

State of California  
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BUTTE AND BIG CHICO CREEKS  
SPRING-RUN CHINOOK SALMON, *ONCORYHNCHUS TSHAWYTSCHA*  
LIFE HISTORY INVESTIGATION  
2007-2008

By

Clint E. Garman

And

Tracy R. McReynolds

NCR – North Central Region

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**ABSTRACT**

This report covers the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) monitoring and life history evaluation in Butte and Big Chico creeks from September 2007 through December 2008.

For Butte Creek, there were 391,363 juvenile Chinook salmon captured near Chico of which 311,063 were subsequently marked with coded-wire tags. The adult spring-run Chinook salmon escapement estimate using the snorkel survey methodology was 3,935. An alternate estimate based upon the modified Schaefer model carcass survey methodology was 10,082. A Schaefer model carcass survey was also conducted to evaluate pre-spawning mortality with an estimated 1,054 fish that died prior to spawning. Combined, the carcass surveys recovered 6 Butte Creek coded-wire tagged adults from BY 04 (5) and BY 05 (1). Based upon tag recoveries and an adjustment for release group size, the year 2008 population contained an estimated 83% age-3, and 17% age-4 fish.

A simple Peterson model carcass survey of Butte Creek fall-run Chinook salmon estimated the population to be 275. There were 0 coded-wire tagged recoveries during the fall-run survey.

For Big Chico Creek, the adult spring-run Chinook salmon escapement was 0 based upon the snorkel methodology.

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<sup>2</sup> California Department of Fish and Game, North Central Region, 2545 Zanella Way, Suite F, Chico, Calif. 95928

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|   |        |
|---|--------|
| Baldwin Construction Yard               | BCY    |
| Brood Year                              | BY     |
| California Department of Fish and Game  | CDFG   |
| Centerville Covered Bridge              | CCB    |
| Coded-Wire-Tag                          | CWT    |
| Fall-run Chinook Salmon                 | FRCS   |
| Fork Length                             | FL     |
| Late Fall-run Chinook Salmon            | LFRCs  |
| National Marine Fisheries Service       | NMFS   |
| Parrott-Phelan Diversion Dam            | PPDD   |
| Quality Control Device                  | QCD    |
| Quartz Bowl Pool                        | QBP    |
| Spring-run Chinook Salmon               | SRCS   |
| Tricaine Methanesulfonate               | MS-222 |
| United States Fish and Wildlife Service | USFWS  |
| Young-of-the-Year                       | YOY    |
| Rotary Screw Trap                       | RST    |

## INTRODUCTION

This is the tenth report summarizing a study begun during 1995 to define life history characteristics of spring-run Chinook salmon (SRCS), *Oncorhynchus tshawytscha*, in Butte and Big Chico Creeks. The nine previous reports, Hill and Webber (1999), Ward and McReynolds (2004), Ward et al. (2004a,b,c), McReynolds et al. (2005), McReynolds et al. (2006), McReynolds et al. (2007) and Garman and McReynolds (2008) summarized project results through December 2007. Butte Creek is one of several streams that form the basis for population trends for the threatened SRCS in the Central Valley of California. Big Chico Creek currently exhibits only a remnant non-sustaining population of SRCS and is not used as a population trend indicator at this time.

This project has:

- 1) developed adult SRCS and fall-run Chinook salmon (FRCS) escapement estimates for Butte Creek and SRCS escapement estimates for Big Chico Creek;
- 2) monitored outmigration timing and relative abundance of age-0+ juvenile SRCS within Butte and Big Chico creeks, including the Sutter Bypass;
- 3) documented outmigration of yearling SRCS; and
- 4) documented relative growth and residence time of juvenile SRCS in the Butte Creek system, including the Sutter Bypass, through coded-wire tagging (CWT) of juvenile salmon collected at the Parrott-Phelan Diversion Dam (PPDD) and released approximately two miles downstream at the Baldwin Construction Yard (BCY).

Other research projects are assisting in tracking CWT Butte Creek SRCS juveniles as they emigrate downstream through the mainstem Sacramento River and Delta. Tagged salmon have been, and will be recovered in the ocean fishery to determine how and where Butte Creek SRCS contribute to the ocean harvest. However, the 2008 California/Southern Oregon ocean salmon season was cancelled and no Butte Creek fish were taken in the ocean commercial/sport fisheries. Recovery of returning tagged adults to Butte Creek is providing information on survival, age structure, and straying.

### Butte Creek Watershed and Hydrology

Butte Creek is located in Butte and Sutter counties (Figures 1 and 2). The headwaters of Butte Creek originate in the Lassen National Forest, within the Jonesville Basin at an elevation of approximately 2,137 meters (m) (7,000 feet (ft)). The watershed is approximately 2,103 square kilometers (km<sup>2</sup>) (809 square miles (mi<sup>2</sup>)) and has an unimpaired average annual yield of approximately 300,000 cubic decameters (dam<sup>3</sup>) (243,000 acre-feet) (Hillaire, 1993). Butte Creek enters the mainstem Sacramento River at two locations, the Butte Slough Outfall gates and the downstream end of the Sutter Bypass near the confluence of the Feather and Sacramento rivers (Figure 1). When flows in the Sacramento River are greater than approximately 595 cubic meters per second (m<sup>3</sup>/s) (21,000 cubic feet per second (cfs)) at Wilkins Slough, part of the

Sacramento River flows into lower Butte Creek and the Sutter Bypass through the Tisdale Weir (Figure 1). Moulton and Colusa weirs are upstream of Tisdale Weir and are staged to spill when the flow in the Sacramento River reaches approximately 1,274 m<sup>3</sup>/s (45,000 cfs) and 1,841 m<sup>3</sup>/s (65,000 cfs), respectively. The capacity of the Sacramento River channel downstream of the Tisdale Weir at Wilkins Slough is approximately 850 m<sup>3</sup>/s (30,000 cfs). These weirs have a combined capacity to pass approximately 3,766 m<sup>3</sup>/s (133,000 cfs) into the Sutter Bypass (Dept. of the Army, 1975). When water is bypassed, outmigrating salmonids from the upper Sacramento River mix with SRCS from Butte Creek.

### **Big Chico Creek Watershed and Hydrology**

Big Chico Creek is located within Butte and Tehama counties (Figure 1). The headwaters of Big Chico Creek originate from the southwest slope of Colby Mountain at an elevation of approximately 1,646 m (5,400 ft), and encompass a watershed area of approximately 116 km<sup>2</sup> (72 mi<sup>2</sup>). The creek is approximately 72 km (45 mi) in length entering the Sacramento River, west of the City of Chico. The unimpaired average annual yield is approximately 66,600 dam<sup>3</sup> (54,000 acre-feet). The watershed also encompasses three smaller drainages to the north including Sycamore, Mud, and Rock creeks.



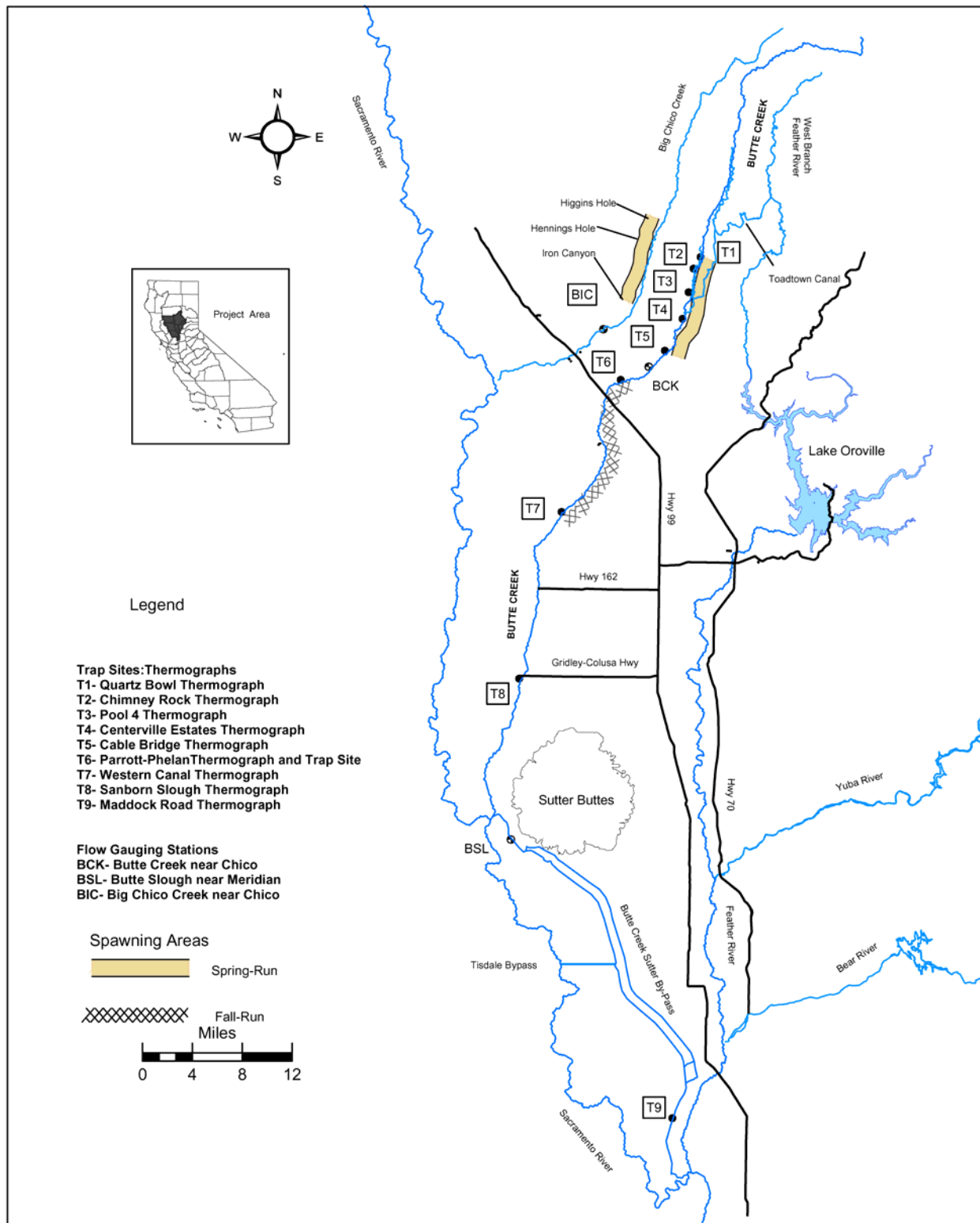


Figure 1. Butte Creek and Big Chico Creek watersheds with trap locations, gaging stations, and salmon spawning areas indicated.

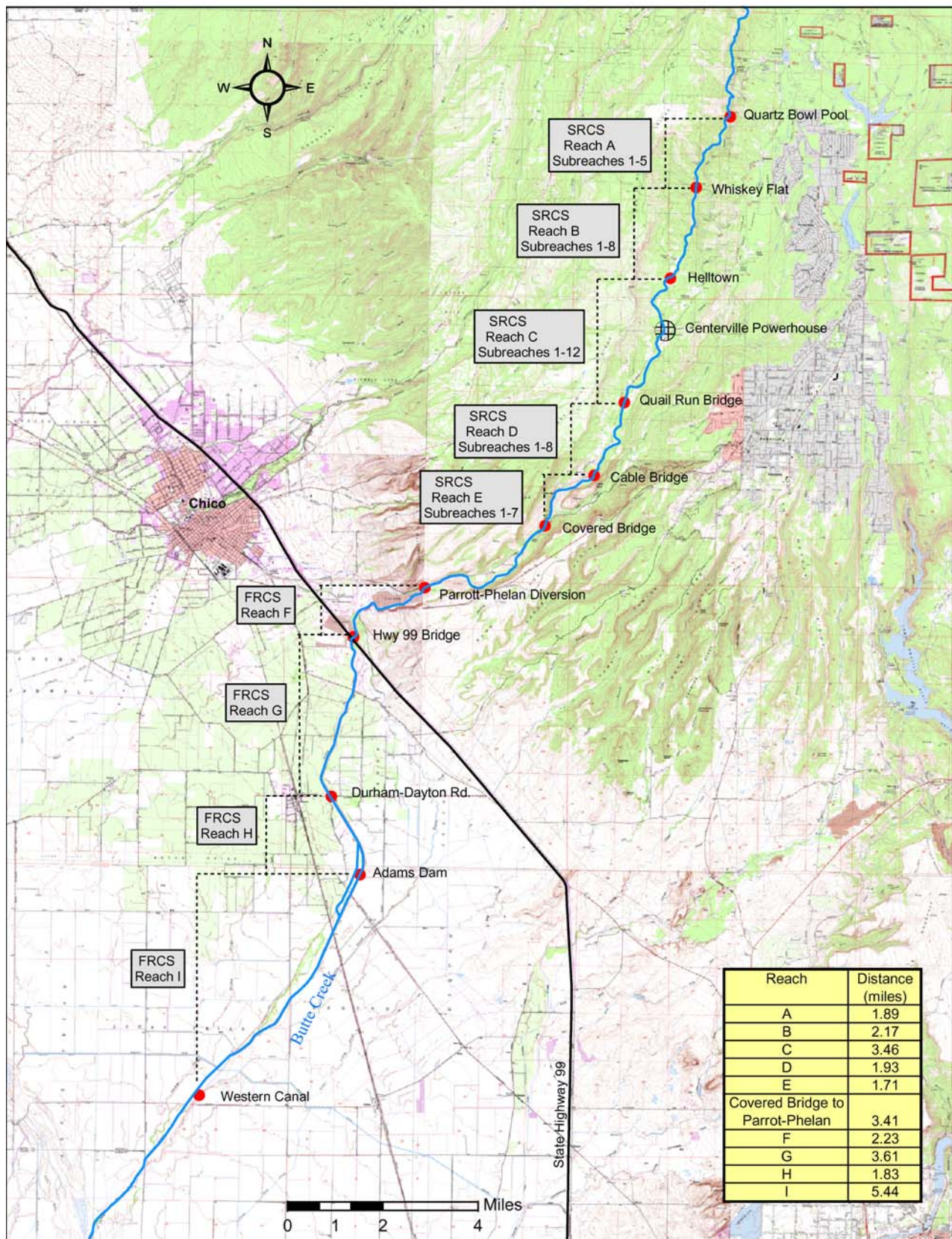


Figure 2. Butte Creek watershed showing spring-run spawning area by reach and sub-reach from Quartz Pool to Covered Bridge and fall-run spawning area by reach from Parrott-Phelan Diversion to Western Canal.



## **MATERIALS AND METHODS**

### **Butte Creek Trapping Sites**

During the 2007-2008 season, fish were trapped at the PPDD location along Butte Creek (Figure 1, Site T6). This site is directly downstream of the SRCS spawning habitat and upstream of the FRCS spawning habitat, although periodically some FRCS spawn above this site. The site was sampled with a 2.4 m diameter (8 ft) rotary screw trap (RST) manufactured by EG Solutions (Eugene, Oregon). The RST was connected to an upstream stationary object, dam, weir, or fish ladder by use of steel cable 0.6 centimeter (cm) (0.25 inch (in)) in diameter. Placement was adjusted regularly to allow for safe operation and access as well as to maximize the efficiency of sampling. In addition to the RST at PPDD, the diversion canal has an off-stream fish screen fitted with a trap box 1.2 m x 0.9 m x 2.1 m (4 ft x 3 ft x 7 ft). The PPDD traps were fished 24 hours a day, seven days a week, except during extraordinarily high flows or during periods of excessive debris.

The Sutter Bypass and Big Chico Creek traps were not operated this season.

### **Physical Measurements**

Four physical measurements were taken daily. Water velocity in meters per second (m/s) was measured at the mouth of the RST cone with a Marsh-McBirney Flo-Mate, Model 2000. The velocity sensor was attached to a graduated staff and submersed to a depth of 0.61 m (2 ft) directly below the shaft of the screw trap cone. Each velocity reading was based upon a preset 45-second averaging period and recorded as the velocity reading for the entire 24 hour period. Additionally, RST cone revolutions were recorded through the use of a mechanical counter (Reddington Counters Inc., Model 1-2936). Total revolutions for the 24 hour period were recorded and the counter reset each day. Water temperature (Celsius) was measured in the live box of each trap using a hand held Enviro-Safe Thermometer. Turbidity was recorded daily using a Hach Model 2100P Portable Turbidimeter. A representative sample of water was collected directly beside the rotary screw trap and the resultant measurement in Nephelometric Turbidity Units (NTU's) recorded on the daily data sheet.

### **Processing Captured Fish**

Daily, all fish were netted from the trap live-boxes and immediately placed into a shallow tub of fresh river water. Juvenile Chinook salmon were sorted from other species and swiftly transferred with small aquarium nets into buckets equipped with portable aerators to be transported to shore for processing. Juvenile Chinook salmon were processed prior to any non-salmonid species. The first 10 of each non-salmonid species were identified to species, measured to the nearest mm fork length (FL), and released. The remainder were counted and released.

A random sub-sample of 50 salmon juveniles was placed into a bucket containing a weak, standardized solution of Tricaine methane sulfonate (MS-222) and anaesthetized (10 grams (g) of MS-222 powder dissolved in 1 liter (L) of fresh distilled water to create a stock solution, which was then used at a dilution of 40 milliliters (ml) stock solution added to 6 L of fresh river water). Upon immobilization, juveniles were individually placed onto a wetted plexiglas measuring board and measured to the nearest mm FL. Salmon greater than 40 mm were transferred to a wetted container on an Ohaus electronic scale and individually weighed to the nearest 0.01 g. Salmon not processed within the sub-sample were hand counted to determine the total catch for the 24 hour sample period. When numbers of fish were too high to hand count

(>2000), five 25 g (0.88-ounce (oz)) sub-samples were weighed on an Ohaus electronic scale to the nearest 1.0 g (0.035 oz). The remaining fish were then added to a previously weighed bucket of fresh water and then weighed to the nearest 25 g on a Chatillon hanging scale. The average number of fish per gram from the five weighed sub-samples was then multiplied by the total grams from the hanging scale to provide an estimate for the total number of fish for the period. All juvenile SRCS were placed in holding pens for subsequent tagging with a CWT.

Salmon were transported in aerated Coleman™ Extreme Marine ice chests to the BCY, approximately two miles downstream of the PPDD site. Fish were tagged using a Northwest Marine Technology Tag Injector Model MKIV and Model MKIV Quality Control Device (QCD). Injectors were fitted with a 1,100-fish/pound (lb) head mold. Fish were anaesthetized in MS-222, adipose fin-clipped, tagged with a half-length (0.5 mm) tag in the rostrum and placed through the QCD. Any miss-tagged or rejected fish were re-tagged. All but a group of 100 tagged fish were recovered in fresh water and released. The remaining fish were held for 24 hours and re-run through the QCD to obtain a 24 hour tag shedding rate and then released. No yearling SRCS were included in the sample tagged.

### **Juvenile Emigration**

By examining length frequency distributions of fish captured at PPDD, young-of-the-year (YOY) and yearlings can generally be identified. Yearling SRCS begin emigrating in the fall, approximately one year after egg deposition. These fish are the only salmon to emigrate before salmon from the newly spawned YOY emerge. Emigration of YOY SRCS is analyzed by examining catches of salmon trapped at PPDD and from tagged fish recovered by other projects in the lower Sacramento River and Delta.

### **Adult Escapement**

Each summer an adult SRCS escapement estimate is developed by conducting snorkel surveys. Adults are counted while in holding behavior, prior to spawning and before the possibility of pre-spawn mortality. On Butte Creek, the snorkel survey extended from the Quartz Bowl Pool (QBP) to PPDD (Figures 1 and 2). On Big Chico Creek, the survey was from Higgins Hole to Iron Canyon (Figure 1). On Butte Creek, the survey was conducted over three days (August 13-15, 2008) each covering discrete reaches, and on one day (August 25, 2008) from Centerville Head Dam to QBP. Each pool was observed only once by each of up to four experienced surveyors, with each of the individual independent estimates recorded. There was subsequent analysis of the entire data set revealing any significant outliers. Such outliers were excluded from calculation of the population estimate. In such instances, the average for the pool only reflected the remaining recorded observations. Individual estimates were then averaged with the annual total escapement estimate calculated by summing the averages for all survey reaches.

### **Adult Pre-spawning Mortality Survey**

A modified Schaefer model (Schaefer, 1951; Taylor, 1974) mark-recapture survey, to identify pre-spawning mortalities, was conducted during the period June 17, through September 18, 2008 as follows:

$$E = N_{ij} = R_{ij}(T_i C_j / R_i R_j) - T_i$$

Where:

E = Total run size which is sum of  $N_{ij}$ ,

$N_{ij}$  = Population size in tagging period i recovery period j,

$R_{ij}$  = Number of carcasses tagged in the ith tagging period and recaptured in the jth recovery period,

$T_i$  = Number of carcasses tagged in the ith tagging period,

$C_j$  = Number of carcasses recovered and examined in the jth recovery period,

$R_i$  = Total recaptures of carcasses tagged in the ith tagging period, and

$R_j$  = Total recaptures of tagged carcasses in the jth recovery period.

The survey extended from QBP to the Centerville Covered Bridge (CCB) (Figures 1 and 2). The approximately 17.7 km (11 mi.) stream section was divided into five reaches. Each reach was covered once per week. Two to four crew members walked downstream covering both sides of the creek. Carcasses were checked for “freshness” and presence/absence of the adipose fin. At least one clear eye and firm flesh constituted a fresh carcass. Each fresh carcass was measured to the nearest mm FL, sexed, tagged with a colored ribbon attached to the lower jaw using a hog ring, and returned to the water near the location where collected. In addition, if obtainable, tissue samples were taken from the first 10 fresh carcasses encountered on each reach each week. Clean scissors were used to cut a small piece (10 mm<sup>2</sup>) of tissue from the caudal fin. If all fins were eroded or decayed, a small piece of skin was taken. Each sample was placed in a pre-labeled vial containing tris-buffer and placed into a container and stored at -20° C. Between each sample, scissors were rinsed in fresh water to prevent cross contamination. Adipose fin-clipped carcasses were measured to the nearest mm FL, tissue sample collected, heads removed and a head tag number assigned with each head placed into a zip-lock bag. Heads were returned to the Chico office and frozen for later recovery of the CWT's. While removing the CWT's from the heads, otoliths were extracted and archived with the previously taken tissue sample. Carcasses that were not tagged were enumerated and chopped in half, preventing them from being counted during future surveys. On each subsequent survey, carcasses were checked for jaw tags, with jaw-tagged carcasses recorded as a “recovery”.

### **Adult Spawning Carcass Survey**

Adult spawning surveys using the modified Schaefer model were conducted for the SRCS population and a simple Peterson mark-recapture model was used for the FRCS population. This was the eighth year an intensive mark-recapture spawning carcass survey was conducted. The primary goal of the survey was to recover CWT's from adults tagged and released as juveniles in Butte Creek during previous years and provided an alternative adult escapement estimate.

The 2008 SRCS spawning survey was conducted from September 23, through October 30, 2008. The survey extended from the QBP to the CCB. The approximately 17.7 km (11 mi.) stream section was divided into five reaches. Each reach was then subdivided into approximately 0.4 km (0.25 mi.) segments. Each reach was surveyed once per week. Department of Fish and

Game personnel spread out and walked downstream, covering both sides of the creek and any side channels. Each fresh carcass (clear eye and firm flesh) was measured to the nearest mm FL, sexed, tagged with a colored ribbon attached to the lower jaw using a hog ring, and returned to the water near the location where collected. All other carcasses were examined for an adipose fin-clip, and then chopped in half to avoid counting during subsequent trips. Tissue samples were taken from the first 10 available fresh carcasses encountered in each reach each week. Clean scissors were used to cut a small piece (10 mm<sup>2</sup>) of tissue from the caudal fin. If all fins were eroded or decayed, a small piece of skin was taken. Each sample was placed in a pre-labeled plastic coin bag and recorded onto a data sheet. Between each sample, scissors were rinsed in fresh water to prevent cross contamination. Each sample was then air dried and placed into a small manila envelope. Heads were removed from adipose fin-clipped carcasses and kept for recovery of the CWT. While removing the CWT's from the heads, otoliths were extracted and archived with the previously taken tissue. As in 2006 and 2007, there was a significant number of fish observed spawning downstream of the CCB. Since the project was not funded for an extensive mark/recapture effort in that reach, a survey to only count and chop carcasses was conducted during four weeks in October. All carcasses were recorded and chopped in half. An expansion factor to account for fish that were not observed was calculated as follows:

$$F = E / (C + T)$$

Where:

F = Expansion Factor

E = Total population estimate for surveyed reaches

C = Total untagged carcasses chopped for surveyed reaches

T = Total tagged carcasses for surveyed reaches

The 2008 FRCS carcass survey was conducted from November 4, 2008 through December 18, 2008. The survey extended from PPDD to the Gorrill Ranch Dam, also covering a 0.8 km (0.5 mi) section near the Western Canal Siphon (Figure 1 and 2). The approximately 15.3 km (9.5 mi) creek section was divided into four reaches. The FRCS survey used a Peterson mark-recapture method because of the paucity of fresh carcasses recovered.

### **Water Temperature**

Onset, HOBO Water Temp Pro, model H20-001, temperature data loggers accurate to  $\pm 0.2^{\circ}\text{C}$  were deployed in pools at five sites within the SRCS spawning habitat (Figure 1). Each data logger was placed in a galvanized steel pipe and suspended by 0.6 cm (0.25 in) steel cable. Data loggers were set for 1 hour interval readings and recorded in degrees Celsius.

## RESULTS

### Butte Creek

#### Trapping Season 2007-2008

The 2007-2008 trapping season began at the PPDD when the diversion trap was installed on October 1, 2007. Low background flows in Butte Creek from early October through November precluded the diversion trap from normal operation and was pulled on October 6 and reset on November 21, 2007. The diversion trap was operated until June 2, 2008. A rotary screw trap was installed on November 16, 2007 and removed on June 2, 2008. A second rotary screw trap was installed on January 15, 2008 and was operated until March 24, 2008 to catch additional juvenile salmon for coded-wire tagging. During the trapping season, there were occasions when one or more of the traps were removed due to high stream flows or excessive debris. A total of 391,363 juvenile salmon, including yearlings, was captured in all traps; 192,404 in the diversion trap and 198,959 in the RST(s) (Tables 1 and 2). Of the total captured, 311,063 were tagged and released at the BCY (Table 3). Trapping was suspended periodically for both the diversion trap and RST during this survey period. Between October and June, the diversion trap was suspended for 33 days and the RST was suspended for a total of 6 days. (Tables 1, 2, and Appendix A, Figure 1).

**Table 1.** Semi-monthly catch summary of juvenile Butte Creek spring-run Chinook salmon caught in the diversion trap at Parrott-Phelan Diversion Dam from October 1, 2007 to June 2, 2008; yearling captures are included.

| Trapping Period |          | Mean FL (mm) | Standard Deviation | Range FL (mm) |       | Total No. Captured | No. Trapping Days |
|-----------------|----------|--------------|--------------------|---------------|-------|--------------------|-------------------|
| 10/1/07         | 10/15/07 | -            | -                  | -             | -     | 0                  | 4                 |
| 10/16/07        | 10/31/07 | -            | -                  | -             | -     | 0                  | 0                 |
| 11/1/07         | 11/15/07 | -            | -                  | -             | -     | 0                  | 0                 |
| 11/16/07        | 11/30/07 | -            | -                  | -             | -     | 0                  | 9                 |
| 12/1/07         | 12/15/07 | 42           | 23.9               | 31            | 96    | 8                  | 12                |
| 12/16/07        | 12/31/07 | 40           | 16.3               | 32            | 114   | 280                | 12                |
| 1/1/08          | 1/15/08  | 36           | 6.4                | 31            | 106   | 9,501              | 10                |
| 1/16/08         | 1/31/08  | 37           | 7.9                | 31            | 116   | 17,488             | 16                |
| 2/1/08          | 2/15/08  | 36           | 1.4                | 32            | 41    | 29,071             | 15                |
| 2/16/08         | 2/29/08  | 36           | 1.5                | 32            | 41    | 72,937             | 14                |
| 3/1/08          | 3/15/08  | 37           | 2.8                | 32            | 64    | 23,982             | 16                |
| 3/16/08         | 3/31/07  | 38           | 4.7                | 32            | 119   | 13,502             | 16                |
| 4/1/08          | 4/15/08  | 41           | 8.4                | 32            | 113   | 9,928              | 15                |
| 4/16/08         | 4/30/08  | 52           | 8.8                | 34            | 81    | 3,663              | 15                |
| 5/1/08          | 5/15/08  | 59           | 8.8                | 28            | 86    | 4,741              | 15                |
| 5/16/08         | 5/31/08  | 65           | 7.2                | 38            | 88    | 7,170              | 16                |
| 6/1/08          | 6/15/08  | 68           | 6.6                | 51            | 81    | 133                | 2                 |
|                 |          |              |                    |               | Total | 192,404            | 187               |

**Table 2.** Semi-monthly catch summary of juvenile Butte Creek spring-run Chinook salmon caught in the RST(s) at Parrott-Phelan Diversion Dam from November 16, 2007 to June 2, 2008; yearling captures are included.

| Trapping period |          | Trap | Mean FL (mm) | Standard Deviation | Range FL (mm) |     | Total No. Captured | No. Trapping Days |
|-----------------|----------|------|--------------|--------------------|---------------|-----|--------------------|-------------------|
| 11/16/07        | 11/30/07 | 1    | -            | -                  | -             | -   | 0                  | 16                |
| 12/1/07         | 12/15/07 | 1    | 66           | 39.6               | 32            | 138 | 12                 | 15                |
| 12/16/07        | 12/31/07 | 1    | 36           | 6.9                | 31            | 109 | 208                | 13                |
| 1/1/08          | 1/15/08  | 1    | 36           | 4.8                | 31            | 110 | 2,146              | 13                |
| 1/16/08         | 1/31/08  | 1    | 36           | 4.3                | 31            | 110 | 8,394              | 16                |
| 1/16/08         | 1/31/08  | 2    | 36           | 1.4                | 33            | 41  | 152                | 10                |
| 2/1/08          | 2/15/08  | 1    | 36           | 1.5                | 32            | 43  | 20,105             | 15                |
| 2/1/08          | 2/15/08  | 2    | 36           | 1.4                | 33            | 39  | 26,932             | 10                |
| 2/16/08         | 2/29/08  | 1    | 36           | 1.5                | 33            | 41  | 47,890             | 13                |
| 2/16/08         | 2/29/08  | 2    | 36           | 1.1                | 34            | 39  | 29,969             | 8                 |
| 3/1/08          | 3/15/08  | 1    | 37           | 4.0                | 33            | 118 | 13,075             | 15                |
| 3/1/08          | 3/15/08  | 2    | 37           | 1.6                | 33            | 51  | 26,202             | 15                |
| 3/16/08         | 3/31/08  | 1    | 38           | 3.7                | 33            | 60  | 7,141              | 16                |
| 3/16/08         | 3/31/08  | 2    | 37           | 1.6                | 34            | 41  | 7,348              | 9                 |
| 4/1/08          | 4/15/08  | 1    | 42           | 7.7                | 32            | 71  | 3,103              | 15                |
| 4/16/08         | 4/30/08  | 1    | 52           | 8.1                | 34            | 79  | 2,146              | 15                |
| 5/1/08          | 5/15/08  | 1    | 59           | 8.1                | 40            | 93  | 2,262              | 15                |
| 5/16/08         | 5/31/08  | 1    | 64           | 7.2                | 42            | 86  | 1,765              | 16                |
| 6/1/08          | 6/15/08  | 1    | 66           | 7.3                | 48            | 88  | 109                | 2                 |
| Total Trap 1    |          |      |              |                    |               |     | 108,356            | 195               |
| Total Trap 2    |          |      |              |                    |               |     | 90,603             | 52                |
| Total           |          |      |              |                    |               |     | 198,959            | 247               |

Sampling by the U.S. Fish and Wildlife Service (USFWS) near Chipps Island in the lower Sacramento River recovered two juvenile tagged Butte Creek SRCS on May 12 and May 19, 2008 (Table 4). Both fish were from Brood Year (BY) 07, captured at PPDD and tagged at the BCY between February 29, and March 10, 2008. No marked juvenile SRCS were salvaged at the State Fish Facility in the central Delta for the 2008 sampling season.



**Table 3.** Summary of coded-wire tagged juvenile Butte Creek spring-run Chinook salmon released at Baldwin Construction site from January 11, to March 20, 2008.

| Tag Code       | Release Date |           | Mean FL<br>(mm) | Total No.<br>Released |
|----------------|--------------|-----------|-----------------|-----------------------|
| 06-02-01-04-07 | 1/11/2008    | 1/29/2008 | 36              | 11,307                |
| 06-02-01-04-08 | 1/14/2008    | 2/7/2008  | 36              | 10,644                |
| 06-02-01-04-09 | 1/16/2008    | 2/4/2008  | 36              | 10,697                |
| 06-02-01-05-00 | 1/30/2008    | 2/7/2008  | 36              | 11,384                |
| 06-02-01-05-01 | 2/11/2008    | 2/22/2008 | 36              | 10,635                |
| 06-02-01-05-02 | 2/7/2008     | 2/14/2008 | 36              | 11,824                |
| 06-02-01-05-03 | 2/11/2008    | 2/15/2008 | 36              | 11,276                |
| 06-02-01-05-04 | 2/14/2008    | 2/20/2008 | 36              | 10,690                |
| 06-02-01-05-05 | 2/15/2008    | 2/21/2008 | 36              | 11,640                |
| 06-02-01-05-06 | 2/20/2008    | 2/23/2008 | 36              | 10,849                |
| 06-02-01-05-07 | 2/22/2008    | 2/26/2008 | 36              | 10,240                |
| 06-02-01-05-08 | 2/21/2008    | 2/25/2008 | 36              | 11,364                |
| 06-02-01-05-09 | 2/23/2008    | 2/29/2008 | 36              | 11,477                |
| 06-02-01-06-01 | 2/23/2008    | 2/27/2008 | 36              | 10,518                |
| 06-02-01-06-02 | 2/25/2008    | 2/28/2008 | 36              | 11,381                |
| 06-02-01-06-03 | 2/26/2008    | 2/29/2008 | 36              | 10,772                |
| 06-02-01-06-04 | 2/27/2008    | 3/1/2008  | 36              | 10,953                |
| 06-02-01-06-05 | 2/28/2008    | 3/3/2008  | 36              | 11,596                |
| 06-02-01-06-06 | 2/29/2008    | 3/4/2008  | 36              | 10,879                |
| 06-02-01-06-07 | 2/29/2008    | 3/10/2008 | 36              | 10,776                |
| 06-02-01-06-08 | 3/1/2008     | 3/5/2008  | 36              | 10,755                |
| 06-02-01-06-09 | 3/4/2008     | 3/6/2008  | 36              | 11,599                |
| 06-02-01-07-01 | 3/4/2008     | 3/6/2008  | 36              | 10,462                |
| 06-02-01-07-02 | 3/6/2008     | 3/19/2008 | 36              | 11,099                |
| 06-02-01-07-03 | 3/7/2008     | 3/17/2008 | 36              | 11,623                |
| 06-02-01-07-04 | 3/7/2008     | 3/17/2008 | 36              | 10,958                |
| 06-02-01-07-05 | 3/17/2008    | 3/19/2008 | 36              | 10,808                |
| 06-01-00-07-06 | 3/18/2008    | 3/20/2008 | 36              | 6,410                 |
| 06-01-00-07-07 | 3/19/2008    | 3/20/2008 | 36              | 4,078                 |
| 06-01-00-07-08 | 3/19/2008    | 3/20/2008 | 36              | 2,367                 |
|                |              |           | Total           | 311,063               |

**Table 4.** Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags by other research projects during 2008.

| Recovery Date | Tag Code*      | Recovery FL (mm) | Recapture Location | ~Days at Large |
|---------------|----------------|------------------|--------------------|----------------|
| 5/12/08       | 06-02-01-07-01 | 57               | Chipps Island      | 68             |
| 5/19/08       | 06-02-01-06-07 | 80               | Chipps Island      | 75             |

\* Both fish were from BY 07 and tagged at BCY.

### Juvenile Emigration 2007-2008

As discussed in previous reports (McReynolds et al., 2006), YOY and yearling juvenile SRCS outmigrants were documented based upon the FL of juvenile salmon captured at PPDD. During this study trapping period, the majority of Butte Creek SRCS that were captured migrated as fry. As observed in previous years, some YOY remained to rear in Butte Creek above PPDD, emigrating later in the spring. During this trapping period, 48 yearling SRCS were captured. The first yearling SRCS was captured on December 5, 2007 and the last on April 4, 2008 (Table 1 and 2; Appendix B, Figure 1). Length-frequency distributions for the entire period (Appendix B, Figure 1) continue to show a bi-modal, and sometimes tri-modal distribution that generally appear to delineate YOY and yearling SRCS and also late fall-run Chinook salmon (LFRCS).

### Adult Escapement 2008

In late June, approximately 250-300 adult SRCS were visually observed holding downstream of State Highway 99. Low flows and high water temperatures precluded their ability to volitionally migrate upstream. On July 2, 2008, the California Department of Fish and Game (CDFG) and National Marine Fisheries Service (NMFS) conducted a fish rescue mission to relocate fish upstream into amicable habitat. Block seines and crowding seines were used to corral and congregate fish inside of the seine “pen”. Large dip nets were then used to transport captured fish up the levee into hatchery trucks and transported upstream to PPDD. A total of 352 adult SRCS were seined and subsequently marked by clipping a small portion of the right ventral fin before being released. Of the 352 adults that were marked, 31 were recovered during the pre-spawning mortality survey and 5 were recovered from the spawning carcass surveys.

### Pre-spawning Mortality Carcass Survey

This was the sixth year that an intensive mark-recapture survey was conducted during the adult SRCS holding period to assess pre-spawn mortalities (Ward et al., 2004d; Ward et al., 2006a,b,c and McReynolds and Garman 2008). From June 17, 2008 through September 18, 2008, a total of 549 carcasses were examined of which 158 were measured, identified by sex (80% female, 20% male) and marked for possible recovery. Of the 158 marked salmon, 7 were recovered. Since recoveries of marked salmon were too low to calculate an estimate using the modified Schaefer model, an expansion factor developed from the subsequent spawning carcass survey of 1.92 (Appendix C) was applied to generate an estimated total pre-spawning mortality of 1,054.

Mortalities appeared to be due to natural attrition. During this survey period, one CWT carcass (BY 05) was collected (Appendix D, Table 1). Carcasses were identified as pre-spawning mortalities due to immature gametes and lack of any visible spawning activity.

### Spawning Carcass Survey

During this study period, an eighth intensive survey directed at recovering CWT's from previous release groups was conducted. A spawning carcass survey began on September 23, and continued through October 30, 2008 covering the 17.7 km (11 mi.) SRCS spawning area (Figures 1 & 2). Additionally, significant spawning activity was noted in the reach downstream of the CCB, extending past the normal survey area. To provide some assessment of this activity, 190 carcasses were counted and chopped during four surveys that covered that reach. Based upon the spawning carcass survey, there were an estimated 10,082 adult SRCS that spawned during 2008. There were a total of 5,238 carcasses examined, including those from downstream of the CCB, with a total of 6 CWT's recovered: BY 04 (5) and BY 05 (1) (Appendix D, Table 1 & 2). For SRCS carcasses and CWT recoveries below the CCB, an expansion factor of 1.92 was calculated as previously described for the pre-spawn mortality estimate.

Subsequent to the SRCS spawning carcass survey, a survey of the FRCS spawning area (Figure 1 and 2) was conducted from November 13 through December 18, 2008. No CWT's were recovered from the 125 carcasses that were examined. Due to low numbers of marked fresh carcasses and low recoveries of marked fish, a simple mark-recapture Peterson model was utilized. The FRCS escapement estimate was 275 (Appendix C, Table 2).

### Snorkel Escapement Survey

The 2008 SRCS adult escapement estimate based upon the snorkel survey method was 3,935. (Table 5).

**Table 5.** Snorkel survey estimates of adult spring-run Chinook salmon escapement in Butte Creek.

| Year | Estimate | Survey Dates                  |
|------|----------|-------------------------------|
| 1995 | 7,480    | July 24 - July 27, 1995       |
| 1996 | 1,400    | August 19 - August 23, 1996   |
| 1997 | 635      | August 18 - August 21, 1997   |
| 1998 | 20,259   | August 18 - August 24, 1998   |
| 1999 | 3,679    | August 23 - August 31, 1999   |
| 2000 | 4,118    | August 25 - September 1, 2000 |
| 2001 | 9,605    | August 13 - August 16, 2001   |
| 2002 | 8,785    | August 12 - August 16, 2002   |
| 2003 | 4,398    | August 18 - August 20, 2003   |
| 2004 | 7,390    | July 12 - July 16, 2004       |
| 2005 | 10,625   | July 26 - July 28, 2005       |
| 2006 | 4,579    | July 24 - July 26, 2006       |
| 2007 | 4,943    | July 9 - July 11, 2007        |
| 2008 | 3,935    | August 13 - August 15, 2008   |

### Water Temperatures 2007-2008

Thermal recording data loggers were installed at the five sites within the SRCS holding and spawning reach of Butte Creek (Figure 1). Recorded mean daily temperatures during the period June through October ranged as high as 21.0° C on August 16, at the Pool 4 location (Table 6; Appendix E, Figures 1 - 5). Average daily temperatures at all sites were above 15.0° C until September 23, 2008. Initial data loggers and back-up loggers deployed at Centerville Estates and Cable Bridge sites were either stolen or lost. Subsequently, no temperature data was recorded during the June to October period.

**Table 6.** Butte Creek spring-run Chinook salmon holding reach average daily temperature exceedance.

| Location            | Period of Record    | Number of Days Equal to or Exceeding |        |        |
|---------------------|---------------------|--------------------------------------|--------|--------|
|                     |                     | 15.0 C                               | 17.5 C | 20.0 C |
| Quartz Bowl Pool    | 6/4/08 to 10/31/08  | 99                                   | 52     | 0      |
| Chimney Rock        | 6/17/08 to 10/31/08 | 99                                   | 66     | 3      |
| Pool 4              | 6/1/08 to 10/31/08  | 112                                  | 73     | 10     |
| Centerville Estates | 6/1/08 to 10/31/08  | -                                    | -      | -      |
| Cable Bridge        | 6/1/08 to 10/31/08  | -                                    | -      | -      |

### **Big Chico Creek**

#### Adult Escapement 2008

The Big Chico Creek spawning escapement survey was conducted August 20th and 22nd, 2008. The estimate was 0 based upon the snorkel survey method (Table 7).

**Table 7.** Snorkel survey estimates of adult spring-run Chinook salmon escapement in Big Chico Creek.

| Year | Estimate | Survey Date          |
|------|----------|----------------------|
| 1998 | 369      | August 1998          |
| 1999 | 27       | September 10, 1999   |
| 2000 | 27       | August 8, 2000       |
| 2001 | 39       | August 8, 2001       |
| 2002 | 0        | August 8, 2002       |
| 2003 | 81       | August 11, 2003      |
| 2004 | 0        | August 11 & 13, 2004 |
| 2005 | 37       | August 10, 2005      |
| 2006 | 299      | July 17, 2006        |
| 2007 | 0        | July 18, 2007        |
| 2008 | 0        | August 20 & 22, 2008 |

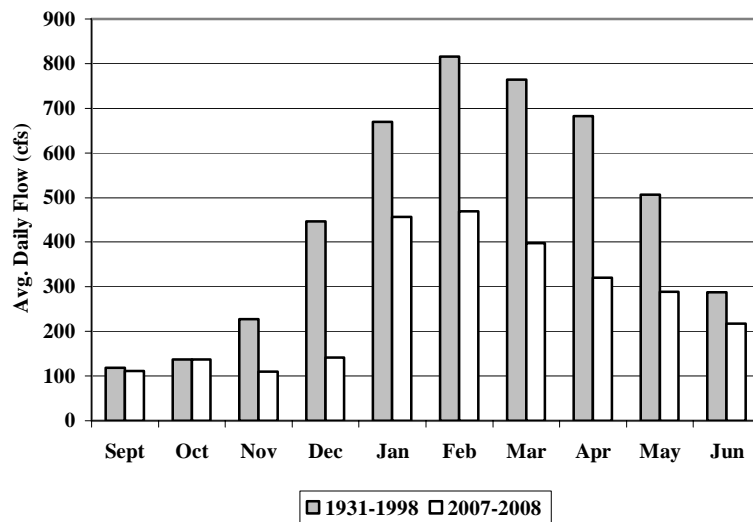
## DISCUSSION

During this study period, emphasis was focused on trapping and tagging juvenile SRCS on Butte Creek at the PPDD, as well as recovering tags from returning adults. As with previous studies, short periods of elevated uncontrolled flows and heavy debris required cessation of trapping (Appendix A, Figure 1) to protect personnel and gear. Of the 246 sampling days, the RST and diversion trap was suspended a total of 6 and 33 trap days, respectively.

### Juvenile Emigration

During this study period, trapping data continued to support previous project conclusions that Butte Creek SRCS primarily emigrate as fry. Earlier project observations found that >95% of the total catch had occurred by the end of January (Hill and Webber, 1999; Ward and McReynolds, 2004). During the 2007-2008 study period, low average creek flows during the peak of Chinook salmon emigration (January/February) delayed the movement timing of juveniles (Figure 3). Of the total catch, 91% had occurred by the end of March. This is in contrast to the 2000-2001, 2001-2002 and 2004-2005 study periods, where the majority of the catch ( $\geq 90\%$ ) had occurred by the end of February. The total season catch for 2007-2008 was 391,363, substantially lower than the 2006-2007 catch of 680,796. During periods of high flows, traps are pulled for personnel safety, protection of trapping equipment and to decrease potential mortality of juvenile salmon. Past study reports (McReynolds, et al. 2006) have shown that increased flows in Butte Creek during peak juvenile emigration (January-February), result in increased juvenile salmon numbers passing PPDD. It is likely that large numbers of salmon emigrated past PPDD this season when traps were pulled.

Figure 3. Comparison of Butte Creek average flows as measured at Butte Creek near Chico Gage (USGS #11390000) during 2007-08 with average flows during the period 1931-1998 (CDWR, 2002).



Emerged fry were captured at PPDD from December 2007 through June 2, 2008 (Appendix B, Figure 1). As with previous years (McReynolds et al., 2005), recently emerged fry captured at PPDD beginning in early April (Appendix B, Figure 1) were assumed to be LFRCS. Again, FRCS were observed spawning above PPDD after mid-October 2008, although numbers were generally small. Fry captured at the site from November through March were assumed to be SRCS.

Many yearling salmon were observed upstream of PPDD during the summer adult escapement surveys. However, during this survey period only 48 yearling salmon were captured at PPDD compared to 14 yearling salmon the previous study year. These results continue to support the conclusion that the majority of Butte Creek SRCS migrate as YOY.

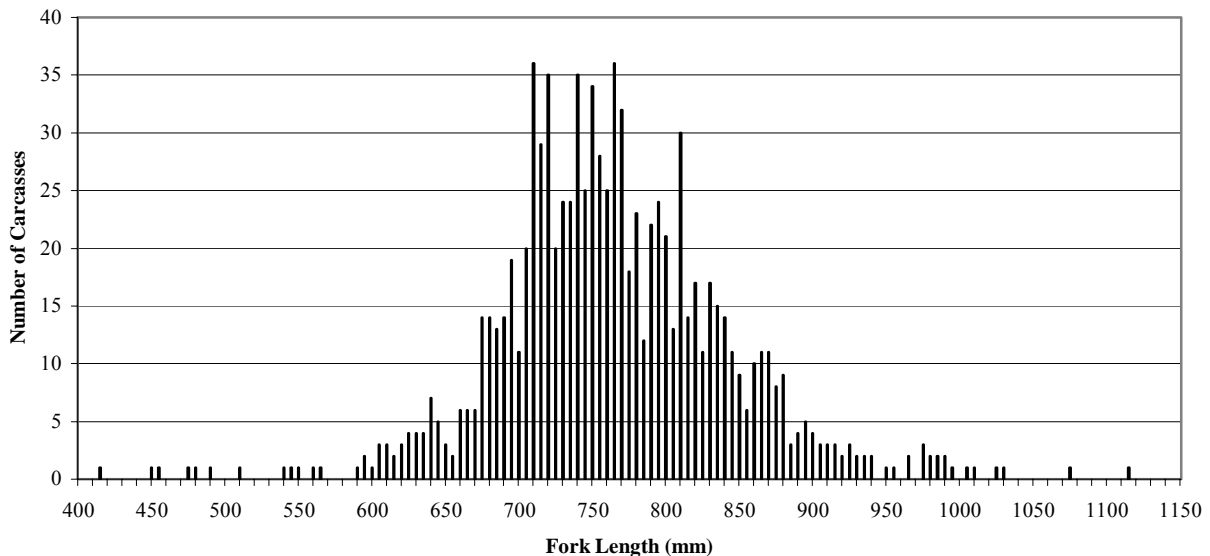
### **Adult Escapement**

During this study period, three discrete surveys were completed to develop an estimate of adult SRCS escapement. A standard swimming snorkel survey was conducted August 13-15, 2008. The snorkel survey has been performed consistently since 1991 and serves as a population index. The 2008 snorkel survey was scheduled during July in an attempt to develop a better estimate prior to any significant pre-spawn mortality. However, the 2008 Butte Lightning Fire Complex postponed the survey until mid-August. There were an estimated 17 pre-spawn mortalities prior to the snorkel survey. Previous project findings have shown that snorkel surveys significantly underestimate salmon abundance (McReynolds et al., 2006). As an alternative, a standard modified Schaefer model spawning carcass survey was initiated beginning in 2001. Based upon significant pre-spawn mortalities observed during 2002, an additional modified Schaefer model survey was completed during 2003-2008 to account for those adults that died prior to spawning. The 2008 escapement estimate based upon the snorkel survey was 3,935 with a range of 3,402 to 4,506. The combined pre-spawn and spawning Schaefer model carcass survey results for 2008 suggest a larger population of 11,136 SRCS; 1,054 that died prior to spawning and 10,082 which survived to spawn (Appendix C, Table 1). During previous surveys (2001-2004) SRCS spawning was almost exclusively confined to reaches above the CCB, with only a small number observed below. However, since 2005, significant spawning in the reach downstream of the CCB has been noted in early October. Since the project is not funded to develop a modified Schaefer model estimate in that reach, four single day surveys to record and chop spawned carcasses were completed during September and October. There were 190 carcasses counted and chopped. Among those that survived to spawn, there were 5,238 carcasses examined including those from the reach downstream of the CCB, of which 943 fresh carcasses (48% female, 52% male) were marked, with a subsequent recovery of 474, a recovery rate of 50%.

On July 2, 2008, 352 adult SRCS were physically rescued from habitat approximately ½ mile (.81 km) downstream of State Highway 99 near Chico and transported upstream of PPDD. Each fish was marked with a right pelvic fin-clip prior to release for identification in subsequent surveys. Five “rescued” fish were recovered (10 expanded) from the carcass survey. However, tissue decay as a result of redd construction and natural decomposition of spawned carcasses made positive identification of the right pelvic fin-clip difficult. Therefore, it is feasible that “rescued fish” survived to spawn but were not detected during the survey. A more strategic mark should be used or considered in the future when conducting fish rescues to improve the ability to determine the identification of “rescued” fish and how they contribute to the spawning population.

Based upon snorkel survey estimates and adults returning as three year olds, the 2008 escapement estimate represents a 0.37 cohort replacement rate (3,935/10,625). However, Butte Creek CWT recoveries continue to demonstrate that a proportion of Butte Creek SRCS return to spawn at age-4. Of the 6 total CWT's recovered for all methods, 1 were age-3 and 5 were age-4 (Appendix D, Table 1). Based upon the limited number of CWT recoveries, and adjusted for release group size, the population contained approximately 83% age-3, and 17% age-4 fish.

**Figure 4.** Length frequency distribution of 944 spawned adult Butte Creek spring-run Chinook salmon carcasses measured and marked for abundance estimate between September 23, and October 30, 2008.



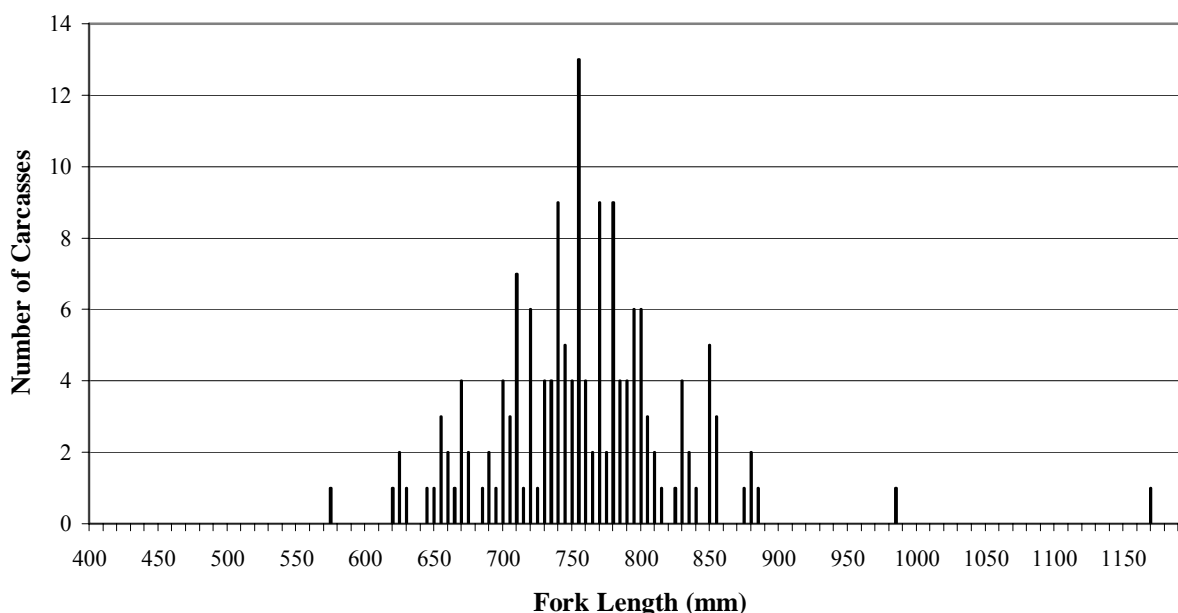
This was the sixth season a fully funded pre-spawning mortality survey was completed starting on June 17 and ending on September 18, 2008 at the onset of spawning. Mortalities were low throughout the study period. There were a total of 549 carcasses examined of which 158 were measured (80% female, 20% male) and identified by sex and marked for possible recovery. Ten were recovered during the 13 week survey. Due to the low number of marks and recoveries it was not possible to generate a modified Schaefer model estimate of total pre-spawn mortality. Instead, an expansion factor ( $F = 1.92$ ) generated from the subsequent modified Schaefer Model was applied (Appendix C). Based upon that expansion factor, the estimate for pre-spawn mortality was 1,054 ( $549 \times 1.92$ ).

For the measured sub-sample of adult Butte Creek SRCS, the percentage of male to female was similar to 2001 and 2002, and represented a closer 1:1 ratio when compared to 2003-2007 (Table 8). Based upon tag recoveries (6) and an adjustment for release group size, the year 2008 population contained an estimated 83% age-3, and 17% age-4 fish. Due to paucity of CWT recoveries, it is difficult to assess age composition by adjusting for CWT release-groups and the development of the CDFG Scale Ageing Program will greatly aid in deriving age specific escapement estimates. Scale analysis of the Butte Creek 2008 adult run year had not been completed at the time of this report.

**Table 8.** Fork lengths of adult Butte Creek spring-run Chinook salmon that spawned during 2001- 2008 which were measured and marked for abundance estimate.

| Year | Female    |         |         |     |      | Male      |         |         |     |      |
|------|-----------|---------|---------|-----|------|-----------|---------|---------|-----|------|
|      | Carcasses |         | FL (MM) |     |      | Carcasses |         | FL (MM) |     |      |
|      | Total     | Percent | Max     | Min | Mean | Total     | Percent | Max     | Min | Mean |
| 2008 | 455       | 48%     | 980     | 551 | 737  | 489       | 52%     | 1116    | 417 | 789  |
| 2007 | 470       | 55%     | 992     | 581 | 762  | 388       | 45%     | 1081    | 440 | 839  |
| 2006 | 458       | 57%     | 972     | 562 | 762  | 342       | 43%     | 1065    | 478 | 817  |
| 2005 | 609       | 55%     | 895     | 518 | 706  | 495       | 45%     | 1090    | 435 | 771  |
| 2004 | 376       | 54%     | 962     | 490 | 723  | 324       | 46%     | 973     | 429 | 765  |
| 2003 | 378       | 60%     | 979     | 494 | 802  | 252       | 40%     | 1110    | 423 | 844  |
| 2002 | 416       | 49%     | 910     | 574 | 708  | 440       | 51%     | 1091    | 349 | 754  |
| 2001 | 784       | 52%     | 910     | 340 | 709  | 711       | 48%     | 1020    | 402 | 760  |

**Figure 5.** Length frequency distribution of 158 adult Butte Creek spring-run Chinook salmon pre-spawn mortalities measured between June 17, and September 18, 2008.

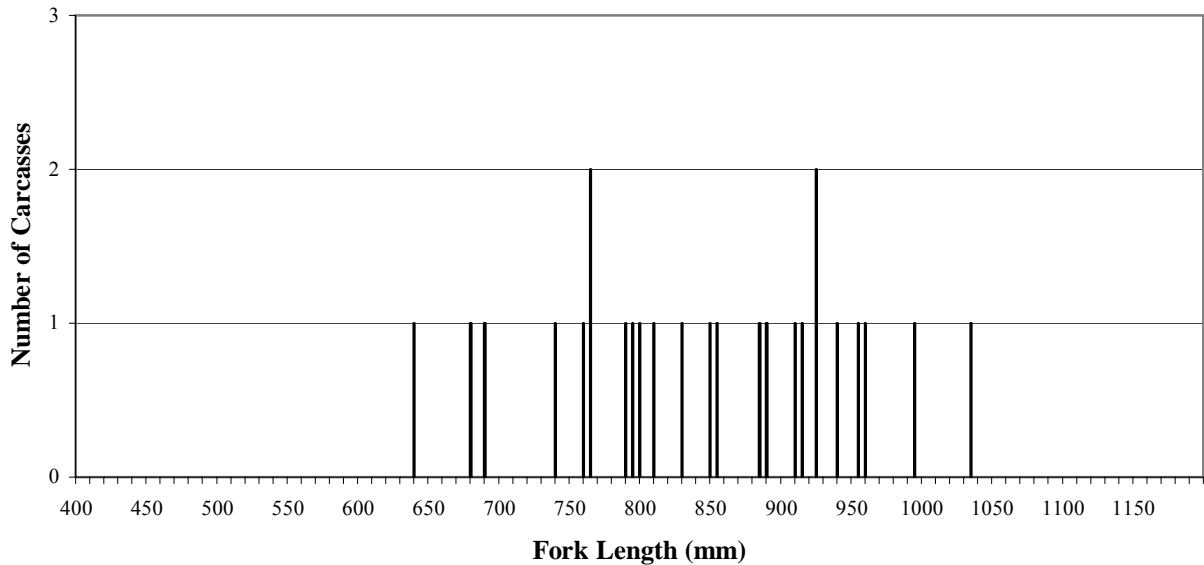


Subsequent to the SRCS spawning carcass survey, a FRCS spawning carcass survey was initiated on November 4, and continued through December 18, 2008. The FRCS survey covered the reaches of Butte Creek downstream of the PPDD (Figure 1 and 2). For the seventh consecutive year, a bar rack was placed in the fish ladder at the PPDD during the last week of September to reduce the number of FRCS that spawn upstream of this site, although a small number of FRCS ascended and spawned above. The bar rack was removed during the first week of December. A survey utilizing a modified Schaefer model was initiated. However, only 100 carcasses were examined, with 25 of the fresh carcasses marked of which 10 were subsequently recovered. A Peterson model estimated 275 FRCS spawned in the reach downstream of



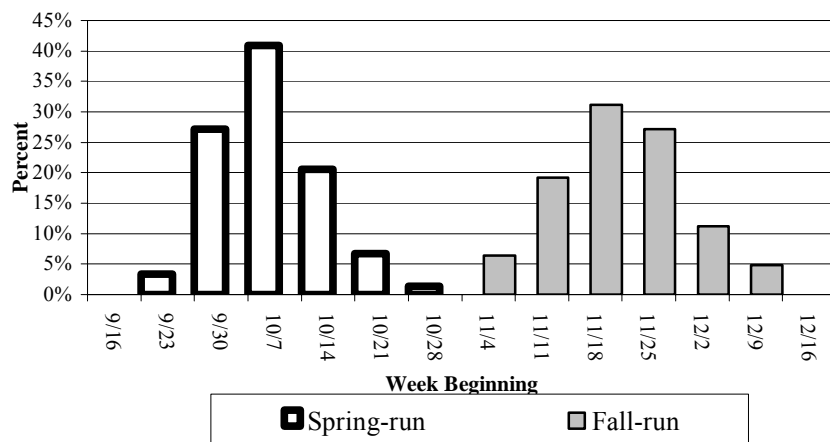
PPDD (Appendix C, Table 2). The mean FL of the measured sub-sample of 25 Butte Creek FRCS was 844 mm (Figure 6). There were no CWT marked carcasses recovered during the FRCS carcass surveys.

**Figure 6.** Length frequency distribution of 25 adult fall-run Chinook salmon carcasses measured and marked for abundance estimate between November 4, and December 18, 2008.



Comparison of Butte Creek SRCS and FRCS spawn timing (Figure 7) continues to show little overlap, with peak SRCS spawning occurring during the week beginning on October 7. For FRCS the peak occurred during the week beginning on November 18, 2008. All of the Butte Creek SRCS spawned upstream of PPDD (Figure 1), while the vast majority of FRCS spawned downstream of that site.

**Figure 7.** Percent of carcasses of spawned Butte Creek spring and fall-run Chinook salmon recovered for period September 23, through December 18, 2008.



### **Adult Straying**

During this reporting period, one Feather River adult CWT Chinook salmon was recovered from surveys conducted on Butte Creek. A female (BY04) at 844 mm (tag code 0601010308) was recovered during the carcass survey on October 2, 2008. Tag information from the Regional Mark Information System (RMIS) lists this tag group as 51,106 FRCS released in the Yolo bypass on March 17, 2005 at an average FL of 52 mm. However, based upon the location, recovery date, average release FL and time of tagging, it was concluded that the fish exhibited phenotypic SRCS life history patterns. The results from the 2007-2008 study period continue to support Butte Creek SRCS as a distinct and sustaining population with little evidence to date of significant introgression from other watersheds. To date, there have been 258 (expanded to 392 for sampling effort) CWT Butte Creek SRCS recovered in Butte Creek and six (no expansion) in other watersheds. It is difficult to assess the magnitude of Butte Creek SRCS straying into other Central Valley watersheds due to the lack of uniform effort to recover CWT fish, particularly among SRCS.

### **Water Temperature**

Butte Creek water temperatures have historically exceeded ideal temperatures as reported for holding and spawning SRCS (Appendix E, Figures 1-5). In general, temperatures for holding adult SRCS should not exceed 15°C (59°F) (Hinze, 1959; Boles, 1988; CDFG, 1998). There are five locations within the summer holding habitat of Butte Creek that have continuously recording data loggers (Figure 1). Average daily temperatures exceeded 15°C at all sites from late-June until September 23, 2008. Average daily temperatures exceeded 17.5°C by June 28, 2008 and did not exceeded 20°C for any day during the holding period at QBP.

### **ACKNOWLEDGMENTS**

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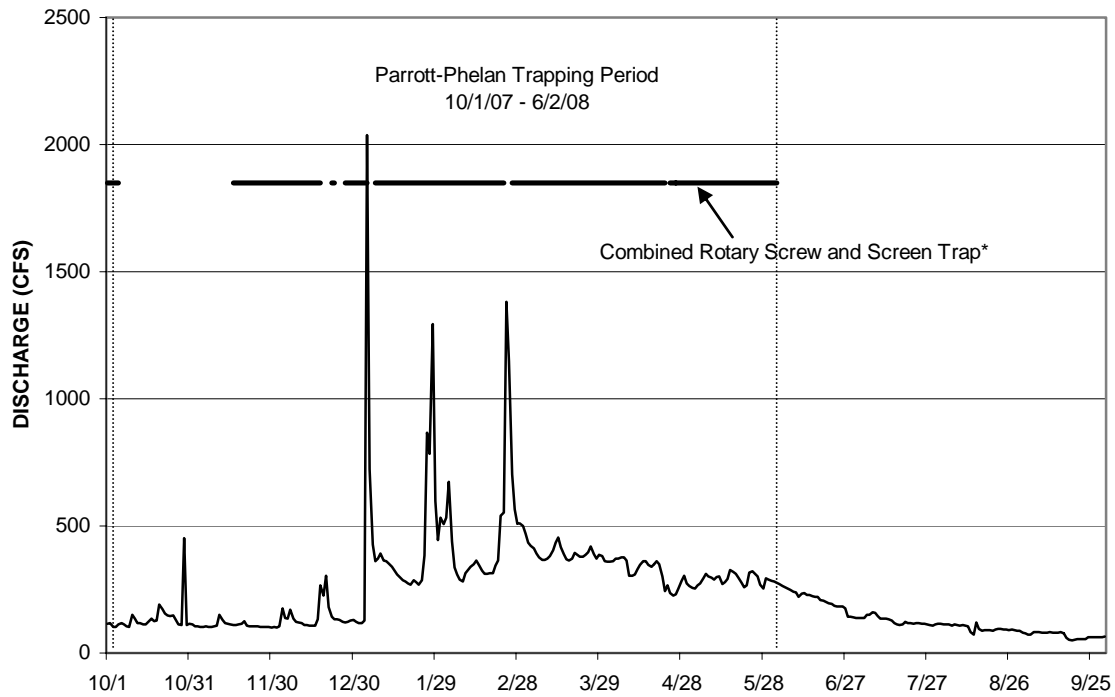
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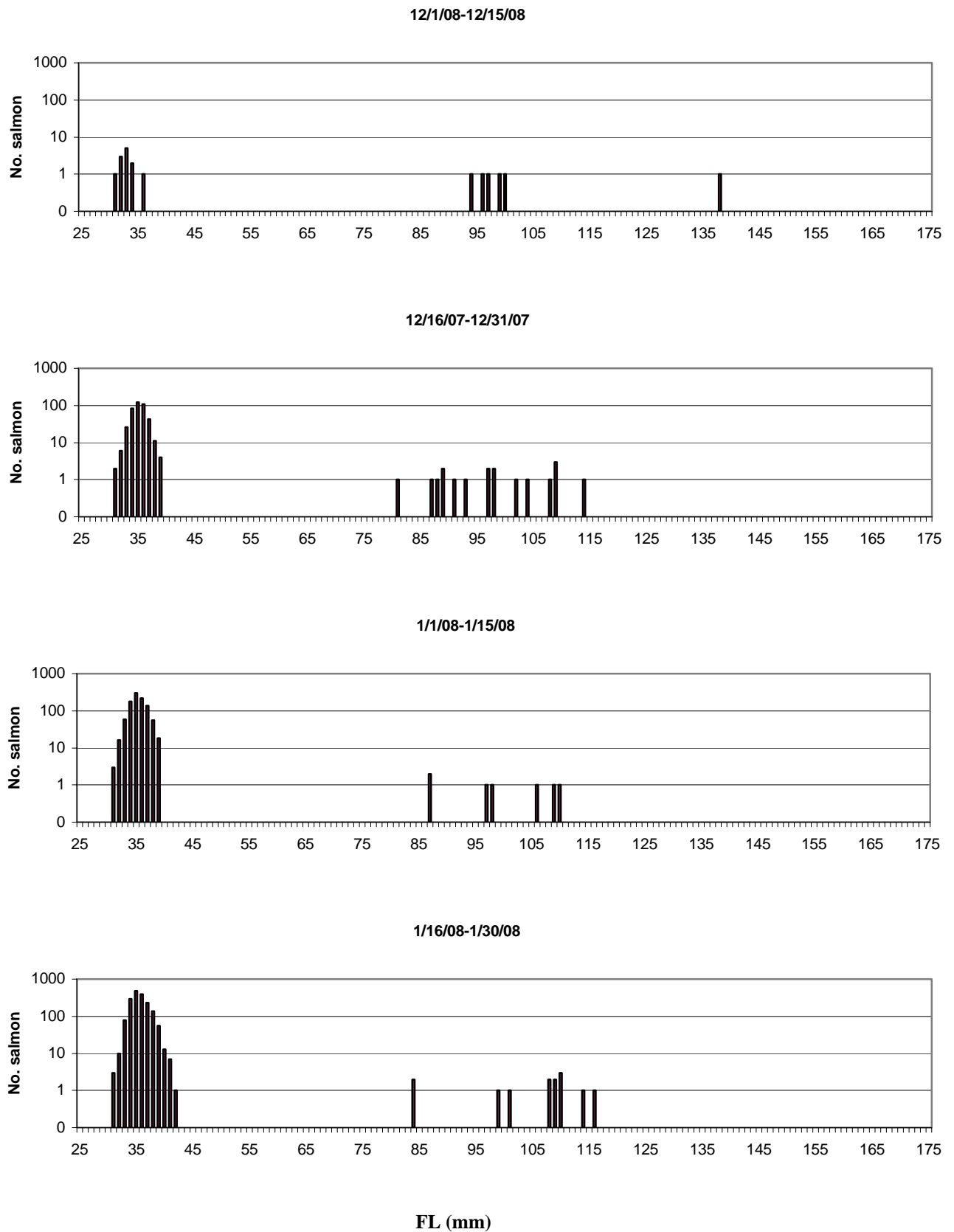
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APPENDIX A, Figure 1. Butte Creek flow at Butte Creek near Chico Gage (USGS - #11390000), water year 2007-08, with trapping period shown. Flow data are provisional and subject to revision.

\*Breaks in horizontal line indicate periods of time when the trap(s) were not fishing.

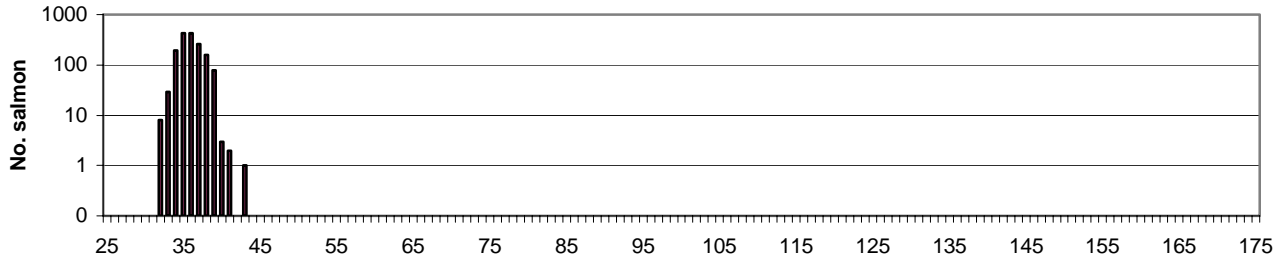


APPENDIX B, Figure 1. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 1, 2007 through June 2, 2008. All fish are assumed to be spring-run Chinook salmon except where indicated.

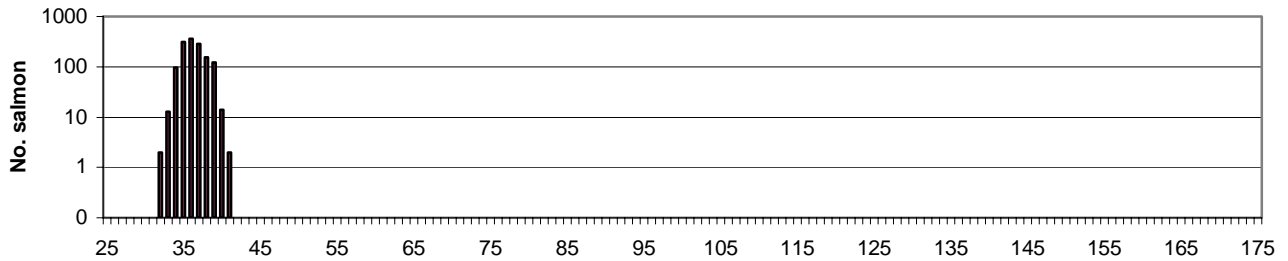


APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 1, 2007 through June 2, 2008. All fish are assumed to be spring-run Chinook salmon except where indicated.

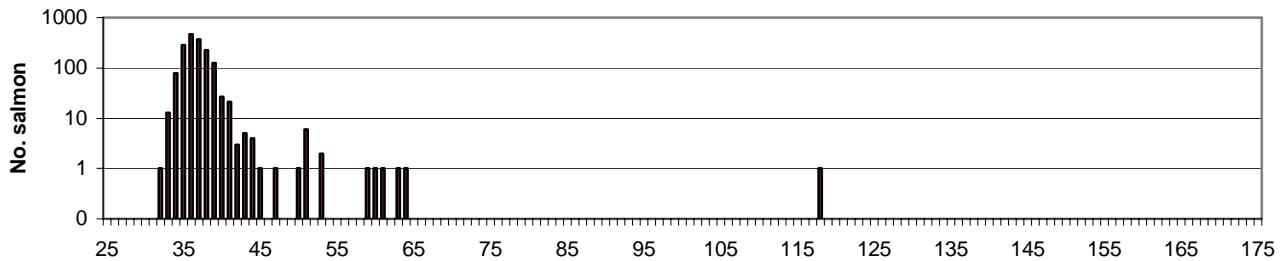
**2/1/08-2/15/08**



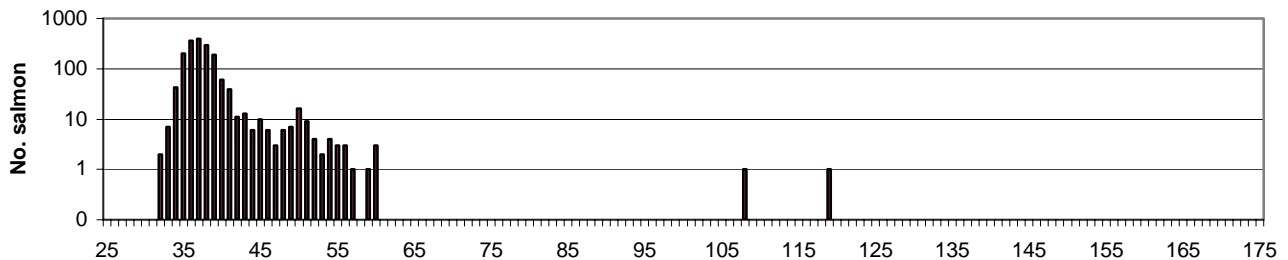
**2/16/08-2/29/08**



**3/1/08-3/15/08**

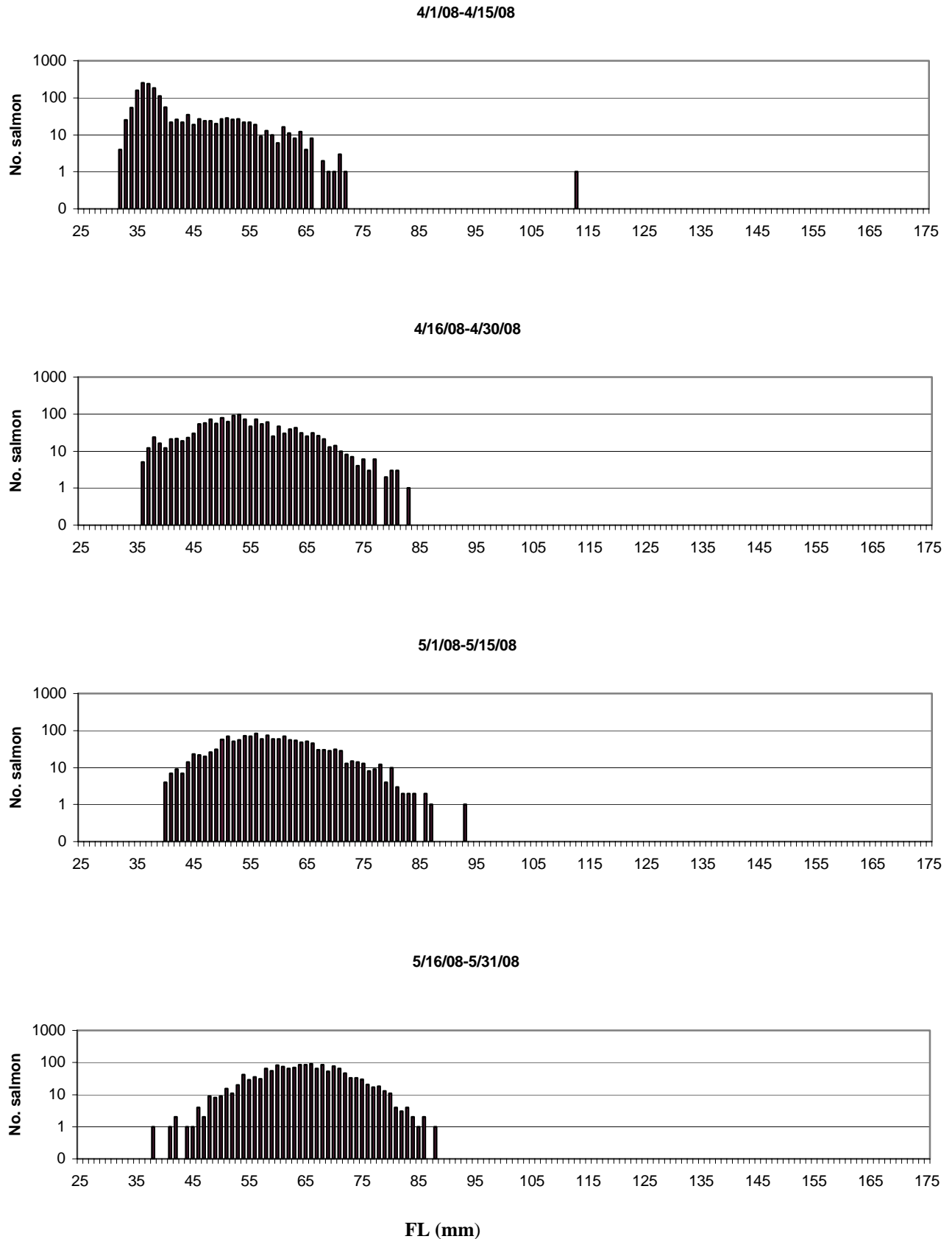


**3/16/08-3/31/08**



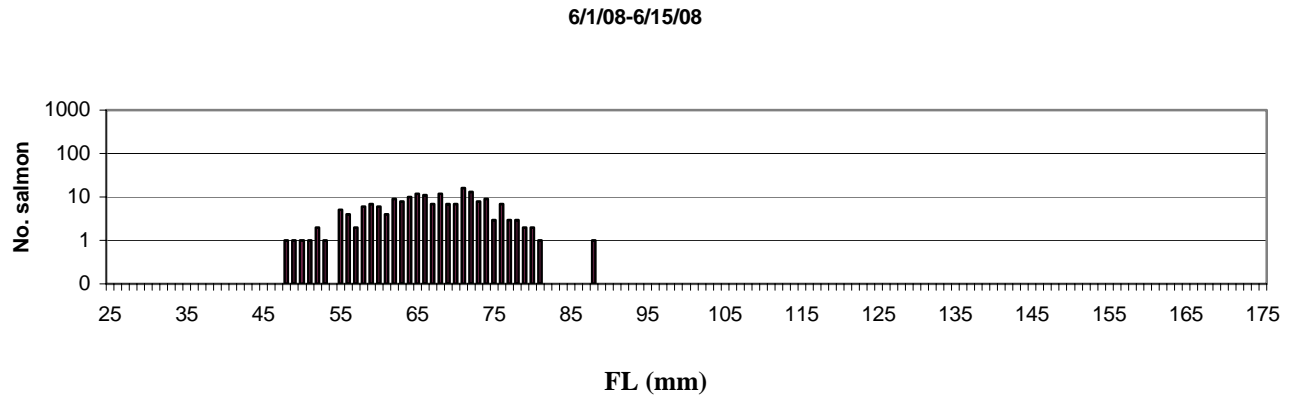
**FL (mm)**

APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 1, 2007 through June 2, 2008. All fish are assumed to be spring-run Chinook salmon except where indicated.





APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 1, 2007 through June 2, 2008. All fish are assumed to be spring-run Chinook salmon except where indicated.



APPENDIX C, Table 1. Butte Creek spring-run Chinook spawning escapement estimate for 2008 using modified Schaefer Model.

| Week of Recovery R <sub>(j)</sub>   | R <sub>(ij)</sub> Week of Tagging T <sub>(i)</sub> |                |          |            |            | Tags Recovered R <sub>(j)</sub>                           | Carcasses Counted C <sub>(j)</sub> | Population Estimate E <sub>(j)</sub> |
|---|--|----------------|----------|------------|------------|---|------------------------------------|--------------------------------------|
|   | 1  | 2              | 3        | 4          | 5          |   |                                    |                                      |
|   | Sept. 23-25  | Sept.30-Oct. 2 | Oct. 7-9 | Oct. 14-16 | Oct. 21-23 |   |                                    |                                      |
| 1<br>Sept. 30-Oct. -2   | 11   | -              | -        | -          | -          | 13  | 1017                               | 3201                                 |
| 2<br>Oct. 7-9   | 4  | 114            | -        | -          | -          | 118   | 1821                               | 4405                                 |
| 3<br>Oct. 14-16   | 2  | 27             | 203      | -          | -          | 232   | 1128                               | 1367                                 |
| 4<br>Oct. 21-23   | 0  | 5              | 29       | 56         | -          | 90  | 403                                | 482                                  |
| 5<br>Oct. 28-30   | 0  | 0              | 7        | 10         | 6          | 23  | 90                                 | 76                                   |
| Tag Recovery R <sub>(i)</sub>   | 17   | 146            | 239      | 66         | 6          | Total   |                                    | 9531                                 |
| Tagged M <sub>(i)</sub>   | 50   | 364            | 361      | 142        | 26         | Carcasses chopped first period (Sept. 23-25, Reaches A-E) |                                    | 119                                  |
| M <sub>(i)</sub> / R <sub>(i)</sub>   | 2.94   | 2.49           | 1.51     | 2.15       | 4.33       | Carcasses chopped last period (Oct. 28-30, Reaches A-E)   |                                    | 67                                   |
| Total Population Estimate Surveyed Reaches A-E  |  |                |          |            |            |   |                                    | 9717                                 |
| *Plus Chops from Covered Bridge to Parrott Diversion (190) adjusted by F = 1.92       |  |                |          |            |            |   |                                    | 365                                  |
| Total Population Estimate   |  |                |          |            |            |   |                                    | 10,082                               |
| * Expansion factor for reaches with incomplete survey and for CWT recoveries F = 1.92 |  |                |          |            |            |   |                                    |                                      |
|   |  |                |          |            |            |   |                                    |                                      |

\* Calculation of expansion factor for reaches with incomplete survey and for expansion of CWT recoveries.

$$F = E / (C + T)$$

Where:

F = Expansion Factor

E = Total population estimate for surveyed reaches

C = Total untagged carcasses chopped for surveyed reaches

T = Total tagged carcasses for surveyed reaches

Where:

$$C = (\sum C_{(j)} - \sum R_{(i)}) + C_{(i)}$$

$$T = \sum M_{(i)}$$

And Where:

$C_{(j)}$  = Carcasses Counted

$R_{(i)}$  = Tag Recovery

$C_{(i)}$  = Carcasses chopped first period

$M_{(i)}$  = Tagged

Appendix C, Table 2. Butte Creek fall-run Chinook spawning escapement estimate for 2008 using a Peterson mark-recapture model.

| # of fish examined | # of fresh fish marked | # of marked fish recovered |
|--------------------|------------------------|----------------------------|
| 100                | 25                     | 10                         |

$$N = C * ( T / R )$$

Where N = population

C = number examined (including those marked during the examination period)

T = number fresh fish marked

R = number marked fish recovered

$$110 * (25 / 10) = \mathbf{275}$$

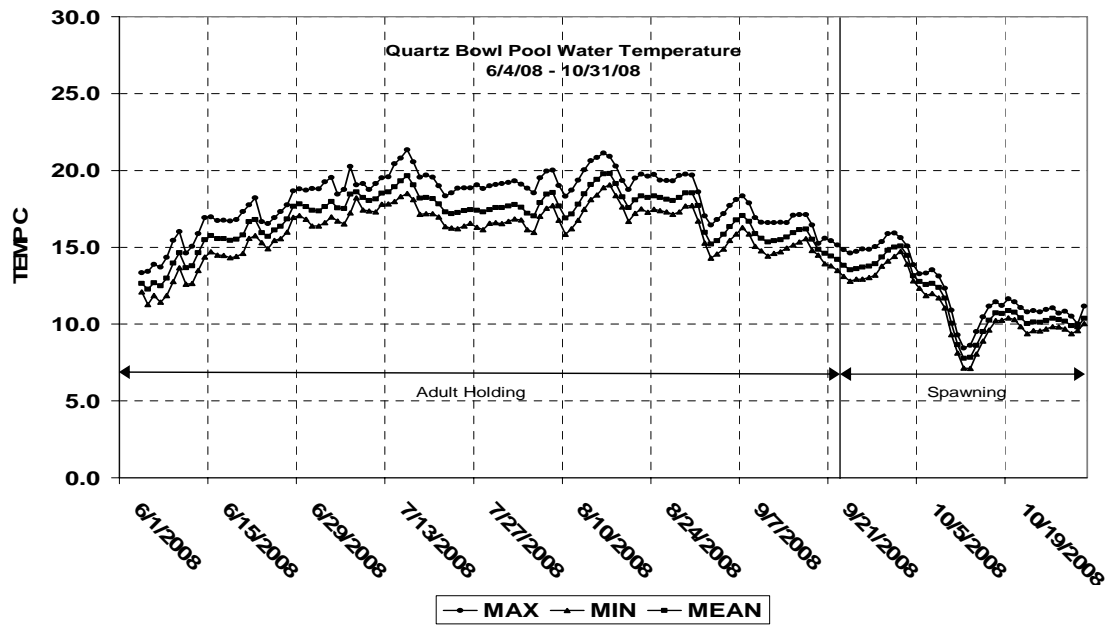
APPENDIX D, Table 1. Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2008. All fish were tagged at Baldwin Construction Yard.

| Release Date        | Brood Year | Tag Code       | Recovery  |         |           |                   |                  |
|---------------------|------------|----------------|-----------|---------|-----------|-------------------|------------------|
|                     |            |                | Date      | FL (mm) | Expansion | Site              | Method           |
| 1/12/2005-1/13/2005 | 2004       | 06-01-00-07-04 | 9/23/2008 | 879     | 1.92      | Butte Cr.-Reach B | Inland Spawn     |
| 1/15/2005-1/18/2005 | 2004       | 06-01-00-08-05 | 10/2/2008 | 893     | 1.92      | Butte Cr.-Reach C | Inland Spawn     |
| 1/16/2005-1/18/2005 | 2004       | 06-01-00-08-09 | 10/7/2008 | 890     | 1.92      | Butte Cr.-Reach B | Inland Spawn     |
| 1/26/2005-1/28/2005 | 2004       | 06-02-01-00-02 | 10/2/2008 | 879     | 1.92      | Butte Cr.-Reach C | Inland Spawn     |
| 2/1/2006-3/22/2006  | 2005       | 06-02-01-01-09 | 8/28/2008 | 671     | 1.92      | Butte Cr.-Reach C | Inland Pre-Spawn |

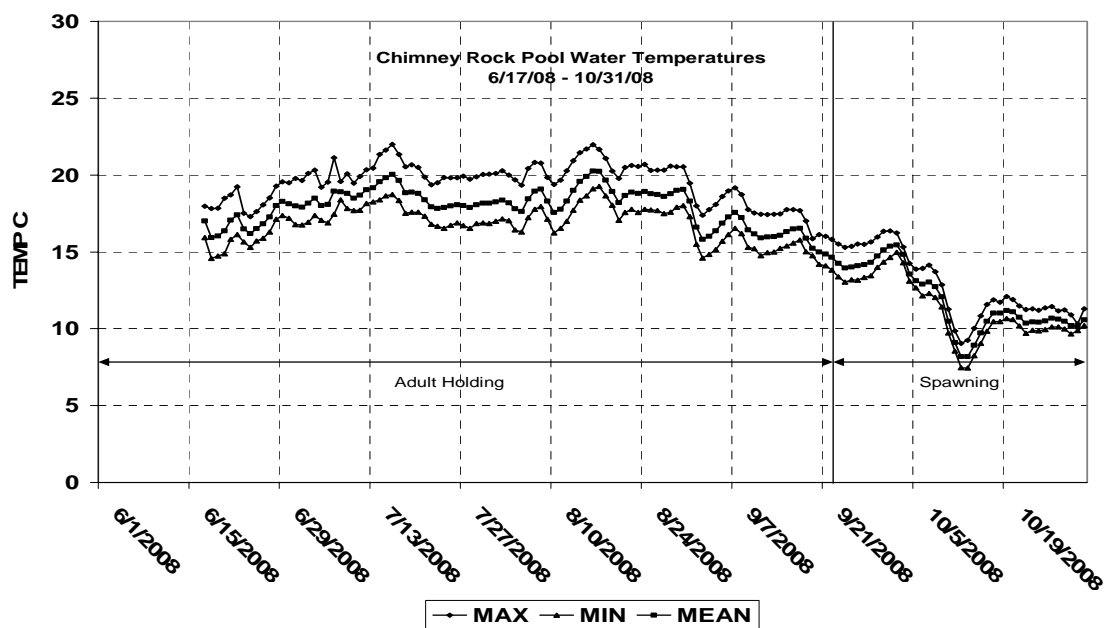
APPENDIX D, Table 2. Recoveries of coded-wire tags from out-of-basin Chinook salmon carcasses collected during spring-run surveys in Butte Creek during 2008.

| Release              |            |                |             | Recovery  |         |           |                   |
|----------------------|------------|----------------|-------------|-----------|---------|-----------|-------------------|
| Stock                | Brood Year | Tag Code       | Site        | Date      | FL (mm) | Expansion | Butte Creek Reach |
| Feather River (FRCS) | 2004       | 06-01-01-03-08 | Yolo Bypass | 10/2/2008 | 844     | 1.92      | C                 |

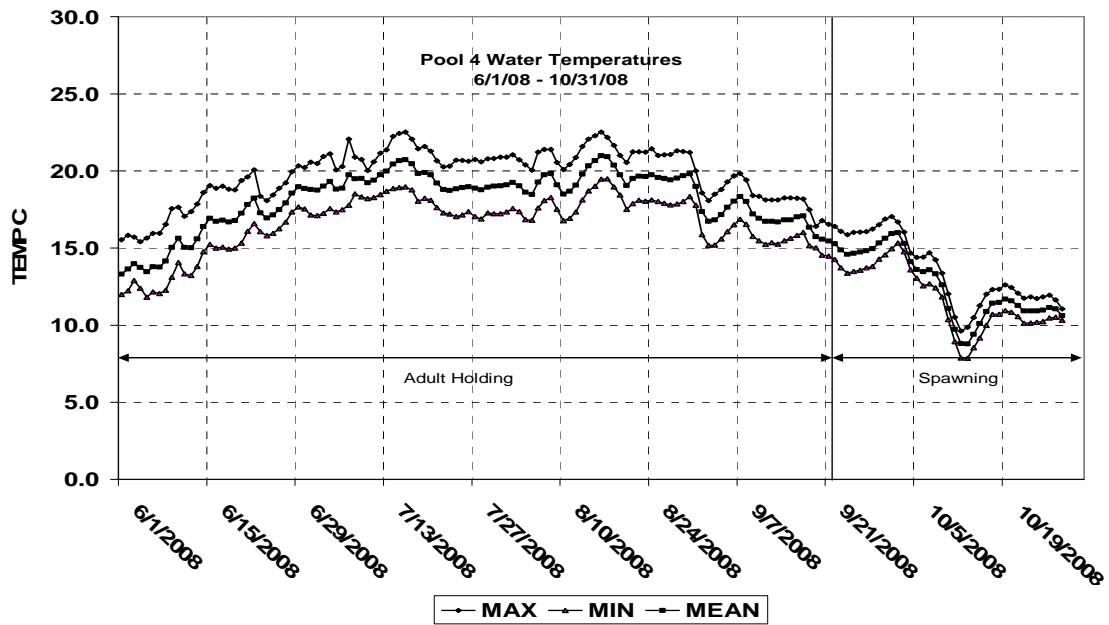
APPENDIX E, Figure 1. Butte Creek water temperature at Quartz Bowl pool.



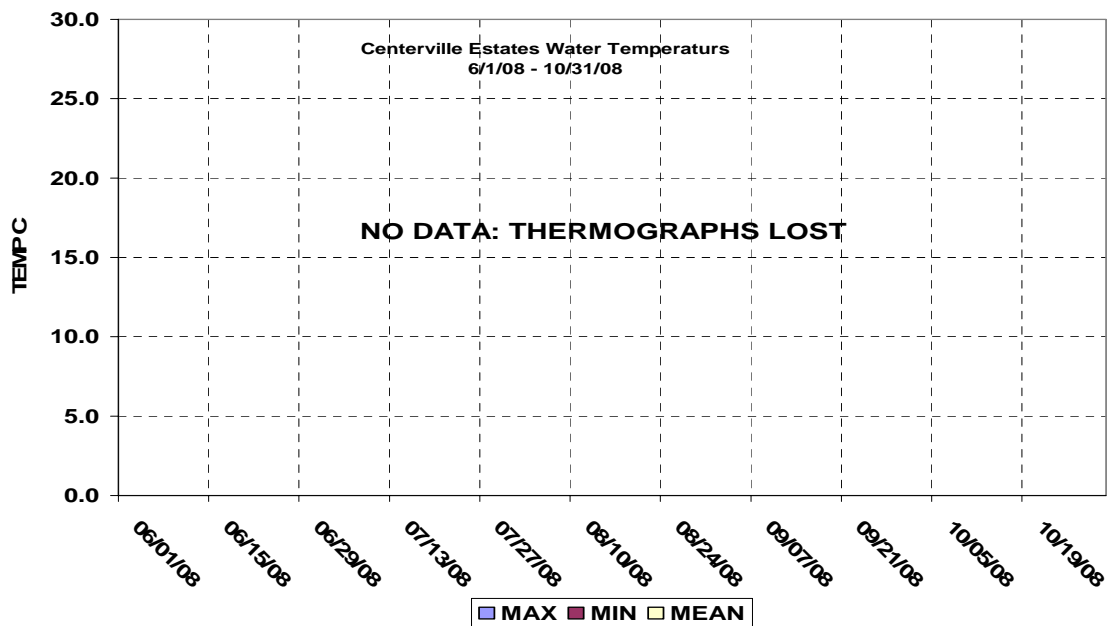
APPENDIX E, Figure 2. Butte Creek water temperature at Chimney Rock pool.



APPENDIX E, Figure 3. Butte Creek water temperature at Pool 4.



APPENDIX E, Figure 4. Butte Creek water temperature at Centerville Estates pool.



APPENDIX E, Figure 5. Butte Creek water temperature at Cable Bridge pool.

