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BUTTE AND BIG CHICO CREEKS SPRING-RUN CHINOOK SALMON, ONCORYHNCHUS TSHAWYTSCHA LIFE HISTORY INVESTIGATION 2004-2005

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Sacramento Valley – Central Sierra Region

Inland Fisheries

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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 2004 through December 2005.

For Butte Creek, there were 870,096 juvenile Chinook salmon captured near Chico of which 400,262 were coded-wire tagged (CWT). The adult spring-run Chinook salmon escapement estimate using the snorkel survey methodology was 10,625. An alternate estimate based upon the modified Schaefer model carcass survey methodology was 16,998. A Schaefer model carcass survey was also conducted to evaluate pre-spawning mortality with an estimated 617 fish that died prior to spawning. The spawning carcass survey recovered 38 Butte Creek CWT adults from BY 01 (3), BY 02 (34), and BY 03 (1). Based upon tag recoveries and an adjustment for release group size, the year 2005 population contained an estimated 0.5% age-2, 97.5% age-3, and 2% age-4 fish. Comparing the expanded recovery rate of ocean catch and inland escapement of BY 01 catch during 2004-2005 suggests an ocean catch rate of approximately 40%. In addition, one adult BY 02 CWT Livingston Stone winter-run, and one adult BY 02 Feather River Hatchery spring-run, was recovered within the spring-run Chinook spawning area.

A modified Schaefer model carcass survey of Butte Creek fall-run Chinook salmon estimated the population to be 4,255. There were 4 CWT recoveries during the fall-run survey. All recovered tags were from fall-run Chinook salmon natal to other watersheds.

For Big Chico Creek, the adult spring-run Chinook salmon escapement was 37 based upon the snorkel methodology.

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INTRODUCTION

This is the seventh 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 six previous reports, Hill and Webber (1999), Ward and McReynolds (2004), Ward et al. (2004a,b,c), and McReynolds et al. (2005), summarized project results through December 2004. 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. Additionally, 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^2) (809 square miles (mi^2) and has an unimpaired average annual yield of approximately 300,000 cubic decameters (dam^3) (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^3/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^3/s (45,000 cfs) and 1,841 m^3/s (65,000 cfs), respectively. The capacity of the Sacramento River channel downstream of the Tisdale Weir at Wilkins Slough is approximately 850 m^3/s (30,000 cfs). These weirs have a combined capacity to pass approximately 3,766 m^3/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^2 (72 mi^2). 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^3 (54,000 acre-feet). The watershed also encompasses three smaller drainages to the north including Sycamore, Mud, and Rock creeks.

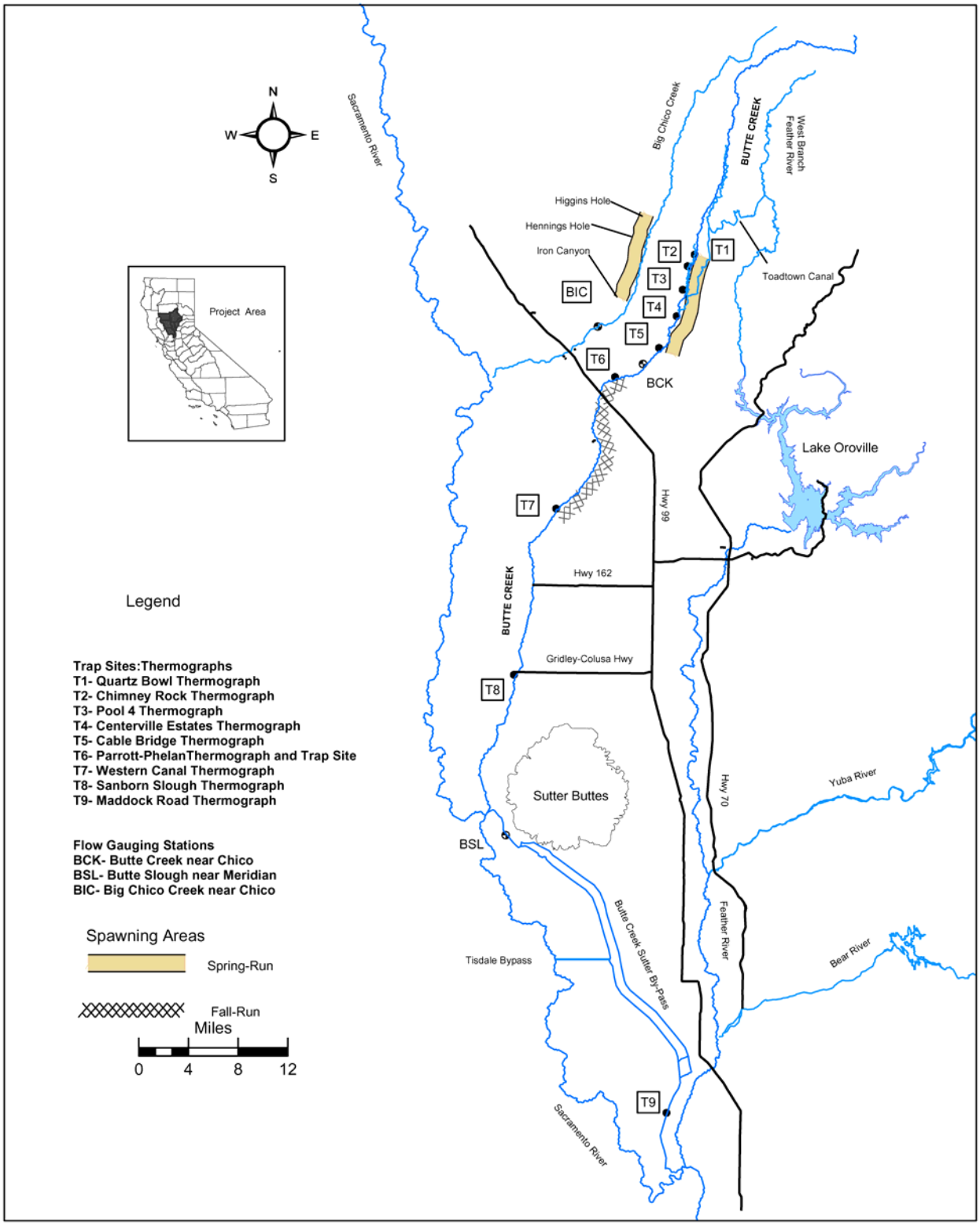
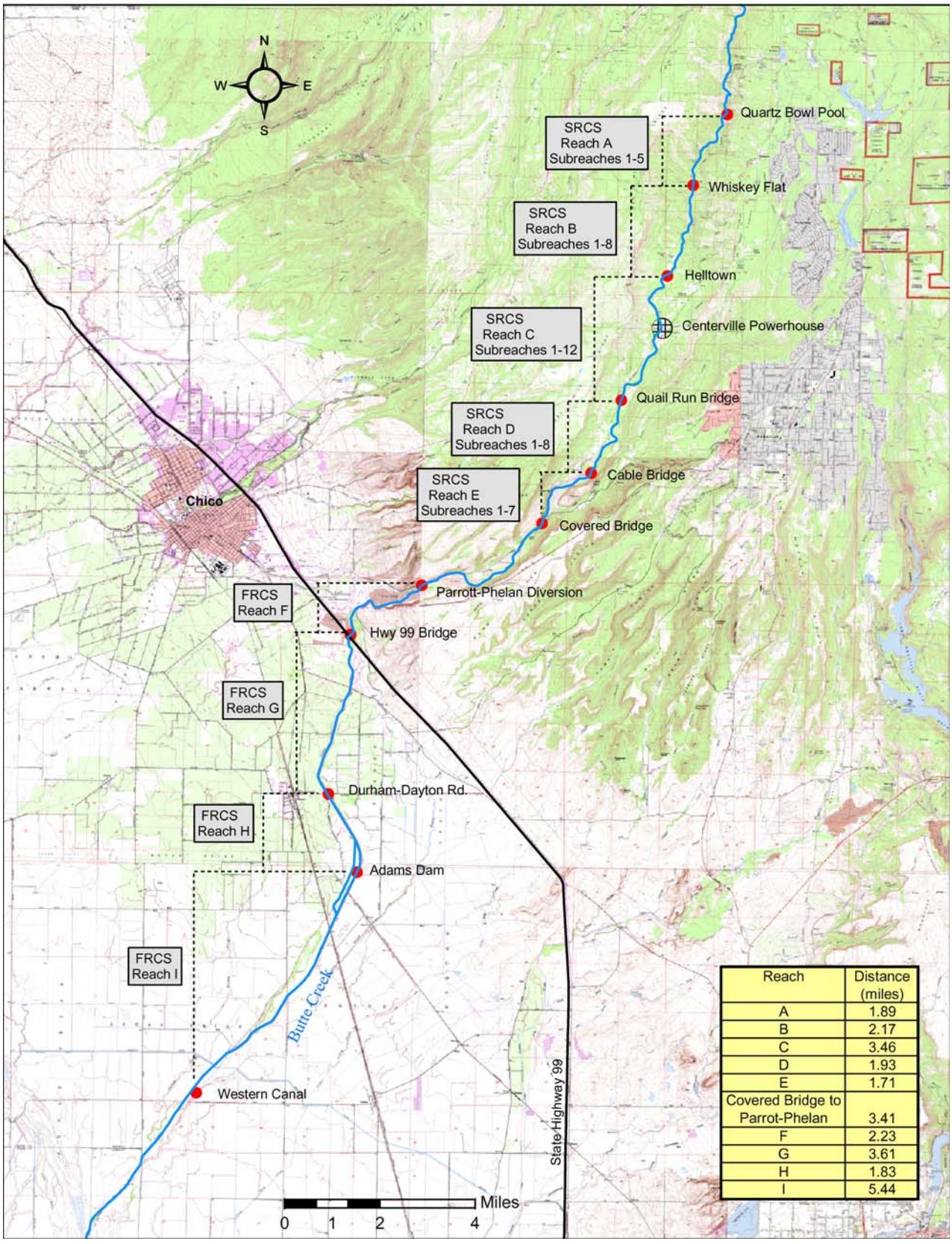


Figure 1. Butte Creek and Big Chico Creek watersheds with trap locations, gaging stations, and salmon spawning areas indicated.



Reach	Distance (miles)
A	1.89
B	2.17
C	3.46
D	1.93
E	1.71
Covered Bridge to Parrot-Phelan	3.41
F	2.23
G	3.61
H	1.83
I	5.44

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 this season fish were trapped only 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 up to two 2.4 m diameter (8 ft) rotary screw trap manufactured by EG Solutions (Eugene, Oregon). Each rotary screw trap 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 rotary screw trap(s) 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 at each trapping site. Water velocity in meters per second (m/s) was measured at the mouth of the screw trap 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, screw trap 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

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. 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. All fish were saved for tagging, unless daily trap numbers were high (>100,000) making the tagging process time extremely long (>10 days).

Salmon were transported in aerated buckets to the Baldwin Construction Yard (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 a snorkel survey. Adults are counted while holding prior to spawning. 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 (July 26 – 28, 2005) each covering a discrete reach, and on one day (August 10, 2005) with three discrete reaches on Big Chico Creek. Each pool was observed only once by each of up to four experienced surveyors, with each of the individual independent estimates recorded. Additionally, where subsequent analysis of the entire data set revealed 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 21, 2005 through September 15, 2005 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, tissue samples were taken from the first 10 fresh carcasses encountered. Clean scissors were used to cut a small piece (10 mm^2) 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 chopped in half, removing 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 completed for both SRCS and FRCS populations. This was the fifth 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; also, the survey provided an alternative adult escapement estimate and an estimate of the proportion taken in the ocean sport /commercial harvest.

The 2005 SRCS spawning survey was conducted from September 20, 2005 through November 3, 2005. 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 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 fresh carcasses encountered in each reach each week. Clean scissors were used to cut a small piece (10 mm^2) 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. 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. Due to the unusual distribution of spawners during 2005, there were significant number of fish observed spawning below the previous lowermost limit at the CCB in the reach downstream to the PPDD. 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 three 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

Estimation of the proportion taken in the ocean sport/commercial harvest was calculated as follows:

$$H = (O_s + O_c)/(O_s + O_c + I_{te})$$

Where:

H = Total ocean sport and commercial harvest
O_s = Total ocean sport harvest
O_c = Total ocean commercial harvest
I_{te} = Total inland escapement to include pre-spawn mortalities and fish surviving to spawn

The 2005 FRCS carcass survey was conducted from November 2, 2005 through December 15, 2005. 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 the same modified Schaefer model as was used for the SRCS survey.

Water Temperature

Onset, HOBO Water Temp Pro, model H20-001, temperature data loggers accurate to ± 0.2° 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 1h interval readings and recorded in degrees C.

RESULTS

Butte Creek

Trapping Season 2004-2005

The 2004-2005 trapping season began at the PPDD when the diversion trap was installed on October 16, 2004. The diversion trap was operated until June 20, 2005. The primary rotary screw trap was installed on January 4, 2005 and removed on February 7, 2005. A second rotary screw trap was operated from January 15-28, 2005 to capture additional fish for the CWT effort. 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 870,096 juvenile salmon, including yearlings, was

captured in all traps; 426,274 in the diversion screen trap and 443,822 in the screw trap(s) (Tables 1 and 2). Of the total captured, 400,262 were tagged and released at the BCY (Table 3). Approximately 96% (832,230) of the entire PPDD SRCS catch occurred between December 1, 2004 and February 28, 2005 (Table 1 and 2). Trapping was suspended for six days between November and January due to high flows (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 screen trap at Parrott-Phelan Diversion Dam from October 16, 2004 to June 20, 2005; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
10/16/04	10/31/04	98	7.1	92	106	3	16
11/1/04	11/15/04	94	-	94	94	1	15
11/16/04	11/30/04	34	1.5	32	35	2	12
12/1/04	12/15/04	34	5.4	30	105	1,370	14
12/16/04	12/31/04	34	1.5	29	42	10,162	14
1/1/05	1/15/05	35	3.0	30	111	38,218	15
1/16/05	1/31/05	35	1.4	31	39	269,972	15
2/1/05	2/15/05	36	1.8	29	52	30,622	15
2/16/05	2/28/05	36	2.2	30	54	38,064	12
3/1/05	3/15/05	37	4.0	30	59	20,062	15
3/16/05	3/31/05	39	9.4	30	139	9,310	16
4/1/05	4/15/05	44	11.2	30	84	2,621	15
4/16/05	4/30/05	57	11.3	31	94	1,890	15
5/1/05	5/15/05	61	11.3	34	92	2,364	15
5/16/05	5/31/05	65	9.4	38	94	764	16
6/1/05	6/15/05	70	7.9	38	104	683	15
6/16/05	6/30/05	75	6.5	55	89	166	5
					Total	426,274	240

Table 2. Semi-monthly catch summary of juvenile Butte Creek spring-run Chinook salmon caught in the screw traps at Parrott-Phelan Diversion Dam from October 16, 2004 to February 7, 2005; yearling captures are included.

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Trapping period		Trap	Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
1/1/05	1/15/05	1	35	2.6	31	87	42,977	11
1/1/05	1/15/05	2	35	2.6	31	87	22,198	13
1/16/05	1/31/05	1	35	1.3	31	39	229,025	12
1/16/05	1/31/05	2	35	1.3	31	39	144,697	11
2/1/05	2/15/05	1	36	1.4	32	39	4,925	4
						Total Trap 1	276,927	27
						Total Trap 2	166,895	24

Table 3. Summary of coded-wire tagged juvenile Butte Creek spring-run Chinook salmon released at Baldwin Construction site from January 7, 2005 to February 9, 2005.

Tag Code	Release Date		Mean FL (mm)	Range FL (mm)		Total No. Released
06-01-00-05-05	01/07/05	01/01/05	36	34	37	5,876
06-01-00-06-02	01/07/05	01/11/05	36	34	38	5,530
06-01-00-06-03	01/10/05	01/11/05	36	33	37	6,798
06-01-00-07-00	01/12/05	01/13/05	36	34	39	5,869
06-01-00-07-01	01/10/05	01/12/05	35	33	38	6,042
06-01-00-07-02	01/12/05	01/13/05	36	34	39	6,616
06-01-00-07-03	01/12/05	01/14/05	36	33	38	6,153
06-01-00-07-04	01/12/05	01/13/05	36	34	39	6,005
06-01-00-08-04	01/13/05	01/15/05	36	34	38	10,791
06-01-00-08-05	01/15/05	01/18/05	36	33	37	11,364
06-01-00-08-06	01/13/05	01/16/05	36	34	38	11,540
06-01-00-08-07	01/15/05	01/17/05	36	34	37	10,701
06-01-00-08-08	01/15/05	01/17/05	36	34	38	10,568
06-01-00-08-09	01/16/05	01/18/05	36	34	38	11,408
06-01-00-09-00	01/17/05	01/22/05	35	34	38	10,372
06-01-00-09-01	01/17/05	01/20/05	35	34	38	9,932
06-01-00-09-02	01/18/05	01/21/05	35	34	38	11,091
06-01-00-09-03	01/19/05	01/22/05	35	34	38	10,881
06-01-00-09-04	01/20/05	01/22/05	35	34	38	10,838
06-01-00-09-05	01/21/05	01/23/05	35	34	38	10,122
06-01-00-09-06	01/22/05	01/25/05	35	34	38	10,610
06-01-00-09-07	01/22/05	01/26/05	35	34	37	11,023
06-01-00-09-08	01/23/05	01/26/05	36	34	37	10,411
06-01-00-09-09	01/25/05	01/27/05	36	33	40	10,554
06-02-01-00-00	01/25/05	01/27/05	36	33	40	10,449
06-02-01-00-01	01/26/05	01/28/05	36	33	40	10,732
06-02-01-00-02	01/26/05	01/28/05	35	33	37	10,289
06-02-01-00-03	01/27/05	01/29/05	35	33	37	10,652
06-02-01-00-04	01/28/05	01/30/05	35	33	37	10,707
06-02-01-00-05	01/29/05	01/30/05	35	33	37	11,006
06-02-01-00-06	01/29/05	01/31/05	35	34	36	10,732
06-02-01-00-07	01/30/05	02/01/05	35	34	36	9,520
06-02-01-00-08	01/30/05	02/01/05	35	34	36	10,008
06-02-01-00-09	01/30/05	02/01/05	35	34	36	7,624
06-02-01-01-00	01/31/05	02/02/05	35	34	38	11,052
06-02-01-01-01	02/01/05	02/03/05	35	34	38	9,394
06-02-01-01-02	02/01/05	02/04/05	36	33	38	10,366
06-02-01-01-03	02/01/05	02/04/05	36	33	38	10,590
06-02-01-01-04	02/02/05	02/04/05	36	33	38	10,109
06-02-01-01-05	02/03/05	02/07/05	36	34	38	9,600
06-02-01-01-06	02/04/05	02/07/05	36	34	38	6,302
06-02-01-01-07	02/04/05	02/07/05	36	34	38	5,746
06-02-01-01-08	02/07/05	02/09/05	36	34	38	4,289
					Total	400,262

Sampling by the U.S. Fish and Wildlife Service (USFWS) at Sherwood Harbor and Chipps Island in the lower Sacramento River recovered five juvenile tagged Butte Creek fish from February 23, 2005 to April 23, 2005 (Table 4). Additionally, salvage at the State Fish Facility in the central Delta

recovered one juvenile tagged Butte Creek fish on April 15, 2005 (Table 4). All fish were from BY 2004, captured at PPDD and tagged at the BCY between January 7, 2005 and February 9, 2005.

Table 4. Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags by other research projects during 2005.

Recovery Date	Tag Code*	Recovery FL (mm)	Recapture Location	Days at Large
2/23/05	06-01-00-08-07	48	Sherwood Harbor	38
4/1/05	06-01-00-07-00	84	Chipps Island	79
4/11/05	06-02-01-00-02	117	Chipps Island	74
4/15/05	06-01-00-08-06	96	State Fish Facilities	91
4/22/05	06-01-00-07-03	100	Chipps Island	99
4/23/05	06-02-01-01-08	93	Chipps Island	74

* All fish were from BY 2004 and tagged at Baldwin Construction Yard.

Juvenile Emigration 2004-2005

As discussed in previous reports (Hill and Webber, 1999; Ward and McReynolds, 2004; Ward, et al., 2004a,b,c; McReynolds et al., 2005), 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 study trapping period only 11 yearling SRCS were captured. The first yearling SRCS was captured on October 16, 2004 and the last on June 7, 2005 (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 2005

Pre-spawning Mortality Carcass Survey

This was the third 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). From June 21, 2005 through September 15, 2005, a total of 443 carcasses was examined (71% female, 29% male). 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 F = 1.39 (Appendix C) was applied to generate an estimated total pre-spawning mortality of 617. Mortalities appeared to be due to natural attrition. Carcasses were identified as pre-spawning mortalities due to immature gametes and lack of any visible spawning activity. During the SRCS pre-spawn mortality survey, one CWT was recovered on July 5, 2005 from a Livingston Stone National Fish Hatchery, BY 02 winter-run (WRCS).

Spawning Carcass Survey

During this study period, the fifth intensive survey directed at recovering CWT's from previous release groups was conducted. A spawning carcass survey was begun on September 20, and continued through November 3, 2005 covering the 17.7 km (11 mi.) SRCS spawning area (Figures 1 and 2). Additionally, significant spawning activity was noted during early October in the reach below the Centerville Covered Bridge (CCB) and below the normal survey area. To provide some assessment of this activity, 1,179 carcasses were counted and chopped during early October. Based upon the spawning carcass survey there were an estimated 16,998 adult SRCS that spawned during 2005. There was a total of 11,024 carcasses examined, including those from below the CCB, with a total of 39 CWT's recovered: BY 01 (3), BY 02 (34), and BY 03 (1). In addition, one Feather River Hatchery SRCS, BY 02, was recovered on October 6, 2005 (Appendix D, Table 2). For those SRCS carcasses recovered below the CCB and SRCS CWT carcasses, an expansion factor of F = 1.39 was calculated as previously described for the pre-spawn mortality estimate. In addition to the Butte Creek carcass recoveries, 32 CWT's were recovered in the ocean fishery, 23 from California and 9 from Oregon (Appendix D, Table 1).

Subsequent to the SRCS carcass survey, a survey of the FRCS spawning area (Figure 1 and 2) was conducted from November 2 through December 15, 2005. A total of 4 CWT's was recovered (Appendix D, Table 3) from 2,341 carcasses that were examined. An expansion factor of F = 1.82 was calculated based upon the modified Schaefer model population estimation methodology as described for the pre-spawn mortality estimate (Appendix C).

Snorkel Escapement Survey

The 2005 SRCS adult escapement estimate based upon the snorkel survey method was 10,625 (Table 5).

Table 5. Estimates of adult spring-run Chinook salmon escapement in Butte Creek from snorkel surveys.

Year	Estimate	Survey Dates
1994	474	June 29 – July 1, 1994
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 – 28, 2005

Water Temperatures 2004-2005

Thermal recording data loggers were installed at the five sites within the SRCS holding and spawning reach of Butte Creek (Figure 1). Both the primary and secondary data loggers at the Chimney Rock site malfunctioned and all data were lost for the period of June 22 – October 10. Recorded mean daily temperatures during the period June through October ranged as high as 21.9° C on July 19, at the Pool 4 and Cable Bridge locations (Table 6; Appendix E, Figures 1 - 5). Average daily temperatures at all sites were above 15.0° C until early-September 2005.

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

Location	Period of Record	Number Days Equal to or Exceeding		
		15.0 C	17.5 C	20.0 C
Quartz Bowl Pool	6/1/05 to 10/31/05	72	37	1
Chimney Rock	Lost Data	-	-	-
Pool 4	6/1/05 to 10/31/05	84	60	17
Centerville Estates	6/1/05 to 10/31/05	87	59	7
Cable Bridge	6/1/05 to 10/31/05	98	66	20

Big Chico Creek

Adult Escapement 2005

The 2005 Big Chico Creek adult escapement estimate was 37 based upon the snorkel survey method (Table 7).

Table 7. Estimates of adult spring-run Chinook salmon escapement in Big Chico Creek from snorkel surveys.

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

* At the request of local constituents a second survey was conducted on September 12, 2005, which encountered a total of 67 salmon, 12 at Hennings Hole and 55 at Higgins Hole (Figure 1). Snorkel surveys are a snapshot in time and to maintain consistency with previous estimates, the original survey done on August 10, 2005 will remain as the official reported estimate.

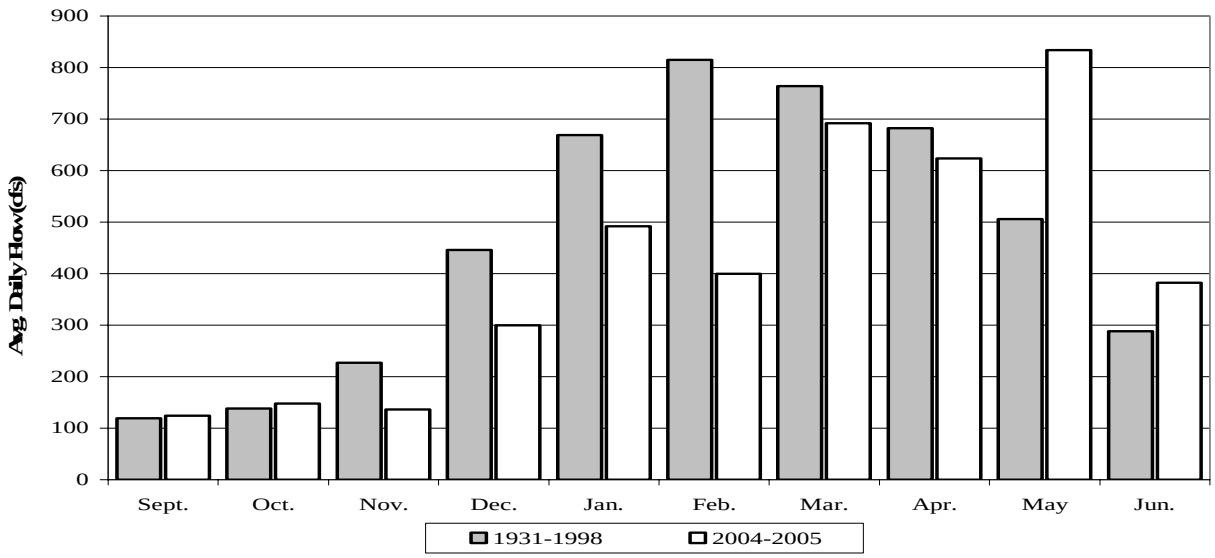
DISCUSSION

During this study period, emphasis was focused on trapping and tagging juvenile SRCS 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. The juvenile trapping effort at the PPDD was suspended a total of 10 days out of the 247-day trapping season.

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). Study years 2000-01 and 2001-02 exhibited a more protracted emigration pattern, apparently due to low stable spring flows (Ward, et al. 2004a,b). During the last two study periods more than 90% of the total catch emigrated by the end of February. During the 2004-05 season, the total season catch was 870,096, significantly higher than during any previous sampling period. Of the total catch, 96% had occurred by the end of February apparently due to relatively stable flows during the period December through February (Figure 3), at an average size of 35 mm (Tables 1 and 2). On a single day, January 27, 2005, an estimated 444,000 juvenile SRCS were trapped.

Figure 3. Comparison of Butte Creek average flows as measured at Butte Creek near Chico Gage (USGS #11390000) during 2004-05 with average flows during the period 1931-1998 (CDWR, 2002).



Recently emerged fry were captured at PPDD from November 2004 through June 2005 (Appendix B, Figure 1). As with previous years (Ward et al., 2004a,b,c; McReynolds et al., 2005), recently emerged fry captured at PPDD beginning in early April (Appendix B, Figure 1) were assumed to be LFRCS using Fisher's length criteria (Johnson et al., 1992). Again, FRCS were observed spawning

above PPDD after mid-October 2004, although numbers were generally small. Fry captured at the site from November through March were assumed to be SRCS.

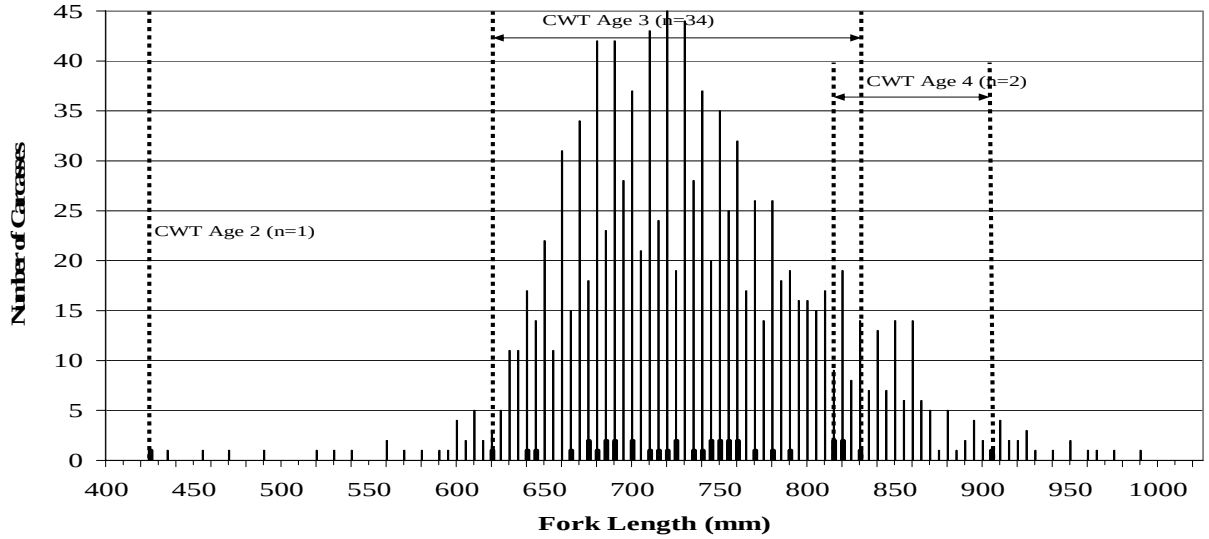
Similar to the previous study period, few yearling salmon were observed upstream of PPDD during the summer adult escapement surveys, and only 11 were captured at PPDD during the entire trapping period. These results continue to support the conclusion that the majority of Butte Creek SRCS migrate as YOY.

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 July 26-28, 2005. The snorkel survey has been performed consistently since 1991 and serves as a population index. The 2005 snorkel survey was conducted during July in an attempt to develop a better estimate prior to any significant pre-spawn mortalities. There were an estimated 26 pre-spawn mortalities prior to the snorkel survey. However, previous project findings have shown that snorkel surveys significantly underestimate salmon abundance (Ward et al. 2004a,b,c; McReynolds et al., 2005). 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, 2004, and 2005 to account for those adults that died prior to spawning. The 2005 escapement estimate based upon the snorkel survey was 10,625 with a range of 8,692 to 13,009. The combined pre-spawn and spawning Schaefer model carcass survey results from 2005 suggest a larger population of 17,615; 617 that died prior to spawning and 16,998 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. During 2005 significant spawning in the reach below the CCB was noted in early October. Since the project was not funded to develop a modified Schaefer model estimate in that reach, three single day surveys to record and chop spawned carcasses were completed during October. There were 1179 carcasses counted and chopped. Among those that survived to spawn, there were 11,024 carcasses examined including those from the reach below CCB, of which 1,104 fresh carcasses (55% female, 45% male) were marked, with a subsequent recovery of 722, a recovery rate of 65%.

Based upon snorkel surveys and adults returning as three year olds, the 2005 escapement estimate represents a 1.21 cohort replacement rate (10,625/8,785). However, Butte Creek CWT recoveries continue to demonstrate that a proportion of Butte Creek SRCS return to spawn at age-4. Of the 38 CWT's recovered on the spawning survey, 1 was age-2, 34 were age-3 and 3 were age-4 (Figure 4). Based upon tag recoveries adjusted for release group size the population contained approximately 0.5% age-2, 97.5% age-3, and 2% age-4 fish. In contrast during 2003, it was estimated that the population consisted of approximately 31% age-3 and 69% age-4 (Ward et al., 2004c).

Figure 4. Length frequency distribution of 1,104 spawned adult Butte Creek spring-run Chinook salmon carcasses measured and marked for abundance estimate between September 20 and November 3, 2005.



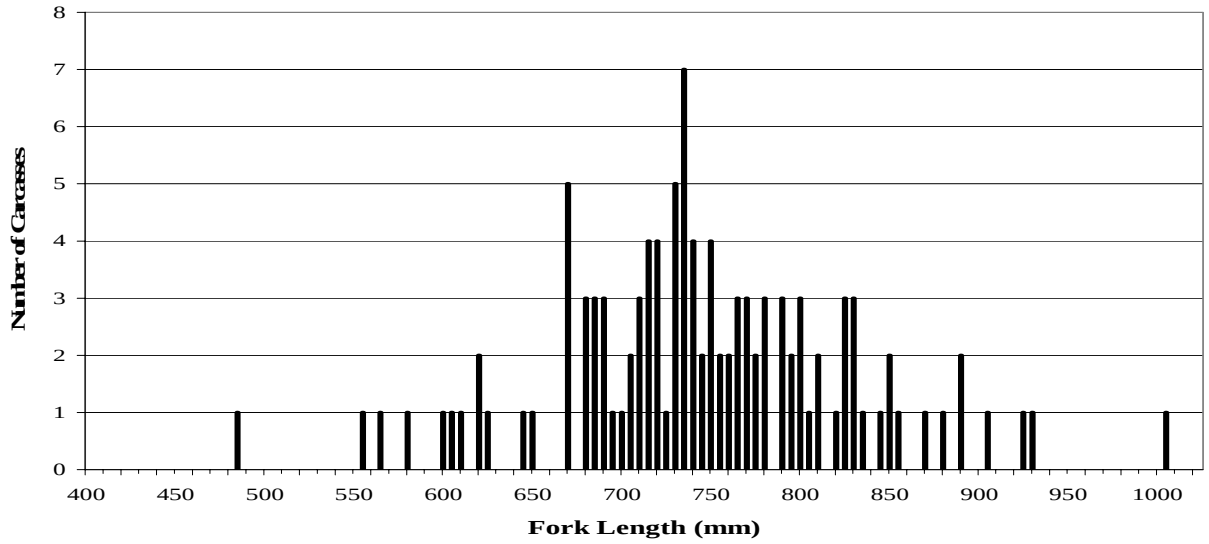
This was the third season a fully funded pre-spawning mortality survey was completed starting on June 21, 2004 and ending on September 15, 2005 at onset of spawning. Mortalities were low throughout the study period. There was a total of 443 carcasses examined of which 190 were measured (71% female, 29% male) and tagged for subsequent recovery. Of the 190 tagged fish over the 13 week period, only five were recovered during the 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 = 1.39) generated from the subsequent modified Schaefer Model estimate of spawning was applied (Appendix C). Based upon that expansion factor, the estimate for pre-spawn mortality was 617 (443 x 1.39).

For the measured subsample of adult Butte Creek SRCS that died prior to spawning and that survived to spawn, the average size of both males and females was similar to 2001, 2002, and 2004, and significantly smaller than observed during 2003 (Table 8, Figure 4, 5).

Table 8. Fork lengths of adult Butte Creek spring-run Chinook salmon that spawned during 2001-2005 which were measured and marked for abundance estimate.

	Female					Male				
	Carcasses		FL (MM)			Carcasses		FL (MM)		
Year	Total	Percent	Max	Min	Mean	Total	Percent	Max	Min	Mean
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 190 adult Butte Creek spring-run Chinook salmon pre-spawn mortalities measured and marked for abundance estimate between June 21 and September 20, 2005.



Ocean recoveries during 2005 (Appendix D, Table 1) extended from April through September, and all were taken from south of Monterey, California to Newport, Oregon. Based upon the current ocean-aging convention that increments SRCS to the next age class on May 1 (Viele et al., 2004), there were 4 age-3, 26 age-4, and 2 age-5 recoveries. Comparing the expanded BY 01 ocean and inland recoveries (Table 9; Appendix D, Table 1) suggests a 40% ocean sport/commercial catch rate, slightly lower than the 43% ocean sport/commercial catch rate for BY99 and BY00 and noticeably lower than the BY98 rate of 48%.

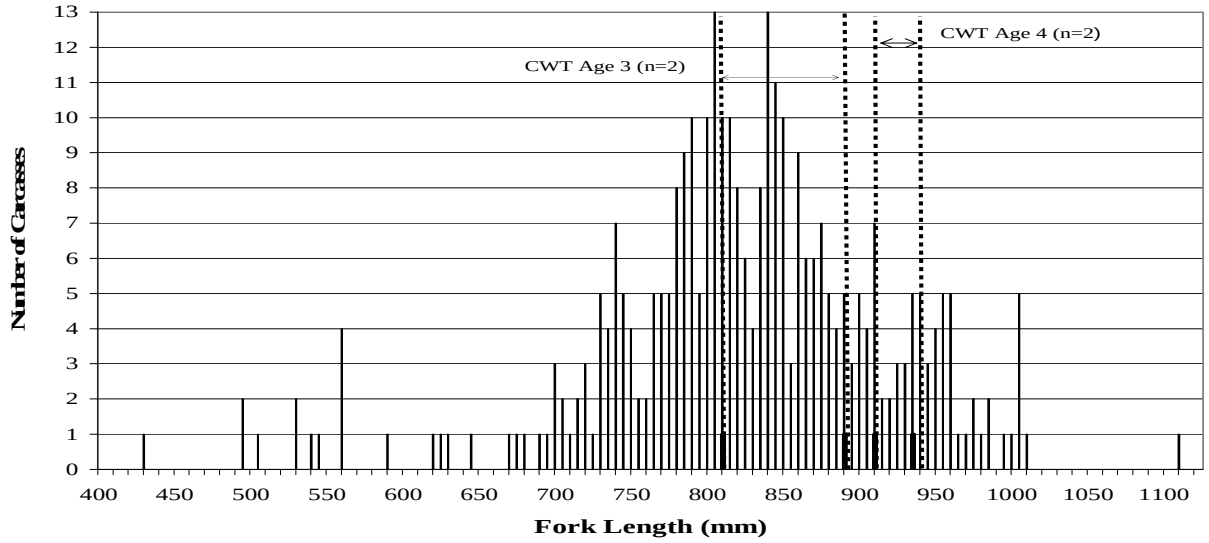
Table 9. Brood Year 2001 ocean and inland recoveries of CWT adult Butte Creek spring-run Chinook salmon.

Source	Inland Age	Ocean Age	Number Recovered		Expanded Number Recovered	
			Ocean	Inland	Ocean	Inland
Sport	3	3	2		8	
Sport	3	4	1		4	
Commercial	3	4	1		3	
Commercial	4	5	2		4	
Spawn	3			11		23
Spawn	4			3		4
Battle Creek	3			1		1
Total			6	15	19	28

Subsequent to the SRCS carcass survey, a FRCS carcass survey was initiated on November 2, and continued through December 15, 2005. The FRCS survey covered the reaches of Butte Creek downstream of the PPDD (Figure 1 and 2). For the fourth 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. Using the modified Schaefer model,

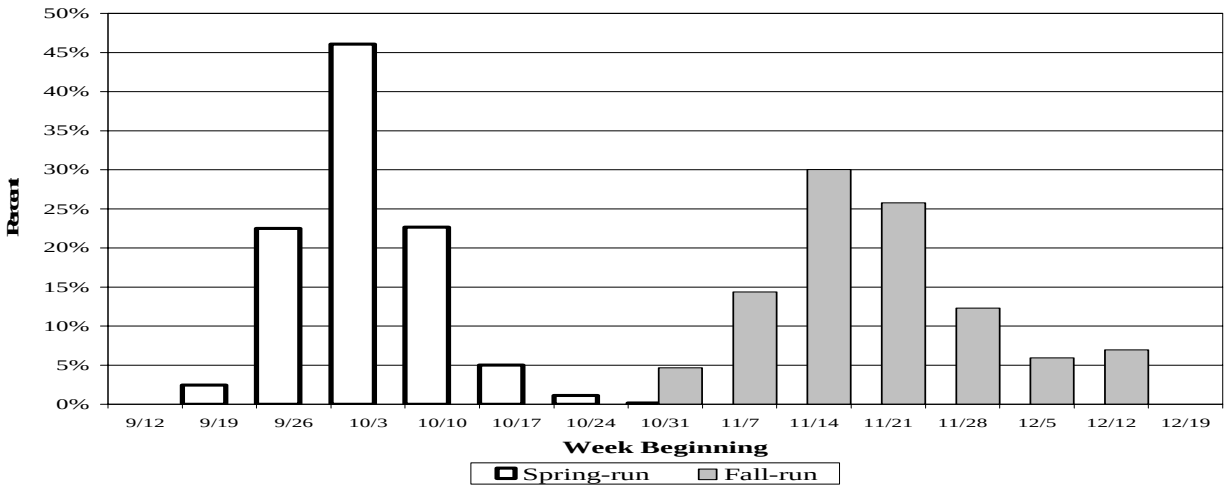
2,341 carcasses were examined, with 330 of the fresh carcasses marked of which 158 were subsequently recovered. For 2005, the modified Schaefer model estimate for FRCS was 4,255 fish which spawned in the reach downstream of the PPDD (Appendix C, Table 2). The mean FL of the measured sub-sample of 330 Butte Creek FRCS was 823 mm (Figure 6). There was a total of 4 CWT marked carcasses recovered during the FRCS carcass survey (Figure 6; Appendix D, Table 3). Each of the recovered CWT's was from FRCS natal to other watersheds, including the Feather, American, Merced and Mokelumne rivers.

Figure 6. Length frequency distribution of 330 adult fall-run Chinook salmon carcasses measured and marked for abundance estimate between November 2 and December 15, 2005.



Comparison of Butte Creek SRCS and FRCS spawning timing (Figure 7) continues to show little overlap, with peak SRCS spawning occurring during the week beginning on October 3; for FRCS the peak occurred during the week beginning on November 14, 2005. All of the Butte Creek SRCS spawned above 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 20, 2005 through December 15, 2005.



Adult Straying

Since inception of the intensive carcass recovery effort for SRCS beginning in 2001, there have been two recoveries of FRFH marked SRCS. The first, tag code 062679 (BY 2000) was recovered on October 22, 2003 during the FRCS spawning survey in Reach I (Figure 2). Based upon the location and recovery date it was concluded that the fish was a FRCS. The second recovery of a FRFH marked SRCS, tag code 062760 (BY 2002) occurred during this study period on October 6, 2005 in Reach C (Figure 2). Based upon the location and recovery date it was concluded that the fish was a SRCS. Review of FRFH CWT SRCS inland recoveries for BY 1998-2001 releases shows that expanded for recovery effort, 88.8% returned to the FRFH or the Feather River, 7.3% returned to the Sacramento River above the Feather River (Upper Sacramento River, Clear and Battle creeks), 0.02% to Butte Creek, 3.1% to the Yuba River, and 0.7% to tributaries below the Feather River (American, Mokelumne, Merced and Stanislaus Rivers). For BY's 1998-2000, all FRFH CWT SRCS juveniles were released below the confluence of the Sacramento and San Joaquin Rivers near the head of San Pablo Bay. BY 2001 releases were split between the San Pablo Bay site(s) and the Feather River near Live Oak. For those inland recoveries of BY 2001 releases in San Pablo Bay 72% returned to either FRFH or the Feather River, 20% to the Sacramento River above the Feather River (Upper Sacramento River, Clear Creek), 6.9% to the Yuba River, 0.04% to below the Feather River (Mokelumne, Merced rivers) and 0.02% to the Guadalupe River. For those BY 2001 releases in the Feather River near Live Oak, all inland recoveries were within the Feather River or at FRFH. While recoveries from the BY 2002 FRFH releases are not yet complete nor reported, the single BY 2002 recovery in Butte Creek during 2005 was from releases at Benecia at the head of San Pablo Bay. Based upon review of the BY 1998-2002 FRH SRCS CWT releases it appears that inland straying is primarily the result of releasing fish in the lower river and bay.

Additionally, a single CNFH BY-02 WRCS, tag code 051298 was recovered on July 5, 2005 in Reach B, during the prespawn mortality survey (Figure 2). Since water temperatures are always above lethal levels for spawning until mid-September, Butte Creek does not support WRCS and this recovery was concluded to have been a stray from the Sacramento River. Although recovery efforts are not systematic throughout the Central Valley during the WRCS & SRCS spawning period, there have been no other recorded recoveries of WRCS inland strays since the WRCS program was moved to the Livingston Stone Hatchery in 1998 (Kevin Niemela, USFWS Red Bluff, personal communication). The results from the 2004-2005 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.

During this reporting period, there were no recoveries of Butte Creek adult CWT SRCS 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. To date, there have been 127 (expanded to 229 for sampling effort) CWT Butte Creek SRCS recovered in Butte Creek and four (no expansion) in other watersheds.

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 the first week of September. Average daily temperatures exceeded 17.5°C by July 5th and exceeded 20°C one day during the holding period at QBP.

ACKNOWLEDGMENTS

This project was supported by funding provided by the CALFED Bay-Delta Program through State Proposition 204, by the Federal Aid in Sport Fish Restoration Act, and by the Pacific Gas and Electric Company in partnership with the California Department of Fish and Game. Additionally we wish to acknowledge the various field crew members that participated during the 2004-05 season to include Chris Bennett, Michael Schommer, Mitch Azevedo, Jeff Humble, Kyle Thompson, Jeremy Notch, and Dave Lunsford.

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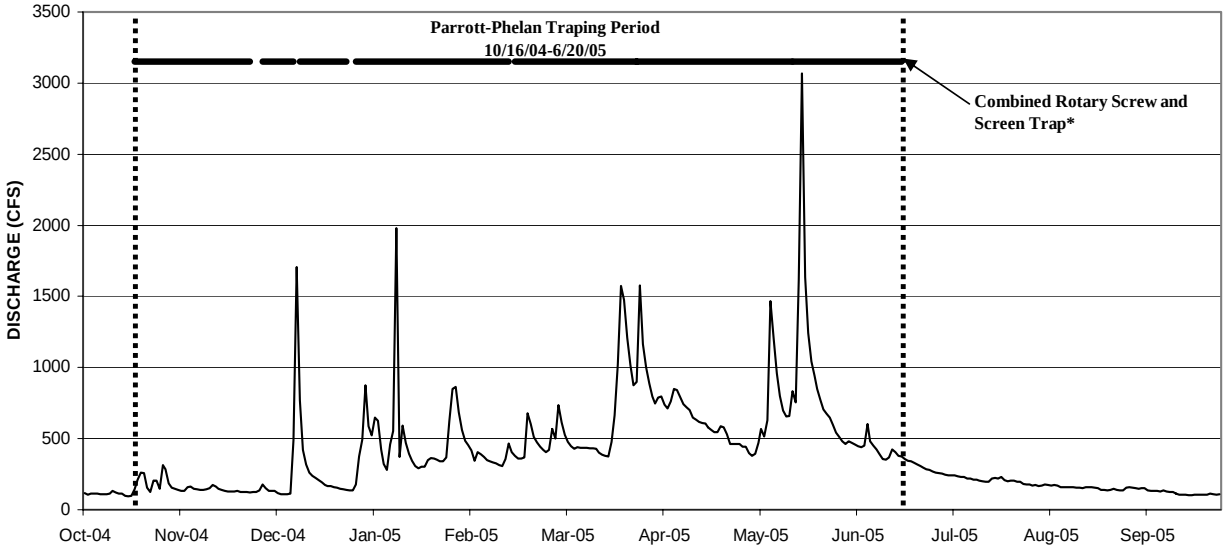
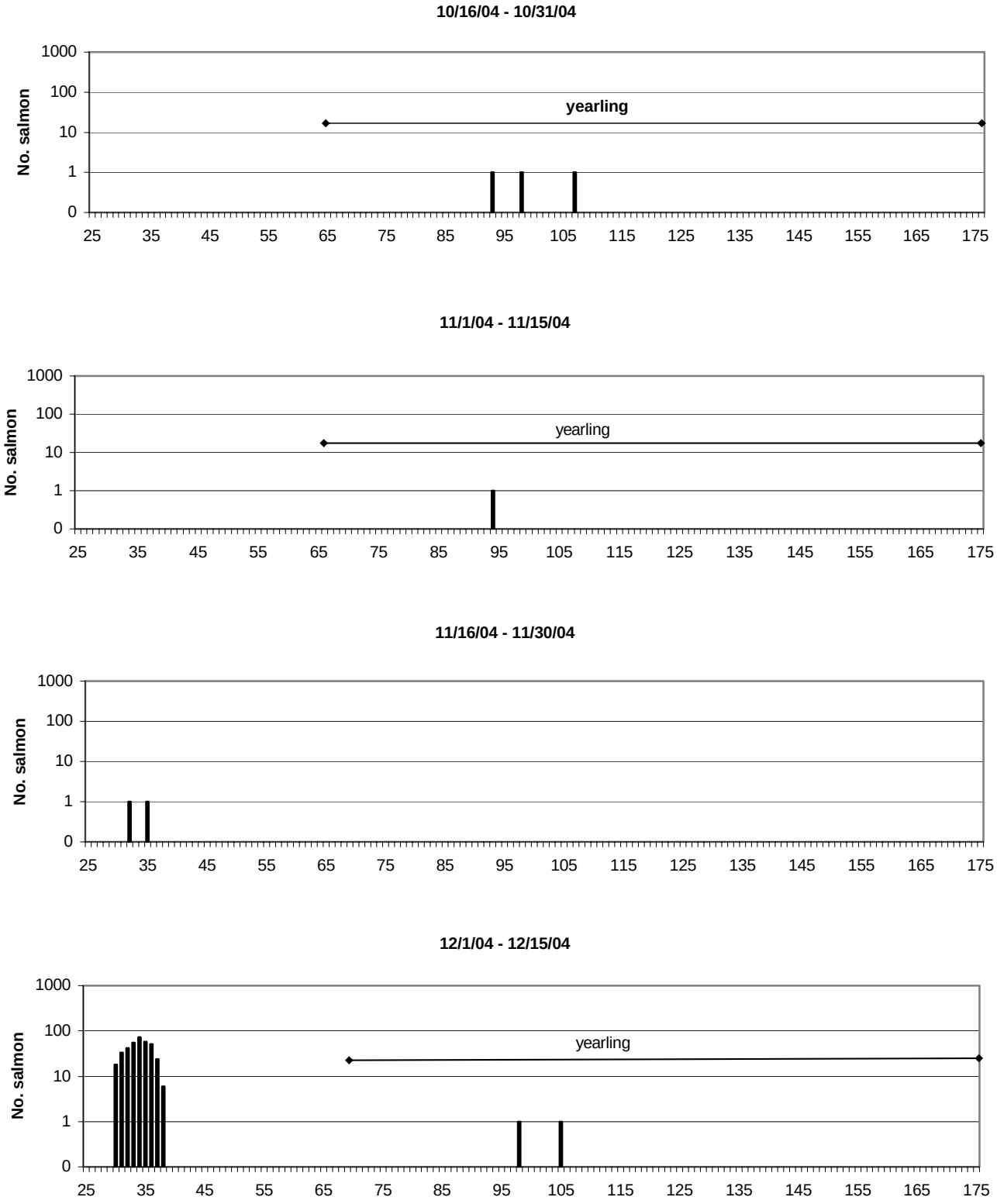
APPENDIX A, Figure 1. Butte Creek flow at Butte Creek near Chico Gage (USGS - #11390000), water year 2004-05, with trapping period shown. Flow data are provisional and subject to revision.

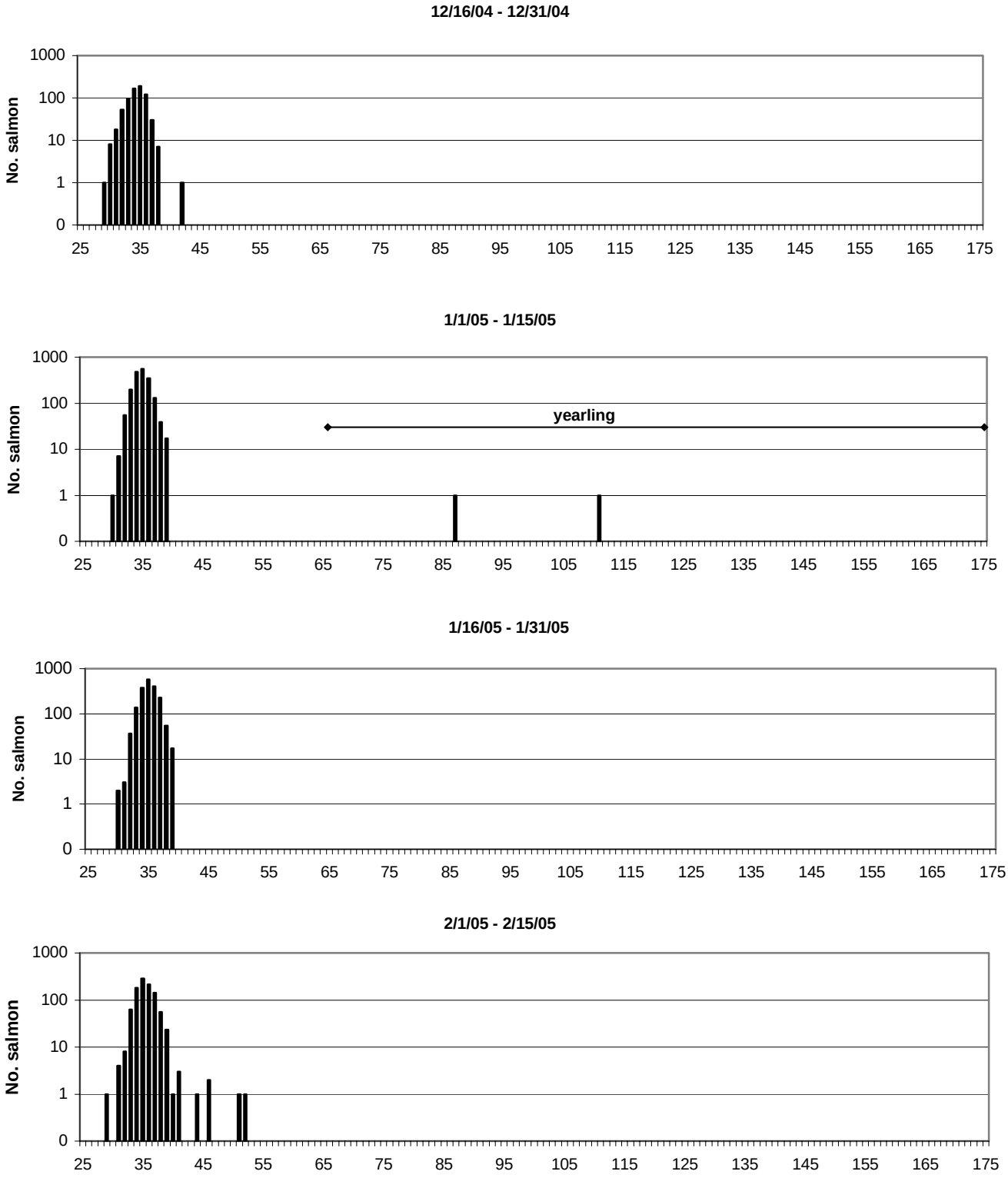


*Breaks in horizontal line indicate periods of time when the trap(s) were not fishing.

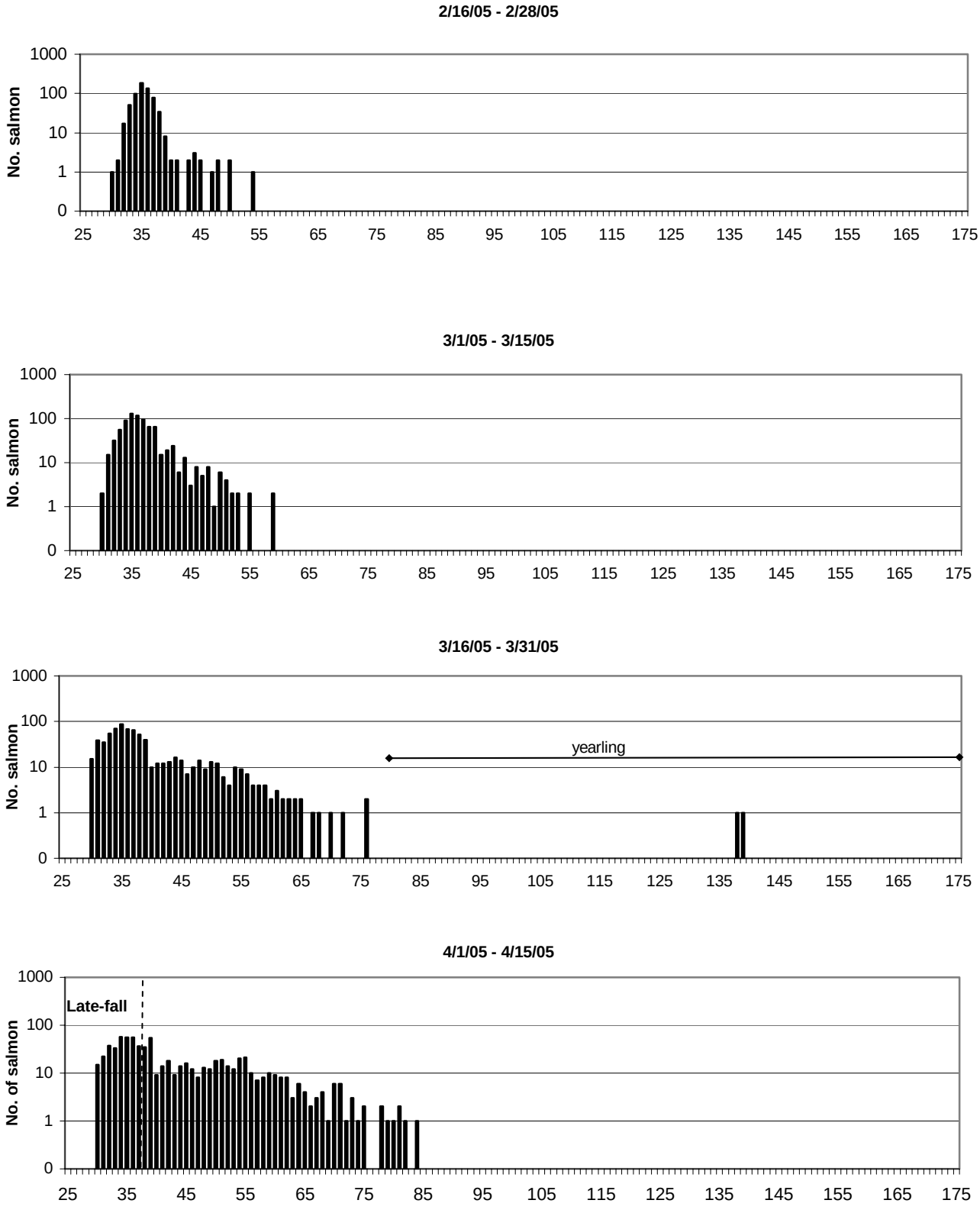
APPENDIX B, Figure 1. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2004 through June 20, 2005. All fish are assumed to be spring-run Chinook salmon except where indicated.



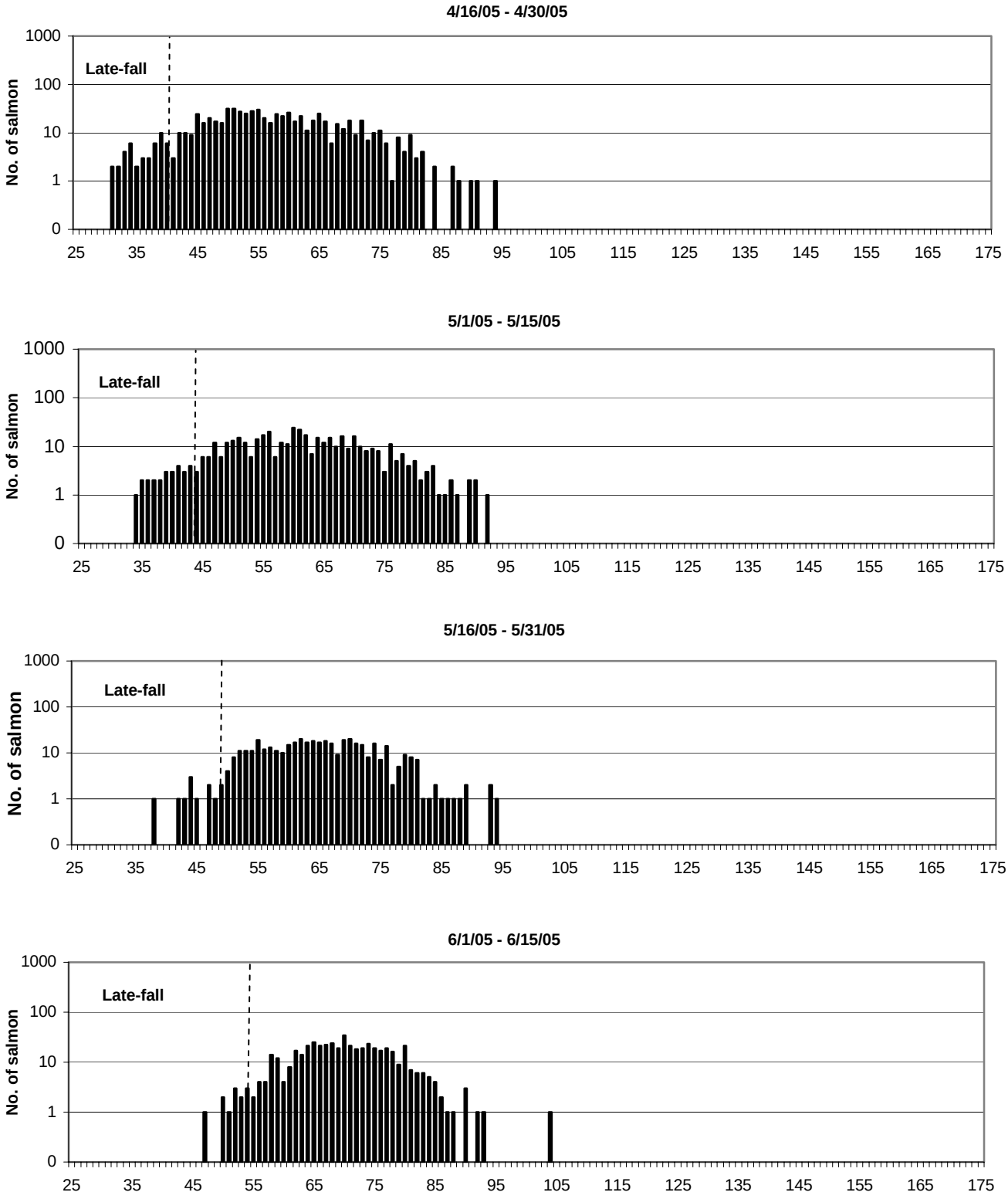
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2004 through June 20, 2005. All fish are assumed to be spring-run Chinook salmon except where indicated.



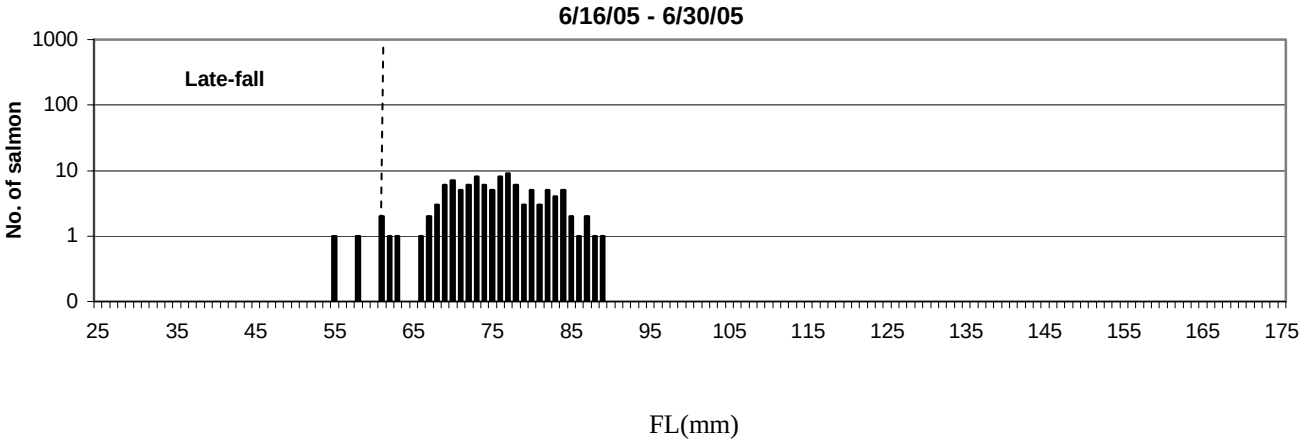
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2004 through June 20, 2005. All fish are assumed to be spring-run Chinook salmon except where indicated.



APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2004 through June 20, 2005. 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 16, 2004 through June 20, 2005. 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 2005 using modified Schaefer Model.

Week of Recovery $R_{(j)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$					Tags Recovered $R_{(j)}$	Carcasses Counted $C_{(j)}$	Population Estimate $E_{(j)}$
	1	**2**	**3**	**4**	**5**			
	Sept. 20-22	Sept. 27-29	Oct. 4-6	Oct. 11-13	Oct. 18-20			
1 Sept. 27-29	55	-	-	-	-	55	2187	4382
2 Oct. 4-6	2	223	-	-	-	225	4864	6621
3 Oct. 11-13	0	26	257	-	-	283	2597	3291
4 Oct. 18-20	0	4	50	83	-	137	671	759
5 Oct. 25-27	0	1	5	7	6	19	142	122
6 Nov. 1-3	0	0	0	1	2	3	22	22
Tag Recovery $R_{(i)}$	57	254	312	91	8	Total		15197
Tagged $M_{(i)}$	112	348	441	184	19	Carcasses chopped first period (Sept. 20-22, Reaches A-E)		159
Total Population Estimate Surveyed Reaches A-E = E								15356
*Plus Chops from Covered Bridge to Parrott Diversion (1179) adjusted by F = 1.39								1642
Total Population Estimate								16998

* Expansion factor for reaches with incomplete survey and for CWT recoveries F = 1.39

APPENDIX C, Table 2. Butte Creek fall-run Chinook spawning escapement estimate for 2005 using modified Schaefer Model

Week of Recovery $R_{(j)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$						Tags Recovered $R_{(j)}$	Carcasses Counted $C_{(j)}$	Population Estimate
	1	**2**	**3**	**4**	**5**	**6**			
	Nov. 2-4	Nov. 10-11	Nov. 15-17	Nov. 21-22	Nov. 29-Dec. 15	Dec. 12-15			
1 Nov. 10-11	8	-	-	-	-	-	8	265	1043
2 Nov. 15-17	0	41	-	-	-	-	41	663	1131
3 Nov. 22-24	1	5	46	-	-	-	52	575	825
4 Nov. 29-Dec. 1	0	2	1	32	-	-	35	300	685
5 Dec. 6-8	0	0	1	3	5	-	9	134	319
6 Dec. 12-15	0	0	2	4	0	7	13	176	176
Tag Recovery $R_{(i)}$	9	48	50	39	5	7	Total		4180
Tagged $M_{(i)}$	34	79	81	80	23	14	Carcasses chopped first period (Nov. 2-4)		75
Total Population Estimate									4255

* Expansion factor for CWT recoveries F = 1.82

* 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 D, Table 1. Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2004 and 2005.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
3/04/02-5/15/02	2001	06-01-00-01-09	9/18/05	849	1.7	San Francisco	Ocean Commercial
1/07/02-1/11/02	2001	06-01-00-00-07	10/06/05	816	1.39	Butte Cr. – Reach D	Inland Spawn
2/27/02-3/27/02	2001	06-01-00-01-07	10/06/05	813	1.39	Butte Cr. – Reach C	Inland Spawn
2/13/02-2/18/02	2001	06-01-00-01-03	10/13/05	907	1.39	Butte Cr. – Reach E	Inland Spawn
3/05/03-3/27/03	2002	06-01-00-04-02	4/17/05	670	3.76	Monterey	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-03-02	5/21/05	655	3.59	Fort Bragg	Ocean Sport
1/30/03-2/13/03	2002	06-01-00-04-00	5/24/05	662	3.59	Fort Bragg	Ocean Sport
1/22/03-1/27/03	2002	06-01-00-03-03	6/13/05	662	3.77	Santa Cruz	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-04-00	6/14/05	640	3.77	Santa Cruz	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-04-00	6/26/05	671	2.52	Bodega Bay	Ocean Sport
2/13/03-2/24/03	2002	06-01-00-04-01	7/7/05	751	3.96	Morro Bay	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-00	7/8/05	718	3.33	Princeton	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-00	7/11/05	705	3.33	Fort Bragg	Ocean Commercial
3/05/03-3/27/03	2002	06-01-00-04-02	7/11/05	674	3.33	Fort Bragg	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-01	7/11/05	716	3.33	San Francisco	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-00	7/18/05	703	2.87	San Francisco	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-01	7/28/05	736	2.87	Bodega Bay	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-01	8/1/05	689	3.23	Fort Bragg	Ocean Commercial
1/17/03-1/22/03	2002	06-01-00-04-00	8/2/05	619	6.4	Shelter Cove	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-03-03	8/11/05	748	6.4	Shelter Cove	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-04-01	8/15/05	742	6.4	Shelter Cove	Ocean Sport

APPENDIX D, Table 1. (continued) Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2003 and 2004.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/17/03-1/22/03	2002	06-01-00-04-00	8/21/05	794	4.58	Shelter Cove	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-04-02	9/29/05	710	1.39	Butte Cr. – Reach E	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	9/29/05	819	1.39	Butte Cr. – Reach D	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	9/29/05	700	1.39	Butte Cr. – Reach D	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	9/29/05	692	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	9/29/05	782	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	9/29/05	683	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	9/29/05	641	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	10/4/05	745	1.39	Butte Cr. – Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/4/05	745	1.39	Butte Cr. – Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	10/5/05	754	1.39	Butte Cr. – Reach CO	Inland Spawn
3/05/03-3/27/03	2002	06-01-00-04-02	10/5/05	755	1.39	Butte Cr. – Reach CO	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	10/5/05	733	1.39	Butte Cr. – Reach CO	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-01	10/6/05	684	1.39	Butte Cr. – Reach C	Inland Spawn
3/05/03-3/27/03	2002	06-01-00-04-02	10/6/05	759	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-01	10/6/05	751	1.39	Butte Cr. – Reach D	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-01	10/6/05	759	1.39	Butte Cr. – Reach D	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/6/05	769	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/6/05	681	1.39	Butte Cr. – Reach E	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/6/05	739	1.39	Butte Cr. – Reach E	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/6/05	818	1.39	Butte Cr. – Reach C	Inland Spawn

APPENDIX D, Table 1. (continued) Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2003 and 2004.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/17/03-1/22/03	2002	06-01-00-04-01	10/6/05	677	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/6/05	789	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/11/05	663	1.39	Butte Cr. – Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-01	10/11/05	751	1.39	Butte Cr. – Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-01	10/11/05	724	1.39	Butte Cr. – Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	10/12/05	676	1.39	Butte Cr. – Reach CO	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/12/05	830	1.39	Butte Cr. – Reach CO	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/13/05	723	1.39	Butte Cr. – Reach D	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/13/05	719	1.39	Butte Cr. – Reach E	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/13/05	622	1.39	Butte Cr. – Reach E	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/13/05	698	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/13/05	715	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-03	10/13/05	647	1.39	Butte Cr. – Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-04-00	10/18/05	692	1.39	Butte Cr. – Reach B	Inland Spawn
1/23/04-1/26/04	2003	06-01-00-04-04	7/15/05	491	5.61	Monterey	Ocean Sport
1/29/04-2/01/04	2003	06-01-00-08-02	7/15/05	465	3.03	Princeton	Ocean Sport
1/28/04-1/29/04	2003	06-01-00-04-07	7/21/05	460	3.12	Princeton	Ocean Sport
1/29/04-2/01/04	2003	06-01-00-08-01	9/29/05	424	1.39	Butte Cr. – Reach C	Inland 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 2005.

Release				Recovery			
Stock	Brood Year	Tag Code	Site	Date	FL (mm)	Expansion	Butte Creek Reach
Sacramento River (WRCS)	2002	051298	Lake Redding Park	7/5/05	890	1.39	B
Feather River (SRCS)	2002	062760	Benecia	10/6/05	677	1.39	C

APPENDIX D, Table 3. Recoveries of adult fall-run Chinook salmon carcasses bearing coded-wire tags in Butte Creek during 2005.

Release				Recovery			
Stock	Brood Year	Tag Code	Site	Date	FL (mm)	Expansion	Butte Creek Reach
American River	2001	062666	Wickland	11/22/05	936	1.82	H
Feather River	2002	062770	Crockett	12/8/05	891	1.82	I
Merced River	2001	064481	Jersey Pt.	11/2/05	910	1.82	G
Mokelumne River	2002	060287	New Hope	11/29/05	809	1.82	G

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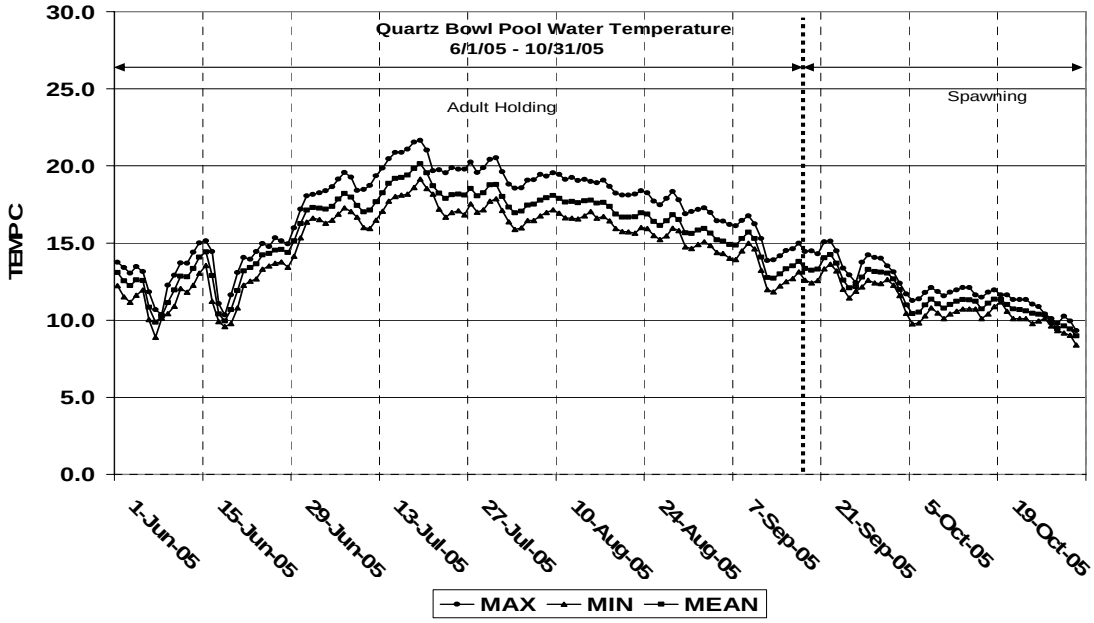
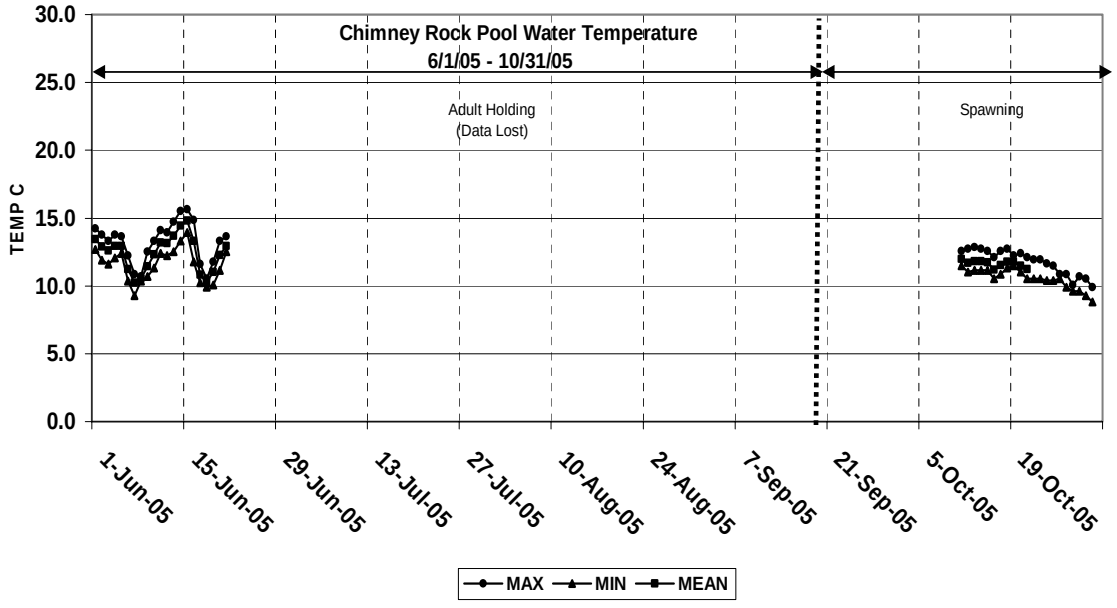
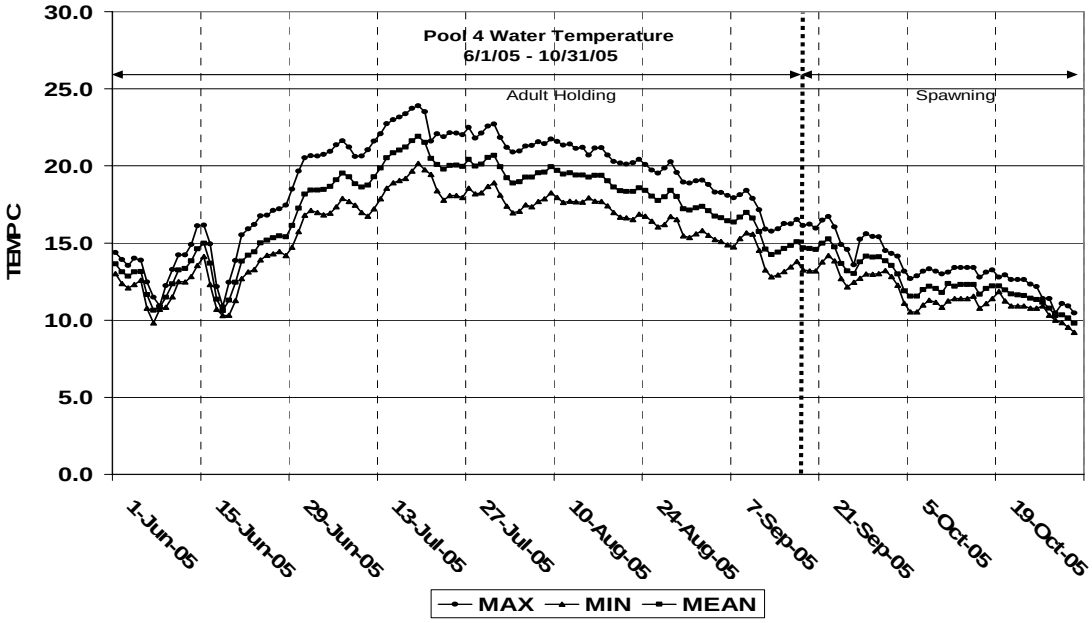
APPENDIX E, Figure 1. Butte Creek water temperature at Quartz Bowl pool.



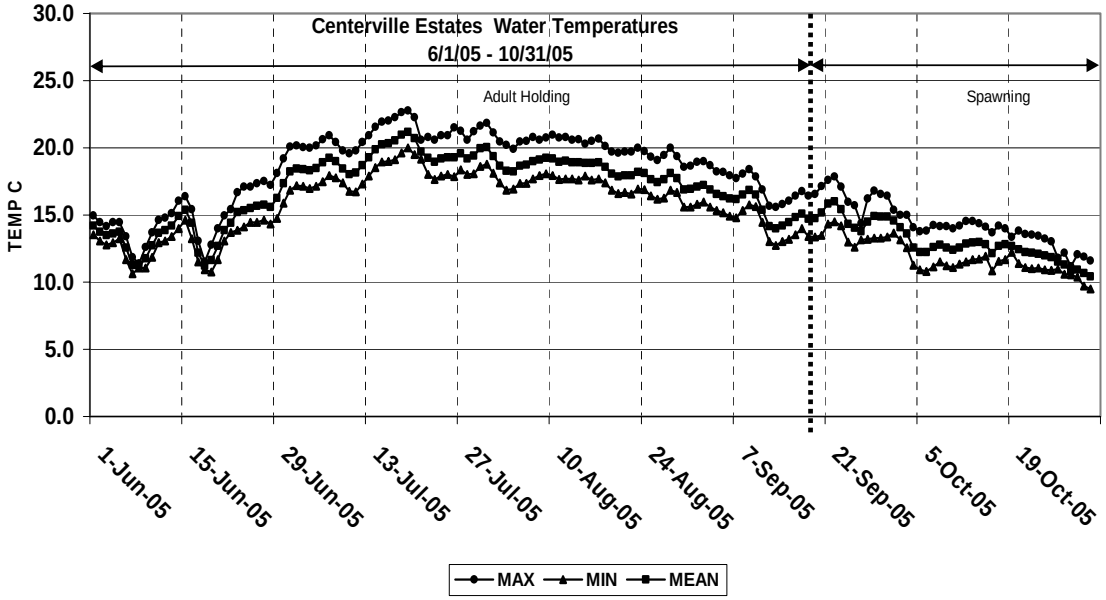
APPENDIX E, Figure 2. Butte Creek water temperature at Chimney Rock pool.



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.