LOWER MOKELUMNE RIVER

Fall-run Chinook Salmon and Winter-run Steelhead Redd Survey Report: October 2007 through March 2008

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Abstract

Weekly fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and winter-run steelhead (*Oncorhynchus mykiss*) spawning surveys were conducted on the lower Mokelumne River from October 10, 2007 through March 26, 2008. Estimated total escapement during this time period was 1,521 Chinook salmon (+/- 72). The estimated number of in-river spawners was 470 Chinook salmon (+/- 72). The first Chinook salmon redd was detected on October 23. Three hundred six Chinook salmon redds were detected, of which 24 (7.8%) were superimposed and 199 were located within gravel enhancement areas. The reach from Camanche Dam to Mackville Road (reach 6) contained 280 Chinook salmon redds (91.5%) and the reach from Mackville Road to Elliott Road (reach 5) contained 26 redds (8.5%). The highest numbers of Chinook salmon redds were detected on November 27 and December 5. The first steelhead redd was detected on December 18. Forty three steelhead redds were detected, of which none were superimposed and 14 were located within gravel enhancement areas. Reach 6 contained 21 redds (49.0%) and reach 5 contained 22 redds (51.0%). The highest number of steelhead redds were detected on February 1.

INTRODUCTION

The Mokelumne River is an east-Delta tributary that drains more than 1,642 km^2 (600 square miles) of the eastern 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 impoundments including Salt Springs Reservoir, Lower Bear Reservoir, Pardee Reservoir and Camanche Reservoir. Water releases to the lower Mokelumne River (LMR) are controlled by Camanche Dam. The LMR is defined as the approximate 101 km (63 mile) long portion of the Mokelumne River between Camanche Dam (the farthest downstream major impoundment) and the confluence with the San Joaquin River. Camanche Dam was completed in 1963 and blocked upstream passage of Chinook salmon and steelhead to much of the available historical spawning habitat in the Mokelumne River. Most of the available spawning habitat in the LMR is limited to the 15.8 km (9.8 mile) section of river directly downstream of Camanche Dam (East Bay Municipal Utilities District [EBMUD] 2003).

Pardee and Camanche reservoirs are owned and operated by EBMUD, 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 by fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and winter-run steelhead (*Oncorhynchus mykiss*) for spawning and rearing. Adult Chinook salmon ascend the LMR as early as August and typically 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 Hatchery (MRFH), constructed in 1964 to mitigate for spawning habitat lost during construction of Camanche Dam, receives approximately 57.1% of the total run per year (1990-2007 average). EBMUD has conducted annual spawning surveys on the LMR since 1990 (Hagar 1991; Hartwell 1996; Setka 1997). EBMUD conducts Chinook salmon carcass surveys concurrent with the redd surveys. The carcass surveys provide estimates of in-river spawning Chinook salmon.

OBJECTIVES

The primary objective of the 2007 redd survey was to enumerate Chinook salmon redds in the LMR. The fall-run Chinook salmon escapement for the LMR during 2007/2008 was estimated by conducting carcass surveys for in-river escapement and adding the number of salmon trapped at MRFH to estimate the total escapement for the LMR. Additional objectives of the redd surveys included:

- Map locations of individual redds;
- Enumerate redds impacted by superimposition; and
- Determine use of enhancement gravel areas.

METHODS

SURVEYS

The LMR is divided into 6 reaches between Camanche Dam and the confluence with the San Joaquin River. Reach delineations are based on gradient, substrate and tidal influence. Salmonid spawning habitat primarily is available in reach 5 and reach 6 of the LMR. Therefore, redd surveys were only conducted in these two reaches. The two reaches cover a 15.8 km (9.8 mile) section of the LMR from Camanche Dam downstream to Elliott Road. Weekly redd surveys were conducted starting on October 10, 2007 and concluding on March 26, 2008. Both reaches were surveyed once per week. Surveys consisted of two to three individuals walking abreast downstream and in the river (water depths to 4 feet) searching for redds. This method has been used in past Mokelumne River spawning surveys and in other rivers and streams (Fritsch 1995; Hartwell 1996; Keefe et al. 1994; Setka 1997). A canoe or drift boat was used to transport surveyors between spawning areas.

In previous years, redds were marked with numbered cattle ear tags and/or colored bricks. Locations were recorded using a Global Positioning System (GPS) unit (Trimble Pro XR) and a laser range finder (Laser Atlanta Advantage). During the 2007 surveys, redd locations were recorded using two hand-held GPS units (Trimble Geo XH). Surveyors positioned themselves directly downstream and behind each redd and recorded the position of the tailspill. Care was taken to avoid impacting redds during the survey. The Trimble Geo XH GPS unit records more accurate positions (<1 meter real-time) and has the capability to display previously recorded data in the field when compared to the Trimble Pro XR GPS unit. The ability to see data from previous surveys eliminated the need to physically mark redds and eliminated the potential of counting one redd more than once. Surveyors determined if previously detected redds were superimposed based on the amount of time that had elapsed since a redd was first detected and the lack of silt or algae within each redd.

DATA COLLECTION AND ANALYSIS

A minimum of ten points were collected for each redd and point data files were stored in the GPS unit using Terrasync software. The point data files were downloaded to an ArcMAP 9.2 (ESRI) data base. Depth and superimposition status for each redd also were recorded. Water temperature and flow data were obtained from EBMUD's McIntire and Elliott gauging stations. Data analyses were performed using ArcMAP, Arc/Info (ESRI) systems, EBMUD LMR GIS and Excel. An emergence timeline was constructed based on an egg model developed by Vogel (1993) from Piper et al. (1982).

RESULTS

CHINOOK SALMON

ESCAPEMENT AND REDD TOTALS

A mark-recapture carcass survey was conducted from October 2007 through January 2008 to estimate fall-run Chinook salmon escapement on the LMR. The in-river escapement estimate was 470 (+/- 72). MRFH's count of hatchery spawners was 1,051. The total escapement estimate on the LMR was 1,521 (+/- 72). The in-river spawning population consisted of 97.8% adults and 2.2% grilse. The adult component consisted of

43.2% male and 56.8% female. The grilse component consisted of 0% male and 100% female. The hatchery spawning population consisted of 96.2% adults and 3.8% grilse. The adult component consisted of 33.2% male and 66.8% female. The grilse component consisted of 72.5% male and 27.5% female.

During the 2007 redd survey period, 306 Chinook salmon redds were detected. The first and last detections occurred on October 23 and January 11, respectively. The highest number of redds were detected on November 27 (50) and December 5 (56; Figure 1). The number of new redds detected after December 5 decreased sharply. Reach 6 contained 280 redds (91.5%) and reach 5 contained 26 redds (8.5%). The 2007 annual redd count is 62.7% below the long term average (1990-2006) of 821 (Figure 2), 50.9% below the pre-JSA average (1990-1997) of 623 and 69.3% below the post-JSA average (1998-2006) of 996.

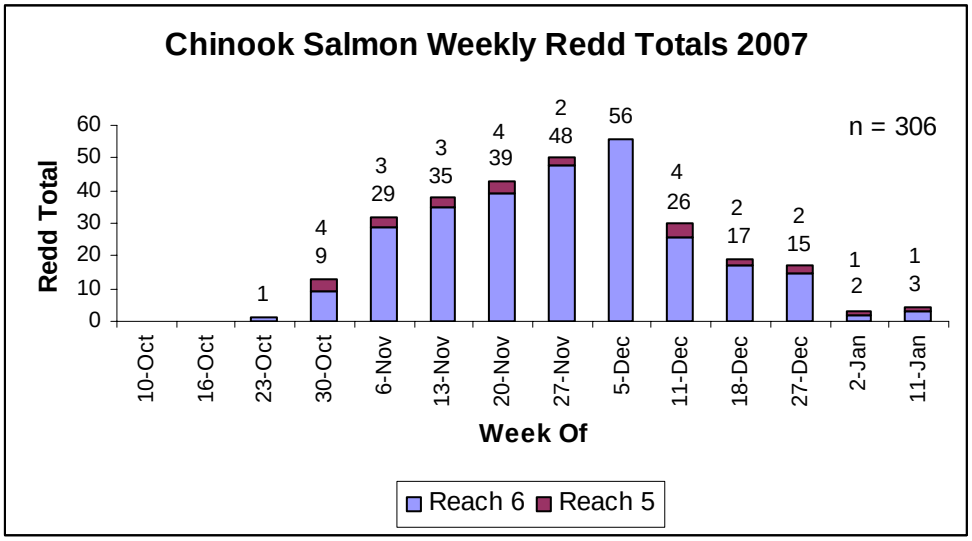

Figure 1. Chinook salmon weekly redd totals by reach on the lower Mokelumne River during the 2007 redd surveys.

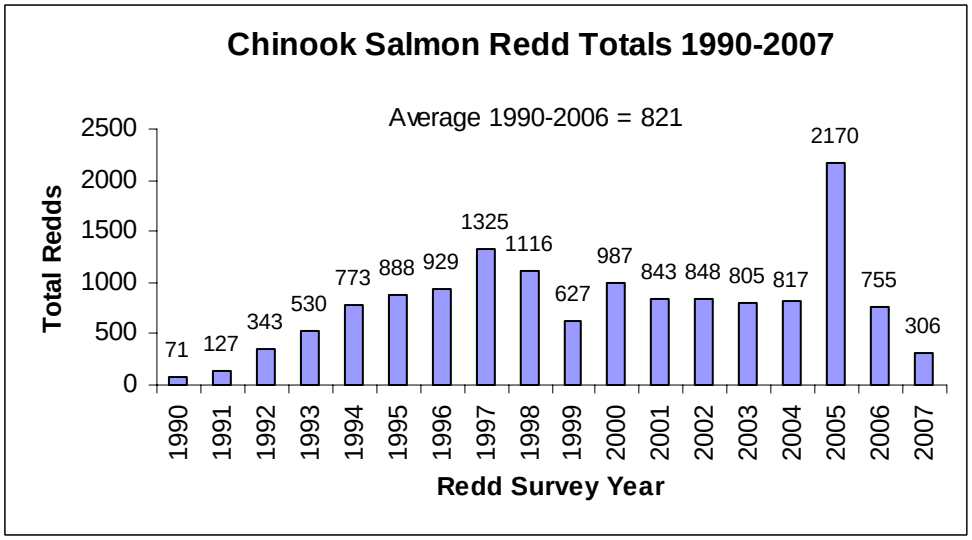

Figure 2. Chinook salmon redd totals on the lower Mokelumne River from 1990 through 2007.

GRAVEL ENHANCEMENT AREA USAGE

In 2007, 199 Chinook salmon redds, or 65.0% of the total number of redds detected (306), were constructed in gravel enhancement areas. Ninety six percent of redds (191) constructed in enhancement areas were located in reach 6 and 4.0% (8) were located in reach 5. This is the highest percentage of redds detected in gravel enhancement areas from 1996 through 2007 (Figure 3).

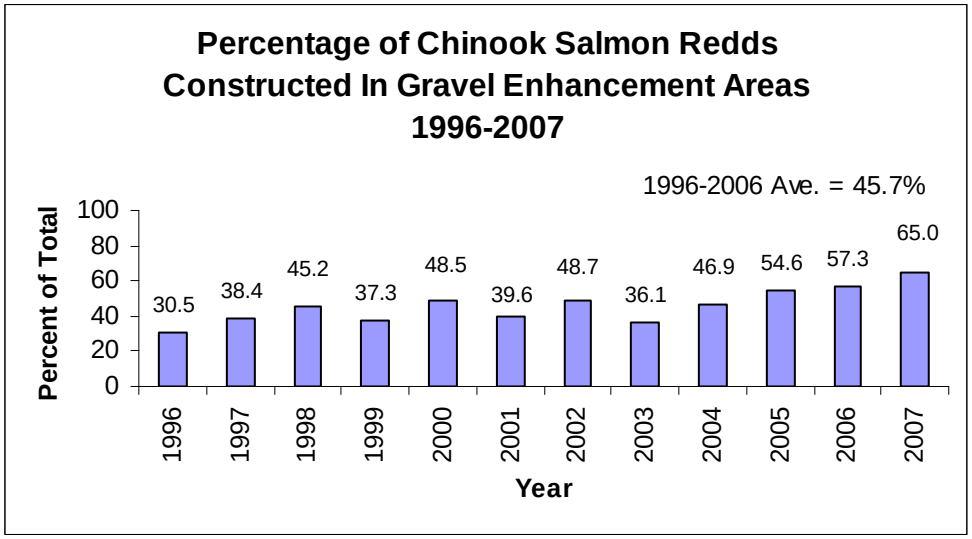

Figure 3. Percentage of Chinook salmon redds constructed in gravel enhancement areas on the lower Mokelumne River from 1996-2007.

SUPERIMPOSITION

Twenty four redds (7.8%) were superimposed during the 2007 redd survey season, all of which were in reach 6. The 2007 superimposition rate is the fourth lowest recorded from 1991 through 2007 (Figure 4) and is lower than the long term average of 11.1% (1991-2006), the pre-JSA average of 9.0% (1991-1997) and the post-JSA average of 12.6% (1998-2006).

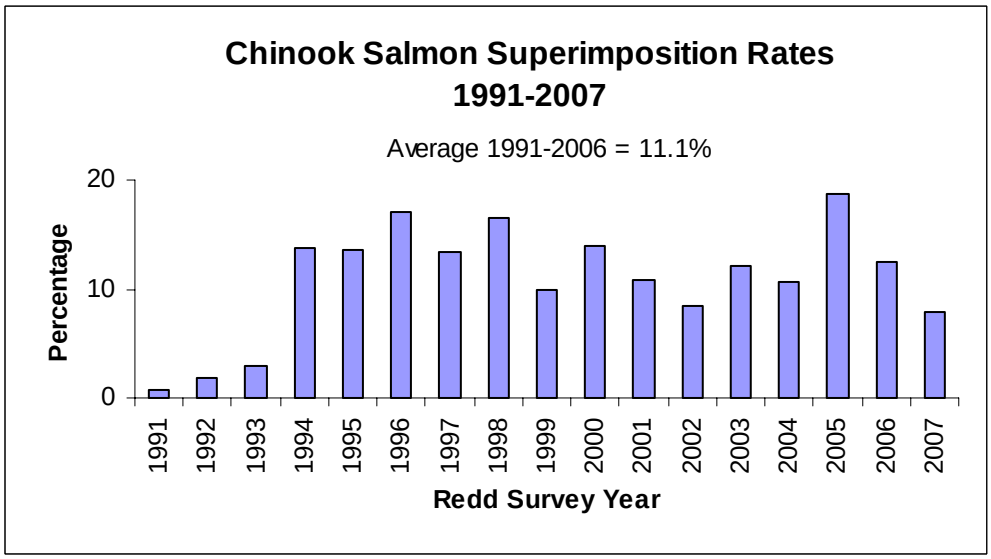

Figure 4. Chinook salmon superimposition rates on the lower Mokelumne River from 1991 through 2007.

WATER TEMPERATURE AND FLOW

Average daily water temperature below Camanche Dam at the McIntire gauging station (reach 6) during the survey period ranged from 8.9°C (48.0°F; February 14) to 15.2°C (59.4°F; October 10; Figure 5) and averaged 12.0°C (53.6°F). Average daily water temperature in reach 6 from October 23 through January 11 (time period redds were detected) ranged from 10.4°C (50.7°F) to 15.1°C (59.2°F) and averaged 13.3°C (55.9°F). The average of the average daily water temperature in reach 6 seven days before November 27 and seven days after December 5 (peak redd construction) was 14.3°C (57.7°F) and 13.3°C (55.9°F), respectively. Average daily water temperature at the Elliott gauging station (reach 5) during the survey period ranged from 8.4°C (47.1°F; February 5) to 16.2°C (61.2°F; October 20; Figure 6) and averaged 11.8°C (53.2°F). Average daily water temperature in reach 5 from October 23 through January 11 (time period redds were detected) ranged from 9.3°C (48.7°F) to 15.6°C (60.1°F) and averaged 12.6°C (54.7°F). The average of the average daily water temperature in reach 5 seven days before November 27 and seven days after December 5 (peak redd construction) was 13.2°C (55.8°F) and 12.3°C (54.1°F), respectively.

Average daily flows below Camanche Dam at the McIntire gauging station (reach 6) during the survey period ranged from 6.4 m^3/s (226 f^3/s; February 7 and 9) to 7.9 m^3/s (278 f^3/s; January 28; Figure 7) and averaged 6.8 m^3/s (241 f^3/s). Average daily flows in reach 6 from October 23 through January 11 (time period redds were detected) ranged from 6.4 m^3/s (227 f^3/s) to 7.8 m^3/s (274 f^3/s) and averaged 6.9 m^3/s (244 f^3/s). Average daily flows at the Elliott gauging station (reach 5) during the survey period ranged from 5.6 m^3/s (197 f^3/s; November 4) to 8.0 m^3/s (281 f^3/s; January 6 and 28; Figure 8) and averaged 6.2 m^3/s (219 f^3/s). Average daily flows in reach 5 from October 23 through January 11 (time period redds were detected) ranged from 7.8 m^3/s (274 f^3/s) to 8.0 m^3/s (281 f^3/s) and averaged 6.3 m^3/s (221 f^3/s).

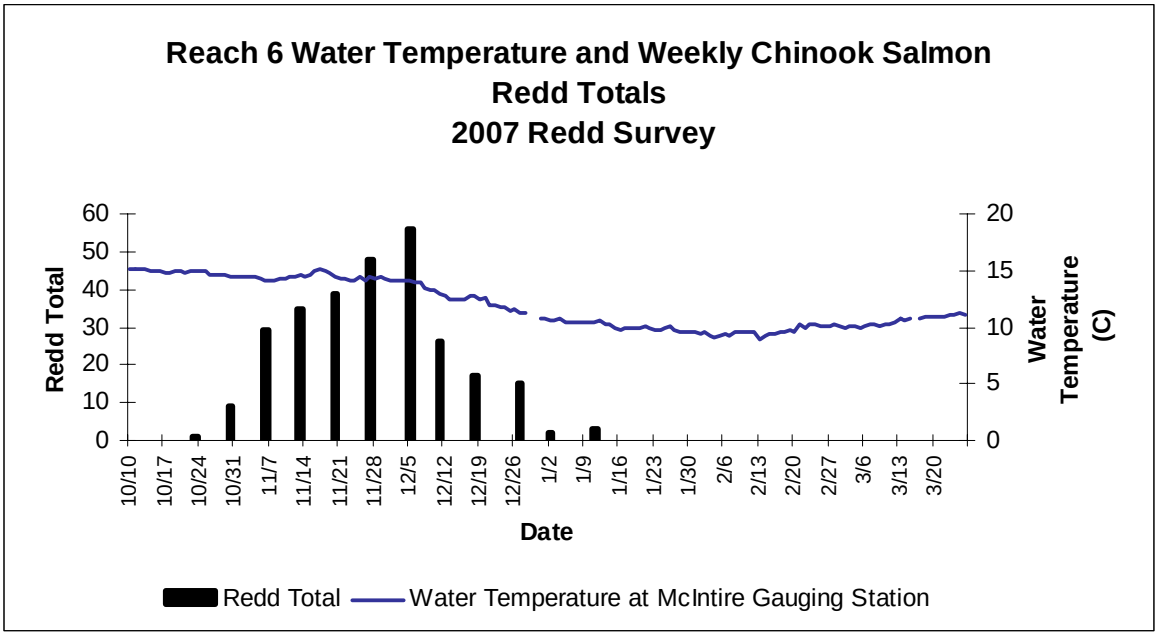

Figure 5. Average daily water temperature (°C) and weekly Chinook salmon redd totals in reach 6 of the lower Mokelumne River during the 2007 redd surveys.

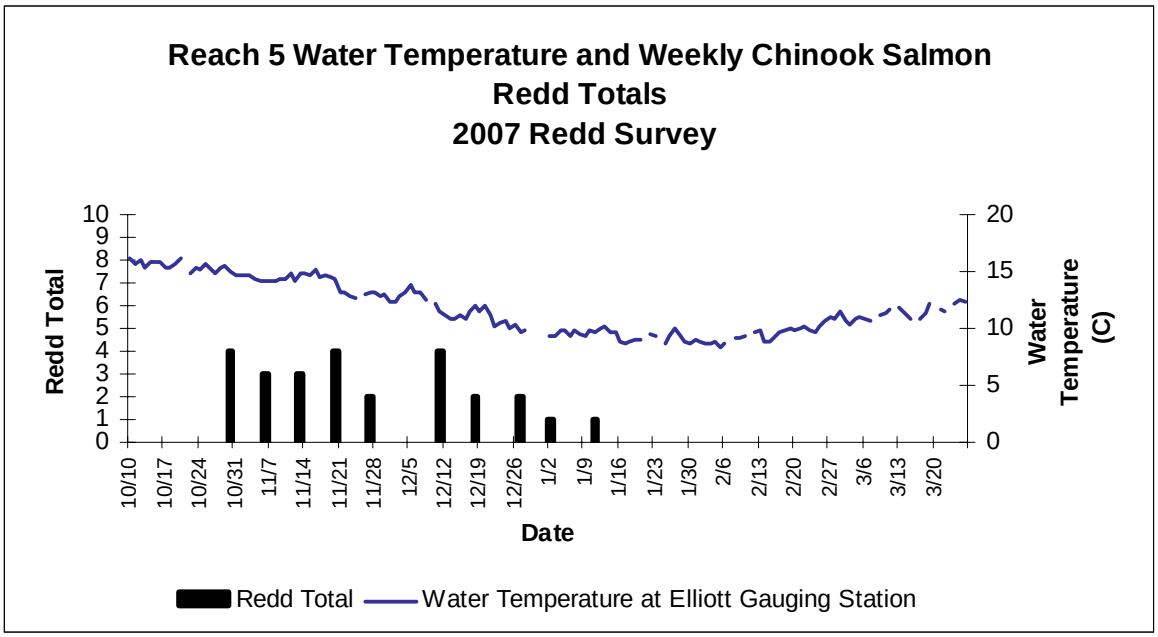

Figure 6. Average daily water temperature (°C) and weekly Chinook salmon redd totals in reach 5 of the lower Mokelumne River during the 2007 redd surveys.

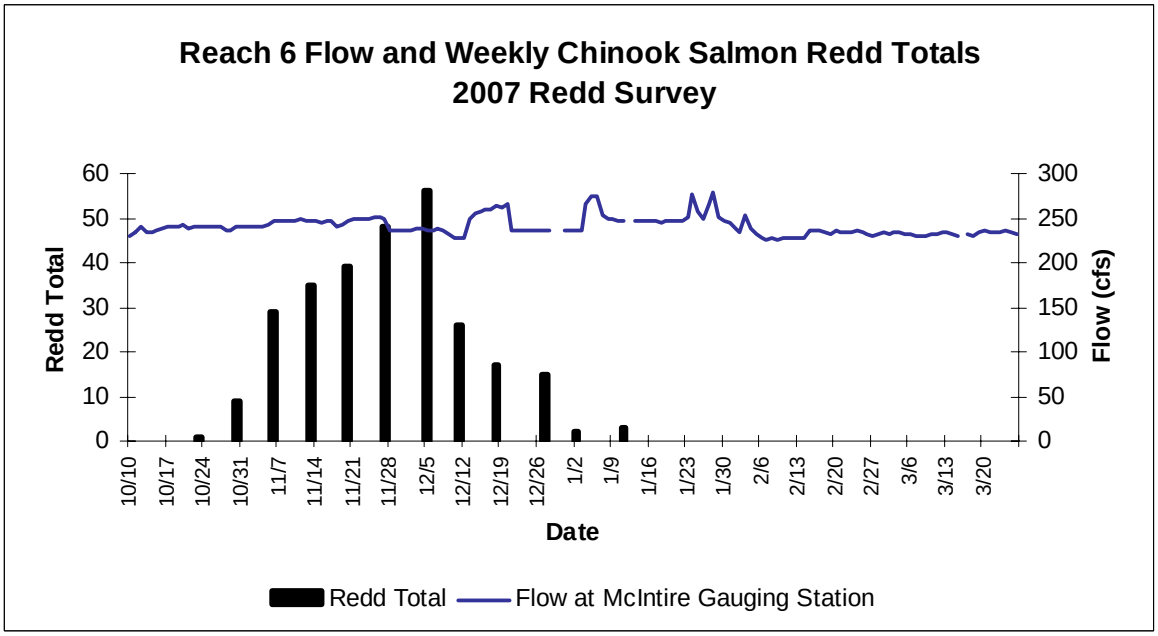

Figure 7. Average daily flow (cfs) and weekly Chinook salmon redd totals in reach 6 of the lower Mokelumne River during the 2007 redd surveys.

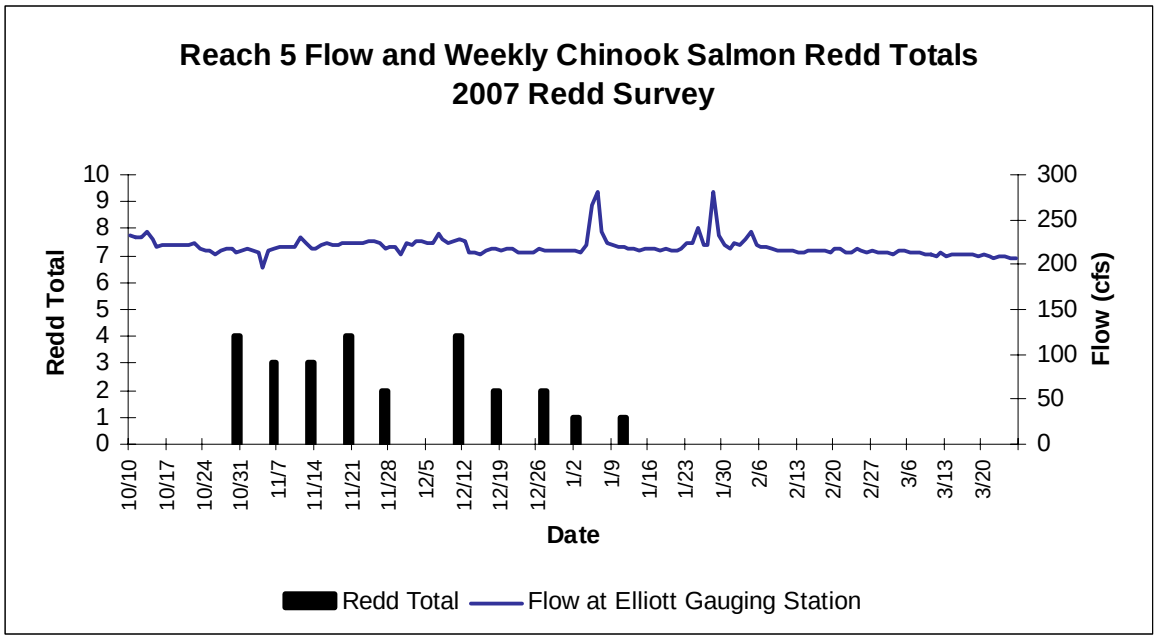

Figure 8. Average daily flow (cfs) and weekly Chinook salmon redd totals in reach 5 of the lower Mokelumne River during the 2007 redd surveys.

EMERGENCE TIMELINE

The egg model forecasted Chinook salmon fry emergence dates of December 25 (corresponding with a redd detection date of October 23) through April 8 (corresponding with a redd detection date of January 11). Peak emergence, based on peak redd detection dates, was estimated to occur from February 14 through February 26.

STEELHEAD

REDD TOTALS

Forty three steelhead redds were detected during the 2007 redd surveys. The first and last detections occurred on December 18 and March 19, respectively. The highest number of steelhead redds were detected on February 1 (9 total; Figure 9). The number of new redds detected after December 18 decreased but remained relatively high through the survey period. Reach 6 contained 21 redds (48.8%) and reach 5 contained 22 redds (51.2%). The 2007 annual redd count is 148.3% above the long term average of 29 (1994-2006; Figure 10), 268.8% above the pre-JSA average of 16 (1994-1997) and 119.4.0% above the post-JSA average of 36 (1998-2006). The duration of the 2007 redd survey is the longest on record since 1994 and the steelhead redd count is the third highest (1994-2006).

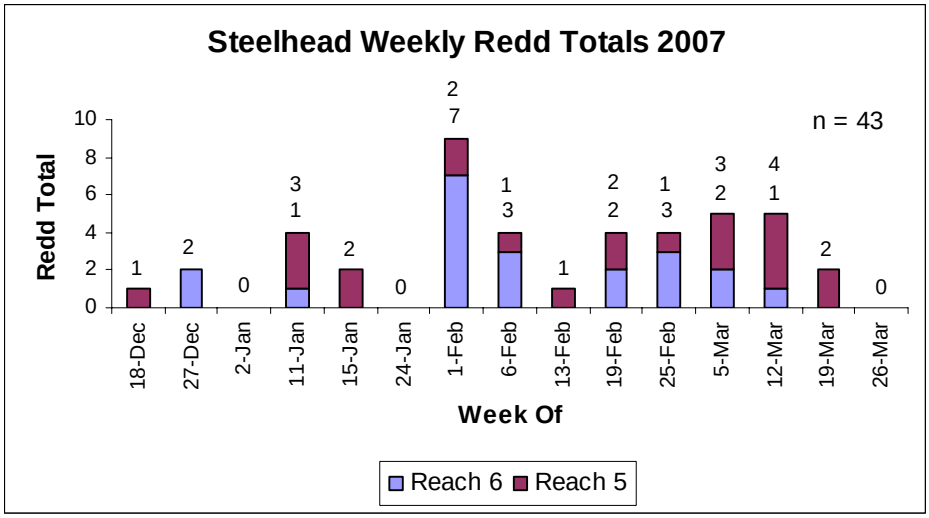

Figure 9. Steelhead weekly redd totals by reach on the lower Mokelumne River during the 2007 redd surveys.

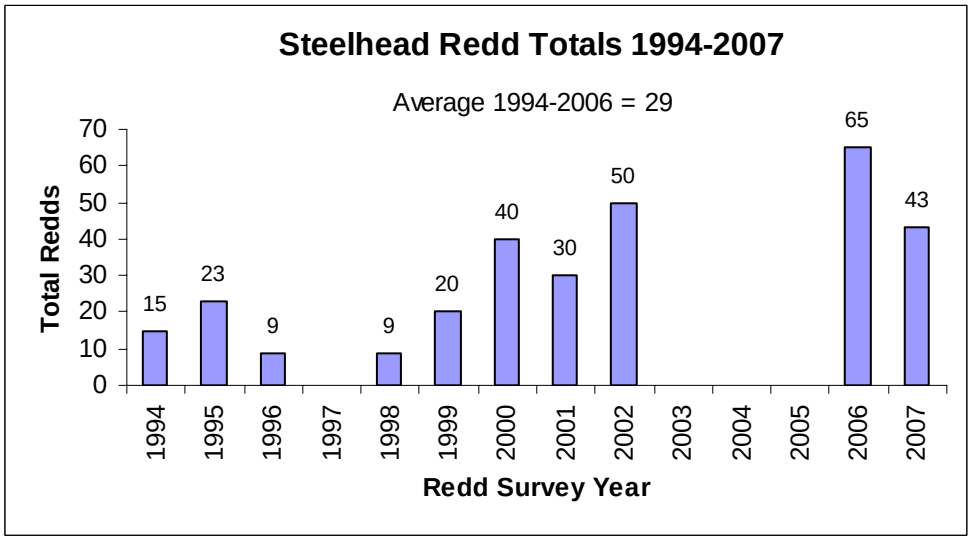

Figure 10. Steelhead redd totals on the lower Mokelumne River from 1994 through 2007.

GRAVEL ENHANCEMENT AREA USAGE

In 2007, 14 steelhead redds, or 32.6% of the total number of redds detected (43), were constructed in gravel enhancement areas. Eighty six percent of redds (12) constructed in enhancement areas were located in reach 6 and 14.3% (2) were located in reach 5.

SUPERIMPOSITION

None of the steelhead redds detected during the 2007 redd surveys were superimposed.

WATER TEMPERATURE AND FLOW

Average daily water temperature below Camanche Dam at the McIntire gauging station (reach 6) during the survey period ranged from 8.9°C (48.0°F; February 14) to 15.2°C (59.4°F; October 10; Figure 11) and averaged 12.0°C (53.6°F). Average daily water temperature in reach 6 from December 18 through March 19 (time period redds were

detected) ranged from 8.9°C (48.0°F) to 12.7°C (54.9°F) and averaged 10.2°C (50.4°F). The average of the average daily water temperature in reach 6 seven days before and seven day after February 1 (peak redd construction) was 9.8°C (49.6°F) and 9.3°C (48.7°F), respectively. Average daily water temperature at the Elliott gauging station (reach 5) during the survey period ranged from 8.4°C (47.1°F; February 5) to 16.2°C (61.2°F; October 20; Figure 12) and averaged 11.8°C (53.2°F). Average daily water temperature in reach 5 from December 18 through March 19 (time period redds were detected) ranged from 8.4°C (47.1°F) to 12.1°C (53.8°F) and averaged 9.9°C (49.8°F). The average of the average daily water temperature in reach 5 seven days before and seven days after February 1 (peak redd construction) was 9.1°C (48.4°F) and 8.7°C (47.7°F), respectively.

Average daily flows below Camanche Dam at the McIntire gauging station (reach 6) during the survey period ranged from 6.4 m^3/s (226 f^3/s; February 7 and 9) to 7.9 m^3/s (278 f^3/s; January 28; Figure 13) and averaged 6.8 m^3/s (241 f^3/s). Average daily flows in reach 6 from December 18 through March 19 (time period redds were detected) ranged from 6.4 m^3/s (226 f^3/s) to 7.9 m^3/s (278 f^3/s) and averaged 6.8 m^3/s (240 f^3/s). Average daily flows at the Elliott gauging station (reach 5) during the survey period ranged from 5.6 m^3/s (197 f^3/s; November 4) to 8.0 m^3/s (281 f^3/s; January 6 and 28; Figure 14) and averaged 6.2 m^3/s (219 f^3/s). Average daily flows in reach 5 from December 18 through March 19 (time period redds were detected) ranged from 5.9 m^3/s (209 f^3/s) to 8.0 m^3/s (281 f^3/s) and averaged 6.2 m^3/s (219 f^3/s).

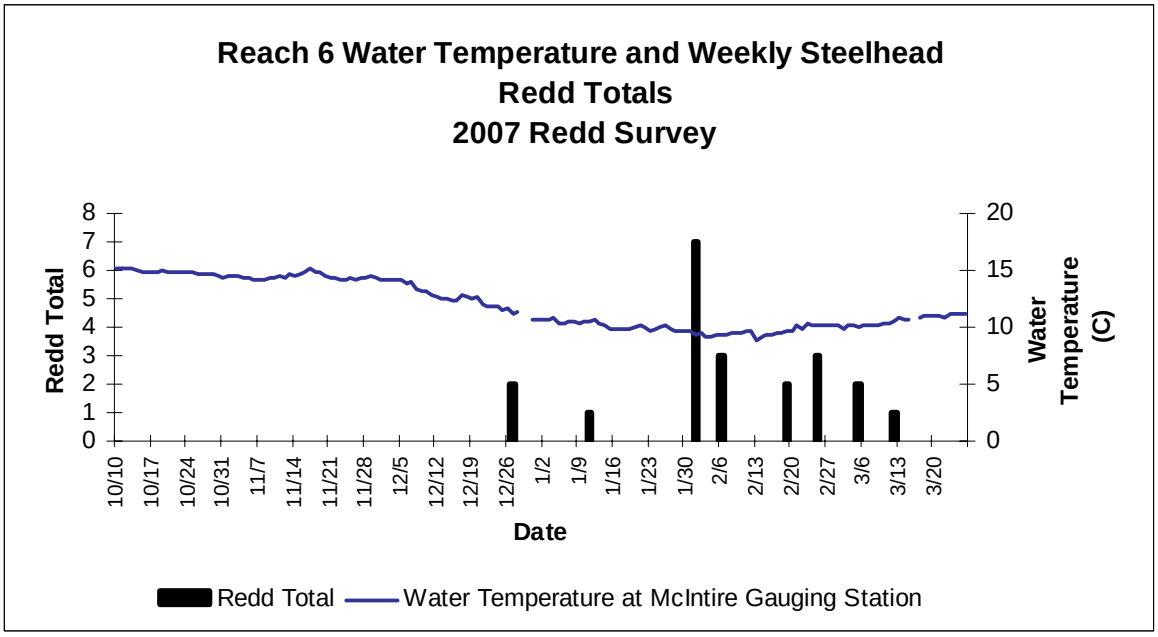

Figure 11. Average daily water temperature (°C) and weekly steelhead redd totals in reach 6 of the lower Mokelumne River during the 2007 redd surveys.

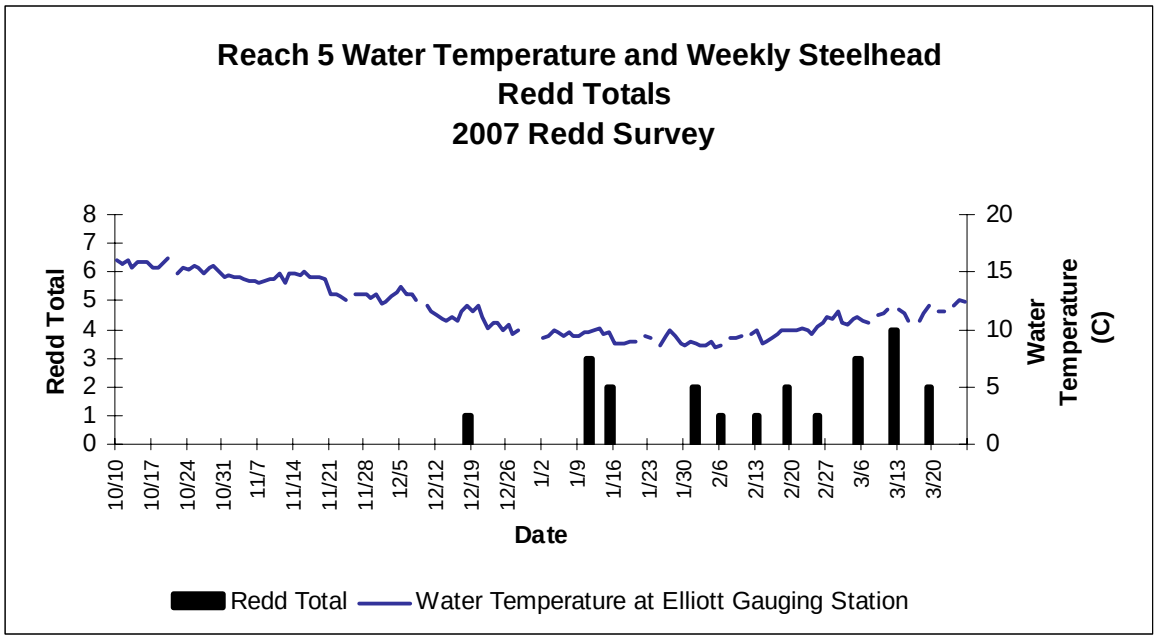

Figure 12. Average daily water temperature (°C) and weekly steelhead redd totals in reach 5 of the lower Mokelumne River during the 2007 redd surveys.

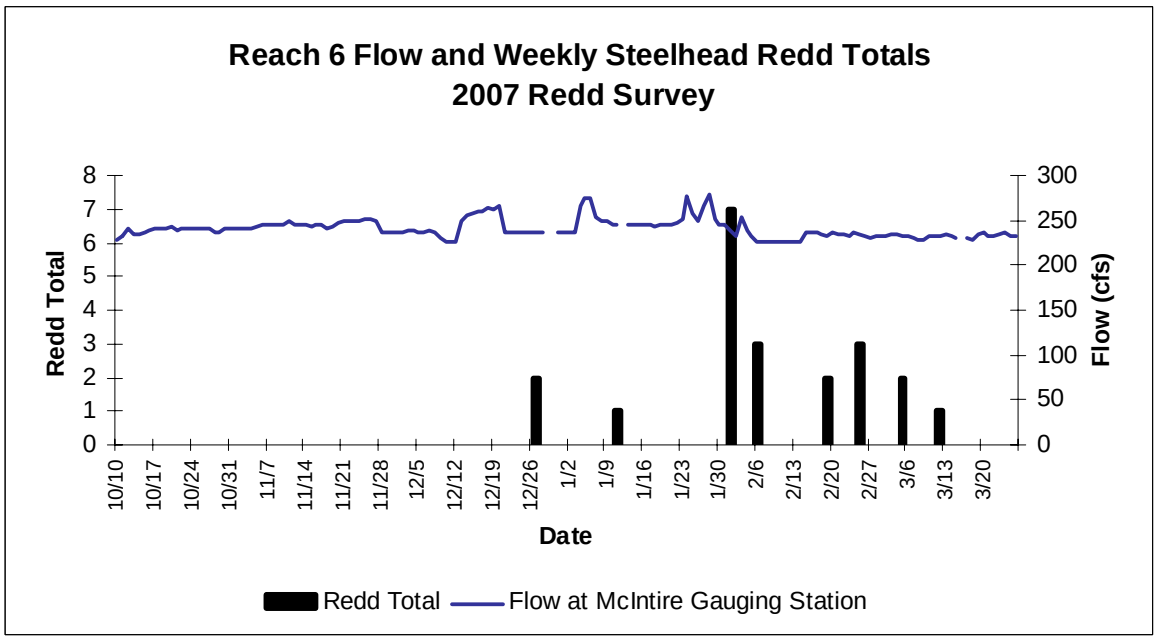

Figure 13. Average daily flow (cfs) and weekly steelhead redd totals in reach 6 of the lower Mokelumne River during the 2007 redd surveys.

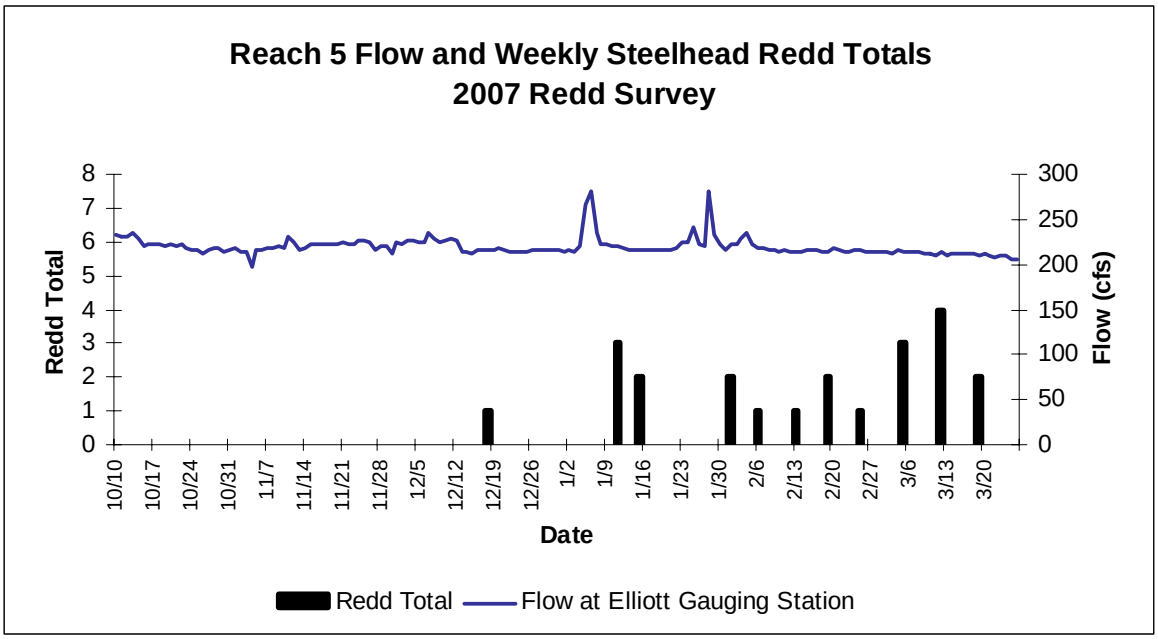

Figure 14. Average daily flow (cfs) and weekly steelhead redd totals in reach 5 of the lower Mokelumne River during the 2007 redd surveys.

DISCUSSION

CHINOOK SALMON

The total 2007-2008 LMR Chinook salmon escapement estimate of 1,521 is 65.0% lower than the historical 1940-2006 average of 4,344 (Figure 15), 56.0% lower than the pre-JSA average of 3,497 and 84.0% lower than the post-JSA average of 9,237. Escapement was very low throughout the Central Valley during the 2007-2008 Chinook salmon run. Pacific Fishery Management Council is investigating the factors responsible for the low returns. However, NOAA Fisheries theorizes poor ocean conditions likely are to blame. The number of redds detected during the 2007 surveys (306) is the third lowest from 1990 through 2007. The 2007 total redd count of 306 is 69.3% below the post-JSA average of 996 (1998-2006). However, this metric is misleading due to the large number of redds detected during the 2005 survey season. The percentage of redds detected in each reach is consistent with observations from 1996 through 2006 (Figure 16). Peak spawning on the LMR typically occurs during the third week of November. In 2007, peak spawning occurred during the fourth week of November and the first week of December. Water temperature and flow profiles may account for the peak occurring slightly later than usual.

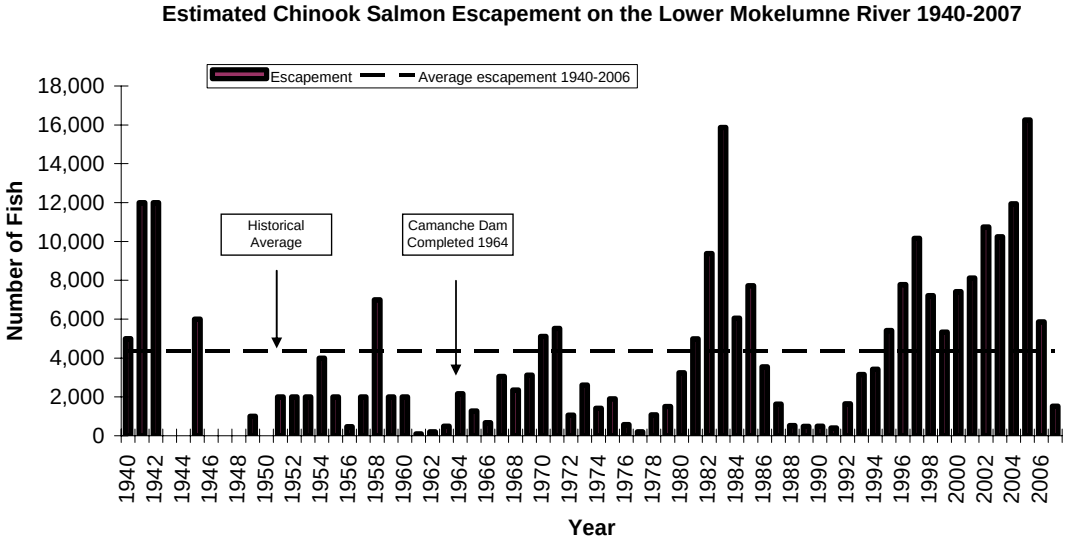

Figure 15. Estimated Chinook salmon escapement on the lower Mokelumne River from 1940 through 2007.

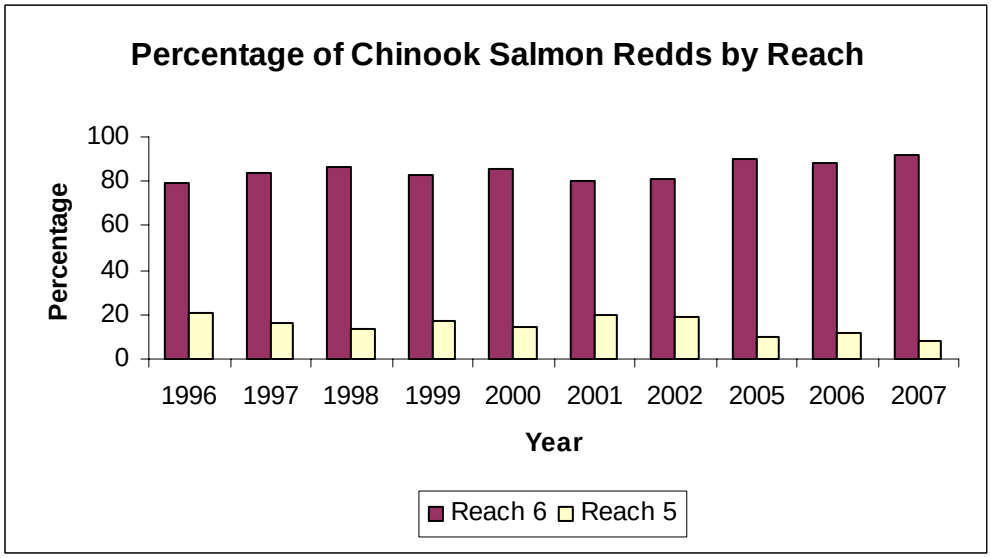

Figure 16. The percentage of Chinook salmon redds detected in each reach of the LMR from 1996 through 2007.

The percentage of redds constructed in gravel enhancement areas during the 2007 redd survey season is the highest on record from 1996 through 2007 (Figure 3). Since 1992, EBMUD has completed 15 gravel enhancement projects in reach 5 and reach 6 on the LMR in cooperation with federal and state agencies. The enhancements consisted of placing appropriately sized gravels to a proper depth to increase spawning habitat availability. In general, the percentage of redds constructed within the enhancement areas has increased each year since 2000. The 2007 escapement estimate is the lowest on record from 1996 through 2007. The high percentage of redds constructed within enhancements areas in 2007 may be the result of fewer Chinook salmon competing for optimal spawning habitat or the increase in overall enhanced area.

The 2007 superimposition rate is the fourth lowest recorded from 1991 through 2007 and the lowest recorded since 1993 (Figure 4). All superimposed redds were located in reach 6 and most were a short distance downstream of MRFH. Based on hatchery production

numbers, a high percentage of LMR Chinook salmon likely are of hatchery origin. Hatchery fish have a strong tendency to return to the hatchery which can cause a stockpiling effect adjacent to the hatchery ladder. This may account for the location superimposed redds were detected during the 2007 redd surveys.

STEELHEAD

Forty three steelhead redds were observed during the 2007 redd surveys which is the third highest from 1994-2006. The duration of the 2007 survey period is the longest on record from 1994-2006. Redd surveys conclude when flows increase, typically in late fall or early winter, due to decreased visibility and safety concerns. Past redd surveys usually concluded in December and January. From 1994 through 2007, flows allowed surveys to continue into March during five survey years (2000, 2001, 2202, 2006, and 2007) and these years account for the five highest annual number of steelhead redds detected.

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