Lower Mokelumne River Salmonid Redd Survey Report:
October 2014 through February 2015

September 2015

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Key words: lower Mokelumne River, salmonid, fall-run Chinook salmon, steelhead, rainbow trout, redd survey, spawning, superimposition, gravel enhancement

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Abstract

Weekly fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and winter-run steelhead/rainbow trout (*O. mykiss)* spawning surveys were conducted on the lower Mokelumne River from 6 October 2014 through 23 February 2015. Estimated total escapement during the 2014/2015 season was 12,117 Chinook salmon. The estimated number of in-river spawners was 3,301 Chinook salmon. The first salmon redd was detected on 20 October 2014. During the surveys, 911 salmon redds were identified. Sixty-two (6.8%) Chinook salmon redds were superimposed on other Chinook salmon redds and 474 (52%) redds were located within spawning habitat restoration sites. The reach from Camanche Dam to Mackville Road (reach 6) contained 745 (82%) salmon redds and the reach from Mackville Road to Elliott Road (reach 5) contained 166 (18%) salmon redds. The highest number of Chinook salmon redds (252) was detected during survey week 9 (1 and 4 December 2014). Sixty-three *O. mykiss* redds were identified during the surveys. The first *O. mykiss* redd was found on 30 December 2014. Nine *O. mykiss* redds were superimposed on Chinook salmon redds. Twelve (19%) *O. mykiss* redds were located within spawning habitat restoration sites. Reach 6 contained 33 (52.3%) *O. mykiss* redds and reach 5 contained 30 (47.7%) *O. mykiss* redds. The highest number of *O. mykiss* redds (21) was detected on 26 January 2015.

INTRODUCTION

The Mokelumne River is an east-Delta tributary that drains more than 1,642 square kilometers (600 square miles) of the western slope of the Sierra Nevada with headwaters at an elevation of 3,048 meters (10,000 feet) on the Sierra Nevada Crest (Jones and Stokes 1999). The Mokelumne River currently has 16 major water impoundments including Salt Springs Reservoir, Lower Bear River Reservoir, Pardee Reservoir and Camanche Reservoir. Water releases to the lower Mokelumne River (LMR) are controlled by Camanche Dam. The LMR is approximately 103 river kilometers (rkm) in length from the confluence with the San Joaquin River (rkm 0) and Camanche Dam (the first major impoundment and limit to anadromy, rkm 103). The construction of Camanche Dam was completed in 1963 and blocked upstream passage of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) to much of the available historical spawning habitat in the Mokelumne River. Most of the available spawning habitat in the LMR is now limited to the 15.8 km (9.8 mile) section of river directly downstream of Camanche Dam (Setka and Bishop 2003).

Pardee and Camanche reservoirs and associated power generating facilities are owned and operated by the East Bay Municipal Utility District (EBMUD) and regulated by the Federal Regulatory Energy Commission (FERC Project P-2916), which provides water for approximately 1.3 million customers in Alameda and Contra Costa counties. Additional reservoirs and power generation facilities are located upstream of Pardee Reservoir and are owned and operated by Pacific Gas & Electric Company (PG&E). Downstream of Camanche Dam, Woodbridge Irrigation District (WID) operates Woodbridge Irrigation District Dam (WIDD) and an associated system of irrigation canals near Lodi, CA.

The LMR is utilized for spawning and rearing by fall-run Chinook salmon and both resident and anadromous forms of *O. mykiss*. Adult Chinook salmon ascend the LMR as early as August and may begin spawning in early September. Spawning activity usually peaks in November and tapers off through the month of December (Hartwell 1996; Marine and Vogel 1994; Setka 1997). The Mokelumne River Fish Installation (MRFI) was constructed in 1964 to mitigate for spawning habitat lost during the construction of Camanche Dam and receives approximately 57% of the total run per year (1990-2013 average). EBMUD has conducted annual spawning surveys on the LMR since 1990 (Hagar 1991; Hartwell 1996; Setka 1997). EBMUD conducts video monitoring at WIDD to assess the upstream passage of anadromous fishes. Video monitoring provides an escapement estimate of the total number of Chinook salmon and steelhead returning to the LMR each season.

OBJECTIVES

The primary objective of the 2014/2015 salmonid redd surveys (referred to as the 2014 season) was to enumerate Chinook salmon and *O. mykiss* redds in the LMR. Additional objectives of the redd surveys included:

- Determine the spatial and temporal distribution of redds in the LMR;
- Enumerate redds impacted by superimposition; and
- Determine use of spawning habitat restoration (SHR) sites.

METHODS

Surveys

The LMR is divided into six reaches between Camanche Dam and the confluence with the San Joaquin River. Reach delineations are based on gradient, substrate, and tidal influence. The majority of salmonid spawning habitat on the LMR is available in reaches 5 and 6. Therefore, redd surveys were conducted within reaches 5 and 6. Specifically, the surveys took place within a 16-rkm reach, from rkm 103 (the base of Camanche Dam) downstream to rkm 87.4 (Figure 1). Weekly redd surveys began on 6 October 2014 and were concluded on 23 February 2015. Both reaches were surveyed once per week during this time frame. Surveys consisted of two to three individuals walking abreast downstream (water depths up to 1.1 meters) searching for redds. This method has been

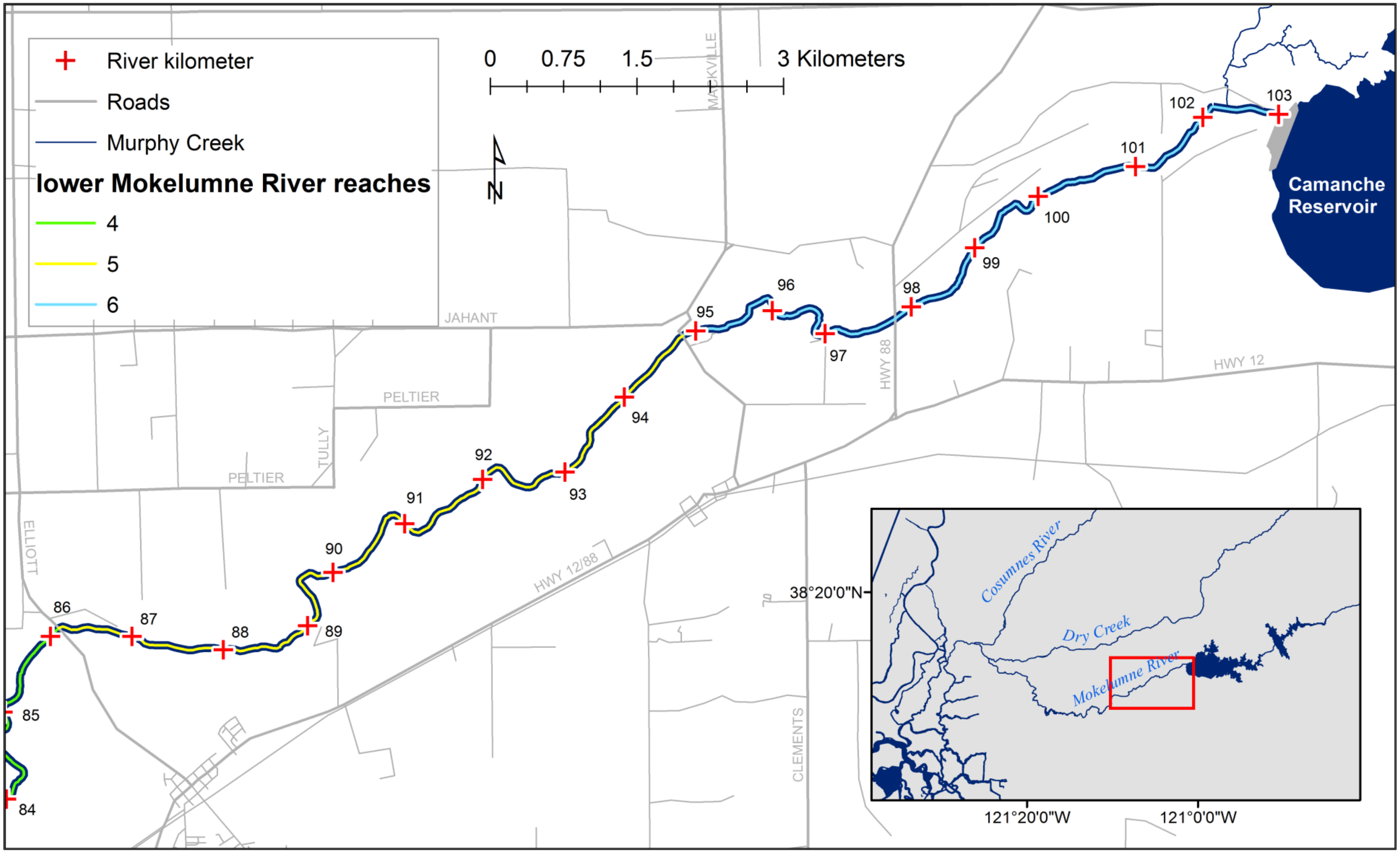

Figure 1. The location of river reaches 5 and 6 on the lower Mokelumne River, where salmonid redd surveys took place during the 2014 season.

used in past LMR spawning surveys and in other rivers and streams (Keefe et al. 1994; Fritsch 1995; Hartwell 1996; Setka 1997). A drift boat was used to transport surveyors between spawning areas and was also used to search for redds in areas that were not wadeable.

In previous years, redd locations were marked with numbered cattle ear tags and/or colored bricks. More recently, however, Global Navigation Satellite Systems (GNSS) have been used to mark salmonid redd locations. The Trimble Geo XH GNSS units record more accurate positions (<1 meter real-time) and have the capability to display previously recorded data in the field. The ability to see data from previous surveys eliminated the need to physically mark redds and reduced the potential of counting a redd more than once. Surveyors positioned themselves directly downstream of each redd and recorded the position of the tailspill. Care was taken to avoid impacting redds during the surveys.

Surveyors determined if previously detected redds were superimposed based on the amount of time that had elapsed since a redd was first detected. A 3-week (21 days) filter was used to help distinguish older redds from newly constructed redds. The filter was based on the estimated life of fall-run Chinook salmon redds (Gallagher et al. 2007). All visible occurrences of redd superimposition were recorded.

Throughout the 2014 salmonid redd surveys, a subset of water depth and velocity measurements was recorded just above the nose of Chinook salmon and *O. mykiss* redds. To assess spatial and temporal variability, a subsample of, water depth and velocity data were recorded from one of every nine Chinook salmon redds detected throughout the survey period. Because fewer *O. mykiss* redds are detected on an annual basis, water depths and velocities were measured at nearly half of the *O. mykiss* redds detected during the survey period. Water depth measurements were recorded to the nearest centimeter (cm) using a top-setting rod. Velocity measurements were taken using a Flo-Mate™ portable velocity meter (Marsh McBirney, Inc.) at 60% of the depth and were recorded in meters per second (m/s).

Surface water temperature and flow data were obtained from EBMUD gauging stations at Camanche Dam (rkm 103), McIntire (rkm 101), and Elliot Road (rkm 86). In addition, a total of sixteen HOBO TidbiT© waterproof temperature loggers were buried below the gravel surface on 6 October 2014 to record subsurface water temperatures on an hourly basis. Two temperature loggers were buried at depths of 25 cm and 40 cm within eight spawning sites between Camanche Dam (rkm 103) and Elliot Road (rkm 86). A Trimble Geo XH™ GNSS unit was used to mark the burial locations of the temperature loggers. The temperature loggers were recovered from the gravel on 23 April 2015, after the majority of Chinook salmon fry were predicted to have emerged from their redds according to an egg model developed by Vogel (1993).

Data Collection and Analysis

A minimum of ten points were recorded on the GNSS unit at each redd location and point data files were stored using Terrasync 5.21 software. After field data were collected, the data files were downloaded and processed using GPS Pathfinder Office 5.30 software. Once downloaded, geographic positions were corrected using the nearest base data providers. The point data files were then imported to an ArcMap 10.0 (ESRI) database.

Data analyses were performed using ArcMap 10.0 (Arc/Info (ESRI) systems), JMPIN 9.0.0 (Academic), Microsoft (MS) Access 2010 and MS Excel 2010. A P-value ≤ 0.05 was considered statistically significant.

RESULTS

Environmental Data

In 2014, a series of pulse flows were released throughout October and November (Figure 2). Average daily flow from Camanche Dam peaked above 300 cubic feet per second (cfs) during six pulses, with the second having the largest magnitude of 491 cfs on 14 October 2014.

During the redd survey period (6 October 2014 – 23 February 2015) average daily discharge from Camanche Dam ranged from 228 to 491 cfs (Figure 2). The average daily flow during this time period was 275 cfs. The average daily flow when Chinook salmon redds were detected (20 October 2014 through 17 February 2015) ranged from 228 to 407 cfs and averaged 273 cfs. The average daily flow when *O. mykiss* redds were detected (30 December 2014 through 23 February 2015) ranged from 234 cfs to 346 cfs and averaged 270 cfs.

Average daily surface water temperatures at the McIntire gauging station (rkm 101, reach 6) ranged from 10.1°C to 17.5°C during the survey period (Figure 2). The average temperature during this time frame was 13.8°C. The average daily water temperatures during the time period salmon redds were detected (20 October 2014 through 17 February 2015) ranged from 10.1°C to 17.3°C and averaged 13.4°C . The average daily water temperatures during the time period when *O. mykiss* redds were detected(30 December 2014 through 23 February 2015) ranged from 10.1°C to 12.2°C and averaged 10.9°C.

Fourteen of the sixteen temperature loggers were recovered from below the gravel surface at burial depths of 25 cm and 40 cm on 23 April 2015. The remaining two temperature loggers, buried at rkm 100.3, were not recovered. A comparison of maximum daily subsurface water temperatures recorded at burial depths of 25 and 40 cm and maximum daily surface water temperatures at the McIntire (rkm 101) and Elliot Road (rkm 86) gauging stations is presented graphically in Figure 3.

Maximum daily subsurface water temperatures recorded at 25 cm below the gravel surface during the first half of the incubation period for the majority of Chinook salmon

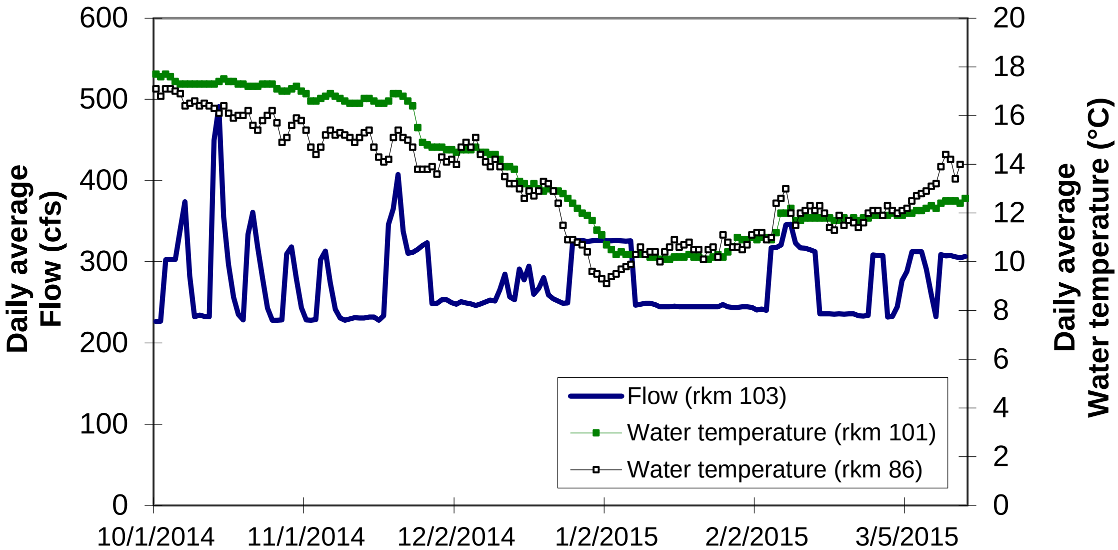

Figure 2. Average daily discharge from Camanche Dam (rkm 103) and surface water temperatures at the McIntire gauging station (rkm 101) and the Elliot Road gauging station (rkm 86) in the lower Mokelumne River during the 2014 salmonid redd surveys.

embryos (20 October through 22 December 2014) averaged 15.6°C and ranged between 13.4 and 17.5°C. During the same time frame, maximum daily subsurface water temperatures recorded at 40 cm below the gravel surface averaged 15.5°C and ranged between 13.3 and 17.3°C. Prior to 25 November 2014, daily maximum surface water temperatures at the McIntire gauge were higher than all daily maximum subsurface water temperatures, regardless of burial depth (Figure 3). Daily maximum surface water temperatures recorded at the Elliot Road gauging station were generally lower than all daily maximum subsurface water temperatures recorded on or before 3 January 2015.

Maximum daily subsurface water temperatures recorded at 25 cm below the gravel surface during the second half of the incubation period for Chinook salmon embryos (23 December 2014 through 23 February 2015) averaged 11.9°C and ranged between 10.0 and 13.9°C. During the same time frame, maximum daily subsurface water temperatures recorded at 40 cm below the gravel surface averaged 11.7°C and ranged between 9.9 and 13.8°C. In general, daily maximum surface water temperatures at the McIntire gauge were similar to, or slightly lower than, most daily maximum subsurface water temperatures recorded during the second half of the incubation period. Daily maximum surface water temperatures recorded at the Elliot Road gauging station were more variable than water temperatures at the McIntire gauge, rising above and falling below daily maximum subsurface water temperatures.

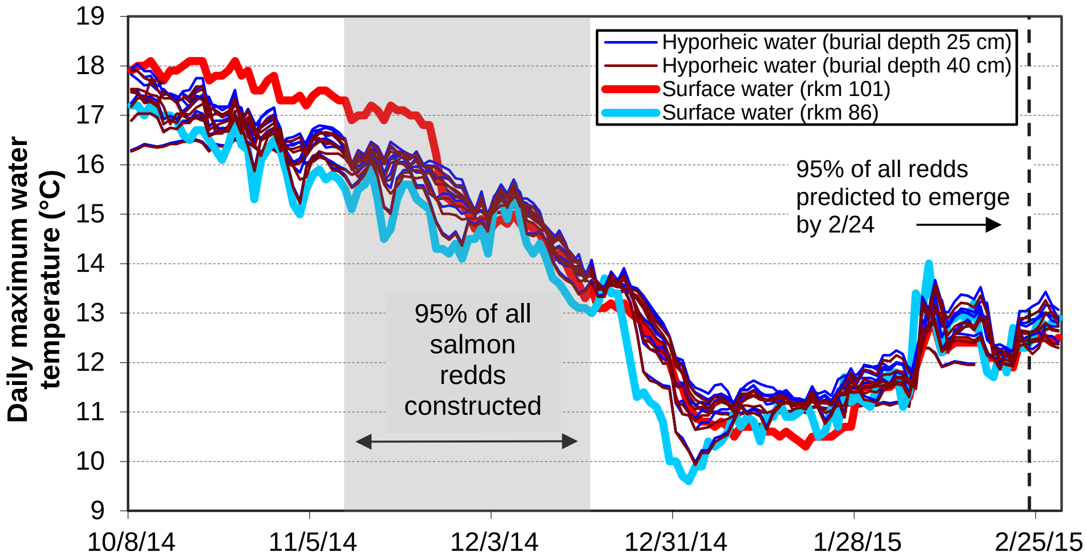

Figure 3. Maximum daily surface and subsurface (hyporheic) water temperatures recorded on the lower Mokelumne River during the 2014 redd survey season.

During the first half of the incubation period (20 October through 22 December 2014), maximum daily subsurface water temperature was significantly different by site (two-way ANOVA: $F_{6, 888}$ = 3.22, P = 0.0039), however, maximum daily subsurface water temperature was not significantly different by burial depth (two-way ANOVA: $F_{1, 888}$ = 1.19, P = 0.2762). Subsurface water temperature at the spawning riffle farthest downstream from Camanche Dam (Redwood Island, rkm 90.2) was significantly lower than subsurface water temperature at three spawning riffles located in reach 6 (rkm 97.2, 101.0, 101.8).

During the second half of the incubation period (23 December 2014 through 23 February 2015), maximum daily subsurface water temperature was significantly different by site (two-way ANOVA: $F_{6, 874}$ = 6.03, P <0.0001) and burial depth (two-way ANOVA: $F_{1, 874}$ = 4.90, P = 0.0271). Subsurface water temperature at the spawning riffles farthest downstream from Camanche Dam and closest to Camanche Dam (rkm 90.2 and 102.7) was significantly lower than subsurface water temperature at all other riffles (rkm 93.6, 94.7, 97.2, , 101.0, 101.8). Subsurface water temperature at burial depths of 25 cm was significantly higher than subsurface water temperature at burial depths of 40 cm.

Chinook Salmon

<u>Redd totals and escapement</u>

During the 21 week redd survey period, 911 Chinook salmon redds were detected. The first and last redd detections occurred on 20 October 2014 and 17 February 2015, respectively. The highest number of redds (252) was detected during survey week 9 on 1 and 4 December 2014 (Figure 4). Reach 6 contained 745 redds (82%) and reach 5 contained 166 redds (18%). Weekly surveys were scheduled to avoid storm events during the 2014 survey season, for improved water clarity and detection ability.

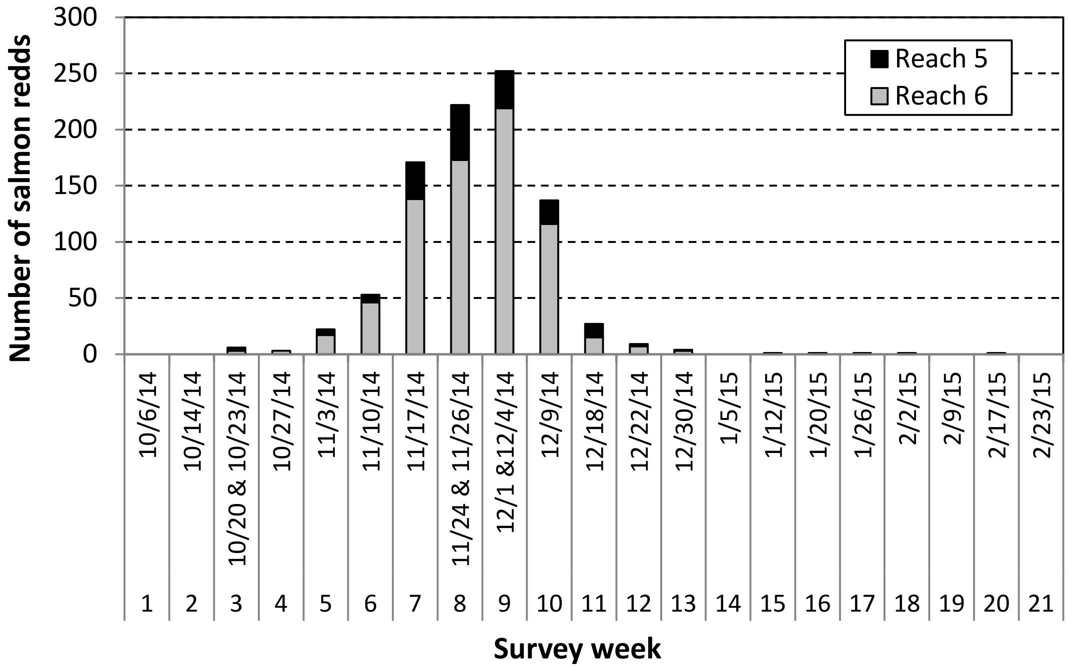

Figure 4. Weekly Chinook salmon redd totals by reach on the lower Mokelumne River during the 2014 surveys.

The 2014 annual redd count was 118% of the long term average (1990-2013) of 774, 146% of the pre-Joint Settlement Agreement (JSA) average (1990-1997) of 625, and 107% of the post-JSA average (1998-2013) of 849 (Figure 5).

To estimate fall-run Chinook salmon escapement in the LMR during the 2014 season, video monitoring was conducted at WIDD from 1 August 2014 to 31 March 2015. During this time, 12,117 Chinook salmon were counted passing the fish ladders at WIDD. The total count of Chinook salmon that entered the MRFI this season was 8,816.

The LMR in-river escapement estimate of 3,301 fall-run Chinook salmon was calculated by subtracting the MRFI salmon count from the video monitoring count at WIDD. Just over half of the Chinook salmon that returned to the LMR were classified as adults (6,390, 53%), while the remaining 47% (5,727) were classified as grilse. Sexual composition of the run was 63% (7,636) male, 37% (4,471) female, and less than 1% (10) could not be determined.

<u>Spawning habitat restoration site use</u>

During the 2014 redd survey, 266 (29.2%) Chinook salmon redds were found within the restored upper 1-km reach, just below Camanche Dam (SHIRA reach). Overall, 474 (52%) Chinook salmon redds were constructed within SHR sites. In reach six, 418 redds (88%) were constructed in SHR sites. Fifty-six salmon redds (12%) were constructed in SHR sites in reach 5.

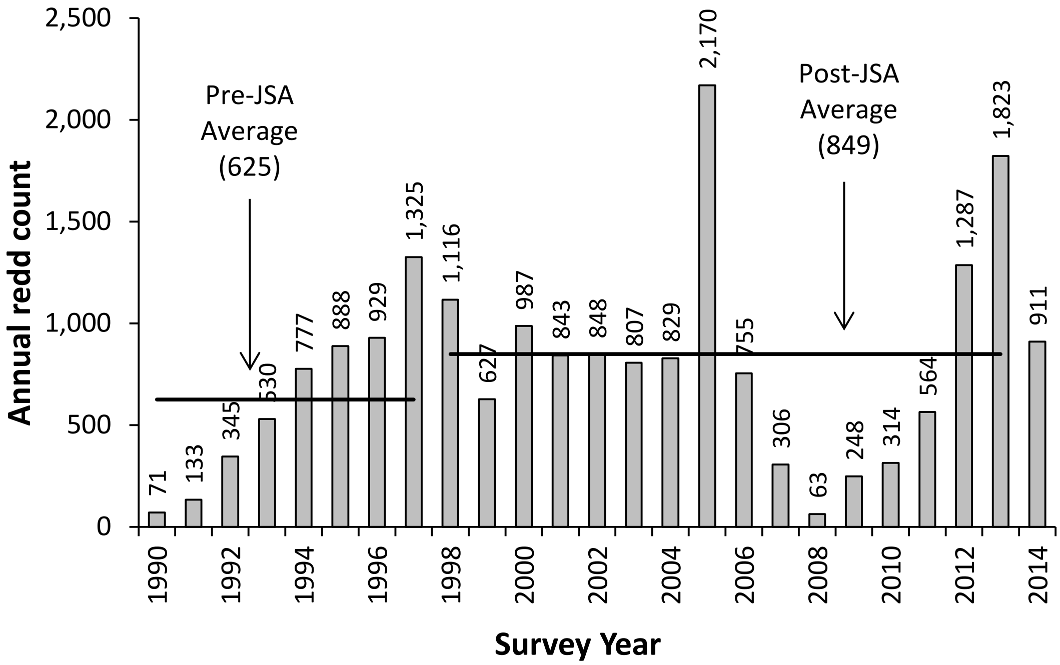

Figure 5. Chinook salmon redd totals on the lower Mokelumne River during pre-JSA flows (1990 – 1997), post-JSA flows (1998 – 2013), and for the 2014 survey season.

<u>Superimposition</u>

Sixty-two Chinook salmon redds (6.8%) were superimposed on other Chinook salmon redds during the 2014 redd survey season. Most of the superimposition took place in reach 6 (51 redds), while just eleven redds were superimposed in reach 5. The 2014 superimposition rate was lower than the long-term average of 10.6% (1991-2013), the pre-JSA average of 9.0% (1991-1997) and the post-JSA average of 11.2% (1998-2013). There was a significant positive linear relationship between the annual redd count and the annual superimposition rate (Linear regression: $F = 25.74$; df = 1, 22; $P < 0.001$). The annual redd count explained 54% of the variation in the annual superimposition rate.

<u>Habitat use – water depth and velocity</u>

One hundred and three water depth and velocity measurements were taken just above the nose of Chinook salmon redds from 20 October to 22 December 2014. During this time frame, average daily discharge from Camanche Dam ranged from 228 to 407 cfs, however discharge did not exceed 334 cfs on the dates the measurements were recorded. Chinook salmon redd water depths ranged from 10 to 110 cm and averaged 50 cm (SD = 20). The central 50% of measured redd depths (between Q1 and Q3) were between 36 and 58 cm. Water velocity measurements ranged from 0.04 to 1.01 m/s and averaged 0.49

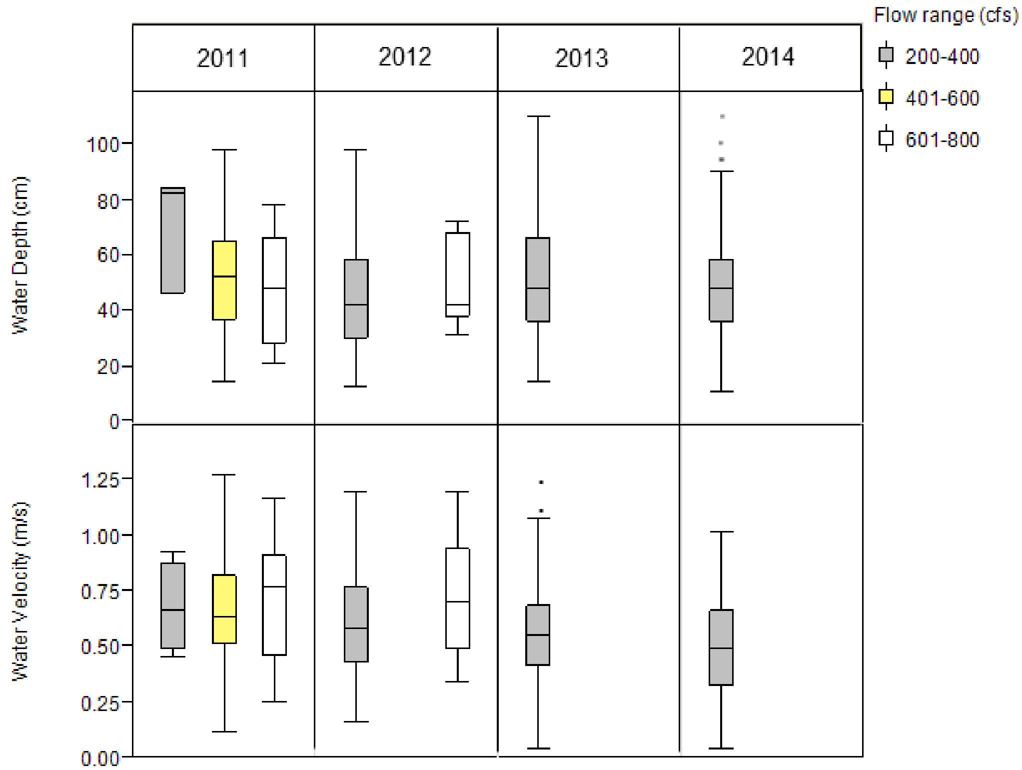

Figure 6. Boxplots of water depths and velocities measured just above the nose of Chinook salmon redds by survey year (2011-2014) and by flow range (200-400 cfs, 401-600 cfs, 601-800 cfs) on the lower Mokelumne River.

m/s (SD = 0.21). The central 50% of measured redd velocities were between 0.32 and 0.66 m/s.

Flow range did not have a statistically significant effect on redd water velocity (two-way ANOVA: $F_{2, 478} = 1.68$, $P = 0.1876$) or redd water depth (two-way ANOVA: $F_{2, 470} = 0.07$, $P = 0.9354$) (Figure 6). Survey year did not have a statistically significant effect on redd water depth (two-way ANOVA: $F_{3, 470} = 1.80$, $P = 0.1459$), however survey year did have a statistically significant effect on redd water velocity (two-way ANOVA: $F_{3, 478} = 5.15$, $P = 0.0016$).

Oncorhynchus mykiss

<u>Redd totals</u>

Sixty-three *O. mykiss* redds were detected during the 2014 salmonid redd survey. The first and last detections occurred on 30 December 2014 and 23 February 2015, respectively. The largest number of *O. mykiss* redds (21) was detected on 26 January 2015 (Figure 7). Reach 6 contained 33 redds (52.3%) and reach 5 contained 30 redds (47.7%). The 2014 annual redd count was 25.4% above the long-term (2000-2013) average of 50 (Figure 8).

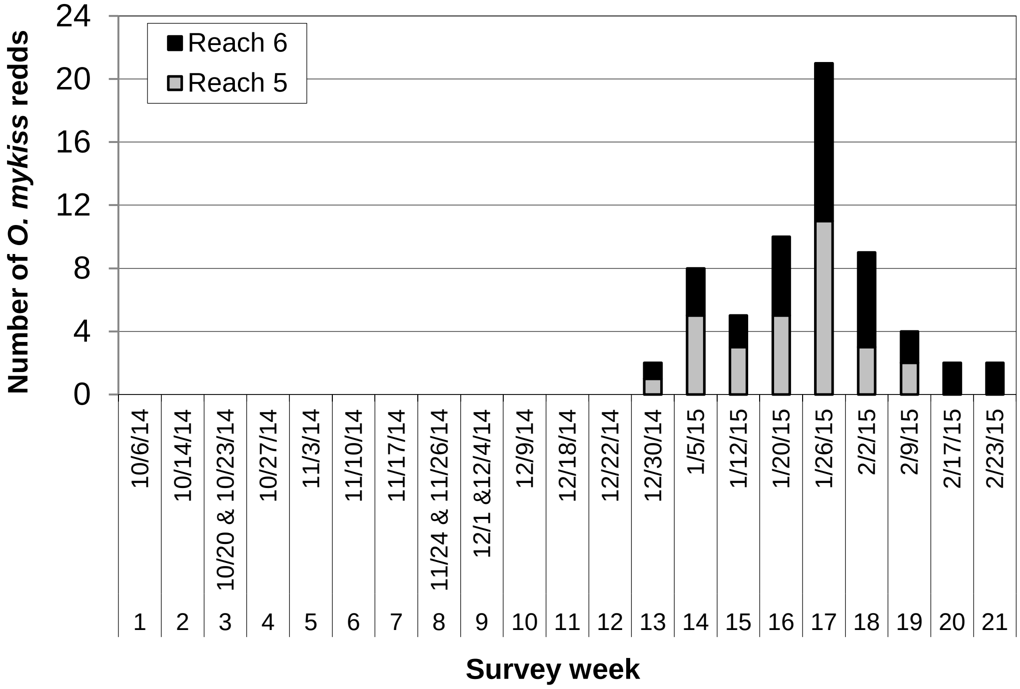

Figure 7. Weekly *O. mykiss* redd totals by reach on the lower Mokelumne River during the 2014 survey season.

<u>Spawning habitat restoration site use</u>

During the 2014 redd survey, four (6 %) *O. mykiss* redds were found within the SHIRA reach. Overall, 12 *O. mykiss* redds, or 19% of the total number of redds detected (63), were constructed in SHR sites. Fifty-eight percent (7) of redds constructed in SHR sites were located in reach 6 and 42% (5) were located in reach 5.

<u>Superimposition</u>

Nine *O. mykiss* redds were superimposed on nine Chinook salmon redds during the 2014 season.

<u>Habitat use – water depth and velocity</u>

Twenty-seven water depth and water velocity measurements were taken just above the nose of *O. mykiss* redds between 5 January and 23 February 2015. Discharge from Camanche Dam ranged from 234 to 346 cfs on the dates the measurements were taken. Water depths ranged from 24 to 100 cm and averaged 57 cm (SD = 22). The central 50% of measured *O. mykiss* redd depths (between Q1 and Q3) were between 39 and 80 cm. Water velocity measurements ranged from 0.18 m/s to 0.90 m/s and averaged 0.52 m/s (SD = 0.23). The central 50% of measured *O. mykiss* redd velocities were between 0.34 and 0.70 m/s.

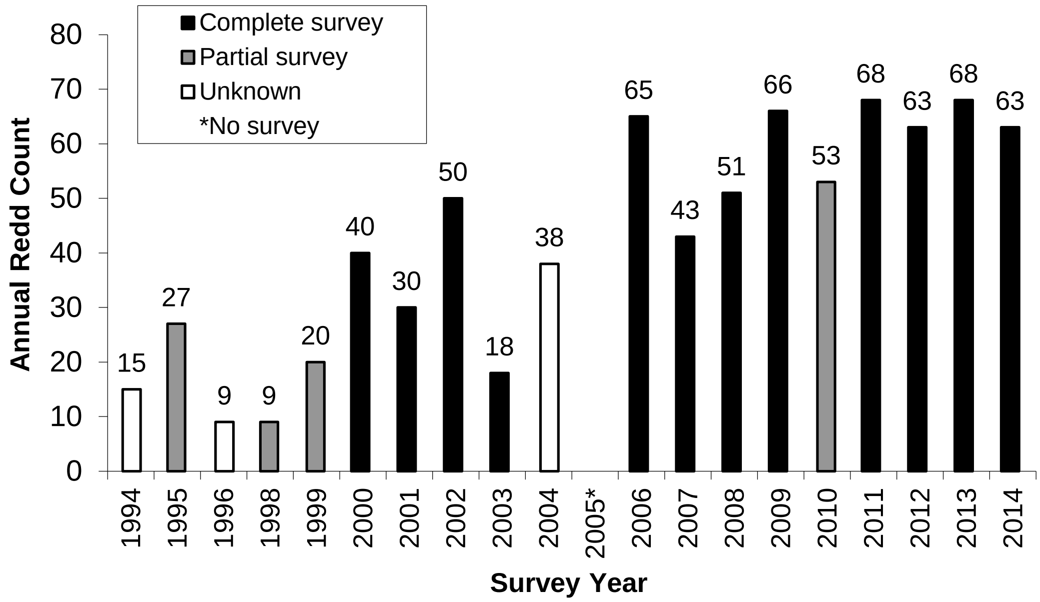

Figure 8. Annual *O. mykiss* redd totals on the lower Mokelumne River from 1994-2014.

DISCUSSION

During the beginning of the Chinook salmon incubation period, the majority of subsurface water temperatures were lower than surface water temperatures recorded at the McIntire gauging station. This time frame coincides with a critical period for incubating Chinook salmon embryos, as maximum daily water temperatures frequently fall outside of the range necessary for maximum embryo survival (5 to13°C) (McCullough 1999). However, last season the majority of subsurface water temperatures at all burial depths fell between the maximum daily surface water temperatures recorded at the McIntire gauge and the Elliot road gauge during the beginning of the Chinook salmon incubation period. Two years of data indicate that daily maximum surface water temperatures at the McIntire gauging station may not always provide a good general estimate of daily maximum subsurface water temperatures at a range of Chinook salmon embryo incubation depths (Devries 1997). It is recommended to continue collecting and comparing subsurface and surface water temperatures over a variety of water years in an attempt to detect any possible trends. These data may be used to help manage cold water releases from Camanche Dam and subsequent water temperatures in the LMR during the early stages of the Chinook salmon embryo incubation period.

The 2014 LMR Chinook salmon escapement estimate of 12,117 was 261% of the historical (1940-2013) average of 4,632, 352% of the pre-JSA (1940-1997) average of 3,439, and 141% of the post-JSA (1998-2013) average of 8,583. Preliminary 2014 escapement data from GrandTab[1] indicate that 255,897 fall-run Chinook salmon returned to the California Central Valley this season. This included 238,176 salmon that returned to the Sacramento River system and 17,721 salmon that returned to the San Joaquin River system. This season, the LMR accounted for 68% of the total return to the San Joaquin River system, which includes the Cosumnes River, the LMR, the Stanislaus River, the Tuolumne River, and the Merced River.

The 2014 Chinook salmon redd total was higher than the annual redd counts over four of the past six years. In addition, it was higher than the post-JSA average of 849. Roughly 53% of the returning population was adult salmon. A larger proportion (73%) of returning Chinook salmon was trapped at the hatchery when compared to 2013 (42%) and 2012 (55%). The other 27% of the population (3,301 salmon) remained in the LMR. Peak spawning on the LMR typically occurs between the middle and the end of November, however, warmer water temperatures may have delayed the peak of spawning to early December this season.

One of the primary objectives of EBMUD's ongoing spawning habitat rehabilitation projects is to supplement depleted coarse sediment with suitable-sized spawning gravel in the LMR. These projects are intended to improve and expand spawning habitat for adult Chinook salmon and steelhead in the LMR. As of 1990, EBMUD has completed 22 annual spawning habitat rehabilitation projects in reaches 5 and 6 of the LMR in cooperation with federal and state agencies, local partnerships, and public organizations. Since 2001, the Spawning Habitat Integrated Rehabilitation Approach (SHIRA) has been implemented to restore geomorphic processes and salmonid spawning habitat within the upper 1-km reach of the LMR, just below Camanche Dam (Pasternack et al. 2004). Since 1990, 46,677 yd^3 of gravel has been added to the LMR. These projects continue to provide high-quality spawning habitat as demonstrated by the large percentage of salmon redds constructed within the SHIRA reach (29.2% this season) and within all SHR sites (52% this season).

The 2014 Chinook salmon redd superimposition rate of 6.8% was lower than the long term average (1991-2013) of 10.6%. Spawning density (using annual redd counts) explained 54% of the variation in the annual salmon redd superimposition rate. During the 2014 spawning season, the Chinook salmon redd count was slightly above the long-term average, but did not result in a higher than average superimposition rate.

Most of the Chinook salmon redd water depths and velocities recorded this season fell within the expected ranges for the species (Moyle 2002) at discharges ranging from 228-491 cfs. Discharge did not have a statistically significant effect on Chinook salmon redd water velocity or water depth from 2011-2014. Survey year did not have a statistically significant effect on Chinook salmon redd water depth, but it did have a significant effect on redd water velocity. These results suggest that the selection for several physical spawning habitat parameters (water depth and velocity) is relatively consistent despite

[1] California Department of Fish and Game - Fisheries Branch Anadromous Assessment, http://grandtab.calfish.org/GTFall4.aspx, accessed on 8/15/2015.

variable discharge ranging from 200-800 cfs. However, there may be annual environmental variation and variation among brood stocks.

Sixty-three *O. mykiss* redds were observed during the 2014 season, which was consistent with or slightly above *O. mykiss* redd counts over the last decade. Interestingly, the hatchery return of adult *O. mykiss* (total length ≥ 16 in.) during 2014 was 136, which was less than six of eight previous seasons when the adult *O. mykiss* count at the hatchery exceeded 200 adults. Several factors that may have contributed to the slightly above average redd count this season include redd survey frequency and the mixed life history characteristics of *O. mykiss* in the California Central Valley. Redd survey frequency is dependent on a number of factors, including weather conditions, flows, and the number of staff available to conduct the surveys. This season, low flows, optimal weather, and adequate staffing allowed for weekly redd surveys to be conducted through the end of February without any weekly surveys missed. Also, given the mixed life history of *O. mykiss* in Central Valley streams, the difference between resident rainbow trout redds and winter-run steelhead redds could not be distinguished during the spawning surveys, and it is possible that many of the *O. mykiss* redds detected were constructed by resident fish (Zimmerman et al. 2009).

MANAGEMENT IMPLICATIONS

In 2014, EBMUD initiated an adaptive management strategy which included reserving 4,788 acre feet of water from the spring to save for shaping pulsed releases in the fall for adult salmonid attraction flows. In addition, Woodbridge Irrigation District (WID) worked collaboratively with EBMUD to coordinate changes in the water surface elevation at Lake Lodi during several of EBMUD's pulse flows. This action enhanced several of EBMUD's planned pulse flows by altering the timing of water releases at Woodbridge Dam, thereby increasing the magnitude of the flow peaks. The series of pulse flows from Camanche Dam and augmented pulse flows from Woodbridge Dam provided an attraction flow for adult spawners, as a large number (12,117) of Chinook salmon returned to the LMR, comprising 68% of the entire San Joaquin River system fall-run return.

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