via web: www.tuolumne.org
Via email: paddle@tuolumne.org

Fees:

$10 Tuolumne River Trust Member
$25 Non-member

Fundraising goals and rewards:

$50 Minimum ~ Prizes tba

Schedule:

		Miles
May 7-9	Meral's Pool	18
May 10-14	Don Pedro	26
May 15	La Grange	8.5
May 16	Waterford	10.5
May 17	Fox Grove	6
May 21	Ceres	7
May 22	Modesto	3
May 23	Riverdale	5
May 24	Big Bend	6
May 25	Highway 132	10
May 26	Stanislaus River	6
May 27	Durham Ferry	4
June 1	Mossdale	13.5
June 2	Lathrop	5
June 3	Stockton	12.5
June 4	Delta Cruise	90
June 5	San Francisco Bay	7
June 5	San Francisco Waterfront	3

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Mountain Sage
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Patagonia

Tuolumne River Trust

The voice for the river

www.tuolumne.org

twitter

To become a sponsor please contact:
Karlha Arias
209.236.0330
karlha@tuolumne.org

Paddle To The Sea

May 7-June 5
2010

Paddle to support
the Tuolumne River Trust

www.tuolumne.org

Who is the Tuolumne River Trust?

The Tuolumne River Trust is the voice for the river. We believe that by inspiring grassroots community support, we can protect our river for future generations and restore this precious ecosystem for fish and wildlife.

Since 1981, we have worked to protect this vital natural resource for our communities.

Today, with offices in Sonora, Modesto and San Francisco, our programs seek to build vibrant communities centered around the river through education, advocacy, restoration and recreation.

"Boundaries don't protect rivers, people do."

-Aristotle

What is Paddle to the Sea?

Paddle to the Sea is a paddle-a-thon from Yosemite through the Central Valley to the San Francisco Bay that raises money and awareness to protect the Tuolumne River. All of the proceeds will go directly to support the Tuolumne River Trust's work to:

Save the salmon
Connect schools to the river
Promote water conservation

Register to paddle for one day or the entire journey, sponsor a paddler or attend one of our river parties along the way!

Family Fun

Don't paddle? Join us at a party!

May 8
Kick Off Concert
Mountain Sage Nursery

May 14
Campout Weekend
Turlock State Rec. Area

May 16
Waterford Paddle Party
River Walk Park

May 22
Green on the Stream
Tuolumne River Regional Park

June 5
Aquarium of the Bay Finale Celebration
San Francisco

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TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

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Email: tjford@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

June 10, 2010 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 2010 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - May FERC Orders on studies
   - Review spring monitoring
   - Planned studies for rest of 2010

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 9, DECEMBER 9

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

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TECHNICAL ADVISORY COMMITTEE MEETING

June 10, 2010 at 9:30 AM

Turlock Irrigation District, Room 152 (1st floor)

Summary

1. INTRODUCTION AND ANNOUNCEMENTS
   - No fishery agencies were present.

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda – no changes
   - Review notes from March meeting – no changes were identified
   - Items since last meeting – the handout listing the material posted at http://tuolumnerivertac.com/ was reviewed. Those included the annual report to FERC, 2009 spawning survey update, 2009 counting weir report, FERC Orders partially approving O. mykiss synthesis report and study plans for IFIM and water temperature, flow schedule and study planning letters to fishery agencies (6/28 reply deadline for comments on updated study schedules).

3. MONITORING/REPORTS: Handouts were reviewed
   - May FERC Orders on planned studies: Ward asked for details on FERC Order requirements. For the May 10, 2010 Order: 1) Population estimates will continue to be conducted in July of each yr., with reference count surveys in June, September, and Feb/Mar (or as modified due to high flows), depending on accessibility due to flow conditions. 2) Tracking study to continue, 3) Annual *O. mykiss* reports by mid-January the next two years with a summary 2005–2012 fisheries report due by July 1, 2013. For the May 12, 2010 Order: 1) FERC delay resulted in a one year slippage in IFIM data collection, 2) Planned Agency Consultation in August/September, 3) possible Fall Pulse Flow test in October, but most of study expected next year, 4) Water temperature modeling to proceed this year
   - Counting Weir: No longer in operation (upper flow limit was found to be 1,300 cfs). Final 2009 estimate through mid-January was 300 Chinook salmon spawners with 280 counted passing the weir and another estimated 20 downstream of the weir. CDFG carcass survey estimate was 124.
   - Screw Trapping: Handouts on catch and size at Waterford and Grayson screw trap sites were reviewed. Catches were characteristically low at Grayson relative to Waterford and mainly only smolts in May; peak catches were associated with turbid conditions in January and March as well as high flows occurring in May as variable spring pulse flows. Some larger salmon from 70-130 mm were also caught in Jan-Feb.
   - Seining size and catch data was reviewed. Peak fry densities occurred in Feb/Mar

with lower densities near the end of the season.

- *O. mykiss* pop. estimate: Stillwater completed their March survey, with a preliminary report including both the March and July surveys to be completed later this year. If flow conditions allow, an August 2010 survey will be conducted.
- *O. mykiss* tracking study: Six larger fish have been tagged which have been recorded using the mobile hydrophone within 10 river miles of La Grange Dam.

4. FLOW OPERATIONS:
   - The SJ Basin Index forecast range resulted in a corresponding FERC flow volume requirement of 300,923 AF.
   - Don Pedro Reservoir is within 5 ft of capacity and river operations include expected high flows of 2,000–3,000 cfs into July. Discussion of timing a possible 1,300 cfs maximum Fall pulse flow and fall spawning flows of 300 cfs.
   - Basin flows and delta CVP/SWP exports graphs were reviewed. Vernalis flows during VAMP were mostly 4,000-6,000 cfs, but exports, which were reduced earlier than before on April 1, increased sharply in late May from 1,500 cfs to 7,000 cfs.

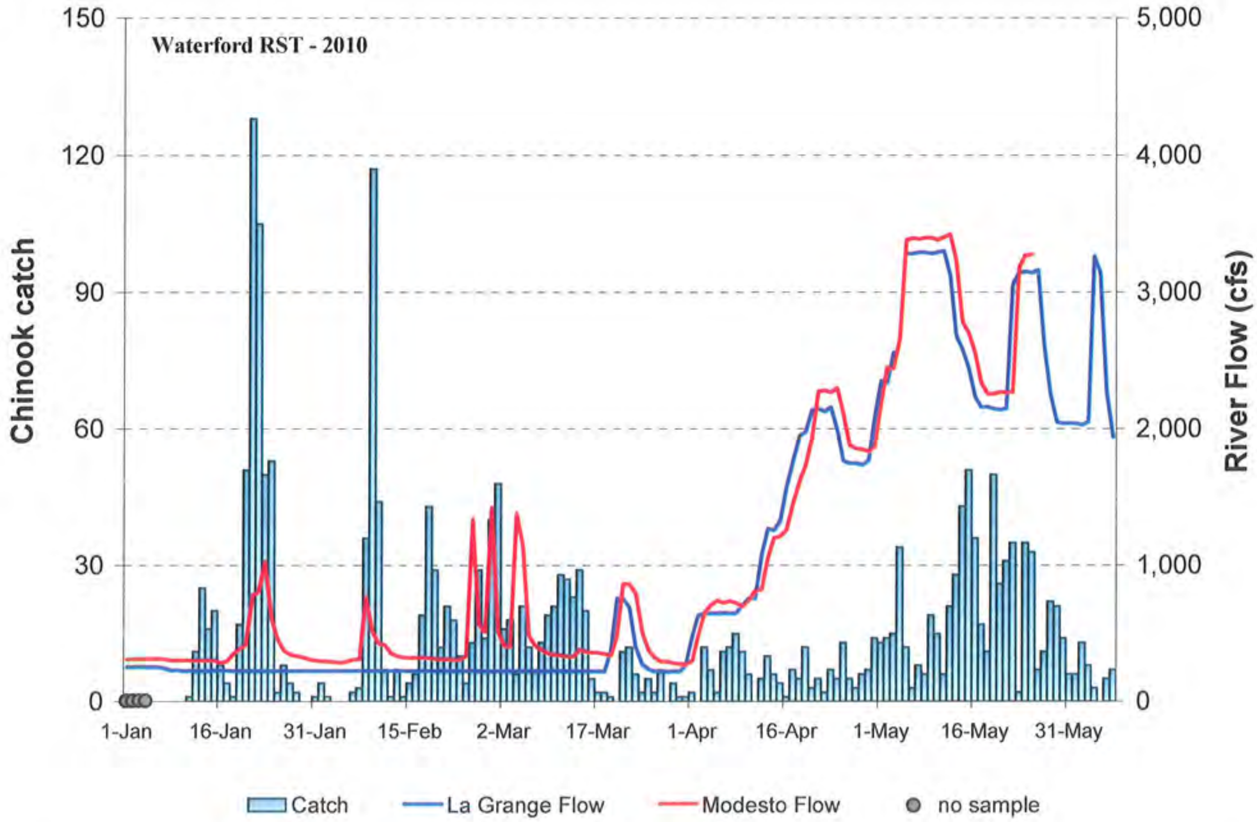
5. AGENCY/NGO UPDATES
   - None

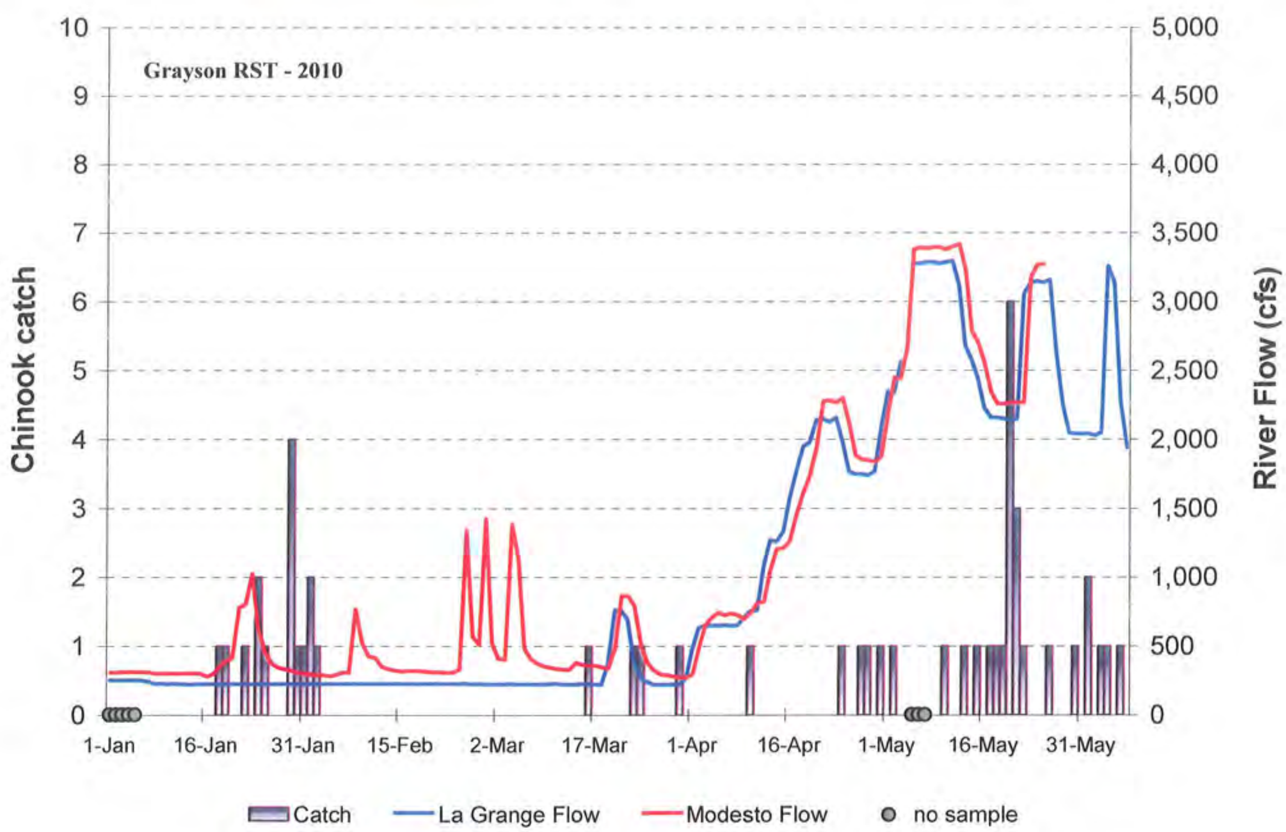
6. ADDITIONAL ITEMS
   - None

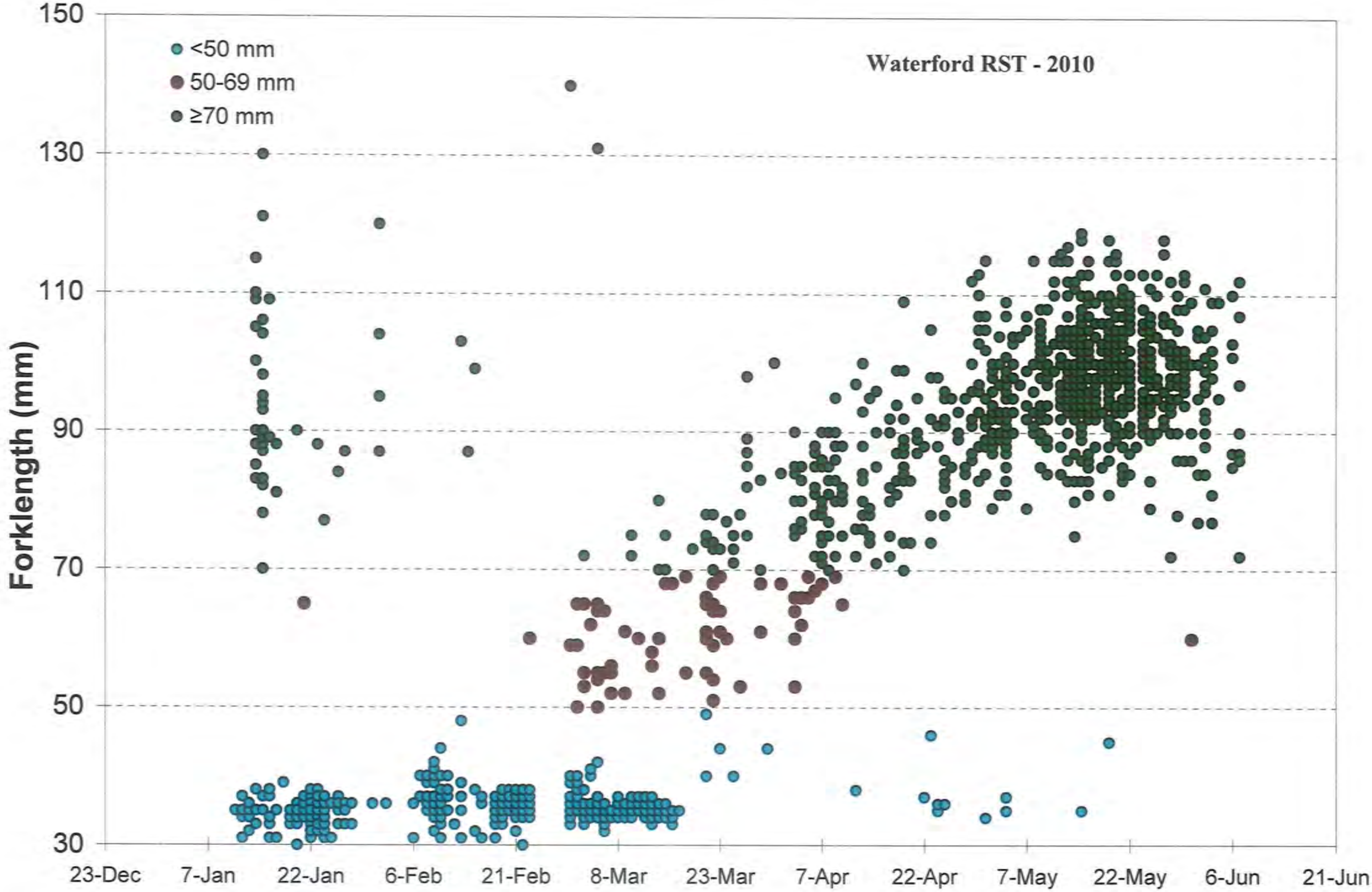
7. NEXT MTG DATES – QUARTERLY ON 2ND THURSDAY: SEPTEMBER 9, DECEMBER 9

TRTAC Meeting Attendees

	Name	**Organization**
1.	Tim Ford	TID/MID
2.	Robert Nees	TID
3.	Roger Masuda	TID
4.	Walter Ward	MID
5.	Noah Hume	Stillwater Sciences
6.	Scott Wilcox	Stillwater Sciences

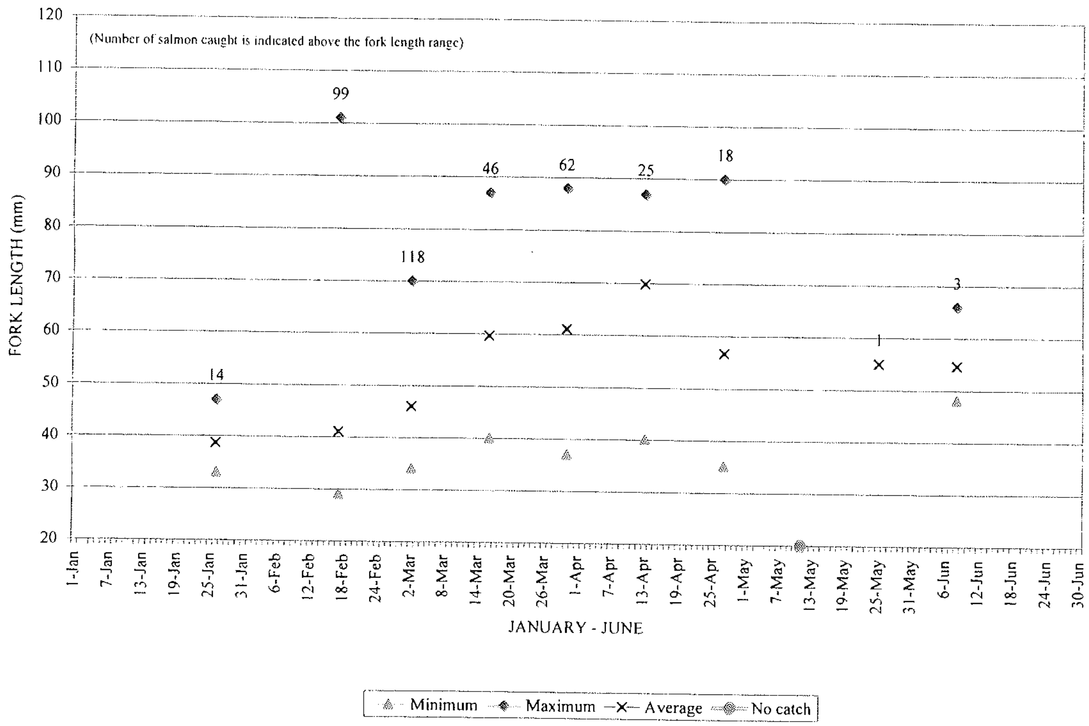

Waterford RST - 2010
Chinook catch
River Flow (cfs)
150
120
90
60
30
0
5,000
4,000
3,000
2,000
1,000
0
1-Jan
16-Jan
31-Jan
15-Feb
2-Mar
17-Mar
1-Apr
16-Apr
1-May
16-May
31-May
Catch
La Grange Flow
Modesto Flow
no sample


Grayson RST - 2010
Chinook catch
River Flow (cfs)
10
9
8
7
6
5
4
3
2
1
0
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1-Jan
16-Jan
31-Jan
15-Feb
2-Mar
17-Mar
1-Apr
16-Apr
1-May
16-May
31-May
Catch
La Grange Flow
Modesto Flow
no sample

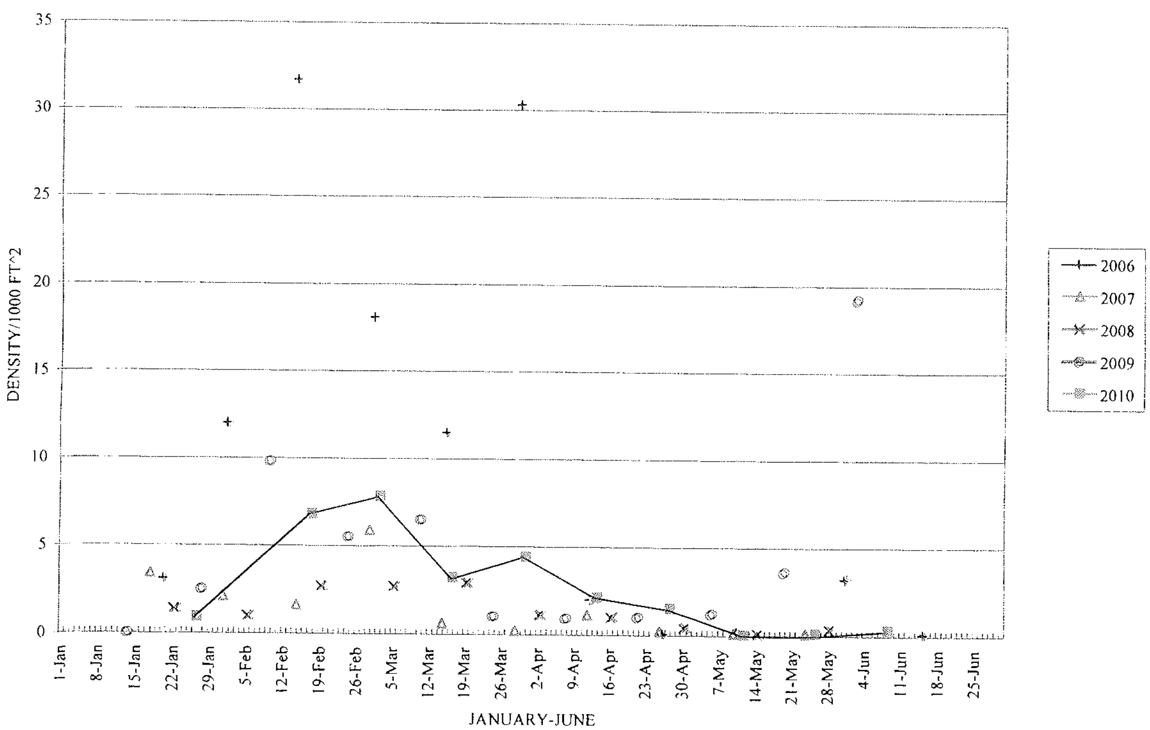


<50 mm
50-69 mm
≥70 mm
Waterford RST - 2010
Forklength (mm)
150
130
110
90
70
50
30
23-Dec
7-Jan
22-Jan
6-Feb
21-Feb
8-Mar
23-Mar
7-Apr
22-Apr
7-May
22-May
6-Jun
21-Jun

2010 TUOLUMNE RIVER JUVENILE SALMON SEINING STUDY



2006-2010 TUOLUMNE RIVER SEINING
COMBINED FRY AND JUVENILE SALMON DENSITY INDEX



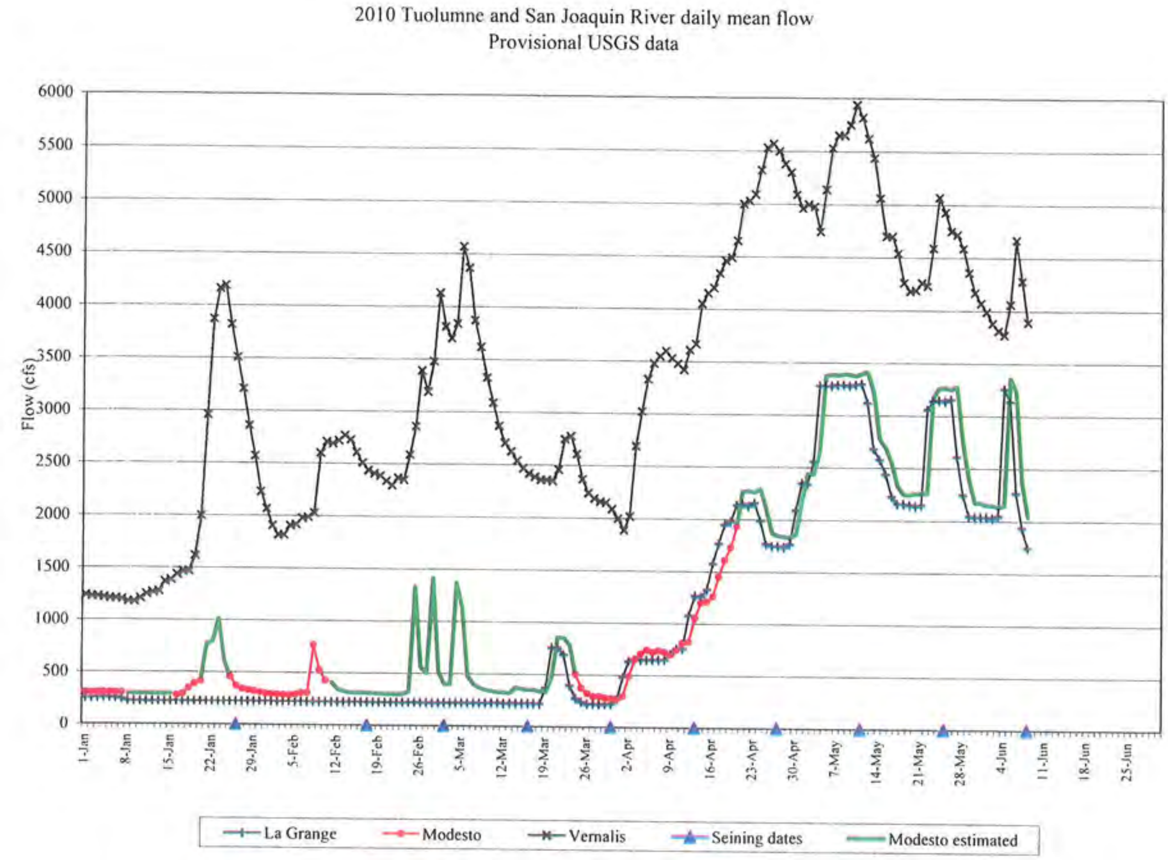
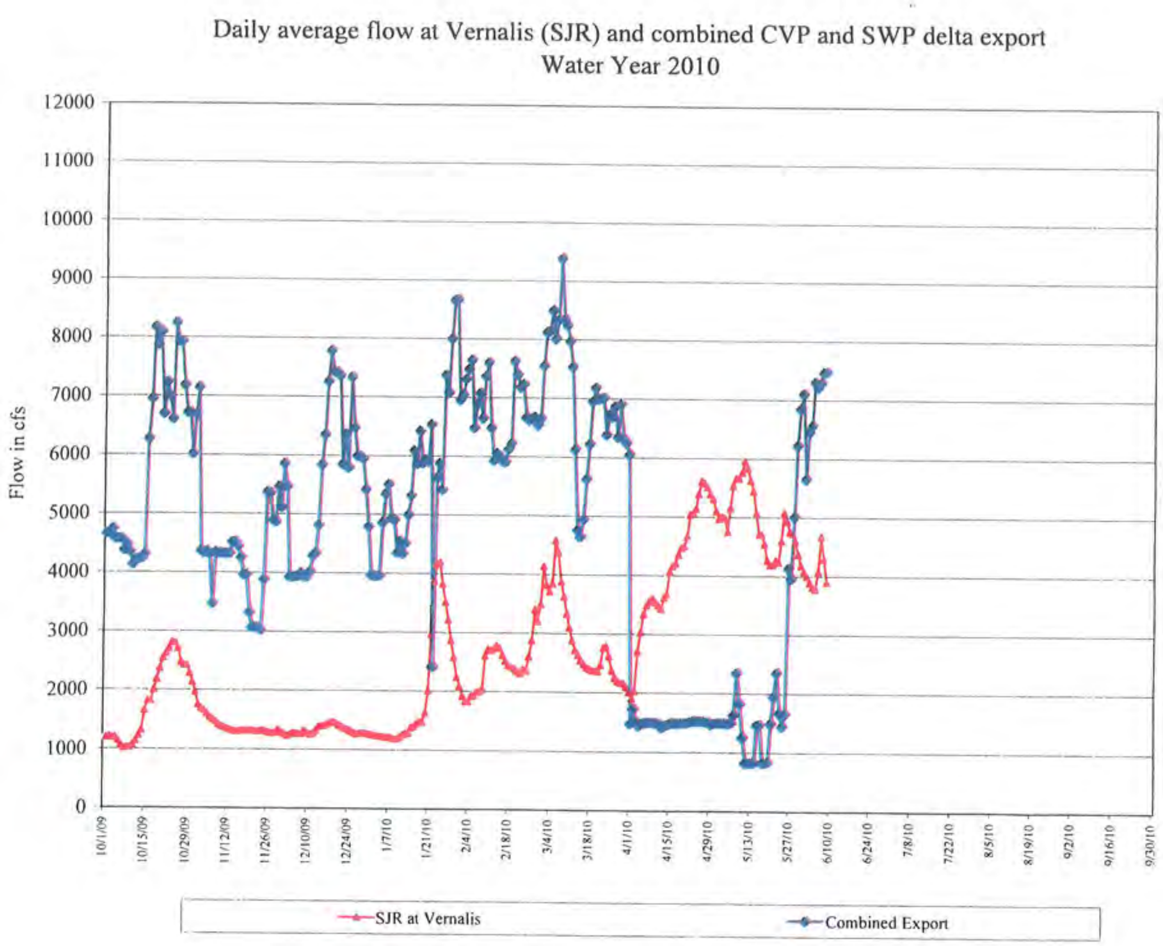


Figure 2. 2009 Tuolumne and San Joaquin River flows.



2010 TRTAC Materials/Postings to Website

2009Dec11-2010Mar18 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2009 TRTAC meeting summary and handouts
  - March 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to FERC re: submittal of the O. mykiss monitoring report dated January 15, 2010.
  - CDFG letter to TID re: comments to O. mykiss monitoring report dated January 5, 2010
  - NMFS letter to FERC re: request for extension to provide comments to O. mykiss monitoring report dated December xx, 2009 (filed Dec24)

- Documents
  - 2009 Aquatic Invertebrate Monitoring and Summary Update
  - 2009 Review of Summer Flow Operations
  - 2009 Rotary Screw Trap Report
  - January 2010 Final Tuolumne River O. mykiss Monitoring Report
  - January 20, 2010 - The Districts' Answer to the Statement of the Resource Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
  - January 5, 2010 - Statement of the Resources Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
  - TID and MID report on O. mykiss pursuant to ordering paragraph (C)(5) of the April 3, 2008 FERC Order

- Data/Monitoring
  - 2010 seine data
  - Updates of basin monitoring newsletter (includes 2010 RST monitoring)
  - 2009-10 Counting weir data

2010Mar19-2010Jun10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2010 TRTAC meeting summary and handouts
  - June 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to fishery agencies re: flow schedule for 2009-2010 and 2010-2011 dated March 25, 2010.
  - Districts' letter to fishery agencies re: final flow schedule for 2009-2010 dated April 2, 2010.
  - Districts' letter to fishery agencies re: minimum flow schedule for 2010-2011 dated April 22, 2010.

- Order modifying and approving in part Tuolumne River O. mykiss 10-year monitoring report dated May 10, 2010.
- Order modifying and approving instream flow and water temperature model study plans dated May 12, 2010.
- Districts' letter to fishery representatives re: instream flow and water temperature study plans schedule dated May 28, 2010

- Documents
  - 2009 Annual Article 58 Report to FERC
  - 2009 Spawning Survey Update
  - 2009 Tuolumne River Weir Report

- Data/Monitoring
  - Update of 2010 seine data
  - Update of 2010 Counting weir data
  - Update of thermograph data
  - Basin monitoring newsletter (includes 2010 screw trap monitoring)

2010Jun11-2010Sep9 Changes to TRTAC website http://tuolumnerivertac.com/

- Updated flow schedule and participant list (July)

- Meetings
  - June 2010 TRTAC meeting notes, handouts
  - Sep 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to FERC requesting revised schedules for instream flow and water temperature study and update on O. mykiss tracking study (June 30 2010)
  - FERC Order granting extension of the May 12, 2010 order modifying and approving instream flow and water temperature modeling study plans (July 21, 2010)
  - E-mail from Scott Wilcox to TRTAC Regarding Tuolumne River Instream Flow Study Planning Meeting dated August 15, 2010 (not posted)

- Documents
  - 2010 Draft Seine Report
  - Tuolumne River Floodplain Inundation Maps

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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

9 September 2010 at 9:30 AM

Turlock Irrigation District, Lunch Rm (2nd floor)

DRAFT AGENDA

1. INTRODUCTION AND ANNOUNCEMENTS

2. ADMINISTRATIVE ITEMS:
   - Review/revise agenda
   - Approve notes from June 2010 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - August reference count survey and population estimate surveys
   - Posted 2009 seine report
   - Discuss fall monitoring and in-progress FERC studies

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 9; MARCH 10, 2011

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) 883-8275
Fax: (209) 656-2180

TECHNICAL ADVISORY COMMITTEE MEETING

9 September 2010 at 9:30 AM

Turlock Irrigation District, Lunch Room (2nd floor)

Summary

1. Introduction and Announcements

2. Administrative Items:
   - Review/Revise agenda – No changes
   - Approve notes from June 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 correspondence regarding the schedules for the IFIM and Water temperature modeling studies included in the May 12, 2010 FERC Order, Draft 2010 Seine report, updated participant list, updates of the basin monitoring newsletter, as well as e-mail correspondences regarding consultation on the planned IFIM study.

3. Monitoring/Reports: Handouts were reviewed
   - August reference count and population estimate results: *O. mykiss* observed from approximately RM 52–39.5 with larger numbers of adult fish than found in the March 2010 surveys or in previous years. A report including both the March 2010 and July 2010 surveys will be done later this year.
   - Acoustic tracking Study: Six adult *O. mykiss* tagged in early 2010 have been tracked using mobile tracking hydrophones, generally remaining within pool habitats in the vicinity of Basso Bridge. 2010–2011 plans include tagging of approximately 20 individuals.
   - 2010 Seine report – located on TRTAC website for review.
   - Other Summer/Fall monitoring and other study plans: FishBio to resume counting weir operations by September 13, 2010.

4. Flow Operations:
   - Reviewed final SJ Basin Index of 3,547,699 AF which corresponds to an Above-Normal Water Year Type with a FERC Flow volume of 300,923 AF. Currently a 6-day pulse flow at 800 cfs is planned for October 1–6, 2010. This will be added to the 300 cfs base flow for a total of 800 cfs for the period. This default schedule will be followed unless the three Agencies come to agreement with the Districts on any recommended changes.
   - No summer operations related to temperature control were carried out in 2010 due to

high flows and cool air temperatures throughout the Central Valley.

5. AGENCY/NGO UPDATES
   - Tuolumne River Trust to hold annual river cleanup at Legion Park on September 11, 2010
   - CDFG expected to expand carcass survey extent downstream of counting weir at RM 24.5

6. ADDITIONAL ITEMS
   - None.

7. NEXT MTG DATES – QUARTERLY ON 2ND THURSDAY: DECEMBER 9, MARCH 10, 2011

TRTAC Meeting Attendees

	Name	Organization
1.	Jason Guignard	FishBio
2.	Andrea Fuller	FishBio
3.	Walter Ward	MID
4.	Robert Nees	TID
5.	Roger Masuda	TID
6.	Noah Hume	Stillwater

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- Documents
    - 2009 Annual Article 58 Report to FERC
    - 2009 Spawning Survey Update
    - 2009 Tuolumne River Weir Report

- Data/Monitoring
    - Update of 2010 seine data
    - Update of 2010 Counting weir data
    - Update of thermograph data
    - Basin monitoring newsletter (includes 2010 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) 883-8275
Fax: (209) 656-2180
Email: tjford@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

9 December 2010 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 2010 meeting
   - Items since last meeting

3. MONITORING/REPORTS:
   - Fall run information – weir; river surveys
   - Draft O. mykiss reports posted
   - Draft Water Temperature Modeling report
   - Other technical reports for 2010 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 10, 2011

TUOLUMNE RIVER TECHNICAL ADVISORY COMMITTEE

DON PEDRO PROJECT - FERC LICENSE 2299

MODESTO IRRIGATION DISTRICT
TURLOCK IRRIGATION DISTRICT
CITY & COUNTY OF SAN FRANCISCO
CALIFORNIA DEPARTMENT OF FISH & GAME
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Turlock, CA 95381-0949
Phone: (209) 883-8214
Fax: (209) 656-2180
Email: rmnees@tid.org

TECHNICAL ADVISORY COMMITTEE MEETING

9 December 2010 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 upcoming relicensing for the Don Pedro Project. Relicensing will follow the integrated relicensing process (ILP) with the notice of intent (NOI) and preliminary application document (PAD) expected to be filed with FERC in February 2011. A webpage has been established to help interested parties keep abreast of relicensing activities and information. The webpage is at: http://www.donpedro-relicensing.com/default.htm. It can also be found by searching for "Don Pedro Relicensing" on the internet.

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 and IFIM workgroup, correspondences regarding Agency review of the 2010 *O. mykiss* monitoring and water temperature modeling reports, and 2-D site-selection rationale memorandum. In addition, FERC Progress Reports on the Water Temperature Modeling Study and IFIM studies were posted at the FERC e-Library. Documents include the 2010 *O. mykiss* monitoring report, the 2010 snorkel survey report, report on the March and August 2010 *O. mykiss* population size estimates in the lower Tuolumne River, Draft water temperature modeling study report, and IFIM study meso-habitat maps.

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

- Data posted on the TAC website included updated 2010 thermograph data through September 27, 2010 as well as fall 2010 counting weir data.
- Preliminary run estimates and fish passage on the Tuolumne and Stanislaus River counting weirs were reviewed. Due to high flows resulting from early season runoff, spawner surveys and counting weir operations were halted the week November 30th with a cumulative season total of 766 as of that date. Flows at Modesto were on the order of 3,000 cfs as of December 9th and since flows <500 cfs are needed for re-installation of the weir an unknown number of additional fish may move upstream

without detection. 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.

- Alison and Dave Boucher (TRC) requested continuation of counting operations during spring pulse flows to detect upstream passage of any steelhead arriving in the lower river, subject to the flow limitations of the weir (~1,300 cfs).
- Results of the 2010 *O. mykiss* population estimate and monitoring summary reports were discussed, including observations of larger fish that may have arrived from upstream. Clarification of flow pathways and durations of bypassed flows will be included in the Final versions of both reports.
- Technical Reports for 2009 FERC Report were distributed as a draft Table of Contents, with a number of reports available on the TRTAC website (seine, snorkel, RST, March/July 2010 Population estimate, and Tracking Study Yr 1 report). Dave Boucher suggested that tracking between June and August would likely represent only resident fish and that location of spawning redds would be extraordinarily difficult as part of this study.
- Alison Boucher and Jesse Roseman (TRT) asked for details regarding the site selection of the 2-D high flow study. Noah Hume (Stillwater) described the site review process and that the Bobcat Flat (RM 43) site was removed from consideration due to planned construction changes in the site topography in 2011. In addition Big Bend (RM 6) and Grayson River Ranch sites (RM 5.5) were removed due to inability to ensure sufficient San Joaquin River flows during Tuolumne River high flow events to provide a hydraulic control and floodplain inundation (backwater effect). Jesse asked questions regarding Tuolumne Flow limitations during flood control releases. Noah will provide Jesse San Joaquin River flow estimates for dates that Big Bend site was found to flood during 2005–2006 monitoring period. Dave described the genesis of the site drainage channels at Grayson and agreed to provide location of portions of the site that may flood at 3,000 cfs.
- Other winter monitoring plans: Winter seining surveys, 2-D site surveys, IFIM surveys, and March 2011 snorkel surveys are in preparation.

4. FLOW OPERATIONS:

- Recent flow operations required to maintain flood control storage in Don Pedro Reservoir were discussed. The operational goals during the December/January egg incubation period are to minimize redd scour and rapid dewatering of any redds established during high flows. Current Tuolumne River flows are approximately 3,000 cfs to the lower river, with additional flows of approximately 800 cfs being diverted through the TID canal system and released at the Hickman and Faith Home spills. The MID canal is currently out of service for winter maintenance.

5. AGENCY/NGO UPDATES

- Tuolumne River Trust: Jesse Roseman summarized TRT activities, including the 2010 Paddle to the Sea fund-raising event, Dos Rios land acquisition, and Dennett Dam draft removal report preparation progress.
- Tuolumne River Coalition: Dave Boucher summarized TRC activities including the site construction plans scheduled at Bobcat Flat (RM 43) during summer 2011. Plans

include floodplain lowering to provide inundation at 3,000 cfs, repair/removal of side channels, construction of point bar complexes, and gravel augmentation. Dave requested that if either IFIM transect surveys or habitat suitability surveys were to result in flows near 100 cfs, the TRC would like to have advance notice to allow coordination of in-channel work activities at Bobcat Flat.

6. ADDITIONAL ITEMS

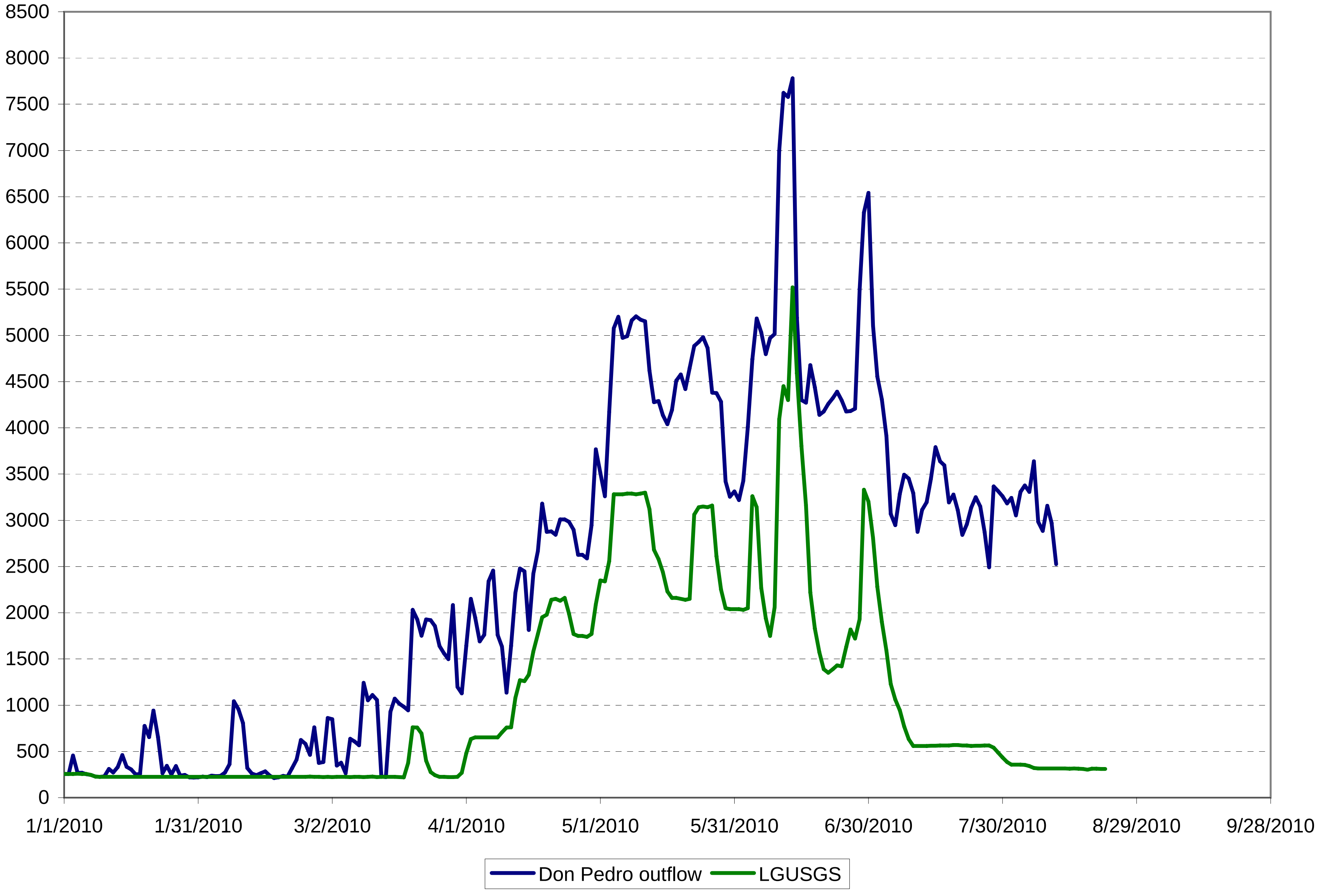
- None

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

- 2011 meeting dates: March 10th, June 9th, September 8th, and December 8th

<u>TRTAC Meeting Attendees</u>

	Name	Organization
1.	Walter Ward	MID
2.	Debbie Liebersbach	TID
3.	Dave Boucher	Tuolumne River Coalition (TRC)
4.	Alison Boucher	TRC
5.	Jesse Roseman	Tuolumne River Trust (TRT)
6.	Noah Hume	Stillwater
7.	Roger Masuda	TID



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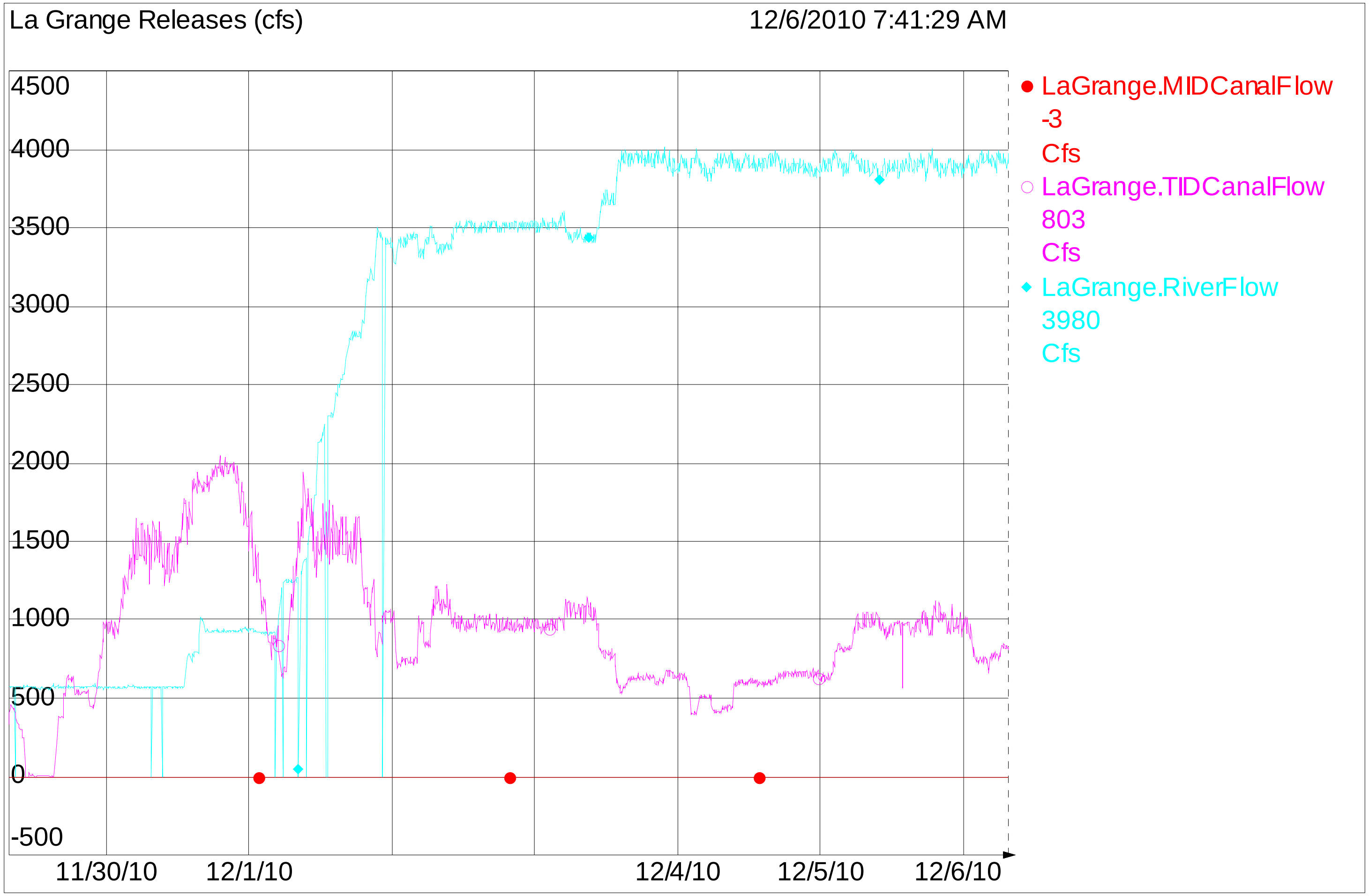
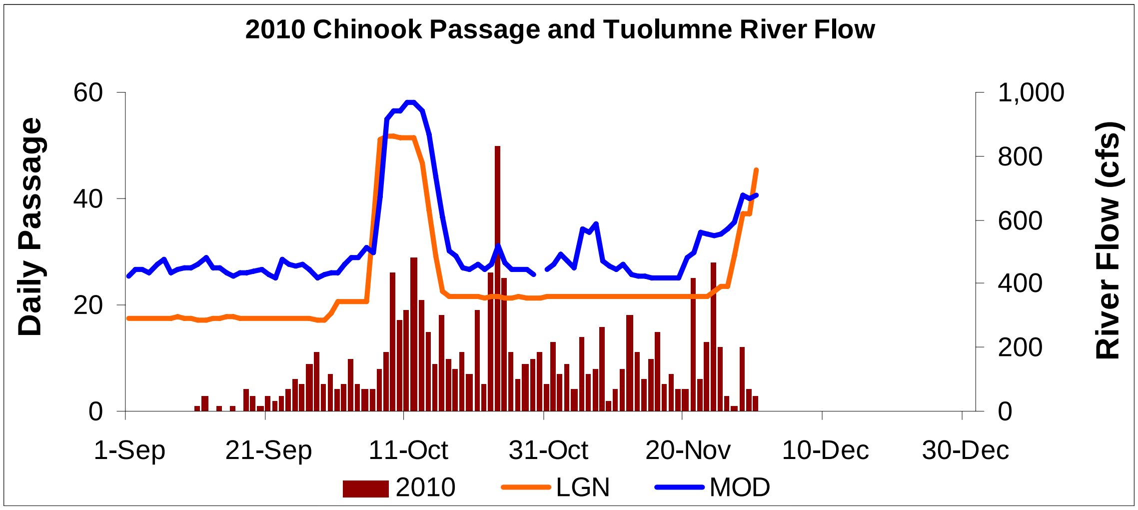
1/31/2010
3/2/2010
4/1/2010
5/1/2010
5/31/2010
6/30/2010
7/30/2010
8/29/2010
9/28/2010
Don Pedro outflow
LGUSGS

La Grange Releases (cfs)

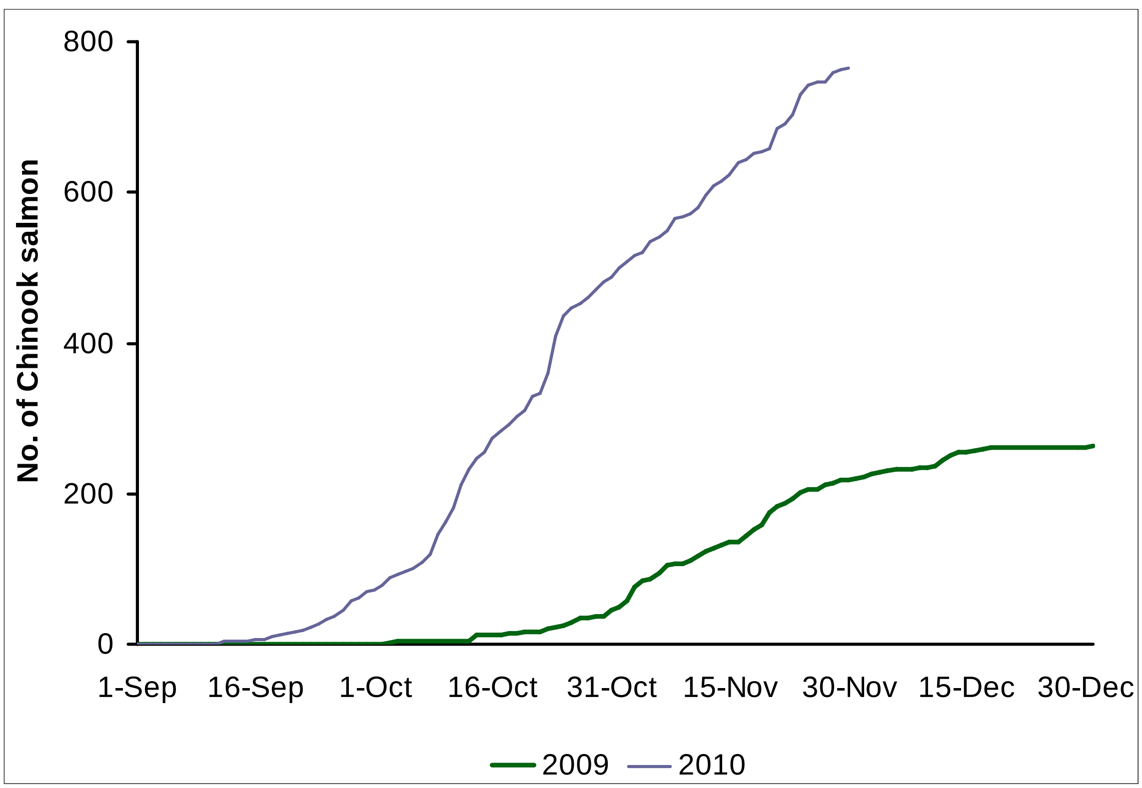


PRELIMINARY RESULTS



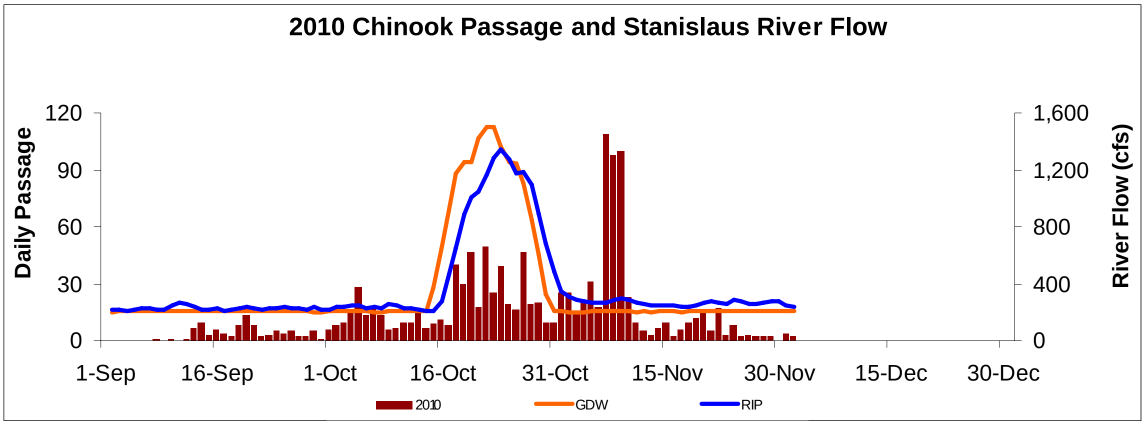
2010 Lower Tuolumne River Chinook Passage

PRELIMINARY RESULTS



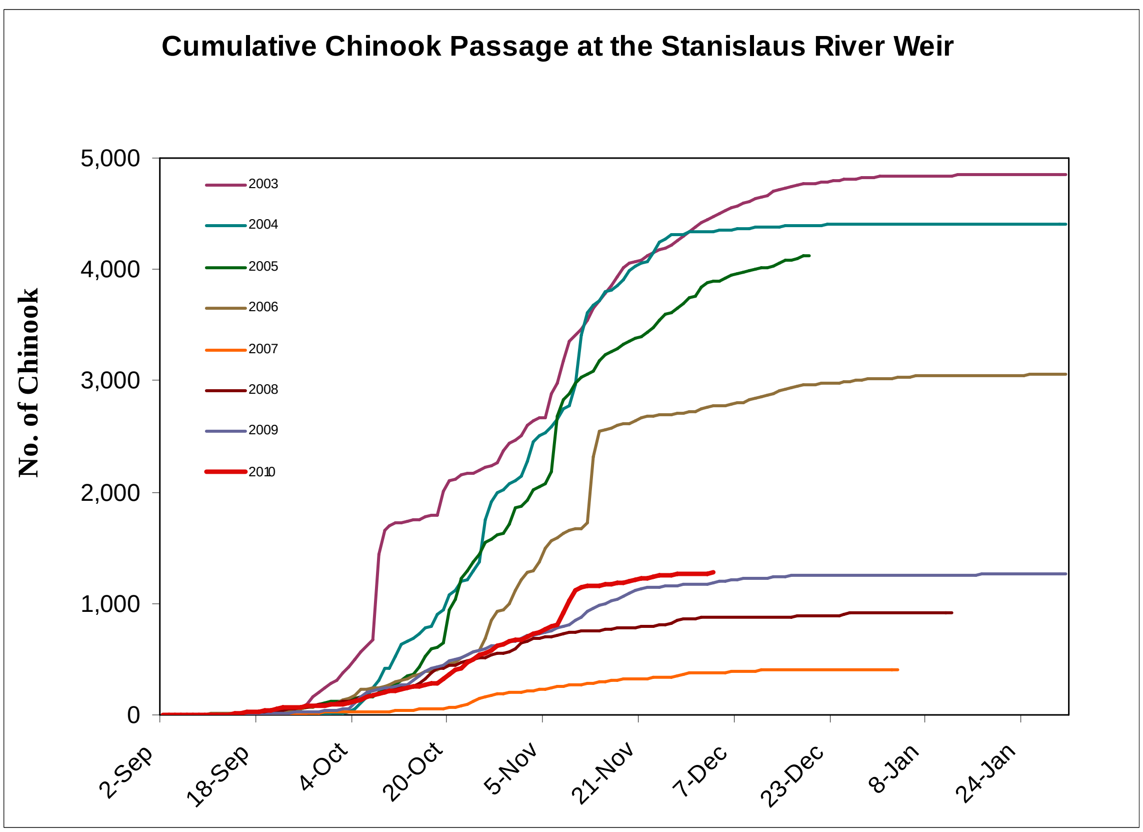
2009-2010 Lower Tuolumne River Chinook Passage

PRELIMINARY RESULTS



2010 Stanislaus River Chinook Passage

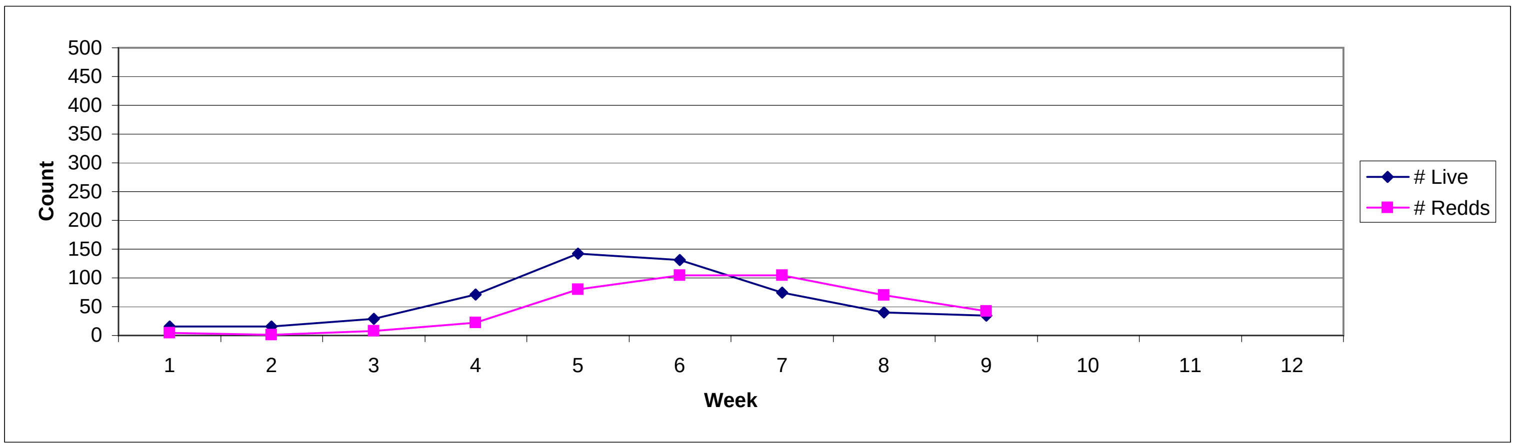
PRELIMINARY RESULTS



2003-2010 Stanislaus River Chinook Passage

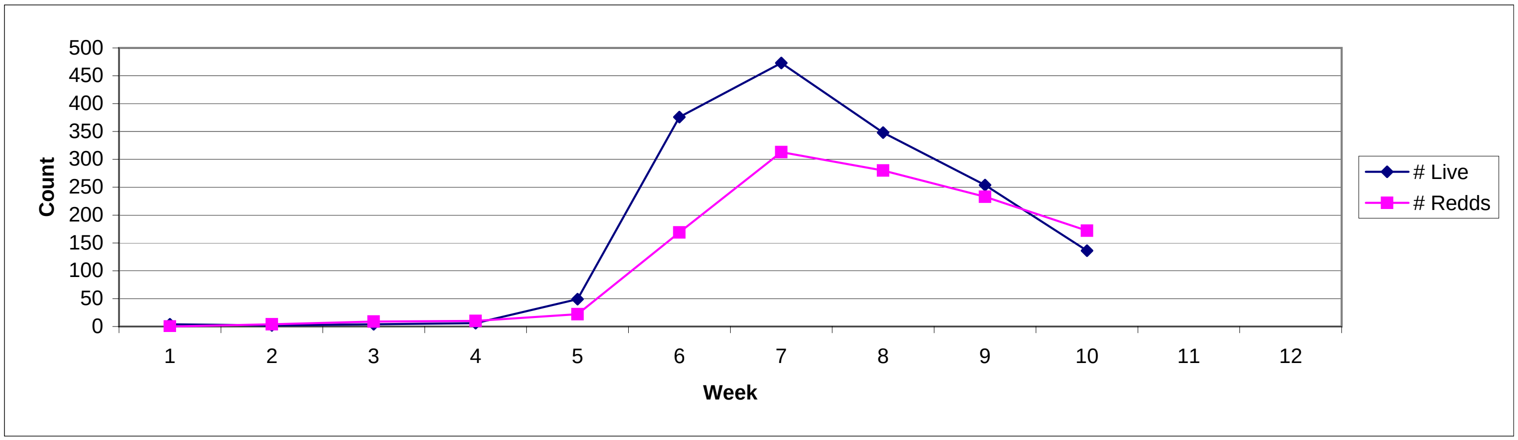
Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)	Comments
1	4-Oct-2010	16	4	2	1	0	1	0	595	
2	11-Oct-2010	16	1	2	2	2	2	0	751	
3	18-Oct-2010	29	8	2	2	2	2	0	358	
4	25-Oct-2010	71	22	3	3	1	3	1	357	
5	1-Nov-2010	142	80	6	12	1	12	3	N/A	
6	8-Nov-2010	131	104	9	10	7	10	4	N/A	
7	15-Nov-2010	75	105	15	35	11	35	7	358.5	
8	22-Nov-2010	40	70	16	15	1	15	14	N/A	
9	29-Nov-2010	34	42	11	5	1	5	8	1146	River has low visiblity due to release o spillway downstream of Waterford
10	6-Dec-2010									
11	13-Dec-2010									
12	20-Dec-2010									



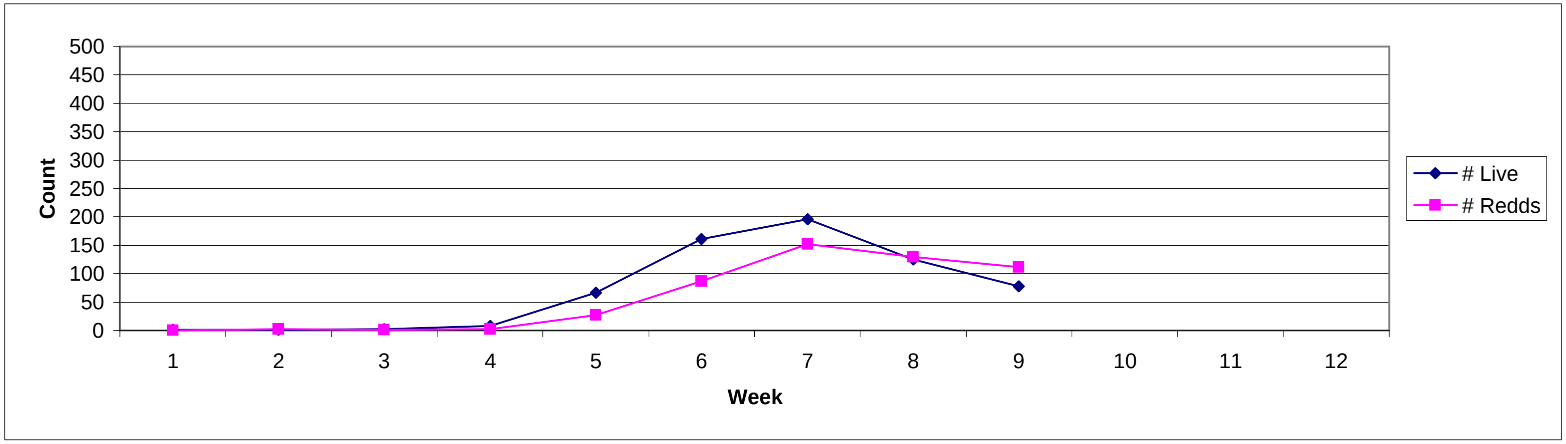
Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)	Comments
1	27-Sep-2010	4	0	0	0	0	0	0	182	
2	4-Oct-2010	2	4	0	0	0	0	0	193	
3	11-Oct-2010	4	9	0	0	0	0	0	200	
4	18-Oct-2010	6	10	0	0	0	0	0	1250	Section 1 (Goodwin caynon and two miles bar were not surveyed due to high flow
5	25-Oct-2010	49	22	3	0	0	0	0	1104	Section 1 (Goodwin caynon and two miles bar were not surveyed due to high flow
6	1-Nov-2010	376	169	4	12	1	11	0	212	
7	8-Nov-2010	473	313	8	30	4	30	2	206	
8	15-Nov-2010	348	280	12	32	8	32	10	202	
9	22-Nov-2010	254	233	12	33	9	33	7	218	
10	29-Nov-2010	136	172	14	36	11	36	10	208	
11	6-Dec-2010									
12	13-Dec-2010									
13	20-Dec-2010									



Preliminary Data

Week	Date	# Live	# Redds	# Skeletons	# Tagged	# AdClipped	# Scale Samples	# Recovered	Average Flow (cfs)	# Females spawned @ MRFF	Comments
1	4-Oct-2010	1	0	0	0	0	0	0	163		
2	11-Oct-2010	1	2	0	0	0	0	0	151		
3	18-Oct-2010	2	1	0	0	0	0	0	155		
4	25-Oct-2010	8	2	0	0	0	0	0	750		
5	1-Nov-2010	67	27	0	0	0	0	0	312	7	
6	8-Nov-2010	161	87	0	5	3	5	0	242.5	7	
7	15-Nov-2010	196	152	5	21	7	21	1	192	13	
8	22-Nov-2010	125	130	14	48	14	48	4	195	11	
9	29-Nov-2010	78	112	17	34	16	34	17	204	2	
10	6-Dec-2010										
11	13-Dec-2010										
12	20-Dec-2010										



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 TRTAC Materials/Postings to Website

2009Dec11-2010Mar18 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - December 2009 TRTAC meeting summary and handouts
  - March 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to FERC re: submittal of the O. mykiss monitoring report dated January 15, 2010.
  - CDFG letter to TID re: comments to O. mykiss monitoring report dated January 5, 2010
  - NMFS letter to FERC re: request for extension to provide comments to O. mykiss monitoring report dated December xx, 2009 (filed Dec24)

- Documents
  - 2009 Aquatic Invertebrate Monitoring and Summary Update
  - 2009 Review of Summer Flow Operations
  - 2009 Rotary Screw Trap Report
  - January 2010 Final Tuolumne River O. mykiss Monitoring Report
  - January 20, 2010 - The Districts' Answer to the Statement of the Resource Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
  - January 5, 2010 - Statement of the Resources Agencies and Conservation Groups on the November 20, 2009 Final Report of the Presiding Judge on Interim Measures
  - TID and MID report on O. mykiss pursuant to ordering paragraph (C)(5) of the April 3, 2008 FERC Order

- Data/Monitoring
  - 2010 seine data
  - Updates of basin monitoring newsletter (includes 2010 RST monitoring)
  - 2009-10 Counting weir data

2010Mar19-2010Jun10 Postings to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - March 2010 TRTAC meeting summary and handouts
  - June 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to fishery agencies re: flow schedule for 2009-2010 and 2010-2011 dated March 25, 2010.
  - Districts' letter to fishery agencies re: final flow schedule for 2009-2010 dated April 2, 2010.
  - Districts' letter to fishery agencies re: minimum flow schedule for 2010-2011 dated April 22, 2010.

- Order modifying and approving in part Tuolumne River O. mykiss 10-year monitoring report dated May 10, 2010.
- Order modifying and approving instream flow and water temperature model study plans dated May 12, 2010.
- Districts' letter to fishery representatives re: instream flow and water temperature study plans schedule dated May 28, 2010

- Documents
  - 2009 Annual Article 58 Report to FERC
  - 2009 Spawning Survey Update
  - 2009 Tuolumne River Weir Report

- Data/Monitoring
  - Update of 2010 seine data
  - Update of 2010 Counting weir data
  - Update of thermograph data
  - Basin monitoring newsletter (includes 2010 screw trap monitoring)

2010Jun11-2010Sep9 Changes to TRTAC website http://tuolumnerivertac.com/

- Updated flow schedule and participant list (July)

- Meetings
  - June 2010 TRTAC meeting notes, handouts
  - Sep 2010 TRTAC meeting agenda

- Correspondence
  - Districts' letter to FERC requesting revised schedules for instream flow and water temperature study and update on O. mykiss tracking study (June 30 2010)
  - FERC Order granting extension of the May 12, 2010 order modifying and approving instream flow and water temperature modeling study plans (July 21, 2010)
  - E-mail from Scott Wilcox to TRTAC Regarding Tuolumne River Instream Flow Study Planning Meeting dated August 15, 2010 (not posted)

- Documents
  - 2010 Draft Seine Report
  - Tuolumne River Floodplain Inundation Maps

2010 Sep9-2010Dec9 Changes to TRTAC website http://tuolumnerivertac.com/

- Meetings
  - Sep 2010 TRTAC meeting notes, materials list
  - August 26, 2010 IFIM Workgroup Coordination Meeting
  - October 5, 2010 IFIM Site Selection
  - October 20, 2010 IFIM HSC Workshop
  - November 18, 2010 IFIM Transect Placement

- Correspondence

- Draft Water Temperature Modeling Study Report transmittal to Resource Agencies 12/9/2010
- 2-D Site selection memorandum for Overbank Flow Study 12/6/2010
- Draft Tuolumne River 2010 Oncorhynchus mykiss Monitoring Summary Report transmittal to Resource Agencies 11/30/2010
- Tuolumne River Water Temperature Model Study Progress Report to FERC, 11/9/2010 (not posted)
- Tuolumne River Instream Flow Study Progress Report to FERC, with attachments 12/9/2010 (not posted)

- Documents
    - 2010 Snorkel Report and Summary Update
    - Draft 2010 *O. mykiss* Monitoring Summary Report
    - March and August 2010 *O. mykiss* Population Size Estimate Report
    - Tuolumne River Instream Flow Meso Habitat Maps - Draft
    - DRAFT Tuolumne River water temperature modeling study report

- Data/Monitoring
    - Update of 2010 Counting weir data
    - Update of thermograph data

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-1

2009 Spawning Survey Report

Prepared by

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

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2009 Tuolumne River Fall Chinook Salmon Escapement Survey

Prepared by:

Jennifer O'Brien
Fisheries Biologist

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

1 INTRODUCTION

The San Joaquin fall-run Chinook salmon is currently a candidate species under Federal and State Endangered Species Acts. Population levels, as measured by escapement of returning adults, in the Tuolumne River declined in the latter half of the 20th century from a high of approximately 130,000 returning adults in 1944 (Fry 1961) to a low of 77 in 1991 (Neilands et al. 1993). Recently, population levels increased to 17,873 in 2000 (Vasques 2001) indicating a slight recovery period, but are once again declining with estimates of 625 in 2006 (Blakeman 2007), 211 in 2007 (Blakeman 2008), and 372 in 2008 (O'Brien. 2009). The decline of the species is believed to be caused by many factors. The reduction of spawning and rearing habitat in combination with stream flow management practices are thought to be the major factors limiting overall population numbers. Numerous additional factors including but are not limited to predation, streambed alteration, pump diversion, gravel mining, land use practices, ocean angler harvest and ocean conditions contribute to a complex web of factors which affect the population dynamics of fall-run Chinook salmon within the Tuolumne River.

The California Department of Fish and Game (CDFG) has conducted escapement surveys on the Tuolumne River since 1953. Mark-Recapture methods have been utilized since 1971 to estimate escapement. Various population models have been used including Schaefer (1951), Jolly-Seber (1973), and the Adjusted Peterson (Ricker 1975). Due to the low number of individuals tagged, the 2009 escapement survey was analyzed using the Adjusted Peterson formula. CDFG escapement surveys have been utilized as part of the New Don Pedro FERC Project No. 2299 license monitoring program and annual reporting.

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

- Estimate the escapement of fall run Chinook salmon on the Tuolumne River.
- Evaluate the distribution of spawning throughout the study area.
- Collect fork length and sex data.
- Collect and analyze coded wire tag data from hatchery fish.
- Collect tissue samples for genetic analysis.
- Collect scale and otolith samples with which to conduct age determination analysis and subsequent cohort analysis.

2 METHODS

General Information

Chinook salmon escapement surveys on the Tuolumne River typically begin around the first week of October and extend into the end of December or early January. The study area is surveyed weekly to monitor the distribution of spawning and to tally the number of carcasses found within the river. Crew members float downstream in a drift boat searching for carcasses, counting live fish and documenting redds in each riffle and subsequent pool. Occasionally, crew members get out of the boat to walk along the sides of the river in search of carcasses that may be too difficult to see from the boat. When a carcass is discovered, it is gaffed out of the water and held on the boat until the entire riffle section (riffle and adjacent downstream pool) has been completely surveyed (Figure 1).

All carcasses found within a riffle section are processed after the area has been adequately searched (Figure 2). "Processing" involves obtaining condition, sex, and forklength (measured in centimeters) data as well as retrieval of scale, ototlith, coded-wire tag, and DNA samples. The survey crew continues floating downstream once all carcasses found within a riffle section have been processed and returned to the tail end of the riffle. The same procedures are followed for each subsequent riffle/pool combination until the entire river section has been completed.

The duration of the survey depends on the availability of new carcasses in the river. Tagging continues until there are less than ten new carcasses found in a survey week. After tagging has ceased, surveys continue for two more "recovery" weeks. Any new carcass found during a recovery week is enumerated, chopped, and returned to the river. Redd and live counts continue during recovery weeks.

Study Area

Approximately 30.5 river miles were surveyed during the escapement survey in 2009 (Figure 3). The survey area was divided into five sections with Section 1 being the upstream most reach. Section 1, also referred to as the primary spawning reach, extends from riffle A1 at river mile 52.0 near La Grange Dam downstream to Basso Bridge at river mile 47.5. Section 2 extends from Basso Bridge down to the Turlock Lake State Recreation Area (TLSRA) at river mile 41.9. Section 3 extends from TLSRA to riffle S1 at river mile 34. Section 4 extends from riffle S1 downstream to Fox Grove Fishing Access at river mile 26. Section 5 extends from Fox Grove Fishing Access to Santa Fe Rd. at river mile 21.5.

Riffle Identification

All riffles in the study area have been identified and mapped using a Trimble GPS unit and the GIS computer program ArcView. Each riffle was systematically re-named in 2001 from upstream to downstream using sequential letter/number designations for river mile and riffle number within each river mile, respectively. For example, the first riffle surveyed below La Grange Dam in the first river mile (51) is named A1. The riffle immediately below La Grange Dam (riffle A1) is surveyed by foot and only redd and live fish counts are made. This numbering system is a departure from the historical riffle numbering system; however, the new riffle identification system is more conducive to editing and tracking riffles as river morphology changes. Changes in riffle locations which may occur during high flow periods, will affect riffle names only within that river mile. There were no changes in riffle names for sections 1-4 from 2008 to 2009 (Table 1). Section 5 riffles were renamed in 2009 using the same sequential letter/number system already being used in sections 1-4. Figure 4 shows the locations and new names for each riffle within section 5.

Redd and Live Fish Counts
Weekly redd and live fish counts are conducted during the carcass survey. These counts utilize the riffle identification system noted earlier. Counts are made using tally counters as the field crew floats downstream through each riffle. The single pass method is utilized for conducting redd and live counts. Generally, one person remains responsible for redd counting throughout the entire season. In doing so, there is less variability in the data. Live fish are counted once they swim upstream past the boat in an attempt to prevent double counting.

Carcass Condition
All carcasses that are that are found within a riffle section (riffle and adjacent downstream pool) are processed after the area has been adequately searched**.** "Processing" involves obtaining condition, sex, and forklength (measured in centimeters) data as well as retrieval of scale, ototlith, coded-wire tag, and DNA samples.

The condition of each carcass is designated as fresh, decayed, skeleton, or recovery depending on the degree of decomposition or the presence of an aluminum jaw tag in the case of "recoveries". The condition of each carcass dictates how each individual will be processed. "Skeletons" are carcasses judged to be in an advanced state of decay and unlikely to have the same probability of recapture as fresh or decayed specimens (Figure 5). Skeleton condition ranges from a fungus covered carcass to an actual skeleton. Skeletons are enumerated and then chopped in half to avoid double counting before returning to the river. A carcass with at least one clear eye is classified as "fresh" (Figure 6). Fish that have cloudy eyes are considered "decayed" (Figure 7). Fresh and decayed carcasses are tagged and used for sample collection.

Coded-Wire Tags
Each fresh or decayed carcass is checked for the presence or absence of an adipose fin. Individuals lacking an adipose fin were raised in a hatchery and usually have a metal, coded-wire tag (CWT) implanted inside their head. Coded-wire tags are collected and later analyzed as part of survival testing of marked outmigrating smolts. Coded-wire tag returns provide information for determining hatchery contribution rates and can be utilized to analyze the incidence of straying from other river systems. Coded-wire tag data is also being used to validate scale and otolith age determination work.

Survey crews remove the upper portion of the heads of CWT carcasses while working on the river. The lower jaw of the carcass remains attached to the rest of the body so that a metal "field tag" can still be attached. Once the head has been removed, it is placed in a labeled "head bag" and catalogued by the unique jaw tag number so that it can be tracked to the specific date and riffle number of collection. Extraction and analysis of CWT's is conducted at the La Grange field office after the spawning season has concluded.

Tissue Collection
Scale, otolith, and DNA samples are taken from as many carcasses as possible. Generally, otolith samples can be obtained from most carcasses, but some individuals may be too badly decomposed to collect DNA and scale samples. All samples are catalogued by the unique jaw tag number which allows the samples to be tracked to the specific date and riffle of collection. Samples are collected from both wild and CWT carcasses and are catalogued, stored, and analyzed at the CDFG La Grange Field Office (Figures 8 and 9).

Otolith Samples
Otoliths are extracted from each carcass found on the river. A horizontal incision is made above the eyes and nostrils towards the posterior end of the fish ending slightly above the gill cover. The incision is made so that the top of the head can be removed and the brain capsule exposed. A pair of tweezers are used to reach inside and extract the otoliths which are the only hard structures found within the capsule (Figure 10). Any adhering tissue is removed from each otolith before placing the pair inside an individual vial marked with the field tag number**.**

DNA Fin Clip and Scale Samples
DNA fin clip samples are taken from the "meaty" region of the pectoral fin. The sample size is between 15-20 mm long and 5-10 mm wide. The samples are dried for at least 48 hours upon arrival to the lab. Scales are collected to determine the size and age composition of annual spawning runs. Scale samples are obtained by using a knife to scrape in a back and forth motion along the side of the carcass. (Scales near the lateral line are avoided) Approximately twenty or more scales are collected from each carcass.

Assignment of Unique Identification Number
Each carcass, with the exception of skeletons, is assigned a unique identification number by affixing a metal, numbered tag to the bottom jaw (Figure 11). This number identifies each individual throughout the season so that it can be identified if found again at a later date. Tags are issued in sequential order throughout the season. Newly processed carcasses are redistributed to moving water in the tail end of the riffle, above the pool from which they were collected, for recovery in subsequent weeks.

Tag Recoveries
Previously tagged carcasses are considered "recoveries" if they are found again during a survey subsequent to the tag week. Each recovery tag number is recorded by the unique tag number before returning the carcass back into the water at the bottom end of the riffle. Recovery totals are essential in calculating annual population estimates because they determine the overall success rate of the field crew's ability to locate carcasses in the river.

In past years' escapement surveys, previously tagged carcasses were chopped in half upon recovery to prevent multiple recaptures. Since 2008, tagged carcasses were recovered as many times as they were found, and returned to the water in tact each time. This new technique is being utilized to determine the longevity of carcass retention within the river system. Multiple recapture data is not currently being utilized in the data analysis for determining the population estimate.

Data Management/Analysis
Datasheets are reviewed by a data entry technician prior to being entered into a Microsoft Access database. All newly entered data goes through a quality control process in which a second individual prints out line-by-lines to check for any data entry errors. The biologist receives a copy of the database after all data entry errors have been corrected. Microsoft Excel is the current program being utilized for data analysis. Escapement reports generate annual population estimates but also analyze other factors such as population composition, egg production estimates, and distribution of spawning within the river.

CDFG has used a variety of population models since escapement surveys began in 1953. This year, the Adjusted Peterson equation was used in calculating the population estimate due to low numbers of Chinook salmon being marked. Carcasses are marked and subsequently recovered during weekly surveys of the spawning reach. A ratio of recoveries to the total tagged available is used to calculate an estimate of the total spawning population. Total fish handled includes total fish tagged, skeletons, and recoveries by week.

The Adjusted Peterson equation was used in generating two separate population estimates for the 2009 Tuolumne River carcass survey. Sections 1-4 were surveyed between October 5, 2009 (week 1) and January 13, 2010 (week 15). A section 1-4 estimate was calculated to represent the approximately 25 mile stretch of river located upstream of the newly constructed Tuolumne Weir. An additional estimate was calculated separately to determine the population of fish spawning downstream of the weir in section 5. Section 5 was surveyed between November 4, 2009 (week 5) and January 6, 2010 (week 14).

Carcasses were tagged for the first 13 weeks of the survey. The final 2 weeks were considered recovery weeks. The three carcasses encountered during weeks 14 and 15 in section one were processed to obtain sex, forklength, condition, and CWT data. DNA, scale, and otolith samples were also taken; however, these three individuals were treated as skeletons in the population estimate.

The Adjusted Peterson equation:

$$N = \frac{(M+1)(C+1)}{R+1}$$

Where:
N=Population estimate
M=Number of carcasses tagged
C=Catch (total number of tagged and skeletons)
R=Number of recoveries

3 TUOLUMNE RIVER WEIR

An Alaskan weir began operation on the Tuolumne River on September 22, 2009 as a method for counting migrating salmonids (Figure 12). This was the first time a weir had been operated on the Tuolumne; however, a similar weir had been in use on the Stanislaus River since 2003. The Tuolumne weir is owned by Turlock Irrigation District but operated by the consultant company Fishbio. The placement of the weir was intended to be in a location well downstream of any potential spawning habitat. The weir was constructed at river mile 24.5 approximately 1.7 miles downstream of Geer Rd. (37° 37’43.44”N 120° 51’42.48”W) where the substrate consists primarily of sand, mixed with small gravel.

On October 30th, 2009 CDFG biologists’ conducted an informal survey below Geer rd. to assess possible spawning activity downstream of the newly constructed Tuolumne weir. The discovery of approximately 25 live salmon and one redd within one mile downstream of the weir led to the inclusion of section 5 in the carcass survey in subsequent weeks.

Spawning activity appeared to have increased downstream of the weir when formal carcass surveys began in section 5 on November 4th (week 5). A total of 5 redds were documented within one mile downstream of the weir as compared to a total of 8 redds that had been observed in the entire 26.5 mile stretch upstream of the weir during the same week. During week 5 of the escapement survey approximately 38% of the total observed spawning activity and 34% of the total live fish observations for the entire river occurred downstream of the weir.

Week 6 survey data continued to show that migrating salmon were likely being subject to a passage delay at the weir. Redd counts continued to rise, with approximately 25% of the total observed spawning activity occurring downstream of the weir. Approximately 25% of the total live fish observations were also observed downstream of the weir during week 6. The discovery of a decayed female carcass within 1.15 miles downstream of the weir on November 12th, increased DFG’s concern that the weir was affecting fish passage.

By week 7 of the escapement survey, it was clearly obvious that a significant number of fish were unable to move upstream past the weir and as a result, were spawning in poor habitat that they would likely not otherwise choose. Live fish continued to be observed in close proximity to the weir, with some individuals choosing to spawn directly underneath the weir panels. An additional 3 carcasses were discovered downstream of the weir during the November 20th survey. In addition, redd counts downstream of the weir continued to rise to a total of 14.

On the morning of November 20th, Fishbio began removing three weir panels to allow unobstructed fish passage past the weir as directed by the Department of Fish and Game (Figure 13). A temporary video monitoring system was setup to attempt to monitor the gap in the weir. CDFG biologists’ reassessed the situation two days later to determine if the panels could be reinstalled. Survey data collected November 22nd indicated an increase in spawning below the weir thus making it necessary to postpone reinstallation of the three panels. After ten days of unobstructed fish passage, Fishbio was permitted to reinstall the weir panels on November 30th.

The Tuolumne weir appeared to have had a significant impact on migrating salmon in 2009. During the 15 weeks of the escapement survey, a total of 15 carcasses (tagged and skeleton) were found within 2 miles downstream of the weir, as compared to a total of 40 that were discovered for the entire 26.5 mile stretch upstream of the weir The inability of fish to move upstream to desirable spawning grounds was unacceptable especially with the current trend of critically low annual escapement numbers.

The Department of Fish and Game addressed its concerns regarding the design and location of the Tuolumne weir after the conclusion of the carcass survey. Modifications to the weir design will be made prior to being placed back in the water for the 2010 season.

4 RESULTS

Survey Duration

The 2009 Tuolumne River carcass survey was conducted between October 5, 2009 and January 13, 2010. Drift boat surveys were conducted weekly between the La Grange Dam and Fox Grove fishing access (sections 1-4) for the entire 15 weeks of the survey. Section 5 was included in the carcass survey beginning in week five in response to spawning activity occurring downstream of the weir. Carcass surveys within section 5 were conducted weekly between November 4, 2009 and January 6, 2010.

Escapement Estimate

Sections 1-4 were surveyed for 15 weeks between October 5, 2009 and January 13, 2010. Section 5 was surveyed for 10 weeks between November 4, 2009 and January 6, 2010. It was necessary to generate two separate Adjusted Peterson estimates in 2009, due to the fact that the stretch of river located upstream of the weir (sections 1-4) was surveyed longer than the stretch of river located downstream of the weir (section 5). The generation of two separate estimates also demonstrates the population of fish that were possibly delayed by the weir, and as a result spawned in poor substrate conditions in section 5.

Section 1-4 Escapement Estimate

A total of 24 carcasses were tagged in sections 1-4 during the 2009 Tuolumne River escapement survey. An additional 16 skeletons were tallied and chopped, giving a total of 40 individual Chinook salmon handled in sections 1-4. There were no live fish counted in sections 1-4 during week 15 of the survey. The overall recovery rate for sections 1-4 was 52.38%. The Adjusted Peterson model utilizes the number of recoveries of tagged carcasses, the total number of tagged fish, and the total number of carcasses handled to generate an escapement estimate**.** Based on the Adjusted Peterson model, the 2009 escapement estimate for sections 1-4 was 75 salmon.

Section 5 Escapement Estimate

A total of 13 carcasses were tagged in section 5 during the 2009 Tuolumne River escapement survey. An additional 2 skeletons were tallied and chopped, giving a total of 15 individual Chinook salmon handled in section 5. There were no live fish counted in section 5 during week 14 of the escapement survey. The overall recovery rate for section 5 was 38.46%. The Adjusted Peterson model utilizes the number of recoveries of tagged carcasses, the total number of tagged fish, and the total number of carcasses handled to generate an escapement estimate**.** Based on the Adjusted Peterson model, the 2009 escapement estimate for section 5 was 37 salmon.

The estimate of 75 salmon for sections 1-4 and the estimate of 37 salmon in section 5 resulted in a total population of 112 salmon for the Tuolumne River in 2009. Table 2 and figure 14 show historical Tuolumne River escapement estimates from 1978 to 2009. The overall recovery rate for sections 1-5 was 45.42%. Females and males accounted for 56.8% and 43.2% respectively of the total tagged fish on the Tuolumne River. Table 3 shows tagged, skeleton, recovery, and CWT weekly totals.

Live Salmon and Redd Counts

Live fish observation peaked at week 8, and demonstrated an overall declining trend throughout the remainder of the survey. Redd counts peaked in week 8 with a maximum of 74 redds counted and then steadily declined for the remainder of the study period. Total carcass counts peaked in week 10, at 10 (Table 4 and Figure 15). The maximum number of redds counted for individual riffles is presented in Table 5.

Distribution of Spawning

The distribution of spawning in 2009 showed changes from the typical spawning patterns observed on the Tuolumne River in prior years' escapement surveys. Typically, spawning activity tends to be highest at the upstream most reach of the river in section one. Section 3 tends to have the next highest spawning activity, followed by section 2. Minimal spawning generally occurs in section 4 as compared to the upper sections.

The 2009 spawning distribution did not show the typical trend of the highest spawning activity being associated with section 1. Minimal spawning activity occurred in section one, with a maximum weekly redd count of just 32 (Figure 16). The highest maximum weekly redd count was observed in section 5, with the majority of spawning occurring within 1.5 miles downstream of the Tuolumne weir. The maximum weekly redd count for section 5 was 40. Sections 2, 3, and 4 had maximum weekly redd counts of 20, 36, and 10 respectively. Figure 17 show weekly maximum redds observed by river mile.

Population Composition

The total composition (tagged fish only) for fall-run Chinook salmon in the Tuolumne River was 54.1% natural females, 35.1% natural males, 2.7% CWT females, and 8.1% CWT males (Figure 18). Table 6 shows the yearly percent composition of fall-run Chinook salmon on the Tuolumne River since 1992. Coded wire tagged fish comprised approximately 11% of the total tagged carcasses. Skeletons were not checked for adipose fin clips due to their advanced state of decomposition; however, it is likely that ratios calculated for tagged fish are representative for skeletons as well. Table 7 shows the tag code, brood year, release year, and release location for all CWT fish collected in the Tuolumne River in 2009.

Twenty one females were tagged in 2009, with forklengths ranging between 54cm and 90cm. The average female forklength was 76.8cm. The sixteen males that were tagged in 2009 had forklengths ranging between 52cm and 110cm. The average forklength for all males tagged was 70.1cm. Figure 19 shows a length frequency histogram for all Chinook salmon tagged in 2009. Total grilse composition was 29.7% of all examined fish. Breakpoints between grilse and adult were determined from basin wide fork length data and applied to Tuolumne River fork length data to determine grilse composition. The breakpoints used in 2009 were <63cm for females and <70 cm for males. Eight males were considered grilse based on fork lengths less than 70cm. Three females had fork lengths of 62cm or less and were also considered grilse.

Scale, Otolith, and DNA Collection
Scale and otolith samples were collected from all tagged carcasses. DNA was also taken from most tagged carcasses; however, several individuals were too badly decomposed to retrieve adequate DNA samples (Tables 8, 9 and 10). Samples were not collected from skeletons due to the advanced state of decomposition. Scale and otolith samples will be utilized in the CDFG age determination program and for subsequent cohort analysis of the San Joaquin River Basin Chinook salmon populations. This data will also be essential for population models being developed as well as ongoing cohort analysis of factors affecting the populations.

Egg Production Estimation
An estimate for the number of eggs produced by the 2009 fall-run was generated using a standard regression equation (158.45 * fork length cm – 6138.91 = number of eggs). This fork length-fecundity relationship was determined for 48 San Joaquin fall-run Chinook salmon females ranging from 62.5 to 94.0 cm fork length (Loudermilk et al. 1990). The number of eggs was calculated for all females (CWT and natural) and expanded by the ratio method. The average fork length for all females in 2009 was 76.8cm. An estimated 379,672 eggs were produced by natural and CWT female Chinook in 2009. CWT females were estimated to have produced 16,802 eggs. Natural females were estimated to have produced 362,870 eggs.

Tuolumne River Flows
The Tuolumne River flows, recorded at the La Grange gauge, for the period of October 1, 2009 through January 17, 20010 are shown in figure 20 (preliminary data obtained from the California Data Exchange Center**)**. A pulse flow was released during the period between October 11th and October 23rd with a maximum flow of 716 cfs on October 18th. The average daily flow between October 1, 2009 and January 17, 2010 was 286 cfs.

Tuolumne River Temperature
Water temperature on the Tuolumne River is recorded using onset temperature monitors at twelve different locations starting below the La Grange powerhouse and ending downstream below the Hickman spillway. Figure 21 shows Tuolumne River water temperatures recorded at riffle C1 and at the above Hickman spillway sites. These water temperatures are plotted verses flow, maximum thermal limit for successful egg incubation, and live fish/redd counts.

Multiple Recaptures
In past years' escapement surveys, tagged carcasses were chopped in half upon recovery to prevent multiple recaptures. Since 2008, tagged carcasses were recovered as many times as they were found, and returned to the water in tact each time. This new technique is being utilized to determine the longevity of carcass retention within the river system. Of the

seventeen carcasses that were recovered during the 2009 survey, eleven were recovered only one time, three were recovered twice, and three were recovered three times (Figure 22). Multiple recapture data was not used in the data analysis for determining the population estimate, as the low number of fish handled would not allow the use of models that incorporate that data.

Spring/Summertime Live Fish and Carcasses

The Department of Fish and Game does not conduct carcass surveys on the Tuolumne River in spring and summer months however, live fish and carcasses have been observed on the river by CDFG during these times of year. The following list documents the timing of these observations in 2009.

1) February 18, 2009 — Seven live fish, 5 redds, two non-adclip carcasses, and two skeletons were found between the La Grange powerhouse and Bassos bridge.

2) February 22, 2009 — Two live fish and one redd were observed in riffle H4 (RM 44.6)

3) February 23, 2009 — One live fish and one redd were observed in riffle T2 (RM 32.5) near Waterford.

4) March 11, 2009 — Six live fish and one skeleton were documented upstream of Hwy J59.

5) March 23, 2009 — Two live fish were observed near riffle A2 (RM 51.6).

6) April 22, 2009 — One skeleton was found in the pool below riffle B1 (RM 50.8).

7) July 15, 2009 — Two non-adclip carcasses were found in the pool below riffle A2 (RM 51.6). Three live fish were also observed swimming in the pools above and below riffle A2 on the same day.

5 DISCUSSION

The 2009 escapement estimate of 112 and 2007's estimate of 211 are the lowest numbers of Chinook returning to the Tuolumne River since the 1991 estimate of 77 adults (Table 2 and Figure 14). Populations of Chinook have been in decline throughout the San Joaquin River system with similar low population trends also occurring on the Stanislaus and Merced Rivers.

The Jolly-Seber model would be a better estimation if tagged and recovered fish were more than 10 for each survey week (Schwarz 1993, p. 1183). In the 2009 Tuolumne River Escapement Survey, both tagged and recovered fish were low. During the 15 weeks of the survey, there were never more than 10 carcasses tagged or recovered in any single week. The Schaefer model overestimates when tagged and recovery are both low (Law 1994). Due to

very low numbers, the Adjusted Peterson method was used to calculate the 2009 escapement estimate of 112 returning adults.
Stream flow dynamics affect the likelihood of collecting carcasses in that it effects both how carcasses are distributed in the system and the effectiveness of recovering carcasses by field crews. The overall recovery rate of 45.42% for sections 1-5 indicates the percentage of carcasses that were recovered at least one time within the river. Since 2008, tagged carcasses were recovered as many times as they were found, and returned to the water in tact each time to determine the longevity of carcass retention within the river system.

Redd counts are affected by time of day, visibility, sunlight, wind rippling the water surface, redd superimposition, and other physical factors as well as the natural variability between observers. Redd counts were conducted with a single pass as opposed to a more complete intensive systematic approach which is beyond the scope of current funding. Maximum weekly redd distribution of section one to section five was 23.2%, 14.5%, 26.1%, 7.2% and 29.0% of total observed redds. The Tuolumne weir appeared to have negatively impacted migrating salmon, thus resulting in a large proportion of fish spawning downstream of the weir in poor substrate conditions. With so few fish returning to spawn there was likely very little redd superimposition occurring in 2009

There were four CWT fish encountered during the escapement survey in 2009. Skeletons were not checked for adipose fin clips due to their advanced state of decomposition. Females made up 56.8% of the returning adult population. The percentage of males returning to the Tuolumne in 2009 was 43.2%. The fork lengths of all salmon examined in the San Joaquin River Basin was utilized in determining grilse breakpoints. Eight males were considered grilse based on fork lengths less than 70cm. Three females had fork lengths of 62cm or less and were also considered grilse. The total percentage of grilse examined in the Tuolumne River was 29.7% of all examined fish.

The 2009 escapement estimate of 112 individuals causes great concern about the future survival of Chinook salmon in the Tuolumne River. There are many unanswered questions as to why the once healthy population has dropped to such dramatically low numbers. At this point, there is no definitive answer as to the cause of the Chinook population decline. A complex web of factors including flow management practices, predation, reduction of spawning and rearing habitat, streambed alteration, pump diversion, gravel mining, land use practices, ocean angler harvest and poor ocean conditions affect the population dynamics of Chinook salmon in the Tuolumne River.

Figure 1. The survey crew drifts through each riffle and subsequent pool until a carcass is found and gaffed out of the river (Photo from 2003 Stanislaus survey).

Figure 2. The survey crew collects data and samples from each fresh or decayed carcass (Photo from 2003 Stanislaus survey).

Figure 3. Tuolumne River Escapement Survey Section Map

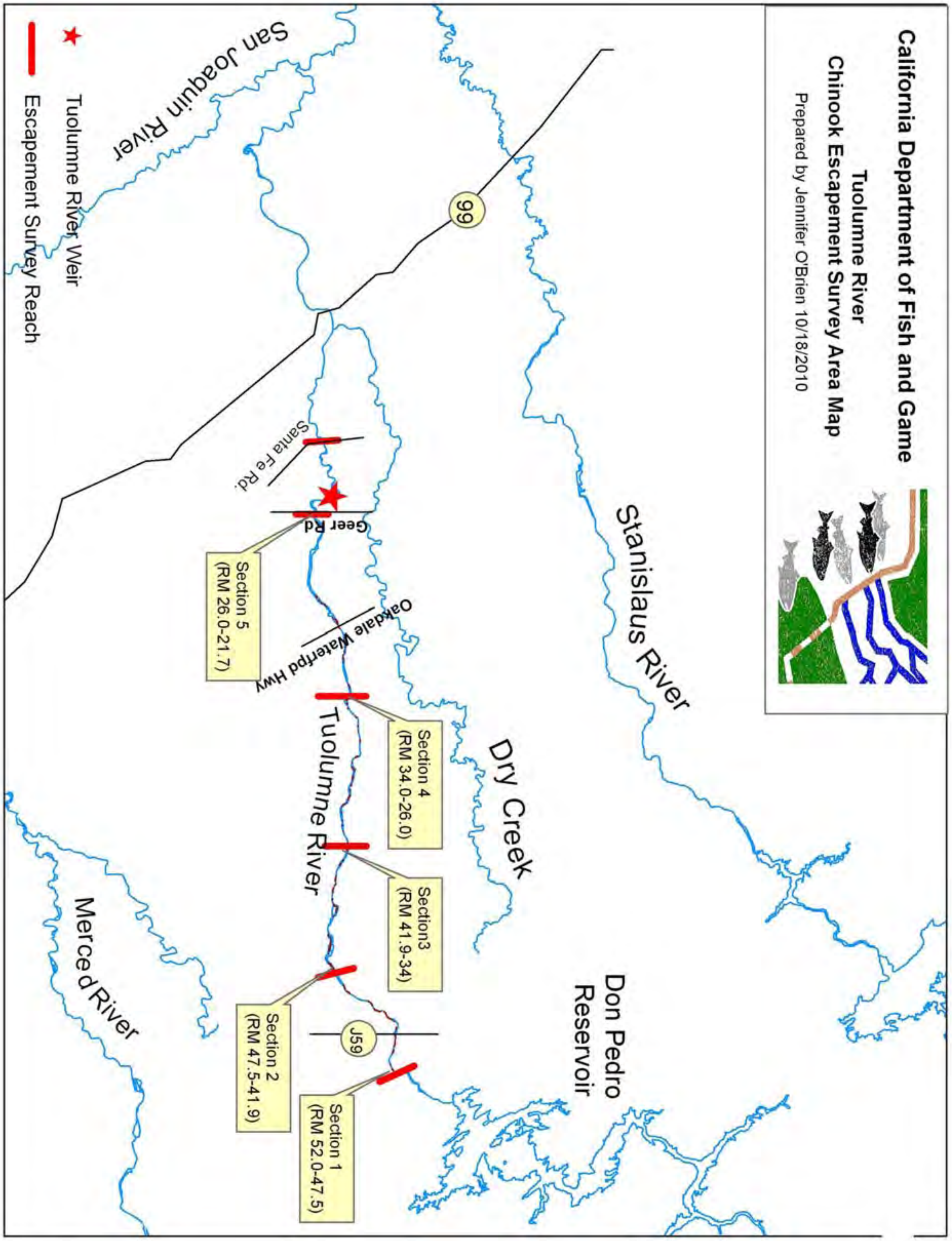

Figure 4. Section 5 Riffle Map

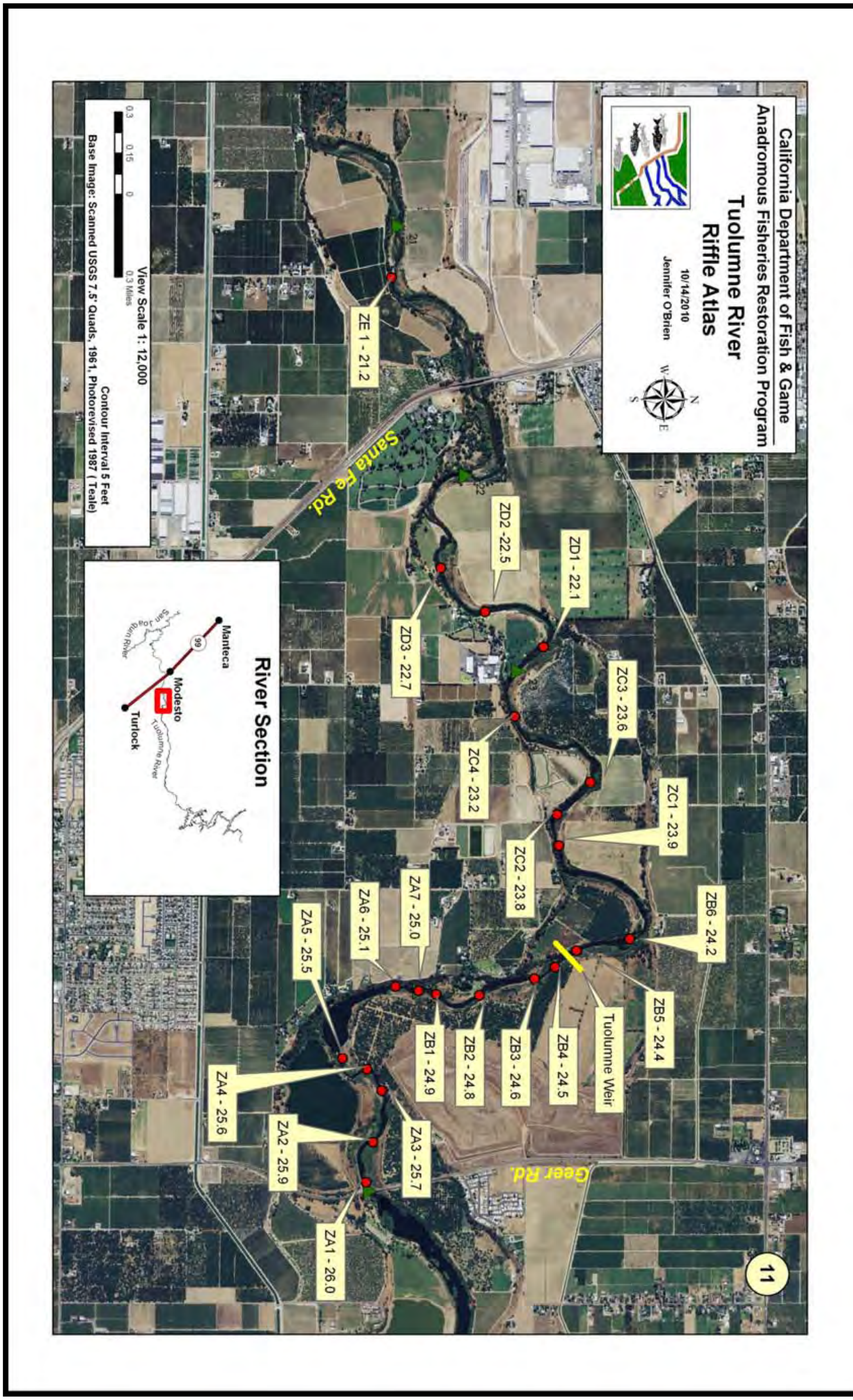

Figure 5. "Skeletons" are in the advanced state of decomposition and are chopped in half to avoid double counting.

Figure 6. Fresh carcass indicated by a clear eye.

Figure 7. Decayed carcass indicated by cloudy eyes.

Figure 8. Scales are analyzed under a microscope for age determination.

Figure 9. A Chinook salmon scale viewed under the microscope.

Figure 10. Extraction of otoliths from a female Chinook salmon.

Figure 11. Each carcass is assigned a unique identification number by affixing a metal, numbered tag to the bottom jaw.

Figure 12. Tuolumne River weir. October 21, 2009.

Figure 13. Tuolumne weir with three weir panels removed. November 22, 2009.

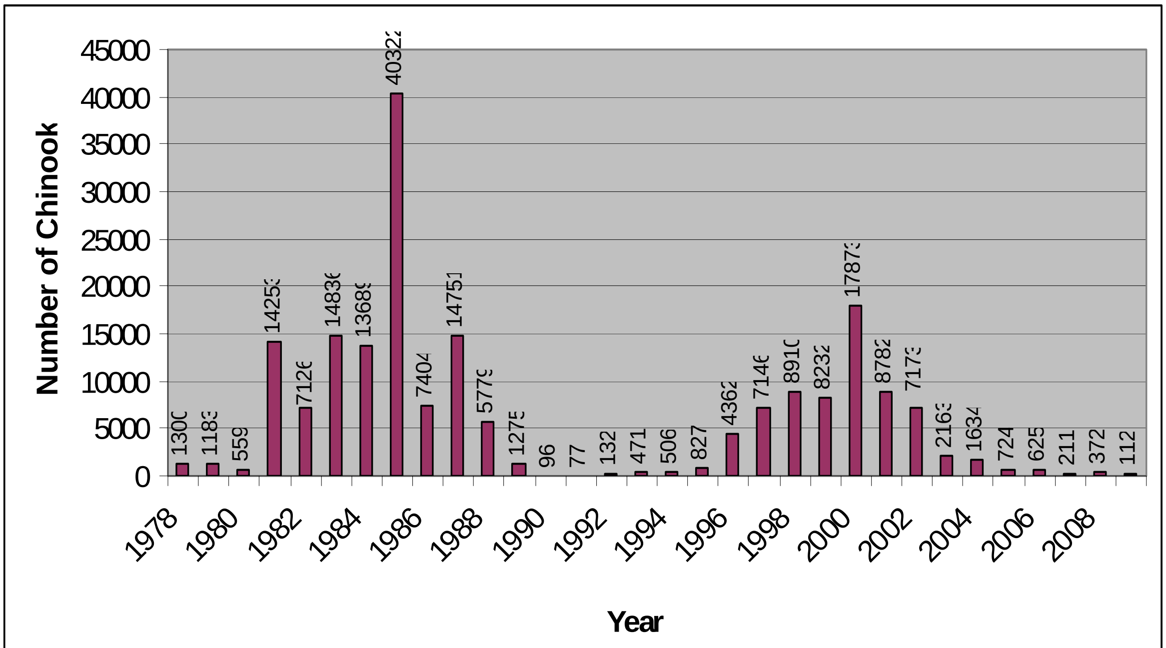

Figure 14. Yearly Tuolumne River Estimates.

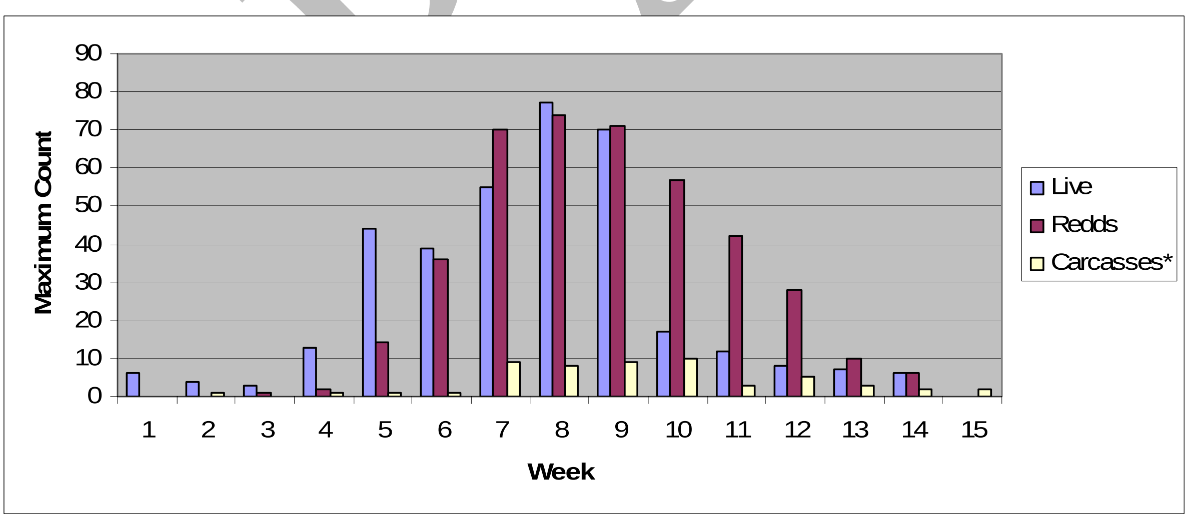

Figure 15. Live fish observation, redd, and carcass counts by week.
*Carcasses include all tagged carcasses and skeletons, but does not include recoveries.

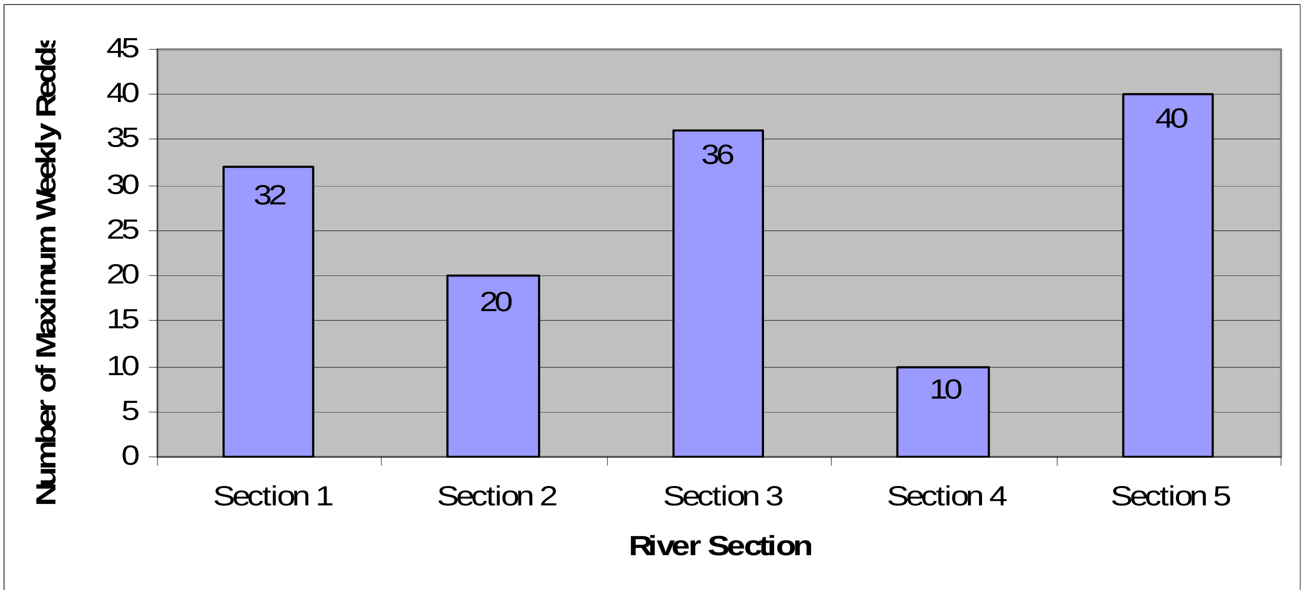

Figure 16. Weekly maximum redds observed by river section.

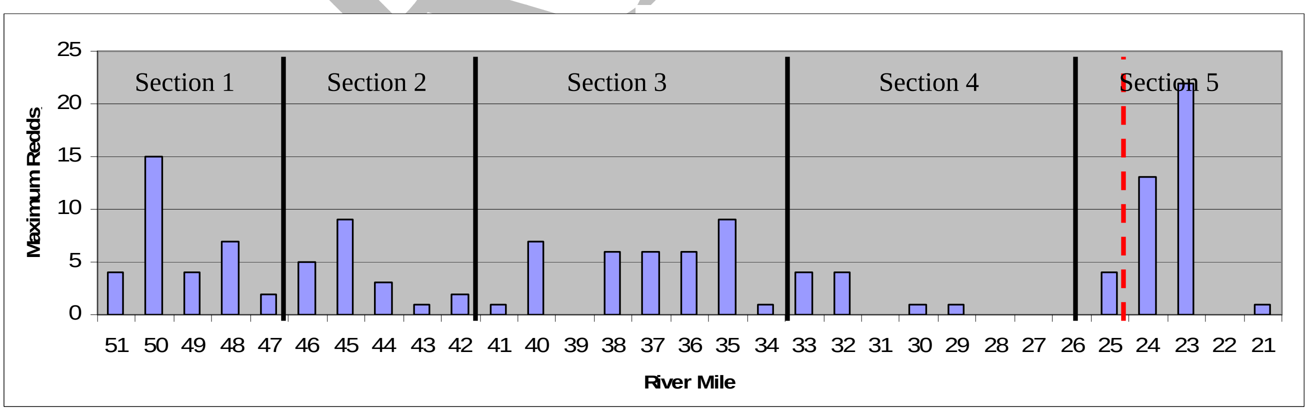

Figure 17. Weekly maximum redds observed by river mile. The approximate location of the Tuolumne weir is indicated by a dashed line.

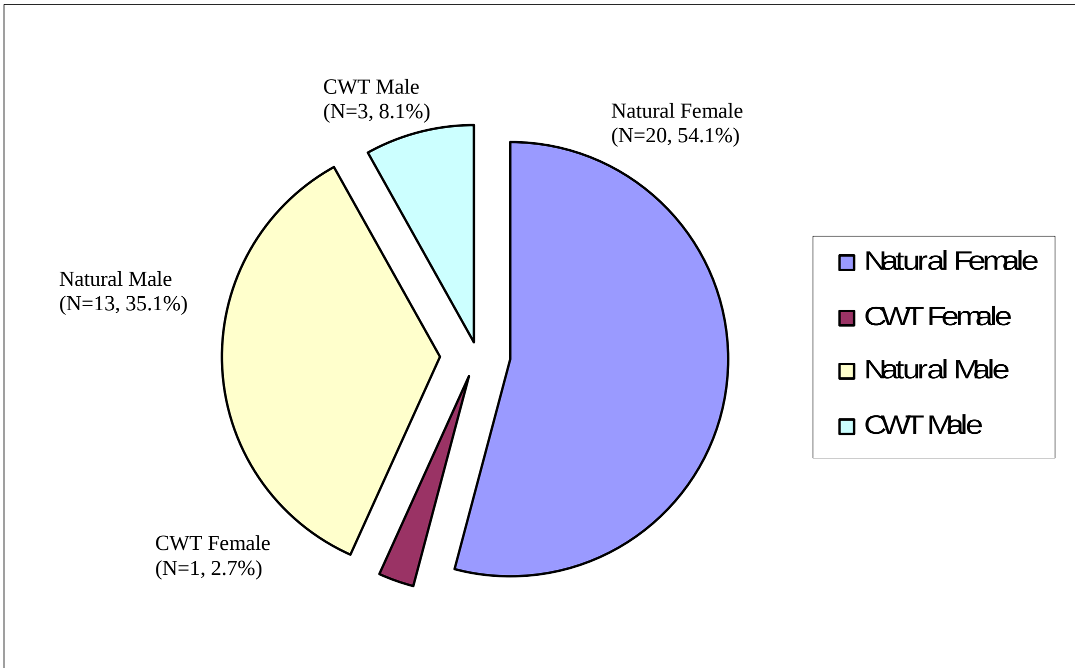

Figure 18. Composition of natural female, CWT female, natural male, and CWT male for the 2009 Tuolumne River escapement survey.

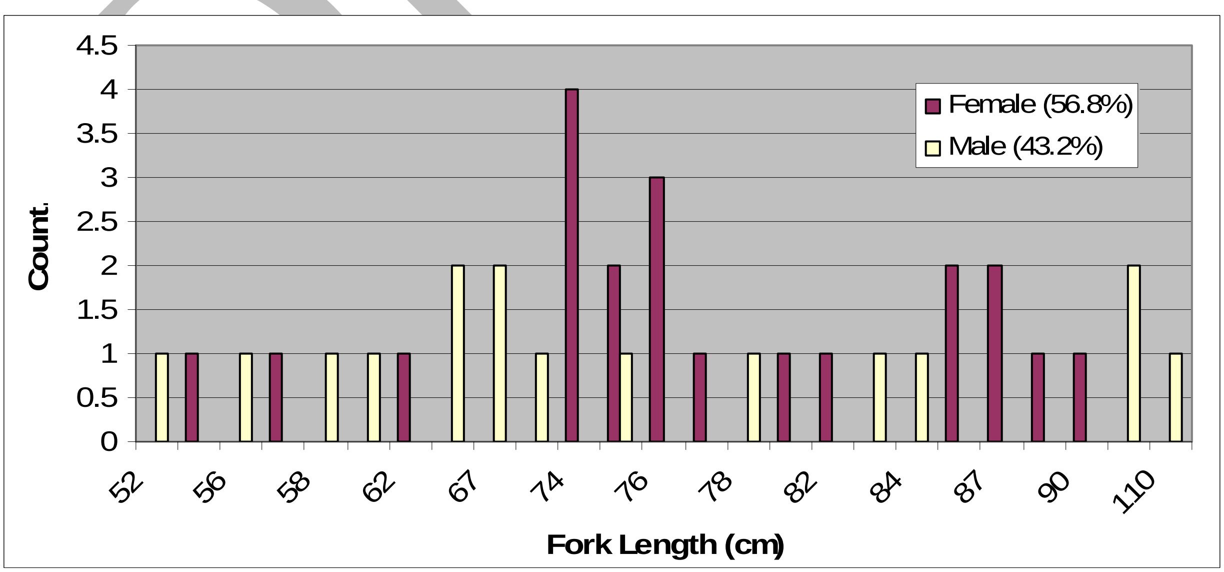

Figure 19. Length frequency histogram of female and male Chinook salmon.

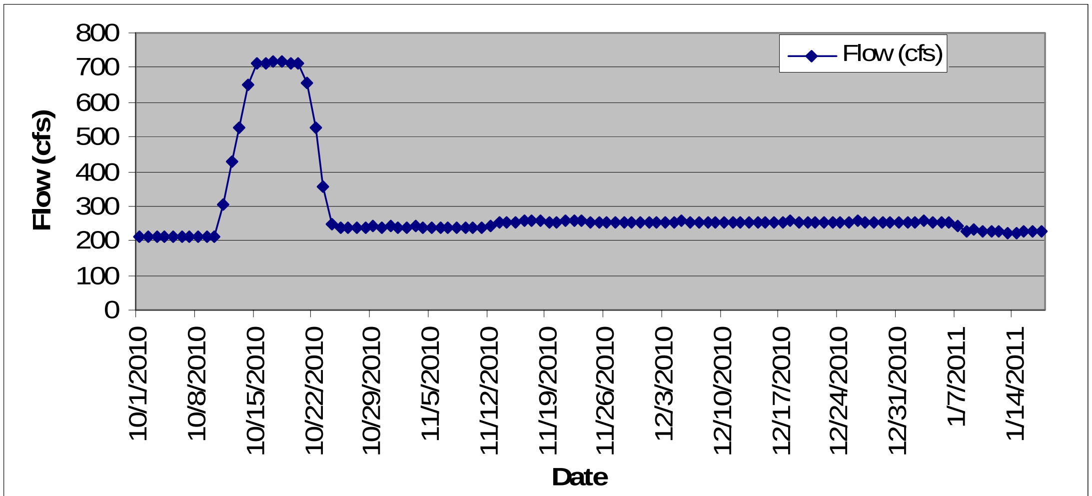

Figure 20. La Grange flow gauge data between October 1, 2009 and January 17, 2010 (California Data Exchange Center). The average flow during the 2009 escapement survey was 286 cfs.

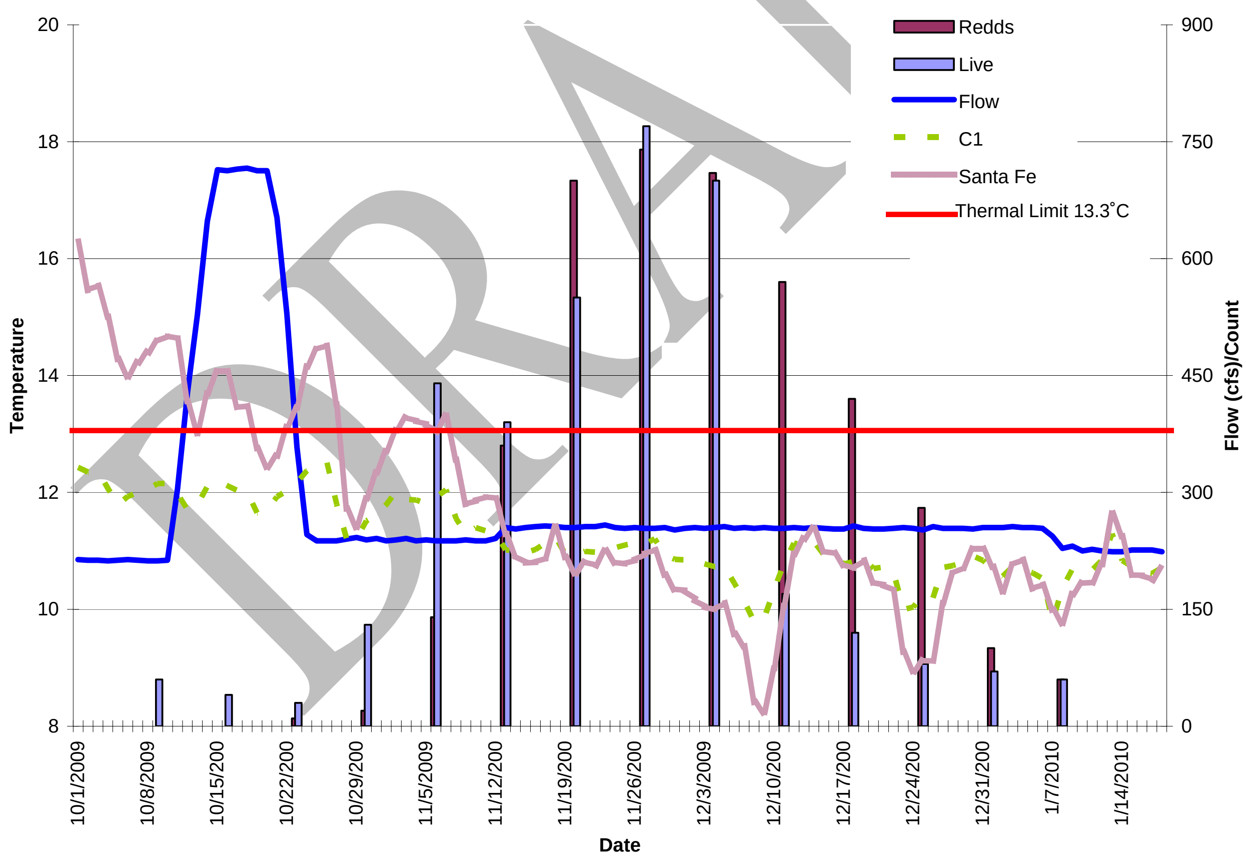

Figure 21. Tuolumne River flows (cfs) at the La Grange gauge, temperature at riffle C1 and the Santa Fe site, upper thermal limit for successful egg incubation (13.3°C) and number of live fish and redds counted.

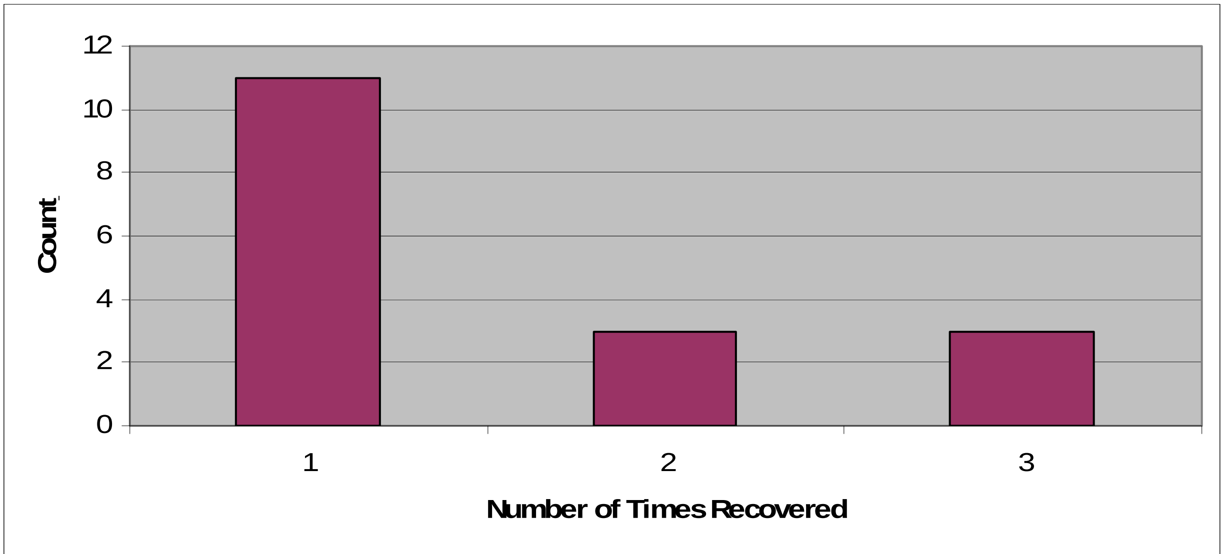

Figure 22. Multiple recapture data for the seventeen carcasses recovered in 2009.

Table 1. Tuolumne River riffle identification cross-reference.

Section 1		Section 2		Section 3		Section 4	
New ID	Old ID	New ID	Old ID	New ID	Old ID	New ID	Old ID
A1	A1	F1	F1	K1	K1	S1	S1
A2	A2	F2	F2	K2	K2	S2	S2
A3	A3	F3	F3	K3	K3	S3	S3
A4	A4	G1	G1	L1	L1	S4	S4
B1	B1	G2	G2	L2	L2	T1	T1
B2	B2	G3	G3	L3	L3	T2	T2
B3	B3	G4	G4	L4	L4	T3	T3
B4	B4	G5	G5	M1	M1	T4	T4
C1	C1	G6	G6	M2	M2	T5	T5
C2	C2	H1	H1	N1	N1	U1	U1
C3	C3	H2	H2	N2	N2	U2	U2
D1	D1	H3	H3	N3	N3	U3	U3
D2	D2	H4	H4	N4	N4	V1	V1
D3	D3	H5	H5	O1	O1	V2	V2
D4	D4	H6	H6	O2	O2	V3	V3
D5	D5	H7	H7	O3	O3	V4	V4
D6	D6	I1	I1	O4	O4	W1	W1
E1	E1	I2	I2	O5	O5	W2	W2
		I3	I3	O6	O6	W3	W3
		I4	I4	O7	O7		
		J1	J1	O8	O8		
		J2	J2	P1	P1		
		J3	J3	P2	P2		
		J4	J4	P3	P3		
		J5	J5	P4	P4		
		J6	J6	P5	P5		
		J7	J7	Q1	Q1		
		J8	J8	Q2	Q2		
				Q3	Q3		
				R1	R1		
				R2	R2		
				R3	R3		

Table 2. Yearly escapement estimates

Year	Tuolumne River Estimate
1978	1,300
1979	1,183
1980	559
1981	14,253
1982	7,126
1983	14,836
1984	13,689
1985	40,322
1986	7,404
1987	14,751
1988	5,779
1989	1,275
1990	96
1991	77
1992	132
1993	471
1994	506
1995	827
1996	4,362
1997	7,146
1998	8,910
1999	8,232
2000	17,873
2001	8,782
2002	7,173
2003	2,163
2004	1,634
2005	724
2006	625
2007	211
2008	372
2009	112

Table 3. Weekly Totals

Week	Total Tagged	Skeletons	Single Recoveries	Total Counted *	CWT's
1	0 (ns)	0 (ns)	0 (ns)	0 (ns)	0 (ns)
2	0 (ns)	1 (ns)	0 (ns)	1 (ns)	0 (ns)
3	0 (ns)	0 (ns)	0 (ns)	0 (ns)	0 (ns)
4	0 (ns)	1 (ns)	0 (ns)	1 (ns)	0 (ns)
5	1 (0)	0 (0)	0 (0)	1 (0)	0 (0)
6	0 (1)	0 (0)	0 (0)	0 (1)	0 (0)
7	2 (6)	1 (0)	0 (3)	3 (9)	0 (0)
8	4 (4)	0 (0)	0 (1)	4 (5)	1 (0)
9	4 (0)	4 (1)	2 (0)	10 (1)	0 (0)
10	6 (2)	2 (0)	1 (1)	9 (3)	1 (2)
11	1 (0)	1 (1)	4 (0)	6 (1)	0 (0)
12	2 (0)	3 (0)	3 (0)	8 (0)	0 (0)
13	1 (0)	2 (0)	1 (0)	4 (0)	0 (0)
14	2 (0)	0 (0)	0 (0)	2 (0)	0 (0)
15	1 (ns)	1 (ns)	1 (ns)	3 (ns)	0 (ns)
Total	24 (13)	16 (2)	12 (5)	52 (20)	2 (2)

Section 5 weekly totals are shown in parenthesis next to totals for sections 1-4. Section 5 totals for week 7 includes data from two surveys that were conducted on November 20th and November 22nd. *Includes total tagged, skeletons, and all recoveries. (ns) – Not surveyed.

Table 4. Total live fish, redds, and carcass counts by survey week

Week	Live	Redds	Carcasses*
1	6 (ns)	0 (ns)	0 (ns)
2	4 (ns)	0 (ns)	1 (ns)
3	3 (ns)	1 (ns)	0 (ns)
4	13 (ns)	2 (ns)	1 (ns)
5	29 (15)	8 (6)	1 (0)
6	29 (10)	27 (9)	0 (1)
7	33 (9)	36 (14)	3 (6)
8	70 (7)	52 (22)	4 (4)
9	67 (3)	62 (9)	8 (3)
10	16 (1)	41 (16)	8 (0)
11	12 (0)	36 (6)	2 (1)
12	8 (0)	27 (1)	5 (0)
13	6 (1)	9 (1)	3 (0)
14	6 (0)	5 (1)	2 (0)
15	0 (ns)	0 (ns)	2 (ns)
TOTAL	302 (59)	306 (105)	40 (15)

Section 5 totals are shown in parenthesis next to totals for sections 1-4. Two surveys were conducted in section 5 during week 7. Section 5 live and redd totals in week 7 come from data collected on November 20th. The section 5 carcass total for week 7 shows carcasses collected on November 20th and November 22nd. *Carcasses include all tagged carcasses and skeletons, but does not include recoveries. (ns) – Not Surveyed.

Table 5. Maximum weekly redd count for each riffle by section.

Section 1		Section 2		Section 3		Section 4		Section 5	
Riffle	Max. # of Redds	Riffle	Max. # of Redds	Riffle	Max. # of Redds	Riffle	Max. # of Redds	Riffle	Max. # of Redds
A1	1	F1	3	K1	0	S1	0	ZA1	1
A2	1	F2	1	K2	1	S2	2	ZA2	1
A3	1	F3	1	K3	0	S3	1	ZA3	0
A4	1	G1	2	L1	5	S4	1	ZA4	0
B1	6	G2	1	L2	2	T1	0	ZA5	1
B2	4	G3	2	L3	0	T2	3	ZA6	1
B3	3	G4	4	L4	0	T3	0	ZA7	0
B4	2	G5	0	M1	0	T4	1	ZB1	0
C1	0	G6	0	M2	0	T5	0	ZB2	0
C2	0	H1	0	N1	2	U1	0	ZB3	0
C3	4	H2	0	N2	4	U2	0	ZB4	0
D1	1	H3	0	N3	0	U3	0	Weir	N/A
D2	3	H4	1	N4	0	V1	1	ZB5	11
D3	0	H5	0	O1	0	V2	0	ZB6	2
D4	0	H6	1	O2	0	V3	0	ZC1	7
D5	2	H7	1	O3	1	V4	0	ZC2	12
D6	1	I1	0	O4	0	W1	0	ZC3	2
E1	2	I2	1	O5	0	W2	1	ZC4	1
		I3	0	O6	2	W3	0	ZD1	0
		I4	0	O7	1			ZD2	0
		J1	0	O8	2			ZD3	0
		J2	0	P1	0			ZE1	1
		J3	0	P2	3				
		J4	0	P3	1				
		J5	0	P4	2				
		J6	1	P5	0				
		J7	0	Q1	3				
		J8	1	Q2	5				
				Q3	1				
				R1	0				
				R2	0				
				R3	1				
Sub Total	32		20		36		10		40
Total				138					

Table 6. Yearly percent composition of fall-run Chinook salmon on the Tuolumne River.

Year	%Female	% Male	% Unknown
1992	41.7%	56.3%	2.1%
1993	57.4%	42.6%	0.0%
1994	42.4%	42.9%	14.7%
1995	52.0%	47.5%	0.5%
1996	33.5%	66.3%	0.2%
1997	57.3%	42.7%	0.0%
1998	50.6%	49.3%	0.1%
1999	45.9%	54.1%	0.0%
2000	62.8%	37.1%	0.0%
2001	54.0%	45.9%	0.1%
2002	54.5%	45.5%	0.0%
2003	59.8%	40.2%	0.0%
2004	59.0%	40.6%	0.4%
2005	66.5%	33.5%	0.0%
2006	47.9%	52.1%	0.0%
2007	37.8%	62.2%	0.0%
2008	57.1%	42.9%	0.0%
2009	56.8%	43.2%	0.0%

Table 7. CWT Recovered from the Tuolumne River in 2009.

Tag Code	Brood Year	Release Year	Hatchery Location	Release Location	Stock Location	# Recovered
06-70-11	2006	2007	Mokelumne River	Wickland Oil Terminal	Mokelumne River	1
06-86-22	2007	2008	Mokelumne River	Tiburon Net Pens	American River	1
06-86-01	2007	2008	Mokelumne River	San Pablo Bay Net Pens	Mokelumne River	1
06-70-14	2006	2007	Mokelumne River	Ocean Net Pens	SACRA - San Joaquin Sys.	1

Table 8. Distribution of scale samples collected by section and week.

Week	Section 1	Section 2	Section 3	Section 4	Section 5	Grand Total
5	1					1
6					1	1
7	1		1		6	8
8	2	1	1		4	8
9	1		3			4
10	1	1	4		2	8
11			1			1
12			2			2
13				1		1
14	2					2
15	1					1
Total	9	2	12	1	13	37

Table 9. Distribution of DNA samples collected by section and week.

Week	Section 1	Section 2	Section 3	Section 4	Section 5	Grand Total
5	1					1
6					1	1
7	1		1		2	4
8	2	1	1		4	8
9	1		3			4
10	1	1	4			6
11			1			1
12			2			2
13				1		1
14	2					2
15	1					1
Total	9	2	12	1	7	31

Table 10. Distribution of otolith samples collected by section and week.

Week	Section 1	Section 2	Seection 3	Section 4	Section 5	Grand Total
5	1					1
6					1	1
7	1		1		6	8
8	2	1	1		4	8
9	1		3			4
10	1	1	4		2	8
11			1			1
12			2			2
13				1		1
14	2					2
15	1					1
Total	9	2	12	1	13	37

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UNITED STATES OF AMERICA
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FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-2

Spawning Survey Summary Update

Prepared by

Stillwater Sciences
Berkeley, CA

March 2011

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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. This report updates Ford and Kirihara 2009 and summarizes the 1971-2010 period. This report contains the latest information provided by CDFG for both 2009 and 2010.

2. SUMMARY UPDATE

2.1 Survey Reach

The reach CDFG surveyed in 2009 and 2010 was extended downstream into Section 5 (Figure 1) that starts near Fox Grove (RM 26.4) and extends to Santa Fe Br. (RM 21.5). Our records indicate that reach has not been reported as surveyed for spawning activity by CDFG since about 1989. The survey was extended downstream to examine for spawning activity above and below the Tuolumne River counting weir (RM 24.5), but there is little comparable data available due to the lack of surveys in prior years.

2.2 Population Estimates, Sex Composition, and Potential Eggs

Tuolumne River carcass numbers, mark/recapture survey results, and population estimates since 1971 are in Table 1. Those 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 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 rivers since 1940 are in Table 2. All estimates in this summary update report for 2009 and 2010 Tuolumne River fall Chinook salmon are based on calculations utilizing the weir count numbers and may differ from numbers contained in the CDFG annual report (2009).

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 1971-2010 period was Oct 31, 1996 and the latest peak was Nov 27, 1972 with a median date of Nov 12 (Table 4). The 2010 run had a peak live count of 142 salmon during the week of Nov 01. During the week of Nov 15, the peak redd count of 105 occurred.

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. This 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.

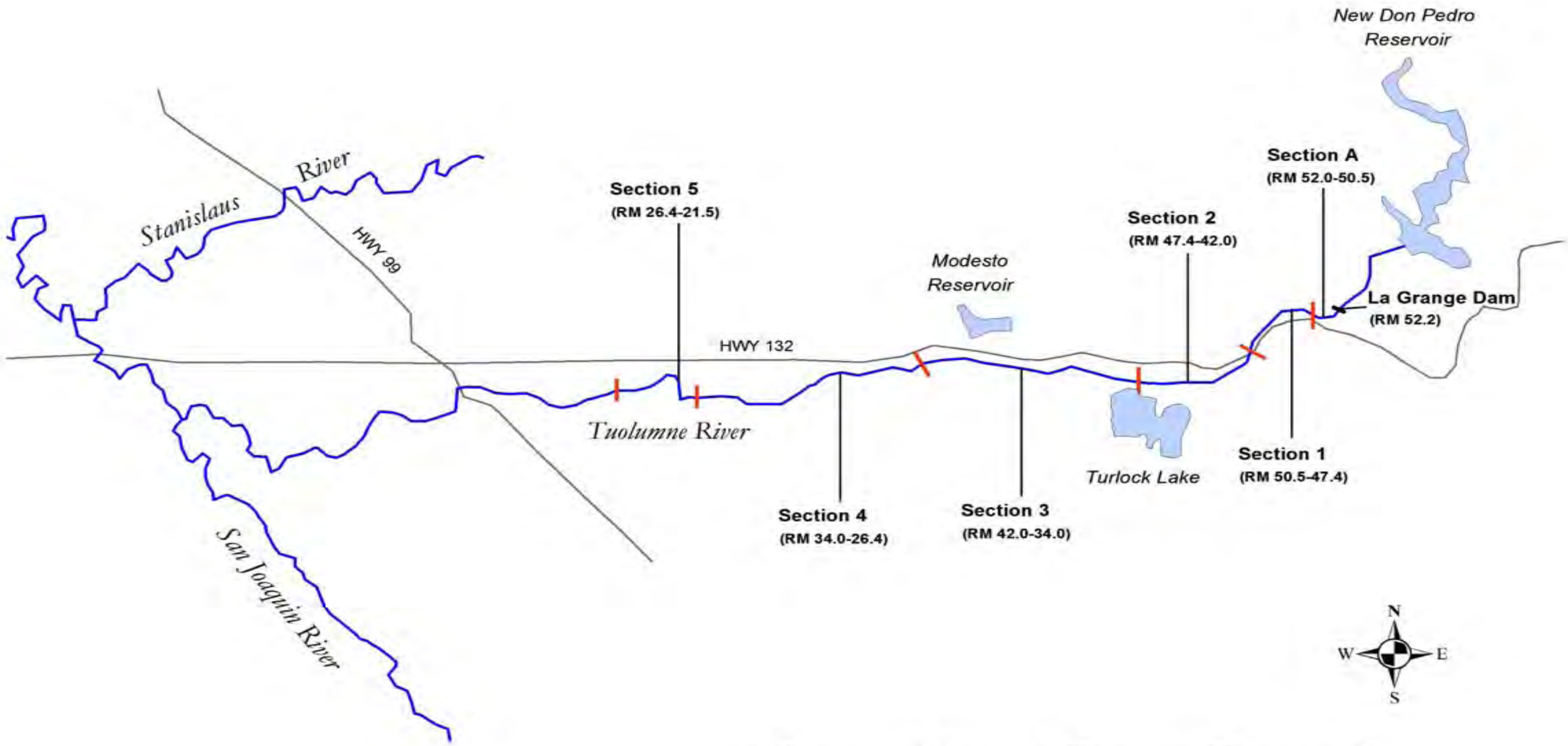


Figure 1. Map of the Tuolumne River salmon spawning survey reaches in 2009 and 2010.

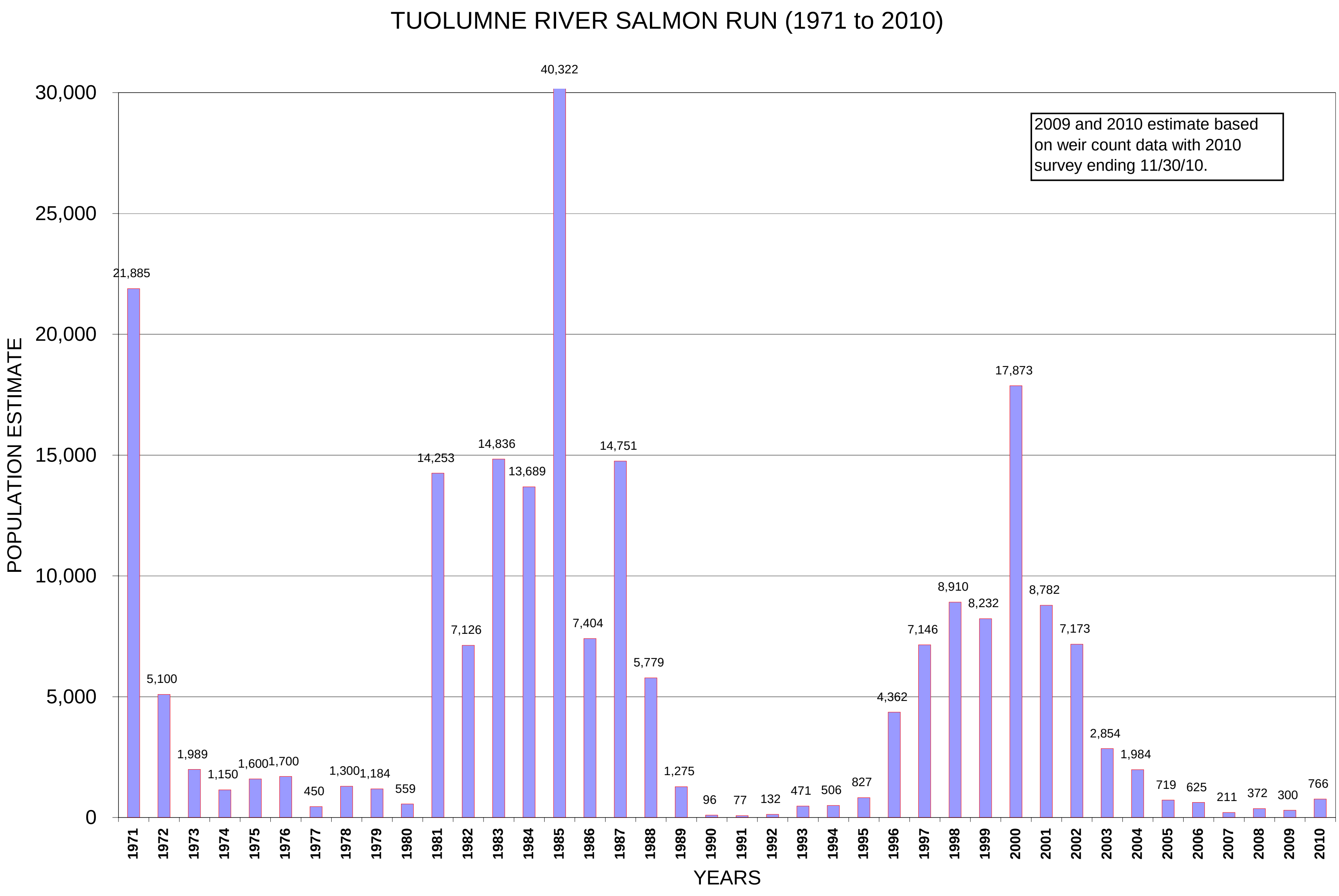


Figure 2. Tuolumne River Salmon Run Population Estimates

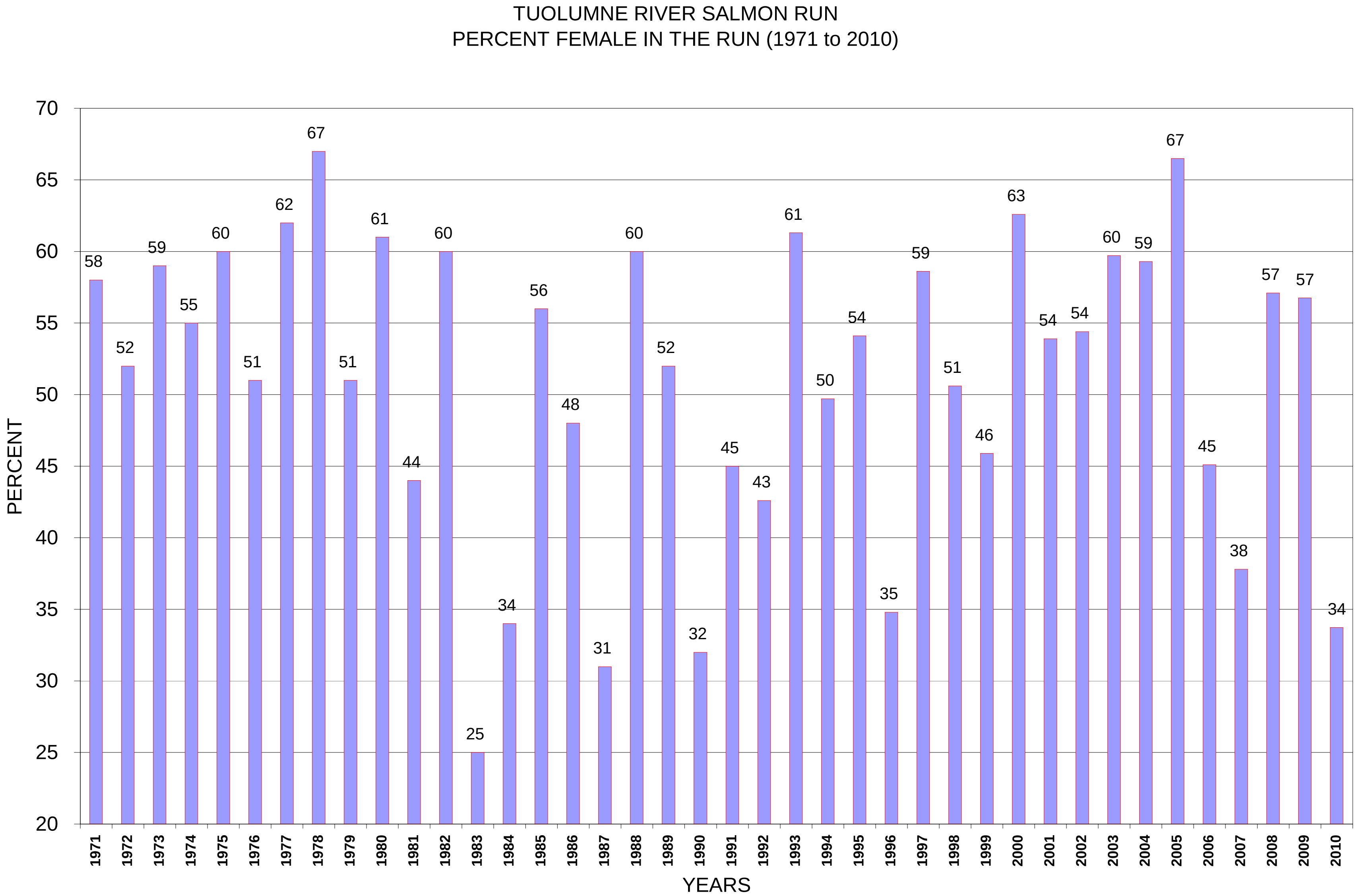


Figure 3. Percent Female salmon in the Tuolumne River runs.

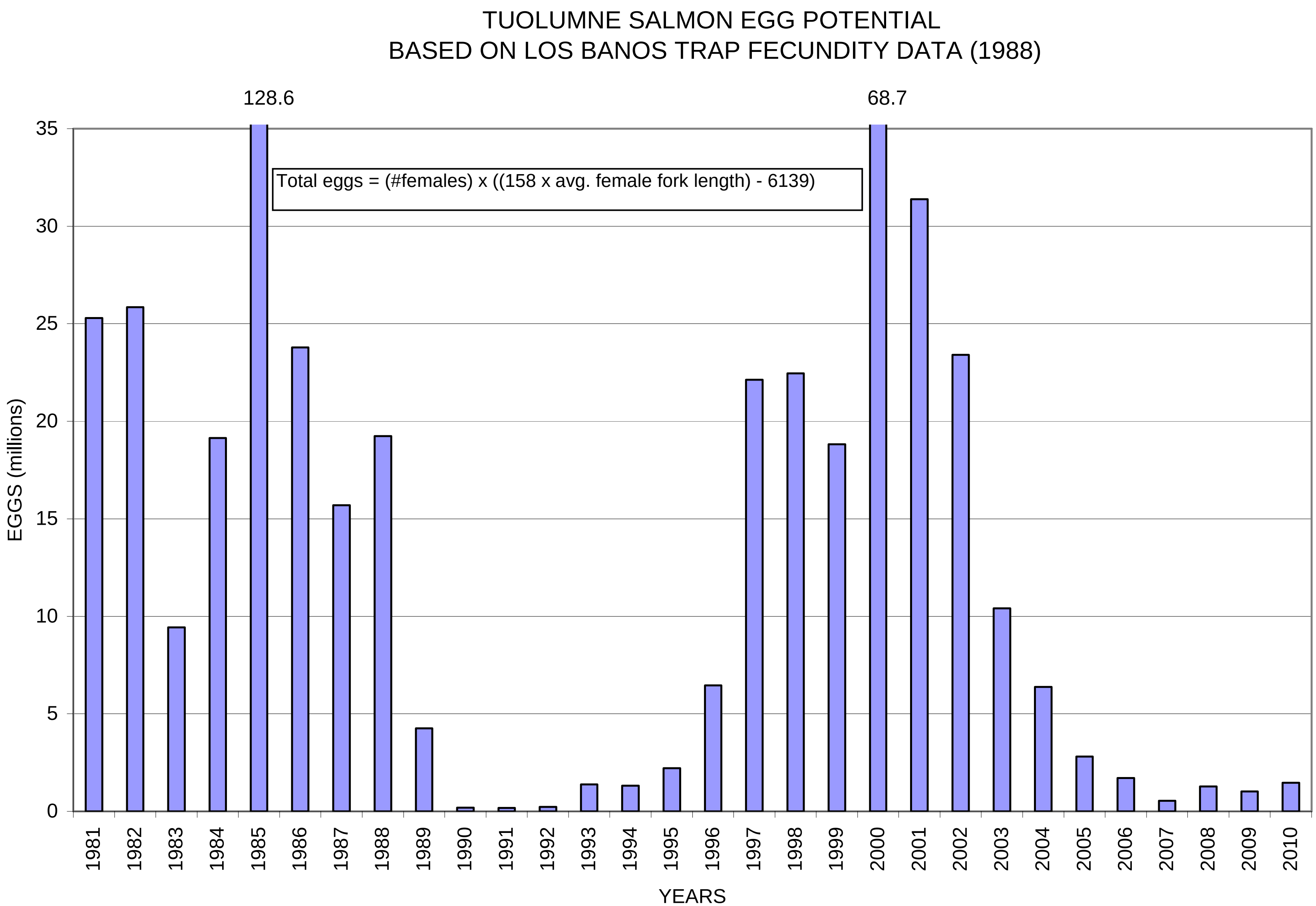


Figure 4. Potential egg deposition for Tuolumne River Chinook salmon, 1981-2010.

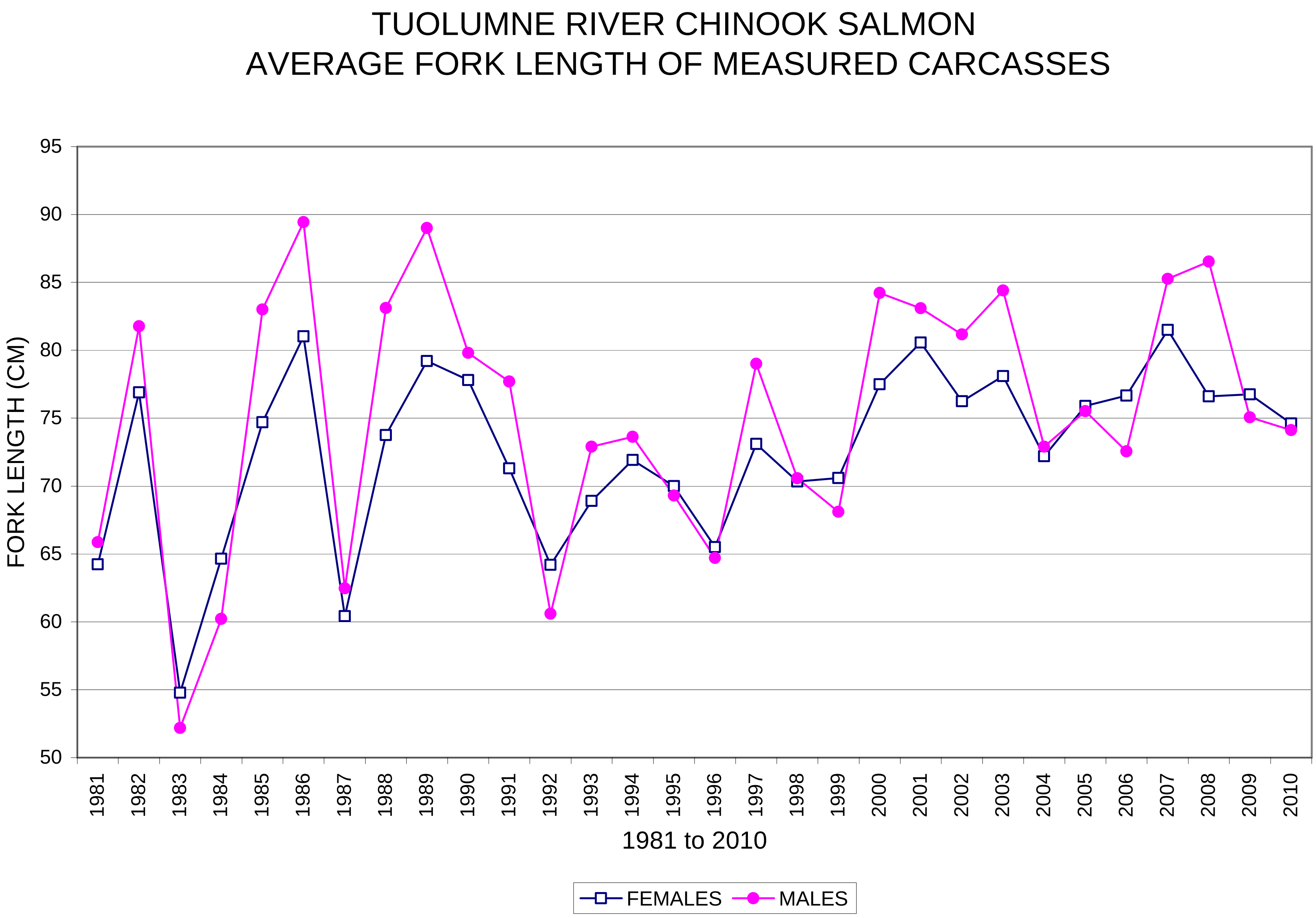
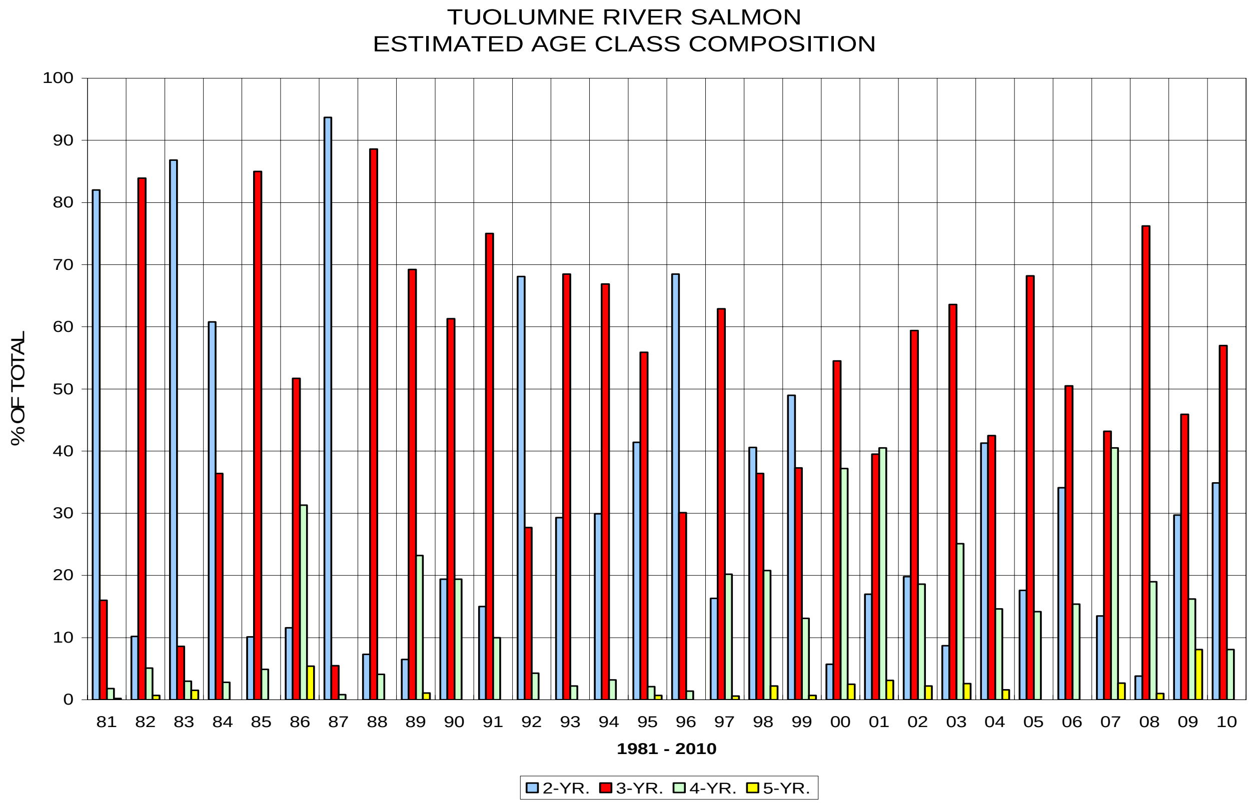


Figure 5. Average fork length of Tuolumne River salmon based on all measured carcasses



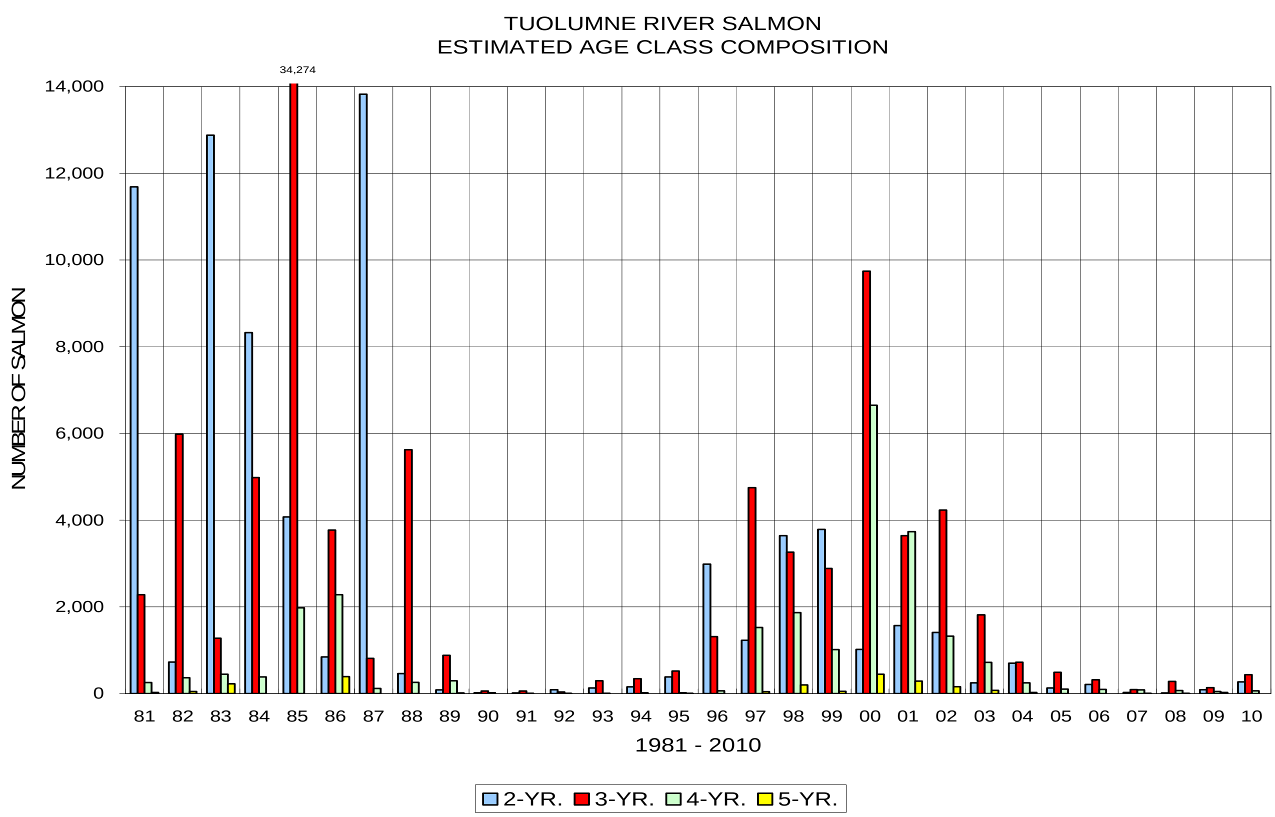
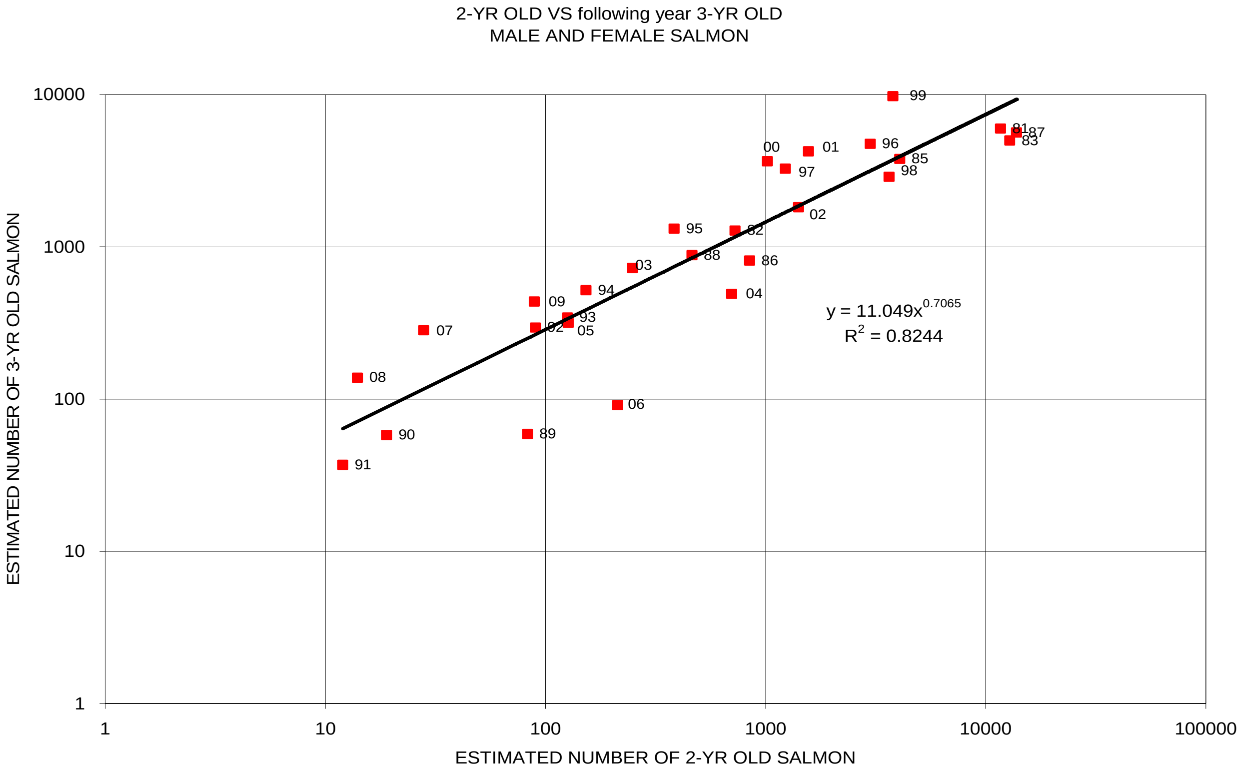


Figure 6. Estimated percent and number by age class for Tuolumne River salmon.



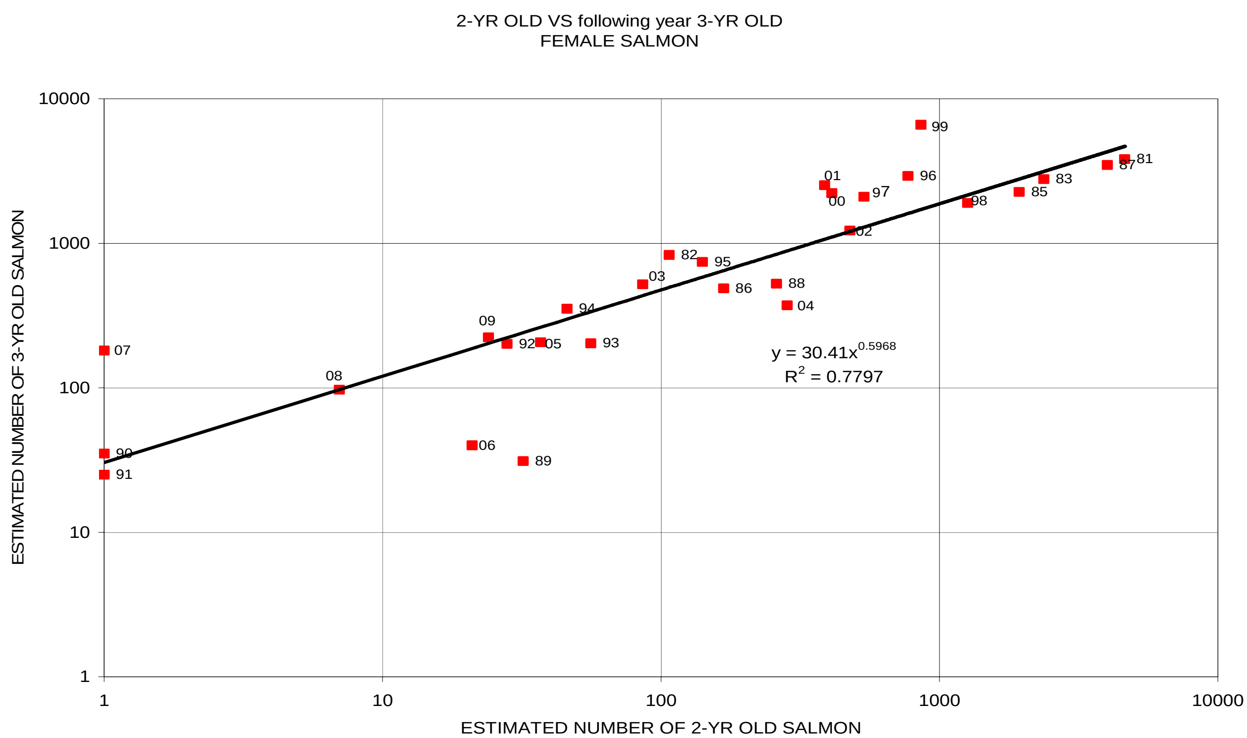


Figure 7. Estimated 2-yr-old salmon versus the following year 3-yr-old (1981-2009 Tuolumne River runs) excluding 1984 outlier, run years are for the 2-yr-olds.

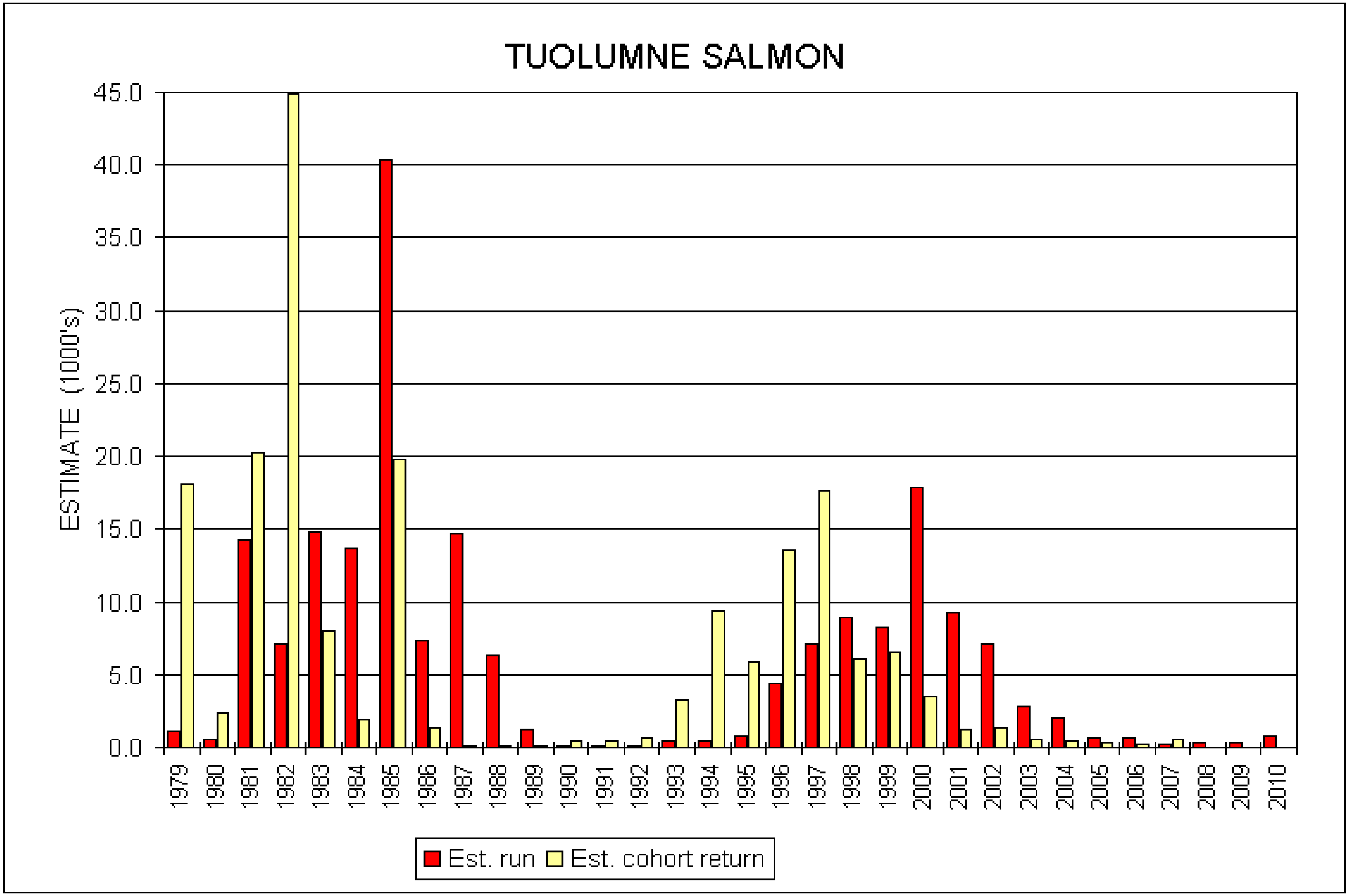


Figure 8. Estimated Tuolumne run numbers and spawner cohort returns.

TABLE 1. TUOLUMNE RIVER SPAWNING SALMON SURVEY COUNTS AND ESTIMATES, 1971-2010.

YEAR	TOTAL CARCASSES	% FEMALE	TAGGED CARCASSES NUMBER TAGGED	NUMBER RECOVERED	% RECOVERED	(WEEKLY) MAXIMUM LIVE COUNT	(1) (WEEKLY) MAXIMUM REDD COUNT	ESTIMATED RUN
1971	2,283	58.0			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

(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 and 2010 survey ended on November 30.
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

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	Survey Period End Date	Peak Live Count Date	Peak Live Count Number	Tuolumne Estimate (x 1,000)	Peak Live / Pop.est. (%)
1940	26-Sep	02-Dec	04-Nov	5,447	122.0	4.5%
1941	21-Sep	18-Nov	13-Nov	2,807	27.0	10.4%
1942	13-Sep	30-Nov	01-Nov	3,386	44.0	7.7%
1944	30-Sep	30-Nov	06-Nov	10,039	130.0	7.7%
1946	11-Oct	20-Nov	04-Nov	6,002	61.0	9.8%
1957	05-Nov	03-Jan			8.0	
1958	06-Nov	09-Jan			32.0	
1959	03-Nov	01-Jan			46.0	
1960	12-Nov	13-Jan			45.0	
1961					0.5	
1962	08-Nov	04-Jan			0.2	
1963	10-Feb				0.1	
1964	04-Nov	18-Dec			2.1	
1965	19-Nov	12-Jan			3.2	
1966	08-Nov	18-Jan	09-Nov	271	5.1	5.3%
1967	18-Oct	13-Jan	21-Nov	184	6.8	2.7%
1968	11-Nov	15-Dec	22-Nov	1,490	8.6	17.3%
1969	20-Nov	12-Jan			32.2	
1970	19-Nov	20-Jan	20-Nov	1,517	18.4	8.2%
1971	15-Nov	27-Dec	16-Nov	2,128	21.9	9.7%
1972	13-Nov	23-Jan	27-Nov	349	5.1	6.8%
1973	05-Nov	17-Jan			2.0	
1974					1.2	
1975	06-Nov	31-Dec	06-Nov	154	1.6	9.6%
1976	03-Nov	29-Dec	15-Nov	241	1.7	14.2%
1977	29-Nov	20-Dec			0.5	
1978	26-Oct	19-Dec	24-Nov	81	1.3	6.2%
1979	05-Nov	17-Dec	02-Nov	153	1.2	12.8%
1980	12-Nov	18-Dec	12-Nov	112	0.6	18.7%
1981	04-Nov	16-Dec			14.3	
1982	08-Nov	29-Nov	15-Nov	545	7.1	7.7%
1983	07-Nov	01-Dec	15-Nov	263	14.8	1.8%
1984	01-Nov	30-Nov	01-Nov	1,084	13.7	7.9%
1985	29-Oct	20-Dec	12-Nov	2,986	40.3	7.4%
1986	27-Oct	05-Dec	03-Nov	1,123	7.3	15.4%
1987	28-Oct	16-Dec	17-Nov	2,155	14.8	14.6%
1988	25-Oct	29-Dec	14-Nov	1,066	6.3	16.8%
1989	24-Oct	29-Dec	09-Nov	291	1.3	22.8%
1990	23-Oct	26-Dec	19-Nov	44	0.1	45.8%
1991	22-Oct	02-Jan	25-Nov	24	0.1	31.2%
1992	05-Nov	21-Dec	19-Nov	49	0.1	37.1%
1993	14-Oct	18-Dec	06-Nov	94	0.4	21.8%
1994	03-Nov	05-Jan	21-Nov	226	0.5	44.1%
1995	27-Oct	30-Dec	03-Nov	270	0.9	29.1%
1996	22-Oct	04-Dec	31-Oct	636	4.4	14.6%
1997	14-Oct	23-Dec	12-Nov	1,258	7.5	16.7%
1998	07-Oct	22-Dec	02-Nov	1,058	9.0	11.8%
1999	04-Oct	28-Dec	01-Nov	1,403	7.7	18.2%
2000	02-Oct	05-Jan	06-Nov	3,269	17.9	18.3%
2001	04-Oct	05-Jan	05-Nov	1,865	9.2	20.2%
2002	01-Oct	02-Jan	04-Nov	1,366	7.1	19.2%
2003	30-Sep	30-Dec	18-Nov	463	3.0	15.6%
2004	04-Oct	06-Jan	08-Nov	718	1.9	37.8%
2005	03-Oct	22-Dec	14-Nov	129	0.7	17.9%
2006	05-Oct	28-Dec	13-Nov	114	0.6	18.2%
2007	02-Oct	28-Dec	19-Nov	92	0.2	43.6%
2008	06-Oct	08-Jan	04-Nov	200	0.4	53.8%
2009	5-Oct	13-Jan	23-Nov	69	0.3	23.0%
2010	4-Oct	30-Nov	1-Nov	142	0.8	18.5%
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

Year	Estimated Run (x 1000)	Age-class composition for salmon run 2-yr (x 1000)	3-yr (x 1000)	4-yr (x 1000)	5-yr (x 1000)	2-yr (%)	3-yr (%)	4-yr (%)	5-yr (%)	Cohort Total (x 1000)	Cohort Composition 2-yr (%)	3-yr (%)	4-yr (%)	5-yr (%)
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					

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-3

2010 Seine Report and Summary Update

Prepared by

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and

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June 2010

EXECUTIVE SUMMARY

The 2010 seining survey was conducted at two-week intervals from 26 January to 08 June for a total of 10 sample periods. This was the 25th consecutive annual seining study on the Tuolumne River conducted by the Turlock and Modesto Irrigation Districts.

A total of 386 natural Chinook salmon were caught in the Tuolumne River and none in the San Joaquin River. This was the 7th lowest number of salmon caught during the 1986-2010 period and salmon were captured downstream to the Charles Rd. location (RM 24.9). Peak density of salmon caught in the Tuolumne was 7.8 salmon per 1,000 square feet on 02 March. Maximum fork length (FL) in the Tuolumne River increased from 47 mm FL to 88 mm FL from 26 January to 30 March and minimum FL was 29 mm.

Flows during the sampling period ranged from about 220 to 3,300 cubic feet per second (cfs) in the Tuolumne River at La Grange and from about 1,200 to 6,000 cfs in the San Joaquin River at Vernalis. Flows in 2010 increased significantly beginning in early April due to above average precipitation.

Water temperature in the Tuolumne ranged from 10.1°C to 18.4°C and in the San Joaquin from 9.4°C to 25.8°C. Conductivity in the Tuolumne River ranged from 27 to 205 µS and in the San Joaquin from 211 to 1,406 µS.

A comparative review of fork length and salmon density for the 2005-2010 period is included. Increase in average fork length in 2010 was typical in timing and magnitude to the pattern observed in other years through early April. After that, average fork length remained fairly stable due to low catch numbers and the outmigration of smolts.

Density of fry (≤ 50 mm) peaked on 17 February, similar in timing to other years of the 2005-2010 period. The density of juveniles (> 50 mm) peaked on 30 March, which was also similar to other years in the period. In 2010, the average density of salmon in the Tuolumne River was 2.9 salmon per 1,000 ft^2, most similar to 1997.

CONTENTS

1 INTRODUCTION

Stillwater Sciences with assistance from FISHBIO conducted seine studies in the Tuolumne and San Joaquin Rivers in 2010 for the Turlock and Modesto Irrigation Districts (TID/MID).

Seine sampling was done in both rivers pursuant to the Don Pedro Project river-wide monitoring program. A primary objective was to document juvenile salmonid size, abundance and distribution, including the relationship of flow and other environmental variables. The salmon in 2010 were the progeny of the 2009 fall spawning run, estimated at about 300 fish counted at the Tuolumne River weir. This was the 25th consecutive annual TID/MID seining study and a summary of salmonid data since 1986 is contained in this report.

1.1 STUDY SITES

The area studied was the Tuolumne River from La Grange Dam (river mile [RM] 52.0) to its confluence (RM 0) with the San Joaquin River at RM 83.8, and the San Joaquin River from Laird Park (RM 90.2) to Gardner Cove (RM 79.4) (Fig. 1). A total of ten sites were sampled each survey period, eight on the Tuolumne and two on the San Joaquin. The locations of the sites were as follows:

Site	Location	River Mile
	Tuolumne River	
1	Old La Grange Bridge (OLGB)	50.5[a]
2	Riffle 5	48.0
3	Tuolumne River Resort (TRR)	42.4
4	Hickman Bridge	31.6
5	Charles Road	24.9
6	Legion Park	17.2
7	Service Rd.,(Big Bend)	8.7,(6.4)
8	Shiloh Road	3.4
	San Joaquin River	
9	Laird Park	90.2[b]
10	Gardner Cove	79.4

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

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

1.2 2010 TUOLUMNE AND SAN JOAQUIN RIVER SAMPLING CONDITIONS

Flows released in the Tuolumne River below La Grange Dam were approximately 220 cfs in January when the surveys began. Several winter rain runoff events occurred from late January to early March as was evident in flows at Modesto. Releases began increasing in early April due to above average precipitation in the watershed (Fig. 2). During April and May, there were several pulse flows of about 3,300 cfs. In mid-June flows increased to a high of 5,520 cfs .

Flows in the San Joaquin River at Vernalis (RM 72.5) ranged from 1,200-6,000 cfs from January through June.

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

The minimum water temperature recorded in the Tuolumne River during the study period, based on hand-held temperature measurements, was 10.1 °C (50.2 °F) at Shiloh Rd on 26 January and at OLGB on 16 March, and the maximum temperature was 18.4 °C (65.1 °F) at Shiloh Road on 30 March (Fig. 3). The lowest San Joaquin River water temperature, 9.4 °C (48.9 °F) was at Laird Park on 26 January; the highest was 25.8 °C (78.4°F) at Laird Park on 08 June.

Dissolved oxygen concentration in the Tuolumne River ranged from 8.6 to 15.2 mg/L (ppm) and from 8.3 to 14.3 mg/L in the San Joaquin River (Fig. 3).

2 METHODS

2.1 STUDY TIMING

The 2010 seining study began on 26 January and ended on 08 June. Sampling was done at two-week intervals, with a total of 10 sampling dates.

2.2 SAMPLING METHODS AND DATA RECORDING

Seining was done using a 4-ft high, 1/8-inch mesh nylon seine net 20 feet in length. The same general areas were sampled each time, to permit comparisons through the sampling period, but sample areas varied somewhat as a result of changes in flow, especially after early April. Seine hauls were made with the current and parallel to shore. The salmon caught were anesthetized with MS-222, measured (FL in mm) and then revived before being released. Other measurements taken were area sampled, (determined from estimating average length and width of a seine haul) water temperature, visibility, conductivity, turbidity, dissolved oxygen, and maximum depth of the area sampled. Other observations include time of day, weather conditions, habitat type, and substrate type. Other fish species were recorded separately. Any salmon undergoing outward signs of smoltification, such as losing scales during handling, were also noted.

2.3 DATA ANALYSIS

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

3 RESULTS AND DISCUSSION

3.1 SEINE CATCH

A total of 386 salmon were caught in the Tuolumne River and 0 in the San Joaquin (Table 1). All salmon were measured and riverwide peak density for the Tuolumne was 7.8 salmon per 1,000 ft^2 on 02 March. Peak density is normally observed in mid to late February.

3.1.1 Density of Fry and Juvenile Salmon

Salmon up to 47 mm fork length (FL) were caught in the Tuolumne River on 26 January. The highest density of salmon fry in the Tuolumne was 6.1 fry/1,000 ft^2 found on 17 February (Table 2). The highest density of juvenile salmon in the Tuolumne was 3.6 juveniles/1,000 ft^2 found on 30 March.

The density of salmon fry exhibited a peak at all sites from 17 February to 02 March. The density of juveniles generally peaked from 02 March to 13 April for all locations (Fig. 4).

The density of salmon fry in the Tuolumne River peaked in the upper section on 17 February, in the middle section on 02 March and none were caught in the lower section (Fig. 5).

The density of juveniles peaked in the upper section on 13 April, the middle section on 30 March and again, none were caught in the lower section. No salmon were caught in the San Joaquin River.

3.1.2 Size, Growth, and Smoltification

The fork length of salmon caught ranged from 29 mm to 101 mm. The average fork length (FL) of salmon generally increased from 26 January to 13 April (Fig. 6). An indirect method to estimate growth rate was made by dividing the increase in maximum FL, over a period of time. Maximum FL in the Tuolumne River increased from 47 to 88 mm during the 26 January to 30 March period (Fig. 6), indicating a potential FL increase of approximately .65 mm per day (41 mm / 63 days).

Length frequency distributions by survey period are in Figs. 7 & 8. The change in FL by location generally shows an increase from late January to late April at most of the Tuolumne River sampling locations (Fig. 9). The first salmon exhibiting smolting characteristics were caught on 16 March with the exception of a 101 mm FL salmon caught on 17 February. For the year, smolting salmon ranged from 55-101 mm FL. Fry were present through 08 June during the 2010 seine survey period.

3.1.3 Conductivity and Turbidity

Conductivity in the Tuolumne River generally increased with increasing distance below La Grange Dam, from a low of 27 µS at OLGB to a high of 205 µS at Shiloh Road (Table 3). Conductivity also decreased as flows increased beginning in April (Fig. 10).

Conductivity in the San Joaquin River was much higher than in the Tuolumne and ranged from a low of 211 µS at Gardner Cove to a high of 1406 µS at Laird Park.

Turbidity in the Tuolumne River was less than 10.2 Nephelometric Turbidity Units (NTU) except for readings downstream of Fox Grove on 26 January and 02 March that were likely the result of storm runoff. 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 14.5 at Gardner Cove to 81.4 NTU measured at Laird Park.

3.1.4 Other Fish Species Caught

The numbers of other fish species caught during the seining study by species, location, and date are in Table 4. Fifteen species other than Chinook salmon were caught in the Tuolumne River and 10 other species in the San Joaquin River. Nine of these species were common to both rivers and 15 species were caught overall. Twenty-nine rainbow trout fry (21-51 mm FL) were caught in the Tuolumne River between 17 February to 11 May at OLGB, R5, and TRR.

2010 Summary of Rainbow Trout caught during the Seining Study

Date	Location	River Mile	Rainbow Catch	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Average Fork Length (mm)
2/17/10	OLGB	50.5	10	24	36	27.9
3/2/10	OLGB	50.5	2	29	30	29.5
3/2/10	TRR	42.3	1	22	22	22.0
3/16/10	OLGB	50.5	5	21	33	29.6
3/16/10	R5	48.0	1	41	41	41.0
3/30/10	OLGB	50.5	1	25	25	25.0
3/30/10	R5	48.0	2	34	35	34.5
4/13/10	R5	48.0	5	29	51	39.8
5/11/10	OLGB	50.5	1	37	37	37.0
5/11/10	R5	48.0	1	37	37	37.0

4 COMPARATIVE REVIEW

4.1 SEINE: 1986-2010

Annual TID/MID Tuolumne River seining surveys began in 1986, with the number, location, and sampling frequency of sites having varied over time (Tables 5 & 6). The number of salmon captured in the Tuolumne has ranged from 120 (1991) to 14,825 (1987) - the total number of salmon captured was 386 in 2010 which is the seventh lowest for all years. In 2010, the average density of salmon in the river was 2.9 salmon per 1,000 ft^2 and was most similar to densities found in 1997.

The San Joaquin River has been sampled upstream and downstream of the Tuolumne River confluence in each of the study years. The total number of salmon caught has ranged from 0 to 854 with average density much lower than the Tuolumne (Table 5). No salmon were captured in the San Joaquin River this year and in eight other years.

4.1.1 Size and Growth

The comparative review of fork length and density is primarily for the 2005-2010 period in this report. Minimum FL found in 2010 remained low, less than 40 mm FL, through April (Fig. 11). In 2010, the increase in average FL during the January to March period was similar in timing and magnitude to the pattern observed in the 2005-2010 period (Fig. 12). After mid-April the average FL declined and then remained somewhat constant due to low numbers of salmon caught and the outmigration of smolts. Maximum FL in 2010 was about average from January through April (Fig. 13). The estimated 2010 growth rate of .65 mm per day was slightly above average for 1986-2010 (Table 5).

4.1.2 Fry and Juvenile Salmon Density

In 2010, the density of salmon fry (≤ 50 mm) in the Tuolumne River peaked on 17 February at a lower level than 2009 (Fig. 14).

The density of salmon juveniles (>50 mm) in 2010 peaked on 30 March most similar in timing to 2006 (Fig. 15).

Combined fry and juvenile densities for the Tuolumne River are shown for the years 2005-2010 (Fig. 16). The 2010 densities peaked on 02 March at 7.8 salmon per 1,000 ft^2.

4.1.2.1 Tuolumne River Section Density

Upper section density of fry generally peaks from early February to early March and steadily declines through March (Fig. 17). For 2010, the density of fry peaked on 17 February and declined to low levels by mid-March. Upper section density of juveniles typically increases beginning in late February and peaks in early April to late May. In 2010, juvenile salmon density peaked on 13 April.

Middle section density of fry generally peaks from early February to mid-March similar timing to the upper section. In 2010, the density of fry peaked on 02 March. Middle section density of juveniles often peak from late February to late March. In 2010 juvenile density peaked on 30 March.

Lower section density of fry and juvenile salmon has been relatively low in most years. This section was often sampled only at the Shiloh Road location in prior years. Since 1999, two sites have been sampled. Peak density of fry ranged from early March (2005) to mid-March (2006) during the 2005-2010 period. In 2010, no salmon fry were caught in the lower section. Peak density of juveniles ranged from late March (2006) to late April (2005) with no juvenile captured in 2010.

Section abundance indices of fry and juvenile salmon combined were standardized as a percent of the annual riverwide average abundance index and plotted at section midpoints for recent years (Fig. 18). In 2010 the standardized section abundance indices were in the middle range for the upper and middle sections.

4.1.2.2 San Joaquin River Density

Densities of salmon caught in the San Joaquin River at Laird Park and Gardner Cove or nearby sites were reviewed to compare relative abundance of salmon upstream and downstream of the Tuolumne River confluence. The abundance indices were calculated for fry and juvenile salmon combined due to low numbers caught. The average salmon abundance at Laird Park, downstream of the Merced confluence, was extremely low for all years during the 1986-2010 period (Fig. 19). The total number of wild salmon caught at Laird Park during this period was 148. No salmon were caught at Laird Park in 2010. The average abundance at Gardner Cove, downstream of the Tuolumne River confluence, was much higher in 1986 and 1999 and moderately higher in 1995, 1998, 2001 and 2006. A total of 1082 salmon were caught at this location during the 1986-2010 period, 509 of which were caught in 1999. No salmon were caught at Gardner Cove in 2010.

4.1.3 Tuolumne River Fry Density Versus Number of Female Spawners

A polynomial equation analysis of peak fry density in the Tuolumne River and the estimated total number of female spawners (TID/MID data), from the preceding fall-run, resulted in an R-squared of .725 for the 1986-2010 period (Fig. 20, Table 7). A similar result with R-squared of .774 was found using average fry density from 15 January -15 March (Figure 21).

4.1.4 Other Fish Species

The number of fish species, other than Chinook salmon, caught during 1992-2010 has ranged from 10 to 16 in the Tuolumne River (Table 8). The counts from each site, by date, for fish species caught in 2010 are in Table 4. Fifteen other species were caught, including 5 native species, in the Tuolumne; 10 fish species, including 2 native, were caught in the San Joaquin River in 2010. The number of species caught in the San Joaquin River was low, similar to the three previous years.

Of native species, rainbow trout, hardhead, and riffle sculpin were caught only in the Tuolumne

River and Sacramento pikeminnow and Sacramento sucker were caught in both rivers. Native species recorded in prior years, but not caught in either river in 2010, were Pacific lamprey, Sacramento blackfish, hitch, Sacramento splittail, tule perch, and prickly sculpin.

The number of species observed in the Tuolumne River during the 1992-2010 period of years has remained fairly constant (Table 8). The number of species observed in the San Joaquin River since 2007 has decreased significantly from earlier years.

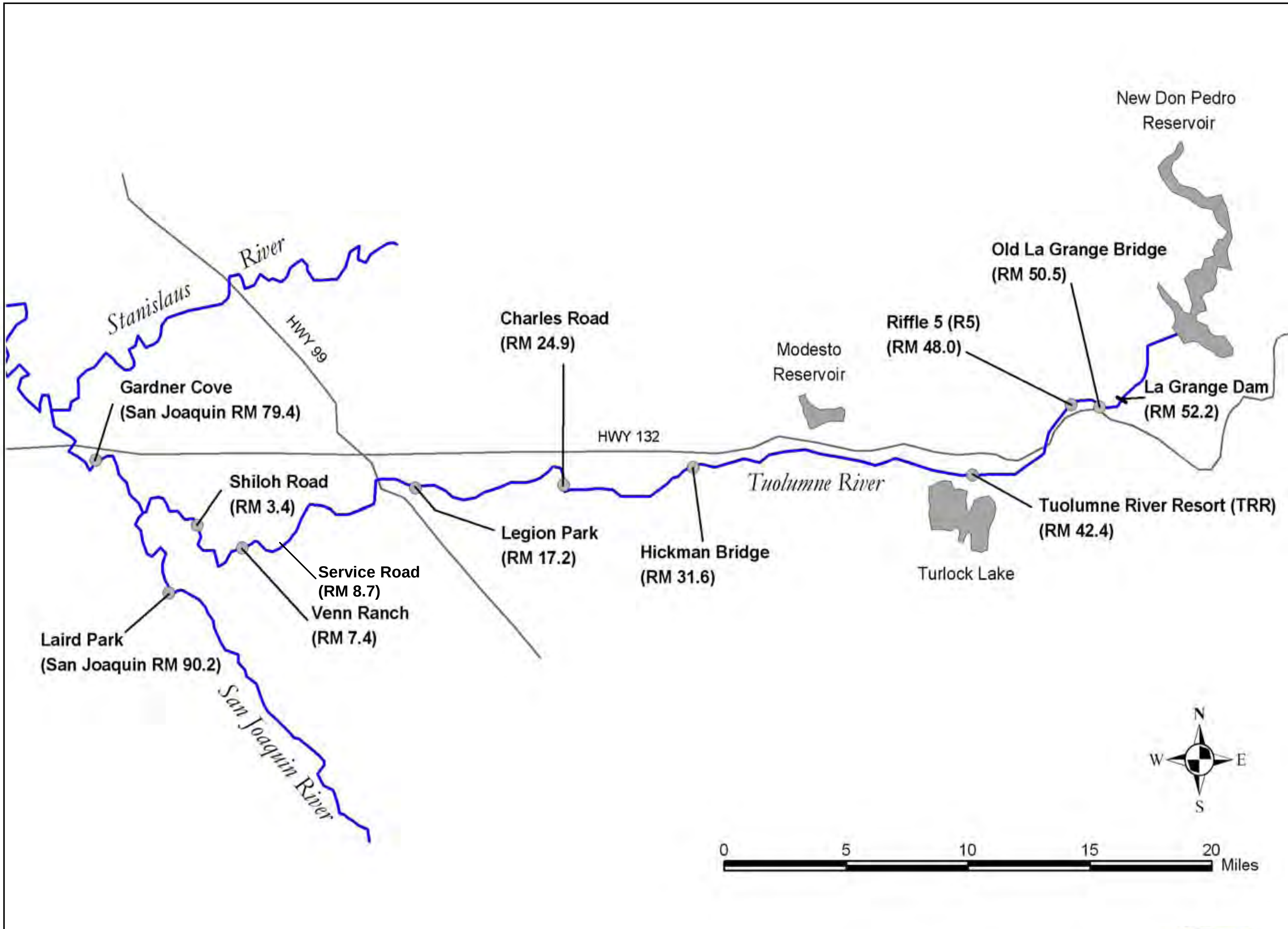

Figure 1. Locations of seine sampling sites on the lower Tuolumne and San Joaquin Rivers, 2010.

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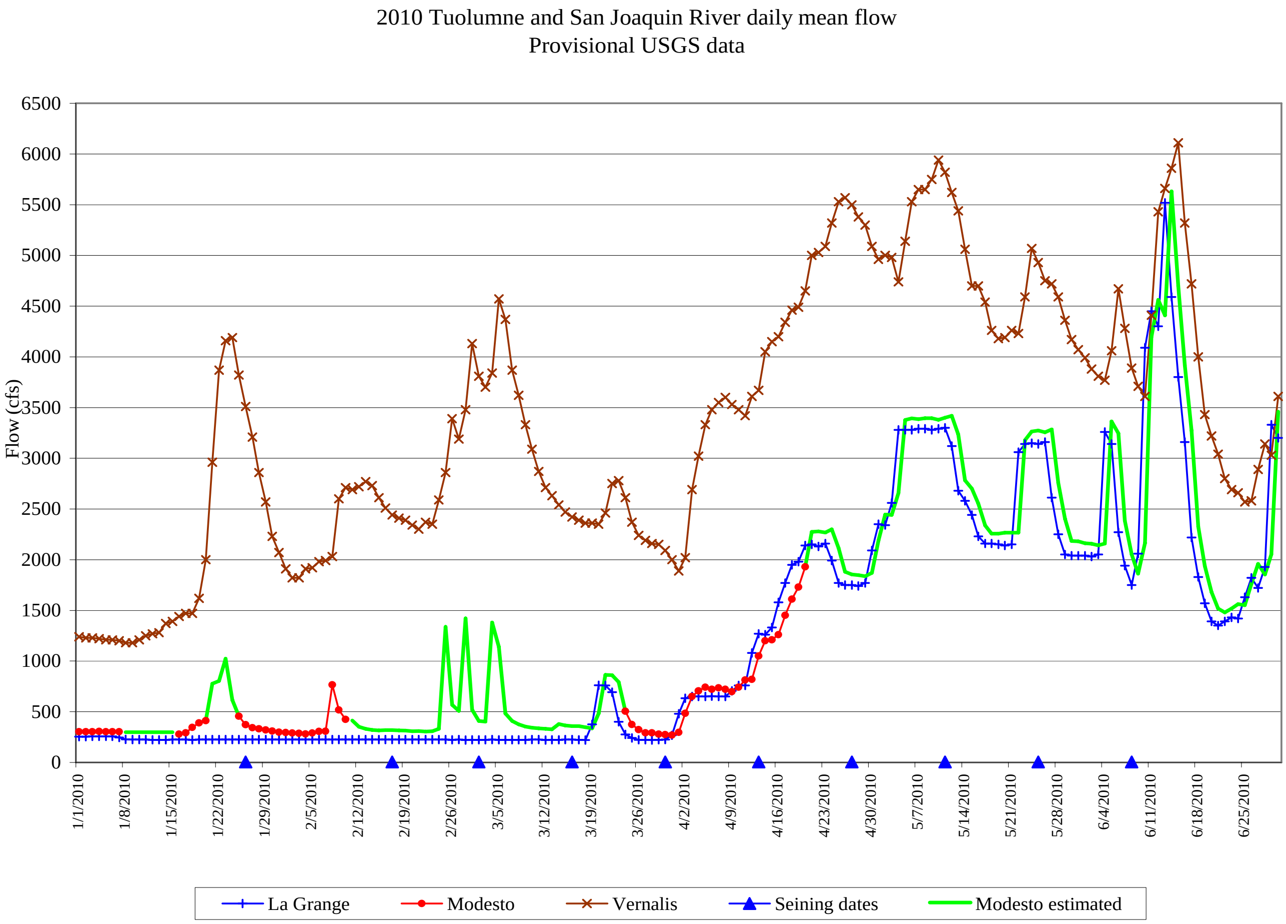


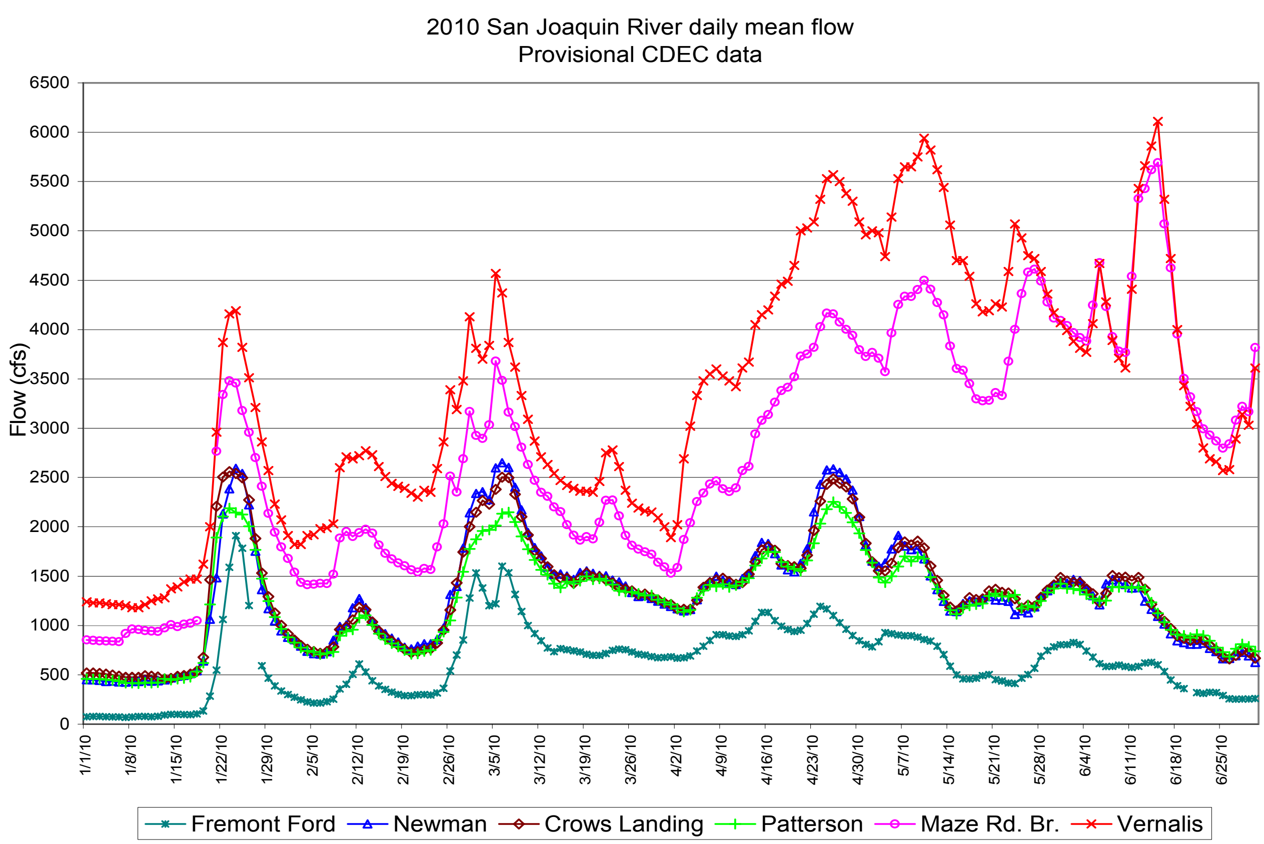
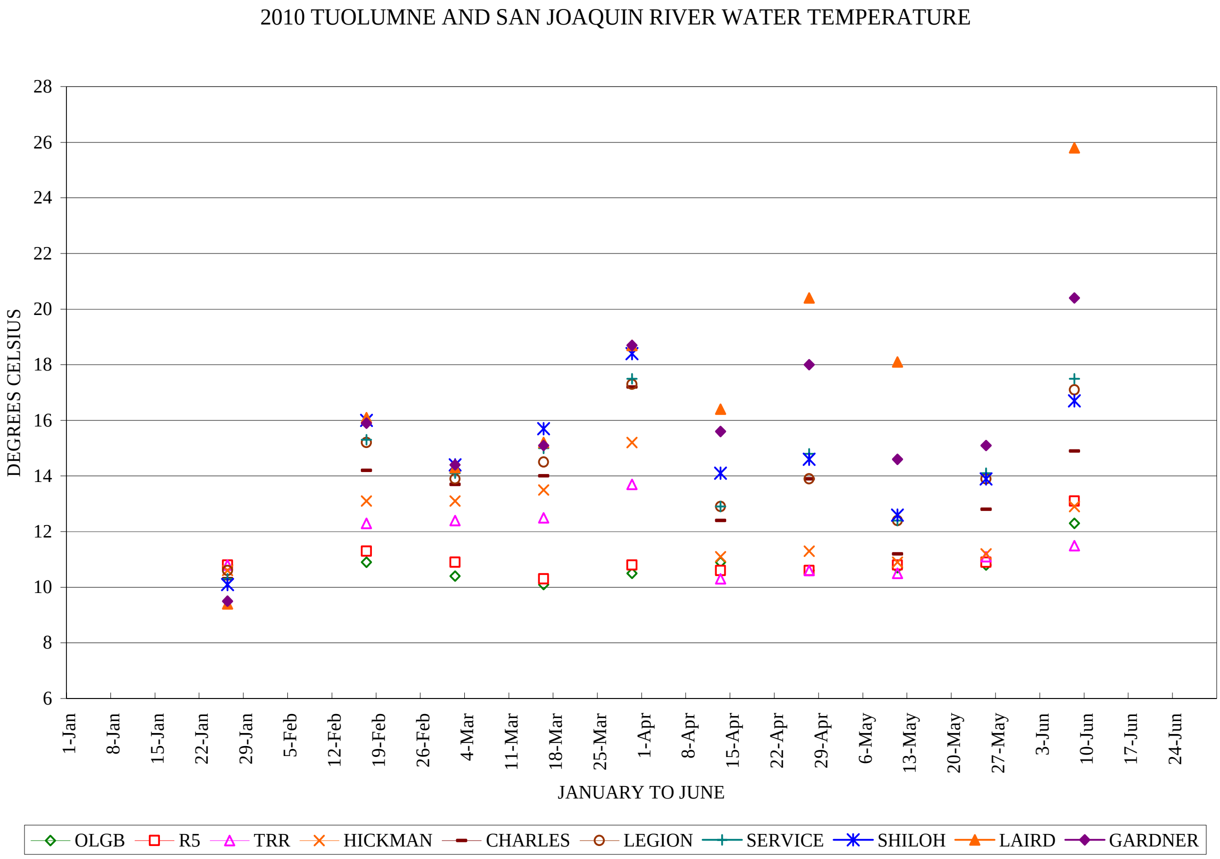


Figure 2. Tuolumne and San Joaquin River daily average flow.



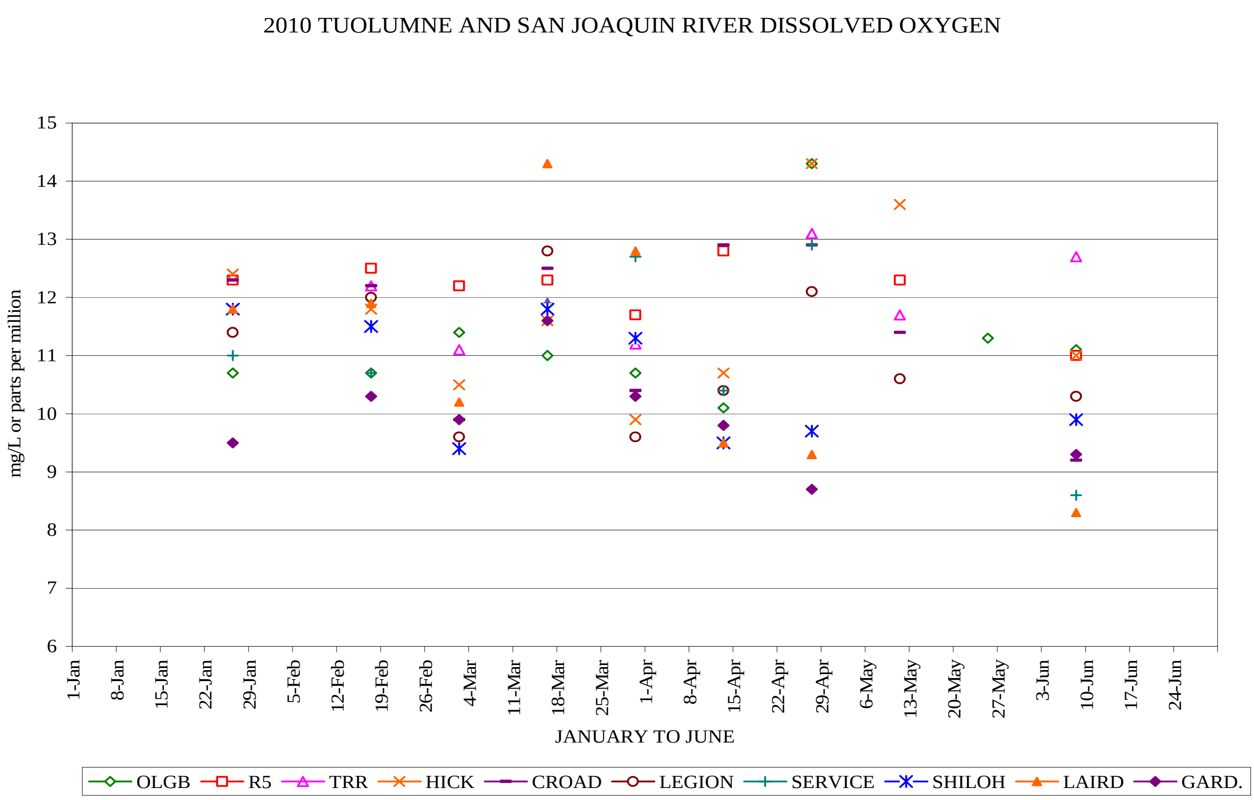
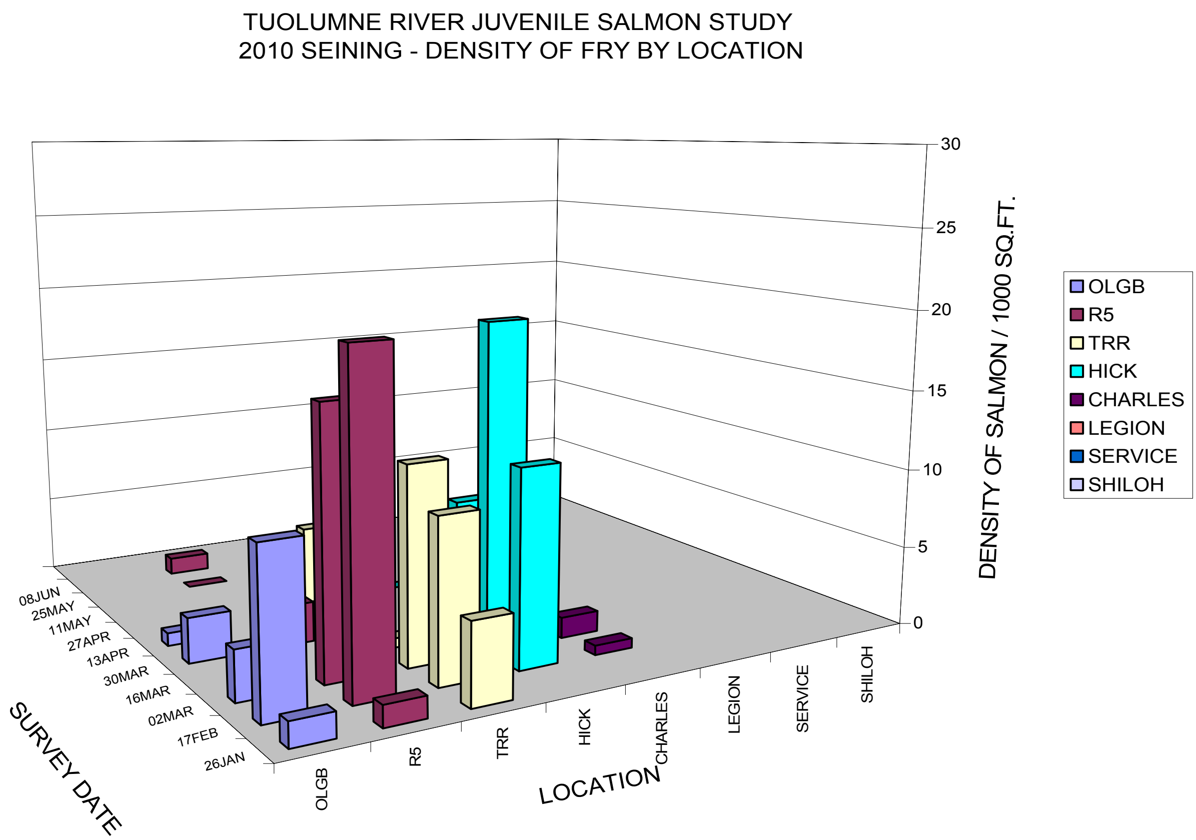


Figure 3. 2010 Tuolumne and San Joaquin River water temperature and dissolved oxygen.



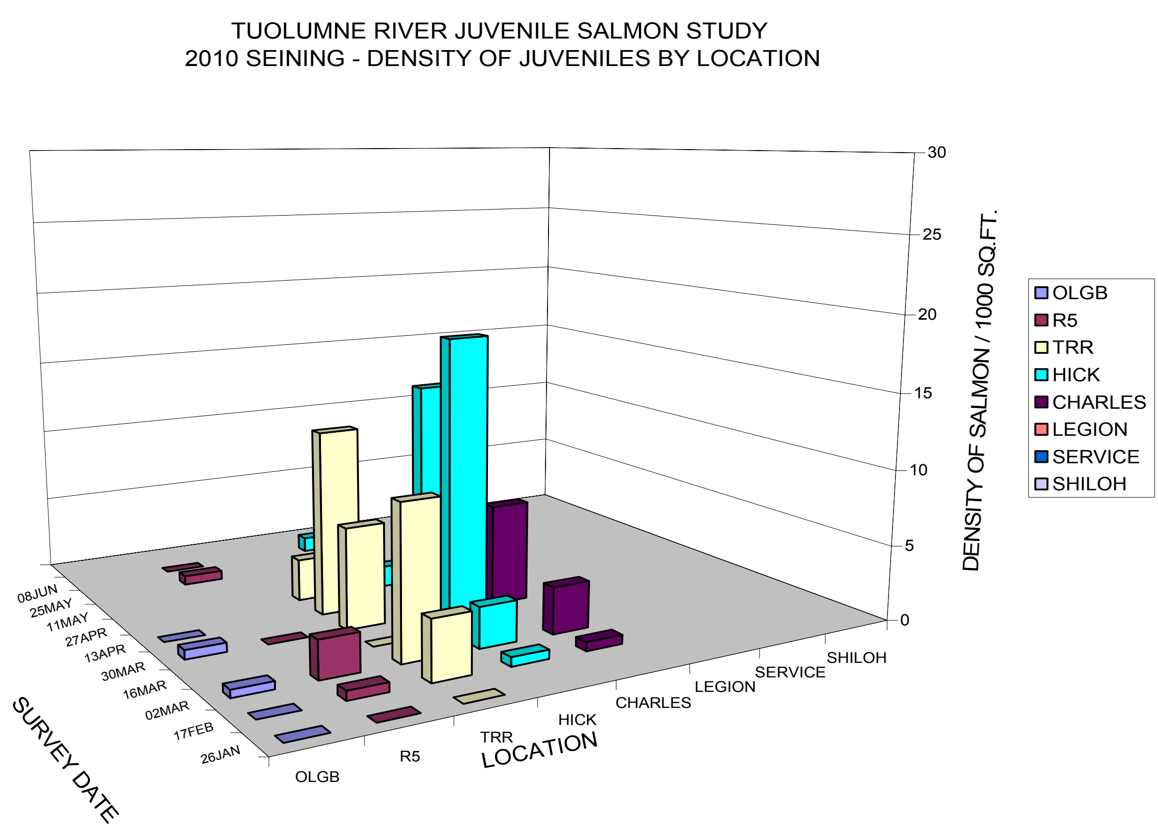


Figure 4. Tuolumne River density of fry and juvenile salmon by location.

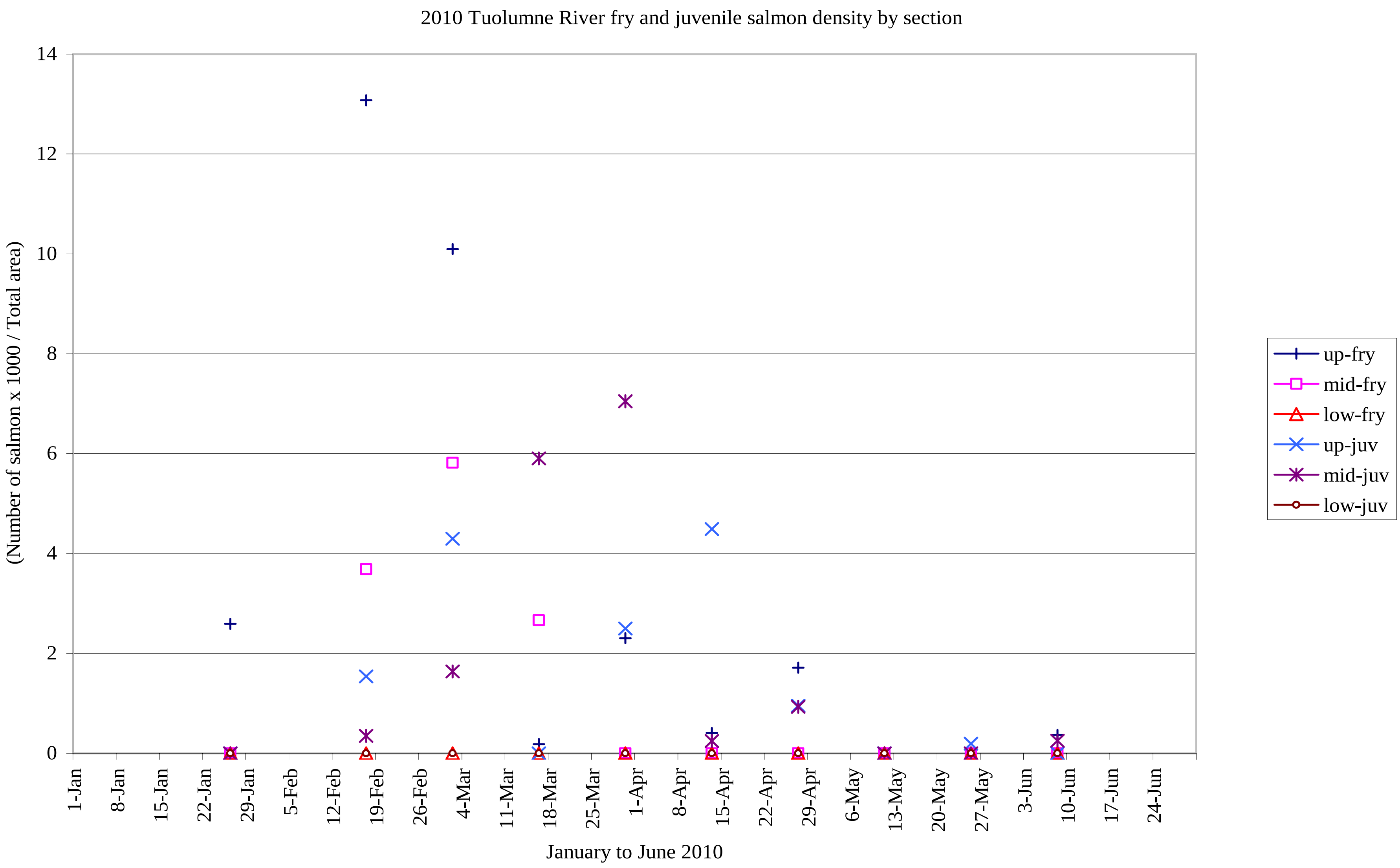


Figure 5. 2010 Tuolumne River fry and juvenile salmon density by section.

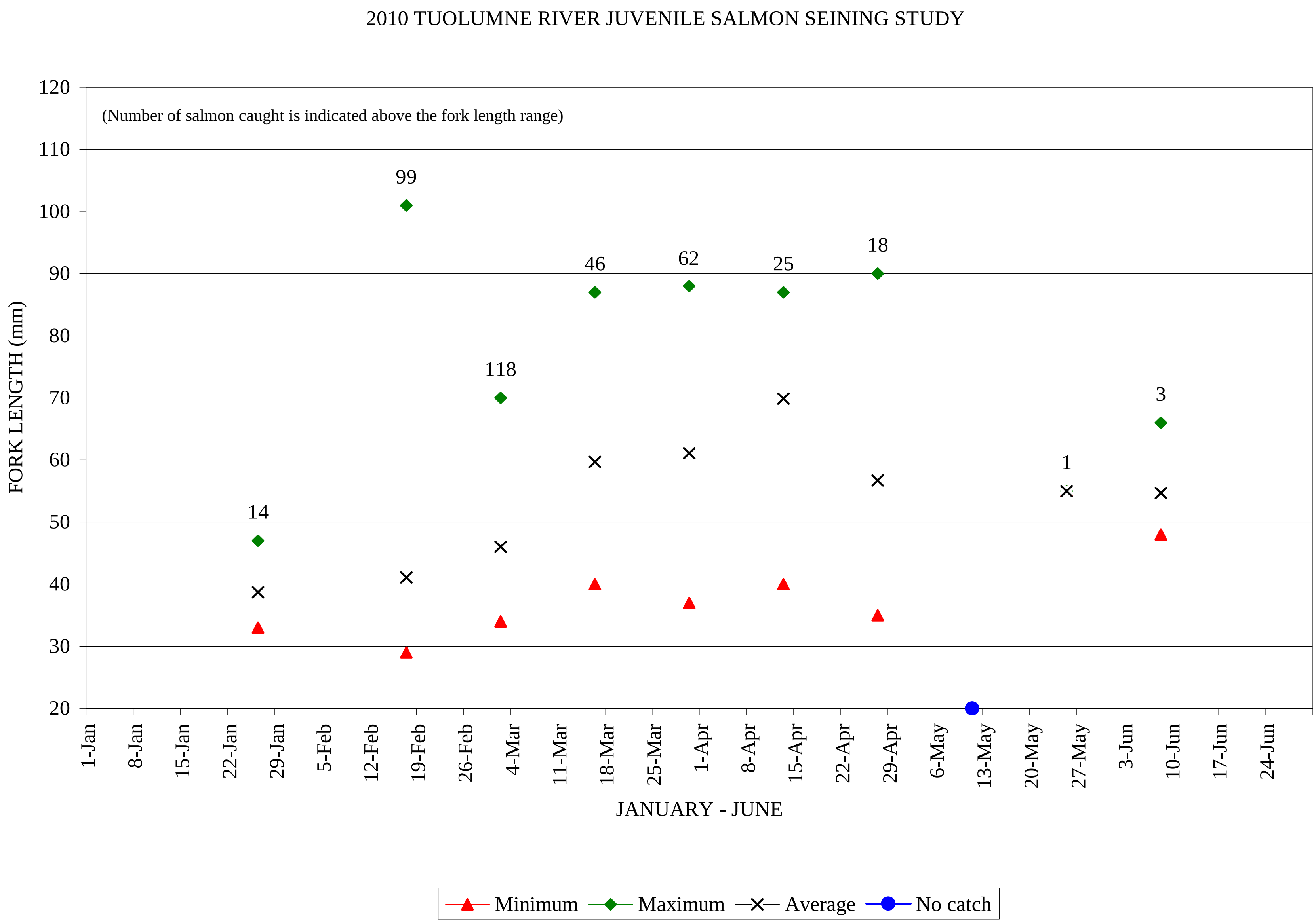


Figure 6. Fork length ranges of wild salmon in the Tuolumne River, 2010.

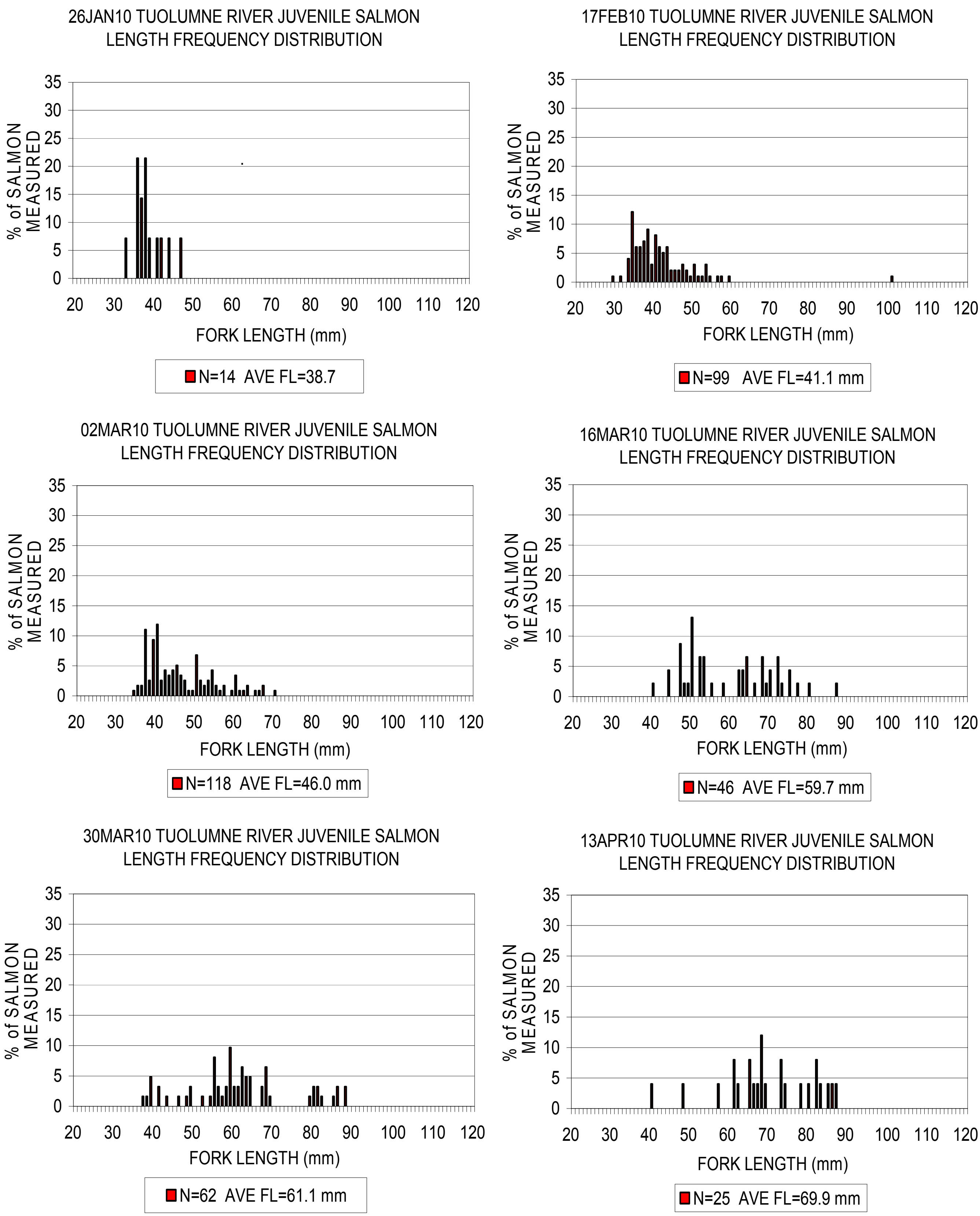


Figure 7. Length frequency distribution by date of salmon in the Tuolumne River, 2010.

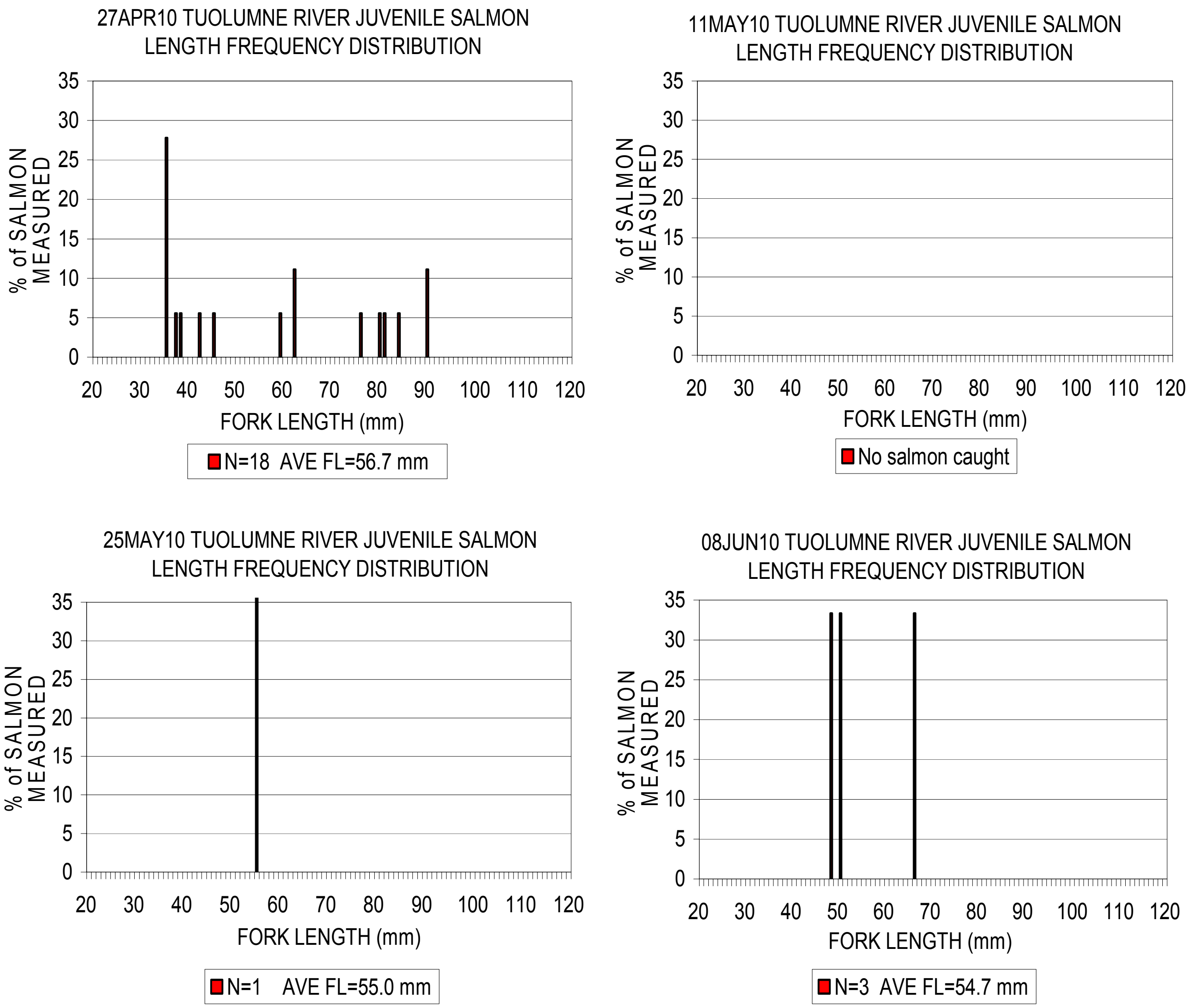


Figure 8. Length frequency distribution by date of salmon in the Tuolumne River, 2010.

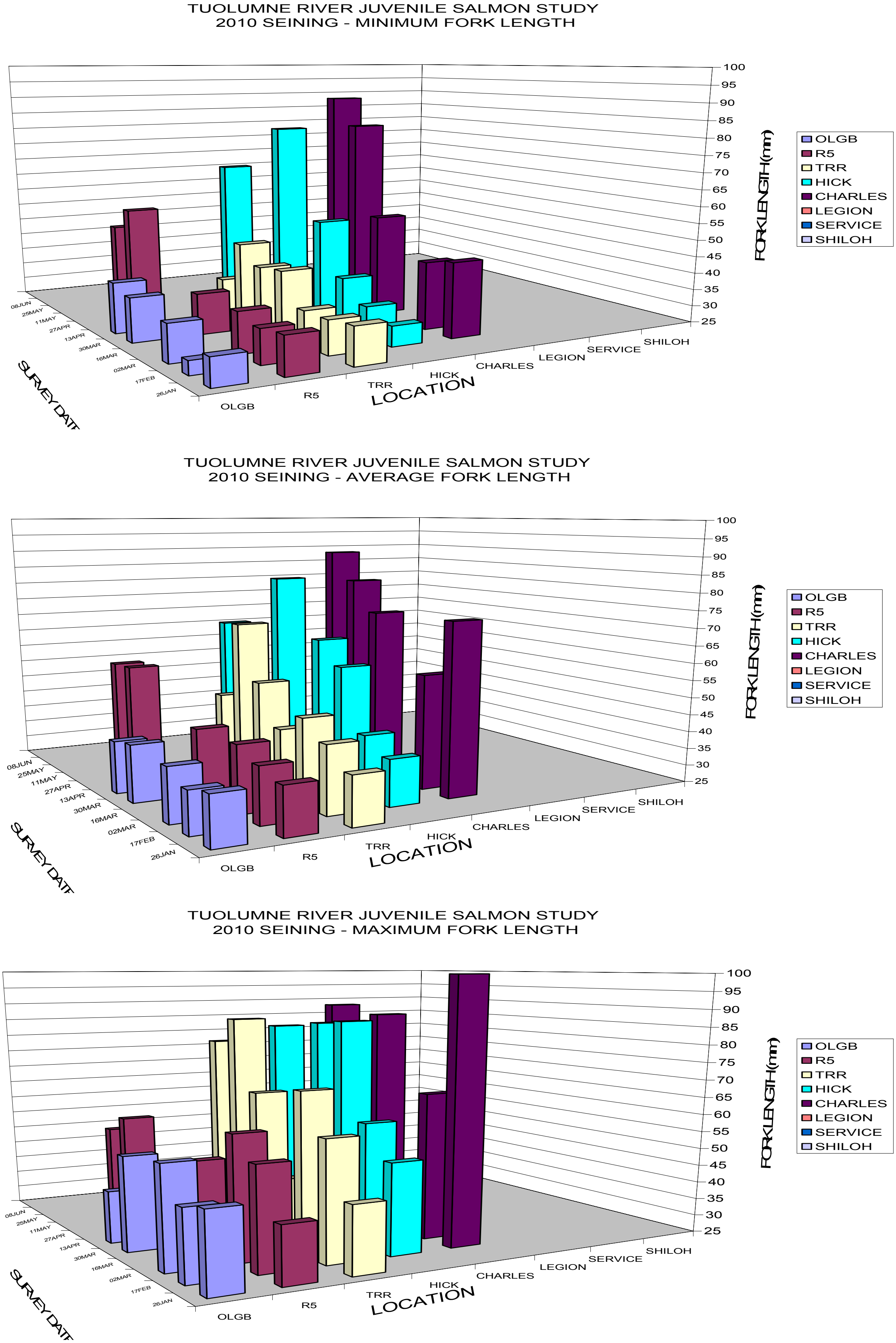
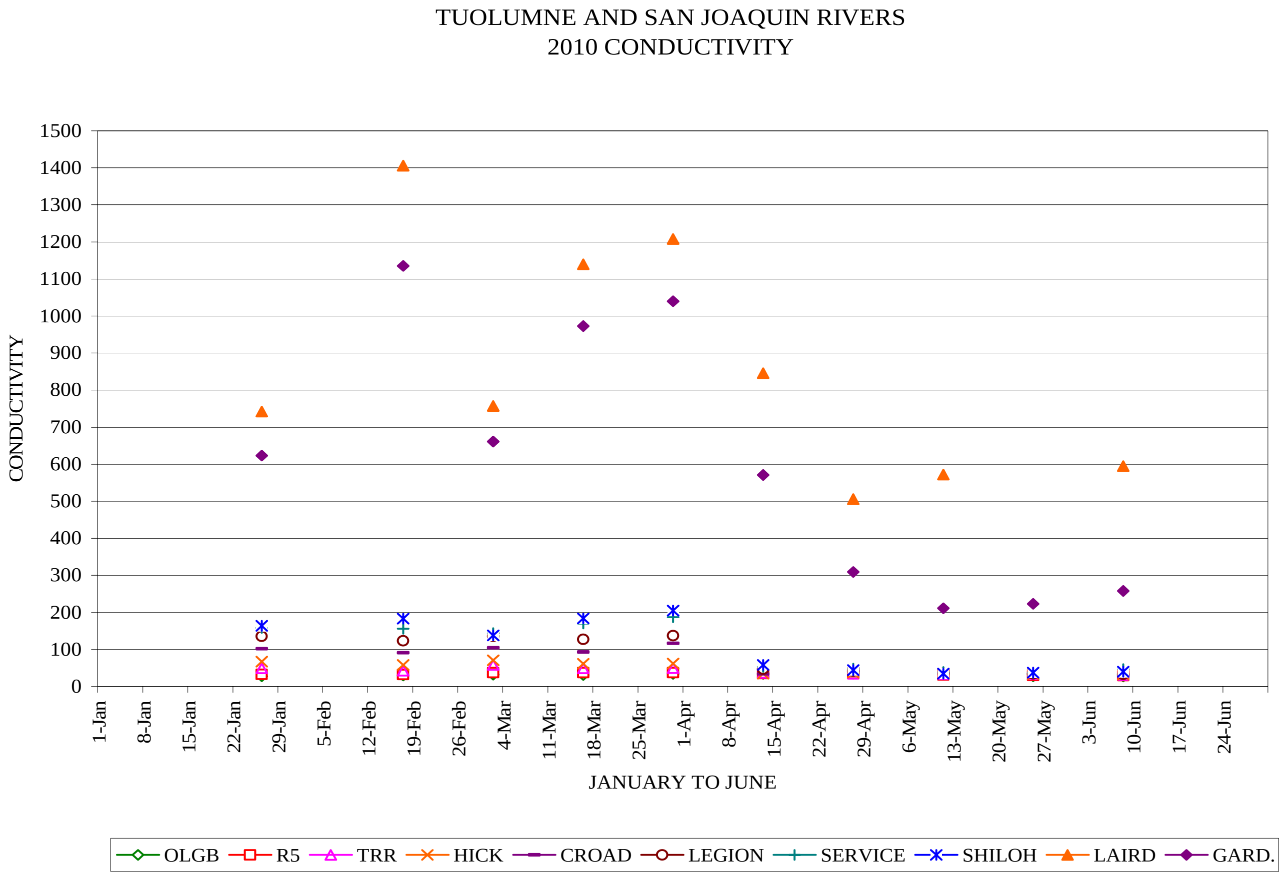


Figure 9. Minimum, average, and maximum fork length by location and survey period, 2010.



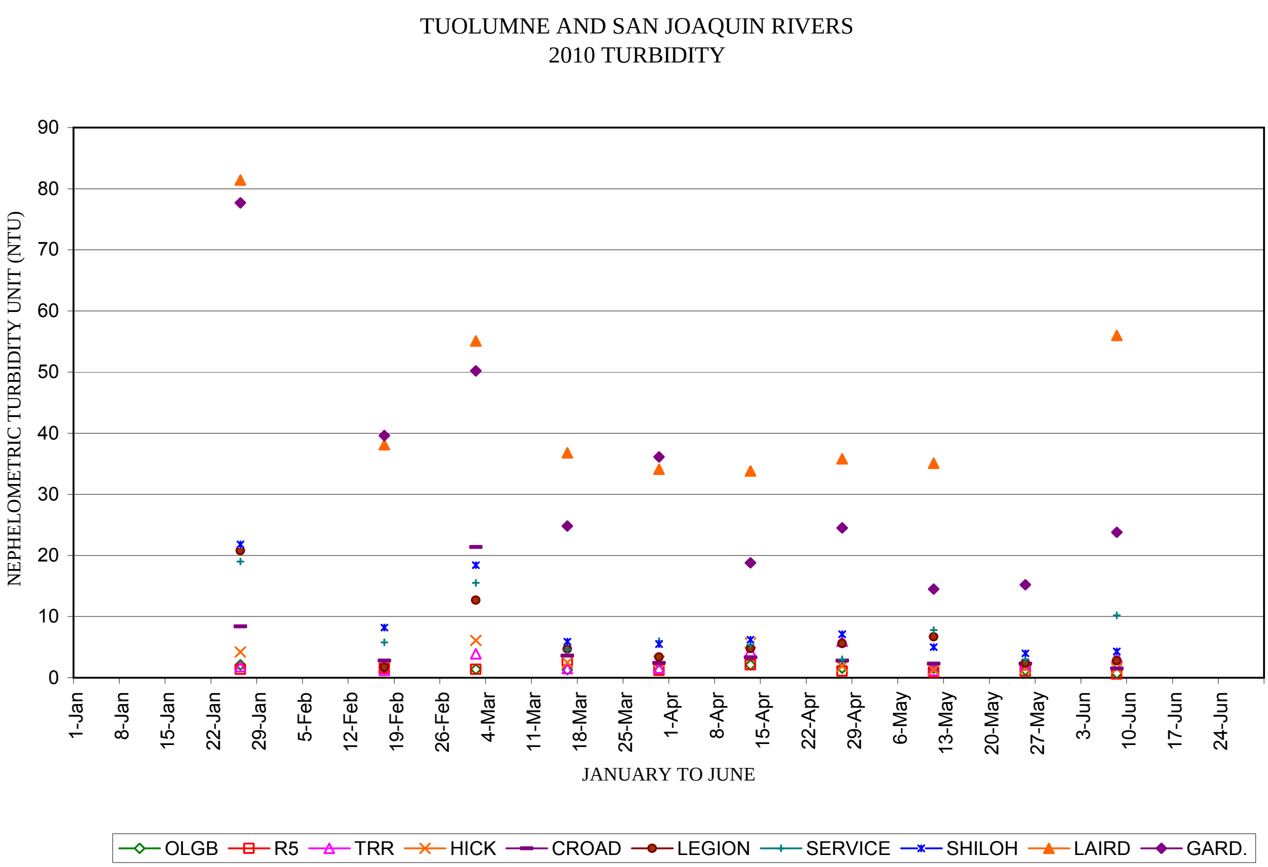
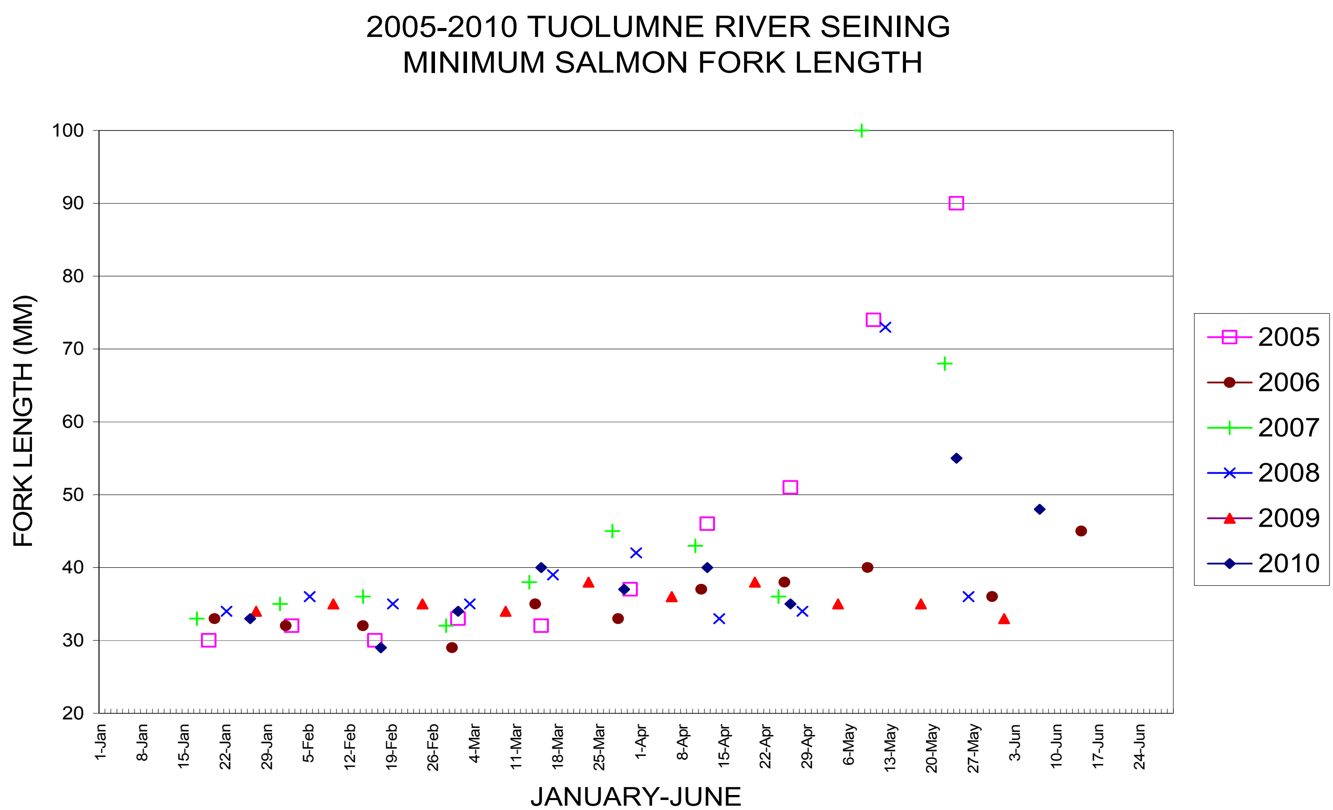
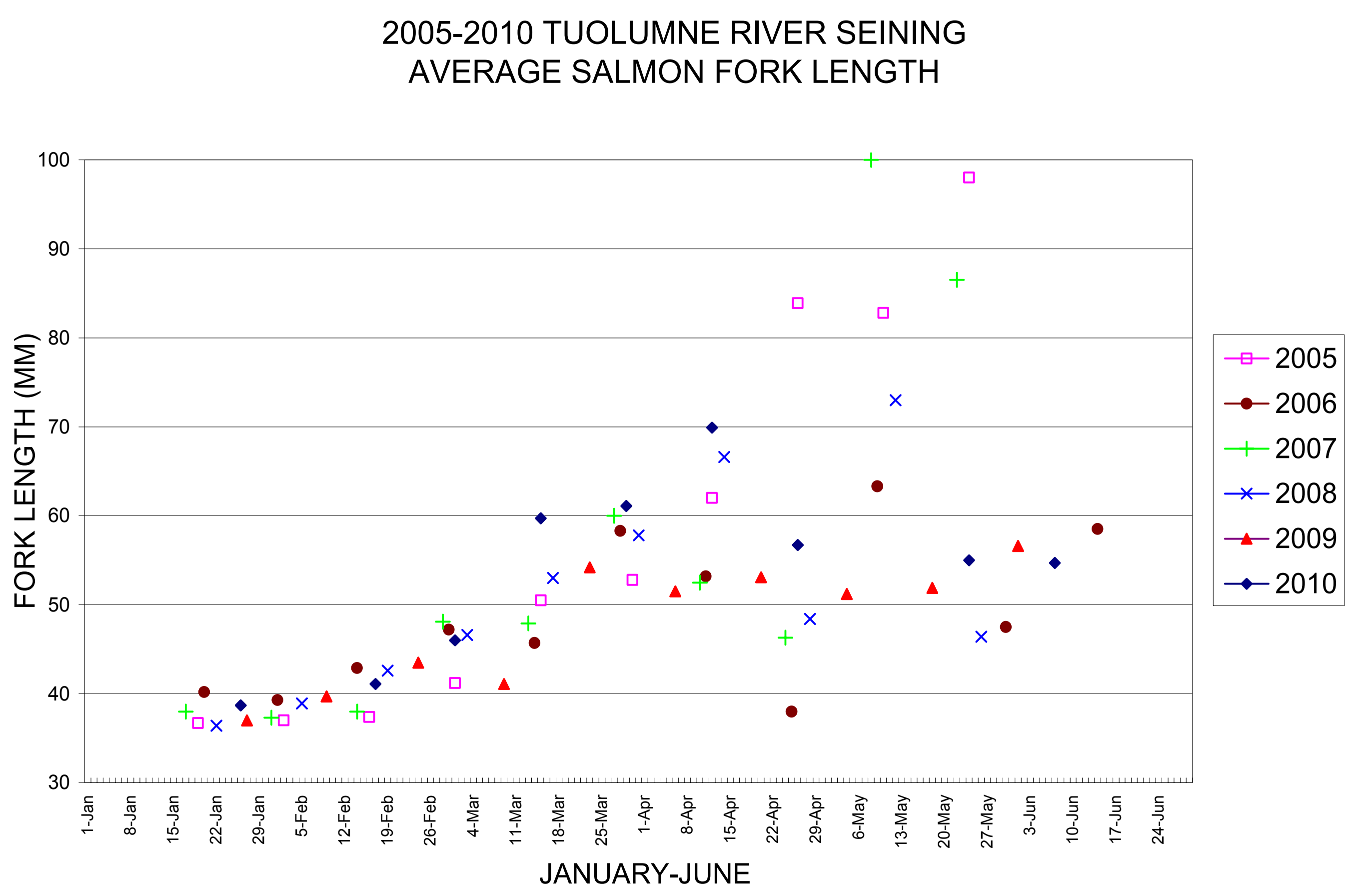
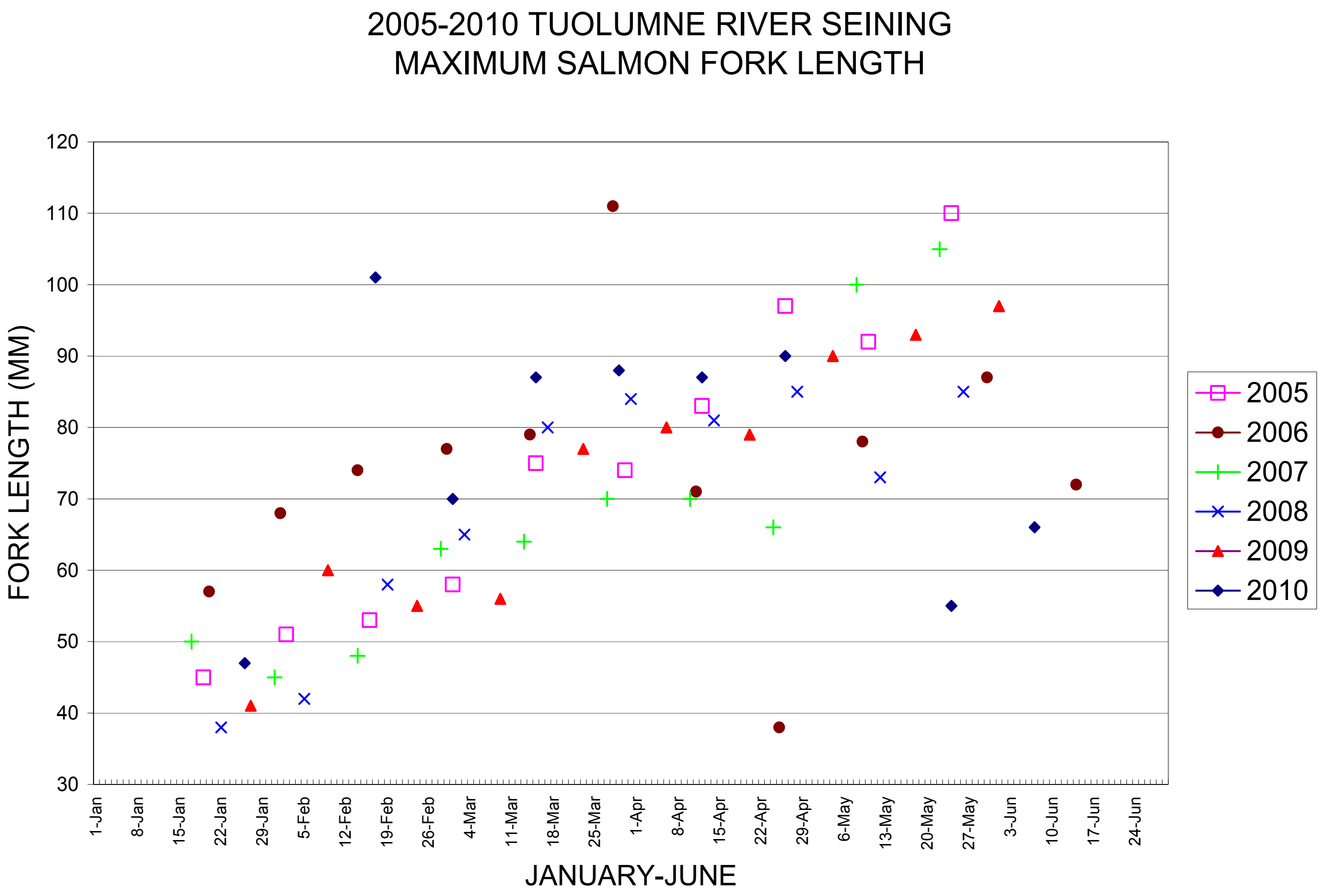


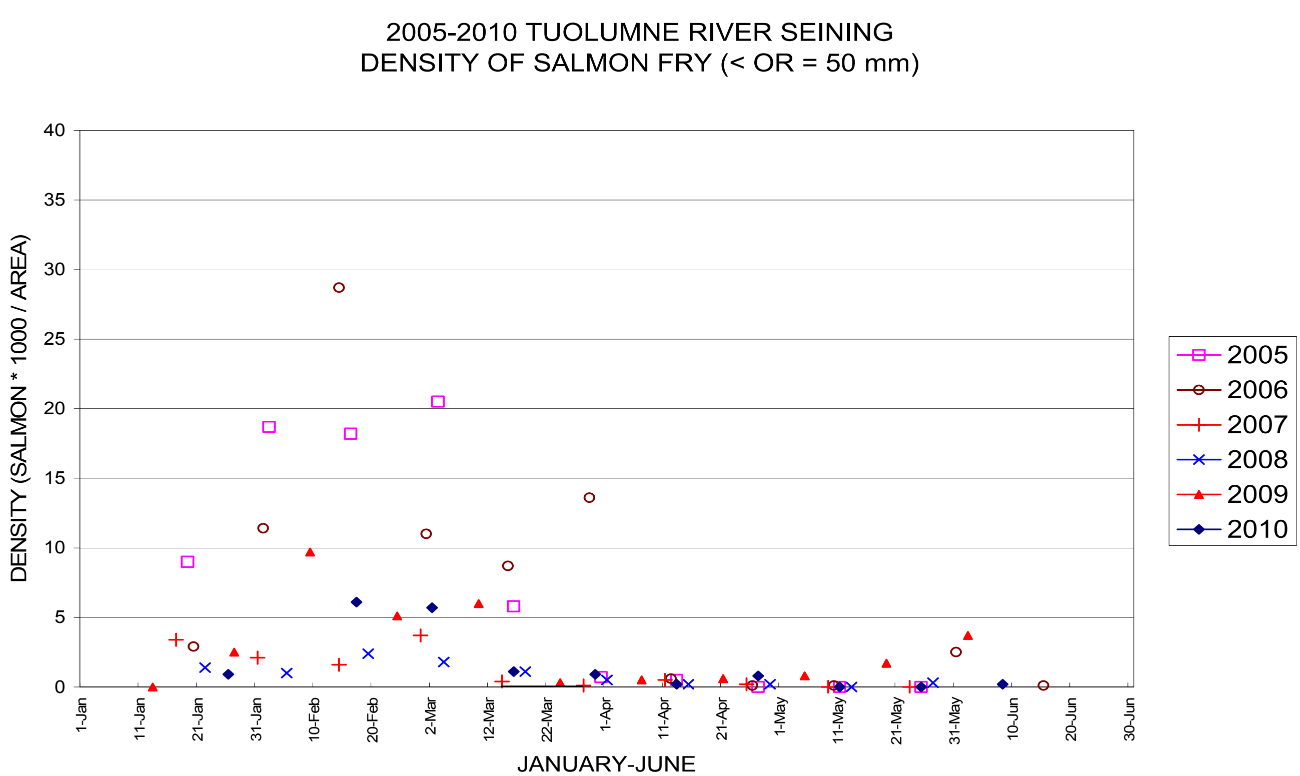
Figure 10. Conductivity and turbidity in the Tuolumne and San Joaquin Rivers, 2010



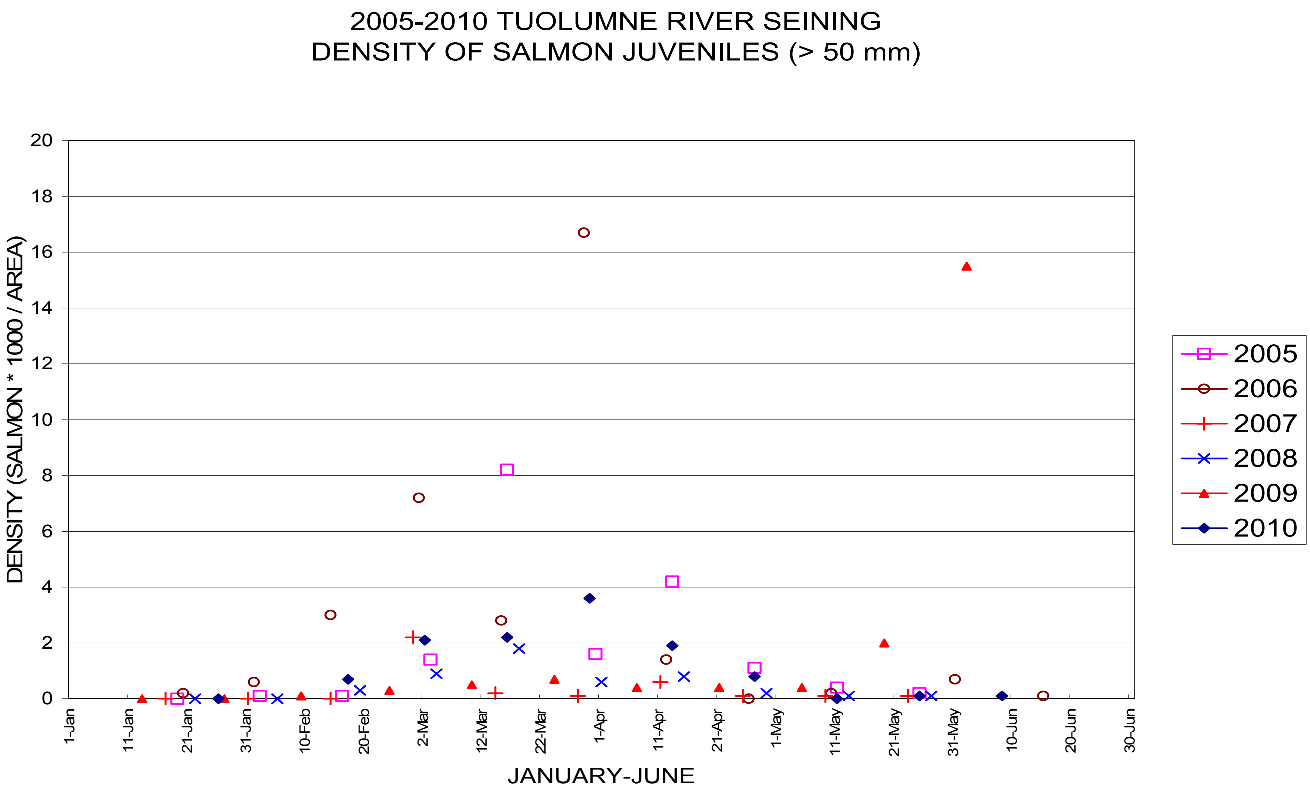


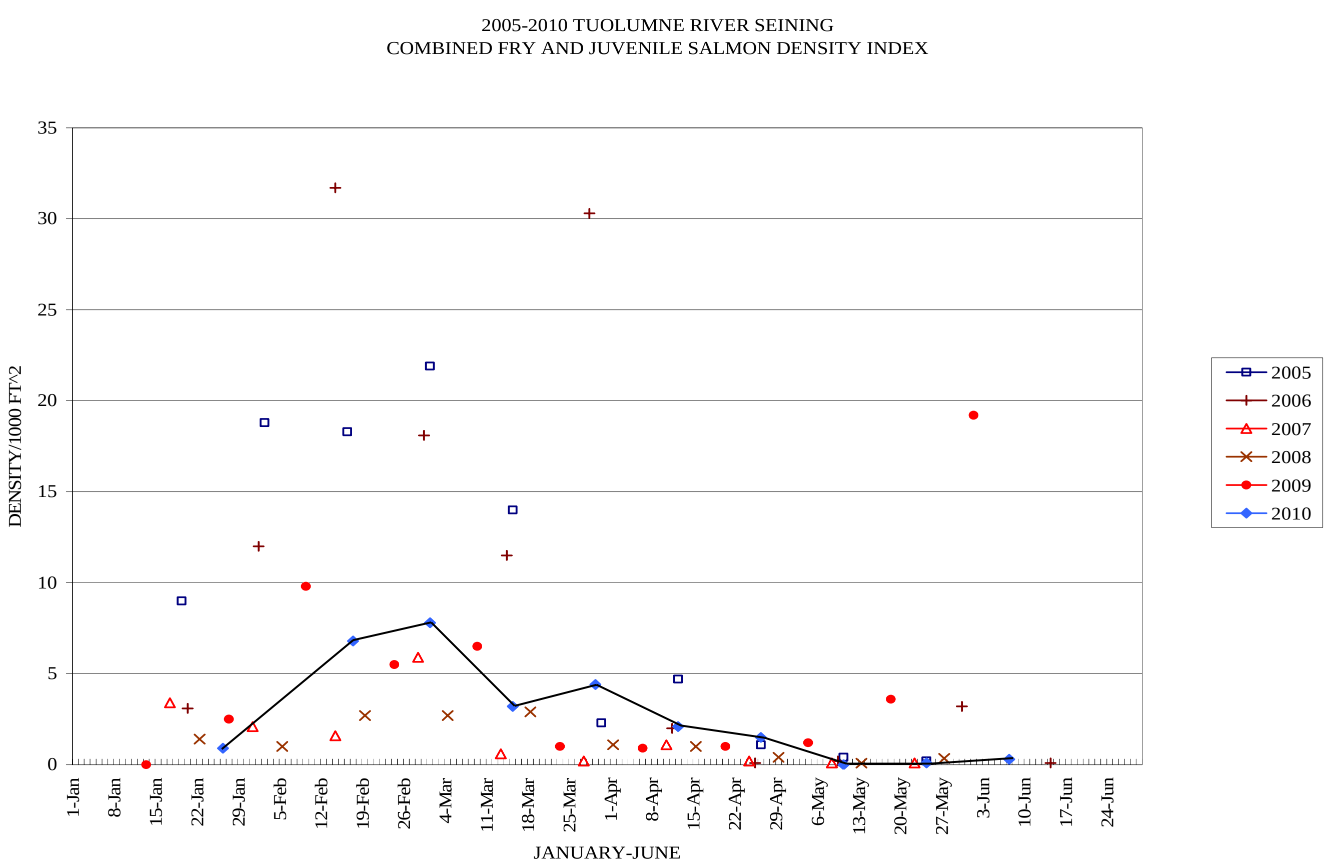
Figures 11 & 12. Minimum and average fork lengths of Tuolumne River salmon, 2005-2010.



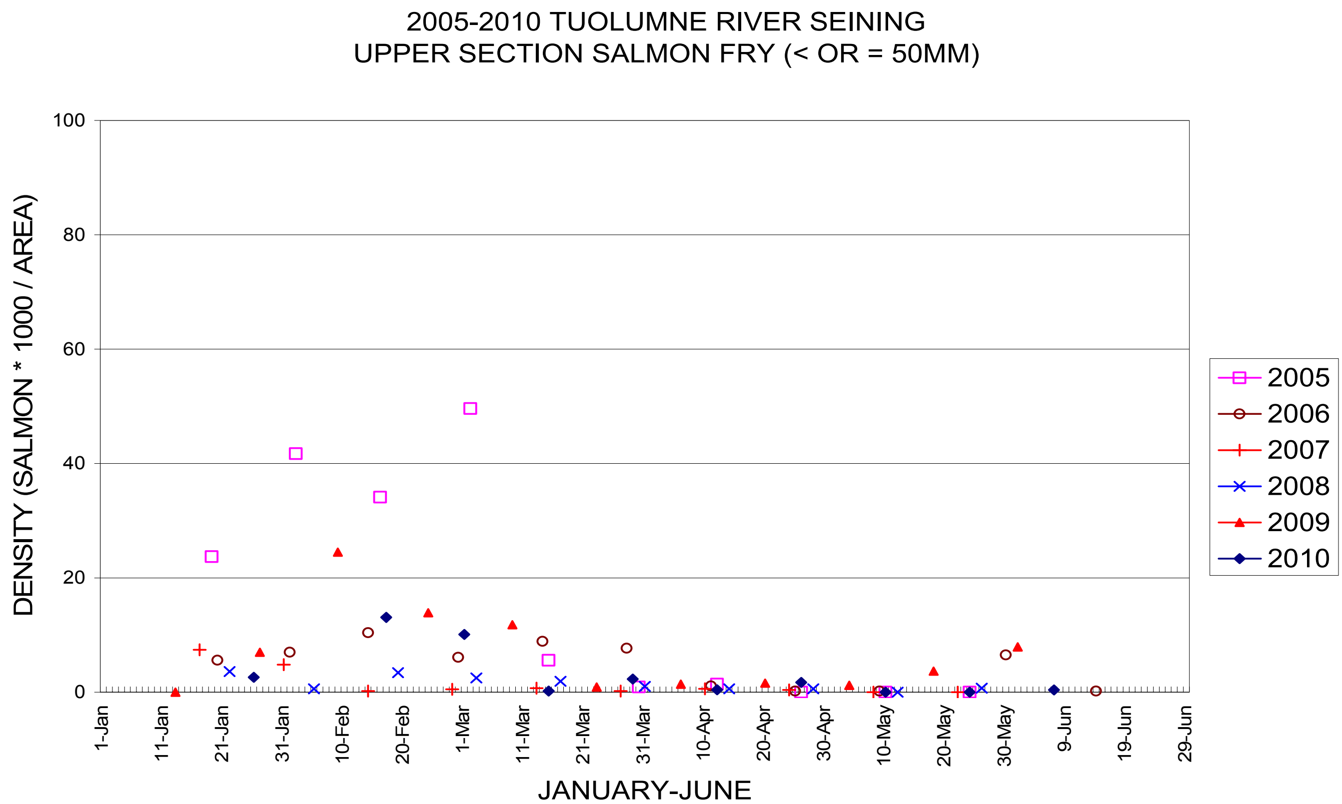


Figures 13 & 14. Maximum fork length and Density index of salmon fry, 2005-2010.





Figures 15 & 16. Density index of salmon juveniles and total river salmon catch, 2005-2010.



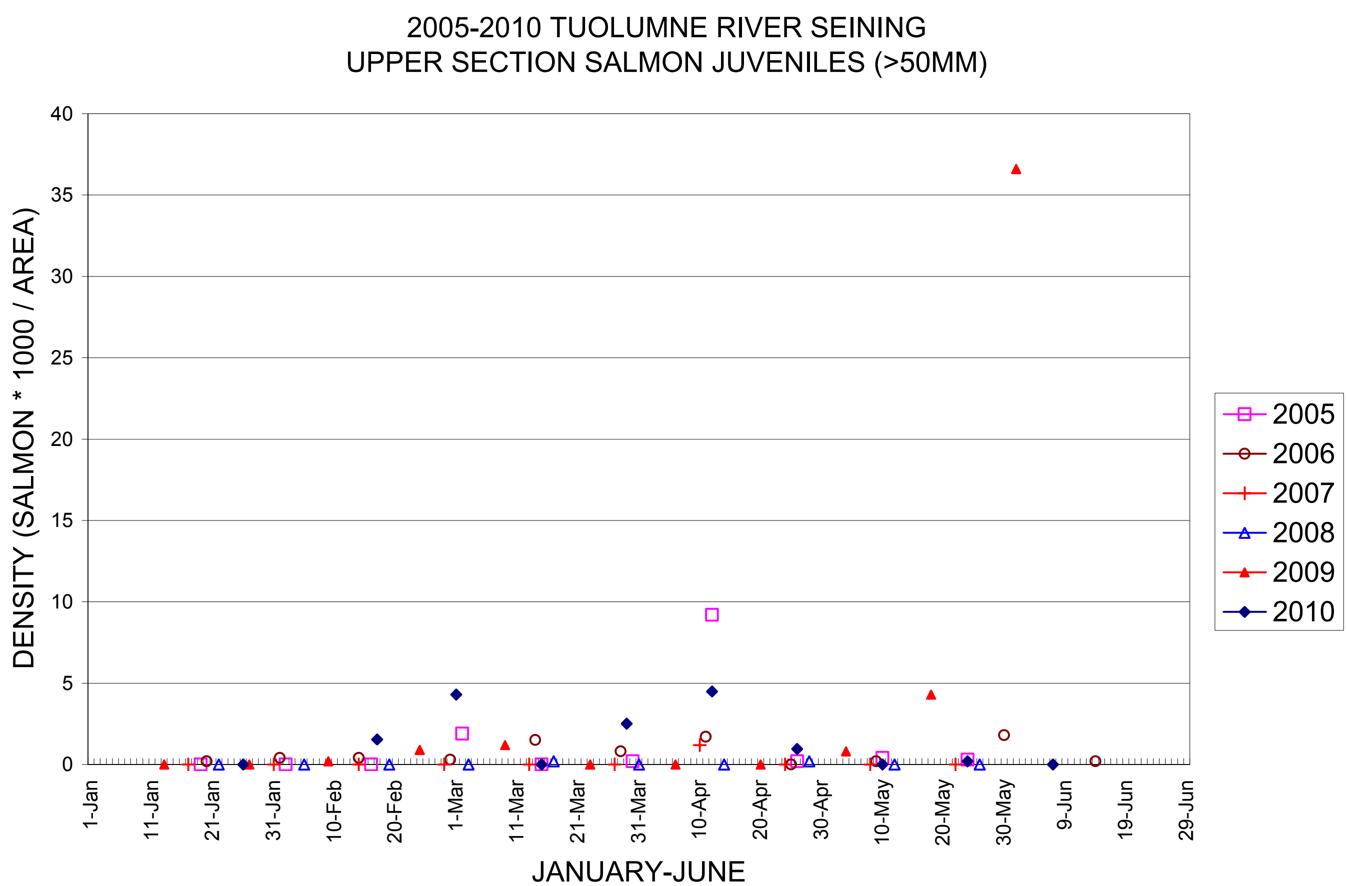


Figure 17. Upper section density indices for salmon fry and juveniles, 2005-2010

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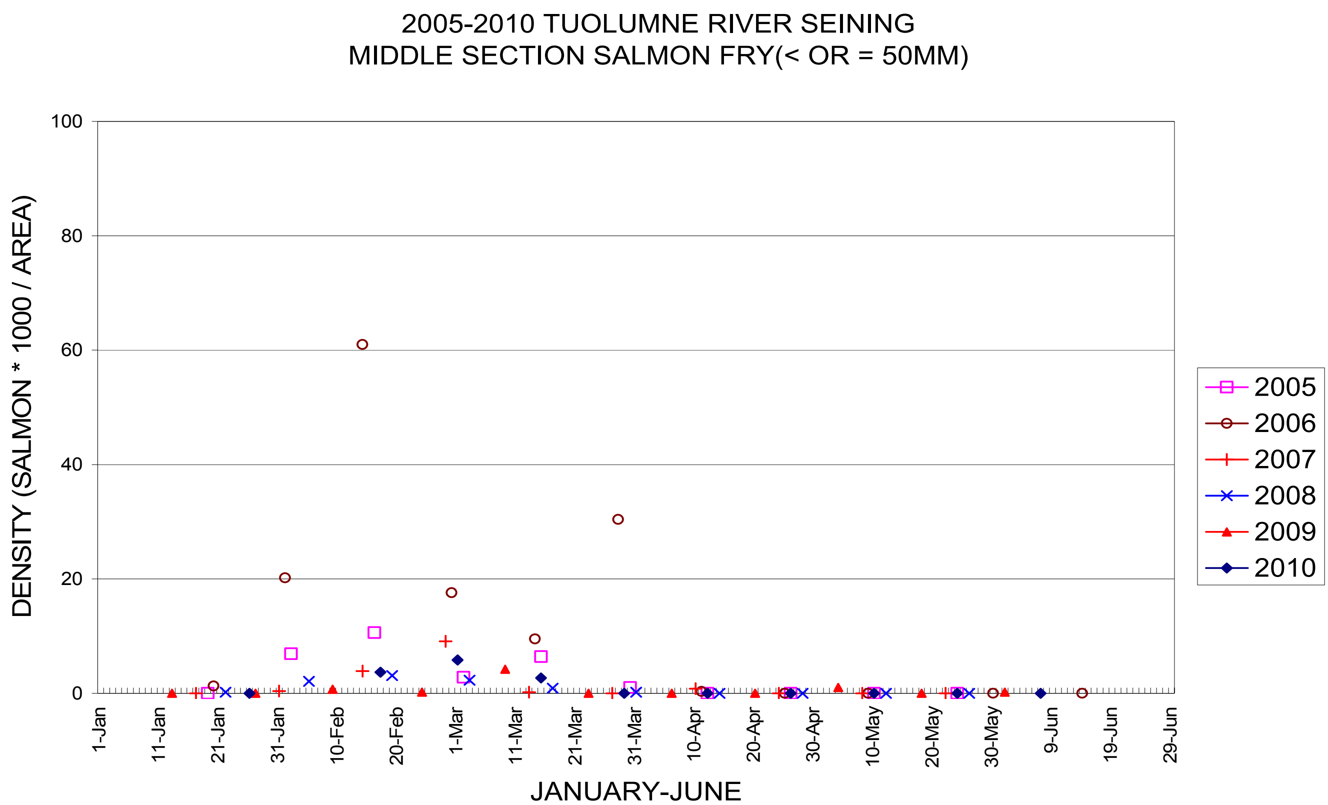


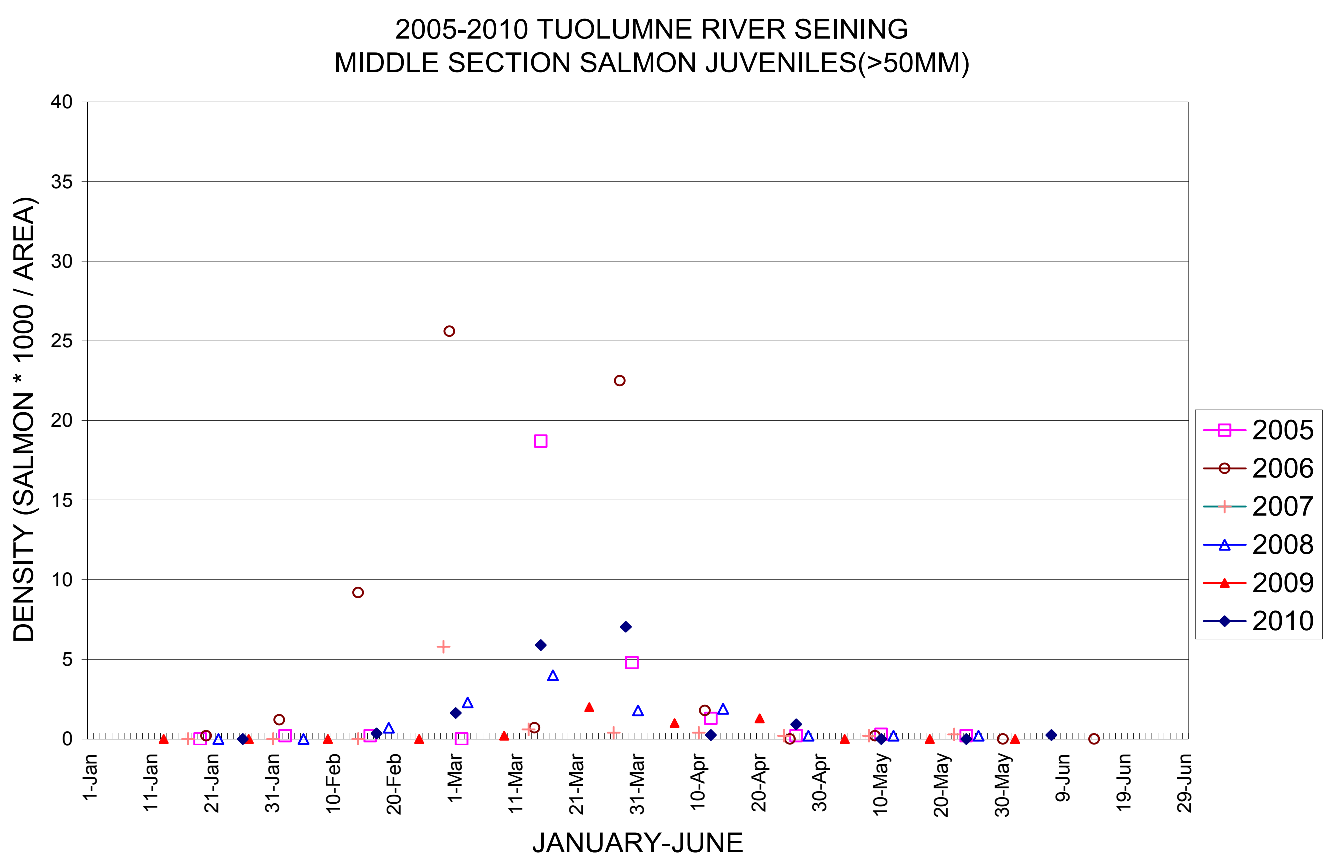
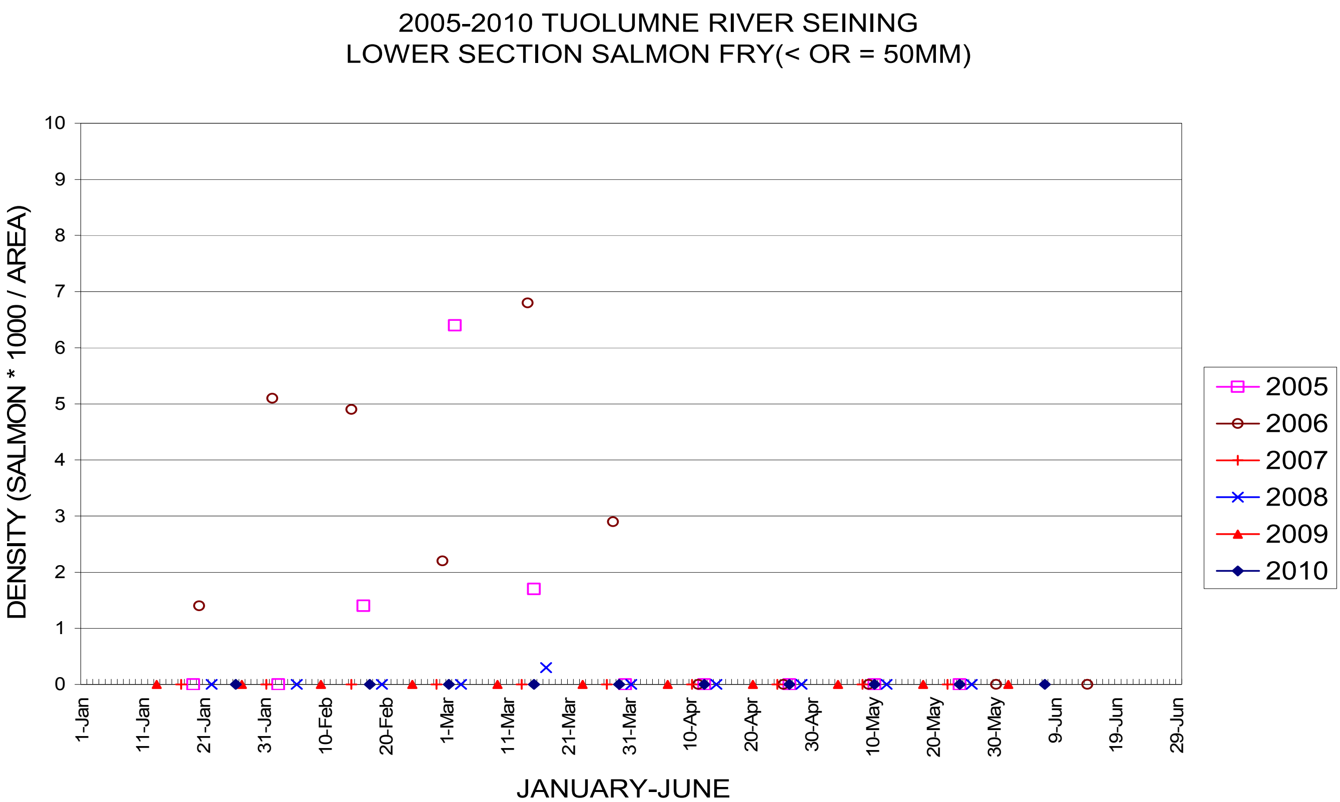


Figure 17. Middle section density indices for salmon fry and juveniles, 2005-2010.



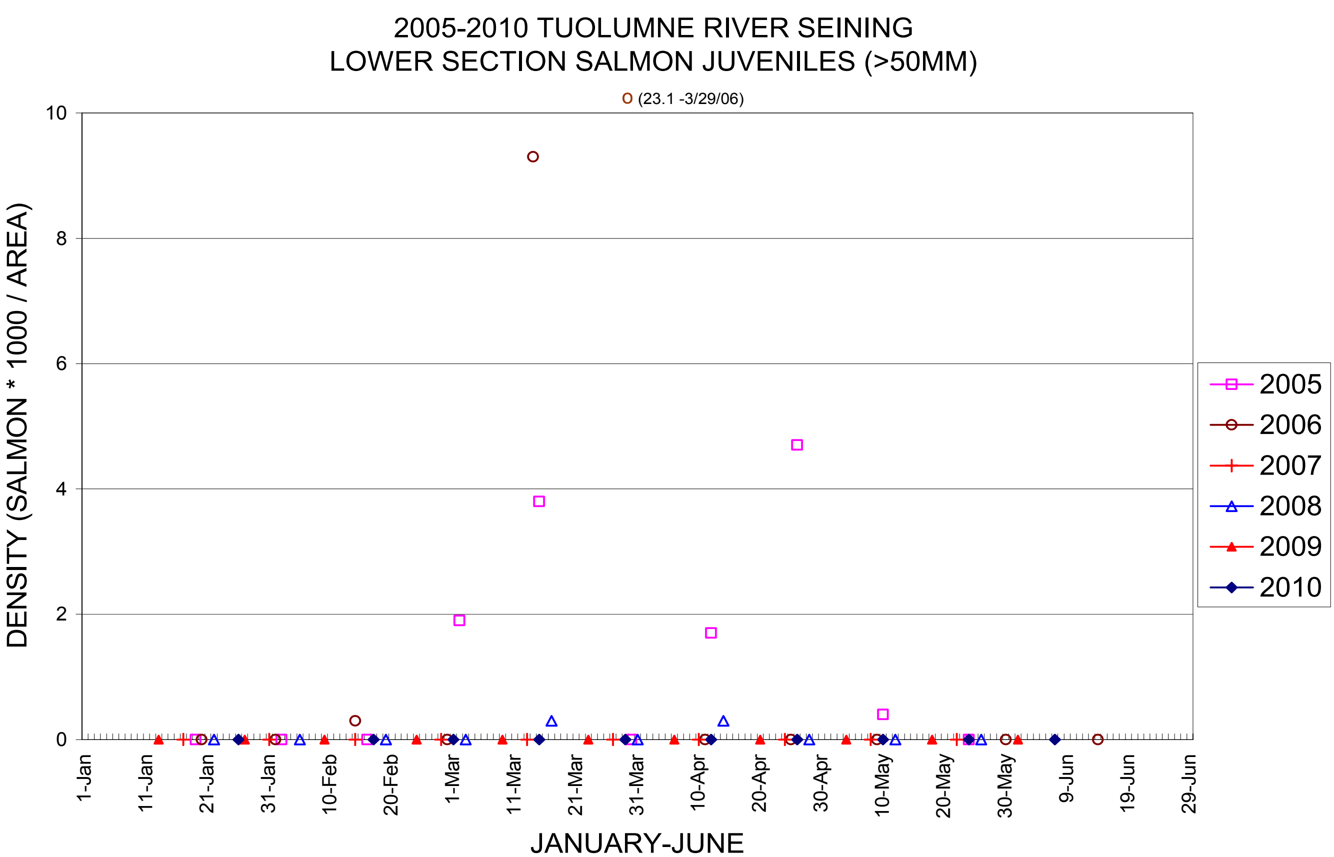


Figure 17. Lower section density indices for salmon fry and juveniles, 2005-2010.

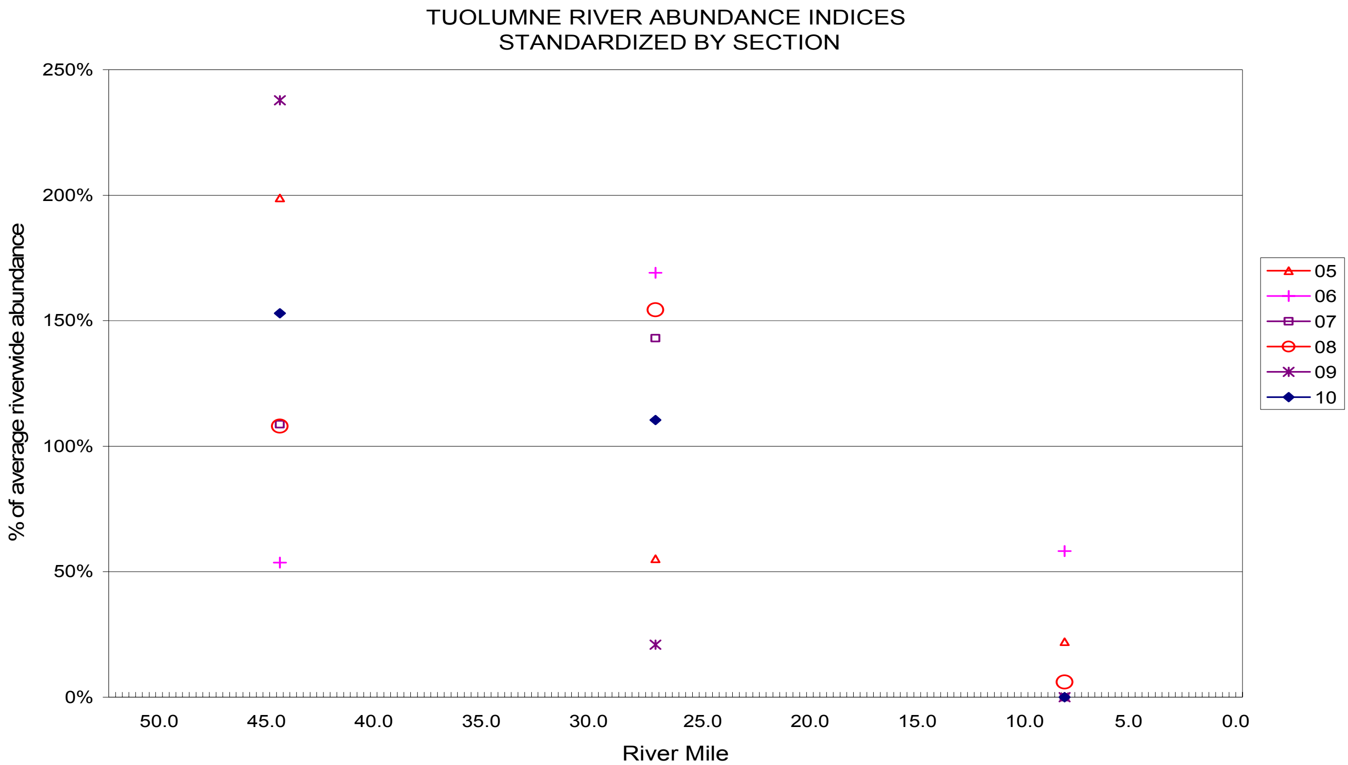


Figure 18. Tuolumne River abundance indices standardized by section, 2005-2010.

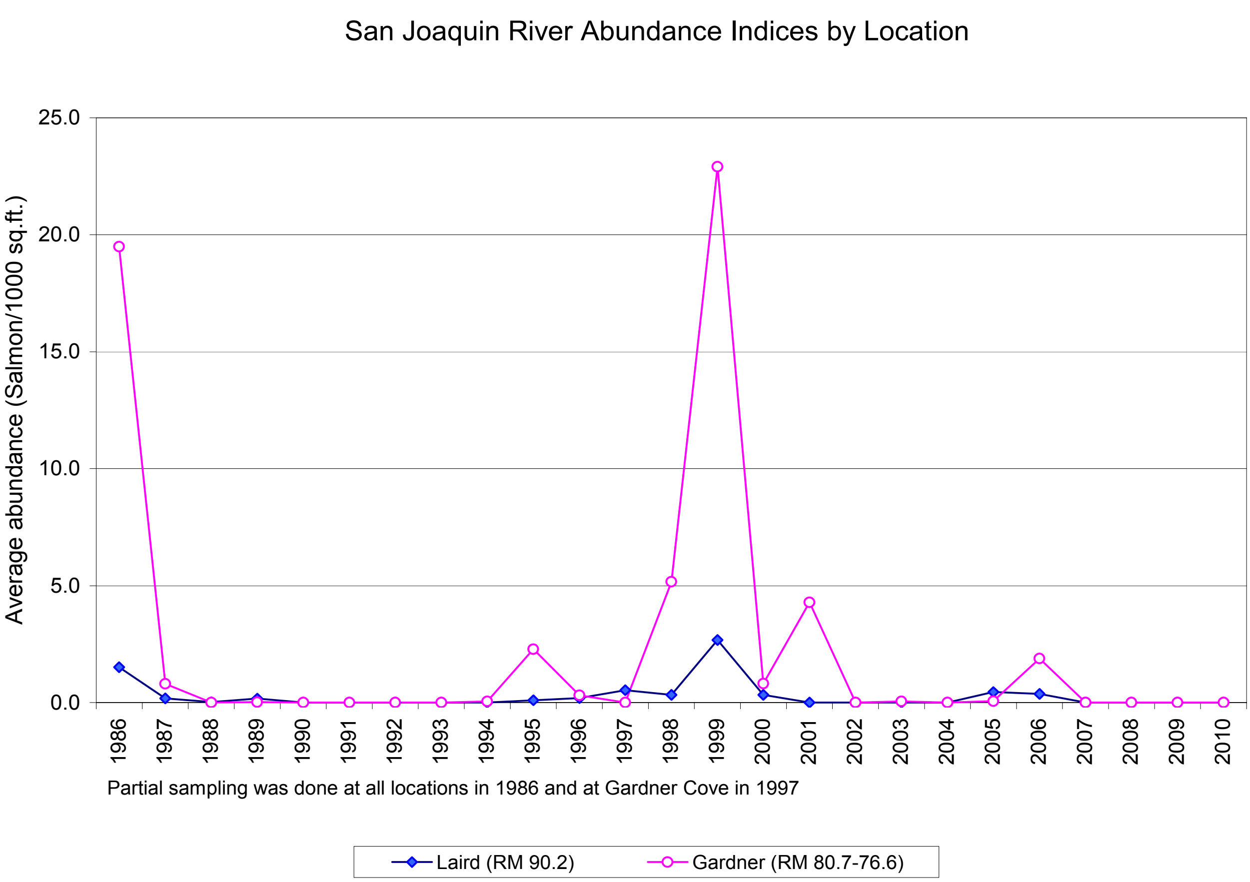


Figure 19. San Joaquin River abundance indices by location, 1986-2010.

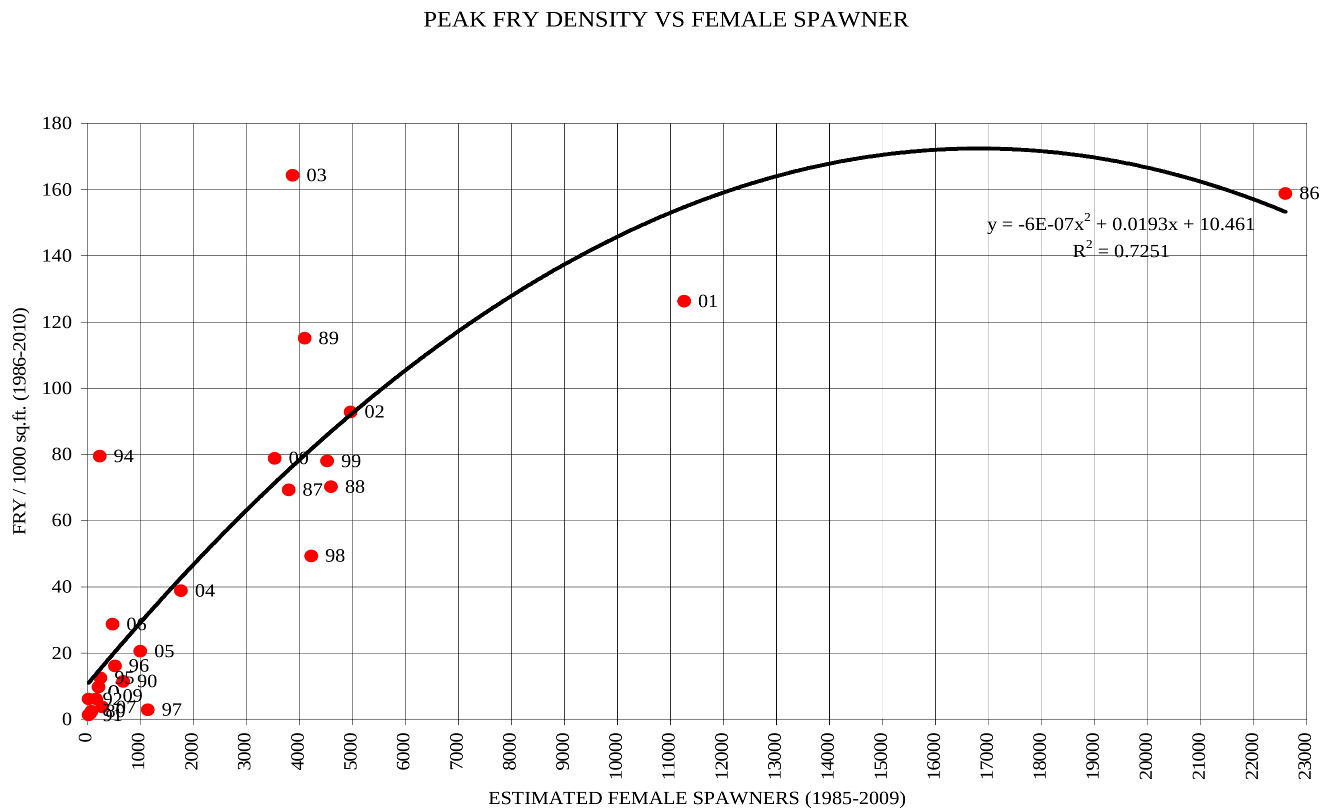


Figure 20. Tuolumne River peak fry density vs female spawners.

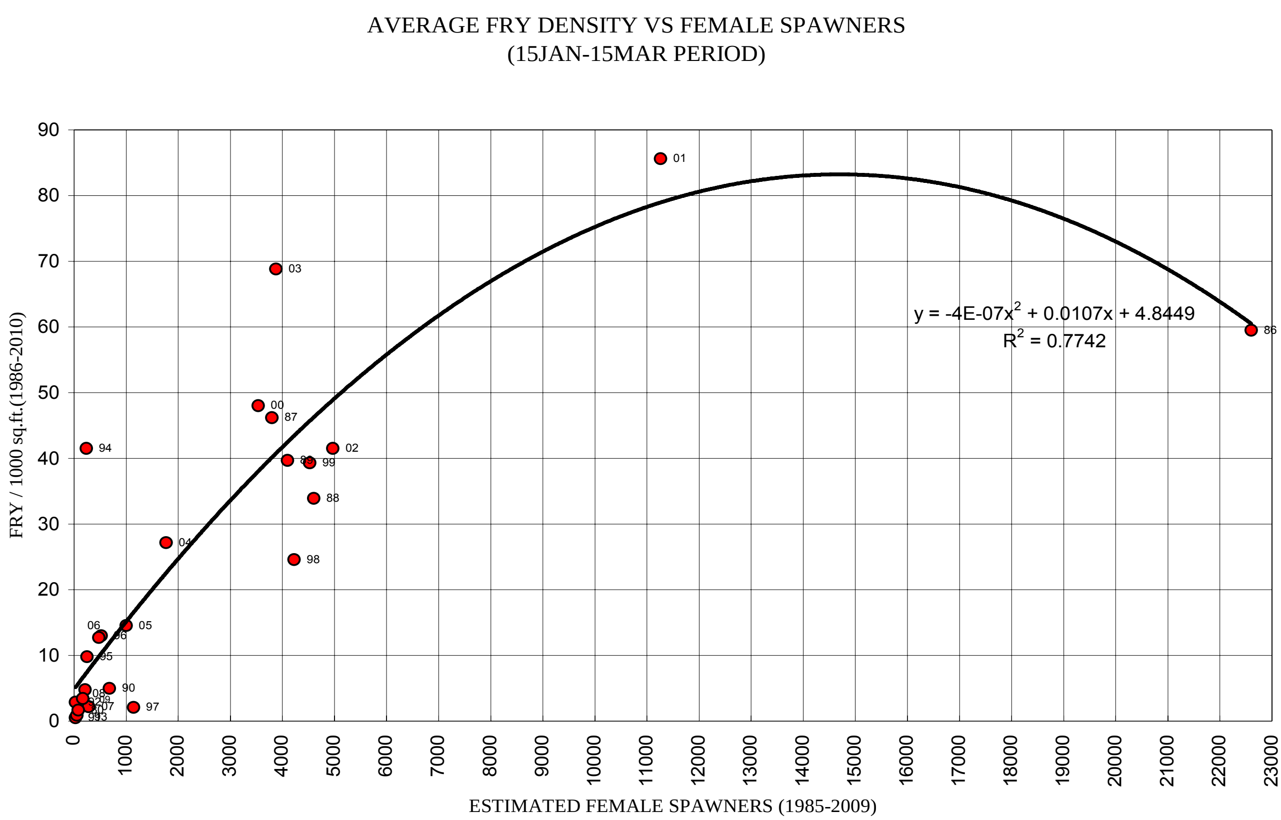


Figure 21. Tuolumne River average fry density vs female spawners.

TABLE 1. 2010 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
26JAN	14	15,250	0.9	33	47	38.7	14	0	0
17FEB	99	14,500	6.8	29	101	41.1	99	0	2
02MAR	118	15,050	7.8	34	70	46.0	118	0	3
16MAR	46	14,250	3.2	40	87	59.7	46	0	0
30MAR	62	14,050	4.4	37	88	61.1	62	0	1
13APR	25	12,050	2.1	40	87	69.9	25	0	0
27APR	18	11,750	1.5	35	90	56.7	18	0	0
11MAY	0	12,700	0.0						
25MAY	1	12,000	0.1	55	55	55.0	1	0	0
08JUN	3	11,600	0.3	48	66	54.7	3	0	0
TOTAL:	386	133,200	2.9				386	0	6

SAN JOAQUIN RIVER

DATE	SALMON CATCH	AREA (SQ. FT.)	DENSITY (/1000 ft^2)	MINIMUM FL	MAXIMUM FL	AVERAGE FL	NUMBER MEAS.	SACFRY	NUMBER KILLED
26JAN	0	2,950	0.0						
17FEB	0	2,100	0.0						
02MAR	0	2,700	0.0						
16MAR	0	1,600	0.0						
30MAR	0	2300	0.0						
13APR	0	2,700	0.0						
27APR	0	2,000	0.0						
11MAY	0	1,750	0.0						
25MAY	0	1,400	0.0						
08JUN	0	2,700	0.0						
TOTAL:	0	22,200	0.0						

Table 2. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2010

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
26JAN	OLGB	3	2,000	3	0	1.5	0.0	1.5	38.7	2.6	0.0	0.0	0.0	0.0	0.0
26JAN	R5	2	1,600	2	0	1.3	0.0	1.3	38.5						
26JAN	TRR	9	1,800	9	0	5.0	0.0	5.0	38.8						
26JAN	HICKMAN	0	1,650					0.0							
26JAN	CHARLES	0	1,800					0.0							
26JAN	LEGION	0	2,400					0.0							
26JAN	SERVICE	0	1,800					0.0							
26JAN	SHILOH	0	2,200					0.0							
26JAN	LAIRD	0	1,350					0.0							
26JAN	GARDNER	0	1,600					0.0							
TUOL.TOT.		14	15250	14	0	0.9	0.0	0.9	38.7						
SJR. TOT.		0	2950					0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
17FEB	OLGB	18	1800	18	0	10.0	0.0	10.0	36.9	13.1	3.7	0.0	1.5	0.4	0.0
17FEB	R5	33	1600	32	1	20.0	0.6	20.6	40.8						
17FEB	TRR	25	1800	18	7	10.0	3.9	13.9	44.3						
17FEB	HICKMAN	21	1650	20	1	12.1	0.6	12.7	38.3						
17FEB	CHARLES	2	1650	1	1	0.6	0.6	1.2	74.0						
17FEB	LEGION	0	2400					0.0							
17FEB	SERVICE	0	1800					0.0							
17FEB	SHILOH	0	1800					0.0							
17FEB	LAIRD	0	900					0.0							
17FEB	GARDNER	0	1200					0.0							
TUOL.TOT.		99	14500	89	10	6.1	0.7	6.8	41.1						
SJR. TOT.		0	2100					0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
02MAR	OLGB	7	1950	6	1	3.1	0.5	3.6	40.3	10.1	5.8	0.0	4.3	1.6	0.0
02MAR	R5	30	1600	26	4	16.3	2.5	18.8	44.0						
02MAR	TRR	40	1800	22	18	12.2	10.0	22.2	49.2						
02MAR	HICKMAN	34	1500	30	4	20.0	2.7	22.7	42.6						
02MAR	CHARLES	7	1600	2	5	1.3	3.1	4.4	57.9						
02MAR	LEGION	0	2400					0.0							
02MAR	SERVICE	0	1800					0.0							
02MAR	SHILOH	0	2400					0.0							
02MAR	LAIRD	0	1500					0.0							
02MAR	GARDNER	0	1200					0.0							
TUOL.TOT.		118	15050	86	32	5.7	2.1	7.8	46.0						
SJR. TOT.		0	2700	0	0			0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
16MAR	OLGB	0	2000					0.0		0.2	2.7	0.0	0.0	5.9	0.0
16MAR	R5	0	1600					0.0							
16MAR	TRR	1	1800	1	0	0.6	0.0	0.6	44.0						
16MAR	HICKMAN	45	1650	14	31	8.5	18.8	27.3	60.0						
16MAR	CHARLES	0	1800					0.0							
16MAR	LEGION	0	1800					0.0							
16MAR	SERVICE	0	1800					0.0							
16MAR	SHILOH	0	1800					0.0							
16MAR	LAIRD	0	Not Done												
16MAR	GARDNER	0	1600					0.0							
TUOL.TOT.		46	14250	15	31	1.1	2.2	3.2	59.7						
SJR. TOT.		0	1600	0	0			0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
30MAR	OLGB	6	1800	5	1	2.8	0.6	3.3	41.3	2.3	0.0	0.0	2.5	7.0	0.0
30MAR	R5	4	1600	4	0	2.5	0.0	2.5	43.8						
30MAR	TRR	15	1800	3	12	1.7	6.7	8.3	55.3						
30MAR	HICKMAN	25	1650	0	25	0.0	15.2	15.2	66.4						
30MAR	CHARLES	12	1800	0	12	0.0	6.7	6.7	73.3						
30MAR	LEGION	0	1800					0.0							
30MAR	SERVICE	0	1800					0.0							
30MAR	SHILOH	0	1800					0.0							
30MAR	LAIRD	0	900					0.0							
30MAR	GARDNER	0	1400					0.0							
TUOL.TOT.		62	14050	12	50	0.9	3.6	4.4	61.1						
SJR. TOT.		0	2300	0	0			0.0							

Table 2 (Continued)

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
13APR	OLGB	1	1200	1	0	0.8	0.0	0.8	40.0	0.4	0.0	0.0	4.5	0.2	0.0
13APR	R5	0	1900					0.0							
13APR	TRR	23	1800	1	22	0.6	12.2	12.8	70.7						
13APR	HICKMAN	0	1050					0.0							
13APR	CHARLES	1	1200	0	1	0.0	0.8	0.8	82.0						
13APR	LEGION	0	1800					0.0							
13APR	SERVICE	0	1500					0.0							
13APR	SHILOH	0	1600					0.0							
13APR	LAIRD	0	900					0.0							
13APR	GARDNER	0	1800					0.0							
TUOL.TOT.		25	12050	2	23	0.2	1.9	2.1	69.9						
SJR. TOT.		0	2700	0	0			0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
27APR	OLGB	0	1050					0.0		1.7	0.0	0.0	1.0	0.9	0.0
27APR	R5	0	2400					0.0							
27APR	TRR	14	1800	9	5	5.0	2.8	7.8	48.3						
27APR	HICKMAN	2	1400	0	2	0.0	1.4	1.4	82.5						
27APR	CHARLES	2	1700	0	2	0.0	1.2	1.2	90.0						
27APR	LEGION	0	1200					0.0							
27APR	SERVICE	0	1200					0.0							
27APR	SHILOH	0	1000					0.0							
27APR	LAIRD	0	1200					0.0							
27APR	GARDNER	0	800					0.0							
TUOL.TOT.		18	11750	9	9	0.8	0.8	1.5							
SJR. TOT.		0	2000					0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
11MAY	OLGB	0	2400					0.0		0.0	0.0	0.0	0.0	0.0	0.0
11MAY	R5	0	1850					0.0							
11MAY	TRR	0	1350					0.0							
11MAY	HICKMAN	0	1600					0.0							
11MAY	CHARLES	0	1800					0.0							
11MAY	LEGION	0	500					0.0							
11MAY	SERVICE	0	1600					0.0							
11MAY	SHILOH	0	1600					0.0							
11MAY	LAIRD	0	700					0.0							
11MAY	GARDNER	0	1050					0.0							
TUOL.TOT.		0	12700					0.0							
SJR. TOT.		0	1750					0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
25MAY	OLGB	0	1800					0.0		0.0	0.0	0.0	0.2	0.0	0.0
25MAY	R5	1	1800	0	1	0.0	0.6	0.6	55.0						
25MAY	TLSRA	0	1500					0.0							
25MAY	HICKMAN	0	1500					0.0							
25MAY	CHARLES	0	1800					0.0							
25MAY	LEGION	0	400					0.0							
25MAY	BIG BEND	0	1400					0.0							
25MAY	SHILOH	0	1800					0.0							
25MAY	LAIRD Not Done														
25MAY	GARDNER	0	1400					0.0							
TUOL.TOT.		1	12000	0	1	0.0	0.1	0.1							
SJR. TOT.		0	1400					0.0							

2010 Weekly Summary of TID/MID Seining Study
Salmon Density is the Number of Salmon / 1000 sq. ft.

Date	Location	Total Catch	Area	Measured Fry	Measured Juvenile	Extrapolated Density Fry	Extrapolated Density Juvenile	Density Total	Average FL	EXTRAPOLATED UPPER SECTION Density Fry	MIDDLE SECTION Density Fry	LOWER SECTION Density Fry	UPPER SECTION Density Juvenile	MIDDLE SECTION Density Juvenile	LOWER SECTION Density Juvenile
08JUN	GASBURG	0	1800					0.0		0.4	0.0	0.0	0.0	0.3	0.0
08JUN	R5	2	1800	2	0	1.1	0.0	1.1	49.0						
08JUN	TRR	0	1800					0.0							
08JUN	HICK	1	1050	0	1	0.0	1.0	1.0	66.0						
08JUN	CHARLES	0	1800					0.0							
08JUN	LEGION	0	1150					0.0							
08JUN	BIG BEND	0	1200					0.0							
08JUN	SHILOH	0	1000					0.0							
08JUN	LAIRD	0	900					0.0							
08JUN	GARDNER	0	1800					0.0							
TUOL.TOT.		3	11600	2	1	0.2	0.1	0.3	54.7						
SJR. TOT.		0	2700					0.0							

Table 3. Summary table of weekly seine catch by location for the Tuolumne and San Joaquin Rivers, 2010.

2010 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)
26JAN	OLGB	50.5	3	2,000	1.5	33	47	38.7	3	0	0	10.8	28		2.6	0.0	0.0	2.1	10.7
26JAN	R5	48.0	2	1,600	1.3	36	41	38.5	2	0	0	10.8	33					1.4	12.3
26JAN	TRR	42.3	9	1,800	5.0	36	44	38.8	9	0	0	10.8	49					1.8	11.8
26JAN	HICK	31.6	0	1,650	0.0							10.6	67					4.2	12.4
26JAN	CHARLES	24.9	0	1,800	0.0							10.3	102					8.4	12.3
26JAN	LEGION	17.2	0	2,400	0.0							10.6	135					20.8	11.4
26JAN	SERVICE	8.7	0	1,800	0.0							10.3	158					19.0	11.0
26JAN	SHILOH	3.4	0	2,200	0.0							10.1	164					21.8	11.8
26JAN	LAIRD	90.2	0	1,350	0.0							9.4	742					81.4	11.8
26JAN	GARDNER	79.5	0	1,600	0.0							9.5	623					77.7	9.5
TR TOT.			14	15250	0.9	33	47	38.7	14										
SJR TOT.			0	2950	0.0														

2010 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)
17FEB	OLGB	50.5	18	1800	10.0	29	45	36.9	18	0	0	10.9	30		14.6	4.0	0.0	1.5	10.7
17FEB	R5	48.0	33	1600	20.6	35	54	40.8	33	0	2	11.3	32					1.5	12.5
17FEB	TRR	42.3	25	1800	13.9	35	59	44.3	25	0	0	12.3	43					1.2	12.2
17FEB	HICK	31.6	21	1650	12.7	31	51	38.3	21	0	0	13.1	58					2.2	11.8
17FEB	CHARLES	24.9	2	1650	1.2	47	101	74.0	2	0	0	14.2	91	101				2.8	12.2
17FEB	LEGION	17.2	0	2400	0.0							15.2	123					1.7	12.0
17FEB	SERVICE	8.7	0	1800	0.0							15.3	156					5.8	10.7
17FEB	SHILOH	3.4	0	1800	0.0							16.0	183					8.2	11.5
17FEB	LAIRD	90.2	0	900	0.0							16.1	1406					38.1	11.9
17FEB	GARDNER	79.5	0	1200	0.0							15.9	1135					39.6	10.3
TR TOT.			99	14500	6.8	29	101	41.1	99	0	2								
SJR TOT.			0	2100	0.0														

2010 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)
02MAR	OLGB	50.5	7	1950	3.6	36	54	40.3	7	0	2	10.4	32		14.4	7.5	0.0	1.4	11.4
02MAR	R5	48.0	30	1600	18.8	37	60	44.0	30	0	1	10.9	37					1.4	12.2
02MAR	TRR	42.3	40	1800	22.2	35	70	49.2	40	0	0	12.4	58					3.9	11.1
02MAR	HICK	31.6	34	1500	22.7	34	60	42.6	34	0	0	13.1	71					6.1	10.5
02MAR	CHARLES	24.9	7	1600	4.4	45	67	57.9	7	0	0	13.7	104					21.4	9.9
02MAR	LEGION	17.2	0	2400	0.0							13.9	135					12.7	9.6
02MAR	SERVICE	8.7	0	1800	0.0							14.1	144					15.5	9.4
02MAR	SHILOH	3.4	0	2400	0.0							14.4	138					18.4	9.4
02MAR	LAIRD	90.2	0	1500	0.0							14.3	757					55.1	10.2
02MAR	GARDNER	79.5	0	1200	0.0							14.4	661					50.2	9.9
TR TOT.			118	15050	7.8	34	70	46.0	118	0	3								
SJR TOT.			0	2700	0.0														

2010 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)
16MAR	OLGB	50.5	0	2000	0.0							10.1	31		0.2	8.6	0.0	1.3	11.0
16MAR	R5	48.0	0	1600	0.0							10.3	37					2.8	12.3
16MAR	TRR	42.3	1	1800	0.6	44	44	44.0	1	0	0	12.5	49					1.5	11.9
16MAR	HICK	31.6	45	1650	27.3	40	87	60.0	45	0	0	13.5	61	22(62-87)				2.5	11.6
16MAR	CHARLES	24.9	0	1800	0.0							14.0	93					3.6	12.5
16MAR	LEGION	17.2	0	1800	0.0							14.5	127					4.7	12.8
16MAR	SERVICE	8.7	0	1800	0.0							15.0	170					4.6	11.9
16MAR	SHILOH	3.4	0	1800	0.0							15.7	184					5.9	11.8
16MAR	LAIRD	90.2	0	Not Done								15.2	1140					36.8	14.3
16MAR	GARDNER	79.5	0	1600	0.0							15.1	973					24.8	11.6
TR TOT.			46	14250	3.2	40	87	59.7	46	0	0								
SJR TOT.			0	1600	0.0														

2010 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)
30MAR	OLGB	50.5	6	1800	3.3	38	52	41.3	6	0	0	10.5	34		4.8	7.0	0.0	1.2	10.7
30MAR	R5	48.0	4	1600	2.5	37	49	43.8	4	0	0	10.8	37					1.2	11.7
30MAR	TRR	42.3	15	1800	8.3	43	67	55.3	15	0	0	13.7	50					1.6	11.2
30MAR	HICK	31.6	25	1650	15.2	55	86	66.4	25	0	1	15.2	62	9(68-86)				2.7	9.9
30MAR	CHARLES	24.9	12	1800	6.7	55	88	73.3	12	0	0	17.2	116	8(67-88)				2.4	10.4
30MAR	LEGION	17.2	0	1800	0.0							17.3	137					3.4	9.6
30MAR	SERVICE	8.7	0	1800	0.0							17.5	187					6.0	12.7
30MAR	SHILOH	3.4	0	1800	0.0							18.4	205					5.5	11.3
30MAR	LAIRD	90.2	0	900	0.0							18.7	1208					34.1	12.8
30MAR	GARDNER	79.5	0	1400	0.0							18.7	1040					36.1	10.3
TR TOT.			62	14050	4.4	37	88	61.1	62	0	1								
SJR TOT.			0	2300	0.0														

Table 3 (Continued)

2010 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)
13APR	OLGB	50.5	1	1200	0.8	40	40	40.0	1	0	0	10.9	34		4.9	0.2	0.0	2.1	10.1
13APR	R5	48.0	0	1900	0.0							10.6	35					2.1	12.8
13APR	TRR	42.3	23	1800	12.8	48	87	70.7	23	0	0	10.3	37	20(61-87)				4.3	
13APR	HICK	31.6	0	1050	0.0							11.1	35					5.7	10.7
13APR	CHARLES	24.9	1	1200	0.8	82	82	82.0	1	0	0	12.4	34	82				3.3	12.9
13APR	LEGION	17.2	0	1800	0.0							12.9	47					4.8	10.4
13APR	SERVICE	8.7	0	1500	0.0							12.9	53					5.4	10.4
13APR	SHILOH	3.4	0	1600	0.0							14.1	58					6.2	9.5
13APR	LAIRD	90.2	0	900	0.0							16.4	846					33.8	9.5
13APR	GARDNER	79.5	0	1800	0.0							15.6	571					18.8	9.8
TR TOT.			25	12050	2.1	40	87	69.9	25	0	0								
SJR TOT.			0	2700	0.0														

2010 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)
27APR	OLGB	50.5	0	1050	0.0							10.6	35		2.7	0.9	0.0	1.6	14.3
27APR	R5	48.0	0	2400	0.0							10.6	35					1.1	15.2
27APR	TRR	42.3	14	1800	7.8	35	80	48.3	14	0	0	10.6	35	(76,80)				6.0	13.1
27APR	HICK	31.6	2	1400	1.4	81	84	82.5	2	0	0	11.3	37	(81,84)				1.9	14.3
27APR	CHARLES	24.9	2	1700	1.2	90	90	90.0	2	0	0	13.9	42	(90,90)				2.8	12.9
27APR	LEGION	17.2	0	1200	0.0							13.9	41					5.6	12.1
27APR	BIG BEND	6.4	0	1200	0.0							14.8	48					3.0	12.9
27APR	SHILOH	3.4	0	1000	0.0							14.6	44					7.1	9.7
27APR	LAIRD	90.2	0	1200	0.0							20.4	506					35.8	9.3
27APR	GARDNER	79.5	0	800	0.0							18.0	309					24.5	8.7
TR TOT.			18	11750	1.5	35	90	56.7	18	0	0								
SJR TOT.			0	2000	0.0														

2010 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)
11MAY	OLGB	50.5	0	2400	0.0							10.7	33		0.0	0.0	0.0	1.6	12.3
11MAY	R5	48.0	0	1850	0.0							10.8	31					0.9	12.3
11MAY	TRR	42.3	0	1350	0.0							10.5	33					1.2	11.7
11MAY	HICK	31.6	0	1600	0.0							10.9	34					1.3	13.6
11MAY	CHARLES	24.9	0	1800	0.0							11.2	36					2.3	11.4
11MAY	LEGION	17.2	0	500	0.0							12.4	35					6.7	10.6
11MAY	BIG BEND	6.4	0	1600	0.0							12.4	39					7.8	N.A.
11MAY	SHILOH	3.4	0	1600	0.0							12.6	35					5.0	N.A.
11MAY	LAIRD	90.2	0	700	0.0							18.1	572					35.1	N.A.
11MAY	GARDNER	79.5	0	1050	0.0							14.6	211					14.5	N.A.
TR TOT.			0	12700	0.0														
SJR TOT.			0	1750	0.0														

2010 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)
25MAY	OLGB	50.5	0	1800	0.0							10.8	28		0.2	0.0	0.0	1.2	11.3
25MAY	R5	48.0	1	1800	0.6	55	55	55.0	1	0	0	10.9	30	55				1.1	N.A.
25MAY	TLSRA	42.0	0	1500	0.0							11.1	33					2.1	N.A.
25MAY	HICK	31.6	0	1500	0.0							11.2	33					1.6	N.A.
25MAY	CHARLES	24.9	0	1800	0.0							12.8	33					2.3	N.A.
25MAY	LEGION	17.2	0	400	0.0							13.9	34					2.4	N.A.
25MAY	BIG BEND	6.4	0	1400	0.0							14.1	37					3.0	N.A.
25MAY	SHILOH	3.4	0	1800	0.0							13.9	37					4.0	N.A.
25MAY	LAIRD	90.2	Not Done																
25MAY	GARDNER	79.5	0	1400	0.0							15.1	223					15.2	N.A.
TR TOT.			1	12000	0.1														
SJR TOT.			0	1400	0.0														

2010 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)
08JUN	GASBURG	50.3	0	1800	0.0							12.3	27		0.4	0.3	0.0	0.7	11.1
08JUN	R5	48.0	2	1800	1.1	48	50	49.0	2	0	0	13.1	29					0.6	11.0
08JUN	TRR	42.3	0	1800	0.0							11.5	31					3.4	12.7
08JUN	HICK	31.6	1	1050	1.0	66	66	66.0	1	0	0	12.9	32	66				1.5	11.0
08JUN	CHARLES	24.9	0	1800	0.0							14.9	31					1.5	9.2
08JUN	LEGION	17.2	0	1150	0.0							17.1	33					2.8	10.3
08JUN	BIG BEND	6.4	0	1200	0.0							17.5	47					10.2	8.6
08JUN	SHILOH	3.4	0	1000	0.0							16.7	40					4.3	9.9
08JUN	LAIRD	90.2	0	900	0.0							25.8	595					56.0	8.3
08JUN	GARDNER	79.5	0	1800	0.0							20.4	258					23.8	9.3
TR TOT.			3	11600	0.3	48	66	54.7											
SJR TOT.			0	2700	0.0														

Table 4. 2010 Other species sampled during seining studies on juvenile salmon.

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
26JAN	1	OLGB	50.5														2															
26JAN	2	R5	48.0										20				6															
26JAN	3	TRR	42.3								14																					
26JAN	4	HICK	31.6																2													
26JAN	5	CHARLES	24.9																					5								
26JAN	6	LEGION	17.2																					1	1					3		
26JAN	7	SERVICE	8.7																3											5		
26JAN	8	SHILOH	3.4												2				2						1					3		
26JAN	9	LAIRD	90.2												300+				5	1												
26JAN	10	GARDNER	77.8												100					2				6						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
17FEB	1	OLGB	50.5			10											1															
17FEB	2	R5	48.0														7															
17FEB	3	TRR	42.3								12								10													
17FEB	4	HICK	31.6																						1							
17FEB	5	CHARLES	24.9																	2												
17FEB	6	LEGION	17.2																					1								
17FEB	7	SERVICE	8.7																4					1	1					3		
17FEB	8	SHILOH	3.4												20				2					1	1							
17FEB	9	LAIRD	90.2												300+																	
17FEB	10	GARDNER	77.8												100+							1BCR		1								
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
02MAR	1	OLGB	50.5			2											1															
02MAR	2	R5	48.0								2						3															
02MAR	3	TRR	42.3			1					1								6													
02MAR	4	HICK	31.6																													
02MAR	5	CHARLES	24.9																7					1	1							
02MAR	6	LEGION	17.2																15													
02MAR	7	SERVICE	8.7												1															1		
02MAR	8	SHILOH	3.4												20																	
02MAR	9	LAIRD	90.2												300+					20												
02MAR	10	GARDNER	77.8												100+					5				2		1						
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
16MAR	1	OLGB	50.5			5											1															
16MAR	2	R5	48.0			1											6															
16MAR	3	TRR	42.3								1																		1			
16MAR	4	HICK	31.6																3													
16MAR	5	CHARLES	24.9																													
16MAR	6	LEGION	17.2																					1						2		
16MAR	7	SERVICE	8.7																3						1					2		
16MAR	8	SHILOH	3.4												1									2	1					1		
16MAR	9	LAIRD	90.2																													
16MAR	10	GARDNER	77.8												100									3	1							
DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
30MAR	1	OLGB	50.5			1																										
30MAR	2	R5	48.0			2											3															
30MAR	3	TRR	42.3																12										1			
30MAR	4	HICK	31.6						1				2						12													
30MAR	5	CHARLES	24.9																5					16								
30MAR	6	LEGION	17.2																10					5	1							
30MAR	7	SERVICE	8.7																3					3								
30MAR	8	SHILOH	3.4																					2	4							
30MAR	9	LAIRD	90.2												100										1							
30MAR	10	GARDNER	77.8												50					6				15	5					1		

Table 4. 2010 Other Species sampled (continued)

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
13APR	1	OLGB	50.5																													
13APR	2	R5	48.0			5					1		1				10												2			
13APR	3	TRR	42.3										2																			
13APR	4	HICK	31.6										1						1													
13APR	5	CHARLES	24.9																					2								
13APR	6	LEGION	17.2														YOY		12													
13APR	7	SERVICE	8.7																2													
13APR	8	SHILOH	3.4												1				6													
13APR	9	LAIRD	90.2												200										1					1		
13APR	10	GARDNER	77.8												50									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
27APR	1	OLGB	50.5														4															
27APR	2	R5	48.0										6				8		2													
27APR	3	TRR	42.3																2										8			
27APR	4	HICK	31.6																					1								
27APR	5	CHARLES	24.9														YOY		2						1							
27APR	6	LEGION	17.2														YOY		1					1								
27APR	7	BIG BEND	6.4														YOY		10													
27APR	8	SHILOH	3.4														YOY								1							
27APR	9	LAIRD	90.2												200										1							
27APR	10	GARDNER	77.8												200					6												

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
11MAY	1	OLGB	50.5			1											YOY															
11MAY	2	R5	48.0			1							6				YOY															
11MAY	3	TRR	42.3														2		10										3			
11MAY	4	HICK	31.6														YOY															
11MAY	5	CHARLES	24.9														YOY							3	1							
11MAY	6	LEGION	17.2														YOY		12													
11MAY	7	BIG BEND	6.4														YOY															
11MAY	8	SHILOH	3.4												4		YOY															
11MAY	9	LAIRD	90.2										1		200																	
11MAY	10	GARDNER	77.8												200					6												

DATE	SITE	LOCATION	MILE	LP	TFS	RT	CP	GF	GSH	SBF	HH	HCH	PM	ST	PRS	FHM	SKR	WCF	GAM	ISS	SB	WCR	GSF	BG	LMB	SMB	BLP	TP	RSCP	RSF	CCF	CENT
25MAY	1	OLGB	50.5														YOY															
25MAY	2	R5	48.0														YOY															
25MAY	3	TLSRA	42.0														YOY		40													
25MAY	4	HICK	31.6														YOY		12													
25MAY	5	CHARLES	24.9														YOY															
25MAY	6	LEGION	17.2														YOY															
25MAY	7	BIG BEND	6.4														YOY															
25MAY	8	SHILOH	3.4												10		YOY		8						1							
25MAY	9	LAIRD	90.2																													
25MAY	10	GARDNER	77.8												200+									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
08JUN	1	OLGB	50.5																										1			
08JUN	2	R5	48.0										3				YOY															
08JUN	3	TRR	42.3														YOY												2			
08JUN	4	HICK	31.6																													
08JUN	5	CHARLES	24.9														YOY		2													
08JUN	6	LEGION	17.2																10				2		1					1		
08JUN	7	BIG BEND	6.4														YOY		10													
08JUN	8	SHILOH	3.4																1													
08JUN	9	LAIRD	90.2												30		YOY		5					1	1	1						
08JUN	10	GARDNER	77.8												50									1								

Table 4. KEY TO OTHER SPECIES SAMPLED AND DISTRIBUTION
(List includes all species caught during 1986-2010 seining studies)

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	SAN JOAQUIN	TUOL.
Petromyzontidae	Pacific lamprey	N	LP		
Clupeidae	threadfin shad		TFS		
Salmonidae	Chinook salmon	N	CS		X
Salmonidae	rainbow trout	N	RT		X
Cyprinidae	carp		CP		
Cyprinidae	goldfish		GF		
Cyprinidae	golden shiner		GSH		X
Cyprinidae	Sacramento blackfish	N	SBF		
Cyprinidae	hitch	N	HCH		
Cyprinidae	hardhead	N	HH		X
Cyprinidae	Sacramento pikeminnow	N	PM	X	X
Cyprinidae	Sacramento splittail	N	ST		
Cyprinidae	red shiner		PRS	X	X
Cyprinidae	fathead minnow		FHM		
Catostomidae	Sacramento sucker	N	SKR	X	X
Ictaluridae	channel catfish		CCF		X
Ictaluridae	white catfish		WCF		
Ictaluridae	brown bullhead		BBH		
Poeciliidae	western mosquitofish		GAM	X	X
Atherinidae	inland silverside		ISS	X	X
Percichthyidae	striped bass		SB		
Centrarchidae	white/black crappie		WCR/BCR	X	
Centrarchidae	warmouth		WM		
Centrarchidae	green sunfish		GSF		X
Centrarchidae	bluegill		BG	X	X
Centrarchidae	redear sunfish		RSF	X	X
Centrarchidae	largemouth bass		LMB	X	X
Centrarchidae	smallmouth bass		SMB	X	X
Percidae	bigscale logperch		BLP		
Embiotocidae	tule perch	N	TP		
Cottidae	prickly sculpin	N	PSCP		
Cottidae	riffle sculpin	N	RSCP		X
TOTAL:	32			10	16

2010 species presence designated with 'X'

Table 5. Tuolumne River Seining Summary, 1986-2010.

	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

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

Table 6. Summary table of locations sampled, 1986-2010

1986 TO 2010 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
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
2	Riffle 4B	48.4	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																							
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
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
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
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
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

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
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
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
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
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
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

Table 8. Summary table of fish species caught during the1992-2010 seine studies.

Fish species caught in the Tuolumne River during the seine studies

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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
Salmonidae	rainbow trout	N	RT						X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinidae	carp		CP														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
Cyprinidae	Sacramento pikeminnow	N	PM	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
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
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
Atherinidae	inland silverside		ISS	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X
Percichthyidae	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
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				
Cottidae	riffle sculpin	N	RSCP	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

(List includes all species caught during 1986-2010 seining studies)

Fish species caught in the San Joaquin River during the seine studies

FAMILY	COMMON NAME	NATIVE SPECIES	ABBREV.	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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				
Salmonidae	rainbow trout	N	RT																		
Cyprinidae	carp		CP	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
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
Cyprinidae	fathead minnow		FHM	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
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
Atherinidae	inland silverside		ISS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Percichthyidae	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				
Centrarchidae	bluegill		BG	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
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				
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

(List includes all species caught during 1986-2010 seining studies)

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-4

2010 Rotary Screw Trap Report

Prepared by

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Outmigrant Trapping of Juvenile Salmonids in the Lower Tuolumne River, 2010

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

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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.

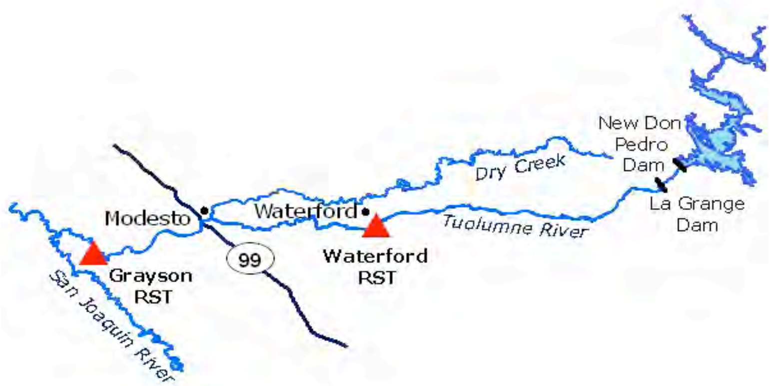

Figure 1. Location map of study area on the Tuolumne River.

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 (Table 1). The Turlock Irrigation District and Modesto Irrigation District ('Districts'), and the City and County of San Francisco funded the entire RST program in 1995-97 and 2003-2010 and at 2-3 upstream sites in 1998-2000.

Current sampling locations include 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 trap monitoring has been conducted annually near the mouth since 1995 (Shiloh in 1995-1998 and Grayson in 1999-2010) 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, 1995-2010.

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
	Grayson (RM 5.2)	Jan 12-Jun 06	93%	19,327	755,604[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	99,797[2]	Multiple regression	Vasques and Kundargi 2001

[1] Passage estimate reported in the annual report cited.
[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*
2001	Grayson	Jan 03-May 29	97%	6,478	99,584[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	9,091[2]	Multiple regression	Blakeman 2004c
2004	Grayson	Apr 01-Jun 09	40%	509	17,771[2]	Multiple regression	Fuller 2005
2005	Grayson	Apr 02-Jun 17	39%	1,317	255,710[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	71,670[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	923[2]	Multiple regression	Fuller 2008
2008	Waterford	Jan 8-Jun 2	96%	3,350	24,894[1]	Average trap efficiency	Palmer and Sonke 2008
	Grayson	Jan 29-Jun 4	82%	193	3,283[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	4,677[2]	Multiple regression	Palmer and Sonke 2010
2010	Waterford	Jan 5-Jun 11	97%	2,281	29,294-55,941[3]	Average trap efficiency	This report
	Grayson	Jan 6-Jun 17	97%	52	4,443[2]	Multiple regression	This report

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

[3] Trap efficiency data not available for parr/smolt lifestage 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.

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 the funnel rotates, fish are trapped in pockets of water and forced 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 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 precluded the need for the “weir” structure used to increase catch efficiency during 2008 and 2009.

Trap Monitoring

Sampling at Waterford began on January 5, 2010. The trap was operated continuously (24 hours per day, 7 days per week) until June 11, 2010, when sampling was terminated due to consistently low catch.

Sampling at Grayson began on January 6, 2010. The traps were operated continuously (24 hours per day, 7 days per week) until sampling was terminated on June 17, 2010, 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 lengths 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 $\geq$ 70 mm = smolt. In addition, the smolting appearance of all measured salmon and trout 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 trout 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 container 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 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 trap. Juvenile salmon captured in the Waterford trap were used to conduct tests whenever catches were sufficient to obtain a group of at least 30 fish over no more than two days. Eleven groups of naturally produced juvenile salmon (ranging in number from 29 to 116 fish) were marked and released at RM 30 (about 0.2 miles upstream of the trap) between January 21 and March 14. All marked fish were released after dark. Catches of naturally produced juvenile salmon at Waterford after March 14th were insufficient for trap efficiency tests. Likewise, catches of natural fish throughout the study period were insufficient for trap efficiency tests to be conducted at Grayson. Additionally, hatchery produced fish were not available for tests during 2010. Trap efficiency calculations for both sites are discussed in further detail below.

Holding Facility and Transport Method

Juvenile salmon were transferred from liveboxes into either 5-gallon buckets or 20-gallon insulated coolers depending on the number of fish, temperature, and distance traveled, and were transported by boat upstream to the release site.

At 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.

Marking Procedure

At the Waterford trapping site, 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, and then 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.

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 2010 were found to have no marks upon examination, consequently, all fish released were presumed to have visible marks.

Release Procedure

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, 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 ten 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. Velocity of water entering the traps was measured using two methods. First, the water velocity entering the traps was measured 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

The estimated daily number of fish passing each site 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).

There is a limited trap efficiency dataset for Waterford because sampling has only been conducted since 2006, and the 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, a multiple regression may be developed similar to the one described below for the Grayson trap. 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 2010 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 2010.

Salmon fry abundance estimates were generated based on trap efficiency tests conducted in 2010 at Waterford. Since no efficiency estimates were available for parr/smolt in 2010, the abundance of parr/smolt at Waterford was calculated as follows:

1. Abundance estimates during flows less than 1,000 cfs were calculated using all results from tests conducted during 2007 with parr/smolt at Waterford under similar flows.
2. Abundance estimates during flows greater than 1,000 cfs were calculated using all results from tests conducted at the 7/11 (RM 38) and Deardorff (RM 35.5) sites under similar flow conditions during 1998-2000 using fish approximately 60-95 mm (Stillwater Sciences 2001). Since these 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).

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. Specifically, average daily river flow at Modesto, average fish size at release, and natural log transformed proportions of fish recovered from each release event were used to develop the following trap efficiency predictor equation (adjusted R^2 =0.64):

$$\text{Daily Predicted Trap Efficiency} = \text{EXP}(-0.29176+(-0.00042*\text{Flow at MOD})+(-0.03410*\text{Fish size}))$$

where Flow 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

Number of Unmarked Chinook Salmon Captured

Juvenile salmon sampled in the 2010 RST operation were the progeny of an estimated 282 salmon (87 females) that spawned in the fall of 2009 (Cuthbert et al. 2010). 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 2010, catches of juvenile Chinook salmon at Waterford were highest in early to mid-March and primarily consisted of fry (<50 mm; Figure 5). Daily salmon catch peaked on January 22 (mainly fry <50 mm) following several days of rain, which began on January 18. Daily catches of juvenile salmon at Waterford between January 5 and June 11 ranged from zero to 128 fish, with a total catch of 2,281 salmon (Figure 3).

At Grayson, catches of juvenile salmon in 2010 were highest in late January and May during the fry and smolt outmigration periods, respectively. Daily catches of juvenile salmon at Grayson between January 6 and June 17 ranged from zero to six fish, with a total catch of 52 salmon (Figure 4). The total numbers captured by lifestage at each site are presented in Table 2.

Table 2. Catch by lifestage at Waterford and Grayson, 2010.

	Fry (<50 mm)	Parr (50-69 mm)	Smolt (≥ 70 mm)
Waterford	1,241	69	971
Grayson	13	0	39

Sampling at Waterford was considered comprehensive and covered 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. In 2010, the total annual catch of juvenile salmon at Waterford was approximately one-third less than the three previous years (i.e., 2007-2009) and only 25% of the number of Chinook captured in 2006, despite the abbreviated sampling during that year (Table 1; Figure 5). Total annual trap catch at Waterford from 2006-2010 ranged from a high of 9,106 in 2006 to a low of 2,281 in 2010, and averaged 4,346 juvenile salmon (Figure 5). 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 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 lower overall abundance. Trap efficiency decreases at higher flows, specifically when flows are higher than approximately 1,000 cfs.

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 2008-2010, 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 3,806 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.

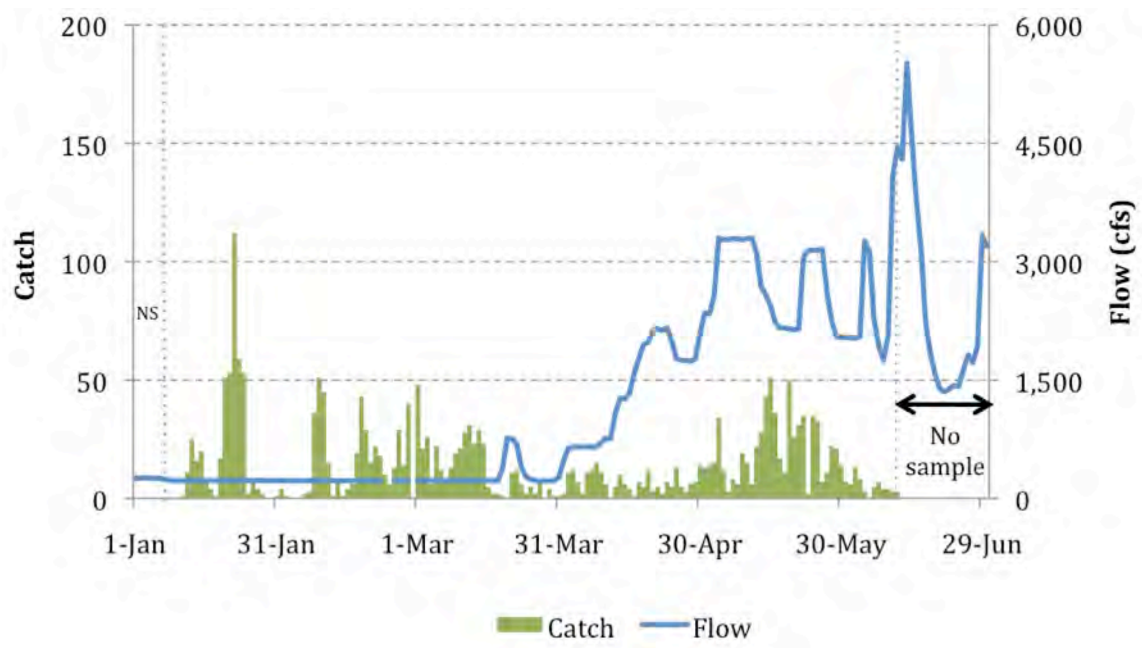

Figure 3. Daily catch of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2010.

Figure 4. Daily catch of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2010. Note: Flow at MOD is estimated on Jan. 8-Jan. 15; Jan. 21-Jan. 24; Feb. 11-Mar. 23; Apr. 21-Jun. 14; Jun. 16-Jun. 19; and Jun. 26-30 due to a malfunctioning gage.

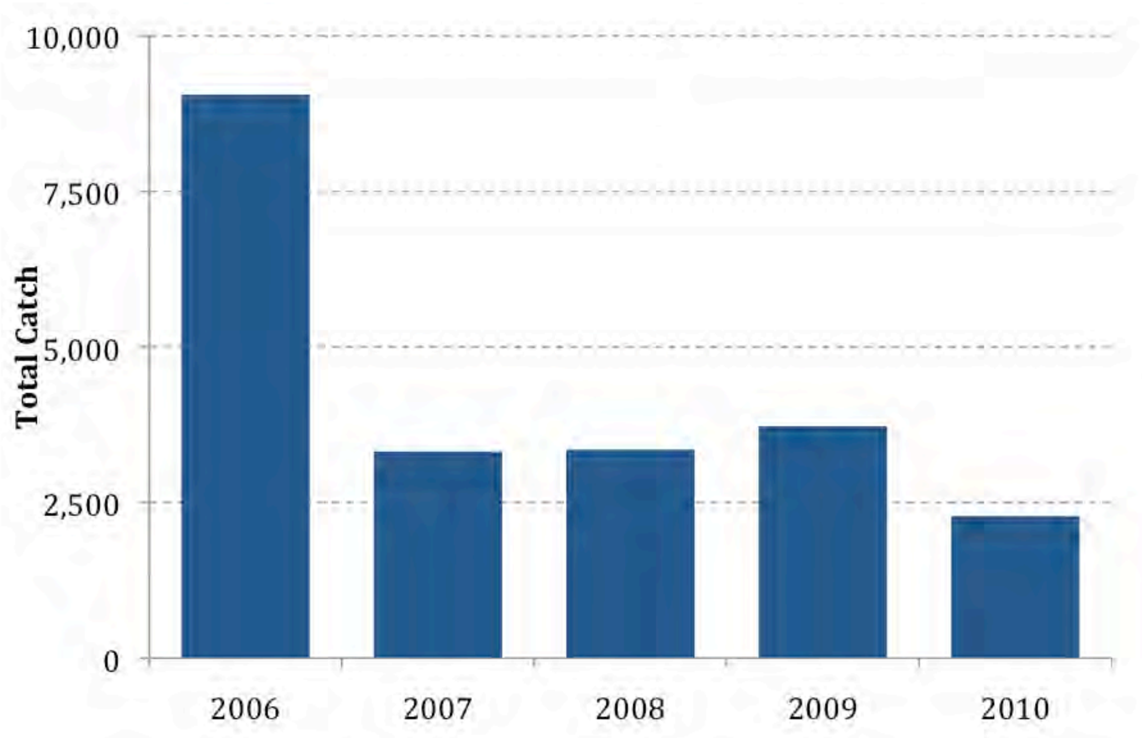

Figure 5. Total annual salmon catch at Waterford during 2006-2010.

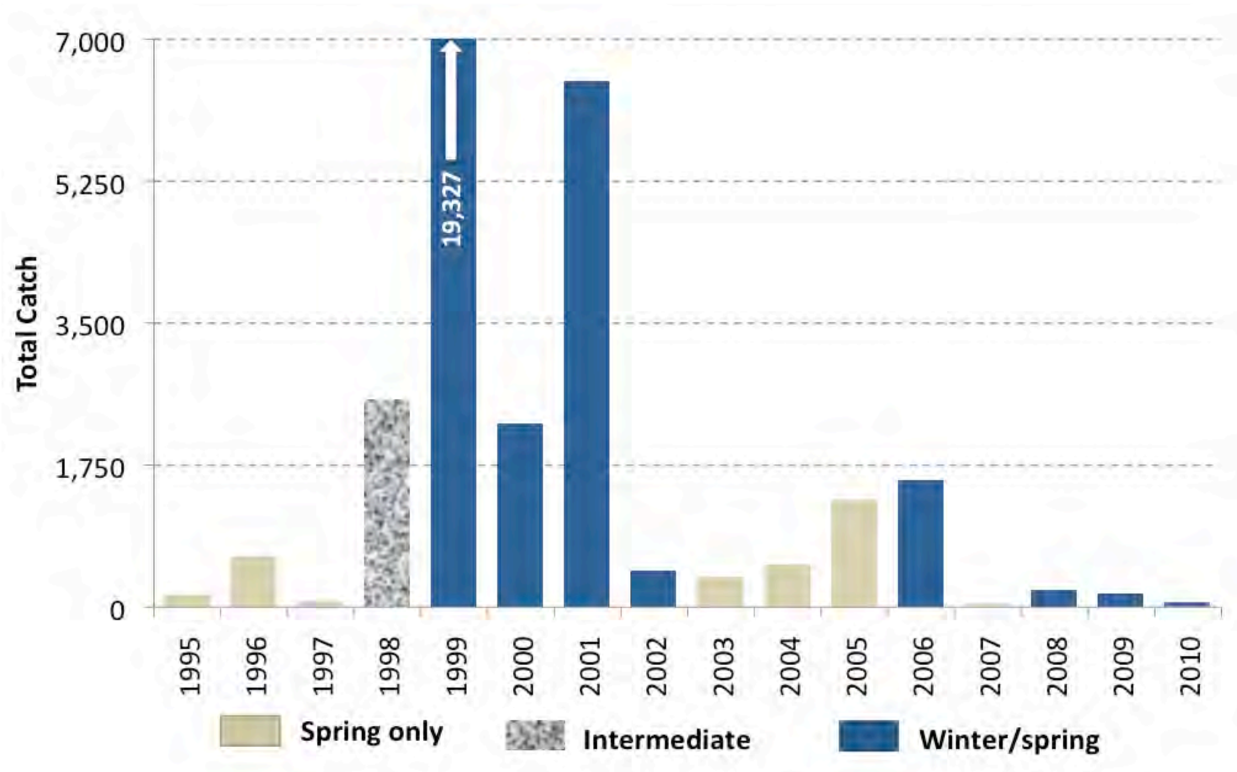

Figure 6. Total annual salmon catch at Shiloh/Grayson during 1995-2010.

Trap Efficiency

In 2010, eleven trap efficiency tests were conducted at Waterford using naturally produced salmon fry. Results from these tests ranged from 2.9% to 20.0% at flows (La Grange) between 223 cfs and 227 cfs (Table 3; Figure 7). No trap efficiency estimates were obtained during the parr/smolt outmigration period due to insufficient catch in the Waterford trap and the lack of hatchery fish available for releases. Average fork length at release for the trap efficiency test groups in 2010 ranged from 35 mm to 37 mm (n=11, Table 3). As mentioned previously, since flows were higher in 2010 than in recent years and there were no comparable trap efficiency data available for the Waterford trap at flows greater than 1,000 cfs, data were used 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). Consequently, in order to account for the uncertainty in trap efficiencies at higher flows at Waterford, a range of parr/smolt abundances were calculated from data collected in previous years during periods flows greater than 1,000 cfs.

Thus, salmon abundance estimate calculations at Waterford in 2010 were based on (Table 3):

Fry:

- trap efficiency tests conducted in 2010 at Waterford = 11.1%

Parr/Smolt:

- trap efficiency tests conducted in 2007 at Waterford at flows < 1,000cfs = 5.3%
- 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) at flows > 1,000cfs = 2.0-5.6%

At Grayson, observed trap efficiency estimates from 1999-2008 ranged from zero to 21.2% at flows (Modesto) ranging between 280 cfs and 7,942 cfs (Table 4; Figure 8). No trap efficiency estimates were obtained at Grayson during 2010 due to insufficient catch in the traps and the lack of hatchery fish available for releases.

Daily predicted trap efficiency, and daily estimated passage at Waterford and Grayson in 2010 are provided in Appendices A and B, respectively.

Table 3. Trap efficiency results used to estimate daily trap efficiencies at Waterford. Note: Only releases for the fry lifestage were conducted in 2010. Results from 2007 were used for predicting daily trap efficiencies during the parr/smolt lifestages at flows less than 1,000 cfs. Historical trap efficiency data from the 7/11 (RM 38) and Deardorff (RM 35.5) traps were used during the parr/smolt lifestages at flows greater than 1,000 cfs.

Lifestage	Release Date	Location	Origin	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at LGN	Turbidity
Fry	1/21/10	Waterford	Wild	110	22	20.0%	35	35	225	33.3
	1/22/10	Waterford	Wild	82	9	11.0%	35	35	225	21.2
	2/9/10	Waterford	Wild	34	1	2.9%	37	40	225	7.99
	2/10/10	Waterford	Wild	116	8	6.9%	37	37	225	1.16
	2/19/10	Waterford	Wild	42	3	7.1%	35	32	225	1.66
	2/20/10	Waterford	Wild	33	1	3.0%	36	35	225	1.14
	2/23/10	Waterford	Wild	29	2	6.9%	36	37	225	0.2
	3/1/10	Waterford	Wild	36	5	13.9%	35	36	224	15.5
	3/9/10	Waterford	Wild	44	8	18.2%	36	36	223	1.53
	3/11/10	Waterford	Wild	32	4	12.5%	36	35	227	1.68
	3/14/10	Waterford	Wild	35	3	8.6%	36	36	224	1.99
			TOTAL	593	66	11.1%				
Parr/smolt	3/5/07	Waterford	Wild	75	3	4.0%	56.2	59.7	341	0.62
	3/29/07	Waterford	Wild	48	3	6.3%	60.3	57.1	337	0.65
	3/31/07	Waterford	Wild	75	3	4.0%	58.4	47.3	337	0.43
	4/5/07	Waterford	Wild	50	2	4.0%	76.0	75.0	337	0.64
	4/11/07	Waterford	Wild	63	6	9.5%	80.6	80.2	343	1.07
	4/24/07	Waterford	Wild	63	3	4.8%	81.9	80.3	869	0.82
	4/26/07	Waterford	Wild	171	9	5.3%	80.2	79.1	646	0.88
	3/5/07	Waterford	Wild	75	3	4.0%	56.2	59.7	341	0.62
			TOTAL	545	29	5.3%				
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

Table 4. Trap efficiency results from 1999-2008 used to derive the regression equation for predicting daily 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
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-	3053	163	5.3%	72	np	1460

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
		clip						
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, ad-clip	2001	22	1.1%	86	np	1210
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

Release Date	Origin	Mark	Adjusted # Released	Number Recaptured	% Recaptured	Length at Release (mm)	Length at Recap. (mm)	Flow (cfs) at MOD
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 orange, anal fin orange	515	19	3.7%	92	91	678

np= not provided

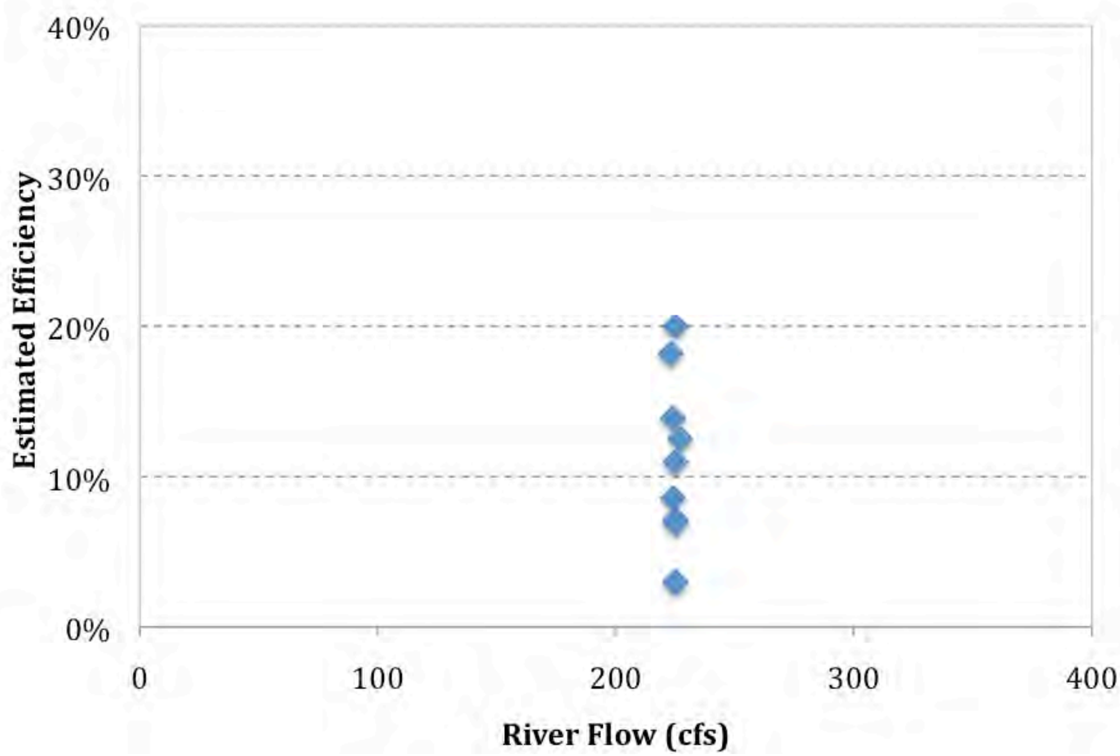

Figure 7. Trap efficiency estimates at Waterford relative to river flow at La Grange (LGN) during 2010.

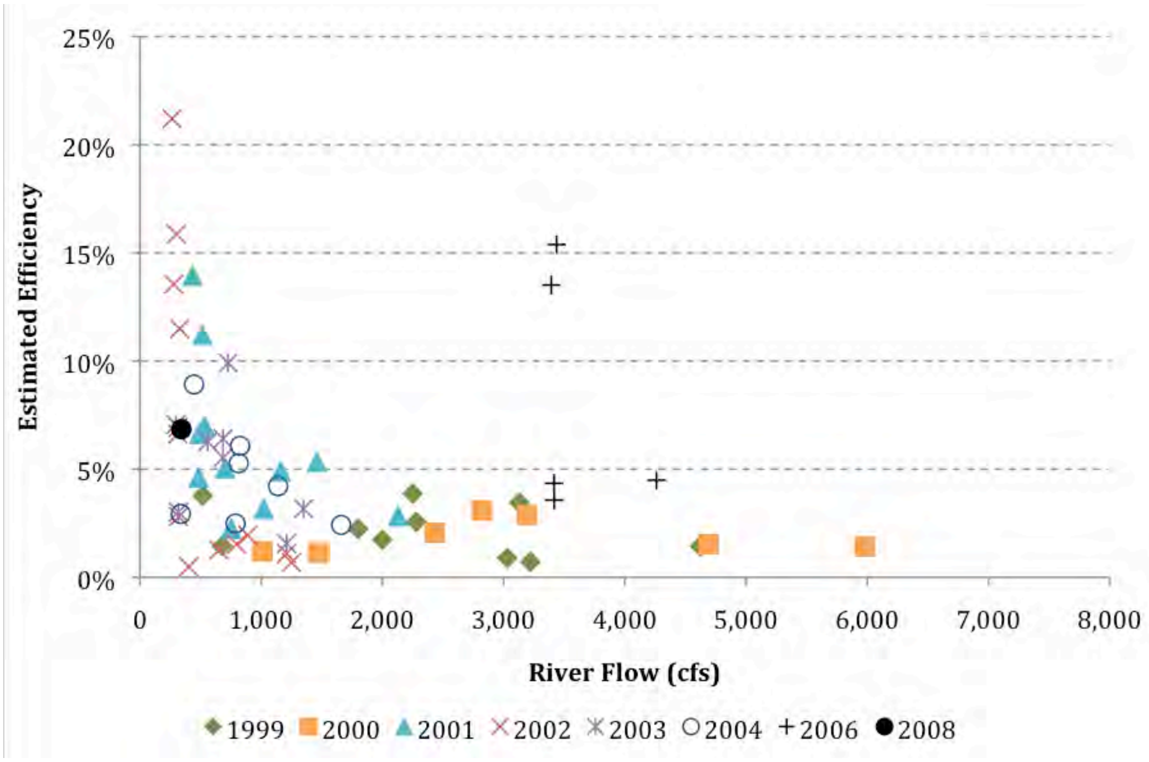

Figure 8. Trap efficiency observations at Grayson relative to river flow at Modesto (MOD), 1999-2008.

Estimated Chinook Salmon Abundance

As mentioned previously, in order to account for the uncertainty in trap efficiencies at Waterford during periods of parr/smolt outmigration (April 11-June 10), 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 42,600 (29,300-55,900) Chinook salmon passed Waterford during 2010, of which 70.7% (58.2%-77.2%) were smolts (Table 5). In comparison, the percentage of fish passing Waterford as smolts was 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). Similar to the pattern observed for catch in 2010, and in previous years, it is estimated that a majority of the salmon passing Waterford in 2010 prior to mid-March were fry and passage was then dominated by smolts from late-March through May (Table 5; Figure 10). Daily estimated salmon passage at Waterford ranged from zero to 1,730 (max. range = 1,153-2,550). The peak in daily passage for fry occurred on January 21 and smolt passage peaked on May 15 (Figure 11).

During the 2009-2010 spawning season, approximately 490 (337-643) juveniles were produced per female spawner relative to the estimated 87[3] female spawners; compared to 175 juveniles in 2009, 311 in 2008, and 205 in 2007 (Table 6). Beginning in 2010 the number of female spawners was estimated using counts from a Vaki Riverwatcher used in conjunction with a resistance board weir, rather than using 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).

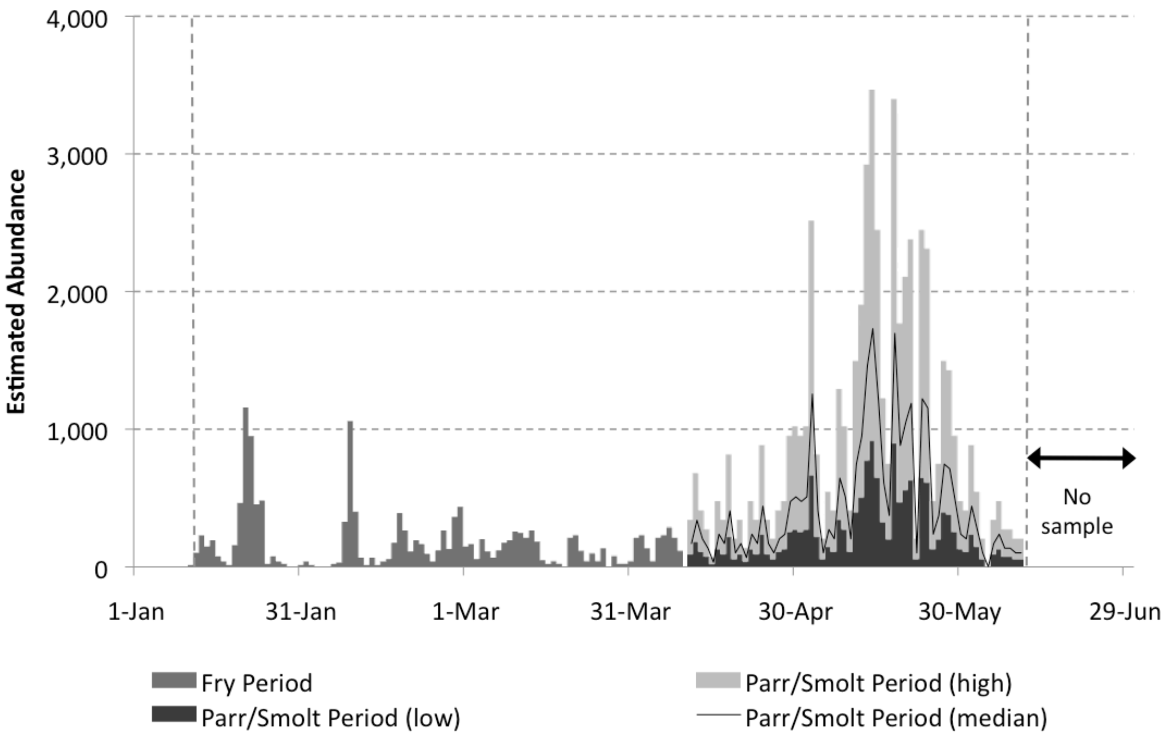

Figure 9. Daily estimated abundance of Chinook salmon at Waterford based on trap efficiencies conducted in 2010 at Waterford during the fry period, and trap efficiencies conducted in 2007 at Waterford (at flows < 1,000cfs) and at the 7/11 and Deardorff traps in 1998-2000 (at flows > 1,000cfs) for the parr/smolt period. A range of abundances were calculated for the parr/smolt period and the median and range are presented in this graph.

[3] Excludes 18 adult salmon of unknown gender.

Table 5. Estimated passage by lifestage at Waterford and Grayson during 1995-2010. *For 2010 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
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	716,858	94.9%	8,452	1.1%	30,293	4.0%	755,604
	2000	w/s	48,338	48.4%	8,431	8.4%	43,028	43.1%	99,797
	2001	w/s	59,153	59.4%	12,480	12.5%	27,951	28.1%	99,584
	2002	w/s	75	0.5%	696	4.9%	13,364	94.5%	14,135
	2003	spring	27	0.3%	0	0%	9,064	99.7%	9,091
	2004	spring	155	0.9%	732	4.1%	16,884	95.0%	17,771
	2005	spring	-	-	416	0.2%	255,294	99.8%	255,710
	2006	w/s	62,901	87.8%	1,536	2.1%	7,233	10.1%	71,670
	2007	spring	-	-	-	-	937	100%	937
	2008	w/s	917	27.9%	14	0.4%	2,352	71.6%	3,283
	2009	w/s	145	3.1%	200	4.3%	4,332	92.6%	4,677
	2010	w/s	183	4.1%	-	-	4260	95.9%	4,443

Table 6. Estimated number of juvenile salmon produced per female spawner, 2006-2010.

	Females	Juveniles/female spawner
2006	478	635
2007	282	205
2008	80	311
2009	212	175
2010	87	337 to 643

An estimated 4,443 unmarked Chinook salmon passed Grayson during 2010 and 95.9% of these were smolts (Table 5). Daily estimated passage at Grayson ranged from 0 to 718 salmon. Peak daily passage for smolts occurred on May 20 (Figure 12). During comparable seasonal sampling in previous years at Grayson (i.e., winter/spring sampling in 1999-2002, 2006, and 2008-2009), total estimated passage ranged from a high of 755,604 in 1999 to a low of 3,283 in 2008 (Table 1; Figure 14); the proportion of passage as smolts was the highest in 2010 (95.9%) and the lowest in 1999 (4.0%). 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

255,710 in 2005 to a low of 937 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.

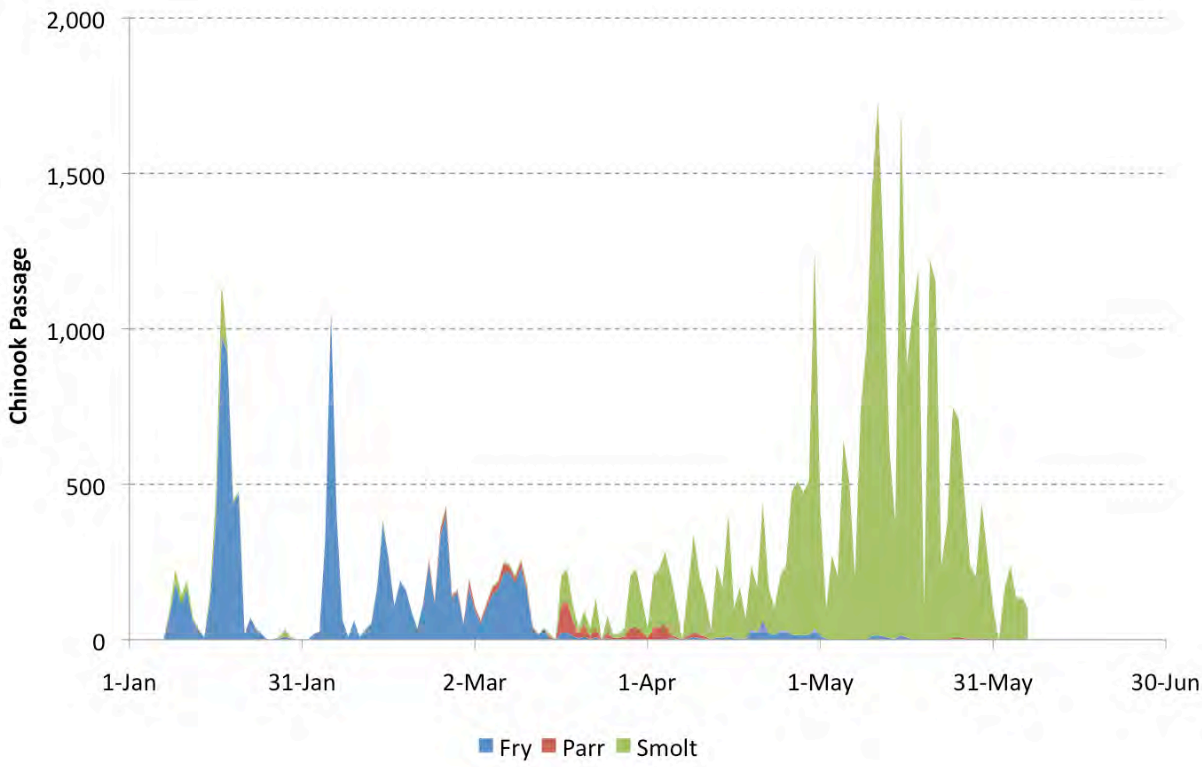

Figure 10. Juvenile salmon passage by lifestage at Waterford during 2010.

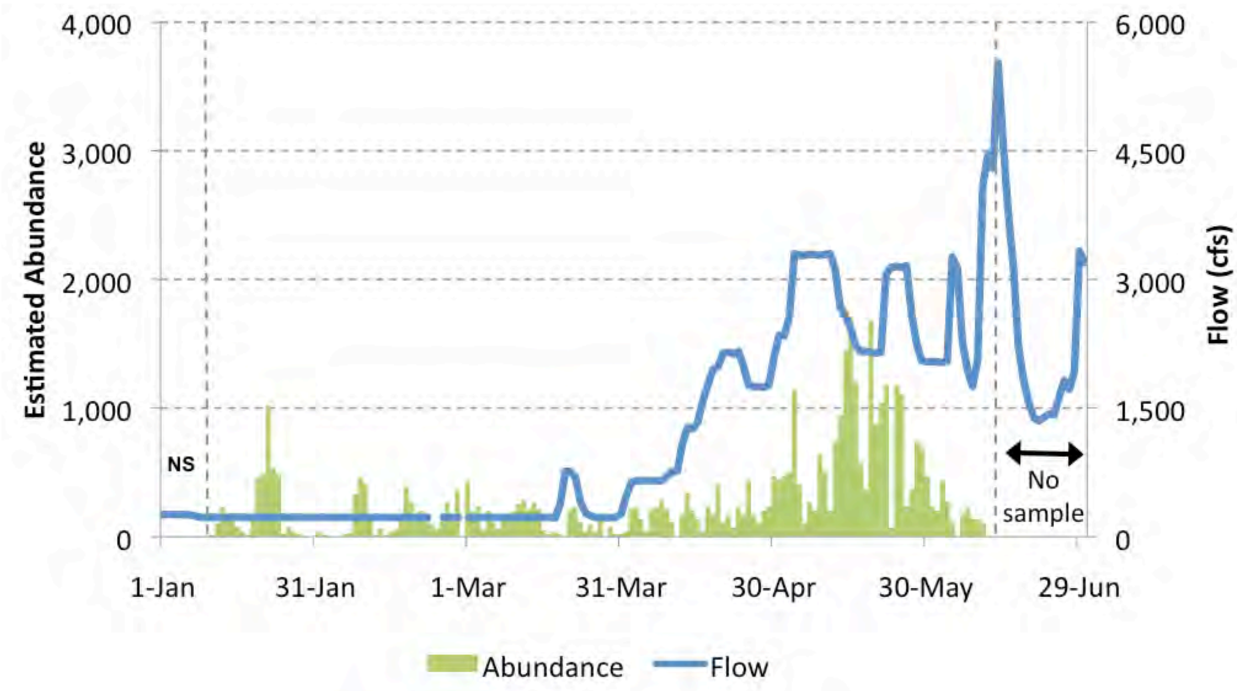

Figure 11. Daily estimated passage of unmarked Chinook salmon at Waterford and river flow at La Grange (LGN) during 2010.

NOTE: From April 11-June 10 the graph depicts median daily passage estimates - See Figure 9.

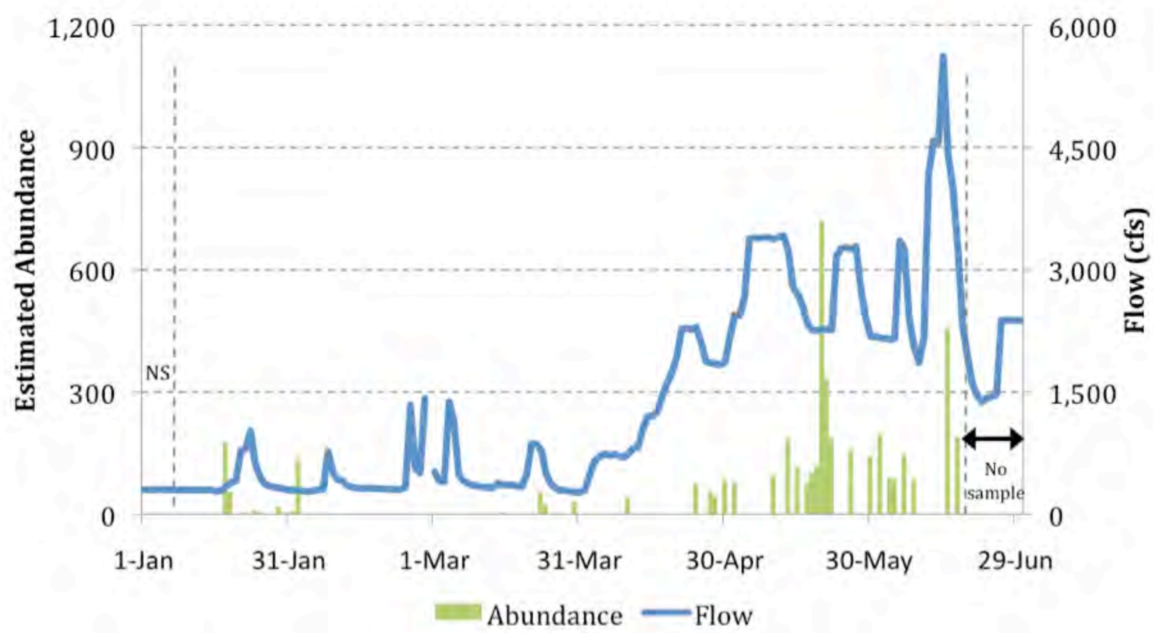

Figure 12. Daily estimated passage of unmarked Chinook salmon at Grayson and river flow at Modesto (MOD) during 2010.

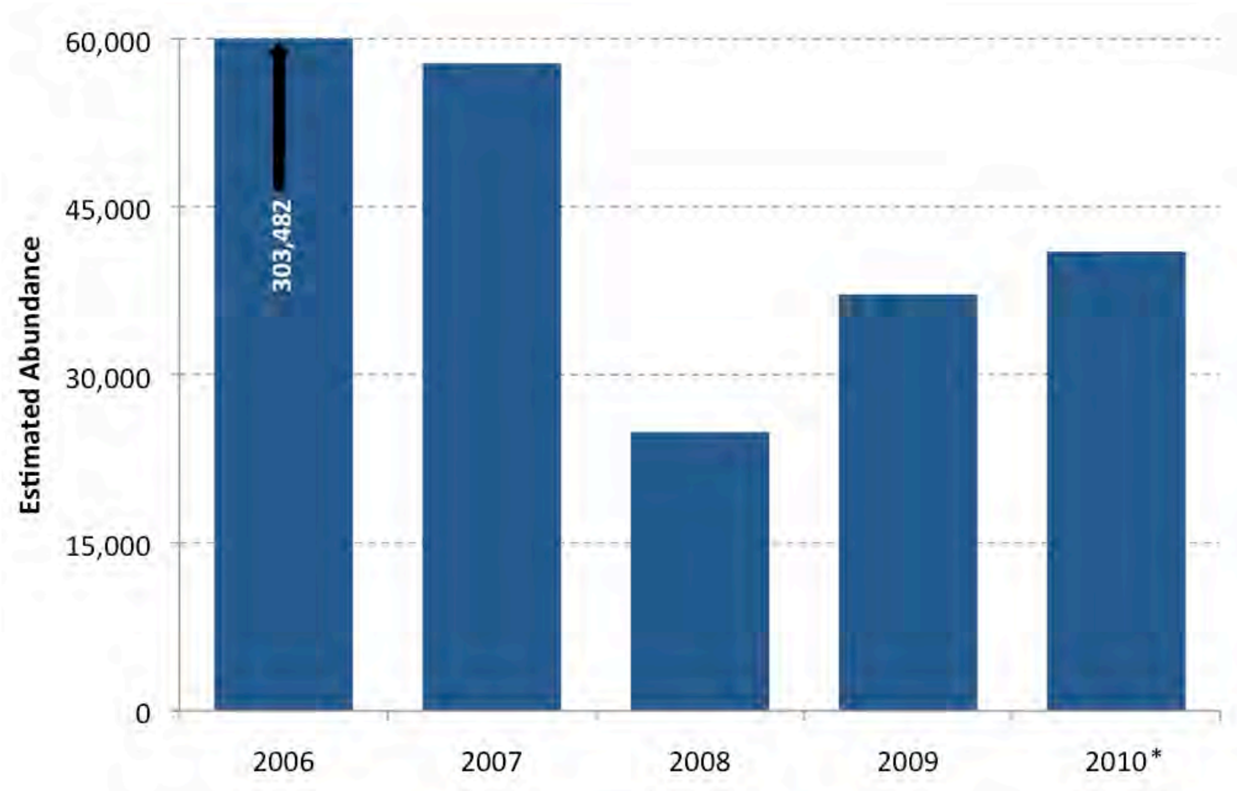

Figure 13. Total estimated Chinook passage at Waterford (2006-2010).

**Note that 2010 estimates are based upon the median of historical trap efficiency. (*range = 29,300–55,900).*

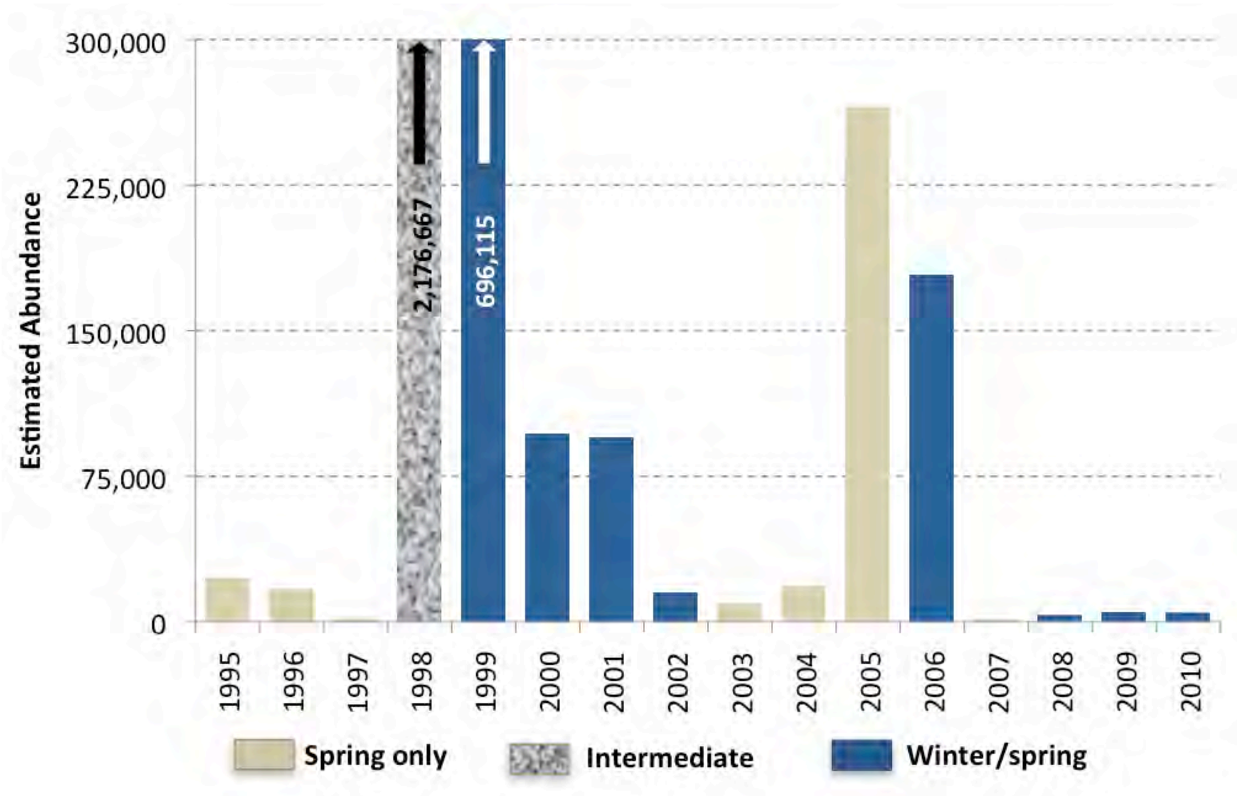

Figure 14. Total estimated Chinook passage at Shiloh and Grayson during 1995-2010.

Estimated Chinook Salmon Abundance and Environmental Factors

Peaks in salmon fry passage at Waterford in the winter were generally associated with peaks in turbidity conditions. River releases were relatively stable during this period (January-mid-March) and ranged from 222 cfs to 259 cfs. River flow near Grayson during the winter period was more variable as a result of storm run-off, particularly from Dry Creek entering at Modesto, and ranged from 279 cfs to 1,423 cfs. During the spring (mid-March through June), higher pulse flows produced several peaks in flow at both traps (Figure 11 and Figure 12).

During 2010 monitoring, daily average water temperatures ranged from 49.6°F to 60.4°F at the Waterford trap (Figure 15) and from 47.7°F to 64.2°F at the Grayson traps (Figure 16). Water temperatures generally increased through the outmigration season, with two peaks in mid- and late-March. There were no obvious correlations between trends in passage and water temperature during 2010.

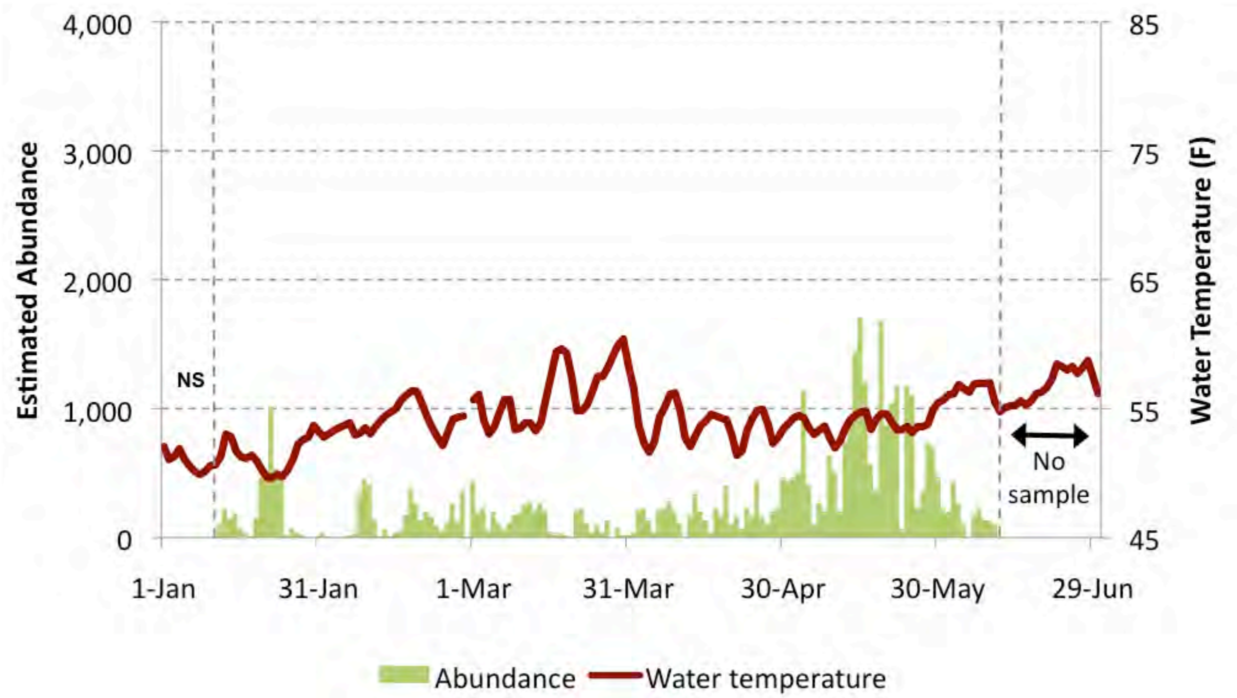

Figure 15. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Waterford trap during 2010. NOTE: From April 11-June 10 the graph depicts median daily passage estimates - See Figure 9.

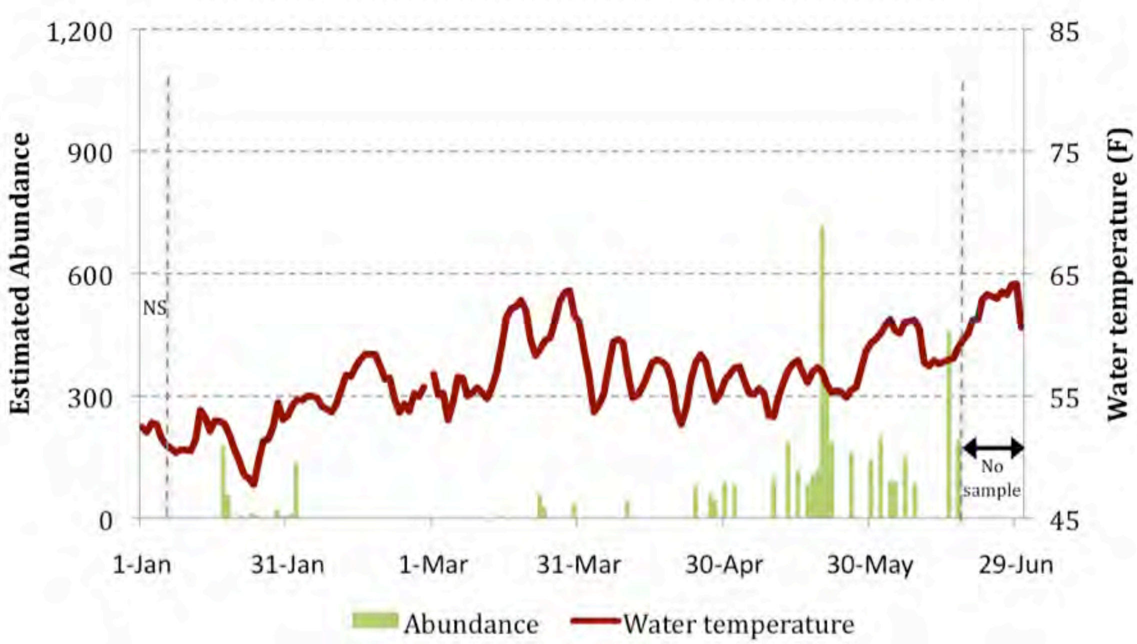

Figure 16. Daily estimated passage of unmarked Chinook salmon and daily average water temperature at the Grayson trap during 2010.

Background turbidity was generally less than 4 NTU at Waterford (Figure 17) and less than 6 NTU at Grayson (Figure 18) during the 2010 monitoring period. During several storm events (Figure 19), spikes in turbidity were observed ranging as high as 33 NTU at Waterford, and ranging as high as 81 NTU at Grayson. Peaks in passage on January 21st and February 9th at Waterford coincided with periods of elevated turbidity.

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 2010, 10.4%, should be interpreted with caution, since there is substantial uncertainty in the total passage estimate for Waterford. This value was calculated using the median estimated total passage for Waterford, and ranges from 7.9% to 15.2% based upon the range of estimated passages. Survival indices of 23.6%, 13.2% and 11.9% were calculated for 2006, 2008 and 2009, respectively. A survival index was not calculated for 2007 because sampling did not begin until mid-March.

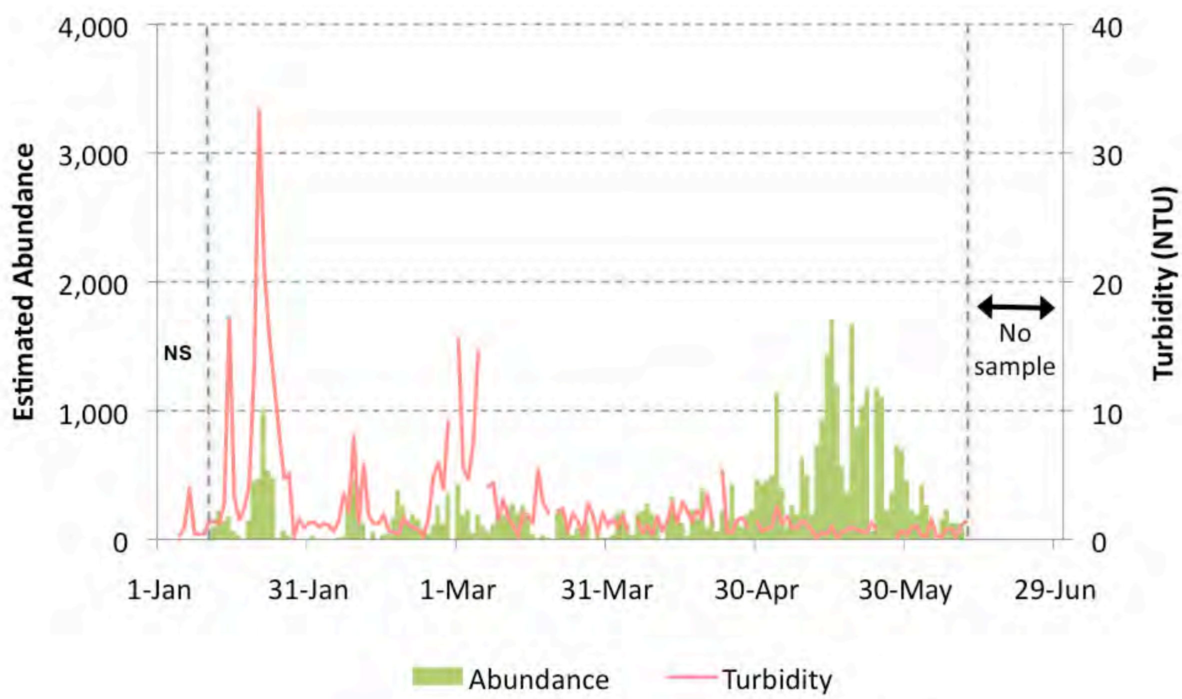

Figure 17. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Waterford during 2010. NOTE: From April 11-June 10 the graph depicts median daily passage estimates - See Figure 9.

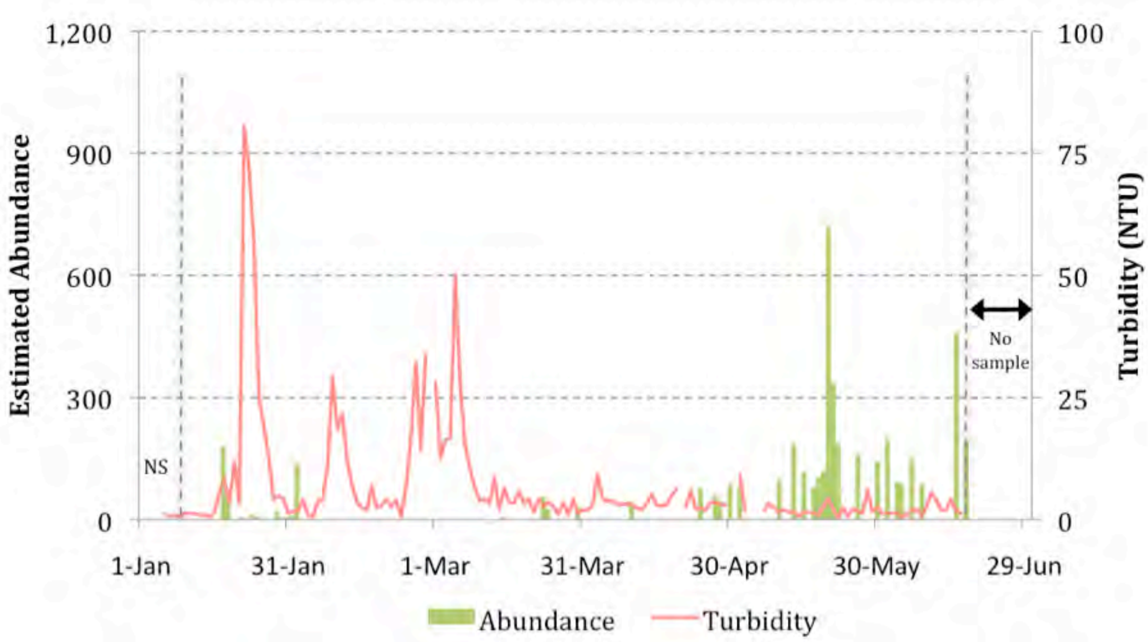

Figure 18. Daily estimated passage of unmarked Chinook salmon and instantaneous turbidity at Grayson during 2010.

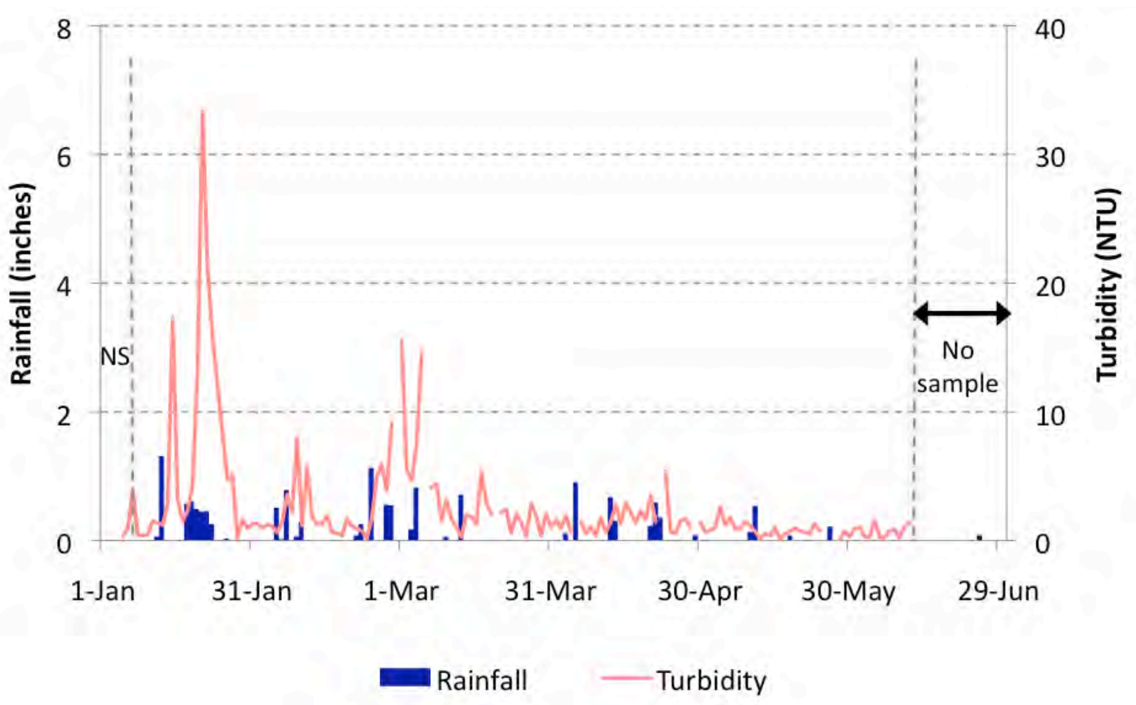

Figure 19. Daily rainfall measured at Don Pedro Reservoir and instantaneous turbidity at Waterford during 2010.

Chinook Salmon Length at Migration

Individual fork lengths of unmarked salmon captured at Waterford during 2010 ranged from 30 mm to 140 mm (Figure 20), and daily average length gradually increased from approximately 36 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 2010 were smolts measuring 80-109 mm, followed by fry measuring 30-39 mm (Figure 23). In total, it is estimated that 11,471 fry (<50 mm), 1,023 parr (50-69 mm), and 30,124 smolts (≥70 mm) passed Waterford during 2010 (Table 5). There were also a number of fish captured throughout the season that were atypical sizes for fall-run Chinook salmon production (Figure 20). For instance, during January through mid-March there were 47 fish much larger than the majority of juvenile salmon captured during that period (average size of larger fish was over 60 mm larger than majority of juvenile salmon captured) and 10 fish in the spring that were much smaller than other juvenile salmon captured during that period (34-38 mm versus 45-125 mm).

Individual fork lengths of unmarked Chinook salmon captured at Grayson during 2010 ranged from 31 mm to 139 mm (Figure 24), and daily average length ranged between 31 mm and 110 mm during the sampling period (Figure 25 and Figure 26). Nearly 78% of the salmon estimated to have passed Grayson during 2010 were smolts measuring 90-109 mm (Figure 26). In total, it is estimated that 183 fry (<50 mm), zero parr (50-69 mm), and 4,260 smolts (≥70 mm) passed Grayson during 2010 (Table 5). Similar to Waterford, three much larger sized Chinook were also captured during January through early March (Figure 24).

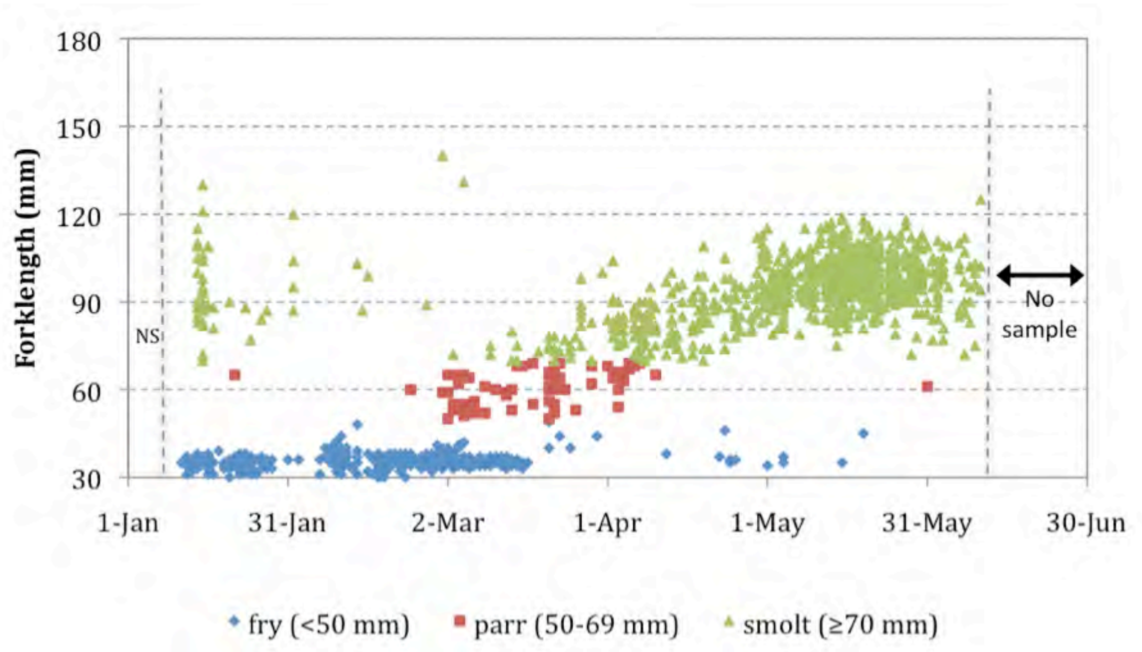

Figure 20. Individual fork lengths of juvenile salmon captured at Waterford during 2010.

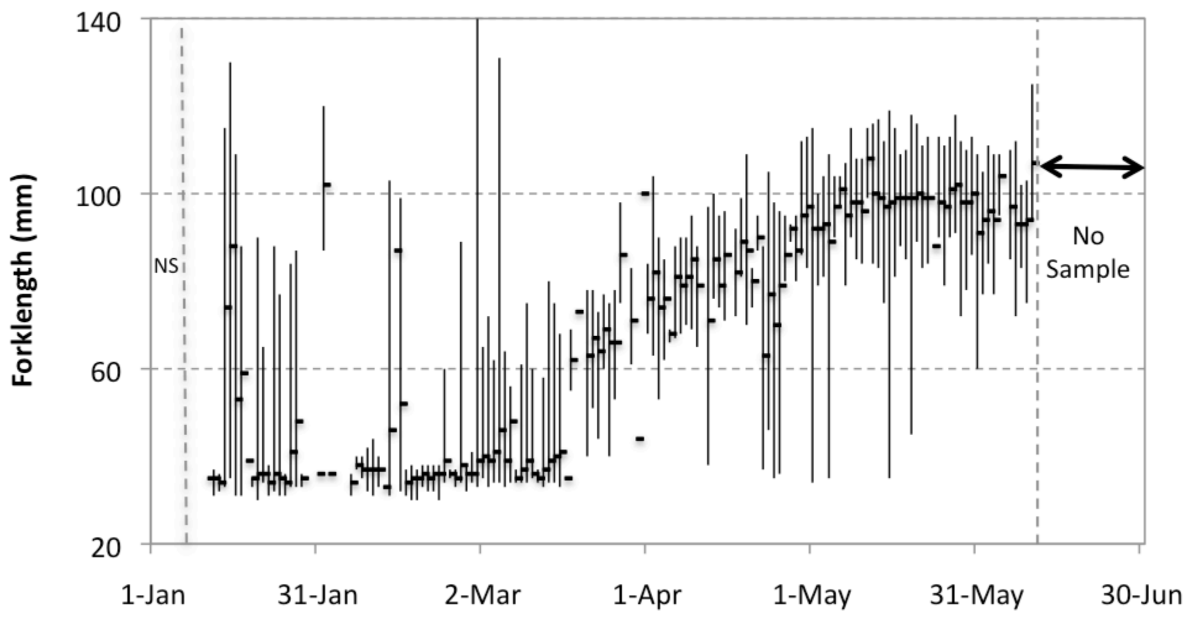

Figure 21. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Waterford during 2010.

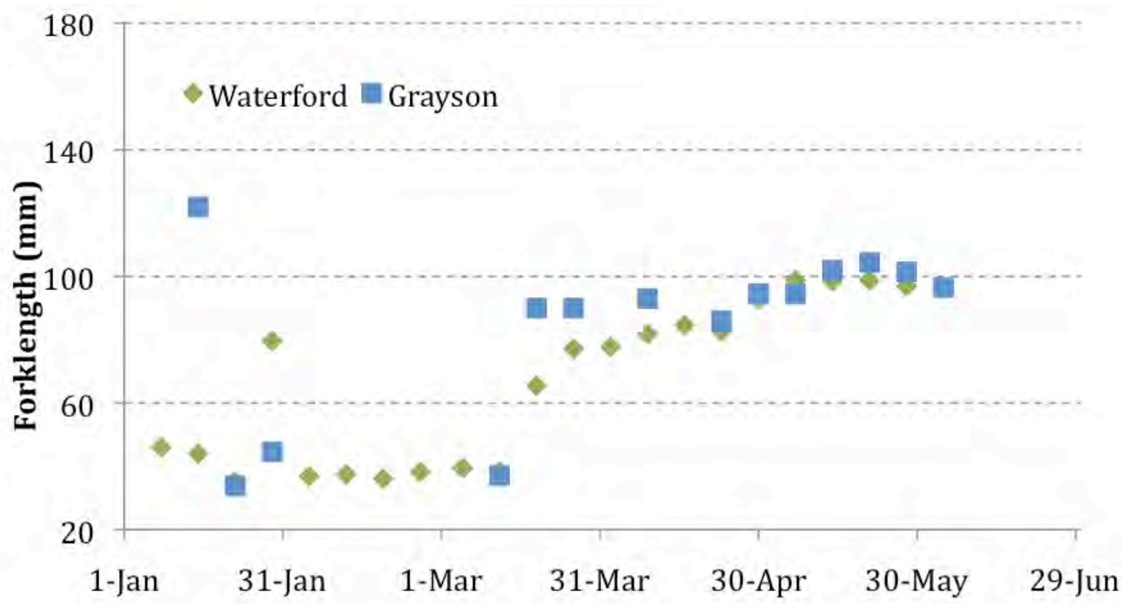

Figure 22. Average fork length of juvenile Chinook salmon captured at Waterford and Grayson by Julian week during 2010.

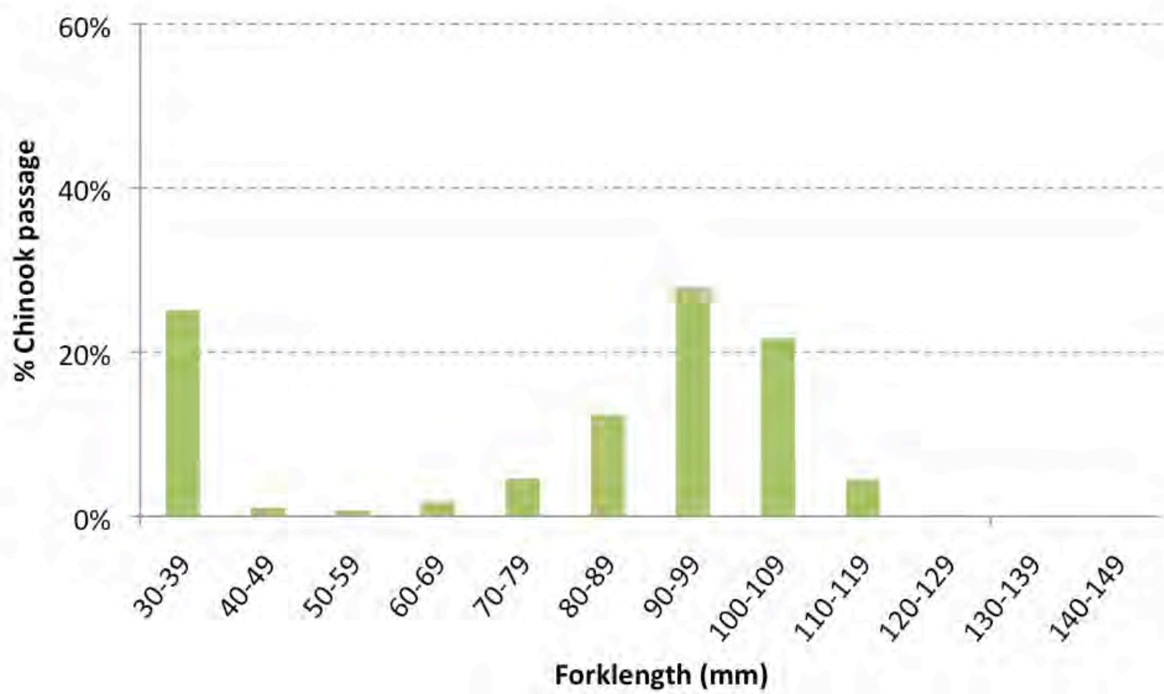

Figure 23. Estimated Chinook passage by 10 mm fork length intervals at Waterford during 2010.

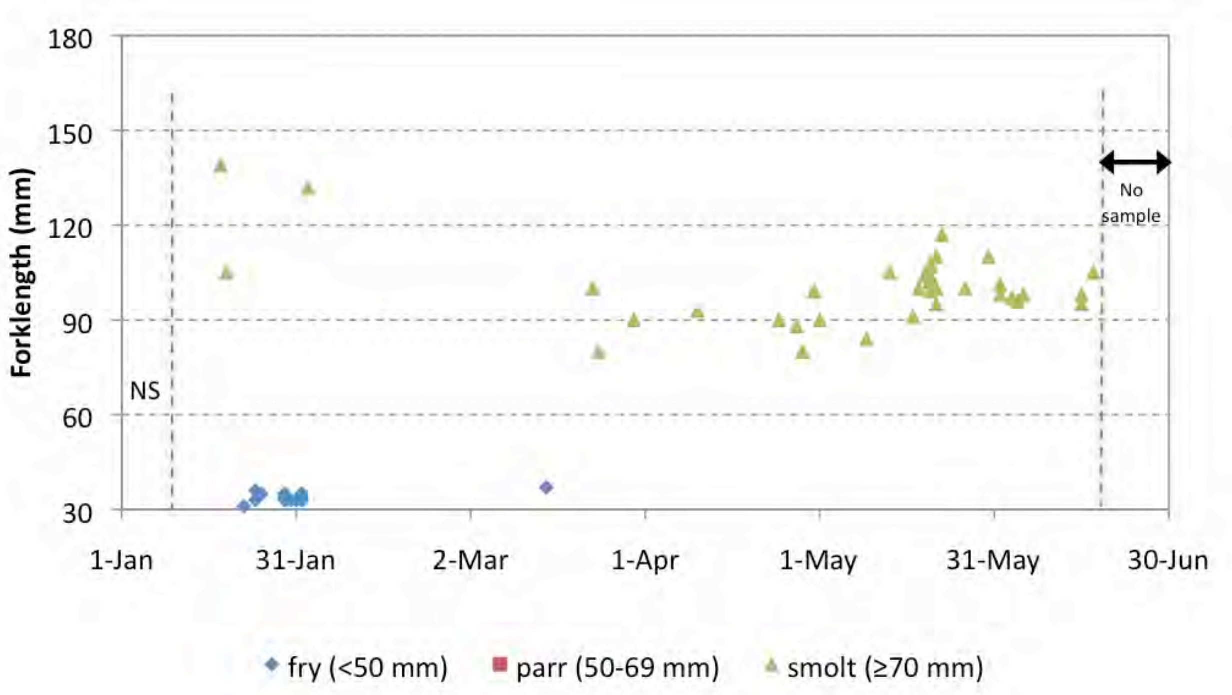

Figure 24. Individual fork lengths of juvenile salmon captured at Grayson during 2010.

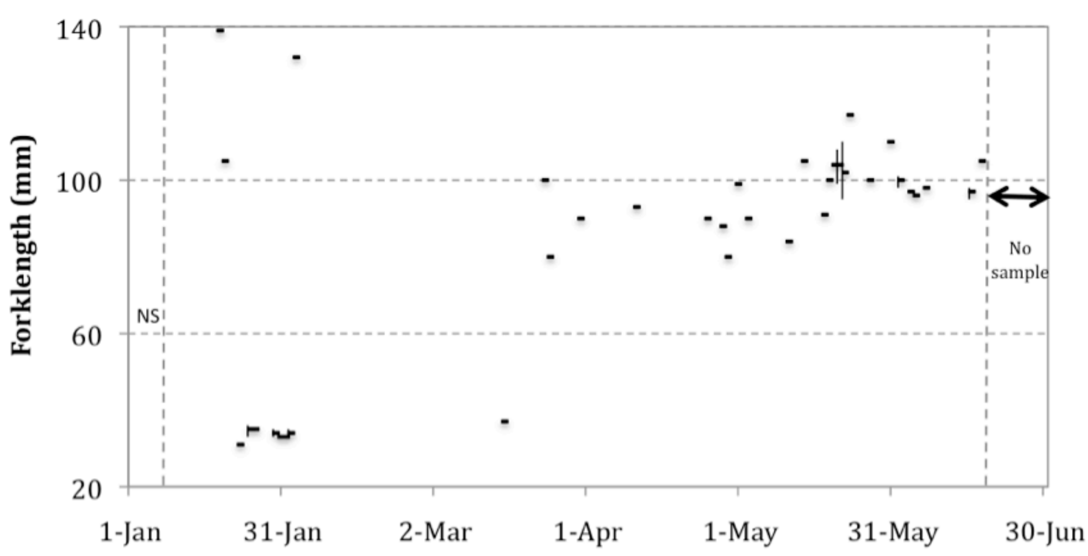

Figure 25. Daily minimum, average, and maximum fork lengths of unmarked Chinook salmon captured at Grayson during 2010.

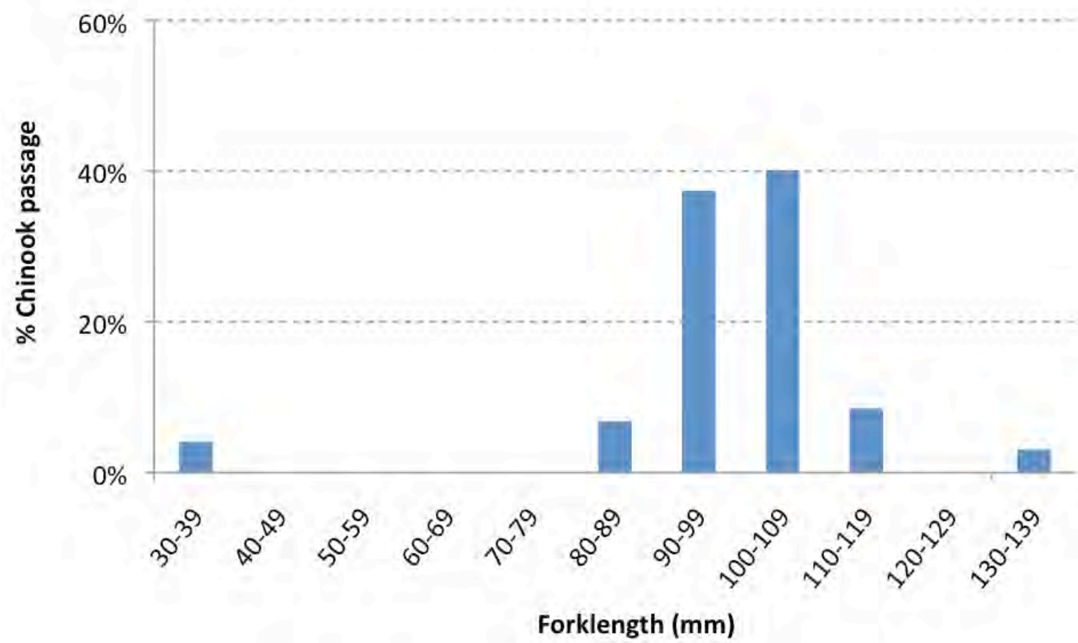

Figure 26. Estimated Chinook passage by 10 mm fork length intervals at Grayson during 2010.

Chinook Salmon Condition at Migration

Juveniles captured at both Waterford and Grayson during 2010 were generally healthy with no apparent signs of disease or stress. The relationship between individual salmon fork length and weight showed a very similar trend between Waterford and Grayson (Figure 27).

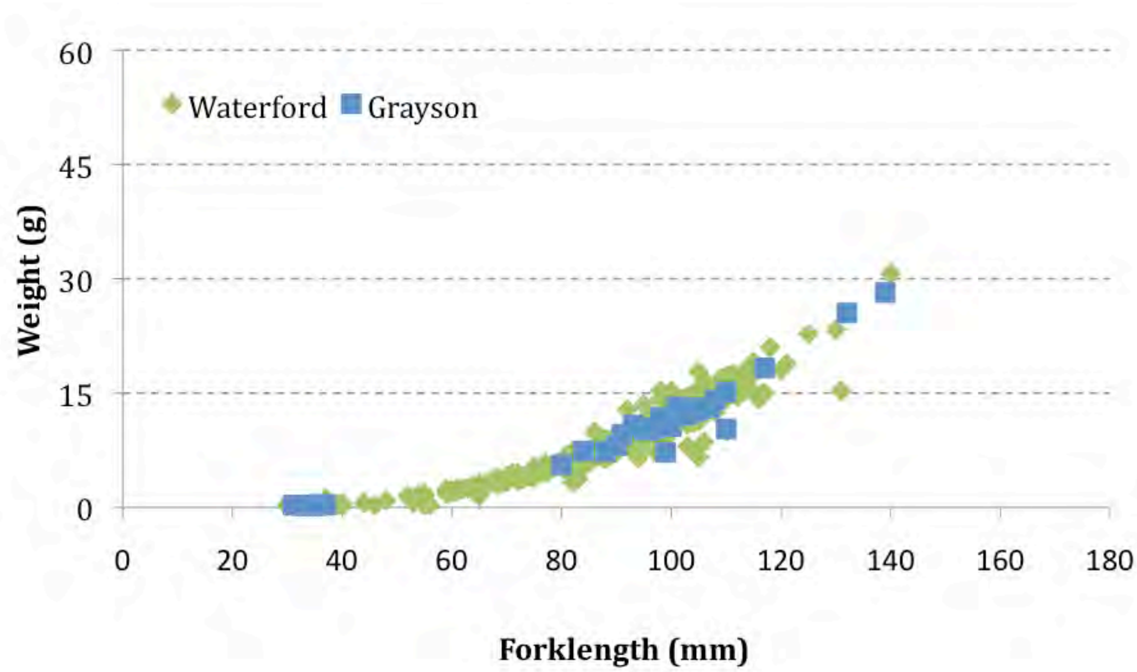

Figure 27. Fork length and weight of individual juvenile Chinook salmon measured at Waterford and Grayson during 2010.

Oncorhynchus mykiss (Rainbow Trout/Steelhead)

No *O. mykiss* were captured at Waterford or Grayson in 2010. Total annual *O. mykiss* catch at the Grayson and Waterford traps between 2007 and 2010 ranged from zero to eleven (Figure 28).

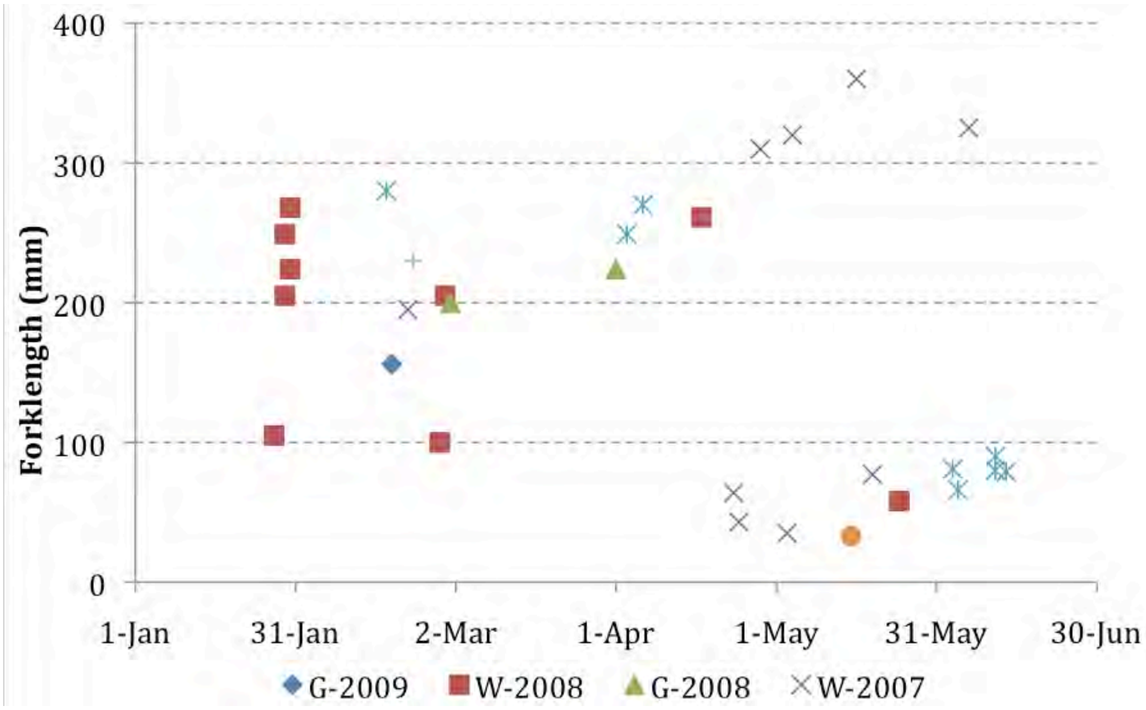

Figure 28. Date, size and location of *O. mykiss* captured at Waterford (W) and Grayson (G).

Other Fish Species Captured

A total of 4,467 non-salmonids representing at least 22 species (5 native, 17 introduced) were captured during operation of the Waterford and Grayson traps in 2010 (Table 7; Appendices C and D). Native species comprised 56.7% of the total non-salmonid catch, consisting primarily of lamprey (n=1,952). Most species captured at Waterford were also recorded at Grayson. Additional species only recorded at Waterford were green sunfish and tule perch. Species only recorded at Grayson were bigscale logperch, black bullhead, brown bullhead, black crappie, goldfish, 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.

Table 7. Non-salmonid species captured at Waterford and Grayson during 2010. Native species are indicated in bold.

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	*Ameiurus melas*	0	-	-	-	1	180	180	180
Brown bullhead	*Ameiurus nebulosus*	0	-	-	-	20	156	184	206
Channel catfish	*Ictalurus punctatus*	57	38	58	80	12	43	64	120
White catfish	*Ictalurus catus*	367	36	58	160	550	36	57	272
Lamprey Family									
Lamprey - unidentified	Not applicable	1,916	-	-	-	36	-	-	-
Livebearer Family									
Mosquitofish	*Gambusia affinis*	14	28	32	47	88	46	47	47
Minnow Family									
Golden shiner	*Notemigonus crysoleucas*	4	31	40	49	56	35	71	172
Goldfish	*Carassius auratus*	0	-	-	-	2	-	-	-
Red shiner	*Cyprinella lutrennsis*	1	54	54	54	88	25	57	155
Sacramento pikeminnow	*Ptychochelius grandis*	401	33	82	169	93	25	80	180
Perch Family									
Bigscale logperch	*Percina macrolepida*	0	-	-	-	1	107	107	107
Sculpin Family									
Prickly Sculpin	*Cottus asper*	14	72	85	140	3	90	108	125
Silverside Family									
Inland silverside	*Menidia beryllina*	0	-	-	-	5	34	54	72

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)
Sucker Family									
Sacramento sucker	*Catostomus occidentalis*	50	34	63	430	21	25	46	193
Sunfish Family									
Bluegill	*Lepomis macrochirus*	177	34	66	174	119	23	75.4	168
Black crappie	*Pomoxis annularis*	0	-	-	-	7	32	93.6	227
Green sunfish	*Lepomis cyanellus*	8	64	129	175	0	-	-	-
Largemouth bass	*Micropterus salmoides*	17	48	68	90	51	33	112	305
Redear sunfish	*Lepomis microlophus*	67	34	87	182	164	30	73	188
Smallmouth bass	*Micropterus dolomieu*	9	52	79	155	34	64	121	285
Warmouth	*Lepomis gulosus*	12	69	123	194	1	33	33	33
Unidentified bass	Not applicable	0	-	-	-	10	34	43.7	67
Surfperch Family									
Tule perch	*Hysterocarpus traskii*	1	89	89	89	0	-	-	-
Unidentified species	Not applicable	0	-	-	-	2	-	-	-

Total Species Captured = 22 (17 introduced, 5 native)

Total Native Individuals Captured = 2,535 (2,382 at Waterford, 153 at Grayson)

Total Introduced Individuals Captured = 1,932 (733 at Waterford, 1,199 at Grayson)

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Appendix A. Daily Chinook catch, length, and estimated passage at Waterford and environmental data from 2010.

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
1/5/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	255	1.8	50.3	0.32
1/6/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	254	1.7	49.6	0.96
1/7/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	244	1.8	50.0	3.96
1/8/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	228	1.9	50.7	0.43
1/9/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	231	1.7	49.6	0.41
1/10/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.9	48.5	0.43
1/11/10	1	35	35	35	0.111	7	0	2	9	0.111	7	0	2	9	9	227	1.5	50.1	1.51
1/12/10	11	31	34	37	0.111	80	0	19	99	0.111	80	0	19	99	99	225	1.7	52.5	1.36
1/13/10	25	32	34	36	0.111	182	0	43	225	0.111	182	0	43	225	225	224	1.8	53.4	1.22
1/14/10	16	33	77	115	0.111	116	0	28	144	0.111	116	0	28	144	144	224	2.2	54.5	2.79
1/15/10	20	35	88	130	0.111	159	1	29	189	0.111	159	1	29	189	189	226	1.7	50.7	17.30
1/16/10	8	31	53	109	0.111	61	0	11	72	0.111	61	0	11	72	72	226	1.5	50.5	3.24
1/17/10	4	31	59	88	0.111	30	0	5	36	0.111	30	0	5	36	36	226	1.7	50.9	1.52
1/18/10	1	39	39	39	0.111	8	0	1	9	0.111	8	0	1	9	9	224	2.1	51.2	2.32
1/19/10	17	33	34	35	0.111	129	1	23	153	0.111	129	1	23	153	153	225	1.7	50.3	4.34
1/20/10	51	30	38	90	0.111	387	3	70	459	0.111	387	3	70	459	459	225	1.8	46.0	13.20
1/21/10	53	34	38	65	0.111	971	8	174	1153	0.111	971	8	174	1153	1153	225	1.8	48.5	33.30
1/22/10	112	31	34	38	0.111	927	0	18	946	0.111	927	0	18	946	946	225	1.9	48.0	21.20
1/23/10	59	32	37	88	0.111	442	0	9	450	0.111	442	0	9	450	450	225	2.4	48.7	15.90
1/24/10	53	31	36	77	0.111	468	0	9	477	0.111	468	0	9	477	477	225	1.7	48.7	12.10
1/25/10	2	31	34	36	0.111	18	0	0	18	0.111	18	0	0	18	18	225	1.9	50.1	8.34
1/26/10	8	33	42	84	0.111	71	0	1	72	0.111	71	0	1	72	72	225	2.1	50.3	4.74
1/27/10	4	33	48	87	0.111	35	0	1	36	0.111	35	0	1	36	36	225	1.8	50.1	5.11
1/28/10	2	33	35	36	0.111	18	0	0	18	0.111	18	0	0	18	18	225	1.8	51.6	0.19
1/29/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.8	51.9	1.61
1/30/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.5	53.0	0.94
1/31/10	1	36	36	36	0.111	3	0	6	9	0.111	3	0	6	9	9	225	1.8	52.1	1.28
2/1/10	4	87	102	120	0.111	12	0	24	36	0.111	12	0	24	36	36	225	1.7	51.8	1.34
2/2/10	1	36	36	36	0.111	3	0	6	9	0.111	3	0	6	9	9	225	1.1	52.1	0.97
2/3/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.7	51.4	1.25
2/4/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.4	53.0	1.09
2/5/10	0	-	-	-	0.111	0	0	0	0	0.111	0	0	0	0	0	225	1.5	54.6	0.63

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
2/6/10	2	31	34	36	0.111	18	0	0	18	0.111	18	0	0	18	18	225	1.8	53.9	1.42
2/7/10	3	37	39	40	0.111	27	0	0	27	0.111	27	0	0	27	27	225	2.2	52.5	3.54
2/8/10	36	35	37	40	0.111	324	0	0	324	0.111	324	0	0	324	324	225	1.9	51.9	2.18
2/9/10	51	32	38	42	0.111	1054	0	0	1054	0.111	1054	0	0	1054	1054	225	1.8	52.6	7.99
2/10/10	45	31	36	44	0.111	396	0	0	396	0.111	396	0	0	396	396	225	2.1	51.6	1.16
2/11/10	15	35	38	40	0.111	63	0	0	63	0.111	63	0	0	63	63	225	1.7	53.7	5.82
2/12/10	1	33	33	33	0.111	9	0	0	9	0.111	9	0	0	9	9	225	1.5	52.7	1.83
2/13/10	7	31	46	103	0.111	61	0	2	63	0.111	61	0	2	63	63	225	1.6	53.2	1.26
2/14/10	1	87	87	87	0.111	9	0	0	9	0.111	9	0	0	9	9	225	1.4	53.6	1.24
2/15/10	4	32	52	99	0.111	35	0	1	36	0.111	35	0	1	36	36	225	1.5	53.7	1.94
2/16/10	6	31	34	37	0.111	52	0	2	54	0.111	52	0	2	54	54	225	1.9	54.5	0.68
2/17/10	19	30	35	38	0.111	165	0	6	171	0.111	165	0	6	171	171	225	1.8	54.8	0.59
2/18/10	43	30	35	37	0.111	373	0	14	387	0.111	373	0	14	387	387	225	2.0	55.2	0.37
2/19/10	29	33	36	38	0.111	259	2	0	261	0.111	259	2	0	261	261	225	2.2	56.1	1.66
2/20/10	15	35	36	38	0.111	107	1	0	108	0.111	107	1	0	108	108	225	1.5	54.2	1.14
2/21/10	22	32	36	38	0.111	187	2	0	189	0.111	187	2	0	189	189	225	1.8	53.9	0.92
2/22/10	18	30	35	38	0.111	161	2	0	162	0.111	161	2	0	162	162	225	1.6	51.9	0.76
2/23/10	10	34	39	60	0.111	89	1	0	90	0.111	89	1	0	90	90	225	2.1	52.5	0.20
2/24/10	6	35	36	36	0.111	36	0	0	36	0.111	36	0	0	36	36	225	2.0	51.0	1.68
2/25/10	13	33	35	37	0.111	116	1	0	117	0.111	116	1	0	117	117	227	1.8	51.2	4.93
2/26/10	29	34	42	89	0.111	243	14	5	261	0.111	243	14	5	261	261	224	1.7	53.5	5.92
2/27/10	14	32	36	38	0.111	117	7	2	126	0.111	117	7	2	126	126	225	1.9	53.4	3.89
2/28/10	40	34	36	41	0.111	335	19	6	360	0.111	335	19	6	360	360	222	1.9	52.2	9.17
3/1/10	48	33	46	140	0.111	402	23	8	432	0.111	402	23	8	432	432	224	1.4	54.6	15.50
3/2/10	21	35	42	65	0.111	134	8	3	144	0.111	134	8	3	144	144	223	-	54.0	5.50
3/3/10	26	33	46	72	0.111	151	9	3	162	0.111	151	9	3	162	162	224	-	54.1	4.67
3/4/10	6	34	41	62	0.111	50	3	1	54	0.111	50	3	1	54	54	225	-	51.0	7.52
3/5/10	22	34	51	131	0.111	169	25	5	198	0.111	169	25	5	198	198	224	2.1	52.1	14.60
3/6/10	12	33	42	64	0.111	92	13	3	108	0.111	92	13	3	108	108	223	-	53.6	-
3/7/10	7	34	48	56	0.111	54	8	2	63	0.111	54	8	2	63	63	224	2.0	53.0	4.11
3/8/10	13	34	35	37	0.111	100	15	3	117	0.111	100	15	3	117	117	224	2.0	55.0	4.41
3/9/10	19	34	42	61	0.111	146	21	4	171	0.111	146	21	4	171	171	223	2.2	50.0	1.53
3/10/10	21	34	44	75	0.111	161	23	5	189	0.111	161	23	5	189	189	226	2.0	52.1	3.15

	Unmarked Chinook Salmon															*Environmental Conditions*			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
3/11/10	28	35	40	60	0.111	215	31	6	252	0.111	215	31	6	252	252	227	1.9	51.8	1.68
3/12/10	31	34	35	37	0.111	216	18	9	243	0.111	216	18	9	243	243	222	1.9	53.4	1.05
3/13/10	23	33	41	58	0.111	184	15	8	207	0.111	184	15	8	207	207	224	1.9	51.2	0.28
3/14/10	29	34	50	80	0.111	232	19	10	261	0.111	232	19	10	261	261	224	2.2	51.6	1.99
3/15/10	23	34	43	75	0.111	160	13	7	180	0.111	160	13	7	180	180	225	1.7	53.7	1.85
3/16/10	5	33	41	68	0.111	40	3	2	45	0.111	40	3	2	45	45	225	1.9	55.7	1.28
3/17/10	2	35	35	35	0.111	16	1	1	18	0.111	16	1	1	18	18	223	2.1	57.9	5.40
3/18/10	2	55	62	69	0.053	34	3	1	38	0.053	34	3	1	38	38	221	1.8	57.9	2.92
3/19/10	1	73	73	73	0.053	2	8	9	19	0.053	2	8	9	19	19	376	1.6	57.0	2.10
3/20/10	0	-	-	-	0.053	0	0	0	0	0.053	0	0	0	0	0	761	2.2	60.9	-
3/21/10	11	40	63	78	0.053	22	90	95	208	0.053	22	90	95	208	208	759	3.6	53.9	2.20
3/22/10	12	51	66	78	0.053	24	98	104	226	0.053	24	98	104	226	226	694	3.3	53.0	2.41
3/23/10	6	44	64	73	0.053	12	49	52	113	0.053	12	49	52	113	113	400	3.2	53.0	0.59
3/24/10	2	60	69	77	0.053	4	16	17	38	0.053	4	16	17	38	38	277	2.5	53.9	2.04
3/25/10	5	40	66	75	0.053	10	41	43	94	0.053	10	41	43	94	94	242	-	56.3	1.44
3/26/10	2	53	66	78	0.053	2	9	27	38	0.053	2	9	27	38	38	224	-	57.3	0.31
3/27/10	7	75	86	98	0.053	8	31	93	132	0.053	8	31	93	132	132	224	-	56.0	2.82
3/28/10	0	-	-	-	0.053	0	0	0	0	0.053	0	0	0	0	0	222	-	57.3	1.93
3/29/10	4	61	71	83	0.053	4	18	53	75	0.053	4	18	53	75	75	223	-	58.2	0.35
3/30/10	1	44	44	44	0.053	1	4	13	19	0.053	1	4	13	19	19	225	-	60.2	2.05
3/31/10	1	100	100	100	0.053	1	4	13	19	0.053	1	4	13	19	19	268	-	57.0	1.06
4/1/10	2	68	76	84	0.053	2	9	27	38	0.053	2	9	27	38	38	480	-	55.4	1.59
4/2/10	11	63	82	104	0.053	0	38	170	208	0.053	0	38	170	208	208	634	-	52.8	0.97
4/3/10	12	53	74	90	0.053	0	41	185	226	0.053	0	41	185	226	226	652	-	51.0	1.89
4/4/10	7	62	76	85	0.053	0	24	108	132	0.053	0	24	108	132	132	652	-	50.5	0.66
4/5/10	2	66	68	69	0.053	0	7	31	38	0.053	0	7	31	38	38	651	-	50.3	-
4/6/10	11	67	81	88	0.053	0	38	170	208	0.053	0	38	170	208	208	653	-	52.0	1.51
4/7/10	12	68	79	90	0.053	0	41	185	226	0.053	0	41	185	226	226	652	-	52.7	0.55
4/8/10	15	70	80	90	0.053	0	51	232	283	0.053	0	51	232	283	283	652	-	54.3	1.04
4/9/10	11	69	85	95	0.053	5	10	192	208	0.053	5	10	192	208	208	707	-	54.3	0.39
4/10/10	6	65	79	88	0.053	3	6	105	113	0.053	3	6	105	113	113	759	-	55.2	1.78
4/11/10	0	-	-	-	0.053	0	0	0	0	0.053	0	0	0	0	0	760	-	52.8	0.67
4/12/10	5	38	71	97	0.02	6	12	232	250	0.056	2	4	83	89	170	1080	-	50.1	1.42

	Unmarked Chinook Salmon																Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
4/13/10	10	76	85	100	0.02	12	24	463	500	0.056	4	9	166	179	339	1270	-	50.2	2.79
4/14/10	6	74	79	95	0.02	7	15	278	300	0.056	3	5	99	107	204	1260	-	52.1	1.31
4/15/10	4	71	86	96	0.02	5	10	185	200	0.056	2	3	66	71	136	1330	-	-	2.94
4/16/10	1	-	-	-	0.02	1	0	49	50	0.056	1	0	17	18	34	1580	-	54.2	2.20
4/17/10	7	72	82	92	0.02	10	0	340	350	0.056	4	0	121	125	238	1770	-	53.9	1.37
4/18/10	5	81	89	99	0.02	7	0	243	250	0.056	3	0	87	89	170	1950	-	52.8	2.30
4/19/10	12	70	87	109	0.02	18	0	582	600	0.056	6	0	208	214	407	1980	-	53.4	1.60
4/20/10	3	74	80	83	0.02	4	0	146	150	0.056	2	0	52	54	102	2140	-	52.1	3.48
4/21/10	5	87	90	95	0.02	7	0	243	250	0.056	3	0	87	89	170	2150	-	50.9	1.48
4/22/10	2	37	63	88	0.02	3	0	97	100	0.056	1	0	35	36	68	2130	-	50.1	-
4/23/10	7	46	82	105	0.02	48	0	302	350	0.056	17	0	108	125	238	2160	-	51.9	5.37
4/24/10	5	35	70	98	0.02	34	0	216	250	0.056	12	0	77	89	170	1990	-	51.8	0.66
4/25/10	13	36	83	96	0.02	89	0	561	650	0.056	32	0	200	232	441	1770	-	52.7	0.55
4/26/10	5	80	86	95	0.02	34	0	216	250	0.056	12	0	77	89	170	1750	-	52.8	1.52
4/27/10	3	89	92	93	0.02	20	0	130	150	0.056	7	0	46	54	102	1750	-	53.0	1.69
4/28/10	6	80	87	95	0.02	41	0	259	300	0.056	15	0	93	107	204	1740	-	51.6	1.06
4/29/10	7	86	95	112	0.02	48	0	302	350	0.056	17	0	108	125	238	1770	-	50.3	-
4/30/10	14	83	97	113	0.02	21	0	679	700	0.056	8	0	242	250	475	2090	-	51.0	1.37
5/1/10	13	34	92	115	0.02	23	0	727	750	0.056	8	0	260	268	509	2350	-	52.0	0.65
5/2/10	14	79	92	100	0.02	21	0	679	700	0.056	8	0	242	250	475	2340	-	52.2	0.80
5/3/10	15	81	93	104	0.02	23	0	727	750	0.056	8	0	260	268	509	2560	-	54.1	1.04
5/4/10	34	35	88	109	0.02	57	0	1793	1850	0.056	20	0	640	661	1255	-	-	52.3	2.60
5/5/10	12	90	97	104	0.02	18	0	582	600	0.056	7	0	208	214	407	3280	-	48.0	1.19
5/6/10	3	97	101	104	0.02	5	0	145	150	0.056	2	0	52	54	102	3280	-	51.2	1.77
5/7/10	8	79	96	107	0.02	0	0	400	400	0.056	0	0	143	143	271	3290	-	52.3	0.95
5/8/10	6	90	98	115	0.02	0	0	300	300	0.056	0	0	107	107	204	3290	-	50.9	0.93
5/9/10	19	85	98	108	0.02	0	0	950	950	0.056	0	0	339	339	645	3280	-	51.0	1.43
5/10/10	15	84	96	108	0.02	0	0	750	750	0.056	0	0	268	268	509	3290	-	52.5	1.15
5/11/10	6	99	108	115	0.02	0	0	300	300	0.056	0	0	107	107	204	3300	4.7	50.0	0.69
5/12/10	22	84	100	116	0.02	0	0	1100	1100	0.056	0	0	393	393	746	3120	5.2	51.6	0.16
5/13/10	28	83	99	117	0.02	0	0	1400	1400	0.056	0	0	500	500	950	2680	-	57.4	0.53
5/14/10	43	75	97	112	0.02	18	0	2132	2150	0.056	7	0	761	768	1459	2580	-	50.8	0.39
5/15/10	51	35	98	119	0.02	22	0	2528	2550	0.056	8	0	903	911	1730	2440	5.1	54.5	0.98

	Unmarked Chinook Salmon															Environmental Conditions			
		Fork Length (mm)			High Range	Estimated Passage - High				Low Range	Estimated Passage - Low				Median	Flow (cfs)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Est. Efficiency	Fry	Parr	Smolt	Total	Passage	La Grange	Velocity (ft/s)	Temp at Trap	Turbidity
5/16/10	36	81	99	115	0.02	15	0	1785	1800	0.056	6	0	637	643	1221	2230	4.6	53.4	0.14
5/17/10	17	88	99	109	0.02	8	0	892	900	0.056	3	0	319	321	611	2160	4.2	53.2	0.52
5/18/10	11	85	99	110	0.02	5	0	545	550	0.056	2	0	195	196	373	2160	5.0	52.3	0.71
5/19/10	50	45	99	118	0.02	21	0	2479	2500	0.056	8	0	885	893	1696	2150	4.7	53.9	0.97
5/20/10	26	89	101	116	0.02	11	0	1289	1300	0.056	4	0	460	464	882	2140	4.6	52.7	0.75
5/21/10	31	83	98	111	0.02	0	0	1550	1550	0.056	0	0	554	554	1052	2150	4.6	53.2	0.65
5/22/10	35	84	100	113	0.02	0	0	1750	1750	0.056	0	0	625	625	1188	3060	4.9	51.0	0.52
5/23/10	2	88	88	88	0.02	0	0	150	150	0.056	0	0	54	54	102	3140	5.3	51.0	1.29
5/24/10	35	90	98	113	0.02	0	0	1800	1800	0.056	0	0	643	643	1221	3150	5.2	51.2	0.76
5/25/10	33	79	97	111	0.02	0	0	1700	1700	0.056	0	0	607	607	1154	3140	5.3	53.2	-
5/26/10	7	90	101	113	0.02	0	0	350	350	0.056	0	0	125	125	238	3160	4.2	52.7	2.05
5/27/10	11	91	102	118	0.02	0	0	550	550	0.056	0	0	196	196	373	2610	5.3	52.8	-
5/28/10	22	72	98	112	0.02	0	12	1088	1100	0.056	0	4	388	393	746	2250	5.1	53.0	0.08
5/29/10	21	78	98	110	0.02	0	12	1038	1050	0.056	0	4	371	375	713	2050	5.0	51.9	0.71
5/30/10	14	86	100	113	0.02	0	8	692	700	0.056	0	3	247	250	475	2040	5.0	53.0	0.31
5/31/10	7	60	91	109	0.02	0	4	346	350	0.056	0	1	124	125	238	2040	4.6	54.5	0.94
6/1/10	6	77	94	105	0.02	0	3	297	300	0.056	0	1	106	107	204	2040	4.5	56.1	1.05
6/2/10	13	84	96	111	0.02	0	7	643	650	0.056	0	3	230	232	441	2030	4.6	54.6	0.32
6/3/10	8	77	94	109	0.02	0	4	396	400	0.056	0	2	141	143	271	2050	3.7	56.1	0.26
6/4/10	3	95	104	109	0.02	0	0	150	150	0.056	0	0	54	54	102	3260	5.1	56.3	1.62
6/5/10	0	-	-	-	0.02	0	0	0	0	0.056	0	0	0	0	0	3140	4.9	55.0	0.26
6/6/10	5	85	97	110	0.02	0	0	250	250	0.056	0	0	89	89	170	2270	5.3	54.3	0.22
6/7/10	7	72	93	112	0.02	0	0	350	350	0.056	0	0	125	125	238	1940	4.8	55.9	0.76
6/8/10	4	83	93	102	0.02	0	0	200	200	0.056	0	0	71	71	136	1750	4.3	55.4	0.85
6/9/10	4	75	94	103	0.02	0	0	200	200	0.056	0	0	71	71	136	2060	4.4	56.3	0.22
6/10/10	3	94	107	125	0.02	0	0	150	150	0.056	0	0	54	54	102	4090	5.1	53.0	1.10
6/11/10	0	-	-	-	0.02	0	0	0	0	0.056	0	0	0	0	0	4450	-	52.7	1.38

Appendix B. Daily Chinook catch, length, predicted trap efficiency, and estimated passage at Grayson and environmental data from 2010.

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temp at the traps	Turbidity
1/6/10	0	-	-	-	-	0	0	0	0	311	2.0	1.9	51.0	1.27
1/7/10	0	-	-	-	-	0	0	0	0	310	1.9	1.8	50.7	0.53
1/8/10	0	-	-	-	-	0	0	0	0	300	1.9	2.0	50.4	0.96
1/9/10	0	-	-	-	-	0	0	0	0	300	1.8	1.9	50.6	0.62
1/10/10	0	-	-	-	-	0	0	0	0	300	2.0	1.9	50.6	1.48
1/11/10	0	-	-	-	-	0	0	0	0	300	1.9	1.8	50.5	1.25
1/12/10	0	-	-	-	-	0	0	0	0	300	1.8	1.8	51.4	1.22
1/13/10	0	-	-	-	-	0	0	0	0	300	1.8	1.9	53.8	0.98
1/14/10	0	-	-	-	-	0	0	0	0	300	1.6	2.0	53.2	1.07
1/15/10	0	-	-	-	-	0	0	0	0	300	1.8	1.9	52.1	0.62
1/16/10	0	-	-	-	-	0	0	0	0	279	1.8	1.8	53.0	1.57
1/17/10	0	-	-	-	-	0	0	0	0	293	1.9	1.6	52.9	5.82
1/18/10	1	139	139	139	0.006	0	0	177	177	345	2.1	2.1	52.7	8.15
1/19/10	1	105	105	105	0.018	0	0	57	57	389	1.8	1.8	51.8	3.46
1/20/10	0	-	-	-	-	0	0	0	0	413	1.8	1.8	50.6	11.80
1/21/10	0	-	-	-	-	0	0	0	0	777	2.1	1.8	49.7	3.27
1/22/10	1	31	31	31	0.185	5	0	0	5	804	3.0	2.9	48.5	80.70
1/23/10	0	-	-	-	-	0	0	0	0	1023	2.9	2.6	48.3	71.60
1/24/10	2	33	35	36	0.178	11	0	0	11	616	2.6	2.9	47.7	56.60
1/25/10	1	35	35	35	0.187	5	0	0	5	457	2.5	2.1	49.7	25.20
1/26/10	0	-	-	-	-	0	0	0	0	372	2.3	2.3	51.3	19.10
1/27/10	0	-	-	-	-	0	0	0	0	344	2.1	2.0	51.5	12.90
1/28/10	0	-	-	-	-	0	0	0	0	332	2.1	2.0	52.5	4.18
1/29/10	4	33	34	35	0.206	17	0	2	19	322	2.0	1.9	54.4	4.87
1/30/10	1	33	33	33	0.213	4	0	1	5	310	1.8	1.8	53.1	4.30
1/31/10	1	33	33	33	0.214	4	0	1	5	299	1.8	1.9	53.4	1.34
2/1/10	2	33	34	35	0.207	9	0	1	10	295	-	-	54.2	1.66
2/2/10	1	132	132	132	0.007	121	0	15	136	291	2.0	1.4	54.7	1.88
2/3/10	0	-	-	-	-	0	0	0	0	288	1.8	1.8	54.6	4.06
2/4/10	0	-	-	-	-	0	0	0	0	282	1.6	1.8	55.0	0.89
2/5/10	0	-	-	-	-	0	0	0	0	290	1.7	1.7	55.0	0.62
2/6/10	0	-	-	-	-	0	0	0	0	306	-	1.8	54.8	3.74
2/7/10	0	-	-	-	-	0	0	0	0	308	1.8	1.8	54.2	4.16
2/8/10	0	-	-	-	-	0	0	0	0	767	1.7	2.4	53.9	11.10
2/9/10	0	-	-	-	-	0	0	0	0	519	2.4	2.4	53.7	29.40
2/10/10	0	-	-	-	-	0	0	0	0	426	2.3	2.3	54.3	18.50
2/11/10	0	-	-	-	-	0	0	0	0	415	2.3	2.2	55.5	21.70
2/12/10	0	-	-	-	-	0	0	0	0	352	1.7	1.6	56.7	12.10
2/13/10	0	-	-	-	-	0	0	0	0	333	2.0	2.0	56.6	6.98
2/14/10	0	-	-	-	-	0	0	0	0	322	1.7	1.9	57.4	3.54
2/15/10	0	-	-	-	-	0	0	0	0	317	1.8	1.9	58.0	2.48
2/16/10	0	-	-	-	-	0	0	0	0	320	2.1	2.1	58.4	1.98

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temp at the traps	Turbidity
2/17/10	0	-	-	-	-	0	0	0	0	318	2.0	2.0	58.4	6.99
2/18/10	0	-	-	-	-	0	0	0	0	317	2.0	2.1	58.4	2.39
2/19/10	0	-	-	-	-	0	0	0	0	314	2.1	2.0	57.5	2.93
2/20/10	0	-	-	-	-	0	0	0	0	309	1.8	1.9	56.4	4.22
2/21/10	0	-	-	-	-	0	0	0	0	309	1.5	1.9	56.4	2.60
2/22/10	0	-	-	-	-	0	0	0	0	307	1.8	1.8	54.7	4.05
2/23/10	0	-	-	-	-	0	0	0	0	308	1.7	2.0	53.6	0.51
2/24/10	0	-	-	-	-	0	0	0	0	332	2.0	2.1	54.3	6.81
2/25/10	0	-	-	-	-	0	0	0	0	1338	2.3	2.1	53.7	16.80
2/26/10	0	-	-	-	-	0	0	0	0	568	2.4	2.1	55.2	32.30
2/27/10	0	-	-	-	-	0	0	0	0	510	2.2	2.1	54.9	14.40
2/28/10	0	-	-	-	-	0	0	0	0	1423	2.3	2.6	55.7	33.80
3/1/10	0	-	-	-	-	0	0	0	0	520	-	-	56.8	28.10
3/2/10	0	-	-	-	-	0	0	0	0	409	-	-	55.1	12.60
3/3/10	0	-	-	-	-	0	0	0	0	403	-	-	55.2	16.30
3/4/10	0	-	-	-	-	0	0	0	0	1380	-	-	53.0	16.70
3/5/10	0	-	-	-	-	0	0	0	0	1140	1.5	1.8	54.5	50.10
3/6/10	0	-	-	-	-	0	0	0	0	482	1.0	2.2	56.5	27.70
3/7/10	0	-	-	-	-	0	0	0	0	410	2.2	2.1	56.5	15.40
3/8/10	0	-	-	-	-	0	0	0	0	376	-	-	55.0	10.48
3/9/10	0	-	-	-	-	0	0	0	0	354	1.8	2.1	55.3	6.53
3/10/10	0	-	-	-	-	0	0	0	0	344	1.8	1.8	55.7	3.89
3/11/10	0	-	-	-	-	0	0	0	0	336	1.8	1.8	55.2	4.24
3/12/10	0	-	-	-	-	0	0	0	0	332	1.4	1.8	54.8	3.28
3/13/10	0	-	-	-	-	0	0	0	0	328	2.0	1.8	55.7	8.65
3/14/10	0	-	-	-	-	0	0	0	0	379	1.9	1.8	56.9	2.11
3/15/10	1	37	37	37	0.181	6	0	0	6	365	1.8	1.7	59.0	6.48
3/16/10	0	-	-	-	-	0	0	0	0	359	1.9	1.6	61.4	3.45
3/17/10	0	-	-	-	-	0	0	0	0	359	1.7	1.7	62.1	3.45
3/18/10	0	-	-	-	-	0	0	0	0	347	1.7	1.6	62.3	5.85
3/19/10	0	-	-	-	-	0	0	0	0	337	1.6	1.8	62.8	3.21
3/20/10	0	-	-	-	-	0	0	0	0	483	1.7	1.5	62.0	4.18
3/21/10	0	-	-	-	-	0	0	0	0	864	2.4	1.9	59.5	1.52
3/22/10	0	-	-	-	-	0	0	0	0	862	2.4	2.2	58.3	4.14
3/23/10	1	100	100	100	0.018	0	0	57	57	793	2.4	2.4	58.9	2.69
3/24/10	1	80	80	80	0.039	0	0	25	25	505	-	-	59.6	3.58
3/25/10	0	-	-	-	-	0	0	0	0	374	-	-	59.7	2.69
3/26/10	0	-	-	-	-	0	0	0	0	323	-	-	61.1	1.12
3/27/10	0	-	-	-	-	0	0	0	0	293	-	-	62.7	3.54
3/28/10	0	-	-	-	-	0	0	0	0	292	-	-	63.4	0.99
3/29/10	0	-	-	-	-	0	0	0	0	280	-	-	63.6	4.22
3/30/10	1	90	90	90	0.031	0	0	32	32	274	-	-	61.5	1.29
3/31/10	0	-	-	-	-	0	0	0	0	271	-	-	61.0	-
4/1/10	0	-	-	-	-	0	0	0	0	296	-	-	58.7	2.02
4/2/10	0	-	-	-	-	0	0	0	0	486	-	-	56.6	2.02

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temp at the traps	Turbidity
4/3/10	0	-	-	-	-	0	0	0	0	651	-	-	53.7	2.96
4/4/10	0	-	-	-	-	0	0	0	0	706	-	-	54.2	9.39
4/5/10	0	-	-	-	-	0	0	0	0	741	-	-	55.1	4.33
4/6/10	0	-	-	-	-	0	0	0	0	722	-	-	57.2	3.69
4/7/10	0	-	-	-	-	0	0	0	0	735	-	-	59.4	4.00
4/8/10	0	-	-	-	-	0	0	0	0	723	-	-	59.6	3.06
4/9/10	0	-	-	-	-	0	0	0	0	698	-	-	59.3	3.26
4/10/10	1	93	93	93	0.023	0	0	44	44	743	-	-	56.8	3.18
4/11/10	0	-	-	-	-	0	0	0	0	813	-	-	54.8	3.18
4/12/10	0	-	-	-	-	0	0	0	0	820	-	-	55.1	2.34
4/13/10	0	-	-	-	-	0	0	0	0	1050	-	-	55.7	2.12
4/14/10	0	-	-	-	-	0	0	0	0	1200	-	-	56.7	3.23
4/15/10	0	-	-	-	-	0	0	0	0	1210	-	-	57.7	5.23
4/16/10	0	-	-	-	-	0	0	0	0	1260	-	-	58.0	3.08
4/17/10	0	-	-	-	-	0	0	0	0	1450	-	-	57.8	2.87
4/18/10	0	-	-	-	-	0	0	0	0	1610	-	-	57.4	3.02
4/19/10	0	-	-	-	-	0	0	0	0	1730	-	-	56.3	4.79
4/20/10	0	-	-	-	-	0	0	0	0	1930	-	-	53.8	6.11
4/21/10	0	-	-	-	-	0	0	0	0	2274	-	-	52.7	-
4/22/10	0	-	-	-	-	0	0	0	0	2280	-	-	54.0	2.66
4/23/10	0	-	-	-	-	0	0	0	0	2267	-	-	56.3	5.92
4/24/10	1	90	90	90	0.013	0	0	76	76	2298	-	-	57.8	2.14
4/25/10	0	-	-	-	-	0	0	0	0	2114	-	-	58.4	2.43
4/26/10	0	-	-	-	-	0	0	0	0	1881	-	-	57.8	1.95
4/27/10	1	88	88	88	0.017	0	0	59	59	1855	-	-	56.1	3.59
4/28/10	1	80	80	80	0.022	0	0	45	45	1848	-	-	54.6	3.48
4/29/10	0	-	-	-	-	0	0	0	0	1836	-	-	55.2	3.23
4/30/10	1	99	99	99	0.012	0	0	86	86	1869	-	-	56.3	3.00
5/1/10	0	-	-	-	-	0	0	0	0	2188	-	-	56.8	-
5/2/10	1	90	90	90	0.012	0	0	80	80	2445	-	-	57.3	-
5/3/10	0	-	-	-	-	0	0	0	0	2441	-	-	57.4	9.29
5/4/10	0	-	-	-	-	0	0	0	0	2659	-	-	56.2	2.07
5/5/10	0	-	-	-	-	0	0	0	0	3378	-	-	55.2	2.46
5/6/10	0	-	-	-	-	0	0	0	0	3392	-	-	55.1	-
5/7/10	0	-	-	-	-	0	0	0	0	3387	-	-	55.6	-
5/8/10	0	-	-	-	-	0	0	0	0	3395	-	-	55.2	1.95
5/9/10	0	-	-	-	-	0	0	0	0	3395	-	-	53.4	3.43
5/10/10	1	84	84	84	0.010	0	0	97	97	3379	-	-	53.3	2.50
5/11/10	0	-	-	-	-	0	0	0	0	3399	4.0	4.3	54.9	1.58
5/12/10	0	-	-	-	-	0	0	0	0	3419	3.0	3.0	56.1	2.05
5/13/10	1	105	105	105	0.005	0	0	187	187	3233	-	-	57.1	1.52
5/14/10	0	-	-	-	-	0	0	0	0	2782	-	-	57.6	1.63
5/15/10	1	-	-	-	0.009	0	0	118	118	2700	3.1	3.2	57.9	0.69
5/16/10	0	-	-	-	-	0	0	0	0	2553	2.8	3.1	56.9	1.51
5/17/10	1	91	91	91	0.013	0	0	80	80	2337	2.8	2.5	56.1	1.52

	Unmarked Chinook Salmon									*Environmental Conditions*				
		Fork Length (mm)				Estimated Passage				Flow (cfs)	Velocity (ft/s)			
Date	Catch	Min	Avg	Max	Est. Efficiency	Fry	Parr	Smolt	Total	Modesto Flow	North	South	Temp at the traps	Turbidity
5/18/10	1	100	100	100	0.010	0	0	105	105	2257	3.1	3.5	56.9	1.43
5/19/10	1	104	104	104	0.008	0	0	120	120	2256	3.0	3.2	57.3	0.92
5/20/10	6	99	104	108	0.008	0	0	718	718	2266	3.0	3.3	57.0	2.68
5/21/10	3	95	102	110	0.009	0	0	333	333	2267	3.0	3.2	55.9	4.28
5/22/10	1	117	117	117	0.005	0	0	187	187	2266	2.1	3.4	55.3	2.28
5/23/10	0	-	-	-	-	0	0	0	0	3178	3.3	3.6	55.4	0.24
5/24/10	0	-	-	-	-	0	0	0	0	3264	3.7	3.1	55.3	2.56
5/25/10	0	-	-	-	-	0	0	0	0	3274	3.7	3.8	54.9	0.70
5/26/10	1	100	100	100	0.006	0	0	159	159	3255	3.6	3.7	55.5	2.25
5/27/10	0	-	-	-	-	0	0	0	0	3284	-	-	55.7	1.77
5/28/10	0	-	-	-	-	0	0	0	0	2757	3.7	3.5	57.2	1.30
5/29/10	0	-	-	-	-	0	0	0	0	2410	3.0	3.2	58.6	6.18
5/30/10	1	110	110	110	0.007	0	0	143	143	2186	2.8	3.0	59.3	1.58
5/31/10	0	-	-	-	-	0	0	0	0	2180	1.7	2.9	59.6	2.66
6/1/10	2	98	100	101	0.010	0	0	197	197	2161	2.4	1.9	60.1	1.13
6/2/10	0	-	-	-	-	0	0	0	0	2159	2.8	3.0	60.7	1.40
6/3/10	1	97	97	97	0.011	0	0	90	90	2146	2.8	3.2	61.2	1.38
6/4/10	1	96	96	96	0.011	0	0	87	87	2157	2.9	3.1	60.3	1.41
6/5/10	0	-	-	-	-	0	0	0	0	3355	3.5	3.6	60.1	0.52
6/6/10	1	98	98	98	0.007	0	0	148	148	3251	3.4	3.2	61.0	0.97
6/7/10	0	-	-	-	-	0	0	0	0	2387	3.1	3.2	61.1	2.10
6/8/10	1	-	-	-	0.012	0	0	86	86	2048	2.7	3.2	61.2	2.03
6/9/10	0	-	-	-	-	0	0	0	0	1862	2.3	2.7	60.5	0.92
6/10/10	0	-	-	-	-	0	0	0	0	2157	2.7	2.8	57.7	2.46
6/11/10	0	-	-	-	-	0	0	0	0	4192	3.4	3.6	57.4	5.56
6/12/10	0	-	-	-	-	0	0	0	0	4585	3.8	4.0	57.9	4.09
6/13/10	0	-	-	-	-	0	0	0	0	4555	3.6	3.8	57.6	2.02
6/14/10	0	-	-	-	-	0	0	0	0	5620	4.1	4.1	57.8	1.94
6/15/10	2	95	97	98	0.004	0	0	458	458	4410	4.5	4.0	58.0	2.26
6/16/10	0	-	-	-	-	0	0	0	0	3997	3.8	3.6	58.1	2.06
6/17/10	1	105	105	105	0.005	0	0	191	191	3283	2.1	2.4	58.9	1.25

Appendix C. Daily counts of non-salmonids captured at Waterford during 2010.

Batch Date	BGS	BRB	CHC	GSF	GSN	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	TP	W	WHC
1/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/5/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1/6/10	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
1/7/10	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1/8/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/10/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/10	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1
1/12/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/10	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
1/14/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1/15/10	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
1/16/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
1/17/10	2	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
1/18/10	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1
1/19/10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/20/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/10	3	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
1/22/10	2	0	0	0	0	4	0	0	0	1	0	0	0	1	0	0	3
1/23/10	3	0	0	0	1	4	0	0	1	0	0	0	1	0	0	0	2
1/24/10	2	0	0	0		1	0	0	0	1	0	0	0	0	0	0	0
1/25/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/26/10	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0	0	2
1/27/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1/28/10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/10	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
1/30/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1/31/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/10	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
2/2/10	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1
2/3/10	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
2/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2/7/10	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	2
2/8/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/10	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
2/10/10	2	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	2
2/11/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2/12/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Batch Date	BGS	BRB	CHC	GSF	GSN	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	TP	W	WHC
2/13/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
2/14/10	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2/15/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/10	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2/17/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/10	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2/19/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2/20/10	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
2/21/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2/25/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
2/28/10	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
3/1/10	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
3/2/10	2	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
3/3/10	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	4
3/4/10	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
3/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3/6/10	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2
3/7/10	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1
3/8/10	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
3/9/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3/10/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
3/11/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/12/10	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
3/13/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
3/15/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/16/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3/17/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
3/19/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/20/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/10	1	0	1	0	0	1	1	0	0	8	0	0	0	0	0	0	16
3/22/10	11	0	0	0	0	1	2	0	0	1	0	0	0	0	0	0	4
3/23/10	6	0	3	0	0	1	1	0	0	1	0	1	0	0	0	0	18
3/24/10	6	0	3	0	0	1	0	0	0	0	0	1	0	0	0	0	6
3/25/10	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2
3/26/10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Batch Date	BGS	BRB	CHC	GSF	GSN	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	TP	W	WHC
3/27/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/10	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
3/29/10	5	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1
3/30/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/31/10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/1/10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/10	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
4/3/10	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6
4/4/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5
4/5/10	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	4
4/6/10	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	17
4/7/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9
4/8/10	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	11
4/9/10	3	0	2	0	0	0	0	0	0	0	0	0	2	0	1		8
4/10/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
4/11/10	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	11
4/12/10	1	0	2	0	0	1	0	1	0	0	0	0	0	0	0	0	7
4/13/10	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/14/10	4	0	2	1	0	1	0	0	0	0	0	5	4	1	0	0	13
4/15/10	0	0	1	0	0	1	0	0	0	0	0	3	0	0	0	0	13
4/16/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/17/10	4	0	1	0	0	0	0	1	0	0	0	1	3	0	0	0	18
4/18/10	5	0	2	0	0	1	1	2	0	1	0	21	2	0	0	1	10
4/19/10	0	0	3	0	0	2	0	2	0	1	0	24	2	0	0	0	19
4/20/10	3	0	1	0	0	2	0	0	0	1	0	18	0	0	0	0	6
4/21/10	0	0	1	0	0	2	0	0	0	0	0	15	1	0	0	1	2
4/22/10	3	0	0	0	0	0	1	0	0	0	0	19	1	0	0	0	2
4/23/10	1	0	1	0	0	1	0	0	0	4	0	22	3	0	0	0	4
4/24/10	5	0	2	2	0	1	1	0	0	1	0	21	0	0	0	0	2
4/25/10	8	0	6	0	0	1	1	0	0	0	0	22	5	0	0	0	5
4/26/10	3	0	3	0	0	1	0	1	0	0	0	9	3	0	0	0	1
4/27/10	2	0	0	0	0	0	0	0	0	1	0	5	3	0	0	0	1
4/28/10	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	3
4/29/10	0	0	0	0	0	1	0	0	0	0	0	3	2	0	0	0	2
4/30/10	1	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1
5/1/10	0	0	1	0	0	1	0	0	0	0	0	4	1	0	0	0	2
5/2/10	0	0	0	2	0	1	0	0	0	0	0	12	1	0	0	0	1
5/3/10	1	0	1	0	0	1	1	0	0	7	0	8	2	0	0	0	2
5/4/10	2	0	0	0	0	1	1	0	0	4	0	12	1	0	0	0	0
5/5/10	1	0	0	0	0	2	1	0	0	0	0	15	0	0	0	0	2
5/6/10	1	1	0	0	0	2	0	0	0	0	0	19	1	0	0	1	1
5/7/10	0	0	0	0	0	2	0	0	0	0	0	18	0	0	0	0	1

Batch Date	BGS	BRB	CHC	GSF	GSN	LAM	LMB	MQK	PRS	RES	RSN	SASQ	SASU	SMB	TP	W	WHC
5/8/10	2	0	0	0	0	1	0	0	0	0	0	9	0	0	0	0	1
5/9/10	0	0	0	0	0	0	1	0	0	2	0	5	1	0	0	0	0
5/10/10	0	0	1	0	0	1	0	0	0	1	0	5	0	0	0	1	1
5/11/10	1	0	0	0	0	0	0	0	0	0	0	4	1	0	0	1	0
5/12/10	2	0	0	0	0	1	2	0	0	0	0	6	0	0	0	0	0
5/13/10	0	0	0	0	0	1	0	0	0	0	0	5	2	0	0	0	0
5/14/10	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1
5/15/10	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
5/16/10	0	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	3
5/17/10	0	0	2	0	0	1	0	0	0	0	0	2	0	0	0	0	0
5/18/10	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5/19/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3
5/20/10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/22/10	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
5/23/10	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
5/24/10	1	0	0	0	0	1	1	0	0	1	0	3	0	0	0	0	0
5/25/10	0	0	0	0	0	1	0	0	0	1	0	5	1	0	0	1	0
5/26/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5/27/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
5/28/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5/29/10	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0
5/30/10	2	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1
5/31/10	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	1
6/1/10	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3
6/2/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3/10	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
6/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/6/10	1	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0
6/7/10	1	0	0	0	0	2	0	0	0	4	0	0	0	1	0	0	1
6/8/10	0	0	0	0	0	0	0	1	0	2	0	1	0	1	0	0	0
6/9/10	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1
6/10/10	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3
6/11/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Appendix D. Daily counts of non-salmonids captured at Grayson during 2010.

Batch Date	BAS	BGS	BKB	BKS	BRB	CHC	GF	GSN	LAM	LMB	LP	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	UNID	W	WHC
1/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1/6/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
1/7/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1/8/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1/9/10	0	1	0	0	0	0	0	0	0	1	0	1	0	0	4	5	0	0	1	0	0	5
1/10/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
1/11/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
1/12/10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	3
1/13/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1/14/10	0	2	0	0	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	0	0	13
1/15/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	7
1/16/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1
1/17/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
1/18/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
1/19/10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	2	0	0	0	0	0	5
1/20/10	0	2	0	0	0	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	5
1/21/10	0	0	0	0	1	0	0	0	1	0	0	0	0	0	9	0	0	0	1	0	0	5
1/22/10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
1/23/10	0	4	0	0	0	1	0	0	3	2	0	2	2	0	2	1	0	0	3	0	0	2
1/24/10	0	2	0	0	1	0	0	2	1	2	0	4	0	0	5	0	0	0	0	0	0	3
1/25/10	0	8	0	0	0	0	0	1	0	0	0	1	0	0	3	0	0	0	1	0	0	0
1/26/10	0	7	0	0	2	0	0	1	2	0	0	1	0	0	12	0	0	1	2	0	0	5
1/27/10	0	6	0	1	1	0	0	3	0	1	0	3	0	0	9	0	0	1	0	0	0	5
1/28/10	0	7	0	0	1	0	0	3	0	2	1	5	0	0	7	0	0	0	1	0	0	16
1/29/10	0	2	0	0	0	2	0	1	0	1	0	1	0	0	7	2	0	0	1	0	0	5
1/30/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	7
1/31/10	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	2	0	0	0	0	0	1
2/1/10	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	4
2/2/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	5
2/3/10	0	0	0	0	1	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	1	3
2/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
2/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	1
2/6/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
2/7/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
2/8/10	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	4
2/9/10	0	1	0	0	0	0	0	4	0	2	0	2	0	1	6	4	0	0	2	0	0	15
2/10/10	0	3	0	0	1	0	0	0	0	6	0	3	0	1	14	10	0	0	0	0	0	27
2/11/10	0	0	0	0	0	0	0	5	0	0	0	1	0	0	4	0	0	0	0	0	0	5
2/12/10	0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	6
2/13/10	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	1	0	0	16
2/14/10	0	4	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	1	0	28

Batch Date	BAS	BGS	BKB	BKS	BRB	CHC	GF	GSN	LAM	LMB	LP	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	UNID	W	WHC
2/15/10	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
2/16/10	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2/17/10	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	5	0	0	0	0	0	14
2/18/10	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	5
2/19/10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8
2/20/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
2/21/10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	3
2/22/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8
2/23/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
2/24/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4
2/25/10	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2/26/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
2/27/10	0	3	0	0	0	0	0	1	0	8	0	0	0	0	1	0	0	0	0	0	0	4
2/28/10	0	0	0	0	0	0	0	5	1	2	0	1	0	0	1	0	0	0	0	0	0	26
3/1/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/10	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0
3/3/10	0	1	0	0	0	0	0	1	0	1	0	3	0	0	5	2	0	0	0	0	0	7
3/4/10	0	2	0	1	0	0	0	0	0	0	0	1	0	0	3	4	0	0	0	0	0	12
3/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/6/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0
3/7/10	0	2	0	0	1	0	0	0	0	0	0	0	0	0	1	3	0	0	2	0	0	0
3/8/10	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	7
3/9/10	0	2	0	0	1	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	3
3/10/10	0	0	0	0	2	0	0	4	0	0	0	0	0	0	1	2	0	0	0	0	0	2
3/11/10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	2
3/12/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
3/13/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3/14/10	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	3
3/15/10	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	5
3/16/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
3/17/10	0	2	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	7
3/18/10	0	2	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	3
3/19/10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	4
3/20/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
3/21/10	0	3	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	4
3/22/10	0	2	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	7
3/23/10	0	0	0	0	0	0	0	1	0	0	0	2	0	0	2	2	0	0	2	0	0	9
3/24/10	0	2	0	0	0	1	0	0	0	0	0	2	1	0	5	1	0	0	0	0	0	8
3/25/10	0	4	0	0	0	0	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	6
3/26/10	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
3/27/10	0	2	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	3
3/28/10	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Batch Date	BAS	BGS	BKB	BKS	BRB	CHC	GF	GSN	LAM	LMB	LP	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	UNID	W	WHC
3/29/10	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4
3/30/10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4/1/10	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1
4/2/10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4/3/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/10	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3
4/6/10	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5
4/7/10	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	10
4/8/10	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	0	9
4/9/10	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	2
4/10/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2
4/11/10	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
4/12/10	0	1	0	0	0	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	5
4/13/10	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	0	0	7
4/14/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4
4/15/10	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	1	0	0	0	0	0	2
4/16/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	7
4/17/10	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	2
4/18/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
4/19/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
4/20/10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	3	0	0	0	0	4
4/21/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/22/10	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0
4/23/10	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	13	0	0	0	0	1
4/24/10	0	2	0	0	0	0	0	0	2	1	0	1	0	0	0	1	18	0	0	0	0	0
4/25/10	0	1	0	0	0	0	0	0	2	0	0	1	0	0	0	0	20	0	0	0	0	3
4/26/10	0	1	0	0	0	1	0	0	0	1	0	3	0	0	0	0	9	0	0	0	0	3
4/27/10	0	1	0	0	1	0	0	0	0	1	0	4	0	0	0	0	7	0	0	0	0	2
4/28/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
4/29/10	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	3	0	0	0	0	1
4/30/10	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
5/2/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/3/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
5/4/10	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
5/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/6/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/7/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/8/10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5/9/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Batch Date	BAS	BGS	BKB	BKS	BRB	CHC	GF	GSN	LAM	LMB	LP	MQK	MSS	PRS	RES	RSN	SASQ	SASU	SMB	UNID	W	WHC
5/10/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
5/11/10	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/12/10	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1
5/13/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/14/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
5/15/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
5/16/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
5/17/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/18/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/19/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
5/20/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
5/22/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/23/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/24/10	0	0	0	0	0	0	0	0	2	0	0	1	0	0	2	6	1	1	0	0	0	2
5/25/10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2
5/26/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0
5/27/10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
5/28/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5/29/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
5/30/10	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	4	0	0	0	1
5/31/10	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	0	0	3
6/1/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
6/2/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1
6/3/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
6/5/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/10	1	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1
6/8/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3
6/9/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6/10/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
6/11/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
6/14/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/10	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
6/16/10	4	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	1
6/17/10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Key to species codes

BAS	Unidentified bass
BGS	Bluegill
BKB	Black bullhead
BKS	Black crappie
BRB	Brown bullhead
CHC	Channel catfish
CHN	Chinook
GF	Goldfish
GSF	Green sunfish
GSN	Golden shiner
LAM	Lamprey, unidentified species
LMB	Largemouth bass
LP	Bigscale logperch
MQK	Mosquitofish
MSS	Inland silverside
PRS	Prickly sculpin
RES	Redear sunfish
RSN	Red shiner
SASQ	Sacramento pikeminnow
SASU	Sacramento sucker
SMB	Smallmouth bass
TP	Tule perch
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	)	

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

<u>Report 2010-5</u>

2010 Snorkel Report and Summary Update

Prepared for

Turlock and Modesto Irrigation Districts

By

Steve Kirihara
Stillwater Sciences
Berkeley, CA

March 2011

SUMMARY

In 2010, higher summer flows in June and July precluded conducting the early summer reference count snorkel survey within the 20-mile reach of the Tuolumne River below La Grange Dam. The 3-day survey was instead conducted on 10-12 August, with an additional survey conducted on 02-04 November. Preliminary USGS flow at La Grange was about 315 cfs and water temperature ranged from 11.1°C (52.0 F) to 20.1°C (68.2 F) in August and flow was about 360 cfs with water temperatures from 11.7°C (53.1 F) to 14.3°C (57.7 F) in November. A total of 152 juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and 268 rainbow trout (*Oncorhynchus mykiss*) were observed in various habitats in August and 170 Chinook salmon (including adult spawners) and 218 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 31 (RM 38.0) in August and Chinook salmon and rainbow trout were both observed downstream to Riffle 41A (RM 35.3) in November. Other native fish species observed were Sacramento sucker, Sacramento pikeminnow, hardhead, Pacific lamprey, and riffle sculpin with the non-native species recorded being largemouth bass, smallmouth bass, redear sunfish, and striped bass during the two surveys.

Early summer surveys in June/July have been conducted in most years since 1986 except in years with high flows (1995, 1998, 2005, 2006, and 2010) that precluded the surveys.

Late summer surveys have been conducted in September of most years during the 2001–2010 period with the exception of 2008 and 2009. Rainbow trout were observed in all years surveyed with the highest counts seen in 2006 and the second highest counts seen in 2010 (August and November). Chinook salmon were seen in much lower numbers or not at during the late summer surveys over the same period of years with the highest counts observed in 2010.

Summer distribution of non-salmonid species (species other than trout or salmon) shifted beginning in 1996. Prior to then, 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 further downstream. The change in species distribution coincided with higher required summer flows and associated cooler water temperatures occurring in non-flood release years.

CONTENTS

1 INTRODUCTION

The Turlock and Modesto irrigation districts (Districts) Tuolumne River snorkel surveys began in 1982 and the number, location, area sampled by site and season having varied over the years. 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 subsequent to 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 (*O. 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 included since 2001 and a comparable September snorkel survey was included in 2001–2007 and again in 2010. In 2010 the survey was conducted in August and was repeated in November. The 2010 surveys were implemented as required studies under the FERC order issued 10 May 2010 regarding *Oncorhynchus 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 2010 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 a “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 2010 SAMPLING CONDITIONS

The flow at La Grange during 10–12 August was approximately 315 cfs and approximately 360 cfs during the 02–04 November survey (Figure. 2). Water temperature ranged from 11.1 °C (52.0 °F) at Riffle A7 on 10 August to 20.1 °C (68.2 °F) at Riffle 57 on 12 August and 11.7 °C (53.1 °F) on 02 November to 14.3 °C (57.7 °F) on 04 November at these same locations. 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 near the city of Waterford. The snorkeling method provided an index of species abundance and these surveys are currently referred to as “reference counts”.

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 2010 surveys required more areas to be searched utilizing the downstream float method.

Usually the total length of an observed fish was estimated using scale markings 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 10–12 August and 02–04 November are summarized in Tables 1 and 2, respectively. The seven 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*), Pacific lamprey (*Lampetra tridentata*) 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 R31 (RM 38.0) in August and both species were observed downstream to R41A (RM 35.3) in November.

During the August surveys, there were 152 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 50–170 mm total length (TL). There were 268 rainbow trout observed ranging in size from 40–480 mm TL and were seen in riffle, run, and run-pool habitats. A total of 195 juvenile (<150 mm TL) and 73 adult rainbow trout were observed between RA7 (RM 50.7) and R31 (RM 38.0). Fish were observed in riffle, run, and run-pool habitats. Water temperature at those locations ranged from 11.1 ºC (52.0 F) to 16.3 ºC (61.3 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 R21 (RM 42.9) for the first time during the reference snorkel surveys.

During the November surveys, there were 170 Chinook salmon including 13 adult spawners observed in riffle, run and pool habitats from RA7 (RM 50.7) to R41A (RM 35.3). The juveniles ranged in size from 70–120 mm TL and the adults ranged in size from 650-920 mm TL . There were a total 218 rainbow trout observed ranging in size from 70–400 mm FL also observed in similar combinations of riffle, run and pool habitats, with 155 juvenile (<150 mm TL) and 63 adults observed between RA7 (RM 50.7) and R 41A (RM 35.3). Water temperature ranged from 11.7 °C (53.1 °F) to 14.2 °C (57.6 °F) at those locations. Similar to the August survey, Sacramento sucker along with Sacramento pikeminnow and hardhead were often co-occurring, while riffle sculpin were observed at 4 locations in low numbers usually hidden under cobble/boulder substrate. Striped bass were again observed at R21 (RM 42.9).

4 COMPARISON WITH OTHER YEARS

4.1 Rainbow trout and Chinook salmon: 1982-2010

Tables 3 and 4 summarize rainbow trout and Chinook salmon observations for all snorkel surveys conducted between 1982 and 2010. Some rainbow trout were observed downstream to R5 (RM 48.0) in limited surveys from 1982 to 1986. Rainbow trout were almost entirely absent during 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 1982–2010 period, Chinook salmon were recorded in all years except 1991 and 1992 although in some years their 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 2000–2010 period are shown in Figures 5 and 6.

4.2 Recent surveys: 2001-2010

Since the early summer snorkel survey could not be completed due to high flows in some years (2005, 2006, 2010), the comparative discussion will focus on the September surveys. The number of rainbow trout and Chinook salmon observed for the 2001 to 2010 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 Br. (RM 31.5). During the August 10-12 and November 2-4 surveys conducted in 2010, the total numbers of both Chinook and rainbow trout increased from 2007, the last year the late summer surveys were conducted.

The locations sampled since 2001 were the same each year and these surveys were the most comparable. September surveys show rainbow trout counts increased from 2001 to 2005 and were much higher beginning in 2006 (Figure 9). The increase in 2006 and 2010 may be the result of more trout being introduced into the lower river from the La Grange reservoir during the flood control releases occurring during the spring of those years. Chinook salmon counts (Figure 10) in September were comparatively low. Salmon counts were highest in 2010 when 152 and 170 were observed in August and November, respectively.

4.3 Other species observed: 1986-2010

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 2010 were Sacramento sucker, Sacramento pikeminnow, hardhead, Pacific lamprey and riffle sculpin with the non-native species recorded being largemouth bass, smallmouth bass, redear sunfish , and striped bass. The observance of striped bass at R21 (RM 42.9) was unusual. It was the first time this species was seen during the reference snorkel surveys.

TABLE 1. AUGUST 2010 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	(1) SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	LARGEMOUTH BASS	SMALLMOUTH BASS	REDEAR SUNFISH	STRIPED BASS and other
10AUG	1000	Riffle A7	50.7	1	6,000	1.5	25	Riffle	cobble,gravel,bedrock	11.1	11.5	21	0.6	25.0	20	(50-75)	4	(40-50)	(70)							
																	12	(100-140)								
	1006			2	4,000	4.0	21	Run-Riffle	cobble,gravel,sand						2	(110,120)	15	(110-140)	(550)							
																	4	(160,320,350,400)								
10AUG	1140	Riffle 2	49.9	1	6,000	1.3	24	Riffle	cobble,gravel,sand	14.2	11.3	25	0.6	23.0			6	(100-140)				(70,90)				
																	17	(150-250)								
	1157			2	6,000	6.5	22	Pool-Run	bedrock,cobble,boulder						16	(70-90)	13	(80-140)								
																	3	(300,360,340)								
	1200			3	12,000	5.0	18	Run-Pool	cobble,sand,boulder						5	(70-90)	11	(150-250)					(120,130)			
																	8	(300-450)								
10AUG	1407	Riffle 3B	49.1	1	4,400	2.5	21	Riffle	cobble,gravel,sand	15.5	12.3	25	0.6	23.0	10	(80-90)	55	(80-140)								
																	4	(160,160,170,200)								
	1406			2	7,500	2.5	18	Run-Riffle	cobble,gravel,bedrock						50	(50-90)	11	(120-140)								
															8	(100-120)	3	(150,160,160)								
10AUG	1523	Riffle 5B	47.9	1	3,000	2.5	16	Riffle	cobble,gravel,sand	16.0	11.7	23	0.8	18.0	7	(80-110)	9	(110-140)	(700)			(60)				
																	5	(160-280)								
	Not done			2				Run																		
	1515			3	9,375	4.0	20	Run-Pool	bedrock,cobble,gravel						7	(50-70)	11	(110-140)	(400,450)	4(250-300)					2(60,80)	
																	1	(300)								
					58,275		185			**Subtotal**					**125**		**192**		**5**	**4**		**3**	**2**		**2**	
11AUG	0936	Riffle 7	46.9	1	6,000	1.5	19	Riffle	cobble,gravel,boulder	12.0	10.6	22	0.8	22.0	4	(50-70)	7	(110-140)								
																	4	(160-180)								
	0933			2	8,000	4.5	22	Run	bedrock,cobble,sand						6	(70-90)	8	(70-120)		2(360,420)						
																	6	(180-480)								
11AUG	1125	Riffle 13B	45.5	1	6,000	2.0	18	Riffle-Run	cobble,gravel,sand	13.4	11.4	24	0.7	18.0	2	(60,100)	27	(50-140)								
																	1	(170)								
	1130			2	3,600	2.0	16	Riffle	cobble,gravel,sand								4	(110-140)		30(130-200)						
																	1	(150)								
11AUG	1327	Riffle 21	42.9	1	4,800	1.5	20	Riffle	cobble,gravel,sand	15.3	10.8	27	1.0	17.0	2	(70,100)	4	(110-140)								
	1328			2	7,500	5.0	18	Run-Pool	cobble,sand,vegetation								4	(110,140,150,160)		(120)	(140)					15(300-500)
11AUG	1452	Riffle 23C	42.3	1	3,000	2.5	23	Run	gravel,sand,bedrock	16.4	10.7	30	1.1	15.0	3	(60,70,90)	3	(120,140,160)								
	1454			2	6,000	2.0	15	Riffle	cobble,gravel,bedrock								4	(80-140)		7(140-200)	(130,140)					
																	2	(150,160)								
					44,900		151			**Subtotal**					**17**		**75**			**40**	**3**					**SB(15)**
12AUG	0944	Riffle 31	38.0	1	7,200	2.0	20	Riffle	cobble,gravel,sand	16.3	10.1	36	1.2	15.0			1	(140)	14(700-800)	(230)		(80)				LP(100)
	0945			2	12,500	4.0	18	Run-Pool	cobble,gravel,sand										(600)	3(250-350)	4(300-350)					
12AUG	1126	Riffle 35A	37.1	1	6,000	2.0	20	Riffle	cobble,gravel,sand	17.5	9.8	36	1.0	14.0						(120,150)			(130)			
	1124			2	15,000	2.5	19	Run	cobble,gravel,sand										8(60-90) 3(450-550)	5(250-350)			(220)			
12AUG	1342	Riffle 41A	35.3	1	2,500	2.2	22	Run-Riffle	cobble,gravel,sand	18.5	10.6	36	1.2	12.0	4	(70-90)			4(200-250)	8(200-300)	5(300-350)			(140,240)		
															2	(160,170)										
	1342			2	2,400	4.5	8	Pool-Run	gravel,sand,cobble											5(220-400)				4(120-400)		
	1350			3	4,000	2.5	10	Riffle-Run	cobble,gravel,sand										30(60-70) 3(650-800)							
12AUG	1515	Riffle 57	31.5	1	3,750	1.5	22	Riffle	cobble,gravel,sand	20.1	10.5	36	1.1	11.0	4	(60-90)			14(400-600)	5(200-300)				(90,130)		
	1515			2	10,000	2.5	20	Run-Riffle	cobble,bedrock,sand										3(650-800)	3(260-360)	(240)		11(70-160)	3(90,140,320)	6(70-160)	
					63,350		159			**Subtotal**					**10**		**1**		**80**	**32**	**10**	**1**	**13**	**11**	**6**	**LP(1)**
					166,525		495			**TOTAL#**					**152**		**268**		**85**	**76**	**13**	**4**	**15**	**11**	**8**	**SB(15) LP(1)**

(1) YOY Sacramento sucker were common below R13B

TABLE 2. NOVEMBER 2010 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	(1) SACRAMENTO SUCKER	SACRAMENTO PIKEMINNOW	HARDHEAD	RIFFLE SCULPIN	SMALLMOUTH BASS	STRIPED BASS
02NOV	0948	Riffle A7	50.7	1	3,750	1.8	24	Riffle	cobble,gravel,boulder	11.7	10.2	20	0.8	18.0	4	(700-900)								
	0950			2	4,000	4.0	22	Run-Riffle	cobble,gravel,sand						4	(750-920)	11	(180-500)						
															43	(70-100)	22	(70-140)						
02NOV	1104	Riffle 2	49.9	1	6,000	1.5	24	Riffle	cobble,gravel,sand	12.6	9.0	27	0.9	18.0			1	(340)				(90)		
	1122			2	6,000	6.5	24	Pool-Run	bedrock,cobble,boulder						32	(70-90)	4	(180-420)	(700)					
																	54	(70-130)						
	1120			3	7,200	5.0	16	Run-Pool	cobble,sand,boulder								8	(160-320)						
02NOV	1317	Riffle 3B	49.1	1	4,000	2.2	19	Riffle	cobble,gravel,sand	13.3	9.8	25	0.8	15.0	1	(700)	4	(120,300,360,450)				(60)		
	1320			2	6,000	2.5	18	Run-Riffle	cobble,gravel,bedrock						4	(650-750)	3	(140,160,160)						
															30	(70-110)	60	(70-90)						
02NOV	1432	Riffle 5B	47.9	1	2,000	2.5	10	Riffle	cobble,gravel,sand	13.8	10.1	21	0.8	15.0			1	(160)				(60)		
	1447			2	12,000	4.5	22	Run-Pool	gravel,cobble,bedrock						20	(70-90)	10	(70-90)	3(350-500)					
	1425			3	6,000	4.0	16	Run-Pool	bedrock,cobble,gravel								4	(70-140)	5(350-500)					
																	1	(320)						
					56,950		195			**Subtotal**					**138**		**183**		**9**			**3**		
03NOV	1005	Riffle 7	46.9	1	5,000	1.0	16	Riffle	cobble,gravel,sand	11.7	9.0	23	0.8	18.0			1	(160)						
	1004			2	8,000	4.5	20	Run	bedrock,cobble,sand								5	(220-450)						
03NOV	1110	Riffle 13B	45.5	1	4,500	2.3	15	Riffle-Run	cobble,gravel,sand	12.1	9.5	24	0.9	15.0			7	(160-180)						
	1114			2	3,200	2.0	12	Riffle	cobble,gravel,sand								7	160-240)						
03NOV	1255	Riffle 21	42.9	1	3,000	1.7	15	Riffle	cobble,gravel,sand	12.7	10.1	26	0.8	15.0	No fish observed									
	1256			2	8,000	5.0	18	Run-Pool	cobble,sand,vegetation								2	(280,300)	(600)					6(300-500)
03NOV	1406	Riffle 23C	42.3	1	2,500	2.3	12	Run	cobble,sand,bedrock	13.1	10.0	30	1.1	13.0			5	(160-180)						
	1408			2	6,000	2.0	10	Riffle	cobble,gravel,bedrock								3	(90-120)						
																	2	(160,220)						
					40,200		118			**Subtotal**					**0**		**32**		**1**					**6**
04NOV	0950	Riffle 31	38.0	1	7,500	1.5	21	Riffle	cobble,gravel,sand	13.1	10.3	30	1.0	15.0	30	(70-90)			25(50-70)					
	0955			2	12,000	4.0	18	Run-Pool	cobble,gravel,sand													(100)		
																						? Scp.		
04NOV	1114	Riffle 35A	37.1	1	2,200	2.0	15	Riffle	cobble,gravel,sand	13.7	10.7	33	1.2	15.0	1	(80)								
	1115			2	12,000	2.3	16	Run	cobble,gravel,sand										200(50-70)	300(30-60)				
04NOV	1300	Riffle 41A	35.3	1	4,800	2.3	15	Run-Riffle	cobble,gravel,sand	14.2	11.1	35	1.2	14.0	1	(120)	3	(160,170,180)	(400,400,450)		(350)			
	1257			2	3,000	4.5	6	Pool-Run	gravel,sand,cobble										(600)	(240)	(300)		(150)	
	1303			3	6,000	2.0	10	Riffle-Run	cobble,gravel,sand										20(30-50)	100(30-50)				
04NOV	1423	Riffle 57	31.5	1	7,200	1.7	16	Riffle	cobble,gravel,sand	14.3	11.4	35	1.1	13.0					12(500-700)	(200,240)				
	1424			2	10,000	2.3	18	Run-Riffle	cobble,bedrock,sand											(180,200,320)	(200,240)			
					64,700		135			**Subtotal**					**32**		**3**		**261**	**406**	**4**	**1**	**1**	
					161,850		448			**TOTAL#**					**170**		**218**		**271**	**406**	**4**	**4**	**1**	**6**

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. 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	
	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
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
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
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
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
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
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
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
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
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
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
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
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
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

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

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. 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	
	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
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
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
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
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
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
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
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
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
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
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
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
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
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

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

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
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
Salmonidae	rainbow trout	N	RT	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
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
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
Centrarchidae	smallmouth bass		SMB	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
Moronidae	striped bass		SB																						X

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

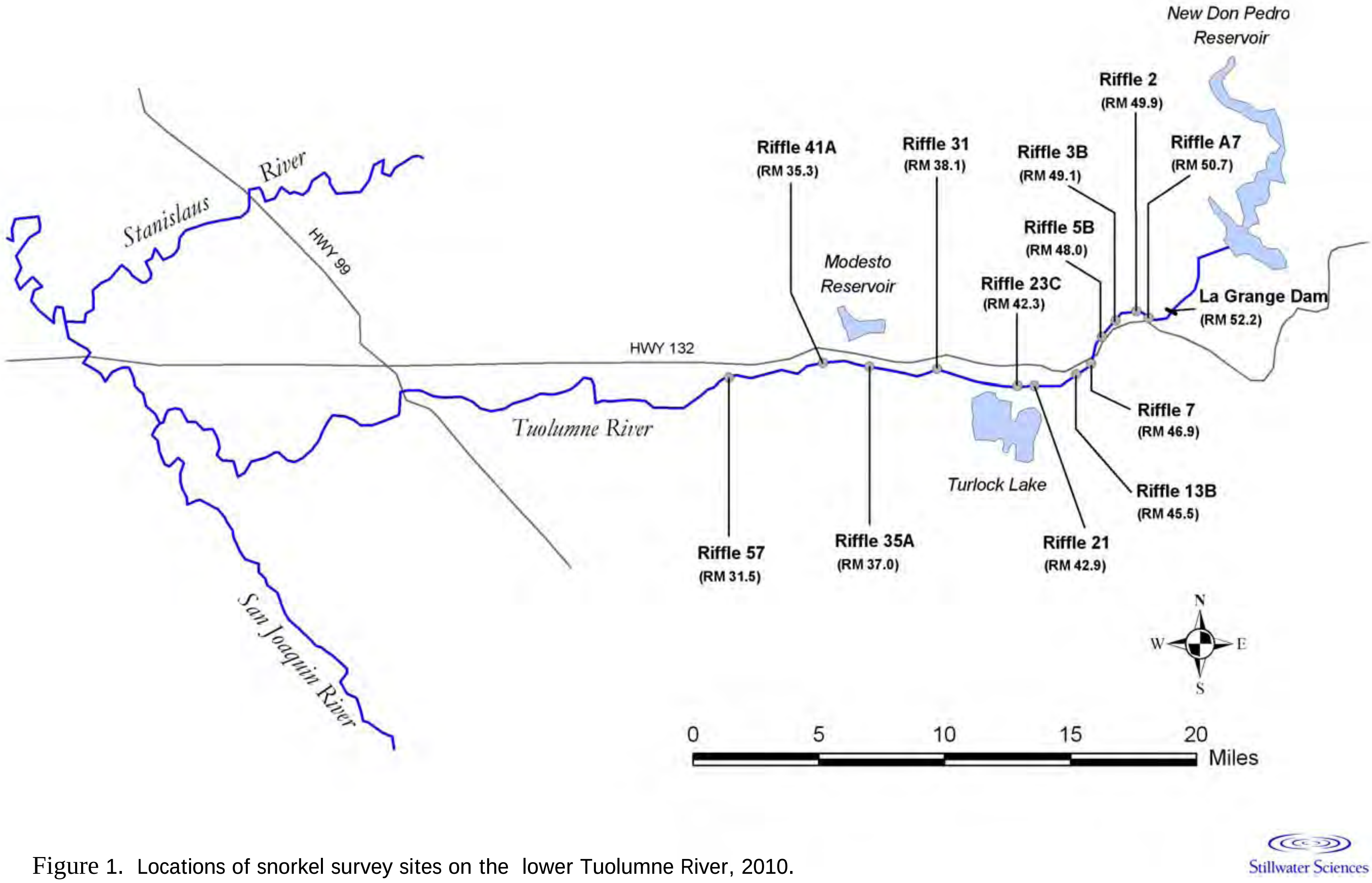

Figure 1. Locations of snorkel survey sites on the lower Tuolumne River, 2010.

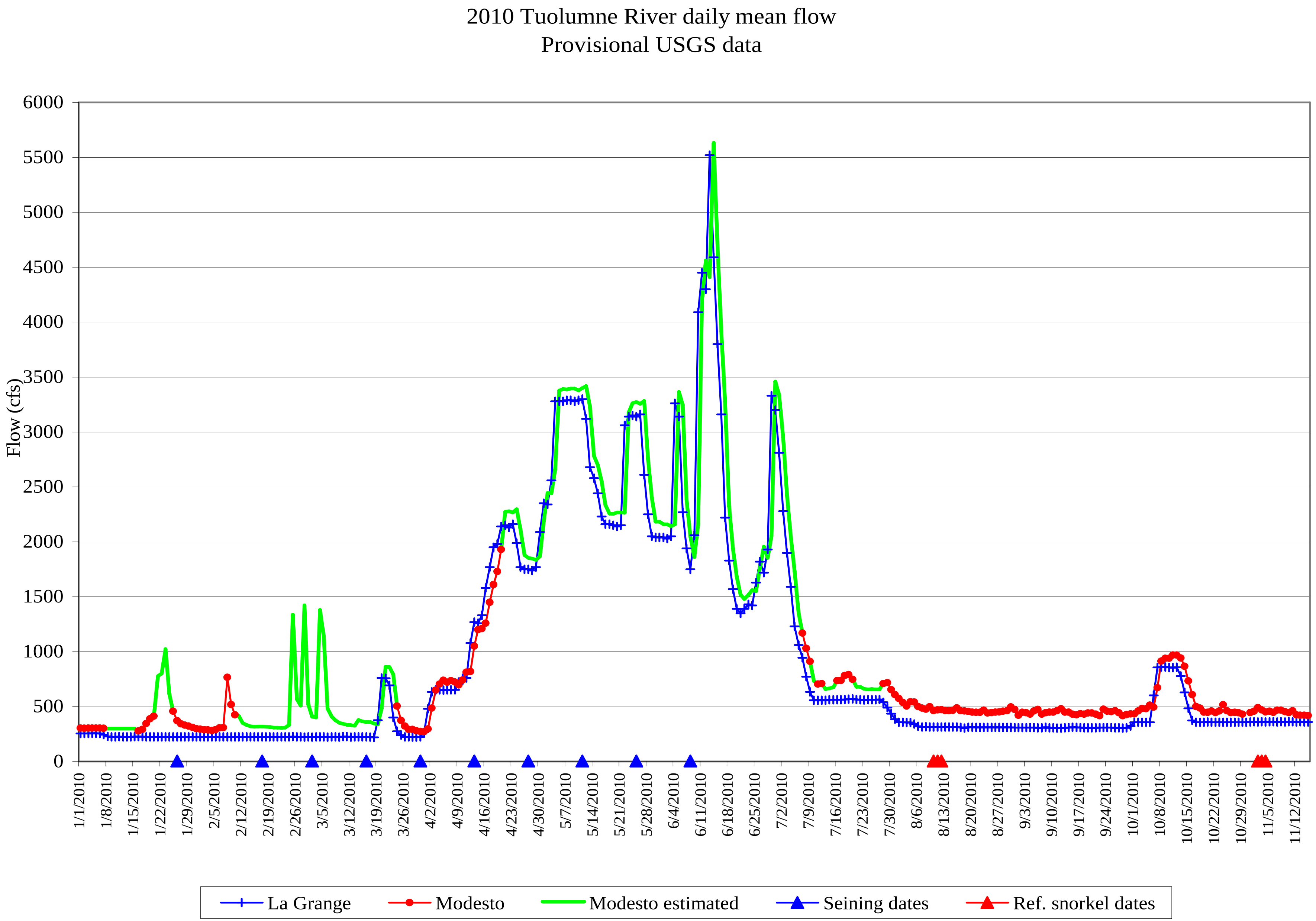

Figure 2. 2010 Tuolumne River flows at La Grange and Modesto

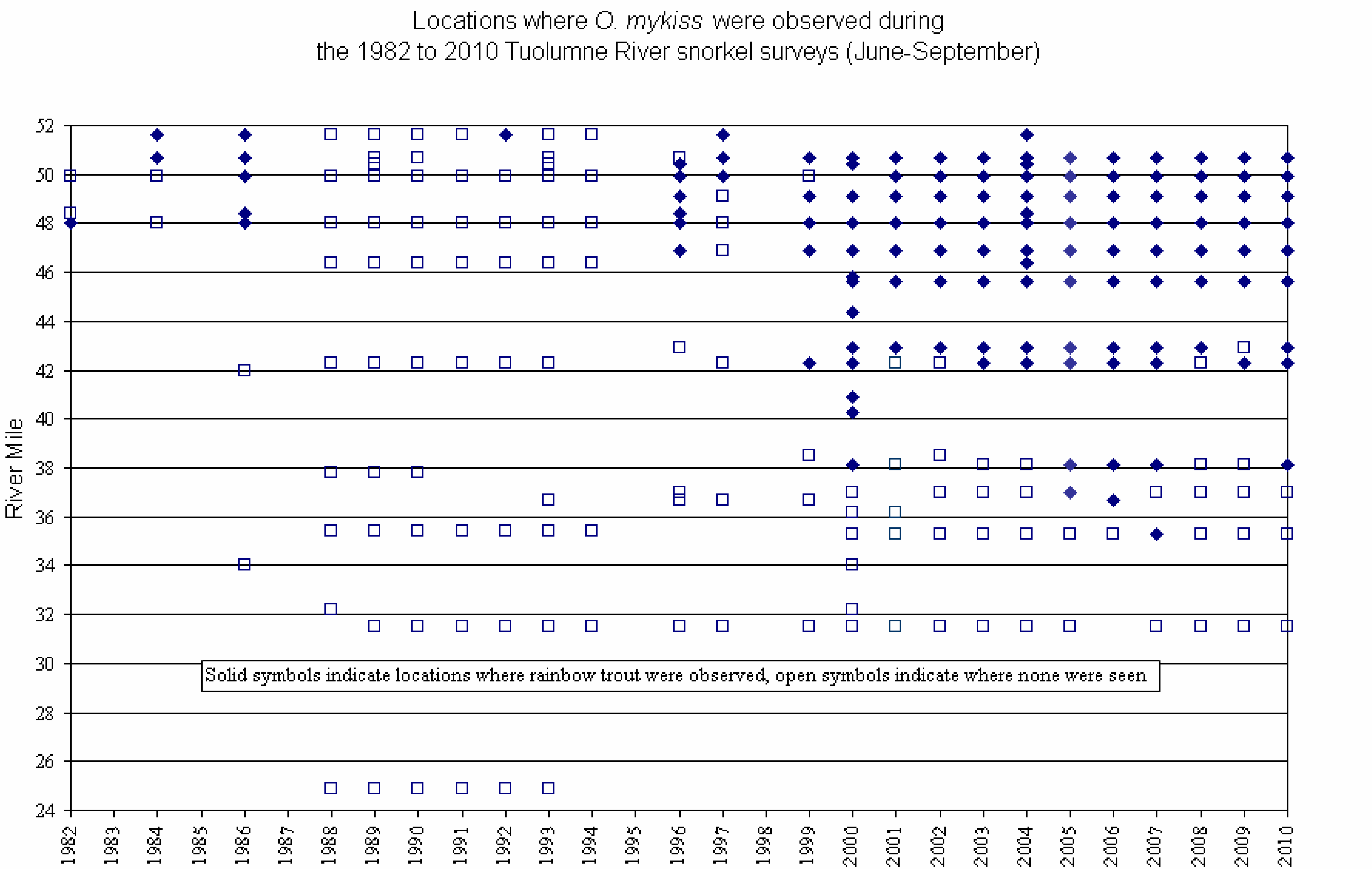

Figure 3. Locations where *O. mykiss* were observed

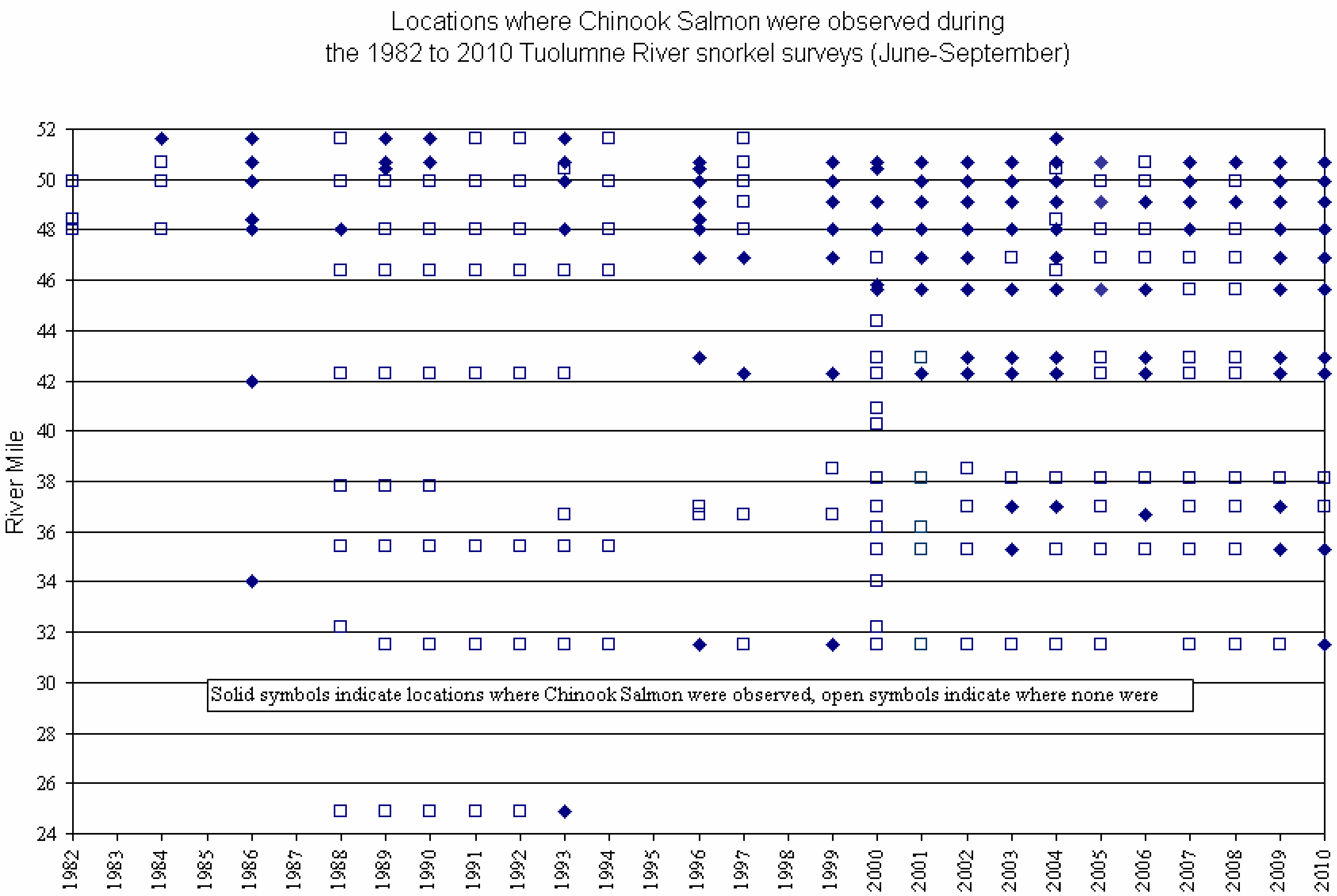

Figure 4. Locations where Chinook salmon were observed

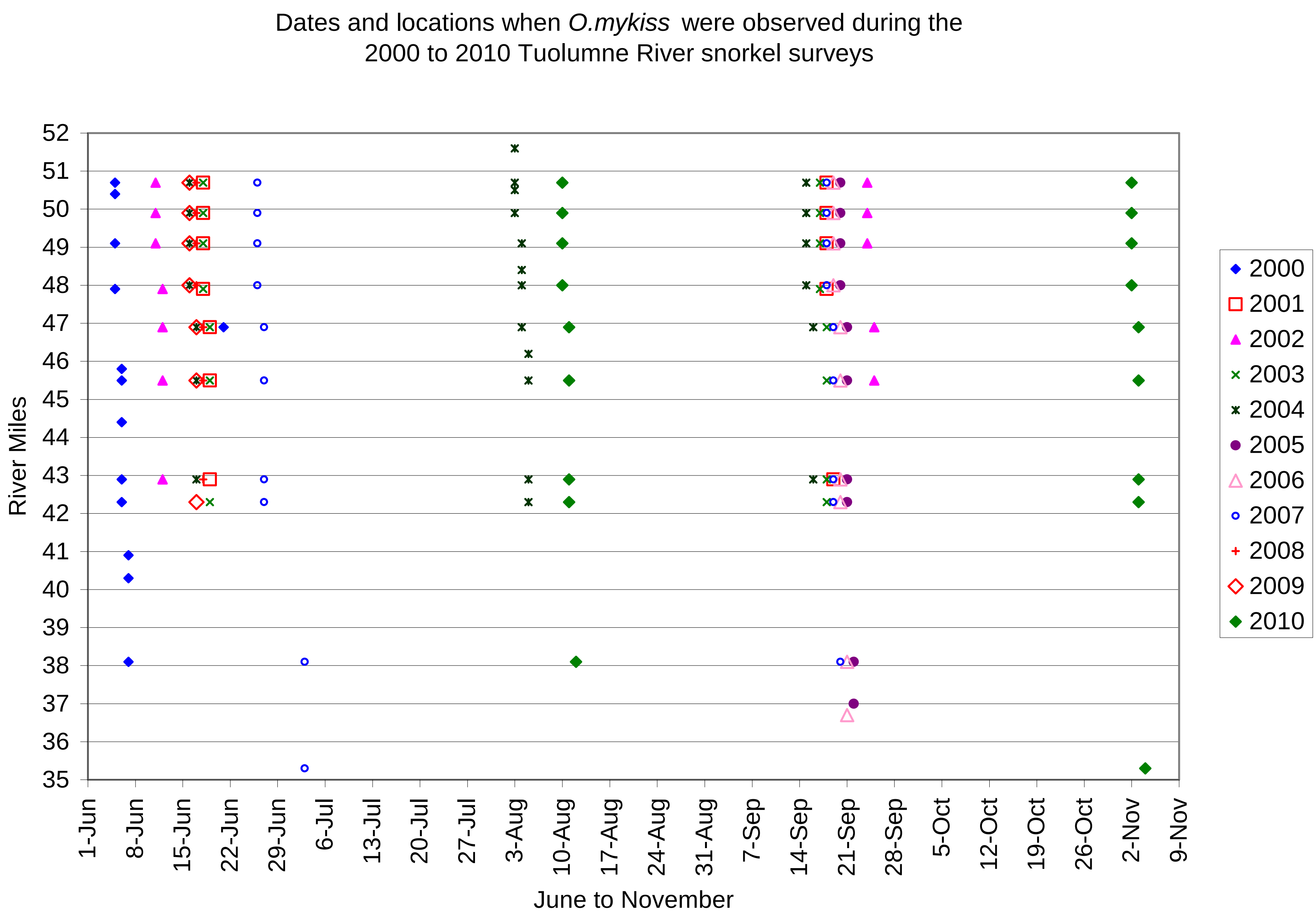

Figure 5. Dates and locations where *O. mykiss* were observed during the snorkel surveys

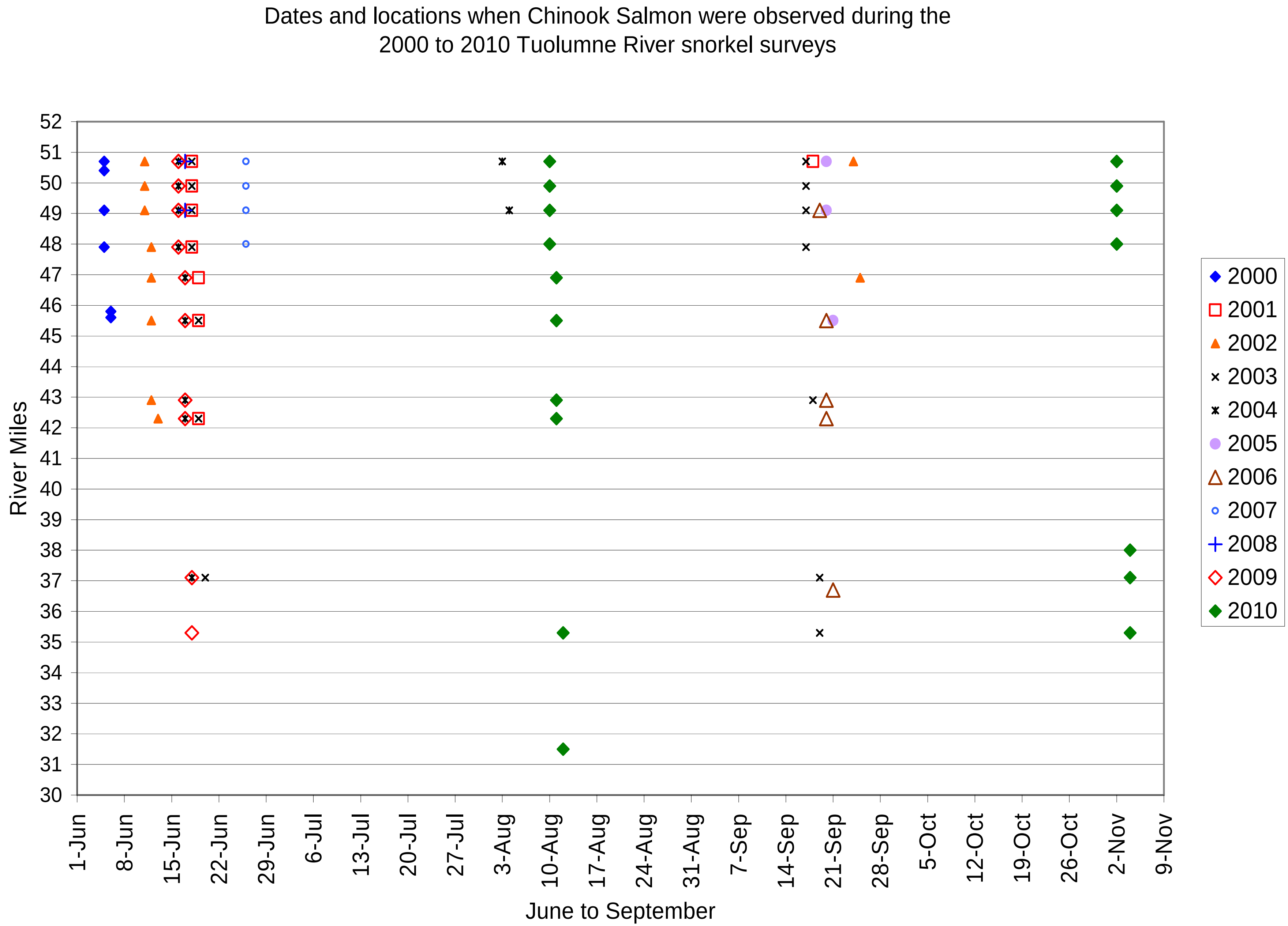

Figure 6. Dates and locations where Chinook Salmon were observed during the snorkel surveys.

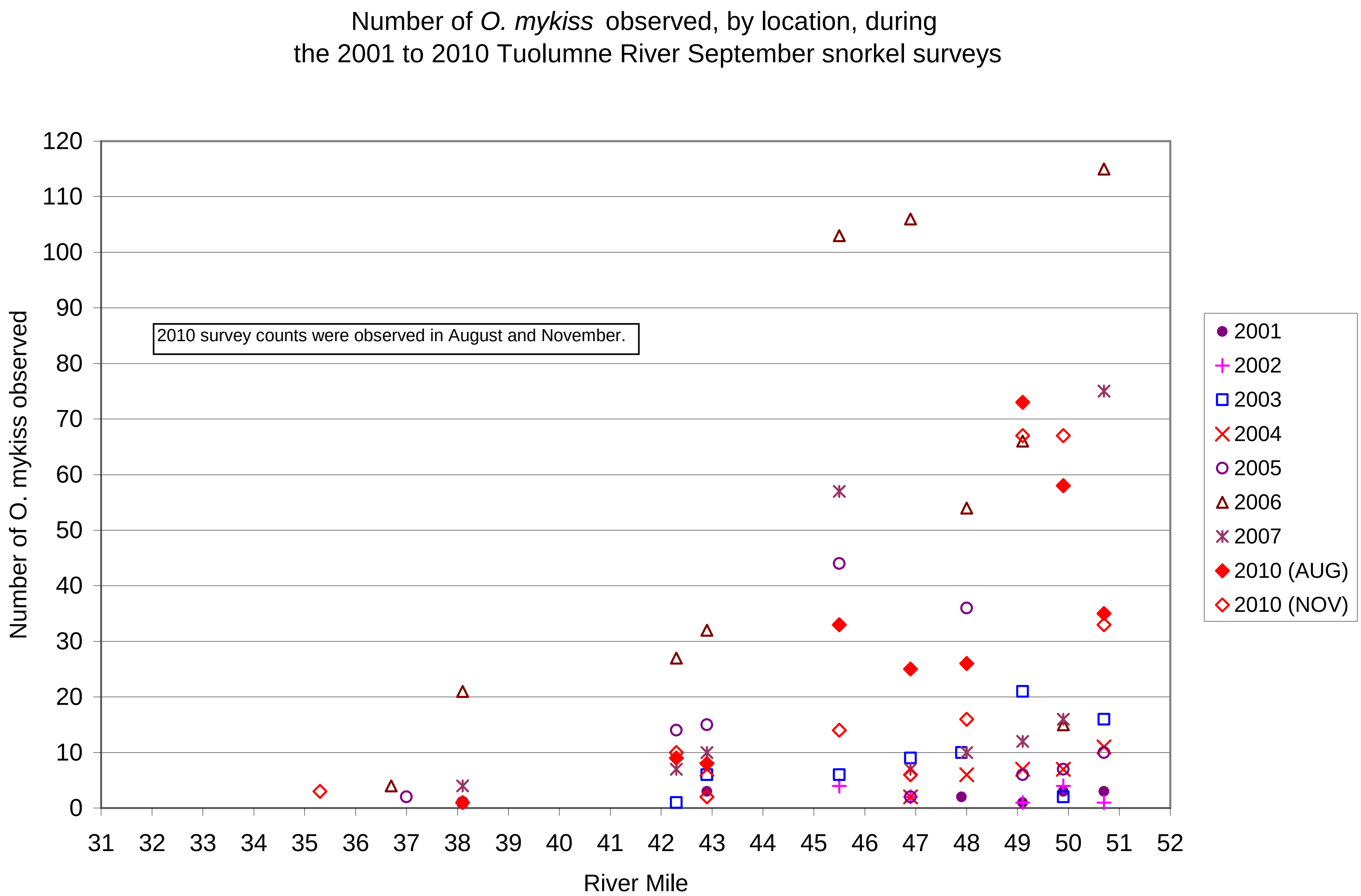

Figure 7. O. mykiss observations during the September snorkel surveys

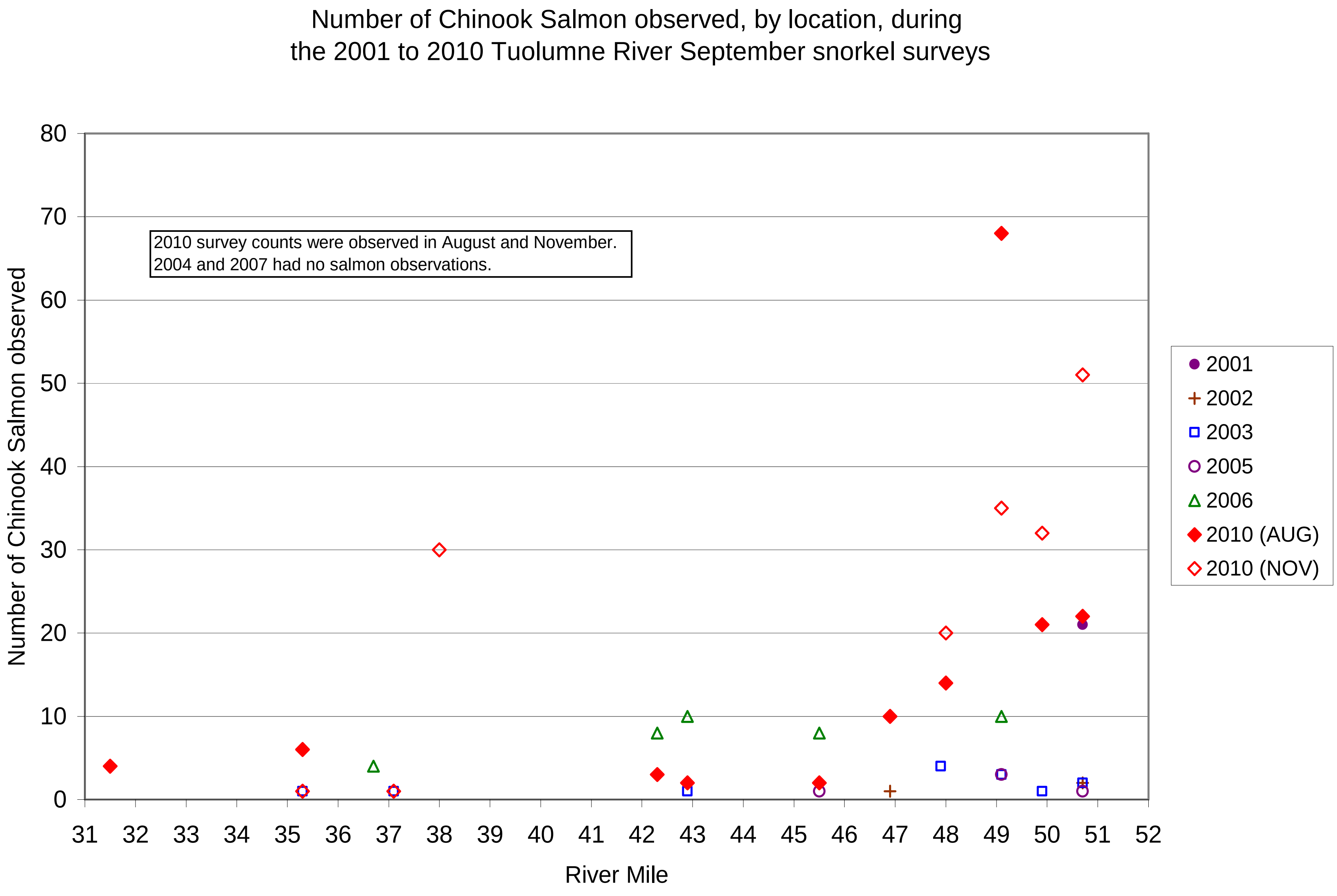

Figure 8. Chinook salmon observations during the September snorkel surveys

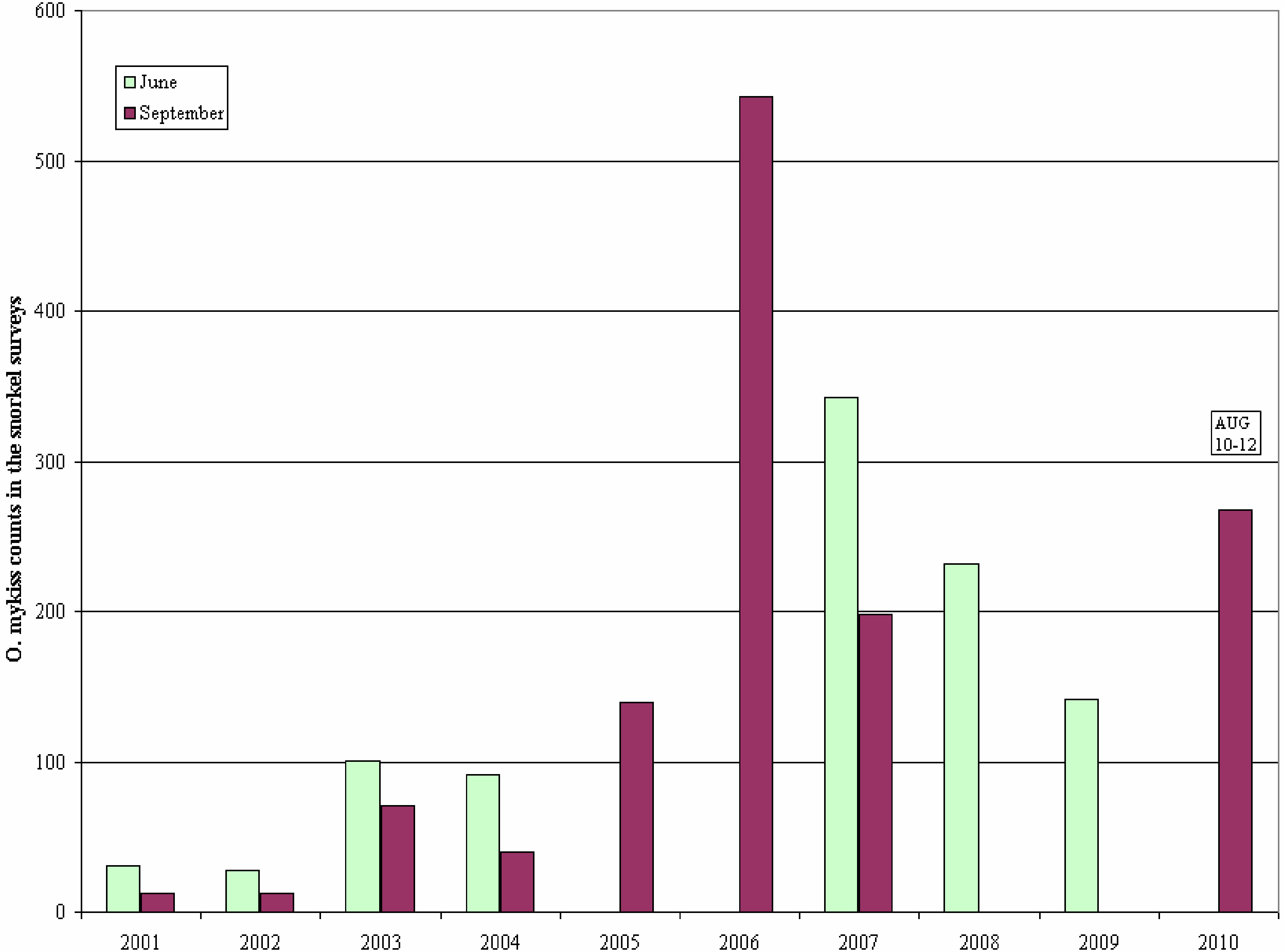

Figure 9. *O. mykiss* counts during the June and September snorkel surveys

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

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-6

March and August 2010 *Oncorhynchus mykiss* Population Estimate Report

Prepared by

Stillwater Sciences
Berkeley, CA

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March and August 2010 Population Size Estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River

Prepared for
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and

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March 2011

Stillwater Sciences

Stillwater Sciences. 2011. March and August 2010 population size estimates of *Oncorhynchus mykiss* in the Lower Tuolumne River. Prepared for the Turlock Irrigation District and the Modesto Irrigation District by Stillwater Sciences, Berkeley, CA. March.

SUMMARY

In both early-March and mid-August 2010, population size estimates of *Oncorhynchus mykiss* were 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 1 to 8 March and from 17 to 24 August 2010 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 reaches extended from RM 51.8 to RM 38.4 near a bridge crossing within the 7-11 gravel operation in March and August 2010. A total of 66 of 181 sampling units in the study reach upstream of RM 38.4 were selected for either single pass or multi-pass snorkel surveys in July 2010. A total of 61 sampling units from the same study reach were selected for either single pass or multi-pass snorkel surveys in March 2010.

O. mykiss population estimates

Based upon the maximum count obtained over all dive passes in each sampled unit, only one young-of-the-year (YOY)/juvenile (< 150 mm FL) and 13 adult (> 150 mm FL) (sum total of 14) *O. mykiss* were observed in March 2010. During the August 2010 surveys, 313 YOY/juvenile (<150 mm FL) and 324 adult (> 150 mm FL) (sum total of 687) *O. mykiss* were observed along the study reach. Using a bounded counts population estimator (BCE) for the March 2010 survey period, a total of approximately 109 adult *O. mykiss* were present within the study reach (RM 51.8–38.4). No estimate was made for juvenile *O. mykiss* due to low count of only one individual. Using the same estimator for August 2010 survey period, approximately 2,405 juvenile and 2,139 adult *O. mykiss* were present within the study reach (RM 51.8–38.4).

The August 2010 juvenile *O. mykiss* population estimate of 2,405 was lower than the July 2009 estimate of 3,475 and similar to the July 2008 estimate of 2,472 juveniles. However, the summer population estimates are within the 95% CI for juvenile *O. mykiss* in all three years (2008-2010). The August 2010 adult *O. mykiss* population estimate of 2,139 was higher than both the July 2009 estimate of 963 and the July 2008 estimate of 643.

Chinook salmon population estimates

For Chinook salmon encountered during the March and August 2010 snorkel surveys, a maximum count of 577 juveniles (< 150 mm FL) were observed during March 2010 within all habitat types along the study reach and a maximum count of 1,028 juvenile Chinook salmon were observed in all habitat types during the August 2010 survey. This corresponded to bounded count population estimates of 6,141 Chinook salmon during the March 2010 surveys, and 6,338 during August 2010. By comparison, the July 2009 juvenile population estimate of 29,389 was much higher and the July 2008 estimate of 2,636 was lower. There were also 14 adult salmon observed in August 2010 as compared with 6 observed in July 2009, and 2 in July 2008.

Other species

A combination of native minnows (hardhead and Sacramento pikeminnow), along with native Sacramento sucker accounted for approximately 97% of non-salmonid fish observed for both the March and August sampling periods, with very low counts of non-native centrarchid species (largemouth bass, smallmouth bass) observed. Native minnows and suckers were found throughout the reaches in both sampling periods.

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 August 2010 survey along the study reach. The data show that temperatures increased in the downstream direction, from 12.0ºC (53.6°F) to 17.8ºC (64.1°F) (maximum weekly average temperature [MWAT]), and that *O. mykiss* density of both adult and juveniles generally decreased along this same gradient. Although the longitudinal distribution of *O. mykiss* was similar for both the March and August surveys, the lower number of *O. mykiss* observations in March 2010, coupled with low water temperatures (maximum observed <14.5 °C [58.1 °F]) precluded any meaningful associations with temperature for the March 2010 surveys.

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 adults in habitat types (riffle, run head, and pool head) common to both groups in the August survey. For juveniles, this comparison showed riffle habitat use at upstream restoration sites was slightly 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 relatively low use of pool head habitat. For adults, this comparison showed a potential reduction of habitat use of riffle habitat at restoration sites, with similar use of run head habitat, and insufficient data for a comparison of pool head habitats.

Comparison with August 2010 Reference Survey Results

A comparison was made of *O. mykiss* and juvenile Chinook data collected during the August 2010 survey to “reference count”, snorkel survey data collected during August 2010 by TID/MID. The comparison shows a similar longitudinal trend, with overall densities decreasing in the downstream direction for both species. Along the study reach common to both surveys, a total of 195 *O. mykiss* juveniles and 73 adults were observed in the August reference count snorkel survey, while 210 juveniles and 253 adults were observed in the August BCE survey. A total of 142 juvenile Chinook were seen in the August reference survey with 889 seen in the August 2010 BCE survey.

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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:

> <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.

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 both March and August 2010, the overall sampling "universe" from which sampling strata were delineated extended from near La Grange Dam at river mile (RM) 51.8 to RM 38.4 at a bridge crossing within the 7-11 Materials, Inc. gravel operation (Figure 1). This reach coincides with the downstream areas where *O. mykiss* were observed (Riffle 31 at RM 38.0) during the August 2010 "reference count" snorkel surveys (Kirihara 2010).

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) 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 March and August 2010 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 20 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 both the March and August 2010 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 base layer 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 March and July 2009 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 1986-87 and later refined to adjust for channel migration. The average daily flow during the March 2010 sampling was 224 cfs, and the average daily flow during the August 2010 sampling was 293 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 March and August 2010 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 March 2010 surveys, a subset of 6–7 units was selected for each of the 5 habitat types, with the exception of the riffle habitat type for which 10 units were selected to capture habitat use at particular gravel augmentation projects (Table 2-3). In August 2010, a subset of 6–7 sampling units was selected from each of 5 habitat types (Table 2-4), with representative riffle habitats corresponding to restoration sites at some locations.

Table 2-3. Sample unit selection and survey count for March 2010.

Habitat	Phase I dives		Phase II survey	
	Initial units	Passes	Repeat units	Passes
Riffle	10	1	3	2
Pool head	6	1	3	2
Pool body /tail	6	1	3	2
Run head	7	1	3	2
Run body /tail	7	1	3	2
Total	**36**		**30**	

Table 2-4. Sample unit selection and survey count for August 2010.

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	6	1	3	2
Total	**31**		**30**	

2.2.2 Snorkel data collection

Snorkel surveys were conducted during daylight hours from 1 to 8 March and 17 to 24 August 2010, respectively. 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 2-5). Total lengths were estimated in 50 mm size ranges (called “bins”) using markings on dive slates to correct for underwater size distortion.

Table 2-5. 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 countss 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 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 2-6). 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 2-6. 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 ocurring at least twice a year.

Water temperature data collection during March and August 2010 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 February through March, and July through August 2010 periods are presented in this report (Figures 2a and 2b).

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 $m_1 \leq m_2 \leq \ldots \leq m_r$, 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

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

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 August 2010 Reference Count snorkel surveys

Data collected during the August 2010 snorkel surveys (17–24 August) were compared to reference count snorkel survey data collected during 10–12 August 2010 (Kirihara 2010). Although the sampled areas of these surveys differ, these data were collected only a few weeks 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 locations since 2001, we limit our comparison to the August 2010 data as these are the most directly comparable. There were no reference count survey data available for comparison with the March 2010 snorkel surveys.

3 RESULTS

3.1 Habitat Characterization

3.1.1 March 2010

For the total reach surveyed in March 2010 (RM 51.8–38.4), "run body/tail" habitat type occupied the greatest length of channel along the study reach, followed by 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 4.8 % 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. Figure 4a presents the distribution of each of the major habitat types sampled in March 2010.

Table 3-1. Summary of habitat types from RM 51.8 to 38.4, March and August 2010.

Habitat type	Count	% by count	Total length (ft)	Total length (mi)	% reach length	Area (ft^2)
Riffle	40	22.1	15,271	2.89	21.4	1,281,867
Pool head	7	3.9	712	0.13	1.0	61,958
Pool body/tail	11/7	9.9	9,238	1.75	12.9	1,143,736
Run head	38	21.0	2,712	0.51	3.8	253,658
Run body/tail	42/36	43.1	43,423	8.22	60.9	4,449,862
Total	**181**	**100.0**	**71,356**	**13.51**	**100.0**	**7,191,081**

3.1.2 August 2010

The total reach surveyed in August 2010 (RM 51.8–34.8), was identical to the reach surveyed in March 2010 and therefore contains the same overall distribution of habitat types as shown in Table 3-1. 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 equal segments of 2 river miles is shown in Figure 3. Figure 4b presents the distribution of each of the major habitat types sampled in August 2010.

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 and Table 3-3). Water quality data for sampling units selected for snorkel surveys are shown in Appendix E.

Because of the strong 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 both the spot measurements (Table 3-3) and in the continuous thermograph record during both the March and July survey periods (Appendix F). Note that the water temperature ranges shown in Table 3-2 and Table 3-3 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.

3.2.1 March 2010

Daily average flow during the March 2010 survey period was 223 cfs. In general, dissolved oxygen concentration was high due to the low water temperatures. Horizontal visibility was reduced at the most downstream location due to local turbidity sources.

Table 3-2. Range of water quality data collected at snorkel sites during fish surveys in March 2010.

River miles	Sample date	Flow (cfs)[1]	Water temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
51.6−50.8	1 March	224	10.6–11.3 [51.1–52.3]	10.6−12.4	13.5	29.1–30.5
50.6−49.7	2 March	223	10.6–11.0 [51.1–51.8]	10.6−11.5	17	28.1–32.5
49.6−48.0	3 March	224	10.2–10.6 [50.4–51.1]	9.9−11.2	15	29.3–31.1
45.9	5 March	224	10.6 [51.1]	10.4	10.5	37.4
45.0−43.0	6 March	223	10.7–12.3 [51.3–54.1]	10.6−11.9	8.5–12	37.4–40.6
42.9−38.9	7 March	224	11.5–14.1 [52.7–57.4]	10.8−12.3	9–11.5	39.9–53.4
38.8−38.5	8 March	224	12.1–12.4 [53.8–54.3]	10.7−11.1	8.5	48.9–49.1

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

3.2.2 August 2010

Daily average flow during the August 2010 survey period ranged from 287–295 cfs. In general, there were only relatively small variations in water quality parameters at this flow range. Horizontal and vertical visibility indicated very low turbidity during the survey period.

Table 3-3. Range of water quality data collected at snorkel sites during fish surveys in July 2009.

River miles	Sample date	Flow (cfs)[1]	Water temp °C [°F]	DO (mg/L)	Horizontal visibility (ft)	Specific conductivity (uS/cm)
51.8−51.6	17 August	293	12.6–12.6 [54.7–54.7]	9.8−9.8	32–32	30.4–30.4
50.8−50.3	18 August	287	12.7–13.1 [54.9–55.6]	11.0−11.2	27.3–31.5	28.8–29.1
49.9−49.7	19 August	294	14.3–14.3 [57.7–57.7]	11.3−11.3	27.3–27.3	29.3–29.3
49.1−48.0	20 August	295	14.2–16.4 [57.6–61.5]	11.2−13.1	25–25	29.4–29.7
46.9−45.1	21 August	294	13.9–15.3 [57.0–59.5]	11.8−12.7	20.5–20.5	30.4–31.1
45.0−43.2	22 August	293	13.3–15.4 [55.9–59.7]	10.9−11.2	19.0–21.5	31.5–32.0
42.7−39.6	23 August	293	15.6–18.5 [60.1–65.3]	11.3−12.0	16.5–15.5	33.2–37.1
39.2−38.8	24 August	293	16.3–16.3 [61.3–61.3]	9.7−9.7	17.5–17.5	38.2–38.2

[1] 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 1–8 March and 17–24 August study periods 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).

3.3.1 March 2010

During the March 2010 survey period, water temperature data collected by thermographs followed similar trends to spot temperature data collected during snorkel surveys, showing an increase in the downstream direction (Table 3-4). Along the study reach, the MWAT increased from 10.6°C (51.1°F) at Riffle A7 to 12.1°C (53.7°F) at the Ruddy Gravel site (Table 3-4). The 7dayMAX temperature ranged from 11.1°C (52.0°F) at the Riffle A7 location to 13.2°C (55.7°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 February to 31 March 2010 are presented graphically in Appendix F.

Table 3-4. 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 March 2010.

Monitoring location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	10.6 [51.1] (2 March)	11.1 [52.0] (2 March)	11.4 [52.5] (1 March)
Riffle 13B	45.5	11.3 [52.3] (7 March)	12.2 [54.0] (6 March)	12.7 [54.8] (1 March)
Roberts Ferry Bridge[1]	39.6	11.8 [53.3] (7 March)	12.8 [55.0] (7 March)	13.7 [56.7] (7 March)
Ruddy Gravel	36.5	12.1 [53.7] (7 March)	13.2 [55.7] (7 March)	14.2 [57.5] (7 March)

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

The average daily Modesto Airport air temperatures over the study period ranged from 8.3 to 12.8 ºC (47.0 to 55.0 °F) with a high temperature of 18.9 °C (66.0 °F) (Table 3-5). The warmest day of March occurred after the study period on 17 March with an average daily temperature of 17.8 °C (64.0 °F) (Figure 2a) and a daily high temperature of 23.9 °C (75.0 °F). The highest daily maximum temperature in March occurred on 28 March with a reading of 26.1 °C (79.0 °F).

Table 3-5. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the March 2010 snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
1 March 2009	12.8 [55]	6.7 [44]	18.3 [65]
2 March 2009	11.7 [53]	7.8 [46]	15.0 [59]
3 March 2009	8.9 [48]	6.7 [44]	11.1 [52]
4 March 2009	10.0 [50]	5.6 [42]	14.4 [58]
5 March 2009	8.3 [47]	2.2 [36]	13.9 [57]
6 March 2009	12.8 [55]	8.3 [47]	17.2 [63]
7 March 2009	12.2 [54]	5.0 [41]	18.9 [66]
8 March 2009	10.0 [50]	5.6 [42]	14.4 [58]

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 2a). With flow being stable throughout period, Figure 2a 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 Roberts Ferry Bridge (RM 39.6).

3.3.2 August 2010

During the August 2010 survey period, water temperature data collected by thermographs followed similar trends to spot temperature data collected during snorkel surveys, which showed a general increase in the downstream direction (Table 3-6). Along the study reach, the MWAT increased from 12.0 °C (53.6 °F) at Riffle A7 to 17.8°C (64.1 °F) at Ruddy Gravel (Table 3-6). The 7dayMAX temperature ranged from 13.3°C (55.9 °F) at the Riffle A7 location to 19.2°C (66.6 °F) at the Roberts Ferry Bridge. 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 July to 31 August 2010 are presented graphically in Appendix F.

Table 3-6. 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 August 2010.

Monitoring location	RM	MWAT ºC [°F] (week ending)	7dayMAX ºC [°F] (week ending)	Instantaneous maximum ºC [°F] (date)
Riffle A7	50.8	12.0 [53.6] (19 August)	13.3 [55.9] (19 August)	13.4 [56.0] (17 August)
Riffle 13B	45.5	14.5 [58.1] (18 August)	16.5 [61.7] (18 August)	16.7 [62.0] (17 August)
Roberts Ferry Bridge[1]	39.6	17.1 [62.7] (19 August)	18.5 [65.3] (18 August)	18.7 [65.6] (17 August)
Ruddy Gravel	36.5	17.8 [64.1] (19 August)	19.2 [66.6] (19 August)	19.5 [67.0] (17 August)

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

The average daily Modesto Airport air temperatures over the study period ranged from 21.7 to 27.8 ºC (71.0 to 82.0 °F) with a high temperature of 38.9 °C (102 °F) (Table 3-7). The warmest day of August occurred just after the study period on 25 August with an average daily temperature of 30.0 °C (86 °F) and a daily high temperature of 41.7 °C (107 °F) (Figure 2b).

Table 3-7. Daily average, minimum, and maximum air temperature recorded at the NWS station at the Modesto Airport during the August 2010 snorkeling study period.

Date	Average air temperature ºC [°F]	Minimum air temperature ºC [°F]	Maximum air temperature ºC [°F]
17 August 2010	24.4 [76.0]	16.1 [61.0]	32.8 [91.0]
18 August 2010	22.8 [73.0]	14.4 [58.0]	31.1 [88.0]
19 August 2010	24.4 [76.0]	14.4 [58.0]	33.9 [93.0]
20 August 2010	25.6 [78.0]	16.1 [61.0]	34.4 [94.0]
21 August 2010	21.7 [71.0]	14.4 [58.0]	28.9 [84.0]
22 August 2010	21.7 [71.0]	12.8 [55.0]	30.0 [86.0]
23 August 2010	24.4 [76.0]	14.4 [58.0]	34.4 [94.0]
24 August 2010	27.8 [82.0]	16.1 [61.0]	38.9 [102.0]

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 2b). High flows through July kept water temperatures relatively low with little variability. Flow reductions in early August to approximately 300 cfs, shows a slight increase in variability among the temperature stations, but a continuation of relatively low temperatures, with a reduced influence of air temperature at thermographs located farther downstream (Figure 2b).

3.4 Snorkel Surveys

3.4.1 March 2010

3.4.1.1 *O. mykiss* observations

During the March 2010 survey period, divers observed 15 *O. mykiss* ranging from 0–600 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (Table 3-8, Table 3-9 and Appendix G). These included one fish classified as a juvenile in the 50–99 mm size category, with the other 14 observed in the adult (>150 mm) size classes (Table 3-8 and Table 3-9). The *O. mykiss* were observed in 9 different sampling units from RM 51.6 to RM 38.5. The *O. mykiss* were observed in all habitat types, with the exception of the “Run body/tail” habitat, with the juvenile observation in a pool head habitat unit at RM 51.6 (Table 3-8 and Table 3-9).

Table 3-8. Maximum count of *O. mykiss* by sampling unit, March 2010 (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	>500 mm
51.6	4	Pool head	Y	1								1		
51.6	5/6	Pool body/tail	Y									2		2
50.9	11	Pool body	N											
50.8	12/13	Run body/tail	N											
50.6	15	Run head	Y								1			
50.5	16/17	Run body/tail	Y											
50.3	18	Riffle	N											
50.3	19	Run head	N										1	
50.1	20/21	Run body/tail	N											
50.1	22	Riffle	Y											
49.7	26	Riffle	Y						2					
49.7	27	Pool head	N											
49.6	28/29	Pool body/tail	Y									1		
48.8	42	Run head	Y											
48.7	43/44	Run body/tail	N											
48.0	54	Pool head	N											
45.9	70	Riffle	N											
45.0	86	Pool head	Y											
44.8	90	Run head	N											
44.7	93	Riffle	Y											
44.5	101	Riffle	N											
43.7	104	Pool body	N											
43.0	111	Riffle	N											
43.0	112	Pool head	Y							2				
43.0	113/114	Pool body/tail	Y											
42.9	116/117	Run body/tail	Y											
42.9	119	Run head	N											

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	>500 mm
42.3	126	Riffle	N								1			
41.9	133	Run head	Y											
41.8	134/135	Run body/tail	N											
39.2	165	Pool head	N											
38.9	166/167	Pool body/tail	N											
38.9	168	Riffle	N											
38.8	172	Run head	N											
38.7	173/174	Run body/tail	Y											
38.5	179	Riffle	N									1		
Total (maximum unit count of all passes)				**1**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**5**	**1**	**2**

Table 3-9. Maximum count of *O. mykiss* by habitat type, March 2010 (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	>500 mm	Total (max. unit count of all passes)
Pool body/tail									3		2	**5**
Pool head	1						2		1			**4**
Riffle						2		1	1			**4**
Run body/tail												**0**
Run head								1		1		**2**
Totals by size class	**1**	**0**	**0**	**0**	**0**	**2**	**2**	**2**	**5**	**1**	**2**	**15**

3.4.1.2 *O. mykiss* population estimate

Table 3-10 shows the March 2010 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001) for the study reach from RM 51.8 to RM 38.4 . Since the YOY/juvenile observations of *O. mykiss* were minimal (n=1), no population estimate for this lifestage was derived from the March 2010 survey. From an observed 13 adult *O. mykiss* in March 2010, an estimated population of 109 adults (with a 95% CI of 50-168) was determined (Table 3-10). Adult *O. mykiss* were observed in all habitat types with the exception of "run body/tail" habitat.

Table 3-10. *O. mykiss* March 2010 bounded count population estimates between RM 51.8 and 38.4 by fish length and habitat type.

Habitat	***O. mykiss*** < 150 mm				***O. mykiss*** ≥ 150 mm			
	Obs.[1]	**Est.**	**St. dev.**	**95% CI**[2]	**Obs.**	**Est.**	**St. dev.**	**95% CI**[2]
Pool head	1	1	0.3	1–2	3	6	2.6	3–11
Pool body/tail	0	--	--	--	4	14	6.2	4–26
Riffle	0	--	--	--	4	37	14.1	9–64
Run head	0	--	--	--	2	53	25.6	3–103
Run body/tail	0	--	--	--	0	--	--	--
Total	**1**	**1**	**0.3**	**1–2**	**13**	**109**	**30.0**	**50–168**

[1] 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.
[2] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.1.3 Chinook salmon observations

Table 3-11 and Table 3-12 show the number of Chinook salmon observed within the study reach during the March 2010 surveys, based on the maximum count by pass, resulting in a total of 577 observations. All Chinook salmon were YOY and juveniles found within the 0–49 and 50–99 mm size classes. These salmon were seen in 16 different sampling units ranging from RM 51.6 to RM 38.8 (Table 3-11) and all habitat types (Table 3-12).

Table 3-11. Maximum counts of juvenile Chinook salmon by size class and sampling unit, March 2010.

River mile	Sampling unit	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm
51.6	4	Pool head	Y	18	
51.6	5/6	Pool body/tail	Y	76	
50.9	11	Pool body	N		
50.8	12/13	Run body/tail	N		
50.6	15	Run head	Y		
50.5	16/17	Run body/tail	Y		
50.3	18	Riffle	N	172	9
50.3	19	Run head	N		
50.1	20/21	Run body/tail	N	80	
50.1	22	Riffle	Y	8	
49.7	26	Riffle	Y		1
49.7	27	Pool head	N		
49.6	28/29	Pool body/tail	Y		
48.8	42	Run head	Y		
48.7	43/44	Run body/tail	N		
48.0	54	Pool head	N		
45.9	70	Riffle	N	41	25
45.0	86	Pool head	Y		
44.8	90	Run head	N		
44.7	93	Riffle	Y	6	16
44.5	101	Riffle	N	1	
43.7	104	Pool body	N		
43.0	111	Riffle	N	2	
43.0	112	Pool head	Y	15	15
43.0	113/114	Pool body/tail	Y		
42.9	116/117	Run body/tail	Y	23	44
42.9	119	Run head	N		
42.3	126	Riffle	N	2	10
41.9	133	Run head	Y		
41.8	134/135	Run body/tail	N	1	
39.2	165	Pool head	N		
38.9	166/167	Pool body/tail	N		
38.9	168	Riffle	N		
38.8	172	Run head	N	8	3

River mile	Sampling unit	Habitat type	Multiple pass survey (Y/N)	0–49 mm	50–99 mm
38.7	173/174	Run body/tail	Y	1	
38.5	179	Riffle	N		
Total (max. unit count of all passes)				**454**	**123**

Table 3-12. Maximum counts of juvenile Chinook salmon by size class and habitat type, March 2010.

Habitat	0–49 mm	50–99 mm	Total (maximum unit count of all passes)
Pool body/tail	76		76
Pool head	33	15	48
Riffle	232	61	293
Run body/tail	105	44	149
Run head	8	3	11
Totals by size class	**454**	**123**	**577**

No adult Chinook salmon were observed within the study reach. The complete Chinook salmon observation data by pass are shown in Appendix G.

3.4.1.4 Chinook salmon population estimate

Table 3-13 shows the March 2010 Chinook salmon population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Since there were no observations of adult Chinook salmon, no population estimate for this lifestage was derived from the March 2010 survey. From an observed 574 YOY/juvenile Chinook salmon in March 2010, an estimated population of 6,141 (with a 95% CI of 2,687–9,596) was determined (Table 3-10). Juvenile Chinook salmon were observed in all habitat types, with riffle habitat providing the highest number of observations and generating the largest portion of the population estimate (approx. 55%).

Table 3-13. Chinook salmon March 2010 bounded count population estimates between RM 51.8 and 38.4 by fish length and habitat type.

Habitat	Chinook salmon < 150 mm				Chinook salmon ≥ 150 mm			
	Obs.[1]	Est.[2]	St. dev.	95% CI[3]	Obs.[1]	Est.[2]	St. dev.	95% CI[3]
Pool head	48	67	22.2	48–111	0	--	--	--
Pool body/tail	76	238	153.8	76–540	0	--	--	--
Riffle	293	3,386	898.0	1,626–5,146	0	--	--	--
Run head	11	--	--	--	0	--	--	--
Run body/tail	146	2,449	1,508.7	146–5,406	0	--	--	--
Total	**574**	**6,141**	**1,762.6**	**2,687–9,596**	**0**	**--**	**--**	**--**

[1] 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.
[2] Estimate for run head habitat type for juvenile salmon not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.
[3] Nominal confidence intervals calculated as + 1.96 standard deviations.

3.4.1.5 Non-salmonid observations

Several other fish species were observed and counted during the March 2010 survey period (Table 3-14). Most other fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families. A combination of hardhead and Sacramento pikeminnow, along with Sacramento sucker accounted for 97.0%. Other observed non-salmonid fish included catfish (*Ictaluridae*), centrarchids (largemouth bass, smallmouth bass), and sculpin (*Cottidae*), accounted for the remaining 3% of observations. Most centrarchids occurred toward the downstream end of the study reach where water temperatures were slightly warmer, while native suckers were found throughout the reach. The complete non-salmonid fish observation data are in Appendix G.

Table 3-14. Maximum counts of non-salmonid species by sampling unit, March 2010.

RM	Sampling unit	Habitat	CF	LMB	SMB	SC	HH/PM	SS
50.8	12/13	Run body/tail						1
50.6	15	Run head						3
50.5	16/17	Run body/tail						35
50.3	18	Riffle						10
50.1	20/21	Run body/tail						10
50.1	22	Riffle						1
49.7	26	Riffle						4
49.7	27	Pool head						1
49.6	28/29	Pool body/tail				1		8
48.8	42	Run head						6
48.7	43/44	Run body/tail						8
48.0	54	Pool head					10	2
45.9	70	Riffle	1					4
44.7	93	Riffle					7	
44.5	101	Riffle						3
43.0	112	Pool head						3

RM	Sampling unit	Habitat	CF	LMB	SMB	SC	HH/PM	SS
43.0	113/114	Pool body/tail		1				
42.9	116/117	Run body/tail					2	3
42.3	126	Riffle						3
41.9	133	Run head						4
41.8	134/135	Run body/tail						19
38.9	166/167	Pool body/tail						1
38.7	173/174	Run body/tail			1	1		1
38.5	179	Riffle						10
Total (all sampled units)			**1**	**1**	**1**	**2**	**19**	**140**

CF = catfish species; LMB = largemouth bass; SMB = smallmouth bass; SC = sculpin species; HH/PM = hardhead/Sacramento pikeminnow; SS = Sacramento sucker

3.4.2 August 2010

3.4.2.1 *O. mykiss* observations

During the August 2010 survey period, divers observed 682 *O. mykiss* ranging from 0–500 mm (50 mm size bins) based upon maximum counts of all dive passes in each sampling unit (Table 3-15, Table 3-16). Approximately half of these fish (320) were YOY/juvenile (<150 mm), with a total of 362 adults (>150 mm) observed (Figure 5). Complete fish observation data by sampling unit and dive pass is presented in Appendix G.

The *O. mykiss* were observed in 22 different sampling units from RM 51.8 to RM 39.7 and in all habitat types (Table 3-15 and Table 3-16). Habitat use and reach-wide distribution of YOY/juvenile and adult *O. mykiss* were similar, based on the maximum count from dive passes (Figure 6a) highest in riffle and run body/tail habitats. Fish densities (Figure 6b) for juvenile size classes (<150 mm) highest in riffle and pool head habitats. Juvenile size classes were also observed in each of the other habitat types, with lowest density in pool body habitats (Figure 6b). Adult-size classes (>150 mm) were observed in highest density in pool head habitats, with lower densities found in each of the other habitat types (Figure 6b).

Adult fish habitat use was concentrated at upstream sampling units (above RM 45.0) and primarily occurred at transitional run head and pool head habitats (Figure 7). Juvenile fish habitat use showed a similar distribution from upstream to downstream and occurred primarily at riffle habitat types, along with transitional run head and pool head habitat types (Figure 8).

Table 3-15. Maximum count of *O. mykiss* by sampling unit, August 2010 (data are divided into 50 mm total length size classes).

RM	Sampling Unit	Habitat	Multiple pass survey (Y/N)	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
51.8	1	Pool Head	Y		1		7	10	6	2	1	
51.6	4	Pool Head	Y					4	3	2	2	1
51.6	5	Pool body/tail	Y		2	2	5	2	4	1	2	1
50.8	12	Run body/tail	Y	50	23	13	2	12	24	10	1	
50.6	14	Riffle	Y	6	60	28	10	4	3	2		
50.3	19	Run Head	Y		6	5	5	3	7			
49.9	24	Run body/tail	N		7	4	1	2	13	4		
49.7	27	Pool Head	Y	3	7	12	2	1	1			
49.6	28	Pool body/tail	Y		2	4	2	8	5	3		
49.1	38	Run Head	N		1							
48.4	45	Riffle	N	9	26	5						
48.1	51	Run body/tail	Y		16	4	1	1	1	1		
48.0	53	Riffle	N		4					1		
48.0	54	Pool Head	N		6	5	1		3			
46.9	62	Run Head	Y		5	8	3		2	1		
45.3	81	Pool body/tail	N									
45.1	83	Run body/tail	N		13	9	3		5			
45.0	86	Pool Head	N		8	11	3	5	2			
44.8	90	Run Head	N									
44.5	101	Riffle	Y		15	13	2	1				
43.7	104	Pool body/tail	N									
43.2	107	Riffle	Y		19	8	3	1	2			
42.7	123	Run Head	N									
42.4	124	Run body/tail	Y	7	21	5		1				
40.3	150	Run body/tail	N		2	3	1					
39.7	156	Riffle	N		1	1						
39.6	157	Run Head	Y									
39.2	165	Pool Head	N									

RM	Sampling Unit	Habitat	Multiple pass survey (Y/N)	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
38.9	166	Pool body/tail	N									
38.9	168	Riffle	N									
38.8	171	Pool body/tail	Y									
Total (maximum unit count of all passes)				**75**	**245**	**140**	**51**	**55**	**81**	**27**	**6**	**2**

Table 3-16. Maximum count of *O. mykiss* by habitat type, August 2010 (data are divided into 50 mm total length size classes).

Habitat	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		4	6	7	10	9	4	2	1	**43**
Pool head	3	22	28	13	20	15	4	3	1	**109**
Riffle	15	125	55	15	6	5	3			**224**
Run body/tail	57	82	38	8	16	43	15	1		**260**
Run head		12	13	8	3	9	1			**46**
Totals by size class	**75**	**245**	**140**	**51**	**55**	**81**	**27**	**6**	**2**	**682**

3.4.2.2 *O. mykiss* population estimate

Table 3-17 shows the August 2010 *O. mykiss* population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an estimated 2,405 juveniles and 2,139 adults *O. mykiss* in August 2010 (an overall population estimate of 4,544), we estimated a 95% confidence interval of 625–4,185 and 727–3,552 for YOY/juvenile and adults, respectively (Table 3-17).

The relative differences between population estimates and observed fish counts are due to differences in habitat unit areas (e.g., run body/tail habitat types occupying approximately 20 times more habitat area than run head units (Table 3-2). This results in higher population estimates in some habitat types even though the observed counts may be similar or lower than those found in other habitat types. In August 2010, juvenile and adult population estimates were shown to be highest in run body/tail and riffle habitat types (Table 3-17).

Table 3-17. *O. mykiss* August 2010 bounded count population estimates by fish length and habitat type.

Habitat	O. mykiss < 150 mm				O. mykiss ≥ 150 mm			
	Obs.[1]	Est.[2]	St. dev.	95% CI[3]	Obs.[1]	Est.	St. dev.	95% CI[3]
Pool head	24	42	8.4	26–58	72	90	6.3	78–102
Pool body/tail	4	12	4.9	4–22	32	136	109.5	32–351
Riffle	139	756	178.0	407–1,105	78	412	118.9	179–645
Run head	12	163	86.8	12–333	26	286	185.3	26–649
Run body/tail	134	1,432	886.2	134–3,169	116	1,215	677.3	116–2,542
Total	**313**	**2,405**	**908.1**	**625–4,185**	**324**	**2,139**	**720.6**	**727–3,552**

1 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 seen assigned to individual (50 mm) size bins may overestimate total fish observed.
2 Estimate for *O. mykiss* juveniles in pool head habitats not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.
3 Nominal confidence intervals calculated as + 1.96 standard deviations. Standard deviation and confidence intervals undefined for multiple pass units with identical dive counts.

3.4.2.3 Chinook salmon observations

Divers observed a large number of juvenile Chinook salmon within the study reach during August 2010 as well as small numbers within the adult size classes (>150 mm). Salmon were seen in 19 different sampling units from RM 51.8 to RM 31.9 (Table 3-18) and all habitat types (Table 3-19). Most salmon were juveniles found within the 50–99 mm size class.

Table 3-18. Maximum counts of juvenile Chinook salmon by size class and sampling unit, August 2010.

RM	Sampling Unit	Habitat	Multiple pass survey (Y/N)	0-49 mm	50-99 mm	100-149 mm	150-199 mm	600-649 mm	650-699 mm	700-799 mm	900-999 mm
51.8	1	Pool head	Y						2	3	1
51.6	4	Pool head	Y								
51.6	5	Pool body/tail	Y		87						
50.8	12	Run body/tail	Y	148	29	14					
50.6	14	Riffle	Y	110	31	4					
50.3	19	Run head	Y	9	40	20		1			
49.9	24	Run body/tail	N	50	37	32	1				
49.7	27	Pool head	Y		3	1					
49.6	28	Pool body/tail	Y		3	1	4				
49.1	38	Run head	N								
48.4	45	Riffle	N	30	104	52					
48.1	51	Run body/tail	Y	14	22	4	2				
48.0	53	Riffle	N		4						
48.0	54	Pool head	N		2						
46.9	62	Run head	Y	10	27	10					
45.3	81	Pool body/tail	N								
45.1	83	Run body/tail	N		20	8					
45.0	86	Pool head	N								
44.8	90	Run head	N		1						
44.5	101	Riffle	Y	5	31	11					
43.2	107	Riffle	Y		18	3					
42.7	123	Run head	N								
42.4	124	Run body/tail	Y		19	11					
40.3	150	Run body/tail	N								
39.7	156	Riffle	N								
39.6	157	Run head	Y								
39.2	165	Pool head	N								
38.9	166	Pool 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	600-649 mm	650-699 mm	700-799 mm	900-999 mm
38.9	168	Riffle	N			2					
38.8	171	Pool body/tail	Y								
Total (maximum unit count of all passes)				**376**	**478**	**174**	**7**	**1**	**2**	**3**	**1**

Table 3-19. Maximum counts of juvenile Chinook salmon by size class and habitat type, August 2010.

Habitat	0-49 mm	50-99 mm	100-149 mm	150-199 mm	600-649 mm	650-699 mm	700-799 mm	900-999 mm	Total (max. unit count of all passes)
Pool body/tail		90	2	4					**96**
Pool head		5	1			2	3	1	**12**
Riffle	145	188	72						**405**
Run body/tail	212	127	69	3					**411**
Run head	19	68	30		1				**118**
Totals by size class	**376**	**478**	**174**	**7**	**1**	**2**	**3**	**1**	**1,042**

Divers observed a total of seven adult Chinook salmon (>600 mm) at two separate sampling units in the upper portion of the study reach at RM 51.8 and RM 50.3. A total of seven salmon in the 150–199 mm size class (a size class technically included as “adult”, but not typically observed) were seen in three separate sampling units between RM 49.9 and 48.1. The complete Chinook salmon observation data by pass are shown in Appendix G.

3.4.2.4 Chinook salmon population estimate

Table 3-20 shows the August 2010 Chinook salmon population estimate for the lower Tuolumne River by length (<150 mm for YOY and juvenile; >150 mm for adults) and habitat type using the method of bounded counts (Hankin and Mohr 2001). Out of an estimated 6,338 juveniles and 117 adult Chinook salmon in August 2010 (an overall population estimate of 6,455), we estimated a 95% confidence interval of 3,291–9,385 and 14–249 for YOY/juvenile and adults, respectively (Table 3-20). The data show that the greatest estimated abundance of YOY and juvenile Chinook salmon occurred in run body/tail and riffle habitats, with the greatest estimated abundance of adults in the run body/tail habitat type (Table 3-20).

Table 3-20. Chinook salmon August 2010 bounded count population estimates by fish length and habitat type.

Habitat	Chinook salmon < 150 mm				Chinook salmon ≥ 150 mm			
	Obs.[1]	Est.	St. dev.	95% CI[2]	Obs.[1]	Est.[2]	St. dev.	95% CI[3]
Pool head	5	13	5.3	5–23	6	7	4.0	6–15
Pool body/tail	92	324	115.8	97–551	4	24	31.1	4–85
Riffle	400	2,149	571.2	1,029–3,268	0	--	--	--
Run head	97	1,054	606.0	97–2,242	1	20	25.4	1–70
Run body/tail	379	2,798	1,307.6	379–5,361	3	65	53.8	3–170
Total	**973**	**6,338**	**1,554.6**	**3,291–9,385**	**14**	**117**	**67.3**	**14–249**

[1] 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 may overestimate total fish observed.
[2] Estimate adult salmon within riffle habitats for adult salmon not included in overall population estimate due to lack of multiple pass data to develop an expansion factor.
[3] Nominal confidence intervals calculated as ± 1.96 standard deviations.

3.4.2.5 Non-salmonid observations

Several other fish species were observed during the August 2010 study period (Table 3-21). Most fish seen within the study reach were native species in the minnow (*Cyprinidae*) and sucker (*Catostomidae*) families. A combination of cyprinids (hardhead and Sacramento pikeminnow), along with Sacramento sucker accounted for 89.5% of observed non-salmonid fish. Non-native striped bass were observed in six sampling units (primarily pool body habitat) from RM 51.8 to RM 38.9. The complete non-salmonid fish observation data are in Appendix G.

Table 3-21. Maximum counts of non-salmonid species by sampling unit, August 2010.

RM	Sampling unit	Habitat	GAM	LP	LMB	HH/PM	SB	SCP	SMB	SS
51.8	1	Pool head				1	1			
51.6	5	Pool body/tail					2			
50.8	12	Run body/tail				5		3		64
50.6	14	Riffle						7		6
50.3	19	Run head		1			1			70
49.9	24	Run body/tail	100			40	1			100
49.7	27	Pool head								1
49.6	28	Pool body/tail								10
49.1	38	Run head	3							40
48.4	45	Riffle	3					2		
48.1	51	Run body/tail				8				24
48.0	53	Riffle						1		3
48.0	54	Pool head								3
46.9	62	Run head								4
45.3	81	Pool body/tail				7				24
45.1	83	Run body/tail				3				77
45.0	86	Pool head				15				1
44.8	90	Run head				1				
44.5	101	Riffle				31		1		14
43.7	104	Pool body/tail			1	1	7			180
43.2	107	Riffle				6				8
42.4	124	Run body/tail				41			1	147
40.3	150	Run body/tail				19				
39.7	156	Riffle				3				150
39.6	157	Run head				2				40
38.9	166	Pool body/tail			1	15	1		1	9
38.9	168	Riffle				1				
38.8	171	Pool body/tail								1
Total (all sampled units)			**106**	**1**	**2**	**199**	**13**	**14**	**2**	**1313**

GAM = Gambusia sp.; LP= Lamprey sp.; LMB = large mouth bass; HH/PM = heardhead/pikeminnow; SB = Striped bass; SCP = Sculpin sp.; SMB = small mouth bass; 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. As noted above, this assumption may be challenged in locations with large numbers of juvenile Chinook salmon, due to low visibility conditions in deeper pool habitats, as well as low visibility due to light and background turbidity variations within the river between seasons or from upstream to downstream. For these reasons, the resulting population estimates may be low-biased.

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. However, because larger habitat units were subsampled at some locations, for run habitat types in particular, 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 due to the lack of habitat boundaries relevant to the sampled fish (e.g., riffle transitions) in many locations.

4.2 Variations in *O. mykiss* Population Estimates

4.2.1 March Survey Period

Overall, the March 2010 population estimate of 109 adult *O. mykiss* (>150 mm) was low, with virtually no representation of juvenile size classes (<150 mm) relative to adults (Table 3-10). Although the high numbers of Chinook salmon juveniles observed during the March 2010 surveys (Table 3-12) may have resulted in misidentification of some *O. mykiss* within the same area, the low numbers of juvenile *O. mykiss* observed is consistent with a winter-spring spawning period that begins in February (Moyle 2002). The low number of adult *O. mykiss* observed are consistent with the results of the March 2009 survey. The low numbers of *O. mykiss* during spring were attributed to one or more of the following potential causes:

1. Adult *O. mykiss* have a heterogeneous (i.e., “patchy”) distribution and it appears that even though the 2010 winter sampling efforts were conducted in the same reach as summer surveys, upstream of Roberts Ferry Bridge (RM 39.5), the resulting observation of adults remains low. Information from other sources (e.g., from angling or tracking) may identify whether habitat use is distributed farther downstream.
2. Adult *O. mykiss* may be more furtive in winter, swimming into or occupying deeper portions of pools or out of range of the diver visibility, which is also reduced in winter due to lower light levels and increased turbidity. Nighttime dive surveys could be considered in future surveys, since low light situations tend to reduce the startle reflex of *O. mykiss*.
3. Lastly, adult *O. mykiss* may be altogether absent from the survey reach because they have migrated downstream of RM 29 or did not survive the previous over-summer conditions. This could be confirmed by any of: a) catch and release angling outside of the survey reach, b) capture, implantation of acoustic tags and tracking as provided in the TID/MID (2007) study plan, or c) video observations at the Districts Alaska type counting weir recently deployed at RM 24 in September 2009.

4.2.2 August Survey Period

The August 2010 population estimate of 4,544 *O. mykiss* indicates a relatively equal proportion of juveniles (2,405) relative to adults (2,139) (Table 3-17). In comparison to the July 2008 results of 2,472 juveniles and 643 adults, and the July 2009 results of 3,475 juveniles and 963 adults, the August 2010 results indicate a relatively similar number of juveniles over the 2008-2010 summer sampling periods, and a noticeable increase in the number and proportion of adults. Juvenile *O. mykiss* population estimates would be expected to vary from year-to-year due to the large number of potential eggs deposited by each additional female spawner. Also, the juvenile estimates (Table 3-17) are all within the with 95% CIs computed from 2008-2010 (Stillwater Sciences 2008b, 2010).

In addition any upstream migration of *O. mykiss*, the August 2010 adult *O. mykiss* population estimate may relate to conditions in the river below La Grange dam that were greatly influenced by flood control releases occurring from April thru July 2010. These releases extend cooler water temperatures farther downstream. These releases resulted in flows that spilled over the La Grange dam and may have resulted in the introduction of *O. mykiss* into the river from upstream reservoirs. In August 2010, small groups of larger sized (>250 mm) adult *O. mykiss* were observed in run body and pool body habitats downstream of where they were observed in previous survey years (2008 and 2009). These adults appeared as similar in size, coloration, and condition and were observed schooling together in circular patterns. Larger numbers of smaller sized (150-200 mm) adult fish were also observed in August 2010 (Figure 5). These sized fish would not have been able to come from the 2010 year class. This suggests the origin of the larger number of smaller sized fish may be due 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

4.3.1 March 2010

During the March 2010 snorkel surveys, water temperatures remained below 14.5°C throughout the study reach, with daily average temperatures exceeding 13.0°C only at the lowest sampling unit (RM 38.4) on 7 March 2010. 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 38.5, similar to the March 2009 survey. As discussed above in Section 4.2, presence/absence of *O. mykiss* downstream of the study reach could be confirmed by any of: a) catch and release angling outside of the survey reach, b) capture, implantation of acoustic tags and tracking as provided in the TID/MID (2007) study plan, or c) video observations at the Districts Alaska type counting weir deployed at RM 24 in September 2009. Counting weir results show only one adult *O. mykiss* (276 mm) detected during the operational period from September 22, 2009 through January 31, 2010 (TID/MID 2010). Preliminary results from an acoustic tag and tracking studying initiated by the Districts' in February 2010 are currently not available, pending completion of the study.

4.3.2 August 2010

To test Hypothesis #1 that summertime distribution of observed life stages of *O. mykiss* across suitable habitat is related to ambient river water temperature, we compared water temperature data taken from thermographs to fish density in the sampled units. The data show that temperatures increase in the downstream direction (Section 3.3.2, Table 3-6) and that the density of adult *O. mykiss* (>150 mm) generally decreased along this same gradient (Figure 9). In sampling units where fish were seen, density of adult fish was generally similar from just downstream of La Grange Dam to approximately RM 47, with a peak density near RM 45 (Figure

9). The density of adults then decreased markedly in the downstream direction. As noted in Section 4.2.2, conditions in the river below La Grange dam were greatly influenced by flood control releases that extend cooler water temperatures farther downstream.

Similar to adults, the density of YOY and juvenile *O. mykiss* decrease in the downstream direction, with generally similar distribution from just downstream of La Grange Dam to approximately RM 43 (Figure 9). Peak density of juveniles occurred near RM 45, with very low densities below RM 43. Juveniles were found in six out of seven riffle sampling units, indicating a strong preference for this habitat type. However, juveniles were also observed in five out of six sampling units, although in lower density (Table 6a and Table 6b). Generally, juveniles were not expected in this habitat type at downstream locations for a number of reasons, including predation and territorial exclusion by the larger size classes of *O. mykiss*. The occurrence of juveniles in this habitat type may also have been related to the earlier flood control releases, where juveniles were simply displaced from an upstream habitat due to increased water velocity, or where physical habitat (e.g. depth, velocity, cover, food supply) became available as microhabitat along the stream margin of run habitats.

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

4.4.1 March 2010

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 March 2010 surveys. Variations in cover types and amounts were limited in all sampling units, with higher percentages of the "No Cover" class found throughout the reach (Appendix D-2). For this reason, the cover results do not provide a meaningful basis for establishing a relationship with habitat use by juveniles or adults of either species. Chinook salmon juveniles were the most observed salmonid during the surveys and were observed primarily in riffle and transitional pool head and run head habitats where higher percentages of cobble were reported (Table 4-1).

Table 4-1. Cover and substrate type found in sampling units with *O. mykiss* present during the March 2010 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	0–10	0–0	0–5	No fish observed	0–10
Wood	0–0	0–5	0–0		0–0
Ledge	0–0	0–0	0–0		0–0
Overhang	0–5	0–0	5–20		0–0
Aquatic vegetation	0–10	0–30	0–0		0–10
No cover	85–90	65–100	80–100		90–90
Substrate type range (% covering channel bed)					
Bedrock	20–50	0–50	0–0	No fish observed	0–0
Boulder	20–20	10–20	10–20		10–20
Cobble	25–40	30–50	50–60		50–60
Gravel	0–10	0–30	20–40		20–40
Sand	5–10	0–10	0–10		0–0
Silt	0–0	0–0	0–0		0–0
Organic	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 March 2010 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	0–0	0–0	0–5	0–0	0–0
Wood	0–0	0–5	0–0	0–0	0–0
Ledge	0–0	0–0	0–0	0–0	0–0
Overhang	0–0	0–0	5–20	0–5	0–5
Aquatic vegetation	0–10	0–30	0–5	0–0	0–0
No cover	90–90	65–100	80–95	95–100	95–95
Substrate type range (% covering channel bed)					
Bedrock	0–50	0–50	0–10	0–15	0–0
Boulder	0–20	10–20	10–20	10–20	0–0
Cobble	0–25	30–50	20–60	40–60	0–60
Gravel	0–0	0–30	20–70	20–30	0–30
Sand	0–5	0–10	0–10	0–10	0–10
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

4.4.2 August 2010

Table 4-3 and Table 4-4 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 August 2010 surveys. As in March 2010, 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-2). 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 4-3).

Table 4-3. Cover and substrate type found in sampling units with *O. mykiss* present during the August 2010 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	0–10	5–10	0–10	0–5	0–0
Wood	0–0	0–5	0–5	0–5	0–5
Ledge	0–0	0–0	0–10	0–0	0–0
Overhang	0–5	5–10	5–10	5–10	5–10
Aquatic vegetation	0–10	0–0	0–5	0–50	0–10
No cover	85–90	85–100	80–95	35–100	90–90
Substrate type range (% covering channel bed)					
Bedrock	20–50	10–50	0–10	10–20	0–0
Boulder	0–20	10–50	10–20	10–60	10–20
Cobble	25–40	30–60	50–70	20–50	60–70
Gravel	0–10	5–30	20–40	10–40	0–20
Sand	5–10	5–10	0–10	10–20	0–0
Silt	0–0	0–0	0–0	0–0	0–0
Organic	0–0	0–0	0–0	0–0	0–0

Table 4-4. Cover and substrate type found in sampling units with Chinook salmon present during the August 2010 snorkel surveys.

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Cover type range (%)					
Boulder	10–10	5–10	0–10	0–5	0–0
Wood	0–0	0–0	0–5	0–5	0–5
Ledge	0–0	0–0	0–10	0–0	0–0
Overhang	0–5	0–5	5–10	5–10	5–10
Aquatic vegetation	0–10	0–0	0–0	0–50	0–10
No cover	85–90	85–90	80–100	35–95	90–90

Cover type	Pool body/tail	Pool head	Riffle	Run body/tail	Run head
Substrate type range (% covering channel bed)					
Bedrock	20–50	10–20	10–10	0–10	0–0
Boulder	20–20	10–50	10–20	10–60	10–20
Cobble	20–40	40–60	50–70	20–50	40–70
Gravel	10–50	5–10	20–40	10–40	20–50
Sand	5–30	5–10	10–10	10–20	0–10
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 and Reference 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, other than the CDFG gravel addition projects near Old La Grange Bridge, completed from 2001–2003, and the joint Tuolumne River Technical Advisory Committee/Friends of the Tuolumne (FOT) gravel augmentation at Bobcat Flat (RM 43) in 2005, no further gravel augmentation projects have been implemented since that time. This has limited the sampling replication and statistical power to detect any differences between restored and reference sites.

As a means to evaluate habitat use of these 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 August 2010. The low number of *O. mykiss* observations in March 2010 do not allow for meaningful comparisons. Figure 10 shows the *O. mykiss* density of juveniles and adults at pool head, riffle, and run head habitats types sampled in August 2010 from sampling units found at both the restoration sites and from all similar sample units within the study reaches upstream of RM 38.0. 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 an overall low density in pool head habitats found at the downstream portion of the reach (Figure 10). These same patterns appear for adult *O. mykiss* the densities throughout the reach.

A similar evaluation was done using juvenile Chinook salmon. Figures 11 and 12 show juvenile Chinook densities as sampled in March 2010 and August 2010, respectively for the same three habitat types. In March 2010, juvenile Chinook densities at the restoration sites were greater in each of the habitat types when compared to the reference sampling units (Figure 11), with the exception of riffle habitats between RM 44-46. In August 2010, juvenile Chinook densities either exceeded or were similar to the reference units (Figure 12). 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 August 2010 Reference Count Snorkel Surveys

Results from the August 2010 snorkel data were compared to observations made during the August 2010 reference count snorkel survey (Kirihara 2010) for the sampled reach common to both surveys and within sampling units surveyed during both sampling events (Table 4-5 and Table 4-6). The August 2010 BCE data are observations from the first pass of the multiple pass bounded count estimation method to allow a direct comparison to August 2010 reference survey, which came from single pass snorkel surveys that employ catch-per-unit-effort (CPUE) methodology. Note that the reference count surveys were not conducted in March, precluding comparison with the March 2010 surveys.

Table 4-5. Salmonid observations in August reference count (single pass) and August BCE (first pass) surveys in 2010 within the reach sampled during both studies.

August 2010 reference count snorkel survey					August 2010 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 – R31	50.7–38.0	195	73	142	1–181	51.8–38.4	210	253	889

Table 4-6. Salmonid counts and estimated densities in August reference count (single pass) and August BCE (first pass) surveys in 2010 for units snorkeled during both dates.

Location	**RM**	August 2010 reference count snorkel survey									August 2010 BCE snorkel surveys								
		Site	**Habitat type**	**Area (ft^2)**	**<150 mm *O. mykiss***		**>150 mm *O. mykiss***		**<150 mm *O. tshawytscha***		**Sampling 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	6,000	16	0.0133	0	0	20	0.186	14	Riffle	45,670	30	0.0007	34	0.0007	120	0.0026
Riffle 2	49.1	2	Pool-Run	6,000	13	0.0014	3	0.0014	16	0.019	28,29	Pool Body/ Tail	23,835	4	0.0002	9	0.0004	105	0.0044
Riffle 5B	46.9	3	Run-Pool	9,375	11	0.0012	1	0.0002	7	0.0007	54	Pool Head	14,569	2	0.0001	9	0.0006	1	0.0001

4.6.1 *O. mykiss* observations

A total of 195 *O. mykiss* juveniles and 73 adults were observed in August 2010 reference count survey, while 210 juveniles and 253 adults were observed in the August 2010 BCE survey (Table 4-5). The between-site comparison shows similar longitudinal trends for juveniles, with observations and density generally decreasing in the downstream direction (Table 4-6). In both surveys, the greatest abundance of *O. mykiss* juveniles occurred within riffle habitat near RM 50.6 (Table 4-6). Adult *O. mykiss* abundance was lower for the August reference survey when compared with the August BCE survey at shared sampling sites. This was particularly evident at the upstream riffle location near RM 50.6 where no adults were observed during the reference survey and 34 adults were observed during the BCE survey (Table 4-6).

It should be noted that the August 2010 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 August BCE surveys was greater (by an order of magnitude in most cases) than in June (Table 4-6). 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 142 Chinook salmon juveniles were observed during the August 2010 reference survey, while a total of 889 juveniles were observed during the August BCE survey (Table 4-5). As noted above, the total area in the BCE surveys is greater than in the reference surveys. Salmon were observed in each habitat type sampled by the two methods. 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 mid-summer indicates that conditions (e.g., water temperature, food availability) in summer 2010 were suitable for survival in upper portions of the reach.

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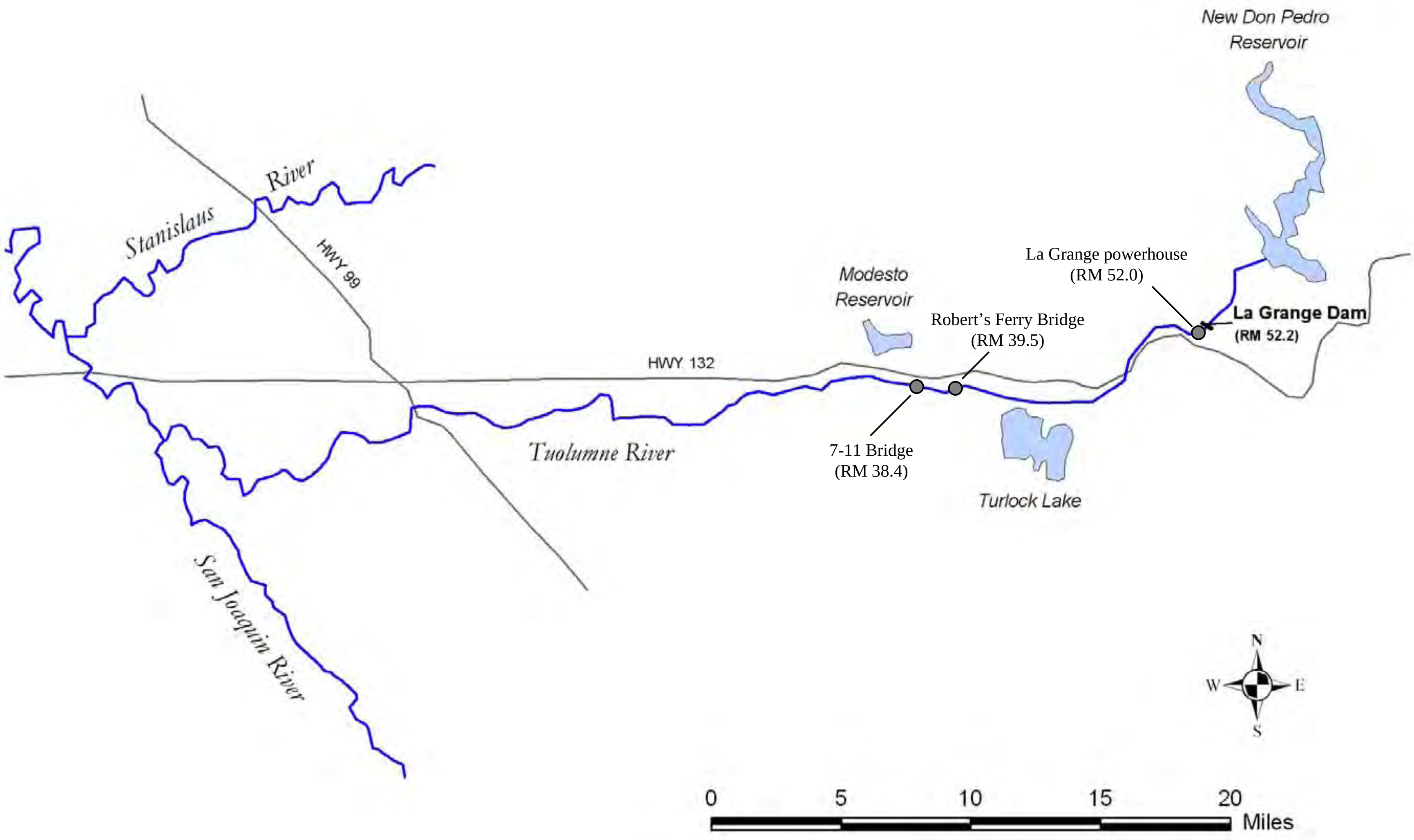

Figure 1. BCE study reach on the lower Tuolumne River, March and August 2010.

Stillwater Sciences

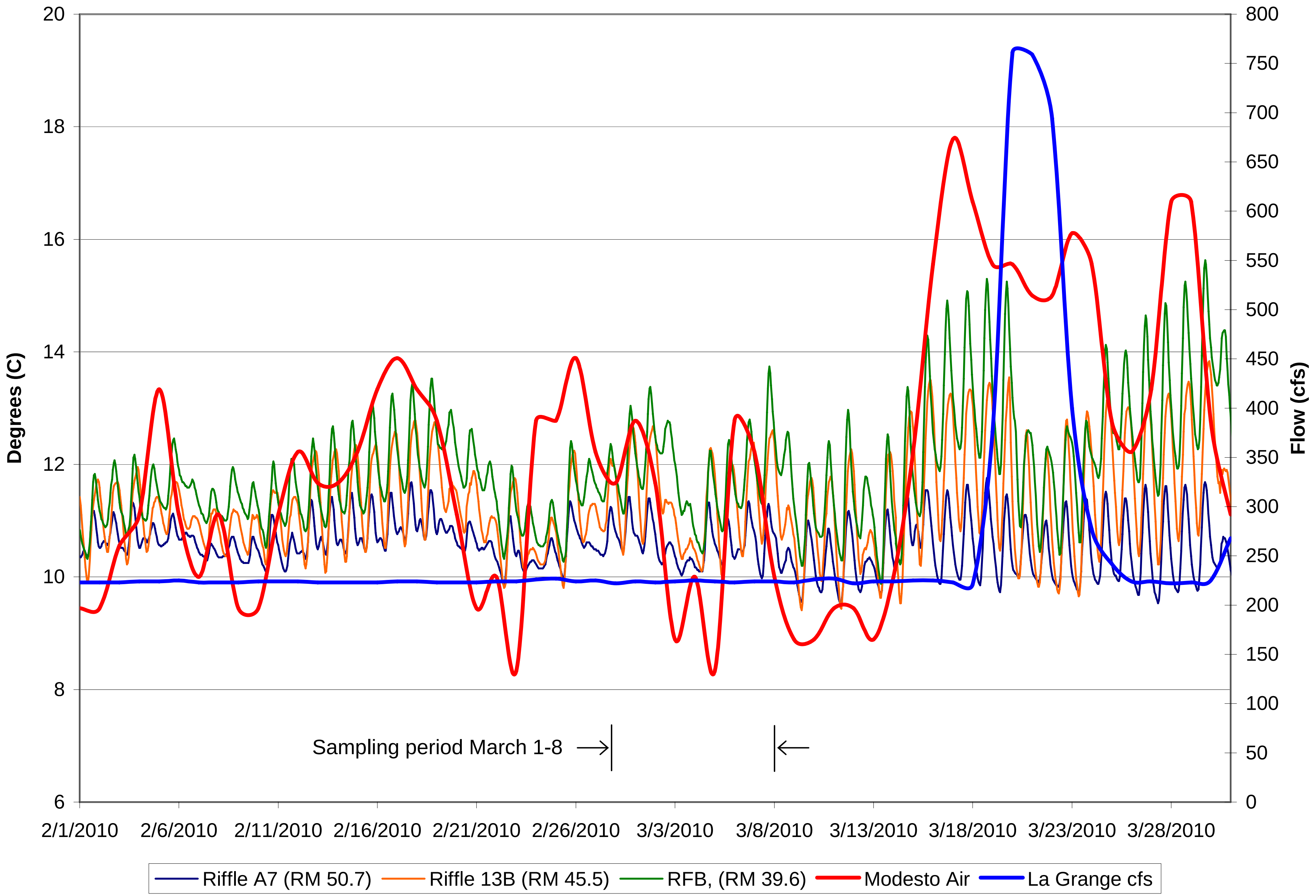

Figure 2a. Hourly water temperature, daily average air temperature, and daily average flow for the study reach from 1 February to 31 March 2010.

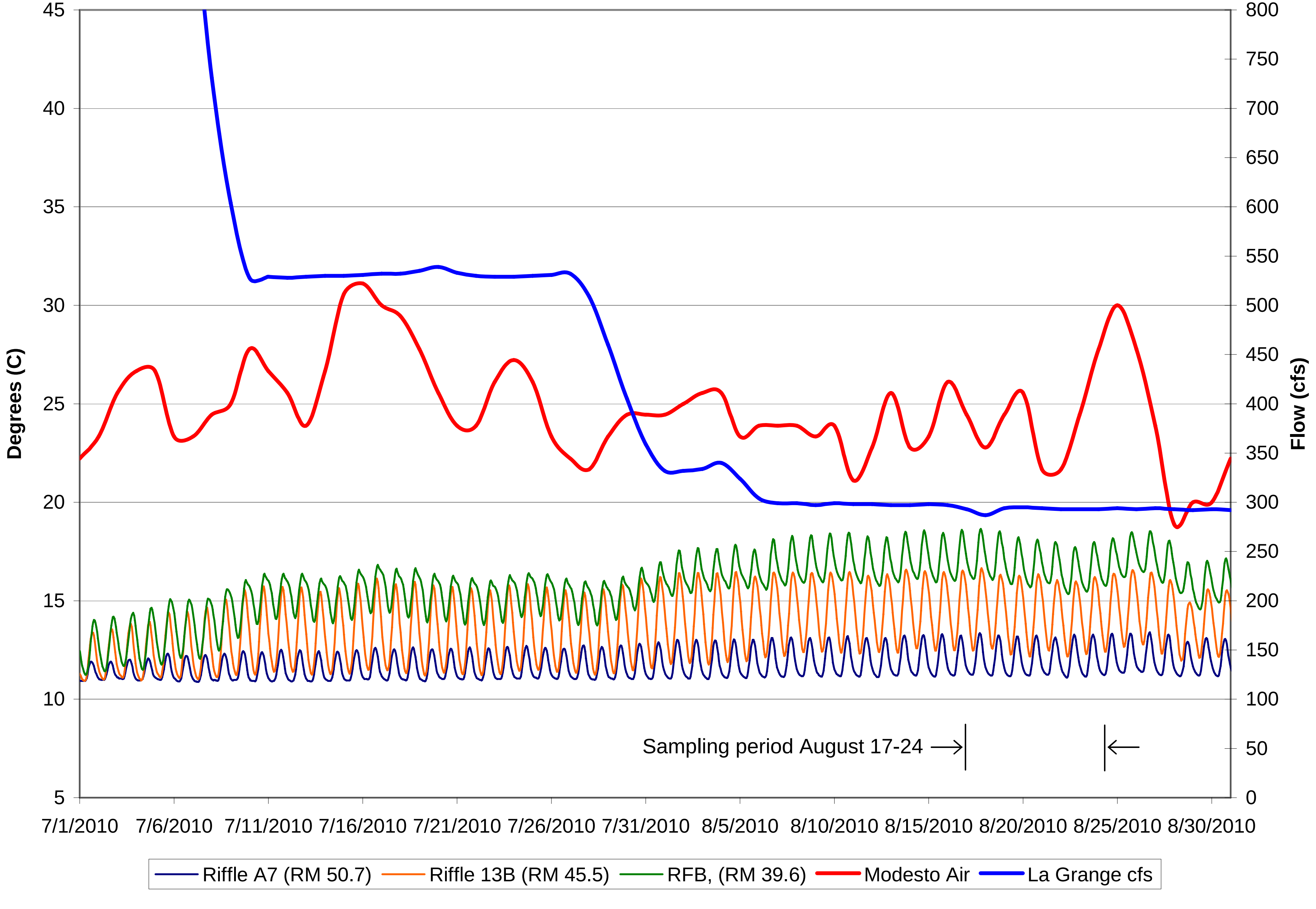

Figure 2b. Hourly water temperature, daily average air temperature, and daily average flow for the study reach from 1 July to 31 August 2010.

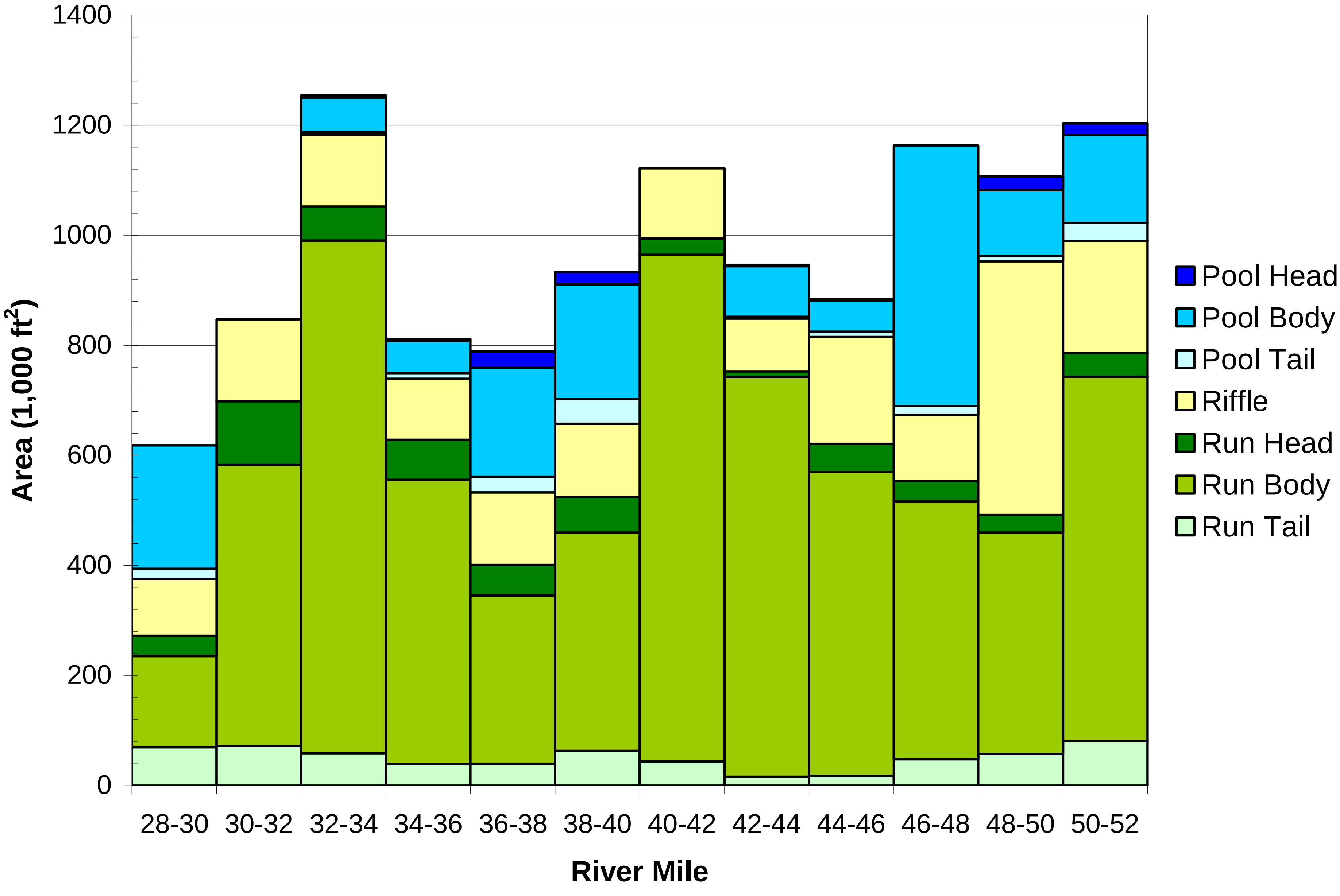

Figure 3. Longitudinal distribution of major habitat type areas by river mile in the lower Tuolumne River (RM 52–30) for March and August 2010 surveys.

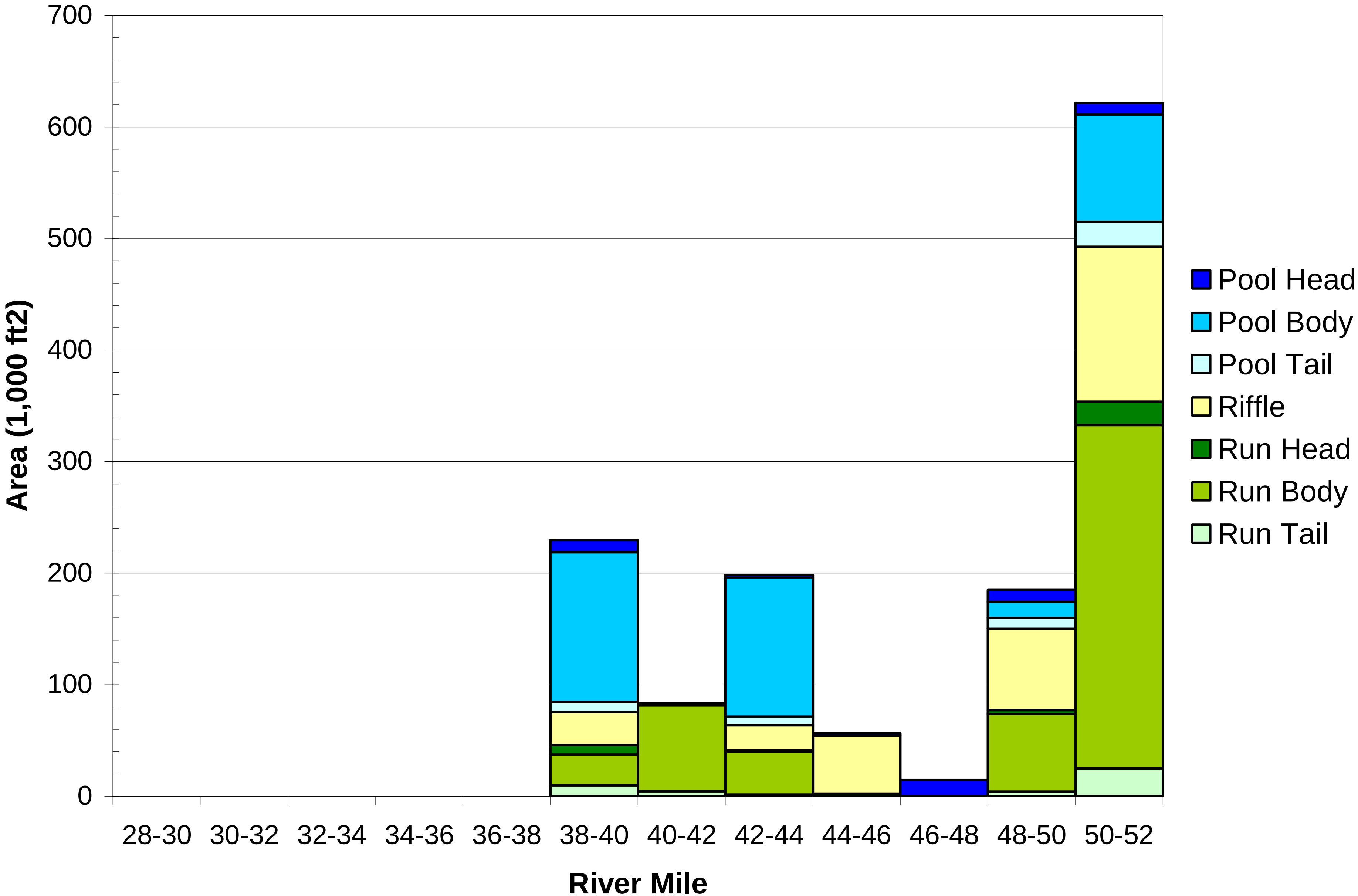

Figure 4a. Longitudinal distribution of major habitat type areas sampled by river mile in the lower Tuolumne River (RM 52–38) for March 2010 survey.

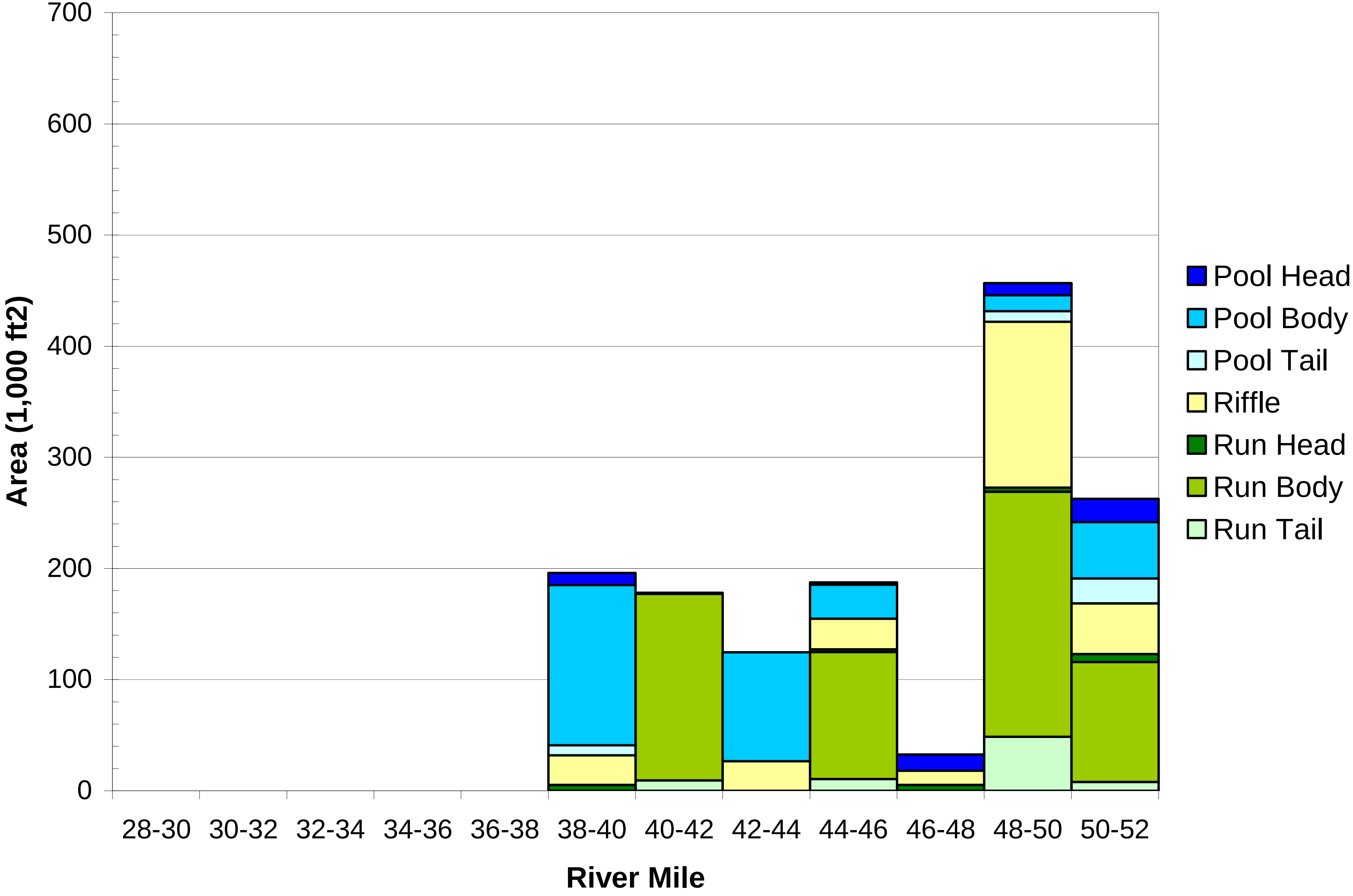

Figure 4b. Longitudinal distribution of major habitat type areas sampled by river mile in the lower Tuolumne River (RM 52–38) for August 2010 survey.

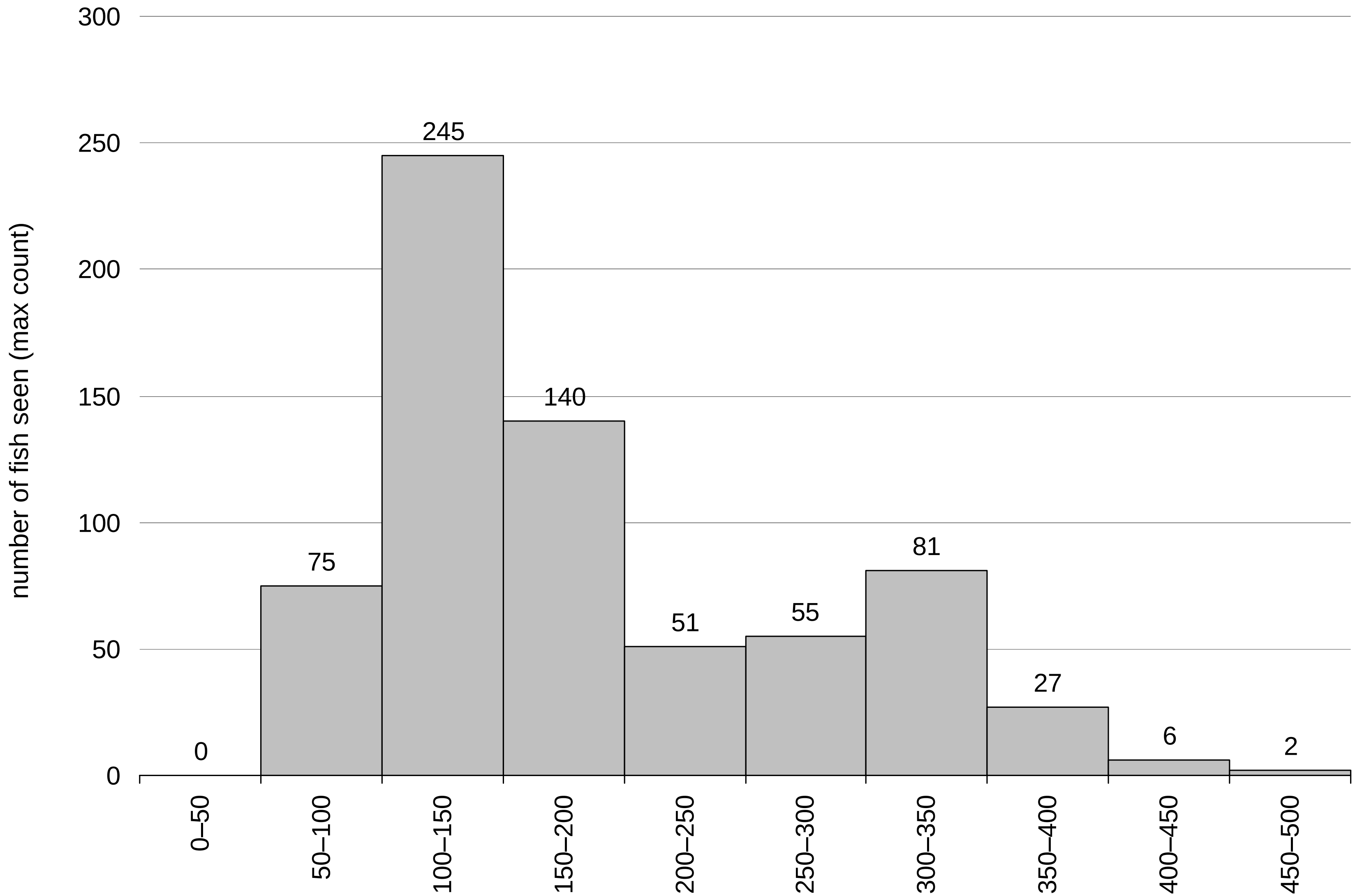

Figure 5. Size distribution of *O. mykiss* observed in Tuolumne River snorkel surveys, August 2010. For units receiving multiple passes, the count is from the pass with the largest count for that size class.

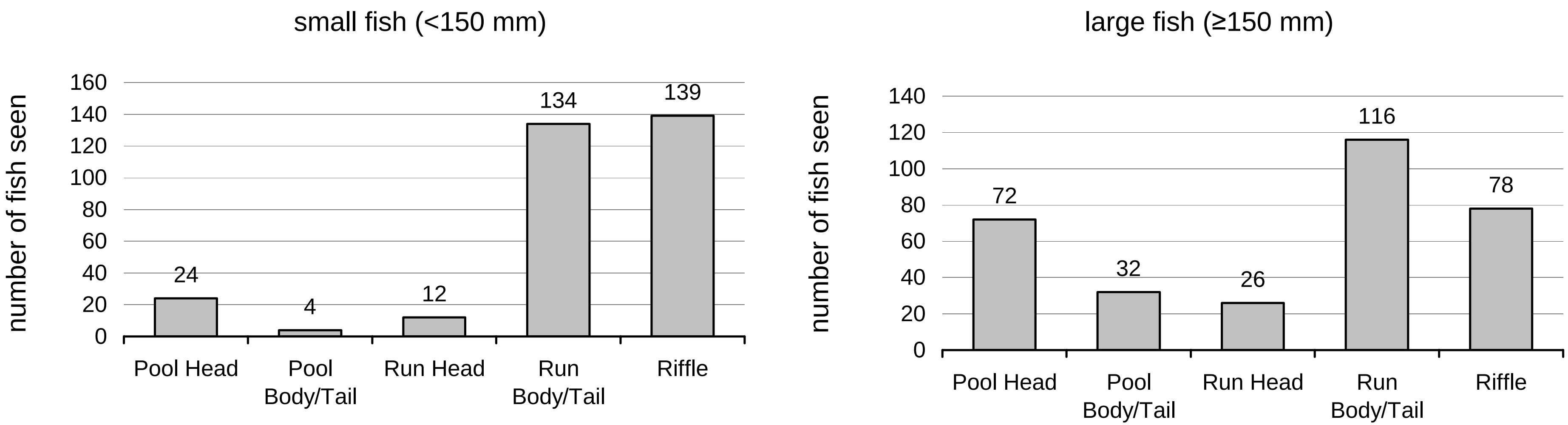

Figure 6a. Distribution of observed *O. mykiss* counts among habitat types, by size class in August 2010. For units receiving multiple passes, the count is from the pass with the largest count.

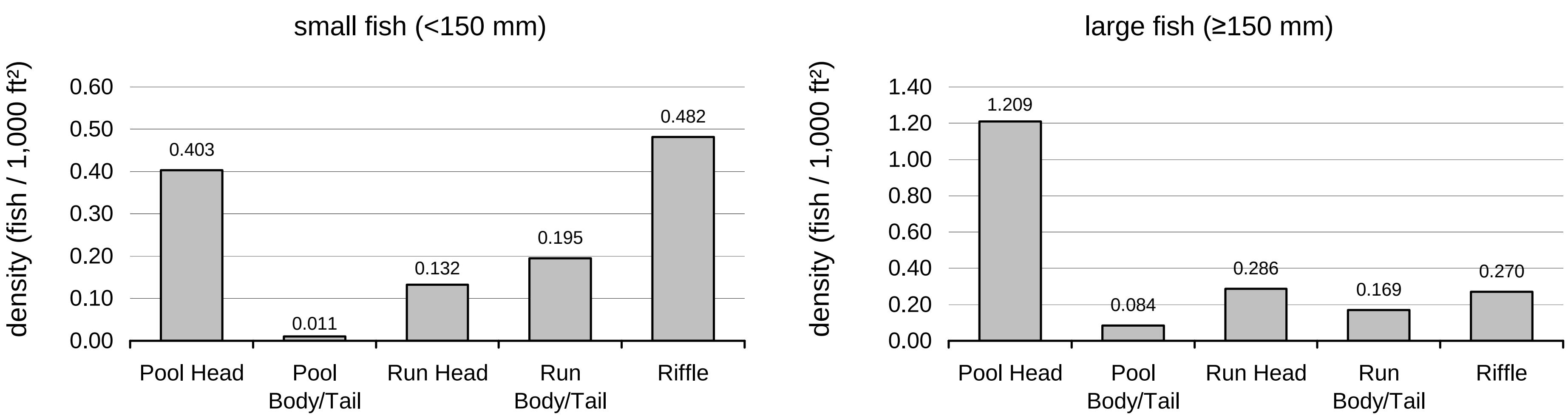

Figure 6b. Distribution of observed *O. mykiss* density based on maximum count among habitat types, by size class in August 2010.

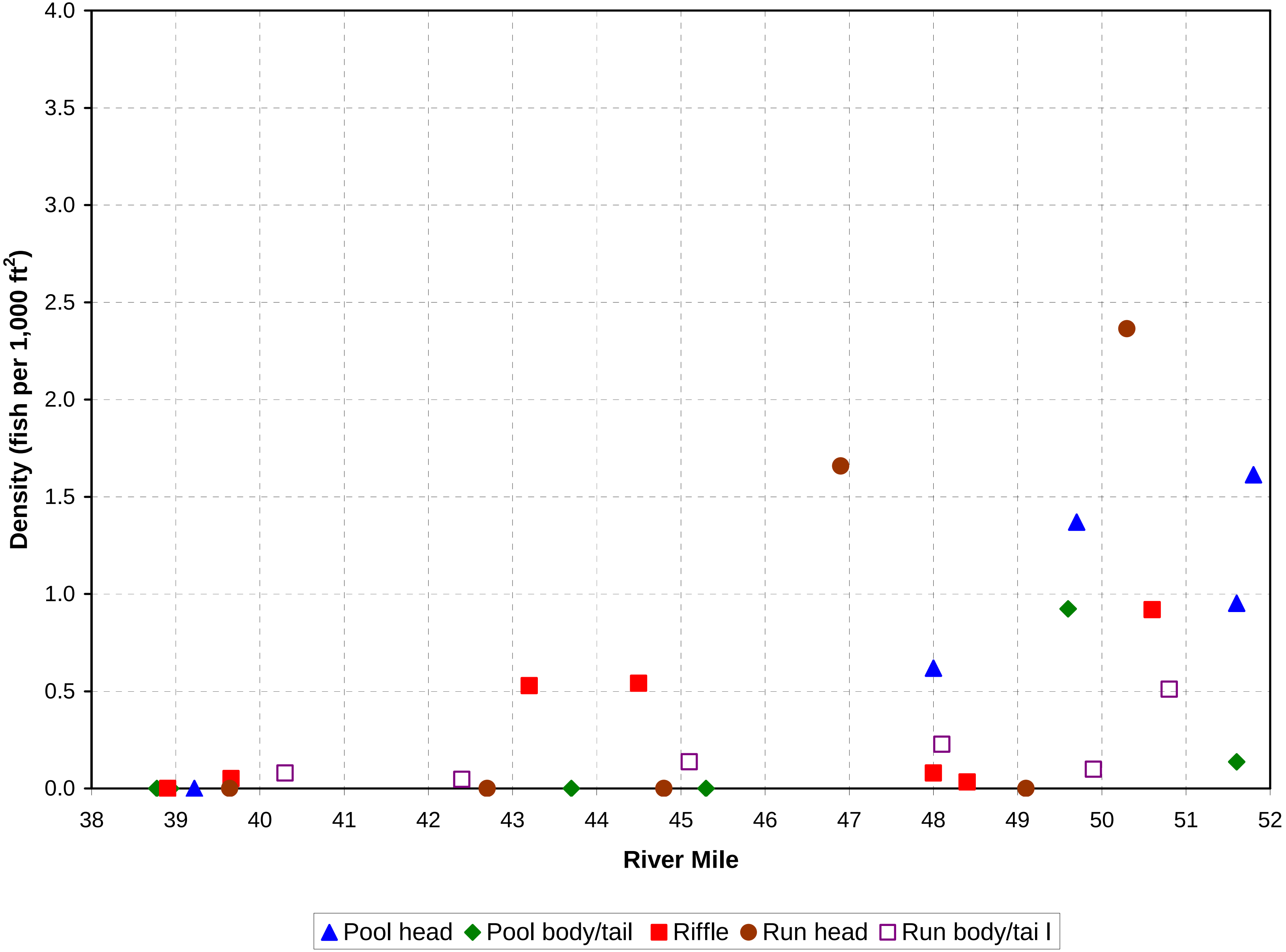

Figure 7. August 2010 adult *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.

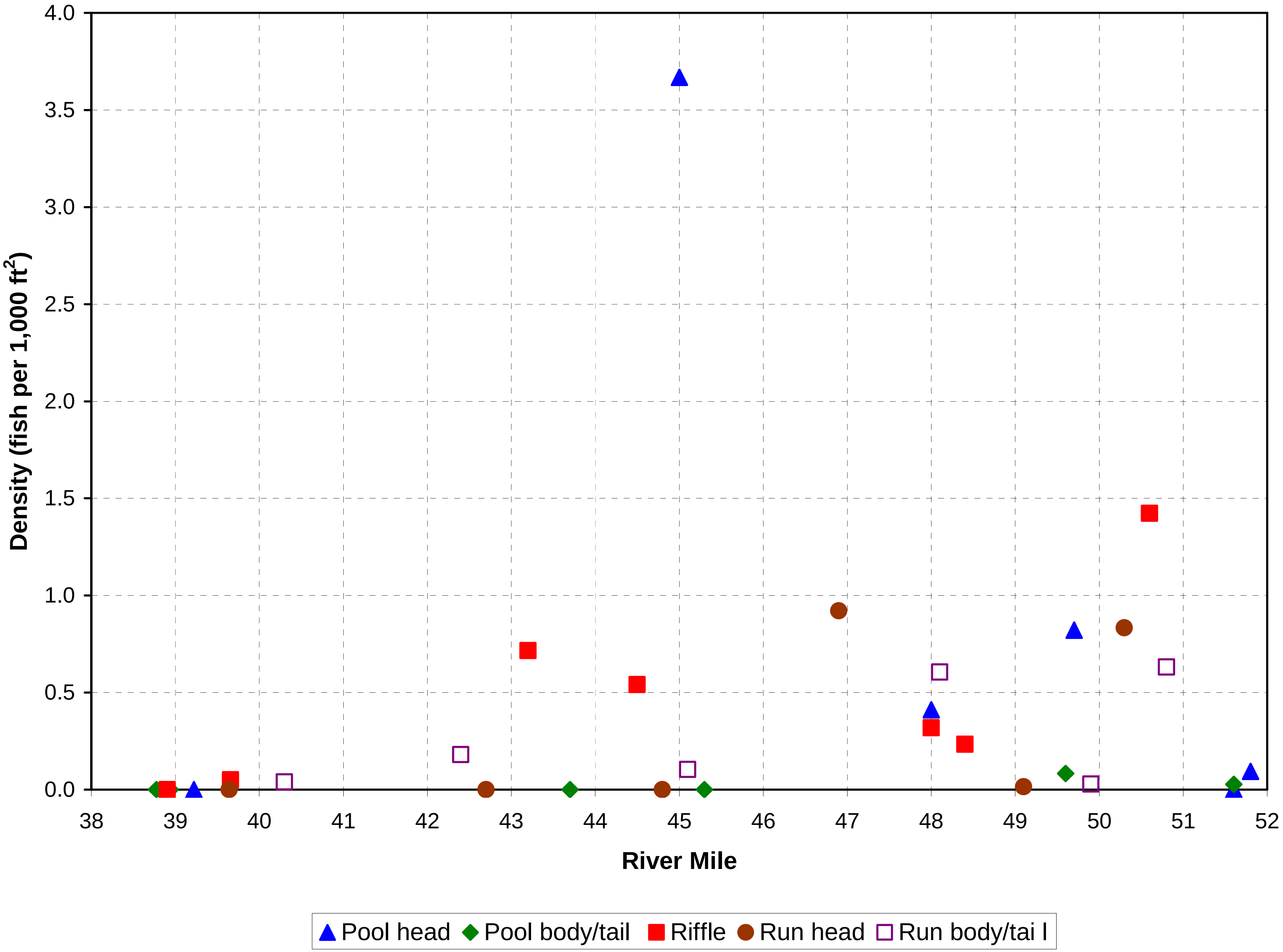

Figure 8. August 2010 juvenile *O. mykiss* density by river mile based upon maximum count in sampling units of each habitat type.

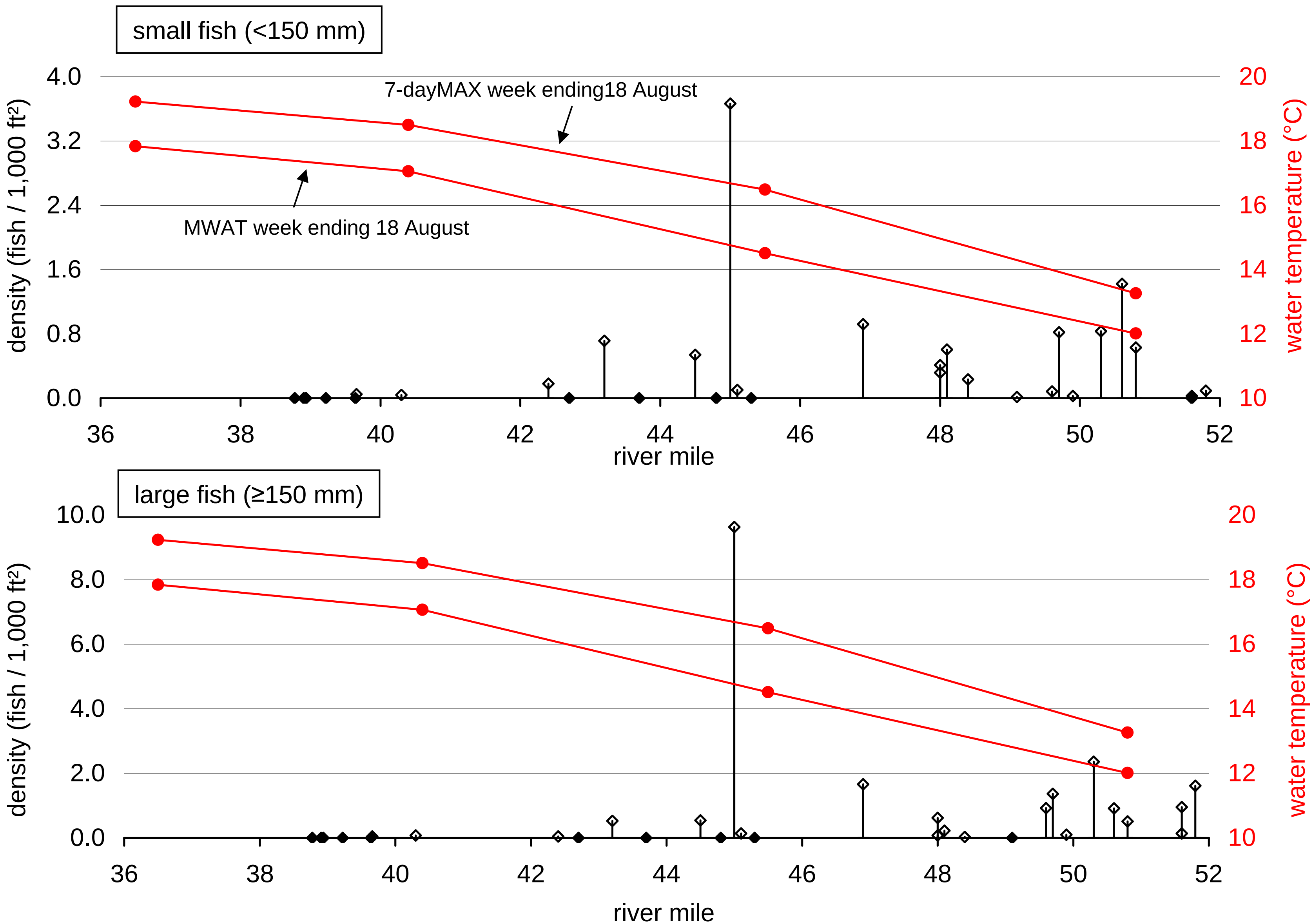

Figure 9. Longitudinal distribution of observed *O. mykiss* and water temperature in the lower Tuolumne River, August 2010. Solid diamonds are observed zeros, open diamonds are observed non-zero values.

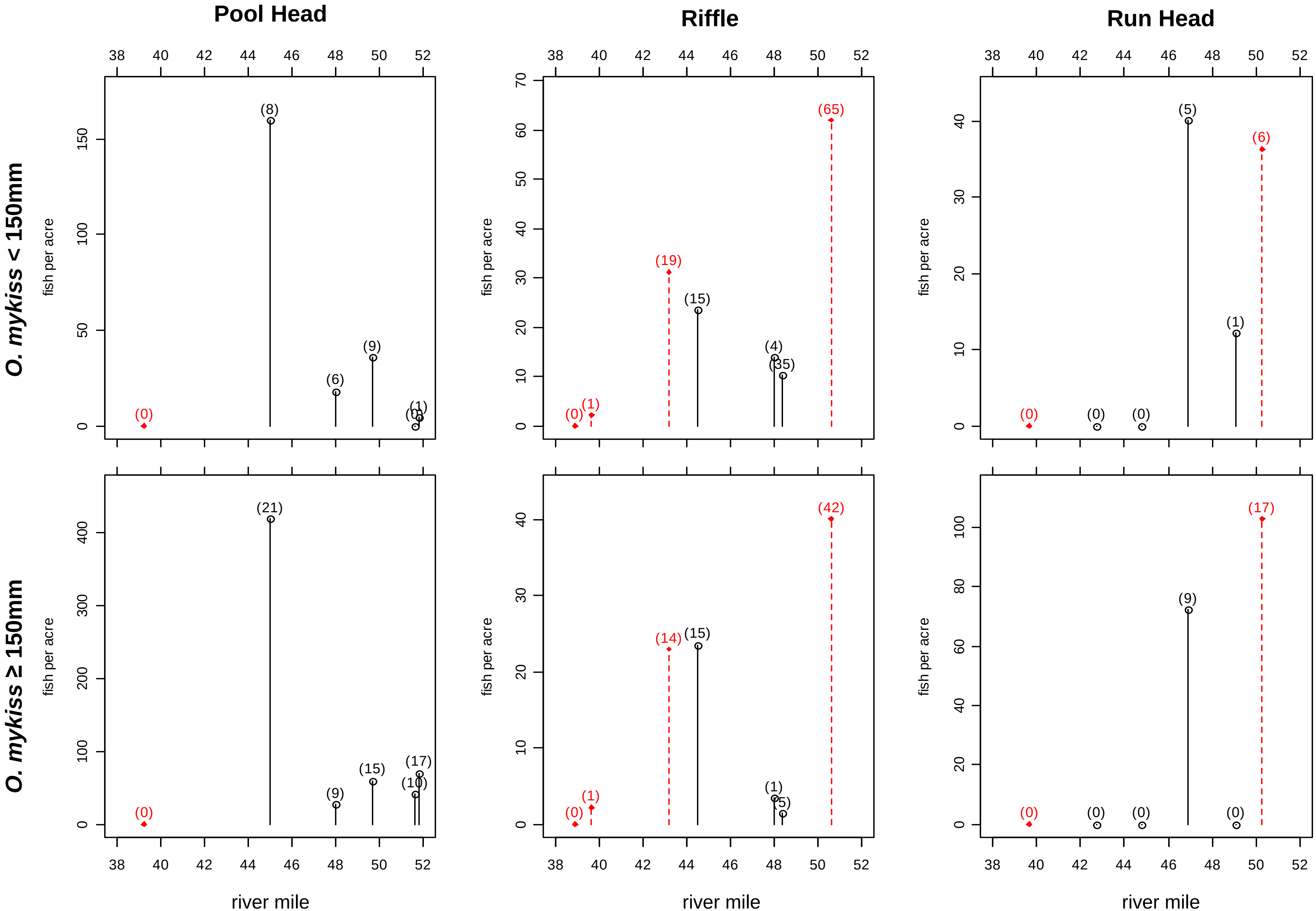

Figure 10. Observed densities of *O. mykiss* in individual sampling units in the March 2010 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (7-11 [RM 39.0], FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

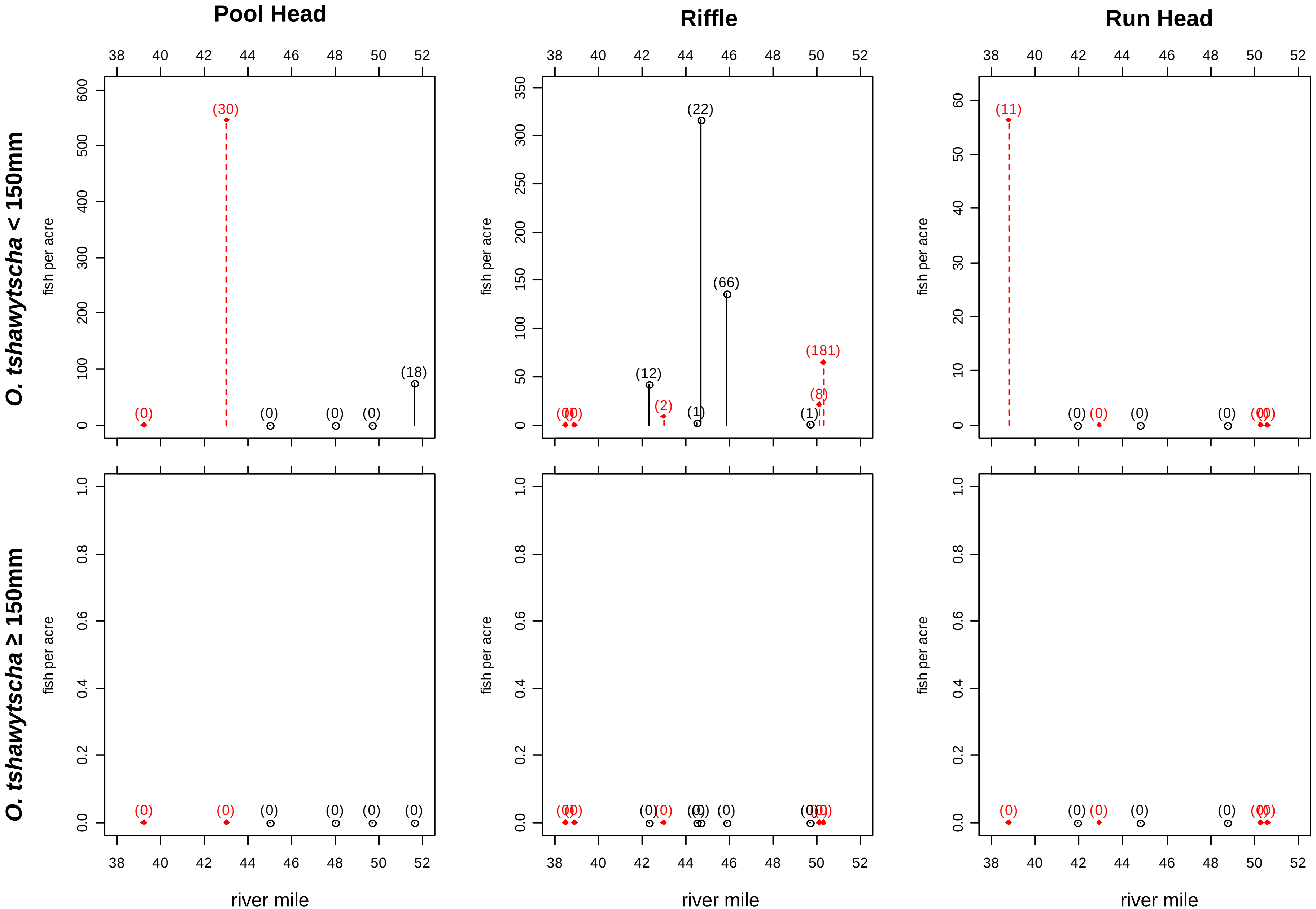

Figure 11. Observed densities of *O. tshawytscha* in individual sampling units in the March 2010 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (7-11 [RM39.0], FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). Non-restoration sites are shown with solid lines.

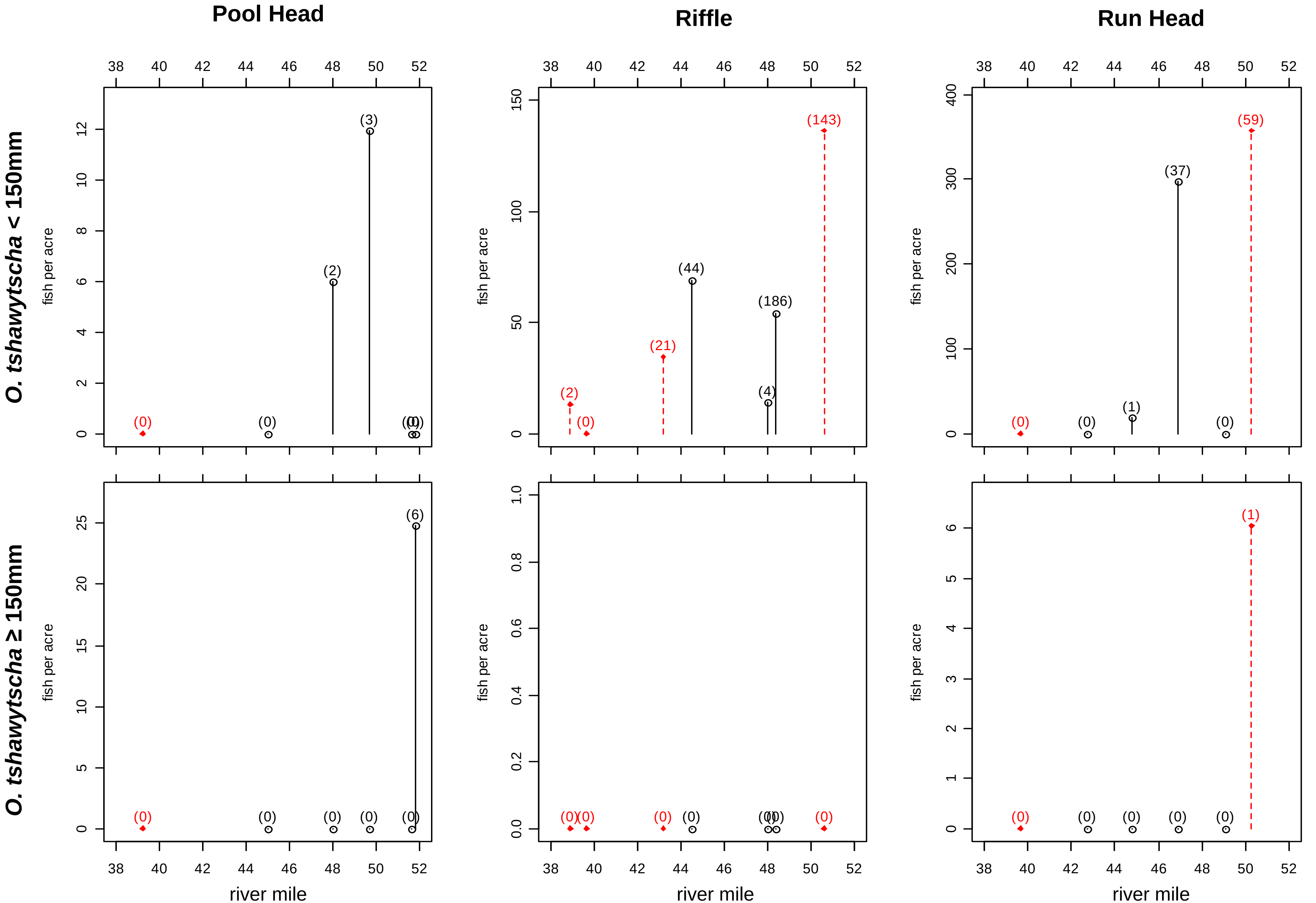

Figure 12. Observed densities of *O. tshawytscha* in individual sampling units in the August 2010 surveys. Densities are maximum dive counts (in parenthesis) divided by the area sampled. Restoration sites are shown with broken lines (7-11 [RM 39.0], FOT [RM 43.0], CDFG 2001 [RM 50.3], CDFG 2003 [RM 50.6]). 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
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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 01

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)
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Tile 02

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

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0 125 250 500 Feet

Runs
Riffles
Pools

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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
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Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)
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Tile 04

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

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
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Tile 05

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

Stillwater Sciences
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Runs
Riffles
Pools

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River Miles

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Tile 06

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

Stillwater Sciences
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Riffles
Pools

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River Miles

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Tile 07

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

Stillwater Sciences
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0 125 250 500 Feet

Runs
Riffles
Pools

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Tile 08

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

Stillwater Sciences
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Riffles
Pools

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Tile 09

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Runs
Riffles
Pools

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Tile 10

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Runs
Riffles
Pools

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River Miles

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Tile 11

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Stillwater Sciences
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0 125 250 500 Feet

Runs
Riffles
Pools

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Tile 12

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

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
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Tile 13

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Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

0 125 250 500 Feet

METADATA
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Tile 14

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

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
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Tile 15

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

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

METADATA
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Tile 16

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0 125 250 500 Feet

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

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0 125 250 500 Feet

Runs
Riffles
Pools
Tile Boundary (shown white on the map)
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Tile 17

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

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

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Tile 18

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

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0 125 250 500 Feet

Runs

Riffles

Pools

Tile Boundary (shown white on the map)

River Miles

METADATA

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Tile 19

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

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
River Miles

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Tile 20

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

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
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Tile 21

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0 125 250 500 Feet

Runs
Riffles
Pools

Tile Boundary (shown white on the map)
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Tile 22

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0 125 250 500 Feet

Runs
Riffles
Pools

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Riffles
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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

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 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

0 125 250 500 Feet

Stillwater Sciences
www.stillwatersci.com

METADATA

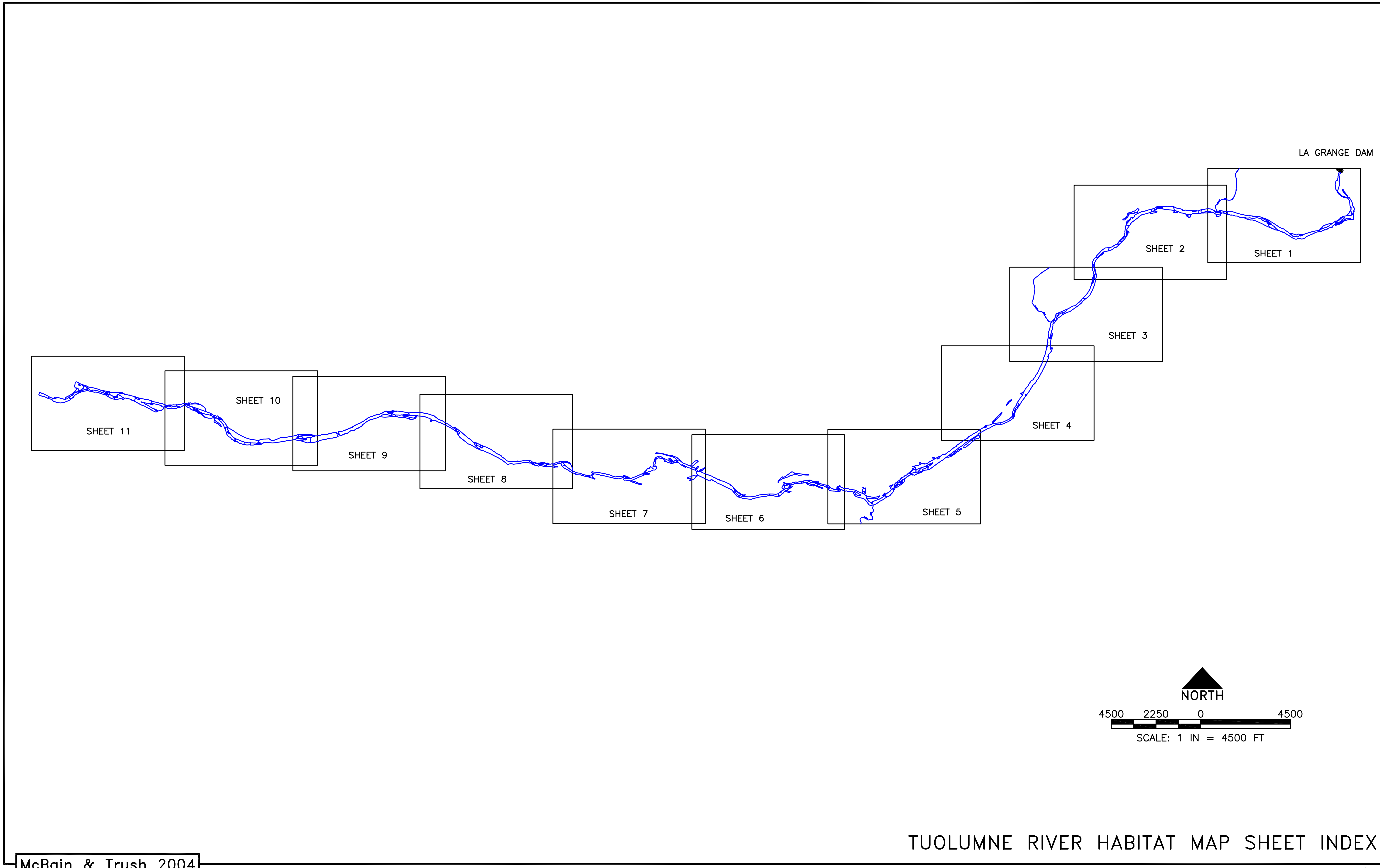
Tiles 29 to 47: NAIP, 6/29/2009 (130 cfs)

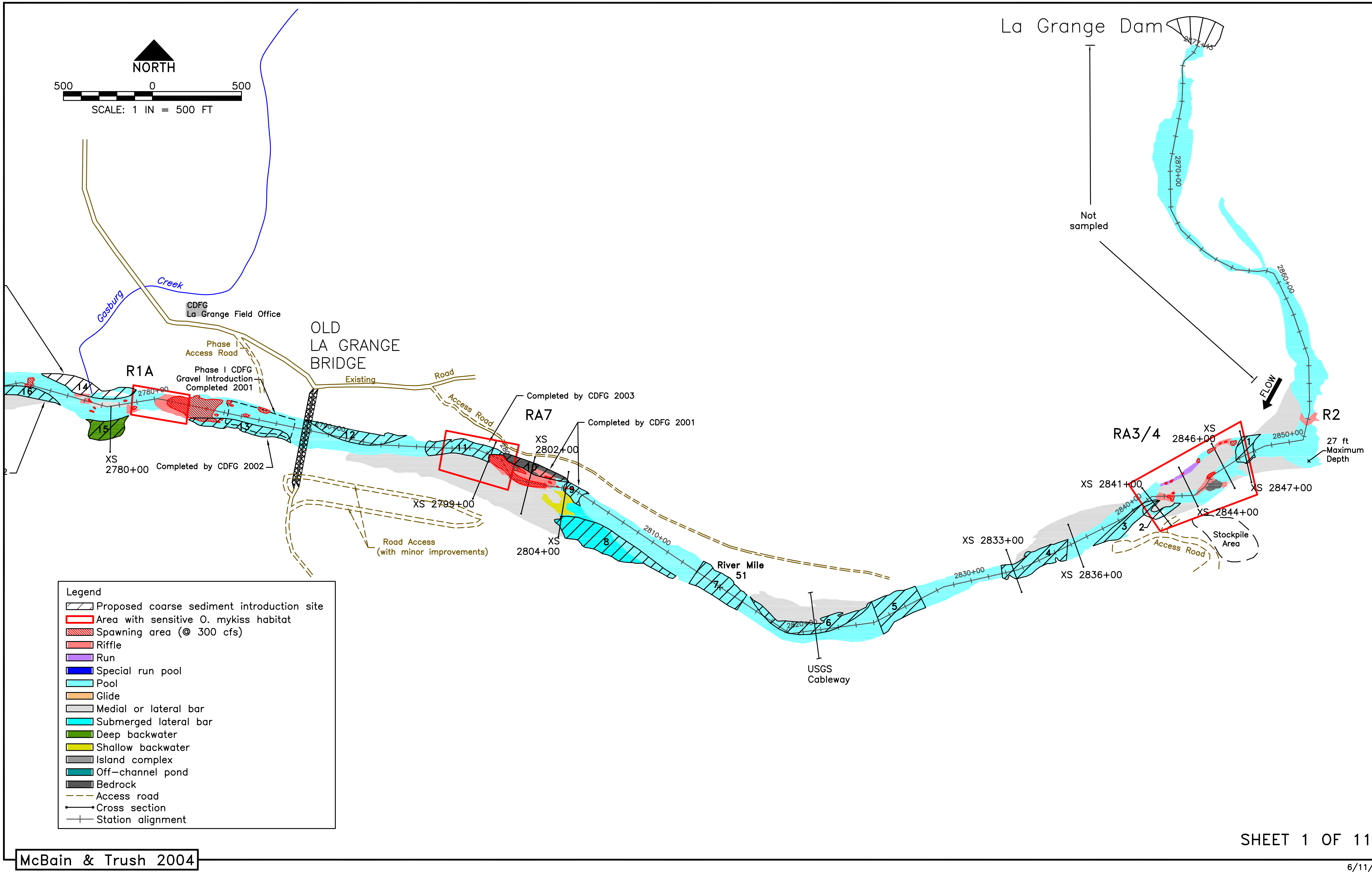
Tiles 1 to 29: Sanborn imagery, 09/25/2005 (335 cfs)

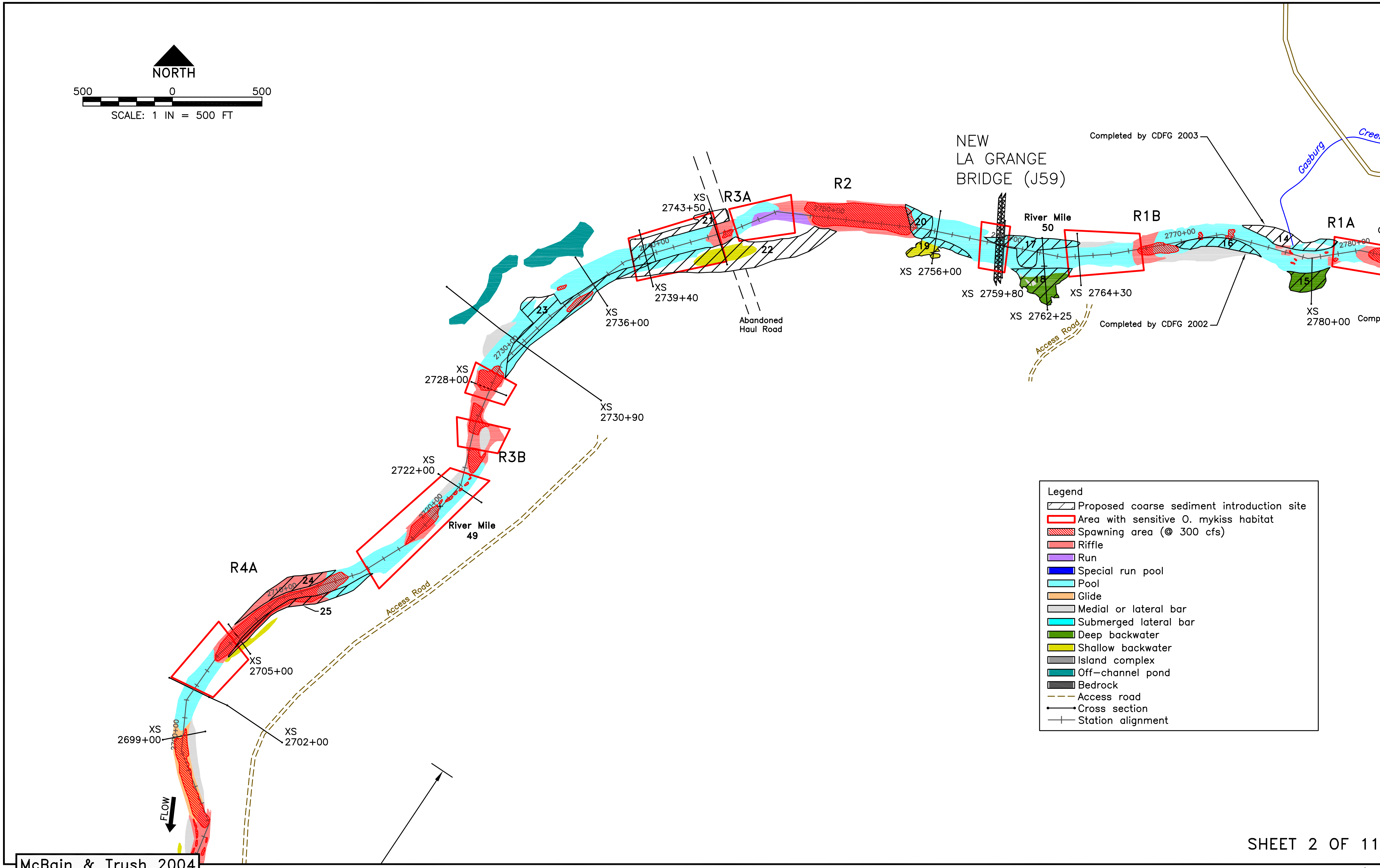
Wetted perimeter were fisrt based on EA_mapping data (90's) at 230 cfs, and later refined using 2005 & 2009 NAIP and field measurements from 2008 and 2009 surveys to adjust for channel migration.

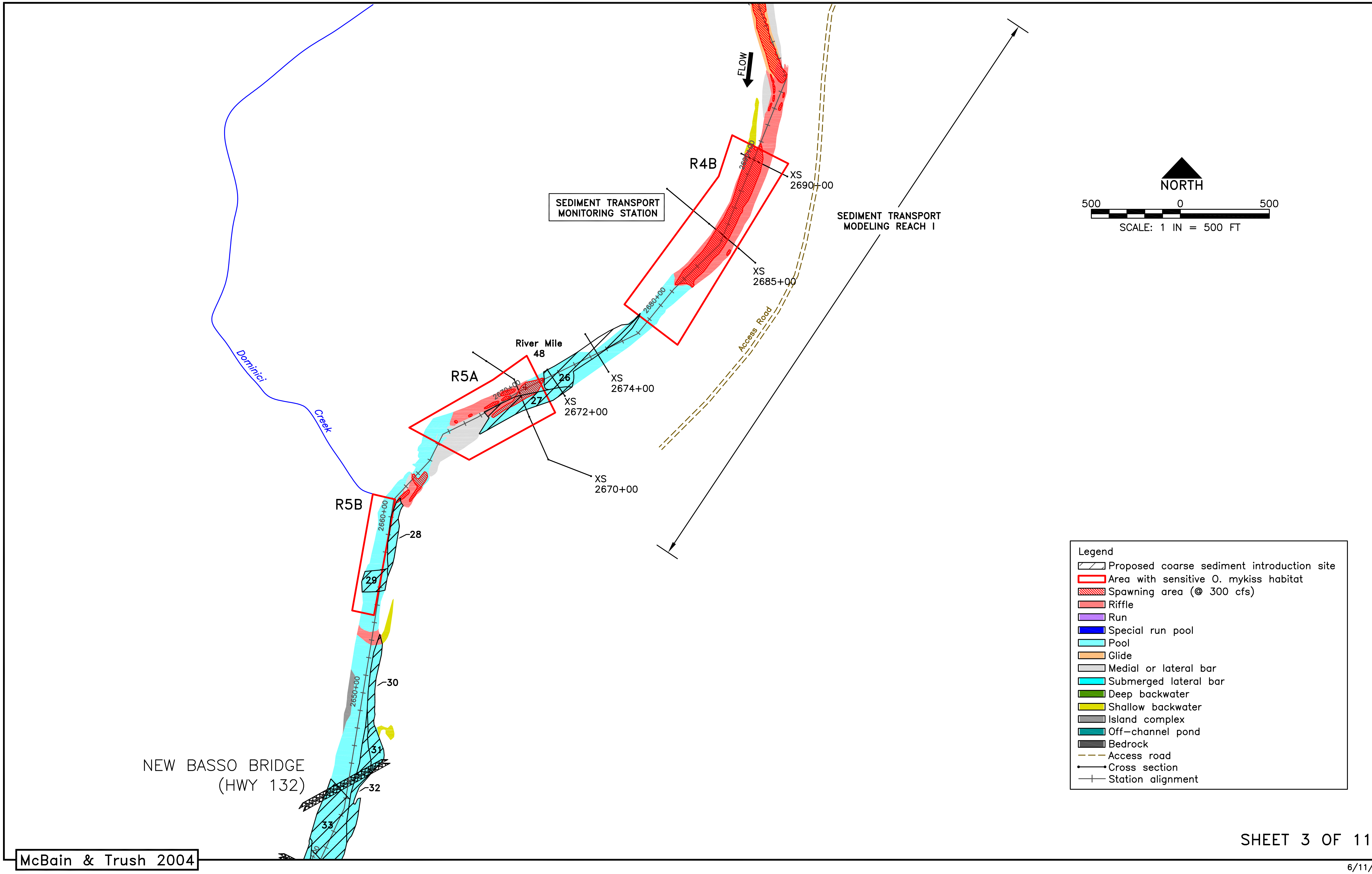
Tile 28

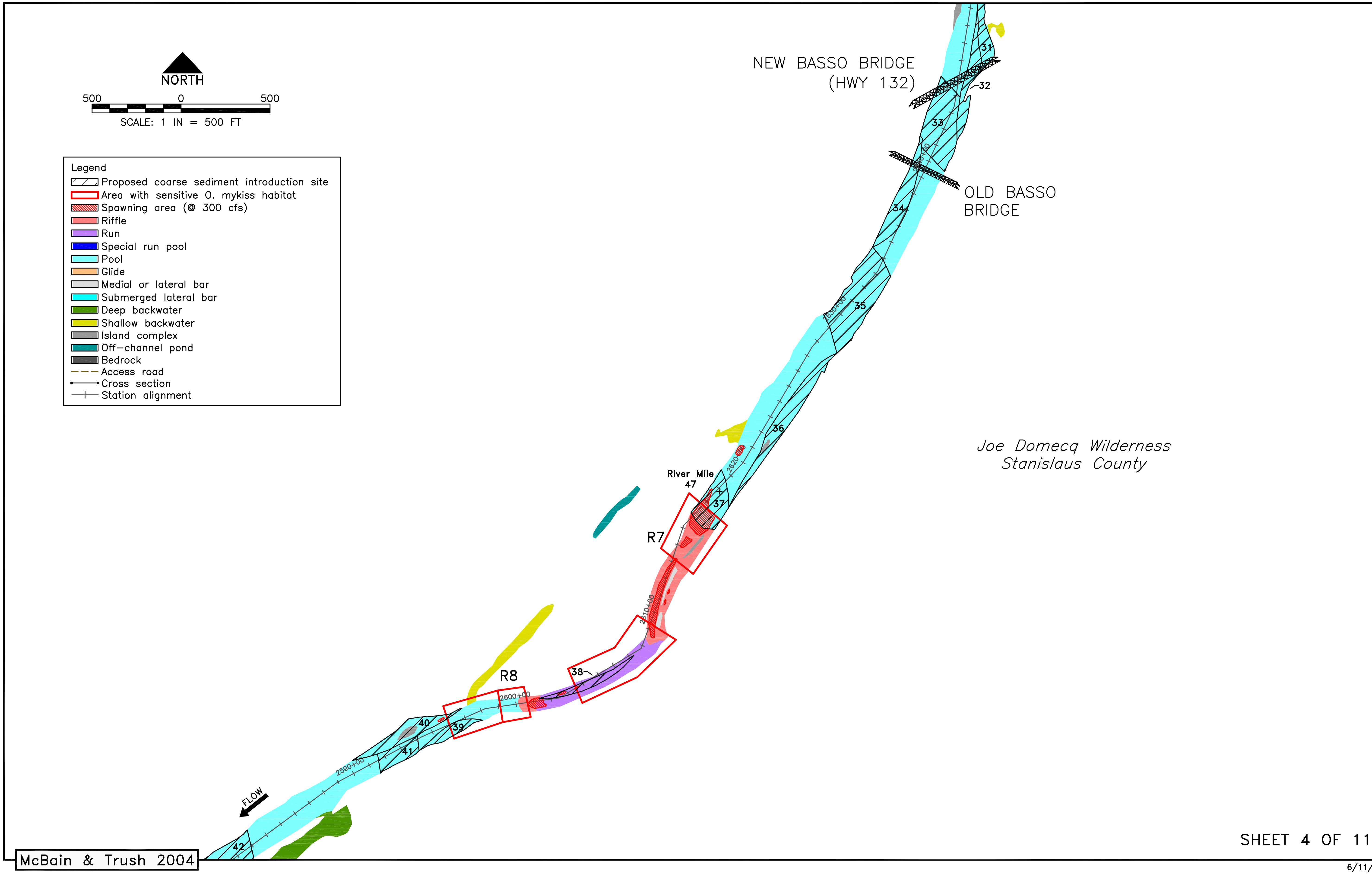
Appendix C: 2004 Habitat Maps


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

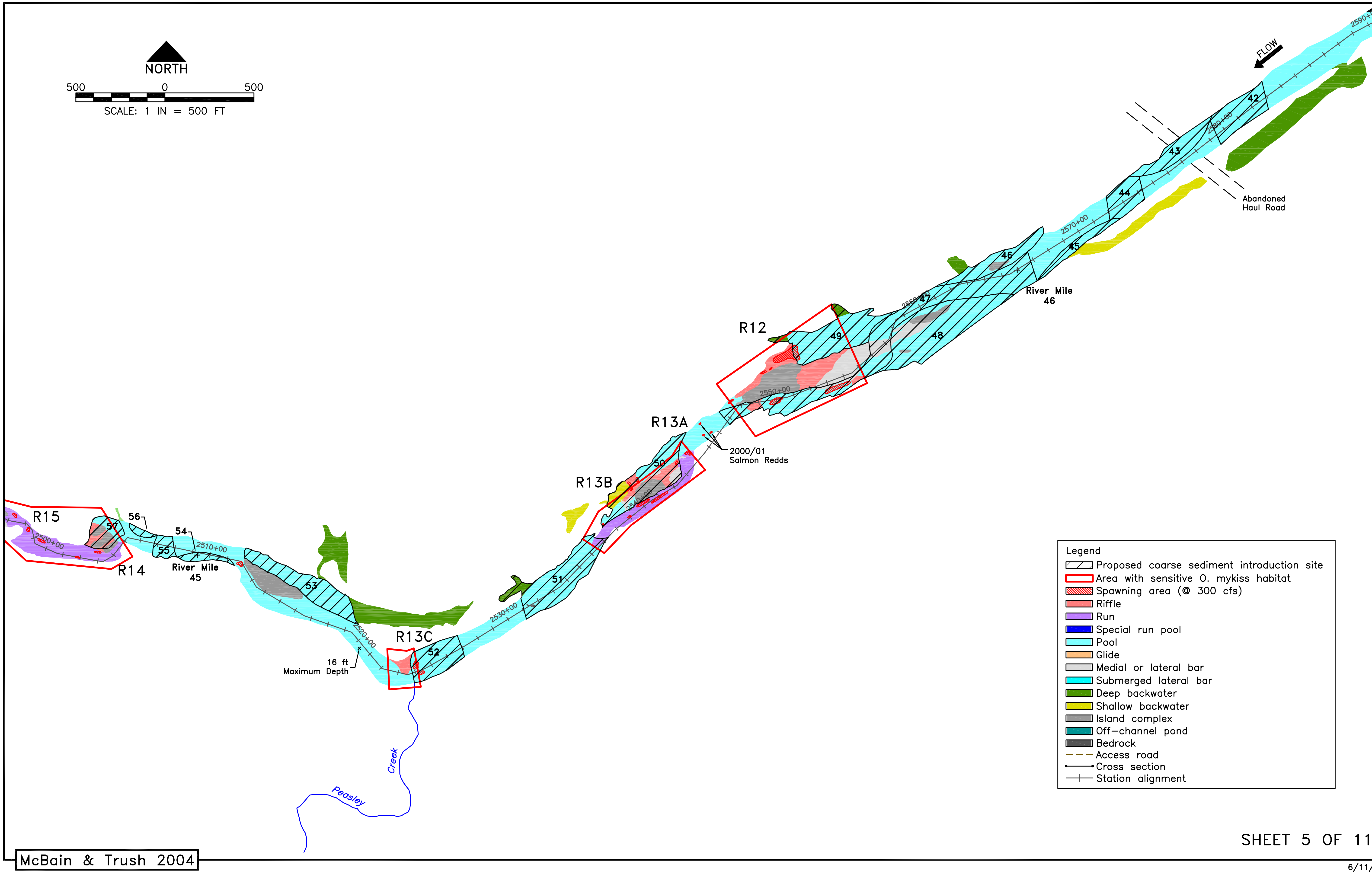

La Grange Dam
NORTH
500 0 500
SCALE: 1 IN = 500 FT
Not sampled
FLOW
R2
27 ft Maximum Depth
RA3/4
XS 2846+00
XS 2841+00
XS 2847+00
XS 2844+00
Stockpile Area
Access Road
XS 2833+00
XS 2836+00
River Mile 51
USGS Cableway
Gasburg Creek
CDFG La Grange Field Office
OLD LA GRANGE BRIDGE
Existing Road
Access Road
Phase I Access Road
Phase I CDFG Gravel Introduction Completed 2001
R1A
XS 2780+00
Completed by CDFG 2002
Completed by CDFG 2003
Completed by CDFG 2001
RA7
XS 2802+00
XS 2799+00
XS 2804+00
Road Access (with minor improvements)
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

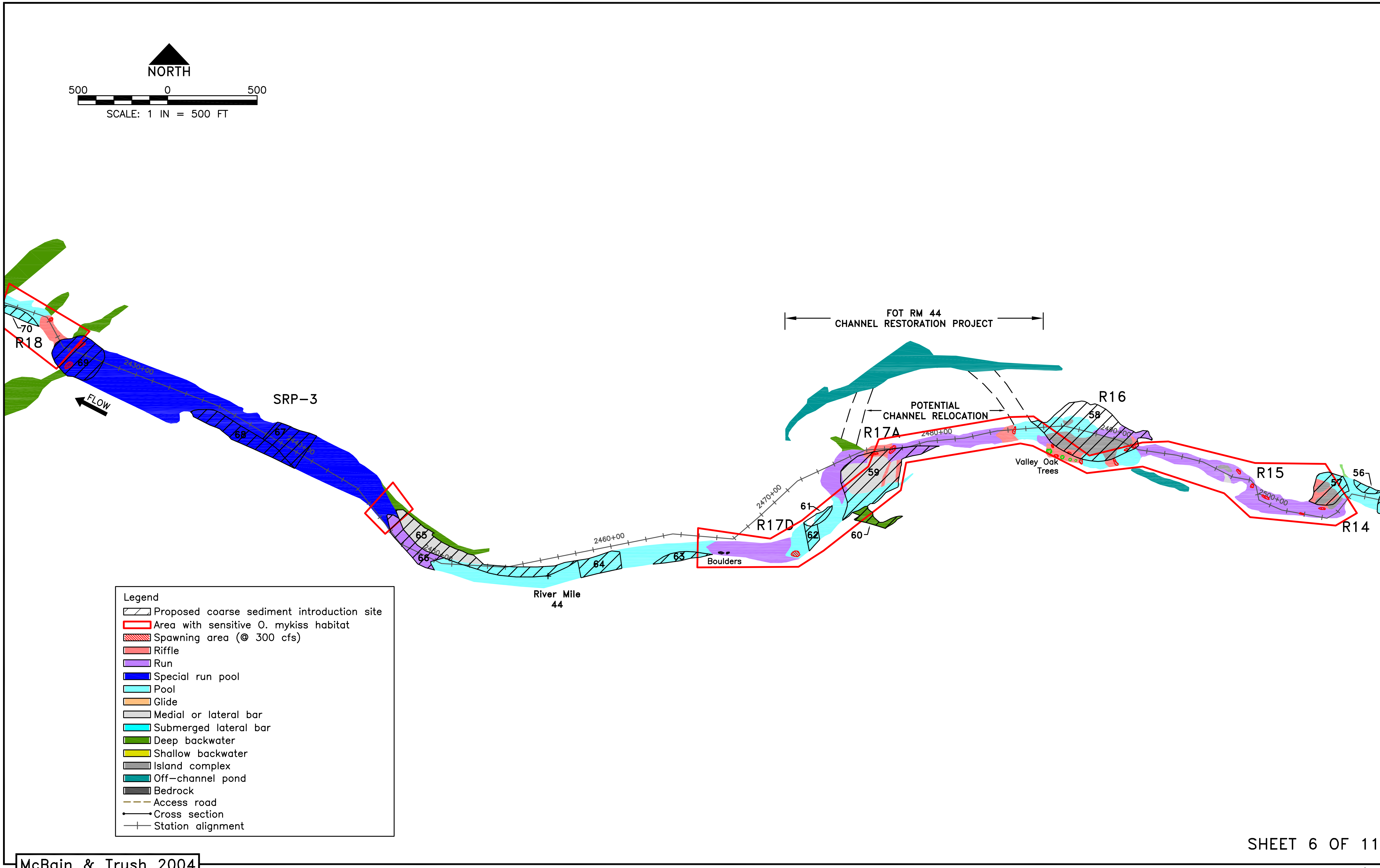

NORTH
500 0 500
SCALE: 1 IN = 500 FT
NEW
LA GRANGE
BRIDGE (J59)
Completed by CDFG 2003
Completed by CDFG 2002
Gasburg Creek
R3A
R2
R1B
R1A
R3B
R4A
River Mile 50
River Mile 49
XS 2743+50
XS 2739+40
XS 2736+00
XS 2730+90
XS 2728+00
XS 2722+00
XS 2756+00
XS 2759+80
XS 2762+25
XS 2764+30
XS 2780+00
XS 2705+00
XS 2702+00
XS 2699+00
Abandoned Haul Road
Access Road
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

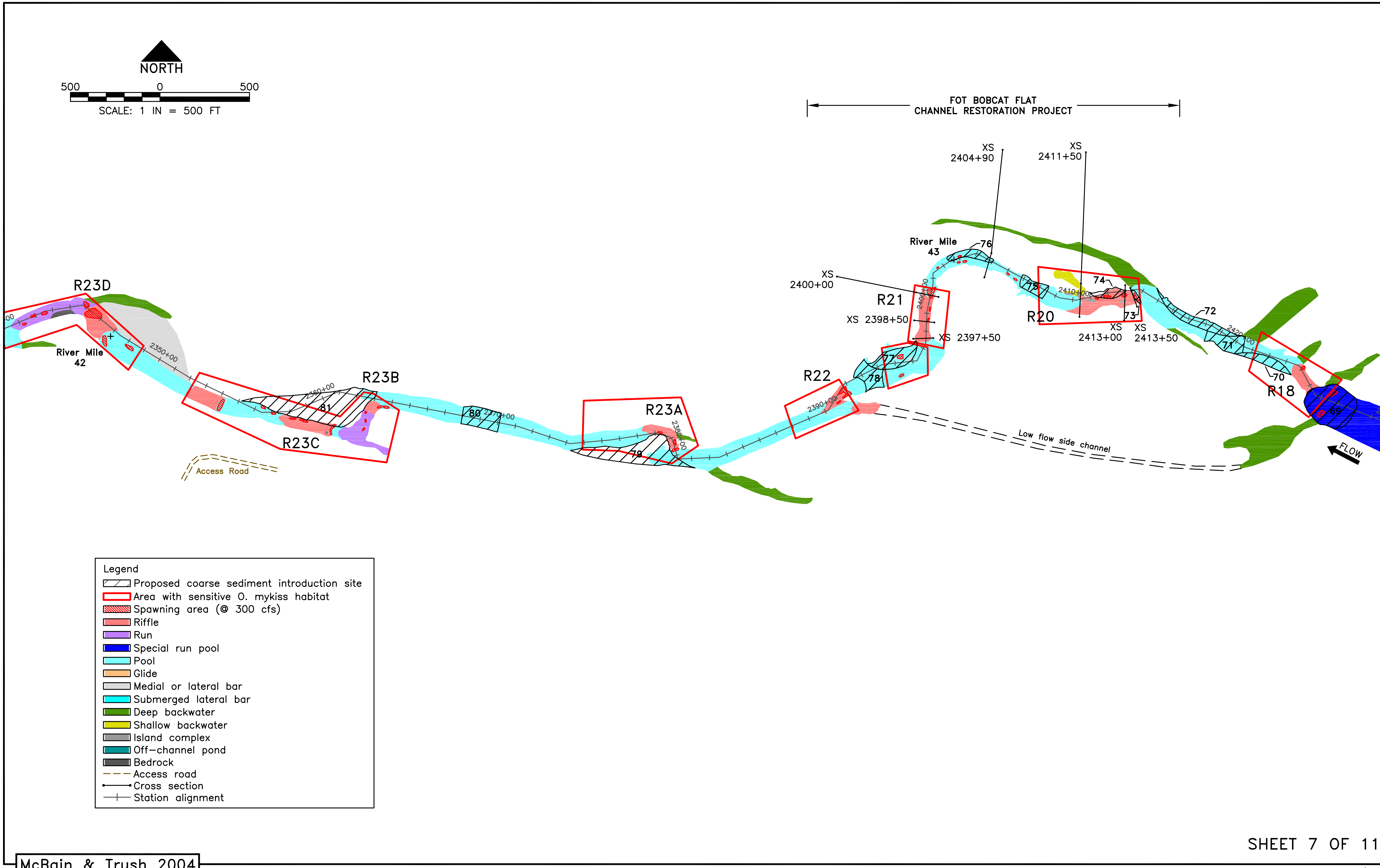

FLOW
R4B
XS
2690+00
XS
2685+00
SEDIMENT TRANSPORT
MONITORING STATION
SEDIMENT TRANSPORT
MODELING REACH I
NORTH
500
0
500
SCALE: 1 IN = 500 FT
Access Road
River Mile
48
R5A
26
27
XS
2674+00
XS
2672+00
XS
2670+00
Dominici
Creek
R5B
2660+00
28
29
30
2650+00
31
32
33
NEW BASSO BRIDGE
(HWY 132)
Legend
Proposed 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

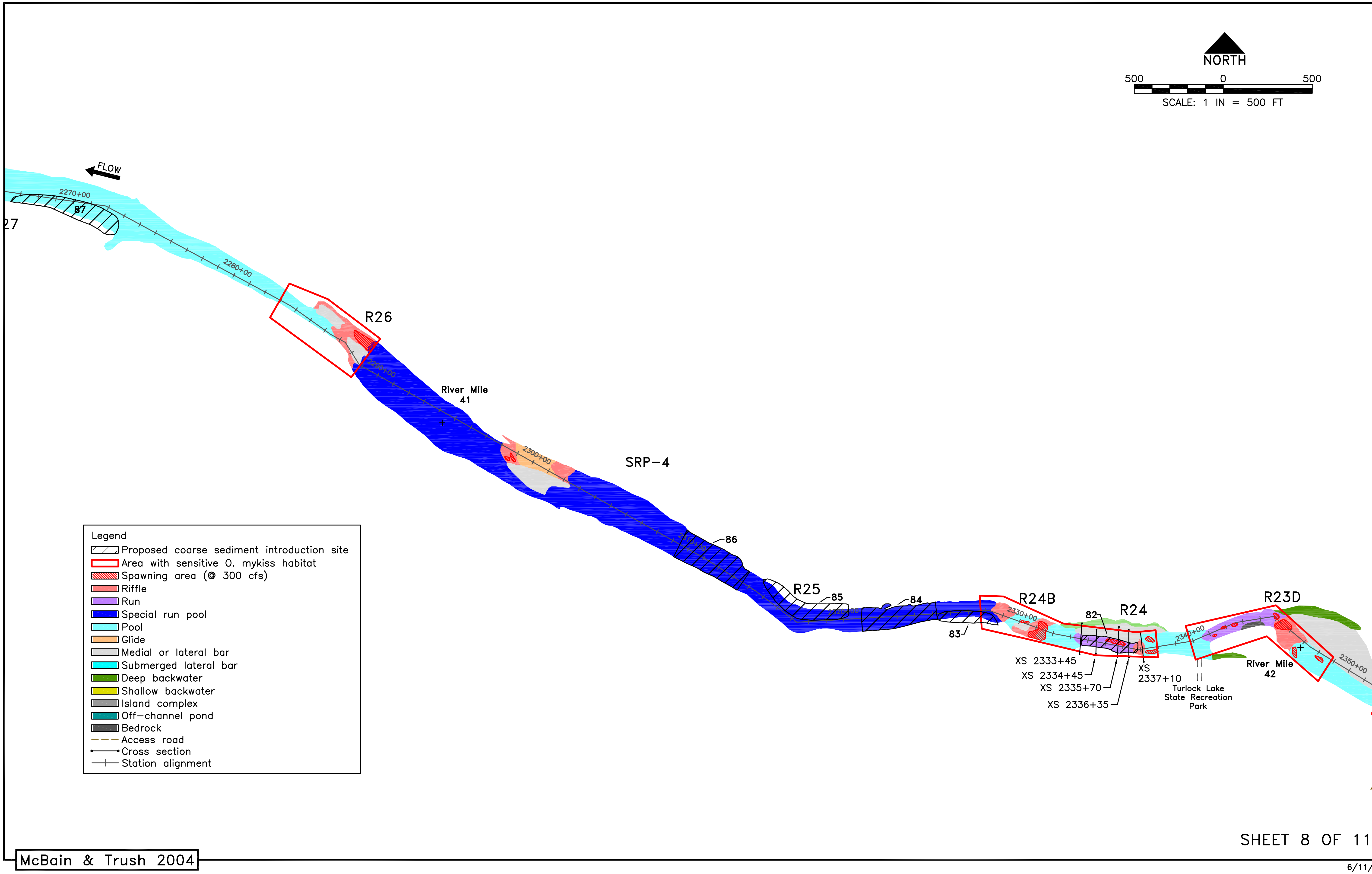

NORTH
500
0
500
SCALE: 1 IN = 500 FT
Legend
Proposed coarse sediment introduction site
Area with sensitive O. mykiss habitat
Spawning area (@ 300 cfs)
Riffle
Run
Special run pool
Pool
Glide
Medial or lateral bar
Submerged lateral bar
Deep backwater
Shallow backwater
Island complex
Off–channel pond
Bedrock
Access road
Cross section
Station alignment
NEW BASSO BRIDGE
(HWY 132)
OLD BASSO
BRIDGE
31
32
33
34
35
36
37
38
39
40
41
42
2620+00
2610+00
2600+00
2590+00
River Mile
47
R7
R8
FLOW
Joe Domecq Wilderness
Stanislaus County
SHEET 4 OF 11
McBain & Trush 2004

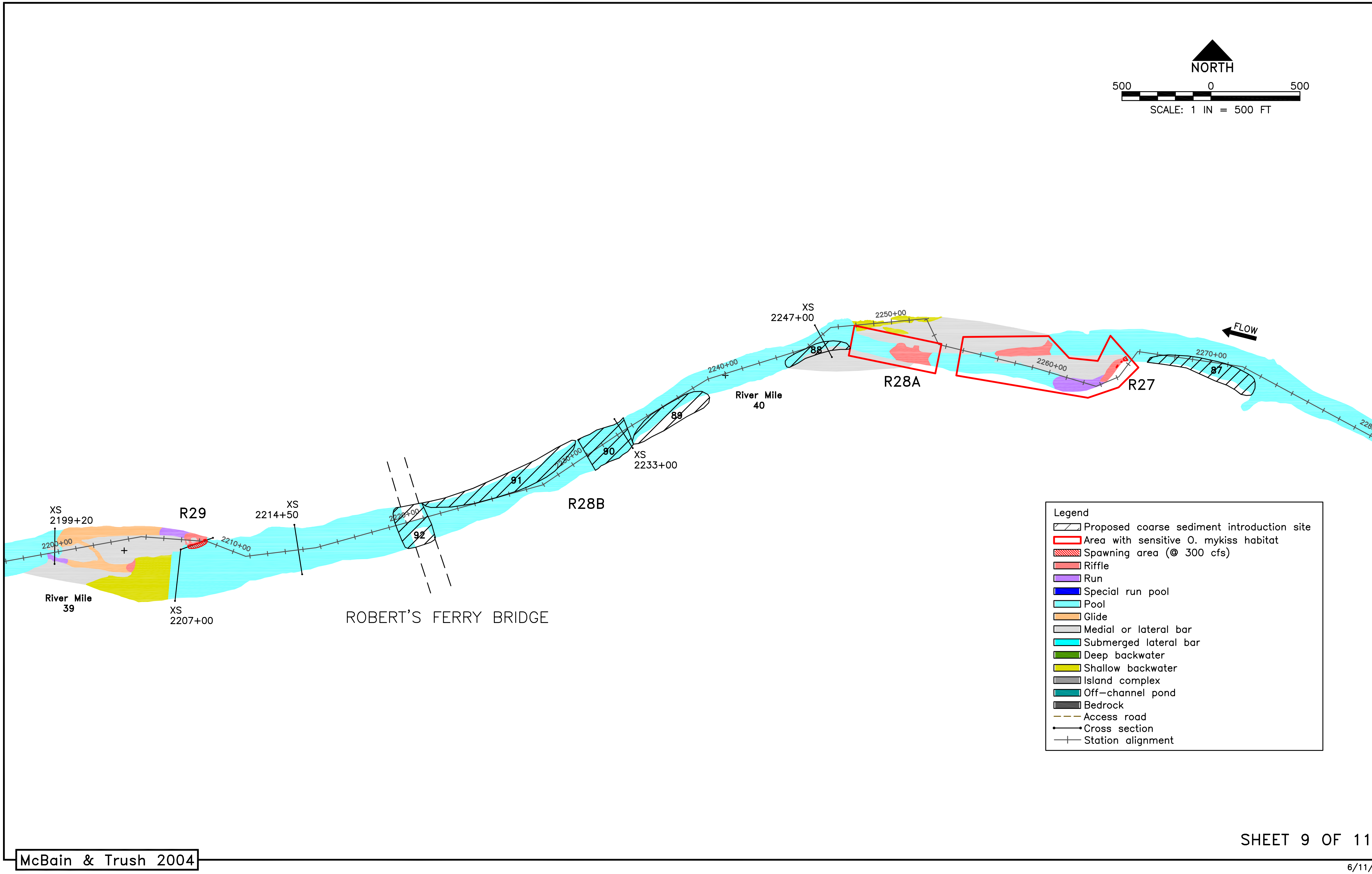
6/11/04

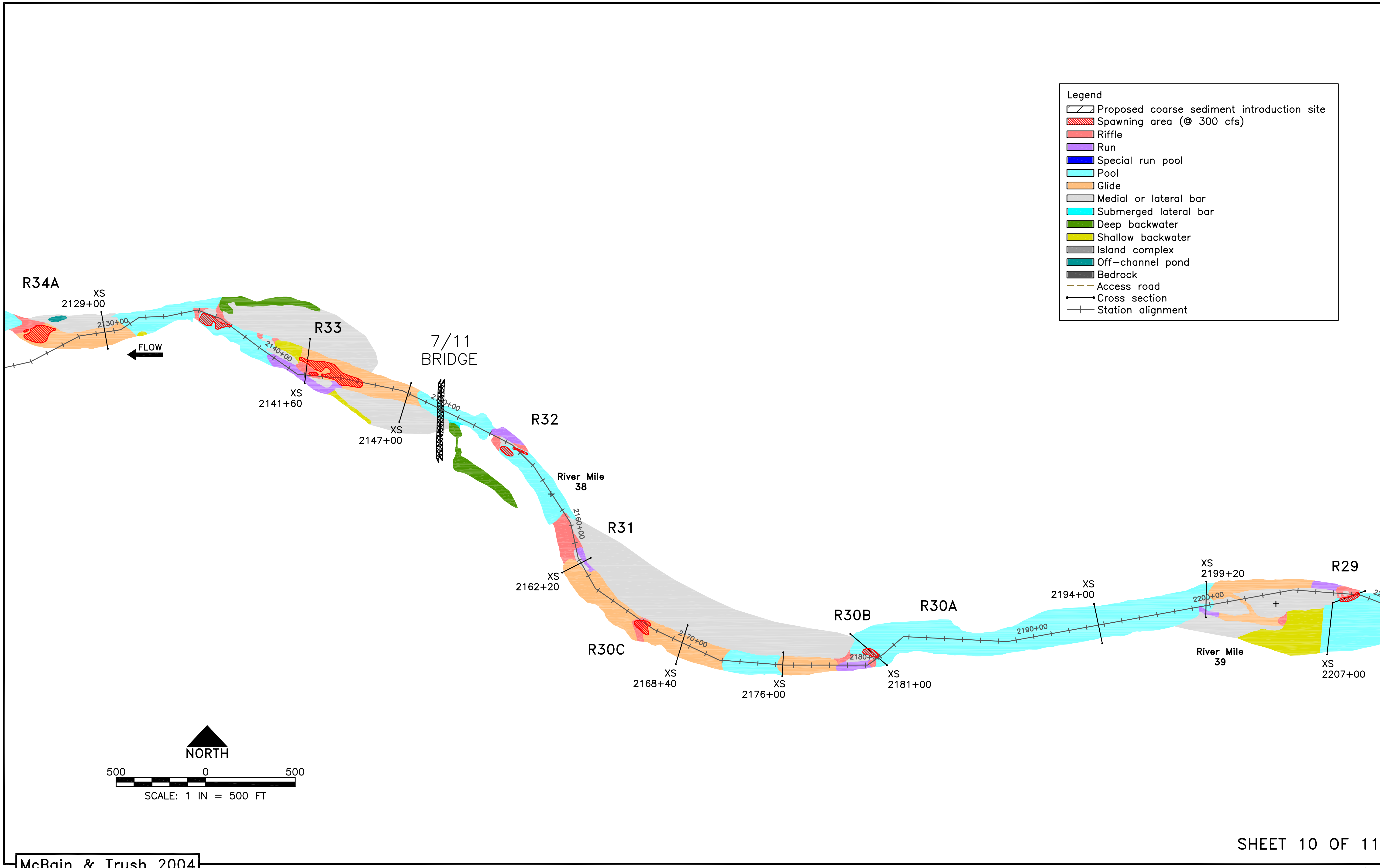

NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
Abandoned Haul Road
River Mile 46
River Mile 45
R12
R13A
R13B
R13C
R14
R15
2000/01 Salmon Redds
16 ft Maximum Depth
Peasley Creek
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
2590+00
2580+00
2570+00
2560+00
2550+00
2540+00
2530+00
2520+00
2510+00
2500+00
Legend
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
6/11/04

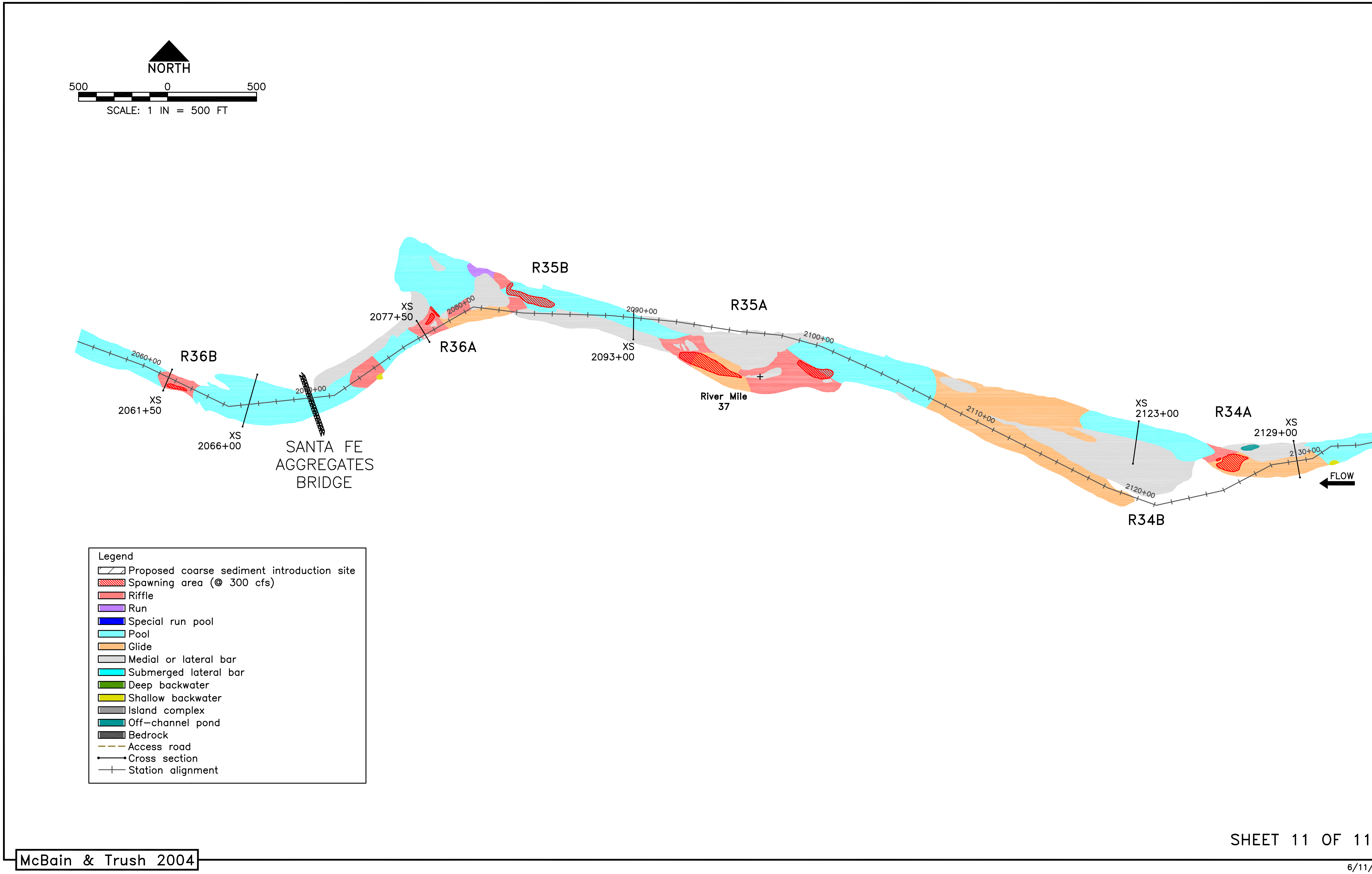

NORTH
500
0
500
SCALE: 1 IN = 500 FT
R18
70
69
SRP-3
FLOW
68
67
65
66
64
63
River Mile
44
Boulders
R17D
61
62
60
59
R17A
FOT RM 44
CHANNEL RESTORATION PROJECT
POTENTIAL
CHANNEL RELOCATION
R16
58
Valley Oak
Trees
R15
56
57
R14
2430+00
2460+00
2470+00
2480+00
2490+00
2500+00
Legend
Proposed coarse sediment 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 6 OF 11
McBain & Trush 2004
6/11/04


NORTH
500
0
500
SCALE: 1 IN = 500 FT
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
6/11/04


NORTH
500
0
500
SCALE: 1 IN = 500 FT
FLOW
2270+00
87
27
2280+00
R26
River Mile
41
2300+00
SRP-4
86
R25
85
84
83
R24B
2330+00
82
R24
R23D
2340+00
XS 2333+45
XS 2334+45
XS 2335+70
XS 2336+35
XS
2337+10
Turlock Lake
State Recreation
Park
River Mile
42
2350+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 8 OF 11
McBain & Trush 2004
6/11/04


NORTH
500 0 500
SCALE: 1 IN = 500 FT
FLOW
XS
2199+20
R29
XS
2214+50
River Mile
39
XS
2207+00
ROBERT'S FERRY BRIDGE
92
91
R28B
90
XS
2233+00
89
River Mile
40
XS
2247+00
88
R28A
R27
87
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
FLOW
R33
XS 2141+60
7/11 BRIDGE
XS 2147+00
R32
River Mile 38
R31
XS 2162+20
R30C
XS 2168+40
XS 2176+00
R30B
XS 2181+00
R30A
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
R35B
R35A
R36B
R36A
XS
2077+50
XS
2093+00
XS
2061+50
XS
2066+00
SANTA FE
AGGREGATES
BRIDGE
River Mile
37
XS
2123+00
R34A
XS
2129+00
FLOW
R34B
2060+00
2080+00
2090+00
2100+00
2110+00
2120+00
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 52–40).

Sampling Unit	RM	March 2010 BCE site	August 2010 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
1	51.8		Yes	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	Yes	85	124	10,506	3.0	5.0	Pool head
5	51.6	Yes	Yes	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	Yes	Yes	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	Yes		161	85	13,760	6.0	7.0	Run head
16	50.5	Yes		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	Yes		941	130	121,948	1.5	2.0	Riffle
19	50.3	Yes	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	Yes		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		Yes	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	Yes		527	139	72,991	1.5	2.0	Riffle
27	49.7	Yes	Yes	127	86	10,955	4.0	6.0	Pool head
28	49.6	Yes	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			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			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	March 2010 BCE site	August 2010 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
42	48.8	Yes		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		Yes	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		Yes	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	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		Yes	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			61	93	5,701	2.0		Run head
72	45.8			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		Yes	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	March 2010 BCE site	August 2010 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
86	45.0	Yes	Yes	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	Yes	22	107	2,350	0.8	1.5	Run head
91	44.8			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	Yes		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	Yes	Yes	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	Yes	Yes	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		Yes	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	Yes		238	42	10,077	0.8	1.2	Riffle
112	43.0	Yes		50	48	2,392	1.5	2.5	Pool head
113	43.0	Yes		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	Yes		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	Yes		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		Yes	18	55	991	2.5	3.0	Run head
124	42.4		Yes	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	Yes		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	March 2010 BCE site	August 2010 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	Yes		41	46	1,877	2.0	2.5	Run head
134	41.8	Yes		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		Yes	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		Yes	219	91	19,859	0.8	1.0	Riffle
157	39.6		Yes	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			123	41	5,102	3.5	4.5	Run head
162	39.3			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			104	98	10,131	1.0	1.5	Riffle
165	39.2	Yes	Yes	93	117	10,818	3.5	4.0	Pool head
166	38.9	Yes	Yes	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	Yes	Yes	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		Yes	121	83	10,096	7.0	10.5	Pool body
172	38.8	Yes		87	98	8,506	3.0	4.0	Run head
173	38.7	Yes		324	85	27,545	4.0	5.0	Run body

Sampling Unit	RM	March 2010 BCE site	August 2010 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	Yes		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			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			46	89	4,147	4.0	6.0	Pool head
193	38.0			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			357	60	21,436	1.5	2.0	Riffle

Sampling Unit	RM	March 2010 BCE site	August 2010 BCE site	Length (ft)	Average width (ft)	Area (ft^2)	Average depth (ft)	Maximum depth (ft)	July 2008 habitat type
218	36.8			157	75	11,815	3.0	4.0	Run head
219	36.6			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			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			89	72	6,363	4.0	9.8	Pool head
231	36.2			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	March 2010 BCE site	August 2010 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	March 2010 BCE site	August 2010 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, March 2010.

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	4-Mar	12:18	10.5	9.93	32.1	8.5		3.0	6.5
51.6	5	Pool Body	1-Mar	11:36	10.6	10.58	29.1	13.5	19.0	15.0	30.0
50.9	11	Pool Body	1-Mar	15:51	11.3	12.35	30.5	13.5	18.0	12.0	25.0
50.8	12	Run Body	1-Mar	15:30	11.3	12.35	30.5	13.5		6.0	10.0
50.6	15	Run Head	4-Mar	14:35	11.5	11.12	33.3	8.0		3.5	6.0
50.5	16	Run Body	2-Mar	10:41	10.6	10.64	28.1	17.0		7.0	11.0
50.3	18	Riffle	5-Mar	12:53	11.3	11.16	30.6	10.5		2.0	5.0
50.3	19	Run Head	5-Mar	13:52	11.3	11.16	30.6	10.5		4.0	8.0
50.1	20	Run Body	5-Mar	13:15	11.3	11.16	30.6	10.5		5.0	12.0
50.1	22	Riffle	2-Mar	16:10	11.0	11.53	32.5	17.0		1.5	4.0
49.7	26	Riffle	4-Mar	15:42	11.8	11.36	35.7	8.5		1.5	3.0
49.7	27	Pool Head	3-Mar	10:43	10.2	9.92	29.3	15.0		3.0	4.0
49.6	28	Pool Body	3-Mar	9:55	10.2	9.92	29.3	15.0		8.0	15.0
48.8	42	Run Head	3-Mar	14:05	10.6	11.18	30.6	15.0		1.5	2.5
48.7	43	Run Body	3-Mar	13:20	10.6	11.18	30.6	15.0		2.5	4.0
48.0	54	Pool Head	3-Mar	12:01	10.5	10.95	31.1	15.0		4.0	7.5
45.9	70	Riffle	5-Mar	10:59	10.6	10.38	37.4	10.5		2.0	3.5
45.0	86	Pool Head	6-Mar	10:44	10.7	10.59	37.4	12.0		5.0	11.0
44.8	90	Run Head	6-Mar	11:31	10.7	10.59	37.4	12.0		0.8	2.0
44.7	93	Riffle	6-Mar	11:52	12.3	11.59	39.4	9.0		2.0	4.0
44.5	101	Riffle	6-Mar	13:32	12.3	11.59	39.4	9.0		2.0	6.5
43.7	104	Pool Body	6-Mar	14:52	12.1	11.92	39.8	8.5	10.0	7.0	12.0
43.0	111	Riffle	7-Mar	10:02	11.5	10.78	39.9	11.5		1.5	3.0
43.0	112	Pool Head	6-Mar	16:24	12.1	11.70	40.6	9.0		2.0	4.0
43.0	113	Pool Body	6-Mar	16:07	12.1	11.70	40.6	9.0	10.0	5.0	10.0
42.9	116	Run Body	7-Mar	10:57	11.5	10.78	39.9	11.5		5.0	10.0
42.9	119	Run Head	7-Mar	12:19	11.5	10.78	39.9	11.5		3.0	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)
42.3	126	Riffle	7-Mar	12:59	12.8	11.70	42.4	11.5		1.0	3.0
41.9	133	Run Head	3-Mar	16:49	10.0	10.25	39.9	8.0		2.5	4.0
41.8	134	Run Body	3-Mar	16:02	10.9	10.25	39.9	8.0		4.0	8.0
39.2	165	Pool Head	7-Mar	15:42	14.1	12.31	53.4	9.0		3.0	5.0
38.9	166	Pool Body	7-Mar	15:45	14.1	12.31	53.4	9.0	12.0	7.0	13.0
38.9	168	Riffle	8-Mar	11:00	12.1	10.65	48.9	8.5		1.5	3.5
38.8	172	Run Head	8-Mar	11:42	12.4	11.12	49.1	8.5		1.5	3.0
38.7	173	Run Body	8-Mar	11:28	12.4	11.12	49.1	8.5		2.0	3.0
38.5	179	Riffle	8-Mar	12:52	12.4	11.12	49.1	8.5		1.5	4.0

Table E-2. Water quality data for the sampling units selected for snorkel sampling, August 2010.

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)
51.8	1	Pool Head	17-Aug	16:54	12.6	9.8	30.4	32.0	7.0	4.0	7.0
51.6	4	Pool Head	17-Aug	14:11	12.6	9.8	30.4	32.0	5.0	4.0	5.0
51.6	5	Pool Body	17-Aug	12:15	12.6	9.8	30.4	32.0	32.0	20.0	32.0
50.8	12	Run Body	18-Aug	15:28	13.1	11.0	29.1	31.5	8.0	6.0	8.0
50.6	14	Riffle	18-Aug	11:43	13.1	11.0	29.1	31.5	4.5	2.0	4.5
50.3	19	Run Head	18-Aug	10:58	12.7	11.2	28.8	27.3	9.0	5.0	9.0
49.9	24	Run Body	19-Aug	12:40	14.3	11.3	29.3	27.3	8.0	4.0	8.0
49.7	27	Pool Head	19-Aug	15:43	14.3	11.3	29.3	27.3	4.0	3.0	4.0
49.6	28	Pool Body	19-Aug	15:00	14.3	11.3	29.3	27.3	18.6	8.0	18.6
49.1	38	Run Head	20-Aug	14:15	14.2	11.2	29.7	25.0	2.5	2.0	2.5
48.4	45	Riffle	20-Aug	11:16	14.2	11.2	29.7	25.0	4.5	2.0	4.5
48.1	51	Run Body	20-Aug	15:25	16.4	13.1	29.4	25.0	8.0	6.0	8.0
48.0	53	Riffle	20-Aug	15:10	16.4	13.1	29.4	25.0	2.5	1.5	2.5
48.0	54	Pool Head	20-Aug	14:50	16.4	13.1	29.4	25.0	10.0	8.0	10.0
46.9	62	Run Head	21-Aug	12:30	13.9	11.8	30.4	20.5	4.5	3.0	4.5
45.3	81	Pool Body	21-Aug	14:40	15.3	12.7	31.1	20.5	19.5	10.0	19.5
45.1	83	Run Body	21-Aug	15:00	15.3	12.7	31.1	20.5	6.0	3.0	6.0
45.0	86	Pool Head	22-Aug	11:36	13.3	10.9	31.5	19.0	7.5	4.0	7.5
44.8	90	Run Head	22-Aug	12:16	13.3	10.9	31.5	19.0	2.0	0.5	2.0
44.5	101	Riffle	22-Aug	12:47	13.3	10.9	31.5	19.0	7.0	2.5	7.0
43.7	104	Pool Body	22-Aug	15:38	15.4	11.2	32.0	21.5	22.0	10.0	22.0
43.2	107	Riffle	22-Aug	17:00	15.4	11.2	32.0	21.5	6.0	1.5	6.0
42.7	123	Run Head	23-Aug	11:27	15.6	11.3	33.2	19.5	3.0	1.5	3.0
42.4	124	Run Body	23-Aug	11:38	15.6	11.3	33.2	19.5	4.5	3.0	4.5
40.3	150	Run Body	23-Aug	15:05	18.5	12.0	37.1	16.5	4.0	1.5	4.0
39.7	156	Riffle	23-Aug	16:18	18.5	12.0	37.1	16.5	2.0	1.0	2.0

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)
39.6	157	Run Head	23-Aug	16:03	18.5	12.0	37.1	16.5	3.0	2.0	3.0
39.2	165	Pool Head	24-Aug	11:24	16.3	9.7	38.2	17.5	4.0	2.0	4.0
38.9	166	Pool Body	24-Aug	11:26	16.3	9.7	38.2	17.5	10.0	5.0	10.0
38.9	168	Riffle	24-Aug	10:57	16.3	9.7	38.2	17.5	3.5	1.5	3.5
38.8	171	Pool Body	24-Aug	10:23	16.3	9.7	38.2	17.5	13.0	9.0	13.0

Appendix F: Water Temperature Data

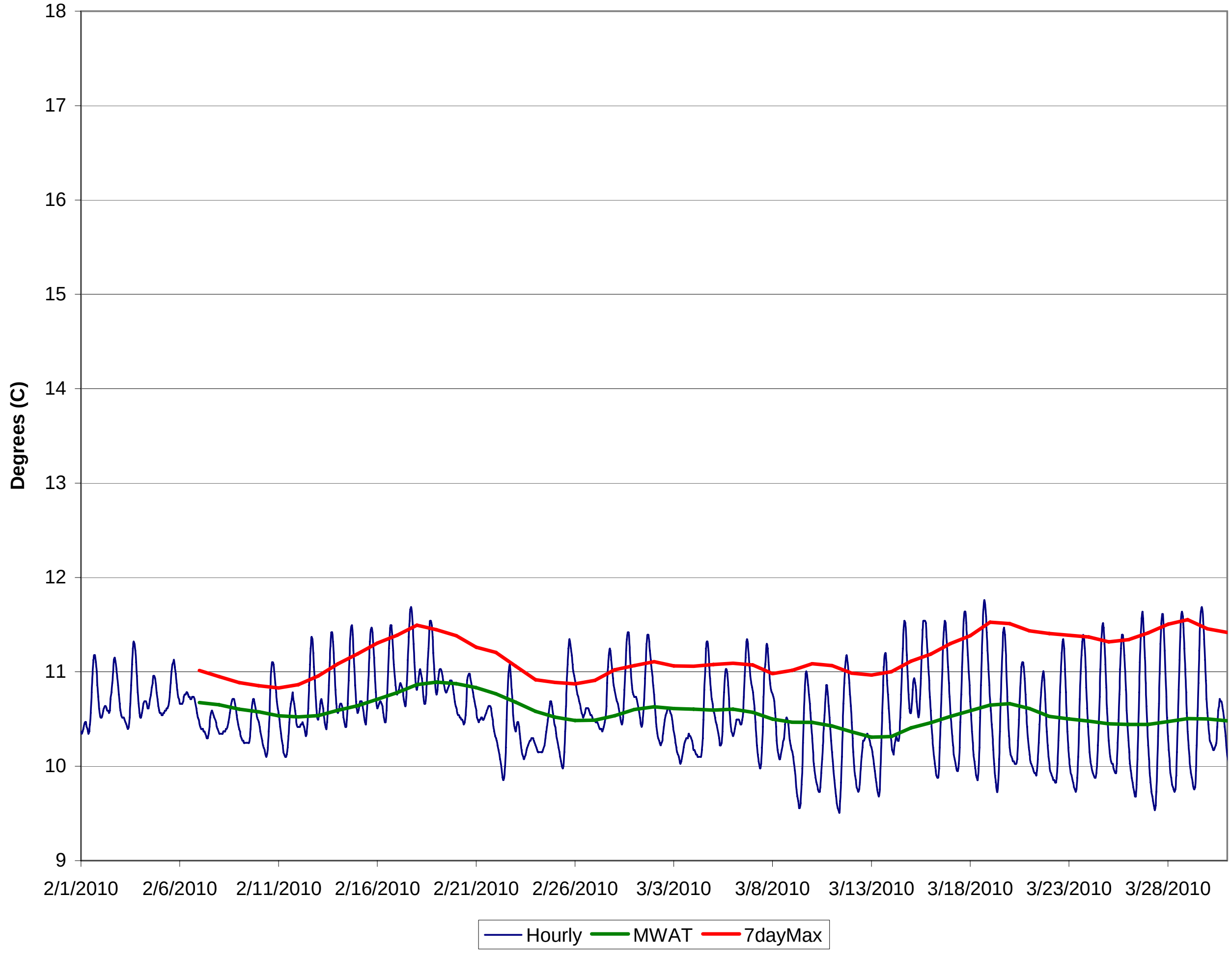


Figure F-1. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle A7 (RM 50.8), February–March 2010.

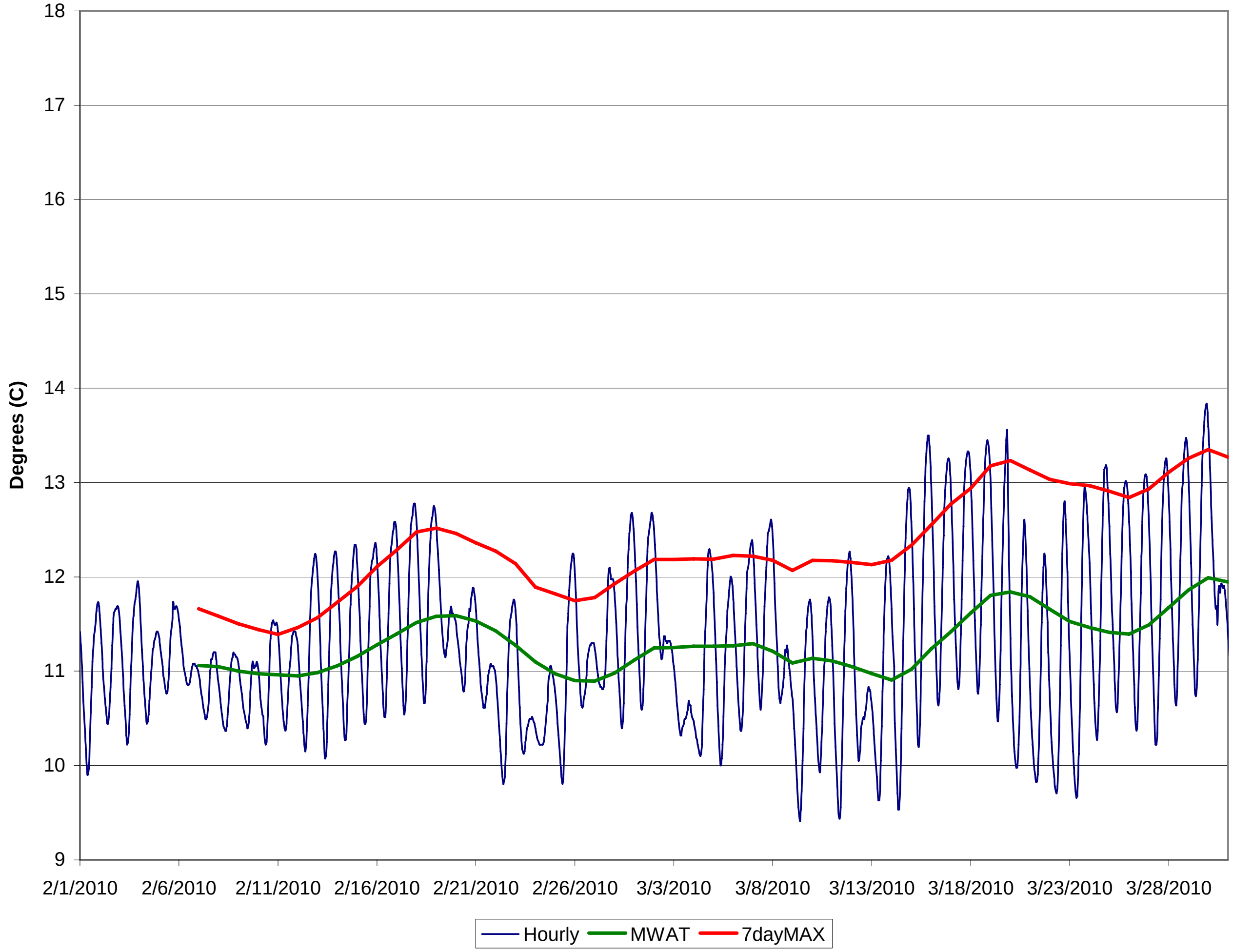


Figure F-2. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 13B (RM 45.5), February–March 2010.

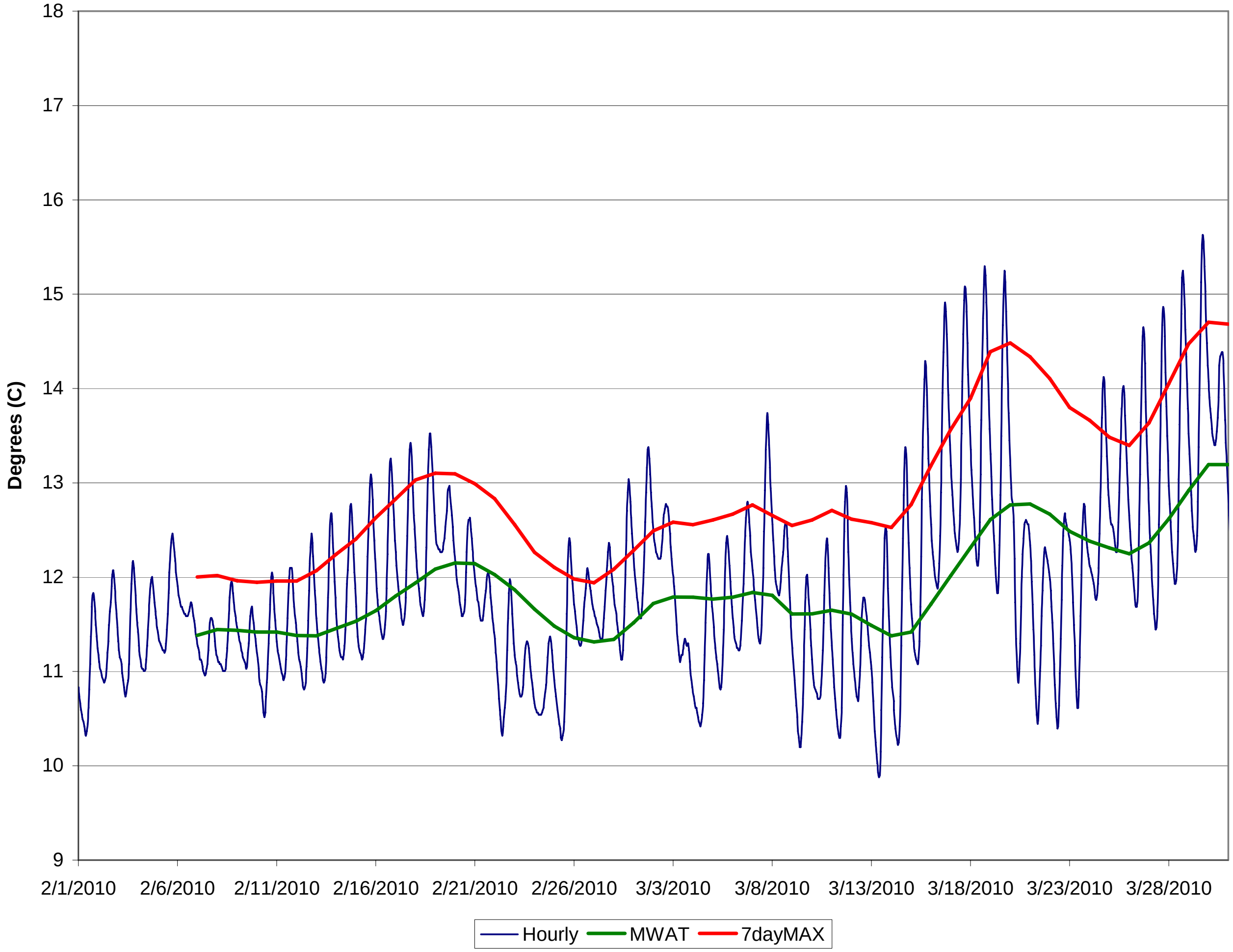


Figure F-3. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Roberts Ferry Bridge (RM 39.6), February–March 2010.

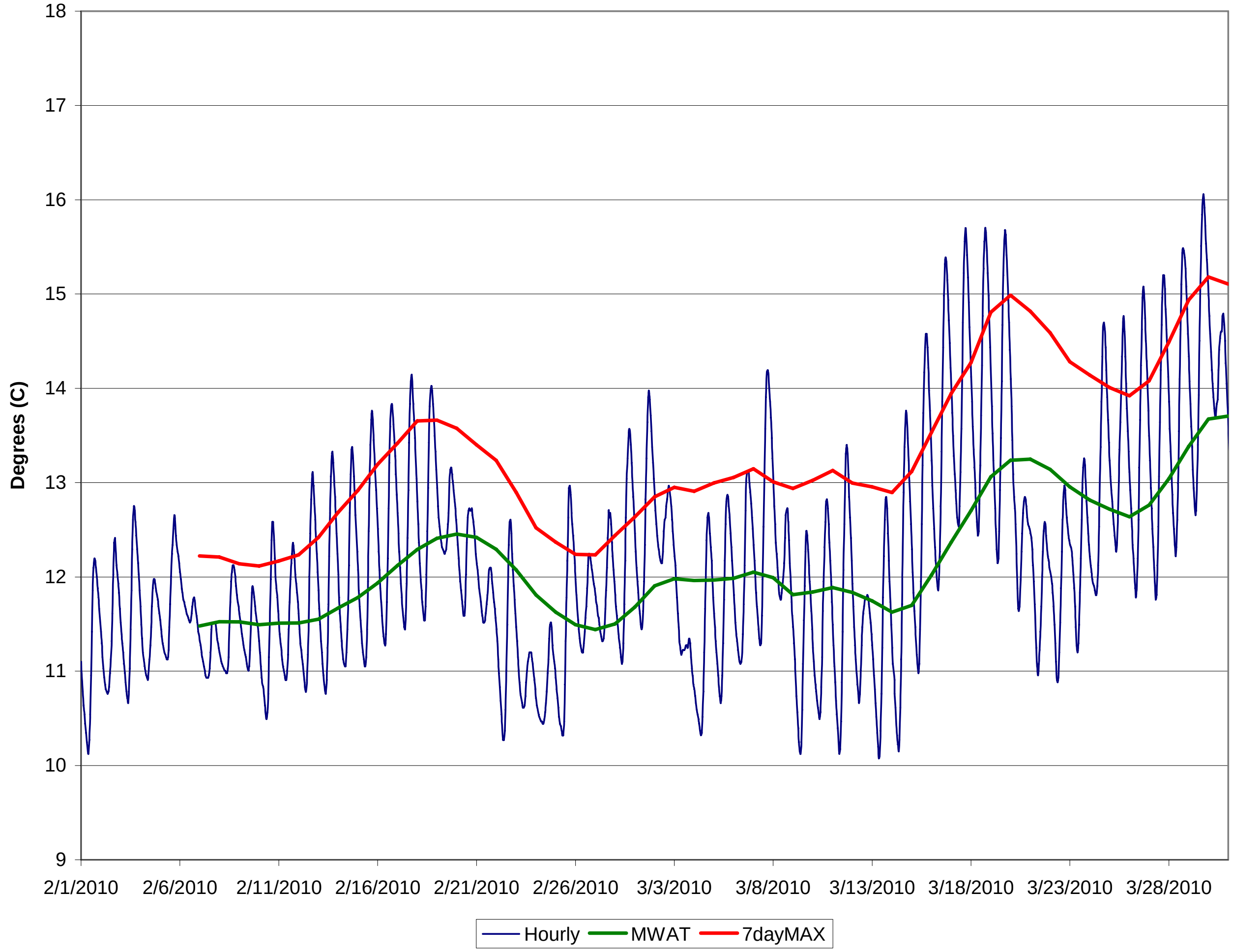


Figure F-4. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Ruddy Gravel (RM 36.5), February–March 2010.

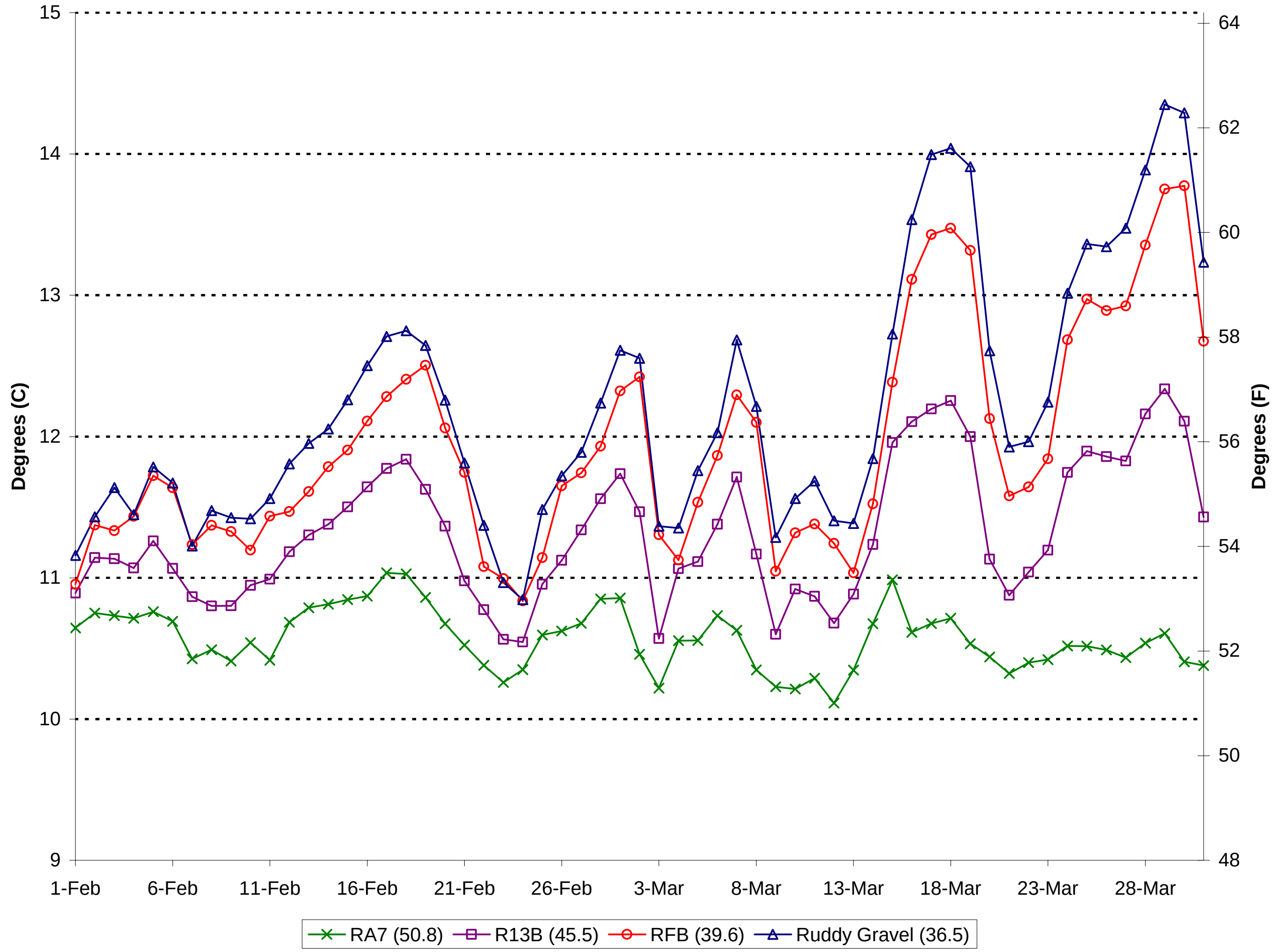


Figure F-5. Average daily water temperature from thermographs, February–March 2010.

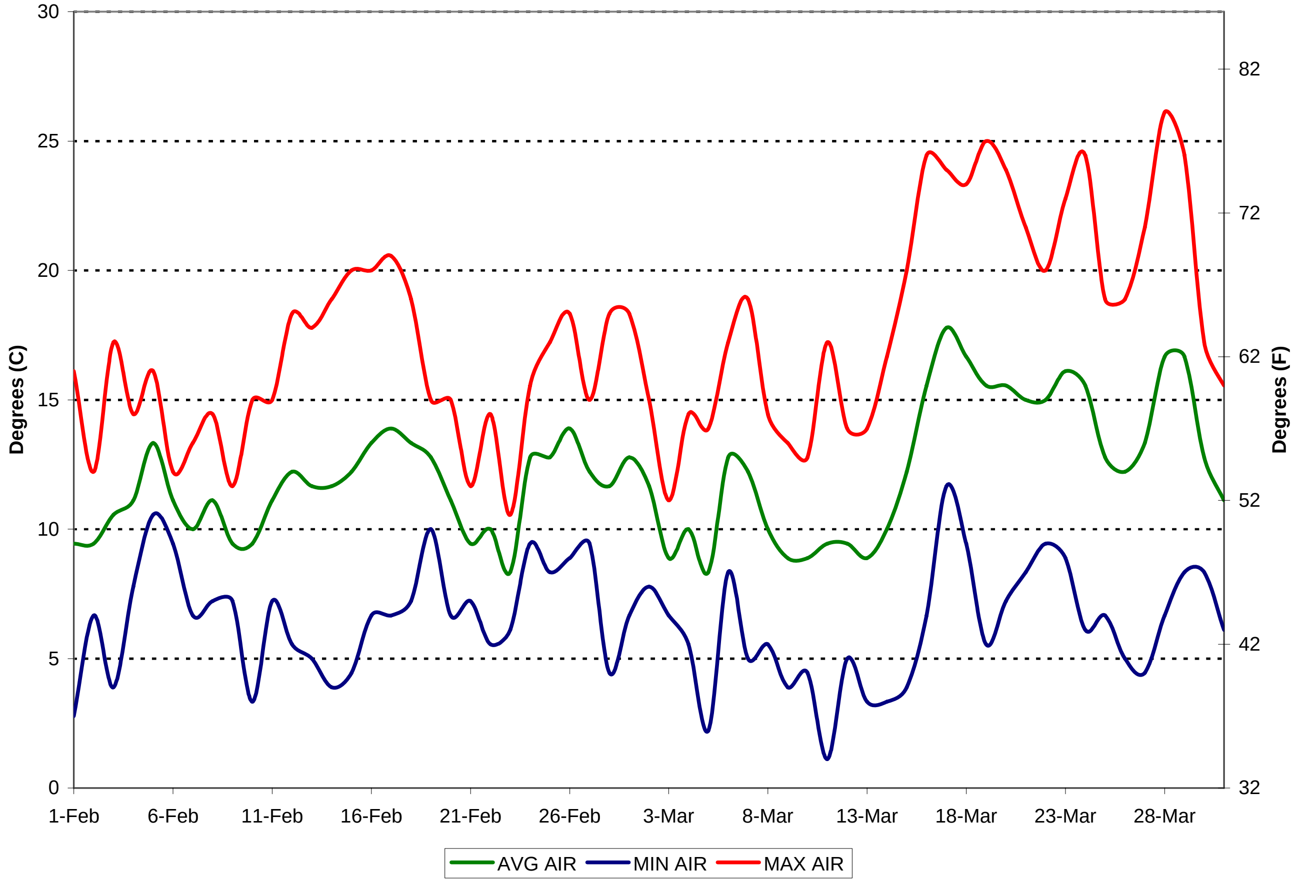


Figure F-6. Daily average, minimum, and maximum air temperature at the Modesto Airport, February-March 2010.

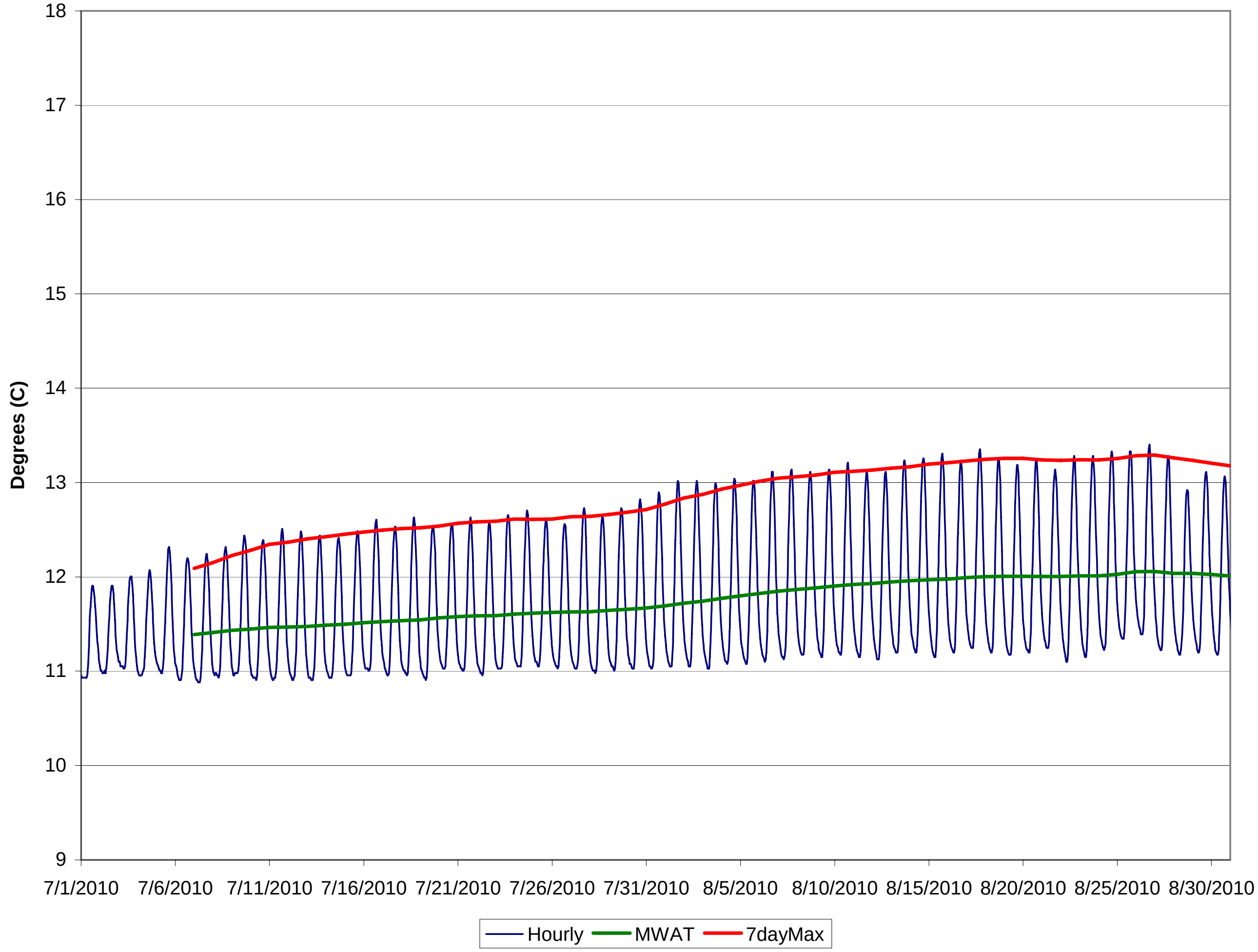


Figure F-7. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle A7 (RM 50.8), July-August 2010.

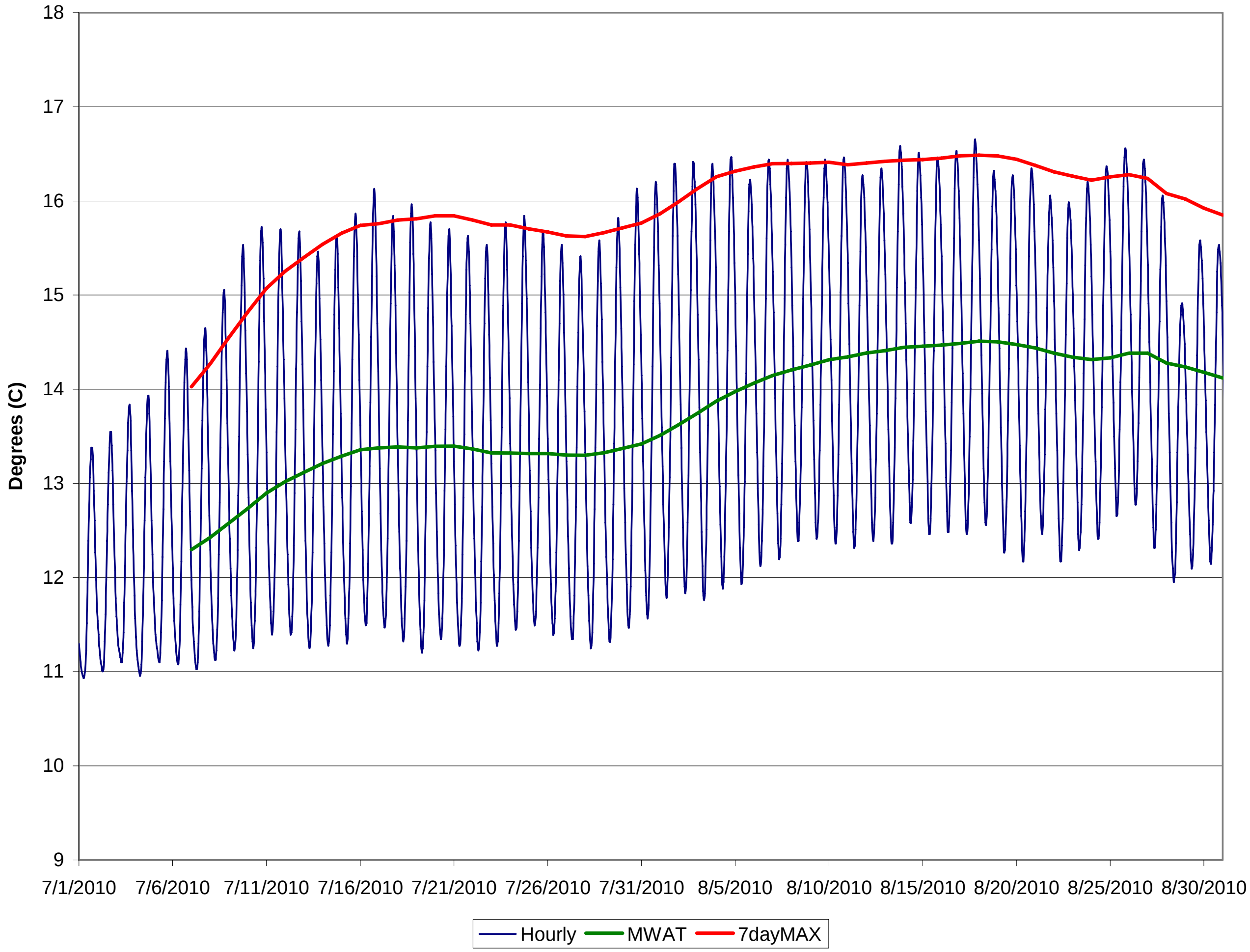


Figure F-8. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Riffle 13B (RM 45.5), July-August 2010.

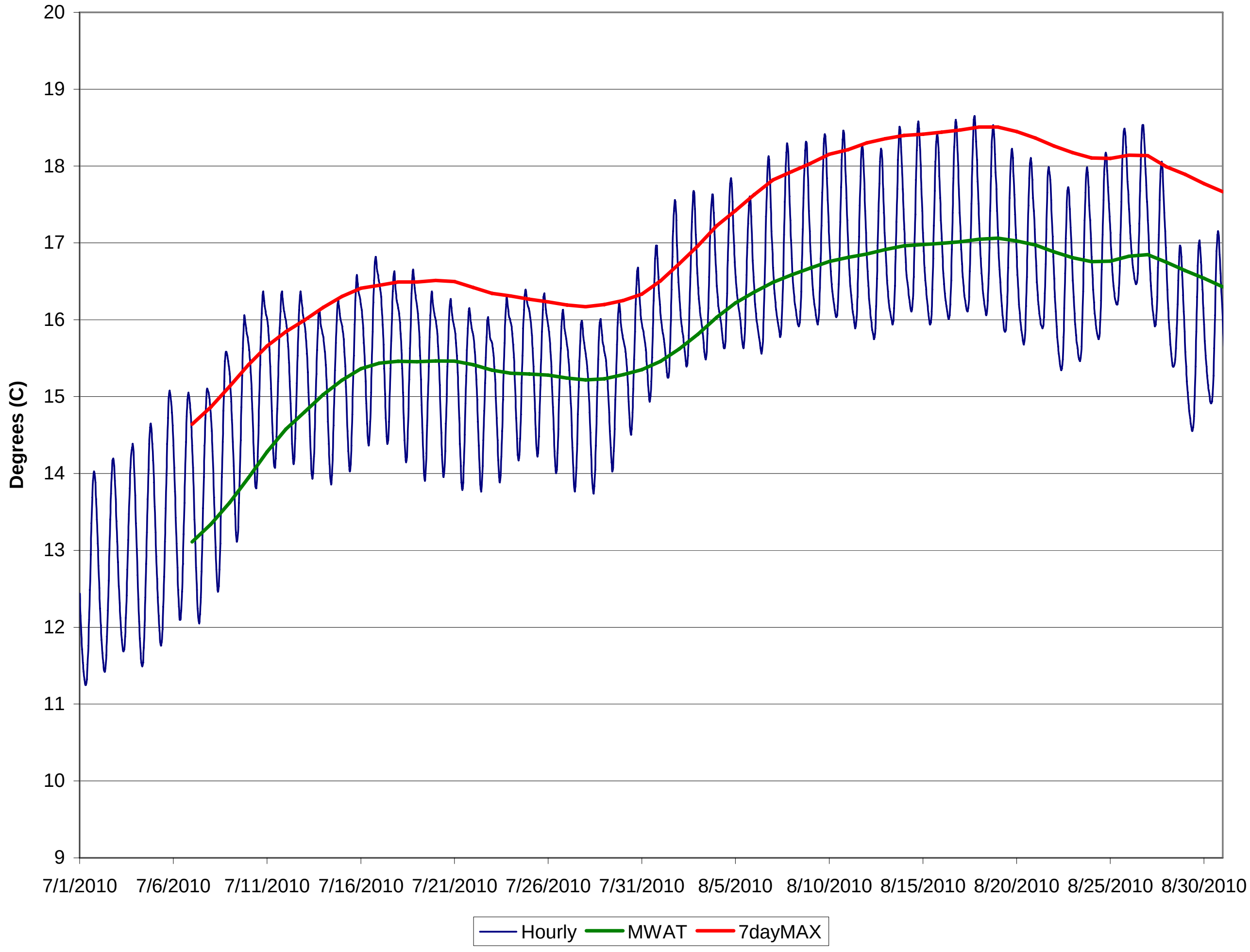


Figure F-9. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Roberts Ferry Bridge (RM 39.6), July-August 2010.

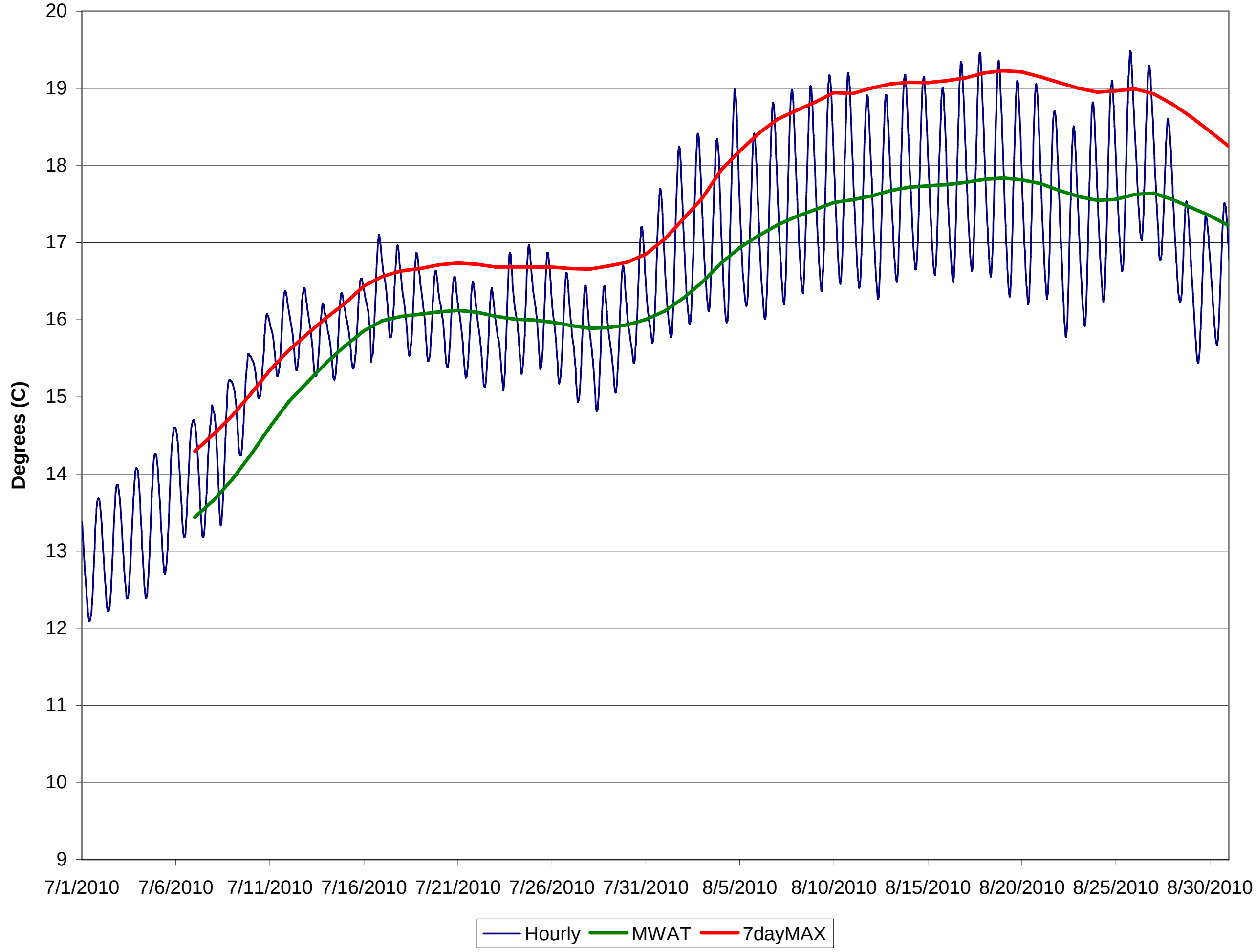


Figure F-10. Hourly, mean weekly average, and 7-day average of daily maximum temperatures at Ruddy Gravel (RM 36.5), July-August 2010.

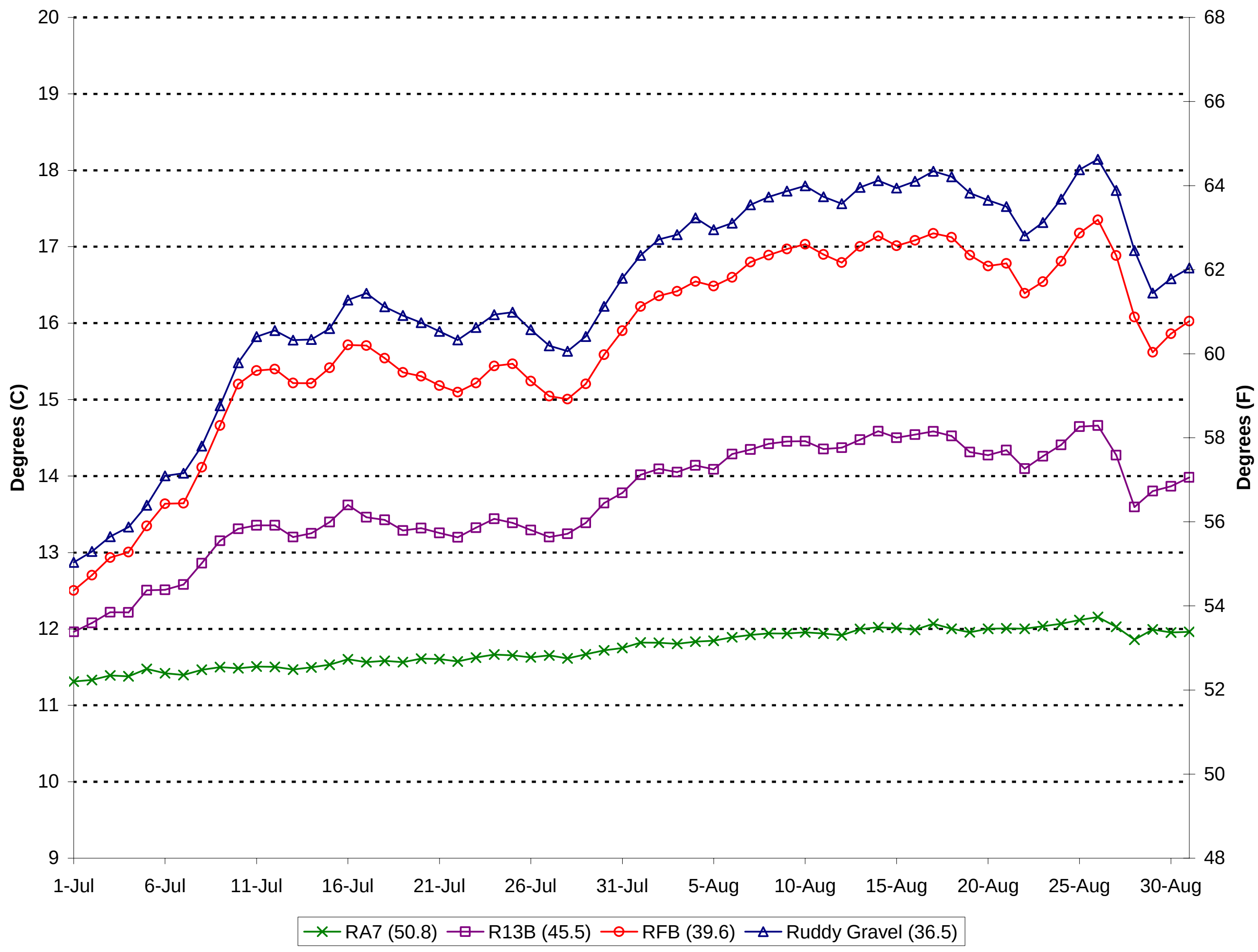


Figure F-11. Average daily water temperature from thermographs, July-August 2010.

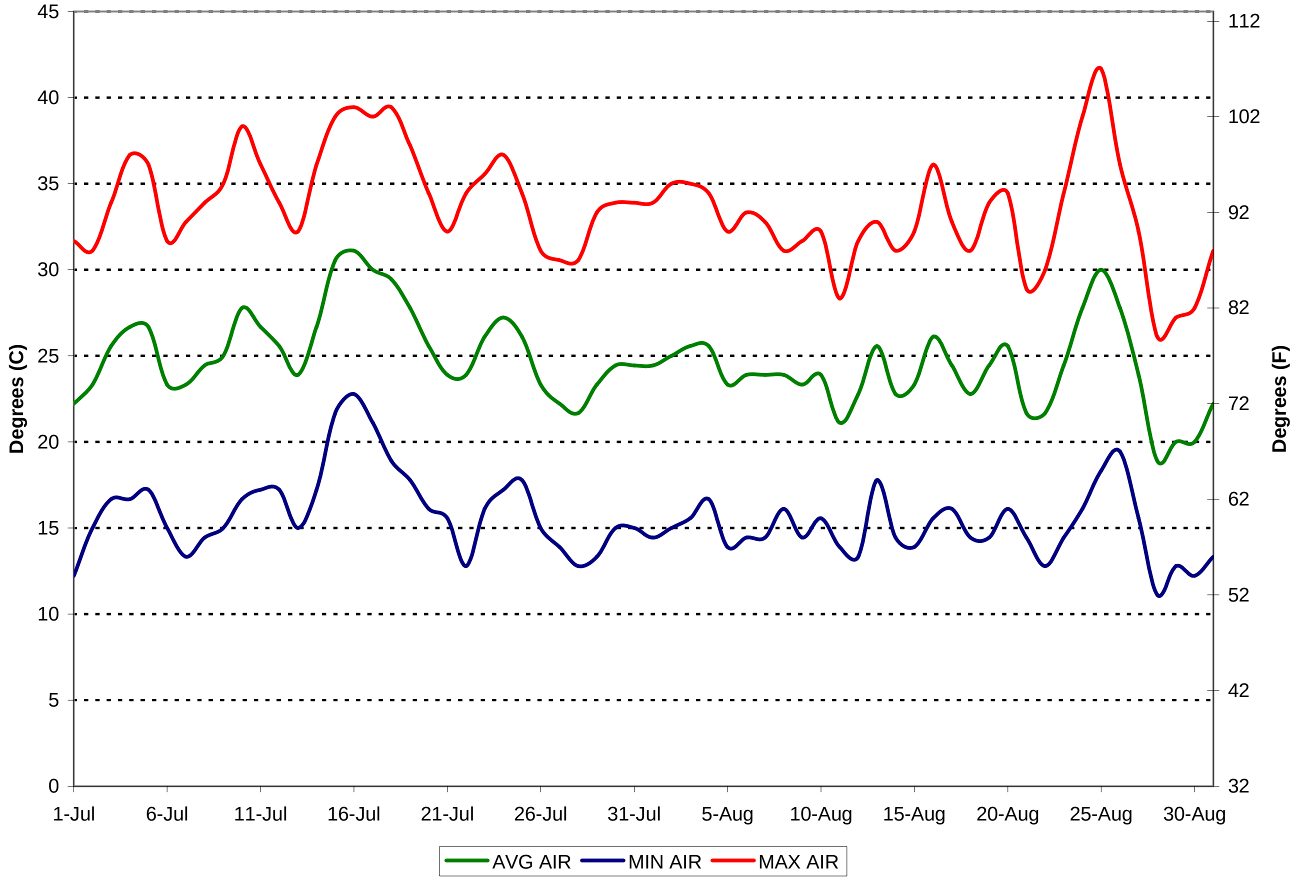


Figure F-12. Daily average, minimum, and maximum air temperature at the Modesto Airport, July-August 2010.

Appendix G: Fish Observation Data

Table G-1. *O. mykiss* observation data for the sampling units, March 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool Head	M	1	1	0-50
51.6	4	Pool Head	M	2	0	--
51.6	4	Pool Head	M	3	1	0-50
51.6	4	Pool Head	M	3	1	400-450
51.6	5	Pool Body	M	1	1	400-450
51.6	5	Pool Body	M	1	2	550-600
51.6	5	Pool Body	M	2	2	400-450
51.6	5	Pool Body	M	3	1	400-450
50.9	11	Pool Body	S	1	0	--
50.8	12	Run Body	S	1	0	--
50.6	15	Run Head	M	1	1	350-400
50.6	15	Run Head	M	2	0	--
50.6	15	Run Head	M	3	0	--
50.5	16	Run Body	M	1	0	--
50.5	16	Run Body	M	2	0	--
50.5	16	Run Body	M	3	0	--
50.3	18	Riffle	S	1	0	--
50.3	19	Run Head	S	1	1	450-500
50.1	20	Run Body	S	1	0	--
50.1	22	Riffle	M	1	0	--
50.1	22	Riffle	M	2	0	--
50.1	22	Riffle	M	3	0	--
49.7	26	Riffle	M	1	1	250-300
49.7	26	Riffle	M	2	0	--
49.7	26	Riffle	M	3	2	250-300
49.7	27	Pool Head	S	1	0	--
49.6	28	Pool Body	M	1	1	400-450
49.6	28	Pool Body	M	2	0	--
49.6	28	Pool Body	M	3	1	400-450
48.8	42	Run Head	M	1	0	--
48.8	42	Run Head	M	2	0	--
48.8	42	Run Head	M	3	0	--
48.7	43	Run Body	S	1	0	--
48.0	54	Pool Head	S	1	0	--
45.9	70	Riffle	S	1	0	--
45.0	86	Pool Head	M	1	0	--
45.0	86	Pool Head	M	2	0	--
45.0	86	Pool Head	M	3	0	--
44.8	90	Run Head	S	1	0	--

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
44.7	93	Riffle	M	1	0	--
44.7	93	Riffle	M	2	0	--
44.7	93	Riffle	M	3	0	--
44.5	101	Riffle	S	1	0	--
43.7	104	Pool Body	S	1	0	--
43.0	111	Riffle	S	1	0	--
43.0	112	Pool Head	M	1	0	--
43.0	112	Pool Head	M	2	1	300-350
43.0	112	Pool Head	M	3	2	300-350
43.0	113	Pool Body	M	1	0	--
43.0	113	Pool Body	M	2	0	--
43.0	113	Pool Body	M	3	0	--
42.9	116	Run Body	M	1	0	--
42.9	116	Run Body	M	2	0	--
42.9	116	Run Body	M	3	0	--
42.9	119	Run Head	S	1	0	--
42.3	126	Riffle	S	1	1	350-400
41.9	133	Run Head	M	1	0	--
41.9	133	Run Head	M	2	0	--
41.9	133	Run Head	M	3	0	--
41.8	134	Run Body	S	1	0	--
39.2	165	Pool Head	S	1	0	--
38.9	166	Pool Body	S	1	0	--
38.9	168	Riffle	S	1	0	--
38.8	172	Run Head	S	1	0	--
38.7	173	Run Body	M	1	0	--
38.7	173	Run Body	M	2	0	--
38.7	173	Run Body	M	3	0	--
38.5	179	Riffle	S	1	1	400-450

Table G-2. *O. mykiss* observation data for the sampling units, August 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.8	1	Pool Head	M	1	10	250-300
51.8	1	Pool Head	M	1	6	300-350
51.8	1	Pool Head	M	1	1	400-450
51.8	1	Pool Head	M	2	1	100-150
51.8	1	Pool Head	M	2	4	200-250
51.8	1	Pool Head	M	2	6	250-300
51.8	1	Pool Head	M	2	3	300-350
51.8	1	Pool Head	M	2	2	350-400
51.8	1	Pool Head	M	3	7	200-250
51.8	1	Pool Head	M	3	9	250-300
51.8	1	Pool Head	M	3	1	300-350
51.6	4	Pool Head	M	1	4	250-300
51.6	4	Pool Head	M	1	1	300-350
51.6	4	Pool Head	M	1	2	350-400
51.6	4	Pool Head	M	1	2	400-450
51.6	4	Pool Head	M	1	1	450-500
51.6	4	Pool Head	M	2	2	250-300
51.6	4	Pool Head	M	2	3	300-350
51.6	4	Pool Head	M	2	1	350-400
51.6	4	Pool Head	M	2	1	400-450
51.6	4	Pool Head	M	3	2	300-350
51.6	5	Pool Body	M	1	1	200-250
51.6	5	Pool Body	M	1	2	200-250
51.6	5	Pool Body	M	1	2	200-250
51.6	5	Pool Body	M	1	1	250-300
51.6	5	Pool Body	M	1	4	300-350
51.6	5	Pool Body	M	2	2	100-150
51.6	5	Pool Body	M	2	1	150-200
51.6	5	Pool Body	M	2	1	200-250
51.6	5	Pool Body	M	2	2	250-300
51.6	5	Pool Body	M	2	1	300-350
51.6	5	Pool Body	M	2	1	350-400
51.6	5	Pool Body	M	2	1	400-450
51.6	5	Pool Body	M	2	1	400-450
51.6	5	Pool Body	M	3	2	100-150
51.6	5	Pool Body	M	3	2	150-200
51.6	5	Pool Body	M	3	1	300-350
51.6	5	Pool Body	M	3	1	350-400
51.6	5	Pool Body	M	3	1	400-450

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	5	Pool Body	M	3	1	400-450
51.6	5	Pool Body	M	3	1	450-500
50.8	12	Run Body	M	1	5	100-150
50.8	12	Run Body	M	1	1	100-150
50.8	12	Run Body	M	1	9	100-150
50.8	12	Run Body	M	1	1	150-200
50.8	12	Run Body	M	1	4	150-200
50.8	12	Run Body	M	1	2	200-250
50.8	12	Run Body	M	1	4	250-300
50.8	12	Run Body	M	1	14	300-350
50.8	12	Run Body	M	1	3	350-400
50.8	12	Run Body	M	1	4	350-400
50.8	12	Run Body	M	1	5	50-100
50.8	12	Run Body	M	2	10	100-150
50.8	12	Run Body	M	2	3	100-150
50.8	12	Run Body	M	2	1	100-150
50.8	12	Run Body	M	2	1	150-200
50.8	12	Run Body	M	2	10	150-200
50.8	12	Run Body	M	2	2	150-200
50.8	12	Run Body	M	2	1	200-250
50.8	12	Run Body	M	2	1	200-250
50.8	12	Run Body	M	2	10	250-300
50.8	12	Run Body	M	2	2	300-350
50.8	12	Run Body	M	2	7	300-350
50.8	12	Run Body	M	2	5	300-350
50.8	12	Run Body	M	2	10	300-350
50.8	12	Run Body	M	2	5	350-400
50.8	12	Run Body	M	2	5	350-400
50.8	12	Run Body	M	3	5	100-150
50.8	12	Run Body	M	3	5	100-150
50.8	12	Run Body	M	3	10	100-150
50.8	12	Run Body	M	3	3	100-150
50.8	12	Run Body	M	3	1	150-200
50.8	12	Run Body	M	3	2	150-200
50.8	12	Run Body	M	3	1	200-250
50.8	12	Run Body	M	3	2	250-300
50.8	12	Run Body	M	3	10	250-300
50.8	12	Run Body	M	3	4	300-350
50.8	12	Run Body	M	3	5	300-350
50.8	12	Run Body	M	3	3	350-400
50.8	12	Run Body	M	3	1	400-450

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
50.8	12	Run Body	M	3	5	50-100
50.8	12	Run Body	M	3	45	50-100
50.6	14	Riffle	M	1	25	100-150
50.6	14	Riffle	M	1	4	100-150
50.6	14	Riffle	M	1	6	150-200
50.6	14	Riffle	M	1	13	150-200
50.6	14	Riffle	M	1	4	200-250
50.6	14	Riffle	M	1	6	200-250
50.6	14	Riffle	M	1	3	250-300
50.6	14	Riffle	M	1	1	250-300
50.6	14	Riffle	M	1	1	300-350
50.6	14	Riffle	M	1	1	50-100
50.6	14	Riffle	M	2	6	100-150
50.6	14	Riffle	M	2	35	100-150
50.6	14	Riffle	M	2	4	100-150
50.6	14	Riffle	M	2	10	100-150
50.6	14	Riffle	M	2	5	100-150
50.6	14	Riffle	M	2	5	150-200
50.6	14	Riffle	M	2	4	150-200
50.6	14	Riffle	M	2	6	150-200
50.6	14	Riffle	M	2	2	200-250
50.6	14	Riffle	M	2	1	200-250
50.6	14	Riffle	M	2	4	200-250
50.6	14	Riffle	M	2	1	200-250
50.6	14	Riffle	M	2	3	300-350
50.6	14	Riffle	M	2	1	50-100
50.6	14	Riffle	M	2	4	50-100
50.6	14	Riffle	M	3	18	100-150
50.6	14	Riffle	M	3	21	100-150
50.6	14	Riffle	M	3	15	100-150
50.6	14	Riffle	M	3	3	150-200
50.6	14	Riffle	M	3	11	150-200
50.6	14	Riffle	M	3	9	150-200
50.6	14	Riffle	M	3	5	150-200
50.6	14	Riffle	M	3	3	200-250
50.6	14	Riffle	M	3	5	200-250
50.6	14	Riffle	M	3	2	250-300
50.6	14	Riffle	M	3	2	300-350
50.6	14	Riffle	M	3	2	350-400
50.6	14	Riffle	M	3	1	50-100
50.6	14	Riffle	M	3	2	50-100

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
50.6	14	Riffle	M	3	3	50-100
50.3	19	Run Head	M	1	5	100-150
50.3	19	Run Head	M	1	1	100-150
50.3	19	Run Head	M	1	3	150-200
50.3	19	Run Head	M	1	3	250-300
50.3	19	Run Head	M	1	2	300-350
50.3	19	Run Head	M	2	5	100-150
50.3	19	Run Head	M	2	5	150-200
50.3	19	Run Head	M	2	5	200-250
50.3	19	Run Head	M	2	7	300-350
50.3	19	Run Head	M	3	5	150-200
50.3	19	Run Head	M	3	3	250-300
50.3	19	Run Head	M	3	7	300-350
49.9	24	Run Body	S	1	3	100-150
49.9	24	Run Body	S	1	3	100-150
49.9	24	Run Body	S	1	1	100-150
49.9	24	Run Body	S	1	4	150-200
49.9	24	Run Body	S	1	1	200-250
49.9	24	Run Body	S	1	2	250-300
49.9	24	Run Body	S	1	11	300-350
49.9	24	Run Body	S	1	2	300-350
49.9	24	Run Body	S	1	4	350-400
49.7	27	Pool Head	M	1	3	100-150
49.7	27	Pool Head	M	1	4	150-200
49.7	27	Pool Head	M	1	4	150-200
49.7	27	Pool Head	M	1	1	200-250
49.7	27	Pool Head	M	1	1	200-250
49.7	27	Pool Head	M	1	1	250-300
49.7	27	Pool Head	M	2	3	100-150
49.7	27	Pool Head	M	2	4	100-150
49.7	27	Pool Head	M	2	4	150-200
49.7	27	Pool Head	M	2	5	150-200
49.7	27	Pool Head	M	2	3	150-200
49.7	27	Pool Head	M	2	1	200-250
49.7	27	Pool Head	M	2	1	200-250
49.7	27	Pool Head	M	2	1	300-350
49.7	27	Pool Head	M	2	2	50-100
49.7	27	Pool Head	M	3	4	100-150
49.7	27	Pool Head	M	3	5	150-200
49.7	27	Pool Head	M	3	3	150-200
49.7	27	Pool Head	M	3	3	150-200

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
49.7	27	Pool Head	M	3	1	200-250
49.7	27	Pool Head	M	3	1	200-250
49.7	27	Pool Head	M	3	3	50-100
49.6	28	Pool Body	M	1	1	100-150
49.6	28	Pool Body	M	1	3	250-300
49.6	28	Pool Body	M	1	3	300-350
49.6	28	Pool Body	M	1	1	300-350
49.6	28	Pool Body	M	1	1	350-400
49.6	28	Pool Body	M	1	1	350-400
49.6	28	Pool Body	M	2	2	100-150
49.6	28	Pool Body	M	2	4	150-200
49.6	28	Pool Body	M	2	2	200-250
49.6	28	Pool Body	M	2	3	250-300
49.6	28	Pool Body	M	2	5	250-300
49.6	28	Pool Body	M	2	5	300-350
49.6	28	Pool Body	M	2	2	350-400
49.6	28	Pool Body	M	2	1	350-400
49.6	28	Pool Body	M	3	2	100-150
49.6	28	Pool Body	M	3	2	150-200
49.6	28	Pool Body	M	3	3	250-300
49.6	28	Pool Body	M	3	1	250-300
49.6	28	Pool Body	M	3	5	300-350
49.1	38	Run Head	S	1	1	100-150
48.4	45	Riffle	S	1	11	100-150
48.4	45	Riffle	S	1	8	100-150
48.4	45	Riffle	S	1	7	100-150
48.4	45	Riffle	S	1	1	150-200
48.4	45	Riffle	S	1	4	150-200
48.4	45	Riffle	S	1	8	50-100
48.4	45	Riffle	S	1	1	50-100
48.1	51	Run Body	M	1	8	100-150
48.1	51	Run Body	M	1	8	100-150
48.1	51	Run Body	M	1	1	150-200
48.1	51	Run Body	M	1	3	150-200
48.1	51	Run Body	M	1	1	300-350
48.1	51	Run Body	M	1	1	350-400
48.1	51	Run Body	M	2	5	100-150
48.1	51	Run Body	M	2	10	100-150
48.1	51	Run Body	M	2	2	150-200
48.1	51	Run Body	M	2	2	150-200
48.1	51	Run Body	M	2	1	300-350

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
48.1	51	Run Body	M	2	1	350-400
48.1	51	Run Body	M	3	6	100-150
48.1	51	Run Body	M	3	1	150-200
48.1	51	Run Body	M	3	1	150-200
48.1	51	Run Body	M	3	1	200-250
48.1	51	Run Body	M	3	1	250-300
48.1	51	Run Body	M	3	1	300-350
48.1	51	Run Body	M	3	1	350-400
48.0	53	Riffle	S	1	2	100-150
48.0	53	Riffle	S	1	2	100-150
48.0	53	Riffle	S	1	1	350-400
48.0	54	Pool Head	S	1	6	100-150
48.0	54	Pool Head	S	1	4	150-200
48.0	54	Pool Head	S	1	1	150-200
48.0	54	Pool Head	S	1	1	200-250
48.0	54	Pool Head	S	1	1	300-350
48.0	54	Pool Head	S	1	2	300-350
46.9	62	Run Head	M	1	3	100-150
46.9	62	Run Head	M	1	5	150-200
46.9	62	Run Head	M	1	1	200-250
46.9	62	Run Head	M	1	2	300-350
46.9	62	Run Head	M	1	1	350-400
46.9	62	Run Head	M	2	1	100-150
46.9	62	Run Head	M	2	2	100-150
46.9	62	Run Head	M	2	5	150-200
46.9	62	Run Head	M	2	2	200-250
46.9	62	Run Head	M	2	1	200-250
46.9	62	Run Head	M	3	5	100-150
46.9	62	Run Head	M	3	8	150-200
46.9	62	Run Head	M	3	1	200-250
45.3	81	Pool Body	S	1	0	--
45.1	83	Run Body	S	1	12	100-150
45.1	83	Run Body	S	1	1	100-150
45.1	83	Run Body	S	1	1	150-200
45.1	83	Run Body	S	1	8	150-200
45.1	83	Run Body	S	1	3	200-250
45.1	83	Run Body	S	1	1	300-350
45.1	83	Run Body	S	1	1	300-350
45.1	83	Run Body	S	1	3	300-350
45.0	86	Pool Head	S	1	7	100-150
45.0	86	Pool Head	S	1	1	100-150

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
45.0	86	Pool Head	S	1	2	150-200
45.0	86	Pool Head	S	1	5	150-200
45.0	86	Pool Head	S	1	1	150-200
45.0	86	Pool Head	S	1	3	150-200
45.0	86	Pool Head	S	1	3	200-250
45.0	86	Pool Head	S	1	2	250-300
45.0	86	Pool Head	S	1	1	250-300
45.0	86	Pool Head	S	1	2	250-300
45.0	86	Pool Head	S	1	1	300-350
45.0	86	Pool Head	S	1	1	300-350
44.8	90	Run Head	S	1	0	--
44.5	101	Riffle	M	1	10	100-150
44.5	101	Riffle	M	1	5	100-150
44.5	101	Riffle	M	1	1	150-200
44.5	101	Riffle	M	1	5	150-200
44.5	101	Riffle	M	1	3	150-200
44.5	101	Riffle	M	1	1	200-250
44.5	101	Riffle	M	1	1	200-250
44.5	101	Riffle	M	1	1	250-300
44.5	101	Riffle	M	2	3	100-150
44.5	101	Riffle	M	2	2	100-150
44.5	101	Riffle	M	2	4	100-150
44.5	101	Riffle	M	2	2	150-200
44.5	101	Riffle	M	2	2	150-200
44.5	101	Riffle	M	2	9	150-200
44.5	101	Riffle	M	2	1	200-250
44.5	101	Riffle	M	2	1	200-250
44.5	101	Riffle	M	3	5	100-150
44.5	101	Riffle	M	3	1	100-150
44.5	101	Riffle	M	3	3	100-150
44.5	101	Riffle	M	3	2	150-200
44.5	101	Riffle	M	3	3	150-200
44.5	101	Riffle	M	3	6	150-200
44.5	101	Riffle	M	3	1	200-250
44.5	101	Riffle	M	3	1	200-250
44.5	101	Riffle	M	3	1	250-300
43.7	104	Pool Body	S	1	0	--
43.7	104	Pool Body	S	1	0	--
43.2	107	Riffle	M	1	8	100-150
43.2	107	Riffle	M	1	5	100-150
43.2	107	Riffle	M	1	3	100-150

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
43.2	107	Riffle	M	1	4	150-200
43.2	107	Riffle	M	1	1	150-200
43.2	107	Riffle	M	1	3	150-200
43.2	107	Riffle	M	1	1	200-250
43.2	107	Riffle	M	1	1	250-300
43.2	107	Riffle	M	1	1	300-350
43.2	107	Riffle	M	2	7	100-150
43.2	107	Riffle	M	2	4	100-150
43.2	107	Riffle	M	2	8	100-150
43.2	107	Riffle	M	2	1	150-200
43.2	107	Riffle	M	2	3	150-200
43.2	107	Riffle	M	2	3	150-200
43.2	107	Riffle	M	2	1	150-200
43.2	107	Riffle	M	2	2	200-250
43.2	107	Riffle	M	2	1	200-250
43.2	107	Riffle	M	2	1	250-300
43.2	107	Riffle	M	2	1	300-350
43.2	107	Riffle	M	2	1	300-350
43.2	107	Riffle	M	3	4	100-150
43.2	107	Riffle	M	3	1	100-150
43.2	107	Riffle	M	3	6	100-150
43.2	107	Riffle	M	3	3	100-150
43.2	107	Riffle	M	3	2	150-200
43.2	107	Riffle	M	3	1	150-200
43.2	107	Riffle	M	3	2	150-200
43.2	107	Riffle	M	3	1	150-200
43.2	107	Riffle	M	3	1	200-250
43.2	107	Riffle	M	3	1	200-250
43.2	107	Riffle	M	3	1	250-300
43.2	107	Riffle	M	3	1	300-350
42.7	123	Run Head	S	1	0	--
42.4	124	Run Body	M	1	11	100-150
42.4	124	Run Body	M	1	10	100-150
42.4	124	Run Body	M	1	2	150-200
42.4	124	Run Body	M	1	2	50-100
42.4	124	Run Body	M	2	9	100-150
42.4	124	Run Body	M	2	5	100-150
42.4	124	Run Body	M	2	2	150-200
42.4	124	Run Body	M	2	3	150-200
42.4	124	Run Body	M	2	7	50-100
42.4	124	Run Body	M	3	15	100-150

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
42.4	124	Run Body	M	3	4	100-150
42.4	124	Run Body	M	3	2	150-200
42.4	124	Run Body	M	3	3	150-200
42.4	124	Run Body	M	3	1	250-300
42.4	124	Run Body	M	3	2	50-100
40.3	150	Run Body	S	1	2	100-150
40.3	150	Run Body	S	1	2	150-200
40.3	150	Run Body	S	1	1	150-200
40.3	150	Run Body	S	1	1	200-250
39.7	156	Riffle	S	1	1	100-150
39.7	156	Riffle	S	1	1	150-200
39.6	157	Run Head	M	1	0	--
39.6	157	Run Head	M	2	0	--
39.6	157	Run Head	M	3	0	--
39.2	165	Pool Head	S	1	0	--
38.9	166	Pool Body	S	1	0	--
38.9	168	Riffle	S	1	0	--
38.8	171	Pool Body	M	1	0	--
38.8	171	Pool Body	M	2	0	--
38.8	171	Pool Body	M	3	0	--

Table G-3. *O. tshawyschta* observation data for the sampling units, March 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.6	4	Pool Head	M	1	2	0-50
51.6	4	Pool Head	M	2	18	0-50
51.6	4	Pool Head	M	3	10	0-50
51.6	5	Pool Body	M	1	1	0-50
51.6	5	Pool Body	M	1	75	0-50
51.6	5	Pool Body	M	2	63	0-50
51.6	5	Pool Body	M	3	64	0-50
51.6	5	Pool Body	M	3	1	0-50
50.9	11	Pool Body	S	1	0	--
50.8	12	Run Body	S	1	0	--
50.6	15	Run Head	M	1	0	--
50.6	15	Run Head	M	2	0	--
50.6	15	Run Head	M	3	0	--
50.5	16	Run Body	M	1	0	--
50.5	16	Run Body	M	2	0	--
50.5	16	Run Body	M	3	0	--
50.3	18	Riffle	S	1	135	0-50
50.3	18	Riffle	S	1	37	0-50
50.3	18	Riffle	S	1	7	50-100
50.3	18	Riffle	S	1	2	50-100
50.3	19	Run Head	S	1	0	--
50.1	20	Run Body	S	1	80	0-50
50.1	22	Riffle	M	1	8	0-50
50.1	22	Riffle	M	2	0	--
50.1	22	Riffle	M	3	0	--
49.7	26	Riffle	M	1	1	50-100
49.7	26	Riffle	M	2	0	--
49.7	26	Riffle	M	3	0	--
49.7	27	Pool Head	S	1	0	--
49.6	28	Pool Body	M	1	0	--
49.6	28	Pool Body	M	2	0	--
49.6	28	Pool Body	M	3	0	--
48.8	42	Run Head	M	1	0	--
48.8	42	Run Head	M	2	0	--
48.8	42	Run Head	M	3	0	--
48.7	43	Run Body	S	1	0	--
48.0	54	Pool Head	S	1	0	--
45.9	70	Riffle	S	1	40	0-50
45.9	70	Riffle	S	1	1	0-50

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
45.9	70	Riffle	S	1	25	50-100
45.0	86	Pool Head	M	1	0	--
45.0	86	Pool Head	M	2	0	--
45.0	86	Pool Head	M	3	0	--
44.8	90	Run Head	S	1	0	--
44.7	93	Riffle	M	1	2	0-50
44.7	93	Riffle	M	1	1	50-100
44.7	93	Riffle	M	2	3	0-50
44.7	93	Riffle	M	2	11	50-100
44.7	93	Riffle	M	3	6	0-50
44.7	93	Riffle	M	3	16	50-100
44.5	101	Riffle	S	1	1	0-50
43.7	104	Pool Body	S	1	0	--
43.0	111	Riffle	S	1	2	0-50
43.0	112	Pool Head	M	1	15	0-50
43.0	112	Pool Head	M	1	15	50-100
43.0	112	Pool Head	M	2	15	0-50
43.0	112	Pool Head	M	2	15	50-100
43.0	112	Pool Head	M	3	15	0-50
43.0	112	Pool Head	M	3	15	50-100
43.0	113	Pool Body	M	1	0	--
43.0	113	Pool Body	M	2	0	--
43.0	113	Pool Body	M	3	0	--
42.9	116	Run Body	M	1	20	0-50
42.9	116	Run Body	M	1	7	50-100
42.9	116	Run Body	M	1	37	50-100
42.9	116	Run Body	M	2	14	0-50
42.9	116	Run Body	M	2	6	50-100
42.9	116	Run Body	M	3	7	0-50
42.9	116	Run Body	M	3	16	0-50
42.9	116	Run Body	M	3	7	50-100
42.9	119	Run Head	S	1	0	--
42.3	126	Riffle	S	1	2	0-50
42.3	126	Riffle	S	1	10	50-100
41.9	133	Run Head	M	1	0	--
41.9	133	Run Head	M	2	0	--
41.9	133	Run Head	M	3	0	--
41.8	134	Run Body	S	1	1	0-50
39.2	165	Pool Head	S	1	0	--
38.9	166	Pool Body	S	1	0	--
38.9	168	Riffle	S	1	0	--

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
38.8	172	Run Head	S	1	8	0-50
38.8	172	Run Head	S	1	3	50-100
38.7	173	Run Body	M	1	1	0-50
38.7	173	Run Body	M	2	0	--
38.7	173	Run Body	M	3	0	--
38.5	179	Riffle	S	1	0	--

Table G-4. *O. tshawyschta* observation data for the sampling units, August 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
51.8	1	Pool Head	M	1	1	600-700
51.8	1	Pool Head	M	1	3	700-800
51.8	1	Pool Head	M	1	1	900-1000
51.8	1	Pool Head	M	2	2	600-700
51.8	1	Pool Head	M	2	3	700-800
51.8	1	Pool Head	M	2	1	900-1000
51.8	1	Pool Head	M	3	1	600-700
51.8	1	Pool Head	M	3	3	700-800
51.8	1	Pool Head	M	3	1	900-1000
51.6	4	Pool Head	M	1	0	--
51.6	4	Pool Head	M	2	0	--
51.6	4	Pool Head	M	3	0	--
51.6	5	Pool Body	M	1	87	50-100
51.6	5	Pool Body	M	2	76	50-100
51.6	5	Pool Body	M	3	72	50-100
50.8	12	Run Body	M	1	4	0-50
50.8	12	Run Body	M	1	133	0-50
50.8	12	Run Body	M	1	5	50-100
50.8	12	Run Body	M	1	2	50-100
50.8	12	Run Body	M	2	7	0-50
50.8	12	Run Body	M	2	112	0-50
50.8	12	Run Body	M	2	10	100-150
50.8	12	Run Body	M	2	23	50-100
50.8	12	Run Body	M	2	5	50-100
50.8	12	Run Body	M	2	1	50-100
50.8	12	Run Body	M	3	148	0-50
50.8	12	Run Body	M	3	4	100-150
50.8	12	Run Body	M	3	10	100-150
50.8	12	Run Body	M	3	5	50-100
50.8	12	Run Body	M	3	8	50-100
50.6	14	Riffle	M	1	62	0-50
50.6	14	Riffle	M	1	32	0-50
50.6	14	Riffle	M	1	1	100-150
50.6	14	Riffle	M	1	3	100-150
50.6	14	Riffle	M	1	11	50-100
50.6	14	Riffle	M	1	7	50-100
50.6	14	Riffle	M	1	4	50-100
50.6	14	Riffle	M	2	39	0-50
50.6	14	Riffle	M	2	60	0-50

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
50.6	14	Riffle	M	2	4	100-150
50.6	14	Riffle	M	2	5	50-100
50.6	14	Riffle	M	2	7	50-100
50.6	14	Riffle	M	2	4	50-100
50.6	14	Riffle	M	3	38	0-50
50.6	14	Riffle	M	3	72	0-50
50.6	14	Riffle	M	3	2	100-150
50.6	14	Riffle	M	3	3	50-100
50.6	14	Riffle	M	3	28	50-100
50.3	19	Run Head	M	1	7	0-50
50.3	19	Run Head	M	1	1	0-50
50.3	19	Run Head	M	1	10	100-150
50.3	19	Run Head	M	1	40	50-100
50.3	19	Run Head	M	1	1	600-650
50.3	19	Run Head	M	2	9	0-50
50.3	19	Run Head	M	2	20	100-150
50.3	19	Run Head	M	2	30	50-100
50.3	19	Run Head	M	3	8	0-50
50.3	19	Run Head	M	3	1	0-50
50.3	19	Run Head	M	3	20	100-150
50.3	19	Run Head	M	3	30	50-100
49.9	24	Run Body	S	1	50	0-50
49.9	24	Run Body	S	1	20	100-150
49.9	24	Run Body	S	1	12	100-150
49.9	24	Run Body	S	1	1	150-200
49.9	24	Run Body	S	1	30	50-100
49.9	24	Run Body	S	1	7	50-100
49.7	27	Pool Head	M	1	1	100-150
49.7	27	Pool Head	M	3	3	50-100
49.6	28	Pool Body	M	1	1	100-150
49.6	28	Pool Body	M	1	3	50-100
49.6	28	Pool Body	M	2	0	--
49.6	28	Pool Body	M	3	4	150-200
49.1	38	Run Head	S	1	0	--
48.4	45	Riffle	S	1	30	0-50
48.4	45	Riffle	S	1	19	100-150
48.4	45	Riffle	S	1	15	100-150
48.4	45	Riffle	S	1	18	100-150
48.4	45	Riffle	S	1	62	50-100
48.4	45	Riffle	S	1	42	50-100
48.1	51	Run Body	M	1	14	0-50

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
48.1	51	Run Body	M	1	4	100-150
48.1	51	Run Body	M	1	3	50-100
48.1	51	Run Body	M	2	8	0-50
48.1	51	Run Body	M	2	3	100-150
48.1	51	Run Body	M	2	3	50-100
48.1	51	Run Body	M	2	2	50-100
48.1	51	Run Body	M	2	17	50-100
48.1	51	Run Body	M	3	12	0-50
48.1	51	Run Body	M	3	2	100-150
48.1	51	Run Body	M	3	2	150-200
48.1	51	Run Body	M	3	18	50-100
48.0	53	Riffle	S	1	2	50-100
48.0	53	Riffle	S	1	2	50-100
48.0	54	Pool Head	S	1	2	50-100
46.9	62	Run Head	M	1	9	0-50
46.9	62	Run Head	M	1	2	100-150
46.9	62	Run Head	M	1	1	100-150
46.9	62	Run Head	M	1	5	50-100
46.9	62	Run Head	M	1	9	50-100
46.9	62	Run Head	M	2	10	0-50
46.9	62	Run Head	M	2	6	100-150
46.9	62	Run Head	M	2	3	100-150
46.9	62	Run Head	M	2	2	50-100
46.9	62	Run Head	M	2	10	50-100
46.9	62	Run Head	M	3	10	100-150
46.9	62	Run Head	M	3	17	50-100
46.9	62	Run Head	M	3	10	50-100
45.3	81	Pool Body	S	1	0	--
45.1	83	Run Body	S	1	8	100-150
45.1	83	Run Body	S	1	20	50-100
45.0	86	Pool Head	S	1	0	--
44.8	90	Run Head	S	1	1	50-100
44.5	101	Riffle	M	1	5	0-50
44.5	101	Riffle	M	1	1	100-150
44.5	101	Riffle	M	1	5	100-150
44.5	101	Riffle	M	1	4	50-100
44.5	101	Riffle	M	1	2	50-100
44.5	101	Riffle	M	1	25	50-100
44.5	101	Riffle	M	2	3	0-50
44.5	101	Riffle	M	2	8	100-150
44.5	101	Riffle	M	2	1	100-150

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
44.5	101	Riffle	M	2	2	100-150
44.5	101	Riffle	M	2	22	50-100
44.5	101	Riffle	M	2	1	50-100
44.5	101	Riffle	M	2	6	50-100
44.5	101	Riffle	M	3	4	0-50
44.5	101	Riffle	M	3	6	100-150
44.5	101	Riffle	M	3	1	100-150
44.5	101	Riffle	M	3	2	100-150
44.5	101	Riffle	M	3	7	50-100
44.5	101	Riffle	M	3	1	50-100
44.5	101	Riffle	M	3	23	50-100
43.2	107	Riffle	M	1	3	100-150
43.2	107	Riffle	M	1	14	50-100
43.2	107	Riffle	M	1	3	50-100
43.2	107	Riffle	M	1	1	50-100
43.2	107	Riffle	M	2	2	100-150
43.2	107	Riffle	M	2	3	50-100
43.2	107	Riffle	M	2	6	50-100
43.2	107	Riffle	M	3	1	100-150
43.2	107	Riffle	M	3	4	50-100
43.2	107	Riffle	M	3	3	50-100
43.2	107	Riffle	M	3	6	50-100
43.2	107	Riffle	M	3	1	50-100
42.7	123	Run Head	S	1	0	--
42.4	124	Run Body	M	1	10	100-150
42.4	124	Run Body	M	1	1	100-150
42.4	124	Run Body	M	1	1	50-100
42.4	124	Run Body	M	1	9	50-100
42.4	124	Run Body	M	2	1	100-150
42.4	124	Run Body	M	2	4	100-150
42.4	124	Run Body	M	2	4	50-100
42.4	124	Run Body	M	2	7	50-100
42.4	124	Run Body	M	3	5	100-150
42.4	124	Run Body	M	3	1	50-100
42.4	124	Run Body	M	3	18	50-100
40.3	150	Run Body	S	1	0	--
39.7	156	Riffle	S	1	0	--
39.6	157	Run Head	M	1	0	--
39.6	157	Run Head	M	2	0	--
39.6	157	Run Head	M	3	0	--
39.2	165	Pool Head	S	1	0	--

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Sum of count	Size range
38.9	166	Pool Body	S	1	1	100-150
38.9	168	Riffle	S	1	2	100-150
38.8	171	Pool Body	M	1	0	--
38.8	171	Pool Body	M	2	0	--
38.8	171	Pool Body	M	3	0	--

Table G-5. Non-salmonid fish observation data for the sampling units, March 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
50.8	12	Run Body	S	1	Sacramento sucker	1	300-350
50.6	15	Run Head	M	1	Sacramento sucker	3	500-550
50.5	16	Run Body	M	1	Sacramento sucker	28	400-450
50.5	16	Run Body	M	1	Sacramento sucker	25	450-500
50.5	16	Run Body	M	1	Sacramento sucker	5	500-550
50.5	16	Run Body	M	2	Sacramento sucker	28	400-450
50.5	16	Run Body	M	2	Sacramento sucker	16	450-500
50.5	16	Run Body	M	2	Sacramento sucker	1	525
50.5	16	Run Body	M	2	Sacramento sucker	1	545
50.5	16	Run Body	M	3	Sacramento sucker	35	400-450
50.5	16	Run Body	M	3	Sacramento sucker	14	450-500
50.5	16	Run Body	M	3	Sacramento sucker	5	500-550
50.5	16	Run Body	M	3	Sacramento sucker	1	525
50.3	18	Riffle	S	1	Sacramento sucker	6	300-350
50.3	18	Riffle	S	1	Sacramento sucker	4	350-400
50.3	18	Riffle	S	1	Sacramento sucker	10	400-450
50.3	18	Riffle	S	1	Sacramento sucker	5	450-500
50.1	20	Run Body	S	1	Sacramento sucker	3	300-350
50.1	20	Run Body	S	1	Sacramento sucker	6	350-400
50.1	20	Run Body	S	1	Sacramento sucker	10	400-450
50.1	20	Run Body	S	1	Sacramento sucker	8	450-500
50.1	22	Riffle	M	2	Sacramento sucker	1	425
49.7	26	Riffle	M	1	Sacramento sucker	2	300-350
49.7	26	Riffle	M	1	Sacramento sucker	1	350-400
49.7	26	Riffle	M	1	Sacramento sucker	4	400-450
49.7	26	Riffle	M	2	Sacramento sucker	3	400-450
49.7	26	Riffle	M	2	Sacramento sucker	3	450-500
49.7	26	Riffle	M	3	Sacramento sucker	1	450-500
49.7	27	Pool Head	S	1	Sacramento sucker	1	550-600
49.6	28	Pool Body	M	1	Sacramento sucker	7	450-500
49.6	28	Pool Body	M	1	Sacramento sucker	8	500-550
49.6	28	Pool Body	M	2	Sacramento sucker	4	450-500
49.6	28	Pool Body	M	2	Sacramento sucker	7	500-550
49.6	28	Pool Body	M	3	Sculpin sp.	1	75
49.6	28	Pool Body	M	3	Sacramento sucker	2	450-500
49.6	28	Pool Body	M	3	Sacramento sucker	5	500-550
48.8	42	Run Head	M	1	Sacramento sucker	6	300-350
48.7	43	Run Body	S	1	Sacramento sucker	8	300-350
48.7	43	Run Body	S	1	Sacramento sucker	8	450-500

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
48.0	54	Pool Head	S	1	Cyprinid sp.	10	0-50
48.0	54	Pool Head	S	1	Sacramento sucker	2	450-500
48.0	54	Pool Head	S	1	Sacramento sucker	1	740
45.9	70	Riffle	S	1	Catfish sp.	1	355
45.9	70	Riffle	S	1	Sacramento sucker	2	400-450
45.9	70	Riffle	S	1	Sacramento sucker	2	450-500
45.9	70	Riffle	S	1	Sacramento sucker	4	500-550
44.7	93	Riffle	M	2	Hardhead/Pikeminnow	5	0-50
44.7	93	Riffle	M	2	Hardhead/Pikeminnow	7	50-100
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	1	0-50
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	2	100-150
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	4	50-100
44.5	101	Riffle	S	1	Sacramento sucker	3	400-450
44.5	101	Riffle	S	1	Sacramento sucker	1	450-500
44.5	101	Riffle	S	1	Sacramento sucker	1	50-100
43.0	112	Pool Head	M	1	Sacramento sucker	1	305
43.0	112	Pool Head	M	1	Sacramento sucker	3	350-400
43.0	113	Pool Body	M	3	Largemouth bass	1	405
42.9	116	Run Body	M	1	Hardhead/Pikeminnow	1	125
42.9	116	Run Body	M	1	Sacramento sucker	1	450-500
42.9	116	Run Body	M	1	Sacramento sucker	1	475
42.9	116	Run Body	M	2	Sacramento sucker	2	400-450
42.9	116	Run Body	M	2	Sacramento sucker	3	450-500
42.9	116	Run Body	M	2	Sacramento sucker	1	500-550
42.9	116	Run Body	M	3	Hardhead/Pikeminnow	1	125
42.9	116	Run Body	M	3	Hardhead/Pikeminnow	2	150-200
42.3	126	Riffle	S	1	Sacramento sucker	3	450-500
41.9	133	Run Head	M	1	Sacramento sucker	4	450-500
41.9	133	Run Head	M	3	Sacramento sucker	1	500-550
41.8	134	Run Body	S	1	Sacramento sucker	14	400-450
41.8	134	Run Body	S	1	Sacramento sucker	15	450-500
41.8	134	Run Body	S	1	Sacramento sucker	19	500-550
41.8	134	Run Body	S	1	Sacramento sucker	1	650-700
38.9	166	Pool Body	S	1	Sacramento sucker	1	390
38.7	173	Run Body	M	1	Sculpin sp.	1	50-100
38.7	173	Run Body	M	1	Smallmouth bass	1	400-450
38.7	173	Run Body	M	2	Sacramento sucker	1	400-450
38.5	179	Riffle	S	1	Sacramento sucker	8	400-450
38.5	179	Riffle	S	1	Sacramento sucker	10	450-500
38.5	179	Riffle	S	1	Sacramento sucker	1	500-550

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
38.5	179	Riffle	S	1	Sacramento sucker	1	525
50.8	12	Run Body	S	1	Sacramento sucker	1	300-350
50.6	15	Run Head	M	1	Sacramento sucker	3	500-550
50.5	16	Run Body	M	1	Sacramento sucker	28	400-450
50.5	16	Run Body	M	1	Sacramento sucker	25	450-500
50.5	16	Run Body	M	1	Sacramento sucker	5	500-550
50.5	16	Run Body	M	2	Sacramento sucker	28	400-450
50.5	16	Run Body	M	2	Sacramento sucker	16	450-500
50.5	16	Run Body	M	2	Sacramento sucker	1	525
50.5	16	Run Body	M	2	Sacramento sucker	1	545
50.5	16	Run Body	M	3	Sacramento sucker	35	400-450
50.5	16	Run Body	M	3	Sacramento sucker	14	450-500
50.5	16	Run Body	M	3	Sacramento sucker	5	500-550
50.5	16	Run Body	M	3	Sacramento sucker	1	525
50.3	18	Riffle	S	1	Sacramento sucker	6	300-350
50.3	18	Riffle	S	1	Sacramento sucker	4	350-400
50.3	18	Riffle	S	1	Sacramento sucker	10	400-450
50.3	18	Riffle	S	1	Sacramento sucker	5	450-500
50.1	20	Run Body	S	1	Sacramento sucker	3	300-350
50.1	20	Run Body	S	1	Sacramento sucker	6	350-400
50.1	20	Run Body	S	1	Sacramento sucker	10	400-450
50.1	20	Run Body	S	1	Sacramento sucker	8	450-500
50.1	22	Riffle	M	2	Sacramento sucker	1	425
49.7	26	Riffle	M	1	Sacramento sucker	2	300-350
49.7	26	Riffle	M	1	Sacramento sucker	1	350-400
49.7	26	Riffle	M	1	Sacramento sucker	4	400-450
49.7	26	Riffle	M	2	Sacramento sucker	3	400-450
49.7	26	Riffle	M	2	Sacramento sucker	3	450-500
49.7	26	Riffle	M	3	Sacramento sucker	1	450-500
49.7	27	Pool Head	S	1	Sacramento sucker	1	550-600
49.6	28	Pool Body	M	1	Sacramento sucker	7	450-500
49.6	28	Pool Body	M	1	Sacramento sucker	8	500-550
49.6	28	Pool Body	M	2	Sacramento sucker	4	450-500
49.6	28	Pool Body	M	2	Sacramento sucker	7	500-550
49.6	28	Pool Body	M	3	Sculpin sp.	1	75
49.6	28	Pool Body	M	3	Sacramento sucker	2	450-500
49.6	28	Pool Body	M	3	Sacramento sucker	5	500-550
48.8	42	Run Head	M	1	Sacramento sucker	6	300-350
48.7	43	Run Body	S	1	Sacramento sucker	8	300-350
48.7	43	Run Body	S	1	Sacramento sucker	8	450-500

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
48.0	54	Pool Head	S	1	Cyprinid sp.	10	0-50
48.0	54	Pool Head	S	1	Sacramento sucker	2	450-500
48.0	54	Pool Head	S	1	Sacramento sucker	1	740
45.9	70	Riffle	S	1	Catfish sp.	1	355
45.9	70	Riffle	S	1	Sacramento sucker	2	400-450
45.9	70	Riffle	S	1	Sacramento sucker	2	450-500
45.9	70	Riffle	S	1	Sacramento sucker	4	500-550
44.7	93	Riffle	M	2	Hardhead/Pikeminnow	5	0-50
44.7	93	Riffle	M	2	Hardhead/Pikeminnow	7	50-100
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	1	0-50
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	2	100-150
44.7	93	Riffle	M	3	Hardhead/Pikeminnow	4	50-100
44.5	101	Riffle	S	1	Sacramento sucker	3	400-450
44.5	101	Riffle	S	1	Sacramento sucker	1	450-500
44.5	101	Riffle	S	1	Sacramento sucker	1	50-100
43.0	112	Pool Head	M	1	Sacramento sucker	1	305
43.0	112	Pool Head	M	1	Sacramento sucker	3	350-400
43.0	113	Pool Body	M	3	Largemouth bass	1	405
42.9	116	Run Body	M	1	Hardhead/Pikeminnow	1	125
42.9	116	Run Body	M	1	Sacramento sucker	1	450-500
42.9	116	Run Body	M	1	Sacramento sucker	1	475
42.9	116	Run Body	M	2	Sacramento sucker	2	400-450
42.9	116	Run Body	M	2	Sacramento sucker	3	450-500
42.9	116	Run Body	M	2	Sacramento sucker	1	500-550
42.9	116	Run Body	M	3	Hardhead/Pikeminnow	1	125
42.9	116	Run Body	M	3	Hardhead/Pikeminnow	2	150-200
42.3	126	Riffle	S	1	Sacramento sucker	3	450-500
41.9	133	Run Head	M	1	Sacramento sucker	4	450-500
41.9	133	Run Head	M	3	Sacramento sucker	1	500-550
41.8	134	Run Body	S	1	Sacramento sucker	14	400-450
41.8	134	Run Body	S	1	Sacramento sucker	15	450-500
41.8	134	Run Body	S	1	Sacramento sucker	19	500-550
41.8	134	Run Body	S	1	Sacramento sucker	1	650-700
38.9	166	Pool Body	S	1	Sacramento sucker	1	390
38.7	173	Run Body	M	1	Sculpin sp.	1	50-100
38.7	173	Run Body	M	1	Smallmouth bass	1	400-450
38.7	173	Run Body	M	2	Sacramento sucker	1	400-450
38.5	179	Riffle	S	1	Sacramento sucker	8	400-450
38.5	179	Riffle	S	1	Sacramento sucker	10	450-500
38.5	179	Riffle	S	1	Sacramento sucker	1	500-550

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
38.5	179	Riffle	S	1	Sacramento sucker	1	525

Table G-6. Non-salmonid fish observation data for the sampling units, August 2010.

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
51.8	1	Pool Head	Y	1	Hardhead/Pikeminnow	1	400-450
51.8	1	Pool Head	Y	1	Striped bass	1	300-350
51.6	5	Pool Body	Y	1	Striped bass	1	400-450
51.6	5	Pool Body	Y	2	Striped bass	2	450-500
50.8	12	Run Body	Y	1	Hardhead/Pikeminnow	1	0-50
50.8	12	Run Body	Y	1	Hardhead/Pikeminnow	1	300-350
50.8	12	Run Body	Y	1	Hardhead/Pikeminnow	5	400-450
50.8	12	Run Body	Y	1	Sculpin sp.	3	0-50
50.8	12	Run Body	Y	1	Sacramento sucker	2	300-350
50.8	12	Run Body	Y	1	Sacramento sucker	4	400-450
50.8	12	Run Body	Y	2	Hardhead/Pikeminnow	4	400-450
50.8	12	Run Body	Y	2	Sculpin sp.	3	0-50
50.8	12	Run Body	Y	2	Sacramento sucker	2	350-400
50.8	12	Run Body	Y	2	Sacramento sucker	3	400-450
50.8	12	Run Body	Y	3	Hardhead/Pikeminnow	3	400-450
50.8	12	Run Body	Y	3	Sculpin sp.	1	0-50
50.8	12	Run Body	Y	3	Sacramento sucker	64	0-50
50.8	12	Run Body	Y	3	Sacramento sucker	3	300-350
50.8	12	Run Body	Y	3	Sacramento sucker	4	400-450
50.6	14	Riffle	Y	1	Sculpin sp.	7	100-150
50.6	14	Riffle	Y	1	Sacramento sucker	6	300-350
50.6	14	Riffle	Y	2	Sculpin sp.	2	0-50
50.6	14	Riffle	Y	2	Sculpin sp.	2	100-150
50.6	14	Riffle	Y	2	Sculpin sp.	6	50-100
50.6	14	Riffle	Y	2	Sacramento sucker	2	0-50
50.6	14	Riffle	Y	3	Sculpin sp.	4	100-150
50.6	14	Riffle	Y	3	Sculpin sp.	2	50-100
50.6	14	Riffle	Y	3	Sacramento sucker	3	300-350
50.3	19	Run Head	Y	1	Lamprey sp.	1	150-200
50.3	19	Run Head	Y	1	Striped bass	1	400-450
50.3	19	Run Head	Y	1	Sacramento sucker	70	0-50
50.3	19	Run Head	Y	2	Striped bass	1	400-450
50.3	19	Run Head	Y	2	Sacramento sucker	65	0-50
50.3	19	Run Head	Y	3	Sacramento sucker	63	0-50
49.9	24	Run Body	N	1	Gambusia sp.	100	0-50
49.9	24	Run Body	N	1	Hardhead/Pikeminnow	40	0-50
49.9	24	Run Body	N	1	Hardhead/Pikeminnow	2	400-450
49.9	24	Run Body	N	1	Striped bass	1	300-350
49.9	24	Run Body	N	1	Sacramento sucker	35	0-50

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
49.9	24	Run Body	N	1	Sacramento sucker	15	300-350
49.9	24	Run Body	N	1	Sacramento sucker	17	350-400
49.9	24	Run Body	N	1	Sacramento sucker	100	400-500
49.9	24	Run Body	N	1	Sacramento sucker	6	50-100
49.7	27	Pool Head	Y	1	Sacramento sucker	1	350-400
49.7	27	Pool Head	Y	2	Sacramento sucker	1	350-400
49.6	28	Pool Body	Y	2	Sacramento sucker	7	0-50
49.6	28	Pool Body	Y	3	Sacramento sucker	10	0-50
49.1	38	Run Head	N	1	Gambusia sp.	3	0-50
49.1	38	Run Head	N	1	Sacramento sucker	40	0-50
48.4	45	Riffle	N	1	Gambusia sp.	3	0-50
48.4	45	Riffle	N	1	Sculpin sp.	2	100-150
48.4	45	Riffle	N	1	Sculpin sp.	1	50-100
48.1	51	Run Body	Y	1	Hardhead/Pikeminnow	8	0-50
48.1	51	Run Body	Y	1	Sacramento sucker	15	0-50
48.1	51	Run Body	Y	2	Sacramento sucker	10	0-50
48.1	51	Run Body	Y	3	Hardhead/Pikeminnow	1	200-250
48.1	51	Run Body	Y	3	Hardhead/Pikeminnow	1	350-400
48.1	51	Run Body	Y	3	Sacramento sucker	24	0-50
48.1	51	Run Body	Y	3	Sacramento sucker	1	300-350
48.0	53	Riffle	N	1	Sculpin sp.	1	100-150
48.0	53	Riffle	N	1	Sacramento sucker	1	350-400
48.0	53	Riffle	N	1	Sacramento sucker	3	50-100
48.0	54	Pool Head	N	1	Sacramento sucker	3	0-50
48.0	54	Pool Head	N	1	Sacramento sucker	1	300-350
46.9	62	Run Head	Y	1	Sacramento sucker	1	100-150
46.9	62	Run Head	Y	1	Sacramento sucker	4	50-100
46.9	62	Run Head	Y	2	Sacramento sucker	3	50-100
46.9	62	Run Head	Y	3	Sacramento sucker	1	100-150
46.9	62	Run Head	Y	3	Sacramento sucker	3	50-100
45.3	81	Pool Body	N	1	Hardhead/Pikeminnow	3	300-350
45.3	81	Pool Body	N	1	Hardhead/Pikeminnow	6	350-400
45.3	81	Pool Body	N	1	Hardhead/Pikeminnow	7	400-450
45.3	81	Pool Body	N	1	Hardhead/Pikeminnow	2	450-500
45.3	81	Pool Body	N	1	Hardhead/Pikeminnow	1	500-550
45.3	81	Pool Body	N	1	Sacramento sucker	16	300-350
45.3	81	Pool Body	N	1	Sacramento sucker	24	350-400
45.3	81	Pool Body	N	1	Sacramento sucker	13	400-450
45.3	81	Pool Body	N	1	Sacramento sucker	10	450-500
45.3	81	Pool Body	N	1	Sacramento sucker	10	500-550

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
45.1	83	Run Body	N	1	Hardhead/Pikeminnow	2	300-350
45.1	83	Run Body	N	1	Hardhead/Pikeminnow	3	350-400
45.1	83	Run Body	N	1	Sacramento sucker	1	0-50
45.1	83	Run Body	N	1	Sacramento sucker	21	300-350
45.1	83	Run Body	N	1	Sacramento sucker	77	350-400
45.1	83	Run Body	N	1	Sacramento sucker	16	400-450
45.0	86	Pool Head	N	1	Hardhead/Pikeminnow	9	150-200
45.0	86	Pool Head	N	1	Hardhead/Pikeminnow	8	200-250
45.0	86	Pool Head	N	1	Hardhead/Pikeminnow	15	250-300
45.0	86	Pool Head	N	1	Hardhead/Pikeminnow	3	300-350
45.0	86	Pool Head	N	1	Sacramento sucker	1	250-300
44.8	90	Run Head	N	1	Hardhead/Pikeminnow	1	50-100
44.5	101	Riffle	Y	1	Hardhead/Pikeminnow	13	150-200
44.5	101	Riffle	Y	1	Hardhead/Pikeminnow	9	200-250
44.5	101	Riffle	Y	1	Hardhead/Pikeminnow	3	300-350
44.5	101	Riffle	Y	1	Sacramento sucker	14	0-50
44.5	101	Riffle	Y	1	Sacramento sucker	1	100-150
44.5	101	Riffle	Y	1	Sacramento sucker	10	50-100
44.5	101	Riffle	Y	2	Hardhead/Pikeminnow	11	100-150
44.5	101	Riffle	Y	2	Hardhead/Pikeminnow	31	150-200
44.5	101	Riffle	Y	2	Hardhead/Pikeminnow	14	200-250
44.5	101	Riffle	Y	2	Hardhead/Pikeminnow	2	300-350
44.5	101	Riffle	Y	2	Sacramento sucker	12	0-50
44.5	101	Riffle	Y	2	Sacramento sucker	1	100-150
44.5	101	Riffle	Y	2	Sacramento sucker	3	200-250
44.5	101	Riffle	Y	2	Sacramento sucker	11	50-100
44.5	101	Riffle	Y	3	Hardhead/Pikeminnow	21	150-200
44.5	101	Riffle	Y	3	Hardhead/Pikeminnow	19	200-250
44.5	101	Riffle	Y	3	Hardhead/Pikeminnow	3	250-300
44.5	101	Riffle	Y	3	Hardhead/Pikeminnow	5	300-350
44.5	101	Riffle	Y	3	Sculpin sp.	1	0-50
44.5	101	Riffle	Y	3	Sacramento sucker	8	0-50
44.5	101	Riffle	Y	3	Sacramento sucker	3	200-250
44.5	101	Riffle	Y	3	Sacramento sucker	9	50-100
43.7	104	Pool Body	N	1	Largemouth bass	1	400-450
43.7	104	Pool Body	N	1	Hardhead/Pikeminnow	1	300-350
43.7	104	Pool Body	N	1	Striped bass	3	250-300
43.7	104	Pool Body	N	1	Striped bass	4	300-350
43.7	104	Pool Body	N	1	Striped bass	6	350-400
43.7	104	Pool Body	N	1	Striped bass	7	400-450

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
43.7	104	Pool Body	N	1	Striped bass	1	450-500
43.7	104	Pool Body	N	1	Sacramento sucker	25	300-350
43.7	104	Pool Body	N	1	Sacramento sucker	180	350-400
43.7	104	Pool Body	N	1	Sacramento sucker	110	400-450
43.7	104	Pool Body	N	1	Sacramento sucker	15	450-500
43.2	107	Riffle	Y	1	Hardhead/Pikeminnow	2	100-150
43.2	107	Riffle	Y	1	Hardhead/Pikeminnow	1	200-250
43.2	107	Riffle	Y	1	Sacramento sucker	6	0-50
43.2	107	Riffle	Y	2	Hardhead/Pikeminnow	4	100-150
43.2	107	Riffle	Y	2	Hardhead/Pikeminnow	6	150-200
43.2	107	Riffle	Y	2	Hardhead/Pikeminnow	3	200-250
43.2	107	Riffle	Y	2	Sacramento sucker	8	0-50
43.2	107	Riffle	Y	3	Hardhead/Pikeminnow	3	100-150
43.2	107	Riffle	Y	3	Hardhead/Pikeminnow	6	150-200
43.2	107	Riffle	Y	3	Hardhead/Pikeminnow	2	200-250
43.2	107	Riffle	Y	3	Hardhead/Pikeminnow	2	250-300
43.2	107	Riffle	Y	3	Sacramento sucker	3	0-50
42.4	124	Run Body	Y	1	Hardhead/Pikeminnow	41	150-200
42.4	124	Run Body	Y	1	Hardhead/Pikeminnow	3	200-250
42.4	124	Run Body	Y	1	Hardhead/Pikeminnow	3	250-300
42.4	124	Run Body	Y	1	Hardhead/Pikeminnow	1	300-350
42.4	124	Run Body	Y	1	Hardhead/Pikeminnow	4	450-500
42.4	124	Run Body	Y	1	Sacramento sucker	3	250-300
42.4	124	Run Body	Y	1	Sacramento sucker	38	300-350
42.4	124	Run Body	Y	1	Sacramento sucker	14	350-400
42.4	124	Run Body	Y	2	Hardhead/Pikeminnow	40	150-200
42.4	124	Run Body	Y	2	Hardhead/Pikeminnow	2	250-300
42.4	124	Run Body	Y	2	Hardhead/Pikeminnow	3	300-350
42.4	124	Run Body	Y	2	Hardhead/Pikeminnow	5	450-500
42.4	124	Run Body	Y	2	Smallmouth bass	1	250-300
42.4	124	Run Body	Y	2	Sacramento sucker	4	150-200
42.4	124	Run Body	Y	2	Sacramento sucker	6	200-250
42.4	124	Run Body	Y	2	Sacramento sucker	33	250-300
42.4	124	Run Body	Y	2	Sacramento sucker	124	300-350
42.4	124	Run Body	Y	2	Sacramento sucker	8	350-400
42.4	124	Run Body	Y	2	Sacramento sucker	5	400-450
42.4	124	Run Body	Y	3	Hardhead/Pikeminnow	2	150-200
42.4	124	Run Body	Y	3	Hardhead/Pikeminnow	3	300-350
42.4	124	Run Body	Y	3	Hardhead/Pikeminnow	1	350-400
42.4	124	Run Body	Y	3	Hardhead/Pikeminnow	3	450-500

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
42.4	124	Run Body	Y	3	Sacramento sucker	3	150-200
42.4	124	Run Body	Y	3	Sacramento sucker	5	250-300
42.4	124	Run Body	Y	3	Sacramento sucker	147	300-350
42.4	124	Run Body	Y	3	Sacramento sucker	12	350-400
42.4	124	Run Body	Y	3	Sacramento sucker	6	400-450
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	3	100-150
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	13	150-200
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	19	200-250
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	1	200-250
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	12	250-300
40.3	150	Run Body	N	1	Hardhead/Pikeminnow	1	250-300
39.7	156	Riffle	N	1	Hardhead/Pikeminnow	3	100-150
39.7	156	Riffle	N	1	Hardhead/Pikeminnow	3	150-200
39.7	156	Riffle	N	1	Sacramento sucker	150	0-50
39.7	156	Riffle	N	1	Sacramento sucker	1	400-450
39.7	156	Riffle	N	1	Sacramento sucker	15	50-100
39.6	157	Run Head	Y	1	Hardhead/Pikeminnow	1	150-200
39.6	157	Run Head	Y	1	Sacramento sucker	10	300-350
39.6	157	Run Head	Y	1	Sacramento sucker	10	350-400
39.6	157	Run Head	Y	1	Sacramento sucker	15	400-450
39.6	157	Run Head	Y	1	Sacramento sucker	40	450-500
39.6	157	Run Head	Y	2	Sacramento sucker	5	300-350
39.6	157	Run Head	Y	2	Sacramento sucker	10	350-400
39.6	157	Run Head	Y	2	Sacramento sucker	30	400-450
39.6	157	Run Head	Y	2	Sacramento sucker	30	450-500
39.6	157	Run Head	Y	3	Hardhead/Pikeminnow	2	250-300
39.6	157	Run Head	Y	3	Sacramento sucker	5	300-350
39.6	157	Run Head	Y	3	Sacramento sucker	10	350-400
39.6	157	Run Head	Y	3	Sacramento sucker	25	400-450
39.6	157	Run Head	Y	3	Sacramento sucker	21	450-500
38.9	166	Pool Body	N	1	Largemouth bass	1	400-450
38.9	166	Pool Body	N	1	Hardhead/Pikeminnow	1	150-200
38.9	166	Pool Body	N	1	Hardhead/Pikeminnow	15	200-250
38.9	166	Pool Body	N	1	Hardhead/Pikeminnow	3	250-300
38.9	166	Pool Body	N	1	Hardhead/Pikeminnow	4	350-400
38.9	166	Pool Body	N	1	Striped bass	1	450-500
38.9	166	Pool Body	N	1	Smallmouth bass	1	200-250
38.9	166	Pool Body	N	1	Sacramento sucker	2	300-350
38.9	166	Pool Body	N	1	Sacramento sucker	9	350-400
38.9	168	Riffle	N	1	Hardhead/Pikeminnow	1	250-300

RM	Unit	Habitat	Single (S) or multiple (M) pass	Pass	Species	Sum of count	Size range
38.8	171	Pool Body	Y	1	Sacramento sucker	1	200-250

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-7

Tuolumne River *O. mykiss* Acoustic Tracking Study
2010 Technical Report

Prepared by

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Tuolumne River *O. mykiss* Acoustic Tracking Study

2010 Technical Report

Submitted To:
Turlock Irrigation District
Modesto Irrigation District

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December 2010

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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.

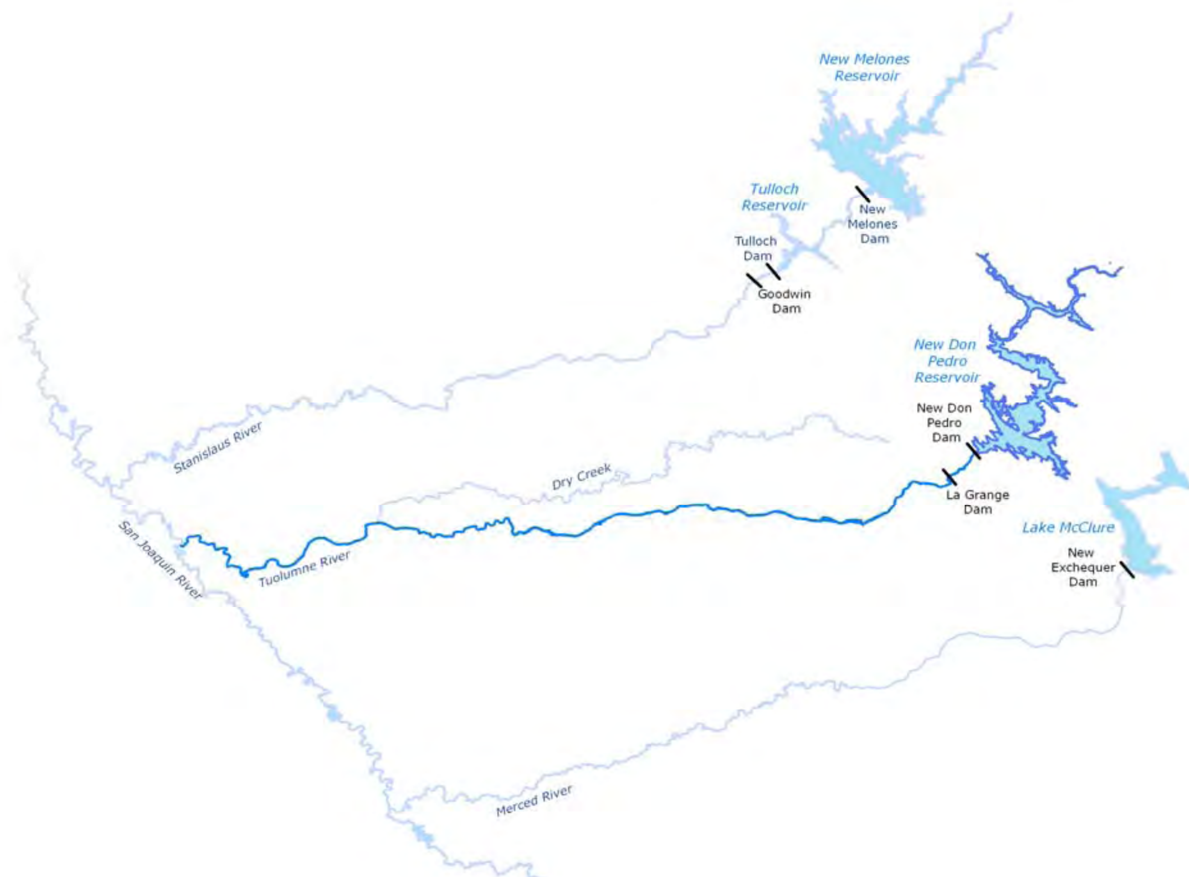

Figure 1. Location of the Tuolumne River within the San Joaquin River Basin.

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.

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 (Figure 2). 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 tricanemethanesulfonate 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 andwere programmed withtag 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. Map of the 2010 adult *O. mykiss* 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 five sites from below La Grange Dam (RM 51.8) to just above TLSRA (RM 42.9). At the time of this report, temperature data are available through September 27, 2010.

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 (Appendix A).

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 (Appendix A).

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 already been tagged. None of the *O. mykiss* captured 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.

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.

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).

Table 2. Date, location, and biological data for all *O. mykiss* tagged during 2010.

Capture Date	River Mile	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

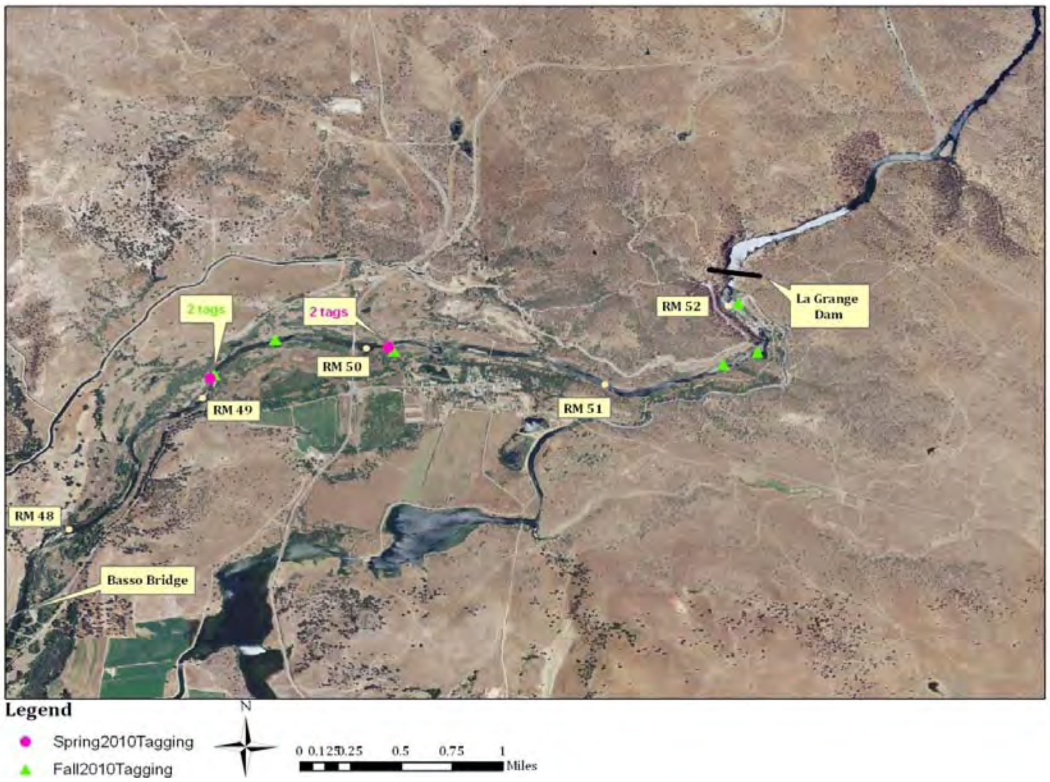

Figure 3. Release locations of tagged *O. mykiss* between La Grange Dam and Basso Bridge.

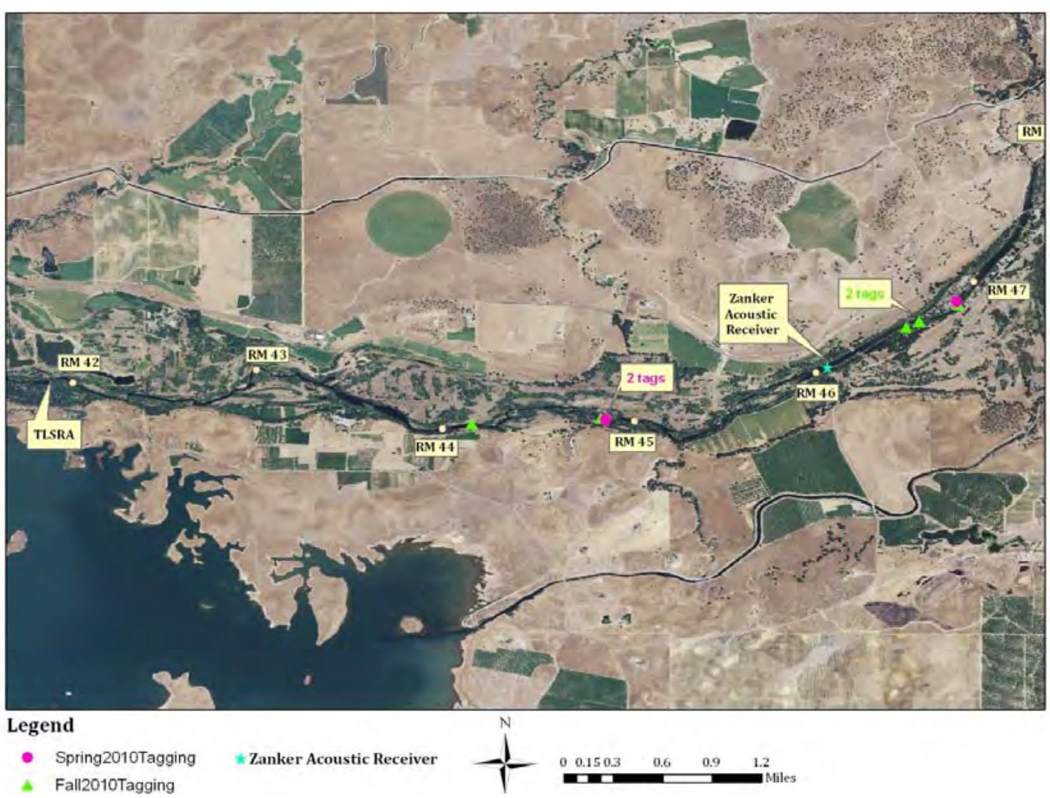

Figure 4. Release locations of tagged *O. mykiss* from Basso Bridge to TLSRA.

Fixed station monitoring

Two acoustic tagged fish were detected at fixed station arrays. Tag 7110.8 was released 1,200 m upstream of the Zanker fixed station array. This fish was detected 260- 425 m downstream of the release location between April 1 and July 27 through mobile tracking. This fish was next detected at the Zanker receiver between August 18 at 19:50 and September 10 at 11:28. The multiple detections in this area indicate that this fish was not migrating downstream, but rather utilizing the pool habitat where the receiver is located.

The other acoustically tagged fish detected by a fixed station array was not associated with this study. The tag (6192.6) was detected passing the Grayson receiver on May 15, 2010 at 15:24 hours. This tag was implanted in a yearling *O. mykiss* from the Mokelumne River Hatchery, and was released downstream in Old River on April 16, 2010 as part of a Department of Water Resources (DWR) South Delta Temporary Barriers study (Kevin Clark, DWR, personal communication). At the time of release, this fishmeasured 265 mm and weighed 194.4 g.

Mobile tracking

A total of 10 mobile tracking surveys were conducted between April 1 and November 1, 2010 (Table 3). Mobile tracking was limited to the reach between La Grange Dam and TLSRA, as no fish tagged for this study were detected moving past the Waterford or Grayson fixed receivers. The locations of all 20 tagged fish were confirmed within a few days after tagging, and movements of the six adult *O. mykiss* tagged during the spring were tracked from early spring through fall. Flows during this period ranged between 300 cfs and 5,520 cfs (Figure 5). Average daily water temperature near La Grange Dam (RM 51.8) ranged from 9.9- 12.1^{o} C, while the temperature near TLSRA (RM 42.9) ranged from 9.8- 15.8^{o} C during the study period (Figure 6).

Each of the six tagged *O. mykiss* tracked from early spring through fall exhibited both upstream and downstream movement. The distance between the most downstream detection and most upstream detection for each fish ranged from 145 m to 5,715 m, with four of the six fish covering a range of approximately 600 m to 1,000 m (Table 3).

The expected life of the HTI X-tags was approximately 300 days, but mobile tracking data suggested that of five of the six tags released during the spring expired within 219 days. As of November 1, one tag was still functioning. Tag life was likely reduced by the cool temperatures in the study reach. The tags used during the fall tagging period are LX-type tags, which feature an updated processor that is expected to increase the life of these tags.

Table 3. Distance between mobile tracking detections by survey date (upstream(+), downstream(-), not detected(ND)).

Tag ID	Distance Between Detections (m)										Total Range
	1-Apr	26-Apr	20-May	15-Jun	7-Jul	27-Jul	9-Sep	27-Sep	20-Oct	1-Nov	
7012.8	+30	-130	-30	+30	+560	ND	ND	ND	ND	ND	590
7054.8	-635	+20	+570	-145	-270	ND	-185	-10	ND	ND	645
7068.8	-2590	+30	-95	-85	+65	+2575	ND	+3075	-3855	-410	5715
7110.8	-260	-165	+30	ND	+50	-45	-585	ND	ND	ND	975
7124.8	-15	0	-80	ND	-35	-15	+120	ND	ND	ND	145
7194.8	-20	0	+620	-10	-640	+5	+195	ND	ND	ND	650

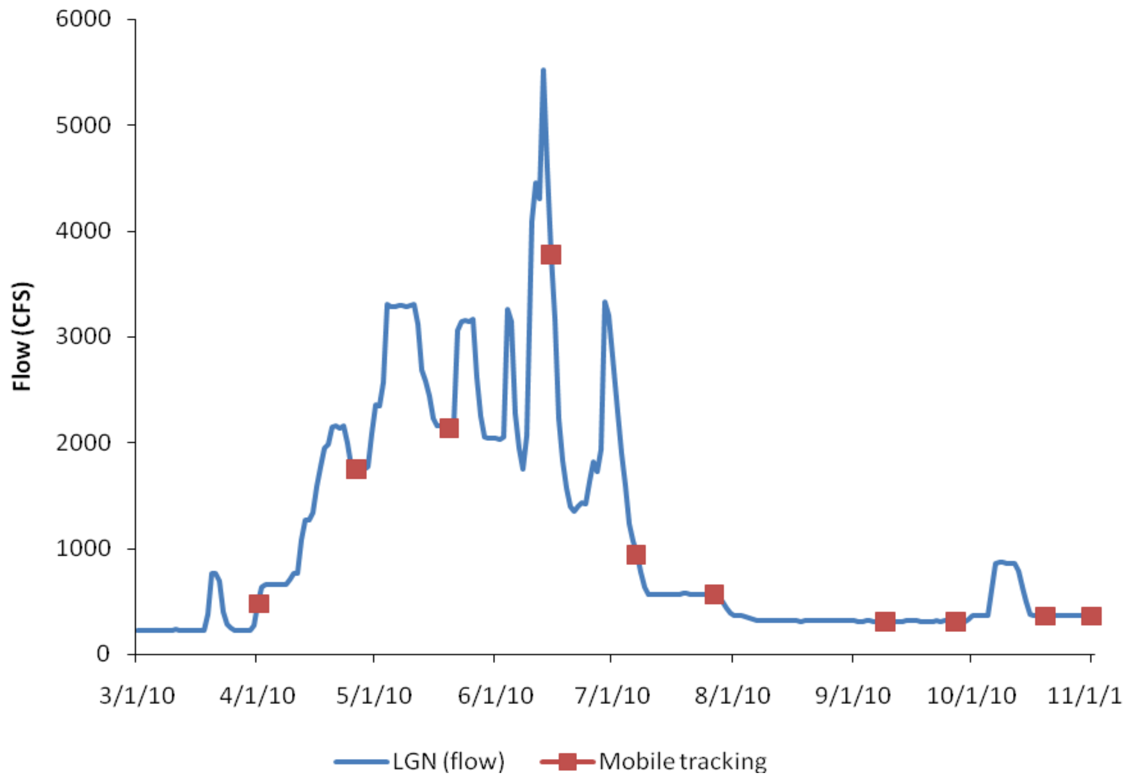

Figure 5. Tuolumne River flow at La Grange (LGN) and dates of mobile tracking surveys.

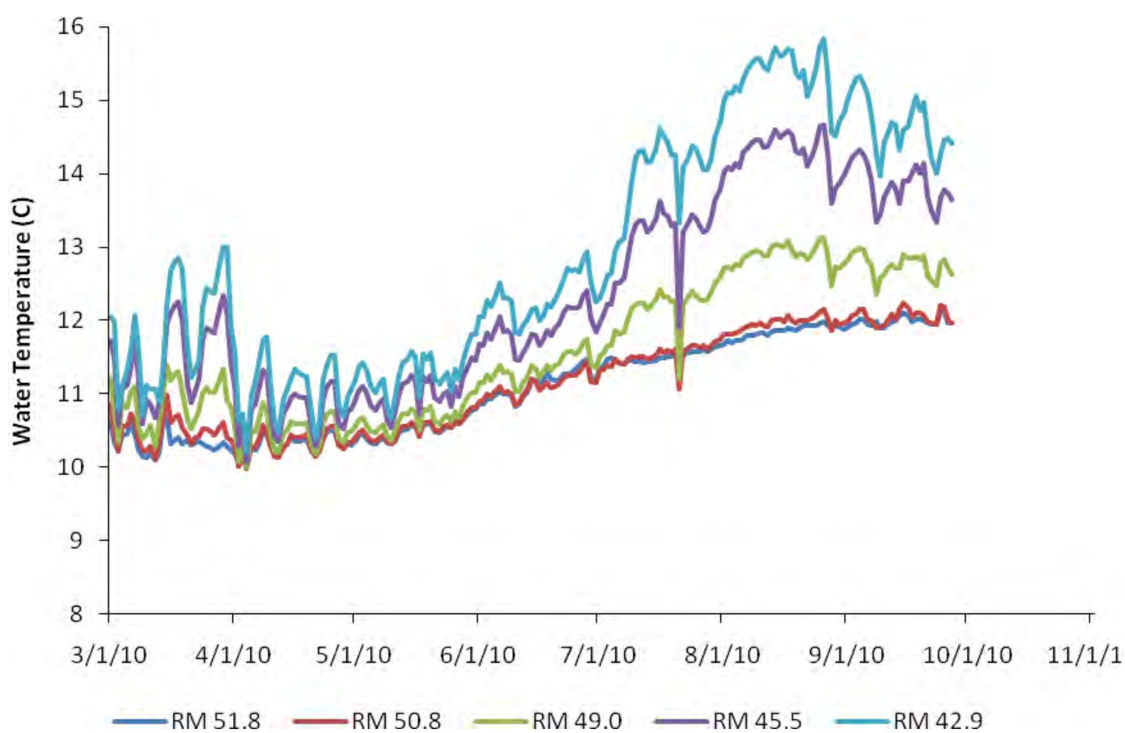

Figure 6. Tuolumne River average daily water temperatures between La Grange Dam and TLSRA.

Tag 7012.8 was implanted in an adult *O. mykiss* captured in habitat unit NSO 033 at RM 49.2 on March 23. During all mobile tracking surveys conducted between April 1 and June 15, this tag was detected within 130 m of the original release location. On July 7, this tag was detected 460 m upstream of the original location, but was not detected during any of the subsequent mobile tracking surveys. However, during hook and line sampling on October 20, an adult *O. mykiss* of similar size and with a surgery scar and a single suture still intact, was captured near the original capture location of 7012.8. The identity of the fish could not be confirmed since a signal was not detected. It is believed that the tag died sometime after July 7 when it was last detected, and there were no indications that the tag had been expelled from the fish. Also, had the tag been expelled, it would have still likely been detected during mobile tracking surveys.

Tag 7054.8 was implanted in an adult *O. mykiss* captured in the run directly upstream of the HWY 59 bridge (NSO 024) on March 23. This tag was detected 635 m downstream of the original capture location on April 1. During April and May it was detected moving back upstream towards the original capture location before moving downstream during June through September, returning to the approximate location where it was detected on April 1.

Tag 7068.8 was implanted in an adult *O. mykiss* captured in the run directly upstream of the HWY 59 bridge (NSO 024) on March 23, and this fish exhibited the longest range of movement. Tag 7068.8 was detected 2,590 m downstream on April 1, and was detected within 30 m upstream and 150 m downstream of this location from April 26 through July 7. On July 27, this tag was found to have returned upstream to the habitat unit where the fish was originally captured. This fish continued to move upstream and was detected directly below the La Grange powerhouse on September 27. During the October and November surveys, this fish was again detected moving downstream and was found 880 m and 1,290 m below the original capture location.

Tag 7110.8 was implanted in an adult *O. mykiss* captured in the run below Basso Bridge (NSO 059) on March 29. Between April 1 and July 27, this tag was detected in a riffle/run sequence (NSO 065-066) located 260 to 425 m downstream of the initial point of capture. On September 9, this tag was detected in a run habitat unit approximately 400 m downstream (NSO 067) of the lower boundary of the riffle/run sequence (NSO 065-066).

Tag 7124.8 was implanted in a female adult *O. mykiss* captured in the pool at NSO 087 on March 29, and this fish exhibited the shortest range of movement. On April 1 and 27, this tag was detected within this same pool (NSO 87). Between May 20 and July 27 this tag was detected in a riffle (NSO 089) 95 to 145 m downstream of the point of capture. On September 9, this tag was detected back in the pool where it was originally captured.

Tag 7194.8 was implanted in a female adult *O. mykiss* captured in the pool at NSO 087 on March 29. On April 1 and 27, this tag was detected within this same pool (NSO 87). On May 20 and June 15 this tag was detected approximately 600 m upstream in another pool directly below the mouth of Peaslee Creek (NSO 081). By July 7 this fish had returned to the pool where it was originally captured (NSO 87), and remained here through at least July 27. On September 9, the tag was detected in a run (NSO 083) approximately 200 m upstream.

Discussion

Spawning locations of tagged adult O. mykiss

Peak spawning activity likely occurs during January through March (McEwan 1996), and initiation of this study was delayed until March 2010 due to permitting issues, which precluded the opportunity to determine spawning locations of tagged *O. mykiss* during winter 2010. However, possible *O. mykiss* redds were identified in riffle NSO 033, and a large female *O. mykiss,* which appeared to have recently spawned, was captured nearby in the same unit suggesting that it may have spawned at this location.

Adult *O. mykiss* tagged during fall 2010 will be tracked during the expected winter spawning period (January-March 2011). It is recommended that tagging should occur during fall 2011 to ensure adequate tag life (estimated at 6-12 months) for tracking through the expected spawning period during January-March 2012, to avoid tagging ripe individuals, and to provide adequate recovery time prior to the expected spawning period.

Use of restored river reaches by tagged adult O. mykiss

During 2010, adult *O. mykiss* were not captured or detected in restored reaches of the Tuolumne River. However, two fish were captured and tagged (tags 7054.8 and 7068.8) just downstream of the CDFG gravel introduction riffle 1A/1B (NSO 18-22) 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.

A total of 47 sites have been identified as sensitive *O. mykiss* habitat between La Grange Dam and Roberts Ferry Bridge (McBain&Trush 2004), and 85% of the adult *O. mykiss* tagged during 2010 were detected in these locations. However, adult *O. mykiss* were only detected in 19% (n=8) of the sensitive habitat sites surveyed.

Migration patterns of tagged adult O. mykiss

During 2010, movements of six tagged adult *O. mykiss* were tracked from early spring through fall under highly varying flow conditions due to flood control operations. Each of the six tagged *O. mykiss* tracked from early spring through fall exhibited both upstream and downstream movements, with no apparent correlations to flow or water temperature. However, conclusions are limited by the small sample size and highly variable instream conditions during the study period. All tagged *O. mykiss* remained in the Tuolumne River during the 2010 monitoring period.

Operation of fixed station acoustic arrays also provided information on straying of hatchery produced *O. mykiss* into the Tuolumne River. An acoustically tagged Mokelumne River Hatchery produced yearling *O. mykiss* released in Old River as part of DWR's South Delta Barriers Study was detected in the Tuolumne River at Grayson, and another five tagged *O. mykiss* from the same study releases were detected entering the Stanislaus River, indicating that at least 2% of the fish released strayed into the San Joaquin Basin tributaries. Straying of hatchery produced *O. mykiss* has also been documented at the Stanislaus River Weir.

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Appendix A. 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.

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UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

2010 LOWER TUOLUMNE RIVER ANNUAL REPORT

Report 2010-8

2010 Counting Weir Report

Prepared by

Chris Becker
Ryan Cuthbert
and
Andrea Fuller

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Oakdale, CA

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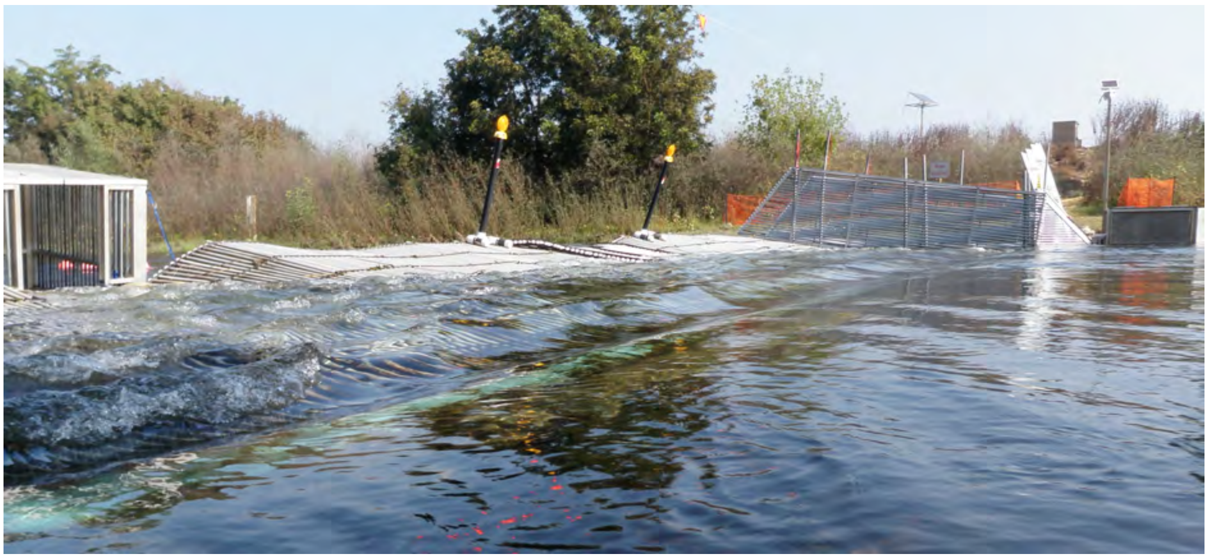
Fall/Winter Migration Monitoring at the Tuolumne River Weir

2010 Annual Report



Submitted To:
Turlock Irrigation District
Modesto Irrigation District

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March 2011

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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 with environmental 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.

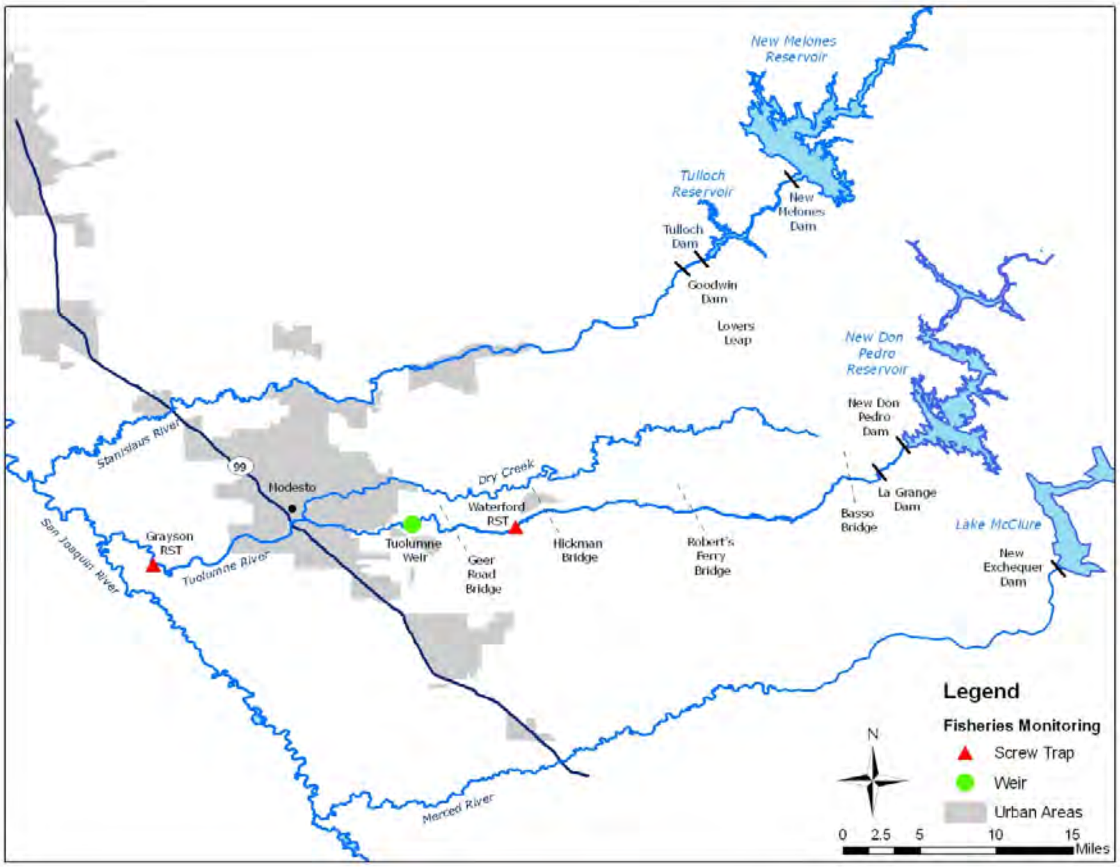

Figure 1. Map of the Tuolumne River displaying the location of the Tuolumne River Weir and other key points of interest.

Methods

A resistance board weir (Tobin 1994; Stewart 2002, 2003) and Vaki Riverwatcher fish counting system (Vaki system) were installed in the Tuolumne River at RM 24.5 on September 9, 2010, monitoring continued until December 1, 2010 when the weir and the Vaki were removed in anticipation of high flow, due to flood control releases, that were expected to exceed the operational threshold (i.e. >1,300 cfs; Figure 8). The weir was not re-installed, as flows remained high throughout the remainder of the fall-run Chinook salmon migration period.

Some modifications were made to the weir design prior to the 2010 season to facilitate passage of fish through the weir. Modifications included: removal of the upstream trap (Figure 2), removal of the fyke at the entrance to the camera viewing lane (Figure 3); removal of a nine foot section of substrate rail; removal of three resistance board panels (i.e. nine feet); installation of two floating bulkheads; and installation of a large nine foot wide by five foot high aluminum fyke (Figure 4). Since the upstream trap was removed no trapping was conducted this season.

Figure 2. Tuolumne River Weir upstream trap and camera box before modifications (left photo) and camera box (upstream trap removed) after modifications (right photo).

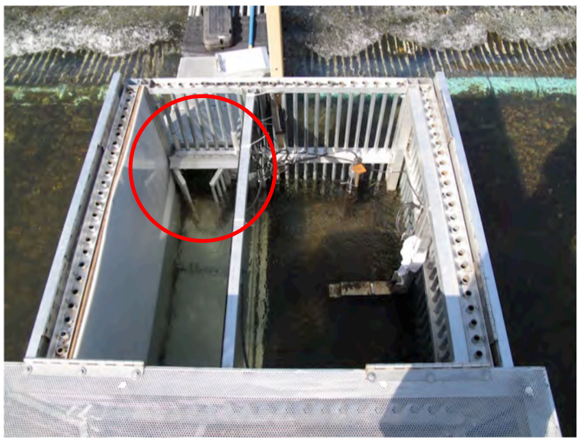

Figure 3. Tuolumne River camera viewing lane before modifications. Circle indicates fyke that was removed.

Figure 4. Tuolumne River Weir passage chute before modifications (left photo) and after modifications (right photo).

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 nine occasions due to debris, and the entire length of the weir was briefly over-topped on October 11, 2010 (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 5).

Table 1. Date, time, and flow of weir over-topping occasions.

Date	Time (hhmm)	Average Daily Flow (cfs)
Sept. 14	0845	309
Sept. 15	1200	312
Sept. 17	0830	309
Sept. 20	1245	307
Oct. 3	1145	358
Oct. 7	0840	857
Oct. 9	0900	860
Oct. 11	1200	855
Nov. 5	1130	361
Nov. 28	1115	619

Figure 5. 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 6).

Figure 6. 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 (Figure 6), and data was relayed to a computer system that generated infrared silhouettes and video clips of passing objects (Figure 7). 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 8). 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 7. 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 8. 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 9), fish condition, and gender.

Video 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.

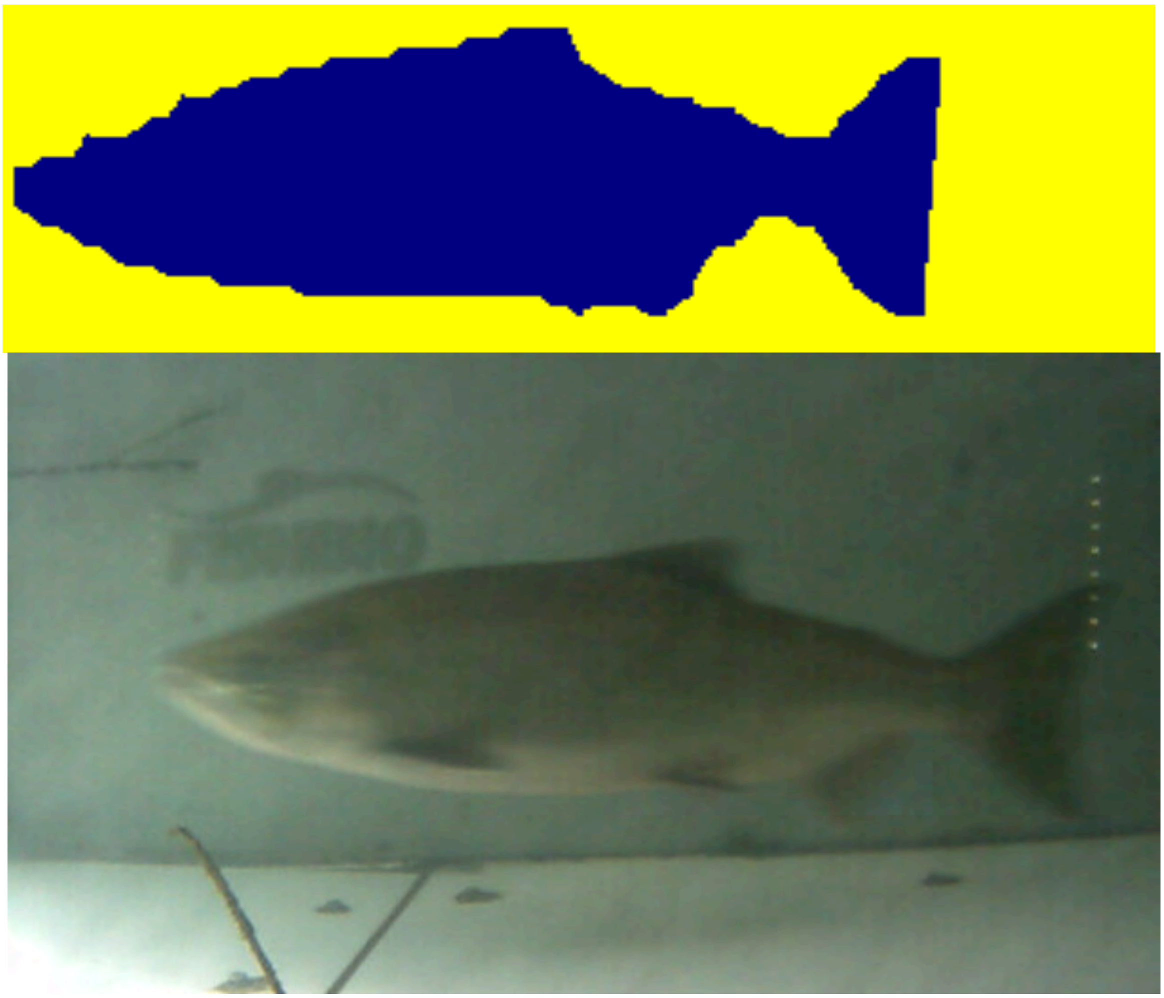

Figure 9. Example of a silhouette image and screen capture from a video clip of the same Chinook salmon that has a clipped adipose fin (ad-clip). Note: Video clips are a higher quality image than the screen capture.

Physical data collected during each weir check included water temperature (°F), dissolved oxygen (mg/L), turbidity (NTU), weather conditions (RAN = rain, CLD = cloudy, CLR = clear, FOG = fog), and water velocity (ft/s) measurements at the opening of the livebox. Instantaneous water temperature and dissolved oxygen were recorded using an Exstick II model DO600 Dissolved Oxygen Meter (Extech Intruments Corporation). Hourly water temperature data was logged using an iBCod type G submersible data logger (Alpha Mach, Inc.). 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 California Data Exchange Center (CDEC).

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 1. 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 will be removed from the weir until CDFG allowed normal operations to resume.

At the request of California Department of Fish and Game an overhead video system was installed to observe fish behavior associated with the weir (Figure 10); however, the overhead video equipment did not give us high enough quality imagery to successfully make any observations. However, only one fish was observed downstream of the weir during visual assessments from a boat, resulting in a maximum stacking ratio of 0.07 for the season, which is substantially less than the 1.15 threshold.

Figure 10. Overhead camera system circled in yellow.

Results

Chinook salmon abundance and migration timing

Between September 9, 2010 and December 1, 2010, the Riverwatcher detected 785 adult fall-run Chinook salmon as they passed upstream of the weir (Figure 11). Due to flood control releases on the Tuolumne River monitoring ended on December 1.

Daily passage ranged between zero and 50 Chinook (Figure 11). Most Chinook salmon passage significantly decreased during the day (1000 hours – 1559 hours), increased at dusk and night (1600 – 2159 hours and 2200 – 0359 hours; respectively), and remained high during the dawn (0400 – 0959 hours) (ANOVA: $F = 8.71, P = 0.01E03$) (Figure 12).

During 2009, 17.6% of fall-run Chinook salmon passed between December 1 and December 31, 2009. If it is assumed that the same proportion of Chinook salmon passed during the same time period in 2009, it is estimated that an additional 138 adult fall-run Chinook salmon may have passed the weir site undetected.

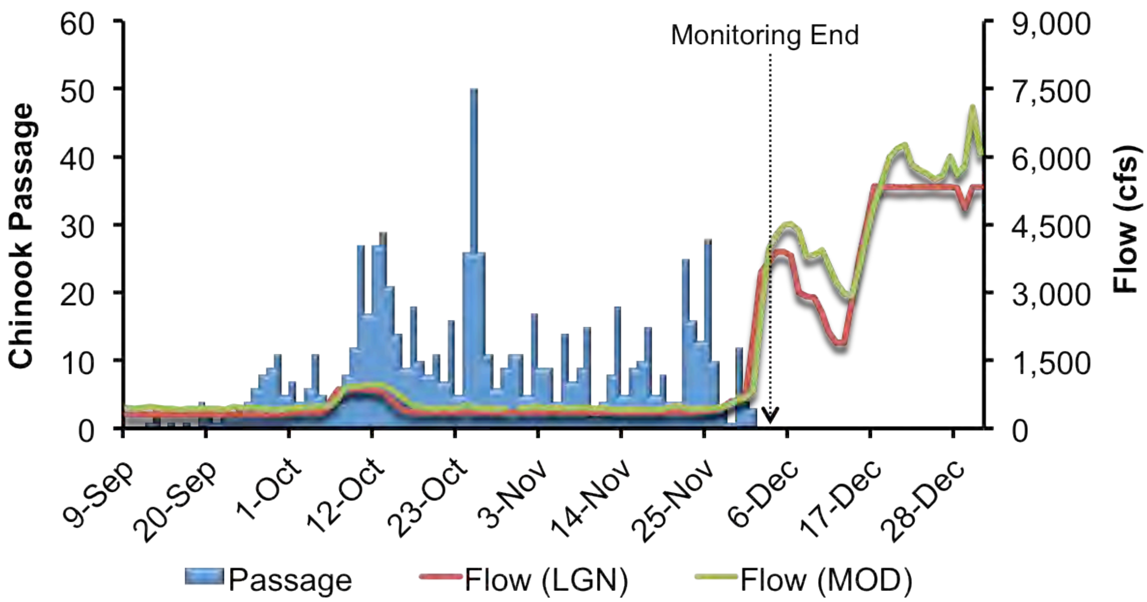

Figure 11. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to daily average flows (cfs) recorded in the Tuolumne River at La Grange (LGN) and Modesto (MOD) between September 9, 2010 and December 31, 2010 [Data source: CDEC – http://cdec.water.ca.gov].

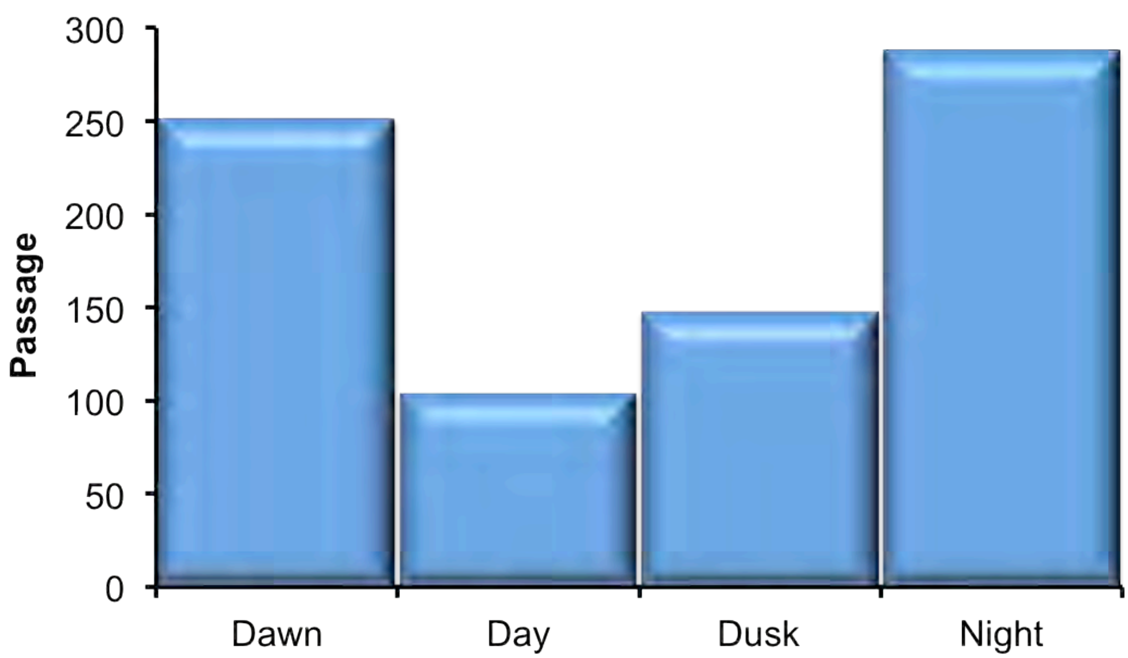

Figure 12. Chinook salmon passage in 6-hour time blocks. Diel Chinook salmon passage was not significant among the different time periods (ANOVA: *F = 8.71, P = 0.01E03*).

One post-spawn male fall-run Chinook salmon carcass was recovered from the top of the weir and one ripe (pre-spawn) male Chinook carcass was impinged between the resistance weir and the substrate on September 22, 2010 (Table 2).

Table 2. Post-spawn and pre-spawn (ripe) fall-run Chinook salmon carcasses recovered from the Tuolumne River Weir between September 9, 2010 and December 1, 2010.

Species	Date	TL (mm)	Adipose Fin Clip	Sex	Post-spawn
Chinook salmon	9/22/10	1,010	No	Male	No
Chinook salmon	11/11/10	760	No	Male	Yes

<u>Chinook salmon gender and size</u>

Total fall-run Chinook salmon passage was composed of 40% male (n = 317), 42% female (n = 326), and 18% unknown (n = 142). Mean total length for Chinook salmon upstream passages were: 708 mm (n = 398) for male, 693 mm (n = 387) for female, 550 mm (n = 194) for unknown; and 670 mm for all Chinook combined (Table 3). While mean lengths were similar for male and female salmon, the length frequency distributions differed with males predominately the 550 – 600 mm size class and females were predominately the 750 – 800 mm size class (Figure 13).

<u>Origin of Chinook salmon production</u>

Adipose fin clips, suggesting hatchery origin, were observed in 32% of Chinook counted at the Tuolumne River weir during 2010. 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 3. Fall-run Chinook salmon upstream passage data from September 9, 2010 through December 1, 2010 (upstream passage counts only, data are not directly comparable to net passage). Parenthesis indicate range.

Sex – Adipose fin clip	Mean TL (mm)	95% CI (mm)	n
Male – No	748 (472 - 1,033)	748 ± 17	243
Male – Yes	650 (480 - 943)	650 ± 18	128
Male – Unknown	625 (500 - 972)	625 ± 41	27
Female – No	733 (463 - 940)	733 ± 12	234
Female – Yes	629 (450 - 845)	629 ± 15	136
Female – Unknown	656 (446 - 841)	656 ± 43	19
Unknown – No	670 (217 - 915)	670 ± 41	64
Unknown – Yes	423 (167 - 865)	423 ± 47	55
Unknown – Unknown	543 (209 - 1,003)	541 ± 41	82

Combined	670 (167 - 1,033)	671 ± 10	984

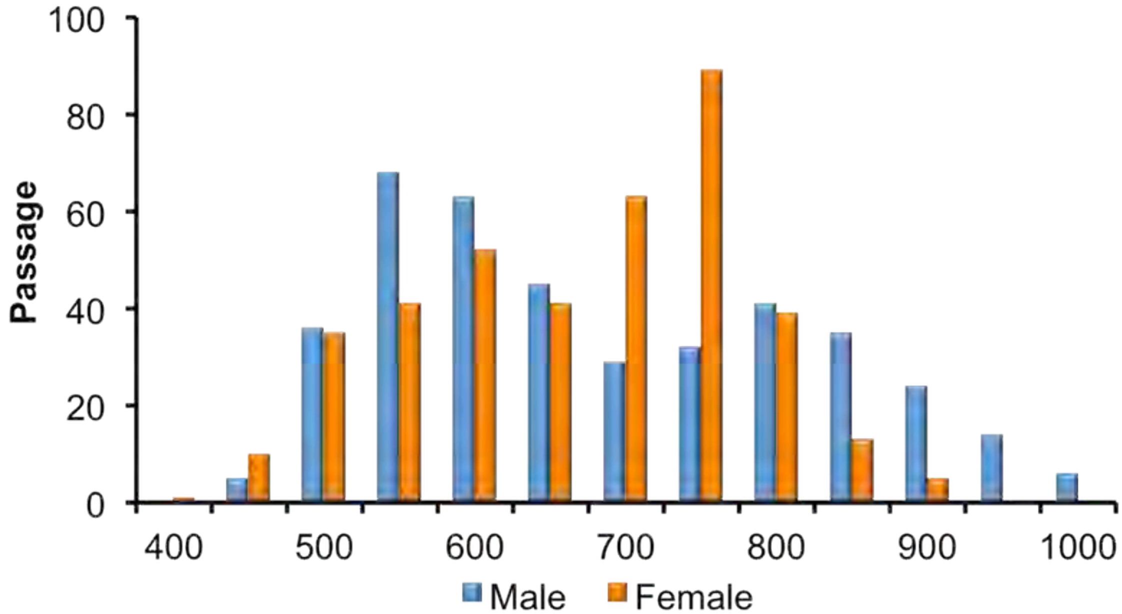

Figure 13. Length frequency of male and female fall-run Chinook salmon passage (upstream passage counts only, data are not directly comparable to net passage).

<u>*O. mykiss*</u>

No *O. mykiss* were recorded passing through the weir between September 9, 2010 and December 1, 2010.

<u>*Non-salmonids*</u>

There were 11 other species identified passing the weir including American shad (*Alosa sapidissima*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), goldfish (*Carassius auratus*), largemouth bass (*Micropterus salmoides*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), smallmouth bass (*Micropterus dolomieu*), striped bass (*Morone saxatilis*), white catfish (*Ictalurus catus*); as well as unknown species of black bass (*Micropterus spp*.), catfish (*Ameiurus spp. and Ictalurus spp*.), and sunfish (Lepomis spp.) (Table 4). There were 67 passages that were identified as fish, but could not be identified to species.

Table 4. Incidental species passage data from September 9, 2010 through December 1, 2010 (upstream passage counts only, data are not directly comparable to net passage). Parenthesis indicates range.

Native Species	Mean TL (mm)	Date Range	Total Passage
Sacramento blackfish	359 (218 – 582)	9/14/10 – 11/30/10	14
Sacramento pikeminnow	272 (208 – 374)	9/13/10 – 11/30/10	63
Sacramento sucker	390 (224 – 767)	9/10/10 – 12/1/10	141
Non-native Species	Mean TL (mm)	Date Range	Total Passage
American shad	250 (247 – 253)	9/17/10 – 9/19/10	2
Common carp	466 (167 – 914)	9/12/10 – 12/1/10	572

Channel catfish	425 (252 – 945)	9/15/10 – 10/31/10	9
Goldfish	339 (303 – 405)	9/18/10 – 11/8/10	4
Largemouth bass	270 (174 – 596)	9/17/10 – 11/30/10	53
Smallmouth bass	276 (148 – 377)	9/25/10 – 11/29/10	8
Striped bass	346 (180 – 878)	9/11/10 – 11/30/10	38
White catfish	336 (180 – 518)	9/11/10 – 11/28/10	102
Unknown – black bass	270 (174 – 500)	9/10/10 – 11/30/10	79
Unknown – catfish	300 (180 – 473)	9/13/10 – 11/29/10	44
Unknown Species	**Mean TL (mm)**	**Date Range**	**Total Passage**
Unknown – sunfish	117 (84 – 134)	9/25/10 – 9/29/10	3
Unknown	462 (240 – 1,008)	9/12/10 – 11/25/10	67

Environmental Conditions

Between September 9, 2010 and December 1, 2010 daily average flow at La Grange (LGN; RM 51.8) ranged between 304 cfs and 860 cfs (399 cfs season average). After the weir was removed, flows ranged between 1,890 cfs and 5,350 cfs through December 31, 2010. Daily average flow at Modesto (MOD; RM 17) ranged between 417 cfs and 968 cfs (502 cfs season average) during weir monitoring and from 2,530 cfs to 7,100 cfs during December after the weir was removed (Figure 11).

Instantaneous water temperatures measured at the weir ranged between 48.3˚F and 70.1˚F (59.7˚F season average; Figure 14). Instantaneous turbidity ranged between 0.22 NTU and 3.48 NTU (1.35 NTU season average; Figure 15), and instantaneous dissolved oxygen ranged between 7.47 mg/L and 10.87 mg/L (8.78 mg/L season average; Figure 16).

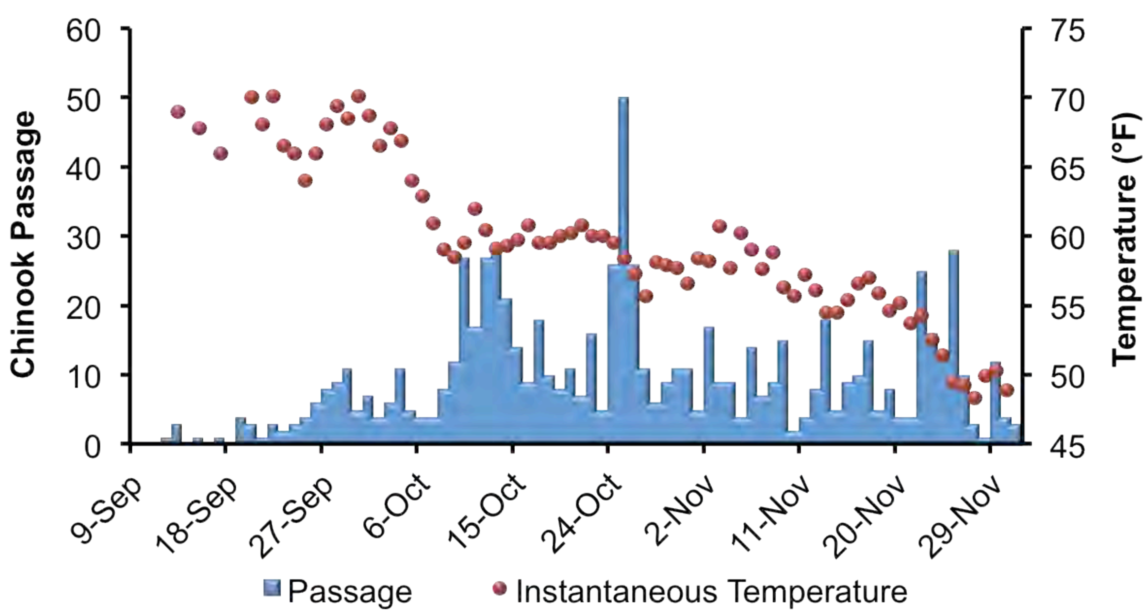

Figure 14. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous water temperature (°F) at the weir and daily average water temperature (°F) at Modesto (MOD) between September 9, 2010 and December 1, 2010 [Data source: CDEC – http://cdec.water.ca.gov].

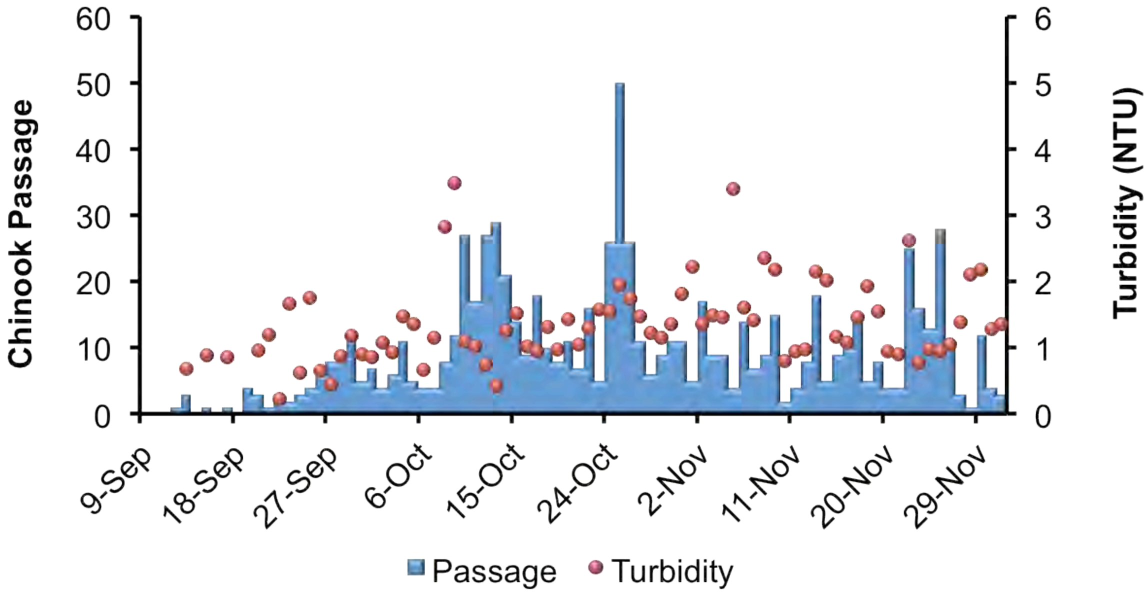

Figure 15. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous turbidity (NTU) between September 9, 2010 and December 1, 2010.

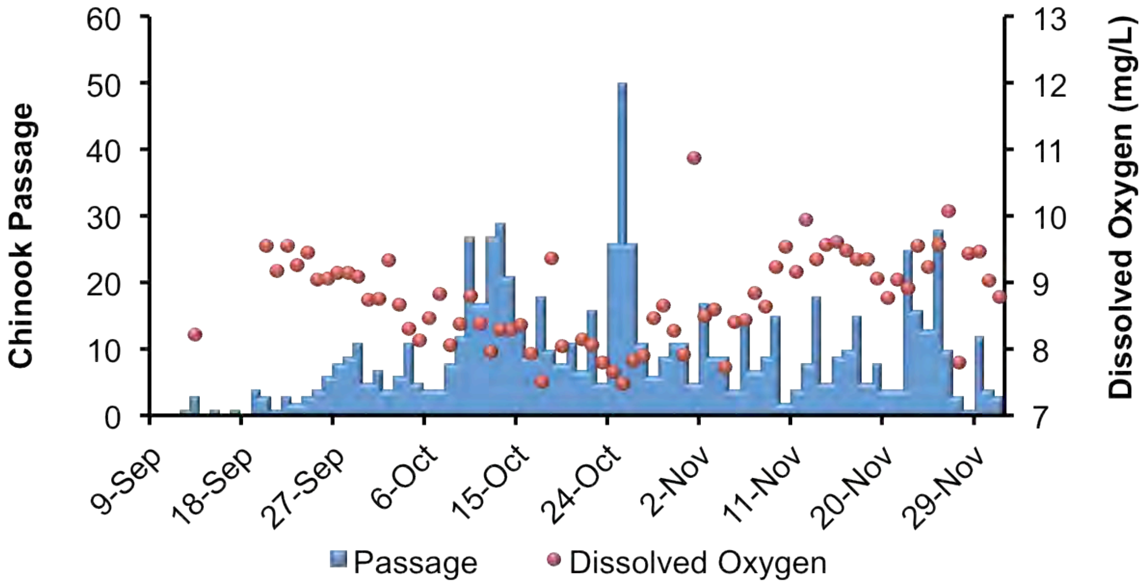

Figure 16. Daily upstream Chinook passage recorded at the Tuolumne River Weir in relation to instantaneous dissolved oxygen (mg/L) between September 9, 2010 and December 1, 2010.

Discussion

The Vaki Riverwatcher detected 785 fall-run Chinook salmon during 2010, which represents a substantial increase over the previous year (Table 4). It is estimated that an additional 138 adult fall-run Chinook salmon may have passed between December 1 and December 31 when the weir was removed due to elevated flows (due to flood control releases) that exceed the operational range of the weir. 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.

Table 4. 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
2010	Fall	September 9 – December 1	785
	Unknown	No sample	-
2009	Fall	September 22 – December 31	264
	Unknown	January 1 – February 10	31

Approximately 31% of the Chinook salmon observed at the Tuolumne River weir were two-year-old fish (≤ 600 mm TL), and the majority (56%) 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.

The Tuolumne River Chinook salmon population is not supplemented with hatchery fish however, the 2010 fall-run was comprised of 33% 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 2010. 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 weir counts and carcass survey differed greatly during 2010, demonstrating the importance of weir monitoring in this system. At the Tuolumne weir, 791 fall-run Chinook salmon were counted while the preliminary adjusted Petersen estimate based on carcass survey data was only 540 fall-run Chinook salmon (CDFG GrandTab). Similarly, carcass surveys also underestimated Chinook salmon escapement to the Stanislaus River during the September to December 2010 period and the Tuolumne River during the previous year. Although the weir was removed prematurely due to elevated flows, the ability for researchers to recover tagged-carcasses during carcass surveys violates assumptions that the adjusted Petersen model must adhere to establish any confidence in the escapement estimate.

In addition to providing information on migrating adult fall run Chinook salmon, the weir also provided information on the movement and sizes of 11 non-salmonid species observed passing the weir. Most (81%) of the non-salmonid species were non-native, any 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.

Although we were unable to observe fish passage behavior with the overhead video monitoring the calculated stacking ratio and visual assessments downstream of the weir suggest that the fish passage modifications provided improved fish passage conditions at the weir.

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