State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME

BUTTE AND BIG CHICO CREEKS SPRING-RUN CHINOOK SALMON, ONCORYHNCHUS TSHAWYTSCHA LIFE HISTORY INVESTIGATION 2003-2004

By

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Sacramento Valley – Central Sierra Region

Inland Fisheries

Administrative Report No. 2005-1

2005

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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 2003 through December 2004.

For Butte Creek, there were 348,445 juvenile Chinook salmon captured near Chico and 19,791 in the Sutter Bypass. There were 202,570 fish captured near Chico that were coded-wire-tagged, and 65 of the tagged fish recaptured in the Sutter Bypass trap. The average time to recapture was 46 days. The adult spring-run Chinook salmon escapement estimate using the snorkel survey methodology, was 7,390. An alternate estimate based upon the modified Schaefer model carcass survey methodology was 10,221. A mark/recapture survey was conducted to evaluate pre-spawning mortality. Based upon the Schaefer model, there were an estimated 418 pre-spawn mortalities. The spawning carcass survey recovered 13 Butte Creek coded-wire-tagged adults from BY 00 (2) and BY 01 (11). Based upon the tag recoveries and an adjustment for release group size, the year 2004 population contained 84% age-3 fish and 16% age-4 fish. Comparing the expanded recovery rate of ocean catch and inland escapement of BY 00 catch during 2003-2004 suggest an ocean catch rate of approximately 43%. Additionally, there was one Butte Creek coded-wire tag recovery from Clear Creek (BY 02), and one recovered from Battle Creek (BY 01).

A Schaefer model carcass survey of Butte Creek fall-run Chinook salmon estimated the population to be 2,456. There were 40 CWT recoveries during the fall-run survey, all recovered tags were from fish natal to other watersheds. The number of out-of-basin CWT recoveries substantiates significant straying.

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

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[1] Inland Fisheries Administrative Report No.2005-1. Edited by John Nelson, Sacramento Valley-Central Sierra Region, 1701 Nimbus Road, Suite A, Rancho Cordova, California 95670. This study was funded in part by the CALFED Bay-Delta Program, Federal Aid in Sport Fish Restoration Program, California Grant No. F-51-R-14, Project 19, Job 5, and a grant from Pacific Gas and Electric Company.

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LIST OF ACRONYMS

Baldwin Construction Yard	BCY
Brood Year	BY
Coded-Wire-Tag	CWT
Coleman National Fish Hatchery	CNFH
Fall-run Chinook Salmon	FRCS
Fork Length	FL
Late Fall-run Chinook Salmon	LFRCS
Parrott-Phelan Diversion Dam	PPDD
Quality Control Device	QCD
Spring-run Chinook Salmon	SRCS
Tricaine Methanesulfonate	MS-222
United States Fish and Wildlife Service	USFWS
Winter-run Chinook Salmon	WRCS
Young-of-the-Year	YOY

INTRODUCTION

This is the sixth 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 five previous reports, Hill and Webber (1999), Ward and McReynolds (2004), Ward et al. (2004a,b,c), summarized project results through December 2003. 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 and Big Chico creeks; 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 m (7,000 ft). The watershed is approximately 2,103 km^2 (809 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 River with the Sacramento River (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.

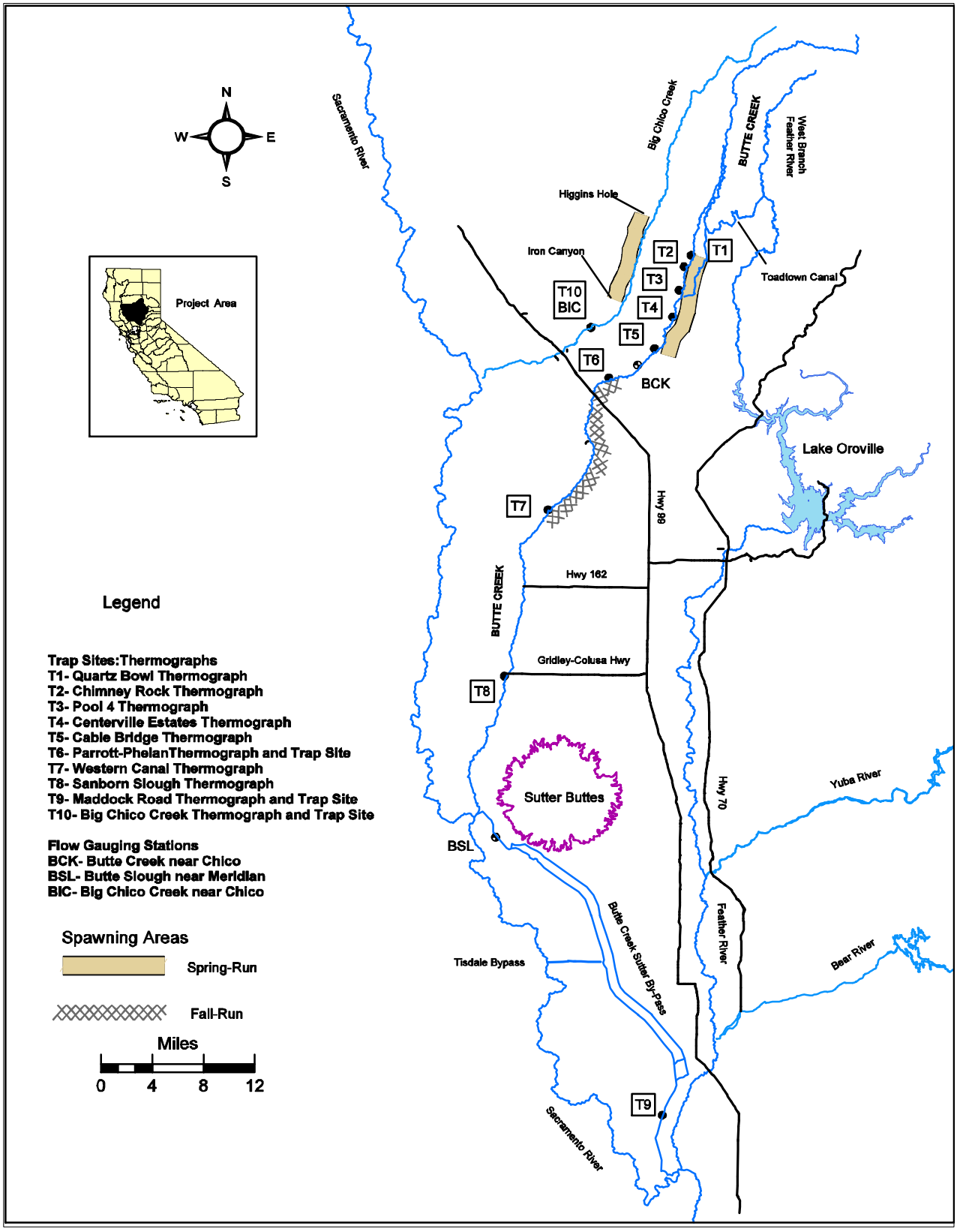

Figure 1. Butte Creek and Big Chico Creek watersheds with trap locations, gaging stations, and salmon spawning areas indicated.

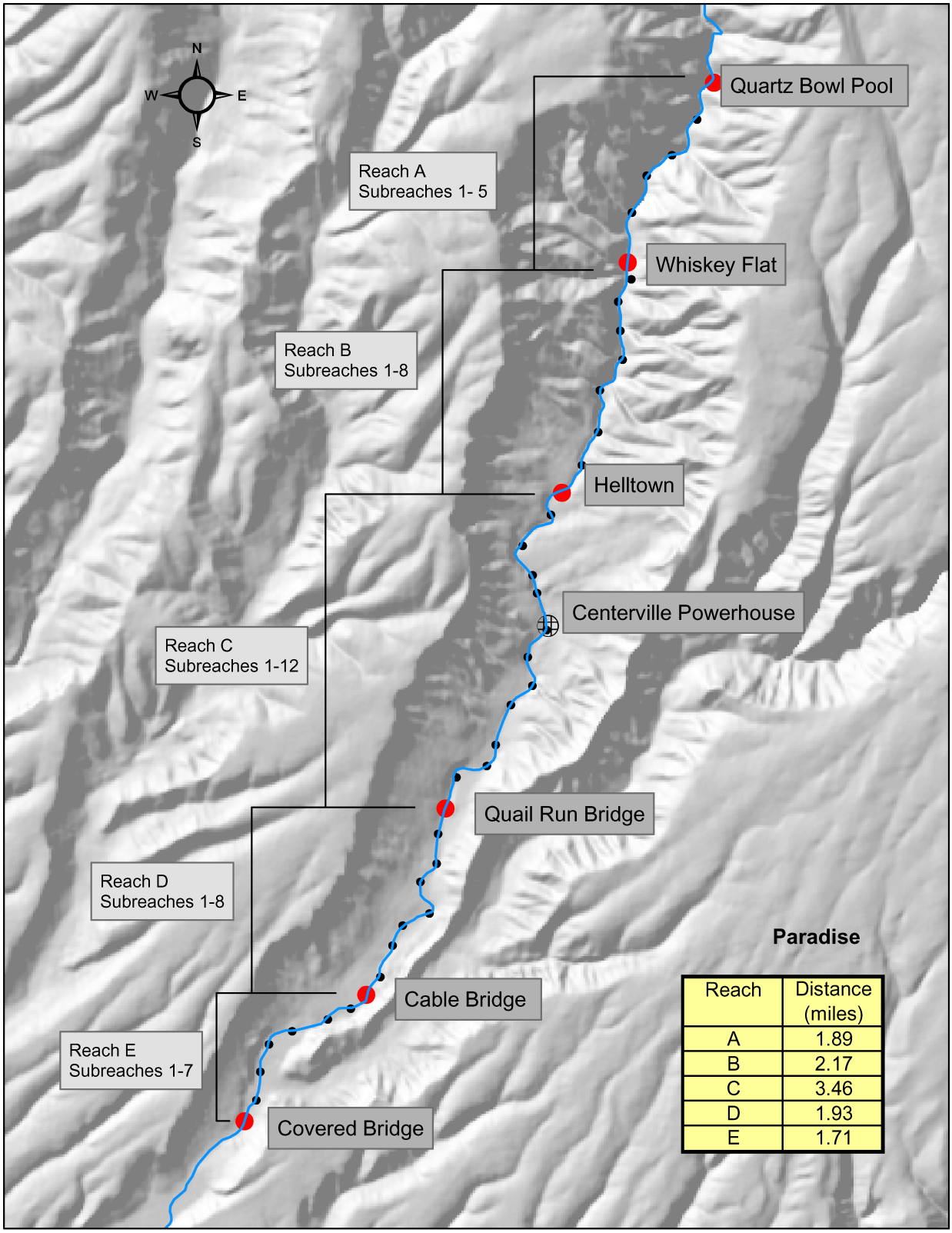

Figure 2. Butte Creek watershed showing spring-run spawning area by reach and sub-reach from Quartz Pool to Covered Bridge.

MATERIALS AND METHODS

Butte Creek Trapping Sites

Fish were trapped at two locations along Butte Creek (Figure 1). The PPDD is the uppermost site (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 second trapping site is located within the Sutter Bypass reach of Butte Creek at Maddock Road, approximately 118 km (73 mi.) downstream of PPDD (Figure 1, Site T9). Each site was sampled with one or 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 bridge by use of steel cable 0.6 cm (0.25 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 water flows or during periods of excessive debris. The Sutter Bypass trap was fished a limited number of days due to budget constraints. Typically, it was fished three or four days per week.

The Big Chico Creek trap was 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 0.61m (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-hr 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-hr 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 MS-222 and anaesthetized (10 g of MS-222 powder dissolved in 1 liter of fresh distilled water to create a stock solution, which was then used at a dilution of 40 ml stock solution/6 liter of fresh river water). Upon immobilization, juveniles were individually

placed onto a wetted Plexiglas measuring board and measured to the nearest mm FL. Thirty salmon of this group that measured greater than 40mm were then transferred to a wetted container on an Ohaus electronic scale and individually weighed to the nearest 0.01 g. All salmon caught in the Sutter Bypass traps were examined for an adipose fin-clip. Salmon with a clipped adipose fin were sacrificed and preserved for future CWT recovery and decoding. Each fish was individually bagged and given a tag having a unique numeric code identifying the date of capture, FL, weight, and capture location. Unclipped fish were placed into a bucket of fresh aerated river water for recovery. After full recovery, all unmarked salmon were released downstream of the trap.

Juvenile SRCS captured at the PPDD trapping site were measured as above. Instead of releasing these salmon at the site, they were placed in holding pens for subsequent tagging with a CWT. All fish were saved for tagging, unless daily trap numbers were extremely high making processing time extremely long (> 10 days). On days with large numbers of salmon, a sub-sample was held for tagging while the rest were released below the trapping site.

Salmon were transported via 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). Initially, injectors were fitted with a 1,100-fish/lb head mold. Head molds were changed periodically to accommodate for growth. 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

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 young-of-the-year (YOY) emerge. By examining length-frequency distributions of fish captured at PPDD, yearlings can generally be identified (Appendix B, Figure 1). Emigration of YOY SRCS is analyzed by examining catches of salmon trapped at PPDD and from tagged fish recovered in the Sutter Bypass, as well as catches 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 to PPDD (Figures 1 and 2). On Big Chico Creek, the survey was from Higgins Hole to Iron Canyon (Figure 1). The survey was conducted over four days (July 12 – 16, 2004) each covering a discrete reach on Butte Creek, and on two days (August 11&13, 2004) 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 the 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) mark/recapture survey, to identify pre-spawning mortalities, was conducted during the period June 15, 2004 through September 23, 2004 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 Quartz Bowl Pool to the Covered Bridge (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 sq.) 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. 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 (Schaefer, 1951) were completed for both SRCS and FRCS populations. This was the fourth 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.

The 2004 SRCS spawning survey was conducted from September 21, 2004 through November 4, 2004. The survey extended from the Quartz Bowl Pool to the Covered Bridge (Figures 1 and 2).

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 sq.) 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. Between each sample, scissors were rinsed in fresh water to prevent cross contamination. In addition, egg retention was recorded on a random sample of female carcasses. The percentage of egg retention to the nearest quartile was subjectively determined by the crew members. Heads were removed from adipose fin-clipped carcasses and returned to the Chico office for recovery of the CWT. While removing the CWT's from the heads, otoliths were extracted and archived with the previously taken tissue.

The 2004 FRCS carcass survey was conducted from November 3, 2004 through December 23, 2004. The survey extended from PPDD to the Gorrill Ranch Dam, also covering a ½-mi section near the Western Canal Siphon (Figure 1). The approximately 15.3-km (9.5-mi.) stream section was divided into four reaches. The FRCS survey used the same modified Schaefer model as was used for the SRCS survey.

Redd Measurement

Based upon a need to assess SRCS spawning habitat, 53 SRCS redds were examined to determine total area. Only fresh solitary redds that could clearly be distinguished and which were not overlapping (superimposed) were measured. Redd area was calculated using a formula for an ellipse (area = π (½ width) (½ length)). Length was defined as the distance from the head of the pit to the crest of the tail spill and width as the maximum distance, taken directly over the pit at its' widest point (Burner, 1951).

Water Temperature

Onset, model WTA032, temperature data loggers accurate to ± 0.2° Celsius (C) were deployed in pools at five sites within the SRCS spawning habitat (Figure 1). Each data logger was placed in a 5 cm x 15.2 cm (2in x 6 in) long 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 C.

RESULTS

Butte Creek

Trapping Season 2003-2004

The 2003-2004 trapping season began at the PPDD when both the diversion and rotary screw traps were installed on September 15, 2003. Both traps were operated until June 18, 2004. A second rotary screw trap was operated from January 15-27, 2004 to capture additional fish for the CWT effort. During the trapping season, there were occasions when one or both of the traps were removed due to high stream flows or excessive debris. A total of 348,445 juvenile salmon, including yearlings, was captured in both traps; 134,039 in the diversion screen trap and 214,406 in the screw trap(s) (Tables 1 and 2). Of the total captured, 202,570 were tagged and released at the BCY (Table 3). Since the diversion screen trap is located off-stream in the diversion canal, trapping data continue to demonstrate the benefit of the PPDD fish screen; any fish captured in the trap would have been lost into the canal if the structure did not exist. Approximately 91% (319,411) of the entire PPDD SRCS catch occurred between December 1, 2003 and February 29, 2004 (Table 1 and 2). Trapping was suspended for five days during December and February 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 September 15, 2003 to June 18, 2004; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
9/15/03	9/30/03	-	-	-	-	0	13
10/1/03	10/15/03	-	-	-	-	0	15
10/16/03	10/31/03	-	-	-	-	0	16
11/1/03	11/15/03	-	-	-	-	0	15
11/16/03	11/30/03	31	1.3	30	33	4	15
12/1/03	12/15/03	35	5.1	30	101	1,402	13
12/16/03	12/31/03	36	4.7	30	125	5,510	14
1/1/04	1/15/04	37	3.3	31	116	16,620	15
1/16/04	1/31/04	36	1.4	32	39	60,324	16
2/1/04	2/15/04	37	1.4	32	44	32,716	15
2/16/04	2/29/04	37	1.9	31	47	4,091	11
3/1/04	3/15/04	38	4.2	31	68	1,461	15
3/16/04	3/31/04	39	7.8	30	79	1,853	16
4/1/04	4/15/04	48	14.8	30	88	470	15
4/16/04	4/30/04	65	13.8	33	100	842	15
5/1/04	5/15/04	68	10.1	38	109	2,415	15
5/16/04	5/31/04	69	6.9	45	92	5,229	16
6/1/04	6/15/04	73	6.4	53	116	1,102	15
6/16/04	6/30/04	-	-	-	-	0	2
					Total	134,039	267

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 September 15, 2003 to June 18, 2004; 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
9/15/03	9/30/03	1	-	-	-	-	0	13
10/1/03	10/15/03	1	-	-	-	-	0	12
10/16/03	10/31/03	1	-	-	-	-	0	13
11/1/03	11/15/03	1	-	-	-	-	0	15
11/16/03	11/30/03	1	32	1.3	31	34	5	15
12/1/03	12/15/03	1	35	2.0	30	39	2,008	15
12/16/03	12/31/03	1	36	3.7	30	120	5,706	14
1/1/04	1/15/04	1	36	1.5	31	44	21,702	14
1/15/04	1/15/04	2	37	1.2	34	39	908	1
1/16/04	1/31/04	1	37	1.4	32	40	63,532	16
1/16/04	1/28/04	2	36	1.4	32	39	36,492	13
2/1/04	2/15/04	1	37	1.4	32	43	57,776	14
2/16/04	2/29/04	1	37	2.6	32	52	10,575	7
3/1/04	3/15/04	1	38	5.1	31	65	2,692	15
3/16/04	3/31/04	1	39	7.0	30	70	2,851	16
4/1/04	4/15/04	1	50	14.3	30	91	713	14
4/16/04	4/30/04	1	63	14.0	34	101	1,295	15
5/1/04	5/15/04	1	66	9.1	39	105	3,873	15
5/16/04	5/31/04	1	68	7.3	36	107	3,864	16
6/1/04	6/15/04	1	71	7.9	44	121	411	15
6/16/04	6/30/04	1	70	11.1	58	80	3	2
						Total Trap 1	177,006	256
						Total Trap 2	37,400	14

Sampling in the Sutter Bypass began on December 17, 2003 at the Maddock Rd. site (Figure 1, Site T9). The trap fished until June 14, 2004. A total of 19,791 juvenile Chinook salmon was captured (Table 4). There were 65 Butte Creek CWT recaptures in the Maddock Rd. trap (Table 5). The first recapture was on January 21, 2004 and the last was on April 23, 2004 (Appendix C, Table 1). Additionally, there were four recaptures of CWT late fall-run Chinook salmon (LFRCS) and nine FRCS released at CNFH between January 2 and February 17, 2004 (Appendix D, Table 1). Sampling by the U.S. Fish and Wildlife Service (USFWS) at Chipps Island and Sherwood Harbor recovered four additional tagged Butte Creek fish from March 22, 2004 to May 3, 2004 (Table 6). Additionally, salvage at the State Fish Facility recovered one tagged Butte Creek fish on March 31, 2004 (Table 6). All fish were from BY 2003, captured at PPDD and tagged at the BCY between December 31, 2003 and February 2, 2004.

Table 3. Summary of coded-wire tagged juvenile Butte Creek spring-run Chinook salmon released at Baldwin Construction site from December 31, 2003 to February 2, 2004.

Tag Code	Release Date		Mean FL (mm)	Range FL (mm)		Total No. Released
06-01-00-03-04	12/31/03	01/06/04	37	34	41	3,757
06-01-00-03-05	01/06/04	01/12/04	37	34	40	4,899
06-01-00-03-06	02/02/04	02/03/04	38	34	40	6,003
06-01-00-03-07	02/02/04	02/04/04	38	34	40	6,270
06-01-00-04-03	01/12/04	01/16/04	36	32	40	11,225
06-01-00-04-04	01/23/04	01/26/04	37	34	40	4,019
06-01-00-04-05	01/26/04	01/28/04	37	34	40	5,351
06-01-00-04-06	01/27/04	01/28/04	37	34	40	5,792
06-01-00-04-07	01/28/04	01/29/04	37	35	39	6,186
06-01-00-04-08	01/28/04	01/29/04	37	34	40	6,164
06-01-00-04-09	02/01/04	02/02/04	38	34	40	6,619
06-01-00-05-00	02/01/04	02/02/04	38	34	40	7,407
06-01-00-05-01	02/04/04	02/05/04	38	34	40	6,462
06-01-00-05-02	02/02/04	02/04/04	38	34	40	5,921
06-01-00-05-03	02/03/04	02/05/04	38	34	40	6,152
06-01-00-05-04	02/04/04	02/06/04	38	34	40	5,540
06-01-00-05-06	01/13/04	01/16/04	37	32	40	10,589
06-01-00-05-07	01/16/04	01/20/04	38	34	40	10,459
06-01-00-05-08	01/16/04	01/20/04	38	34	40	11,174
06-01-00-05-09	01/20/04	01/23/04	38	34	40	9,751
06-01-00-06-00	01/20/04	01/23/04	38	34	40	11,092
06-01-00-06-01	01/23/04	01/27/04	37	34	40	10,037
06-01-00-08-00	01/28/04	01/30/04	37	34	40	10,211
06-01-00-08-01	01/29/04	02/01/04	38	34	40	9,834
06-01-00-08-02	01/29/04	02/01/04	38	34	40	10,712
06-01-00-08-03	01/31/04	02/02/04	38	34	40	10,944
					Total	202,570

Table 4. Semi-monthly catch summary of juvenile Chinook salmon caught in the screw trap in the Sutter Bypass at Maddock Road from December 17, 2003 to June 14, 2004.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
12/15/03	12/31/03	51	22.2	32	113	36	8
1/1/03	1/15/04	-	-	-	-	-	4
1/16/03	1/31/04	48	12.7	34	153	823	12
2/1/04	2/15/04	49	17.1	32	178	2,070	8
2/16/04	2/29/04	-	-	-	-	-	0
3/1/04	3/15/04	43	8.6	35	76	56	4
3/16/04	3/31/04	62	10.5	38	105	12,170	9
4/1/04	4/15/04	70	9.3	43	99	3,130	9
4/16/04	4/30/04	75	9.8	47	104	1,138	7
5/1/04	5/15/04	69	6.6	48	85	288	8
5/16/04	5/31/04	68	7.3	50	93	69	8
6/1/04	6/15/04	72	5.2	62	79	11	7
					Total	19,791	84

* Fish captured at this location cannot be identified as SRCS due to mixing of juvenile salmon of other races from the Sacramento River.

Table 5. Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags in the Sutter Bypass at Maddock Rd.

Tag Code*	Total No.	Length at Recapture FL (mm)			Days At Large		
		Mean	Min.	Max.	Mean	Min.	Max.
06-01-00-03-04	2	74	70	78	86	83	90
06-01-00-03-05	3	60	40	91	41	12	76
06-01-00-03-07	1	75	-	-	51	-	-
06-01-00-04-03	5	72	38	89	66	7	90
06-01-00-04-04	1	64	-	-	60	-	-
06-01-00-04-05	2	54	37	70	36	8	63
06-01-00-04-06	3	59	37	75	41	8	64
06-01-00-04-08	4	61	36	73	47	6	63
06-01-00-04-09	2	58	41	76	34	11	58
06-01-00-05-00	4	68	64	73	52	52	53
06-01-00-05-01	3	45	37	60	19	7	43
06-01-00-05-02	1	65	-	-	51	-	-
06-01-00-05-03	2	49	38	60	27	6	48
06-01-00-05-04	1	79	-	-	57	-	-
06-01-00-05-06	2	78	72	83	73	70	75
06-01-00-05-07	2	53	35	70	34	9	59
06-01-00-05-08	5	55	34	78	40	3	80
06-01-00-05-09	4	59	38	75	49	5	70
06-01-00-06-00	2	77	75	78	69	68	70
06-01-00-06-01	5	54	35	79	34	10	67
06-01-00-08-00	3	69	60	74	54	50	57
06-01-00-08-01	4	67	39	85	47	11	62
06-01-00-08-02	3	60	34	73	48	6	83
06-01-00-08-03	1	39	-	-	12	-	-
Total	65						

* All fish were from BY 2003 tagged at Baldwin Construction Yard (Appendix C, Table 1 for detail)

Table 6. Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags by other research projects during 2004.

Recovery Date	Tag Code*	Recovery FL (mm)	Recapture Location	Days at Large
3/22/04	06-01-00-05-06	70	Sherwood Harbor	67
3/31/04	06-01-00-05-08	80	State Fish Facilities	73
4/9/04	06-01-00-03-07	92	Chipps Island	66
5/2/04	06-01-00-05-07	79	Chipps Island	105
5/3/04	06-01-00-08-01	83	Chipps Island	93

* All fish were from BY 2003 and tagged at Baldwin Construction Yard.

Juvenile Emigration 2003-2004

As discussed in previous reports (Hill and Webber, 1999; Ward and McReynolds, 2004; Ward, et al., 2004a-c), 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. Emigration appears to have been hastened by high flows during the period December through February (Tables 1 and 2; Appendix A, Figure 1). 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 25 yearling SRCS were captured. The first yearling SRCS was seen on December 12, 2003 and the last on June 8, 2004 at a length of 116 mm FL (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 yearling SRCS.

Adult Escapement 2004

Pre-spawning Mortality Carcass Survey

This was the second 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. 2005). From June 15, 2004 through September 24, 2004, a total of 201 carcasses was examined (75% female, 25% male). Since recoveries of the marked salmon were too low to calculate an expansion factor using the Schaefer model, the expansion factor generated by the subsequent spawning carcass survey of 2.08 was applied to generate an estimated total pre-spawning mortality of 418. That expansion factor was based upon the Schaefer estimate for the number of fish spawning divided by the number of carcasses examined (10,221/4,906). 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.

Spawning Carcass Survey

During this study period, the fourth intensive survey directed at recovering CWT's from previous release groups was conducted. A spawning carcass survey was begun on September 21, and continued through November 4, 2004 and covered the 17.7 km (11 mi.) SRCS spawning area (Figures 1 and 2). There were 4,953 carcasses examined with a total of 13 CWT's recovered: 2 from BY00, and 11 from BY01 (Appendix E, Table 1; Appendix F, Table 1). For those carcasses recovered during the SRCS spawning period, an expansion factor of 2.08 was calculated as previously described for the pre-spawn mortality estimate. In addition to the Butte Creek carcass recoveries, 13 CWT's were recovered in the ocean fishery, nine from California and four from Oregon (Appendix F, Table 1).

Subsequent to the SRCS carcass survey, a survey of the FRCS spawning area (Figure 1) was conducted from November 3 through December 23, 2004. A total of 40 CWT's was recovered (Appendix E, Table 2; Appendix F, Table 2) from 1,636 carcasses that were examined. An expansion factor of 1.54 was calculated based upon the Schaefer model population estimation methodology as described for the pre-spawn mortality estimate.

Redd measurements

Measurements were taken from 53 SRCS redds between September 17 and September 27, 2004 (Appendix H). The average length was 2.22 m (7.3 ft), width 1.49 m (4.9 ft) while redd area ranged from 0.86 m^2 (9.3 ft^2) to 8.2 m^2 (87.7 ft^2) with an average of 2.7 m^2 (29.2 ft^2).

Egg Retention

A total of 108 female carcasses was observed for egg retention. The majority (77%) were completely spawned. Seven percent were estimated to have more than half of their egg mass remaining (Table 7).

Table 7. Summary of estimated egg retention of Butte Creek spring-run Chinook salmon carcasses examined during spawning period September 22, through November 4, 2004.

Estimated Egg Retention	0%	25%	50%	75%	100%
Number of Females Examined (N =108)	83	11	6	1	7
Percent of Total	77%	10%	6%	1%	6%

Snorkel Escapement Survey

The 2004 SRCS adult escapement estimate based upon the snorkel survey method was 7,390 (Table 8).

Table 8. Estimates of adult spring-run Chinook salmon escapement in Butte Creek from snorkel surveys conducted annually from 1994 through 2004.

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

Water Temperatures 2003-2004

Thermal recording data loggers were installed at the five sites within the SRCS holding and spawning reach of Butte Creek (Figure 1). Recorded average daily temperatures during the period June through October ranged as high as 22.0° C on July 6 and 7, at the Cable Bridge location (Table 9; Appendix G, Figures 1 - 5). Average daily temperatures at all sites were above 15.0° C until mid-September 2004.

Table 9. 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	6/1/04 to 10/21/04	98	48	2
Chimney Rock	6/1/04 to 10/21/04	104	72	4
Pool 4	6/1/04 to 10/22/04	107	83	18
Centerville Estates	6/1/04 to 10/22/04	112	81	11
Cable Bridge	6/21/04 to 10/22/04	121	91	29

Big Chico Creek

Adult Escapement 2004

The 2004 Big Chico Creek adult escapement estimate was 0 based upon the snorkel survey method (Table 10).

Table 10. 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

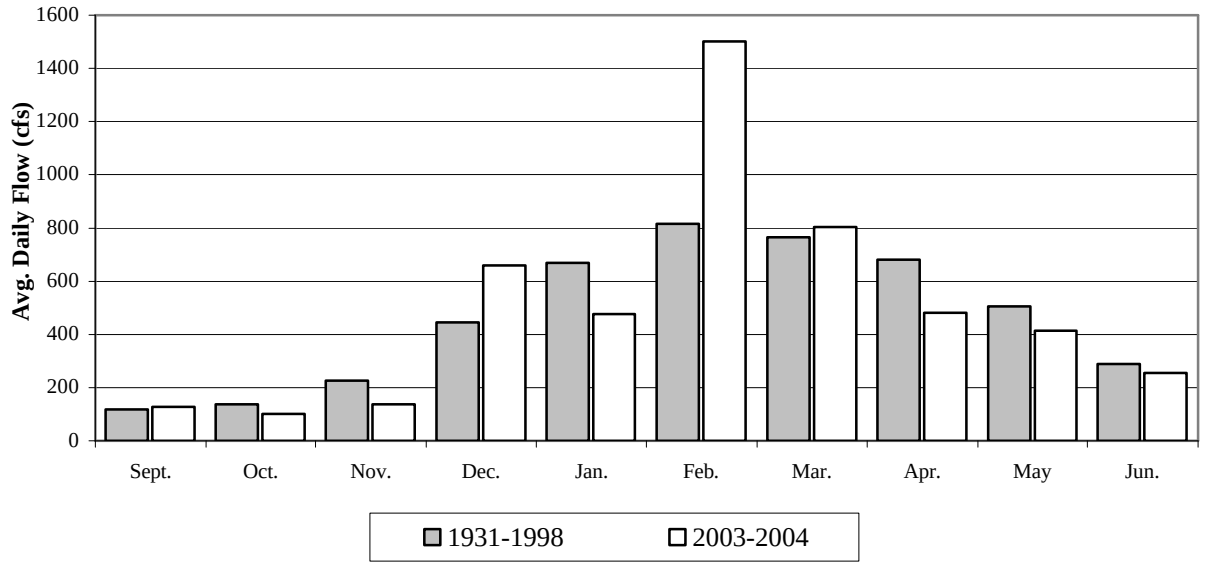
DISCUSSION

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 load required the cessation of sampling (Appendix A, Figure 1) to protect personnel and gear. The juvenile trapping effort at the PPDD was suspended a total of 5 days out of the 277-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, due to low stable spring flows (Ward, et al. 2004a,b). During the 2002-03 season, 86% of the total catch occurred by the end of February, at an average size of 35 mm. However, the total season catch of 50,953 was significantly lower than during previous study years. This study period, 91% of the total catch had occurred by the end of February, at an average size of 36 mm (Tables 1 and 2). The total trapped during this season was 348,445 and significantly higher than the 2002-03 season. These trapping totals are an important indicator because both followed summers with significant pre-spawn mortalities. Pre-spawn mortality was estimated to be 3,431 and 11,231 adult SRCS during 2002 and 2003, respectively. The 2002-03 season seemed to have reduced juvenile production while production during this season seemed to be less affected by the significant summer mortality. However, inability to trap during higher than average flows during December and January 2002 may have been a contributing factor (Ward et al., 2004c), while flows during 2003 were more moderate during the same period when compared to the historic record (Figure 3).

Figure 3. Comparison of Butte Creek average flows as measured at Butte Creek near Chico Gage (USGS #11390000) during 2003-04 with average flows during the period 1931-1998 (CDWR, 2002).



Recently emerged fry were captured at PPDD from November 2003 through June 2004 (Appendix B, Figure 1). As with previous years (Ward et al., 2004a,b,c), 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 2003, although numbers were generally small. Fry captured at the site from November through March were assumed to be SRCS.

There were 25 SRCS captured at PPDD during the entire trapping period which were identified as yearlings. The first yearling was captured on December 12, 2003, and the last on June 8, 2004. Similar to the previous study period, few yearling salmon were observed upstream of PPDD during the summer adult escapement surveys.

A total of 65 Butte Creek SRCS juveniles CWT marked at the BCY site was subsequently recaptured at the Maddock Rd. site, within the Sutter Bypass (Table 5). The earliest recaptures occurred on January 21, 2004, when three juvenile Butte Creek SRCS, 34, 38, and 40 mm FL, released between January 6-20, 2004, were recovered. The latest recapture was on April 23, 2004, at 73 mm FL, released between January 29 and February 1, 2004. The average time at large calculated for all fish marked at BCY and recaptured in the Sutter Bypass trap was 46 days. This study period continues to support the apparent value of the Sutter Bypass as a major nursery area.

During this evaluation period, the Sacramento River overflowed into the Sutter Bypass at either or both the Colusa and Tisdale weirs a total of 49 days (Appendix A, Figure 2). The Sacramento River first overflowed into the Sutter Bypass via the Colusa/Tisdale weirs on December 15, 2003, and for the last time on March 14, 2004. There were 13 recaptures of CWT fish from the upper Sacramento River marked by the USFWS (Appendix D, Table 1). Four were CNFH LFRCS released in Battle Creek and nine were CNFH FRCS released at the Red Bluff Diversion Dam. Average time at large for the group from date of release to date of recapture was 36 days. Five CWT recaptures originating from Butte Creek were from other sampling projects downstream of the Sutter Bypass (Table 6). Three were captured by the USFWS at Chipps Island and one at Sherwood Harbor near Sacramento. One was salvaged at the State Water Project facilities. All recaptures occurred from late March to early May.

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 during the second week in July 2004. The snorkel survey has been performed consistently since 1991 and serves as a population index. The 2004 snorkel survey was moved to early July to develop a better estimate prior to any significant pre-spawn mortalities. There were still an estimated 36 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). 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 and 2004 to account for those adults that died prior to spawning. The 2004 escapement estimate based upon the snorkel survey was 7,390 with a range of 6,575 to 8,252. The combined pre-spawn and spawning carcass

survey results from 2004 suggest a larger population of 10,639; 418 that died prior to spawning and 10,221 which survived to spawn (Appendix E, Table 1). Among those that survived to spawn, there were 4,953 carcasses examined of which 700 fresh carcasses (54% female, 46% male) were marked with colored ribbons and returned to the water, with a subsequent recovery of 316, or a recovery rate of 45%. Based upon snorkel surveys and adults returning as three year olds, the 2004 escapement estimate represents a 0.77 cohort replacement rate (7,390/9,605) . However, Butte Creek CWT recoveries continue to demonstrate that a proportion of Butte Creek SRCS return to spawn at age-4. Of the 13 CWT's recovered on the spawning survey, 11 were age-3 and 2 were age-4 (Figure 5). Based upon tag recoveries adjusted for release group size the population contained approximately 84% age-3, and 16% age-4 fish. During 2003, it was estimated that population consisted of approximately 31% age-3 and 69% age-4 (Ward et al., 2004c).

This was the second season a fully funded pre-spawning mortality survey was conducted starting on June 15, 2004 and ending on September 23, 2004 at onset of spawning. Mortalities were low throughout the study period. There was a total of 201 carcasses examined, of which 111 were measured (75% female and 25% male), tagged with a colored ribbon and returned to the water for subsequent recovery. Of the 111 tagged fish, only five were recovered during the survey. Due to the low number of recoveries it was not possible to generate a Schaefer model estimate of total pre-spawn mortality. Instead, an expansion factor generated from the subsequent Schaefer Model estimate of spawning was applied. The expansion factor was 2.08 and was based upon the Schaefer estimate for the number of fish spawning divided by the number of carcasses examined (10,221/4,906). Based upon that expansion factor, the estimate for pre-spawn mortality was 418 (201 x 2.08).

Based upon 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 significantly smaller than those encountered during 2003, and similar to 2001 and 2002 (Table 11, Figure 4, 5).

Table 11. Fork lengths of adult Butte Creek spring-run Chinook salmon that spawned during 2001- 2004 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
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 4. Length frequency distribution of 111 adult Butte Creek spring-run Chinook salmon pre-spawn mortalities measured and marked for abundance estimate between June 15, and September 23, 2004.

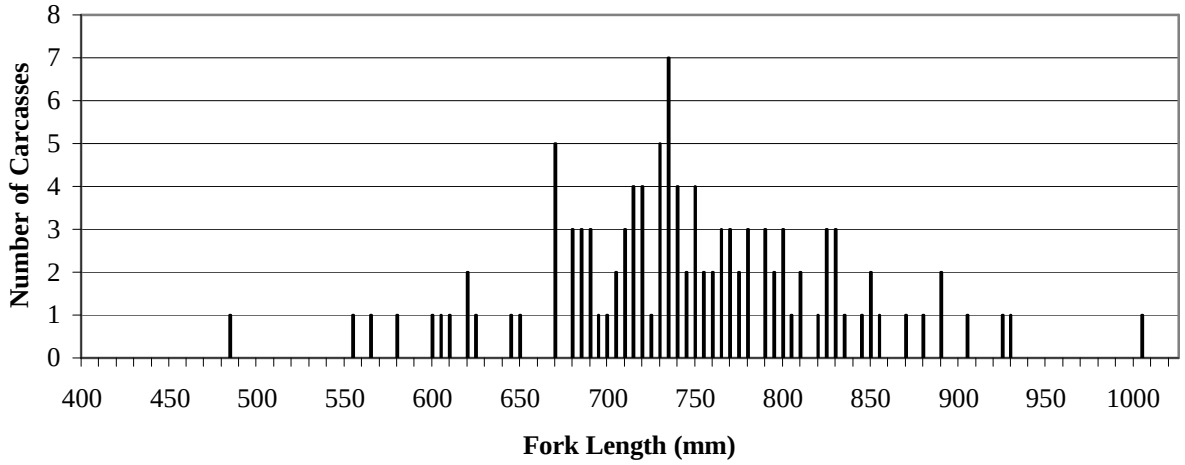
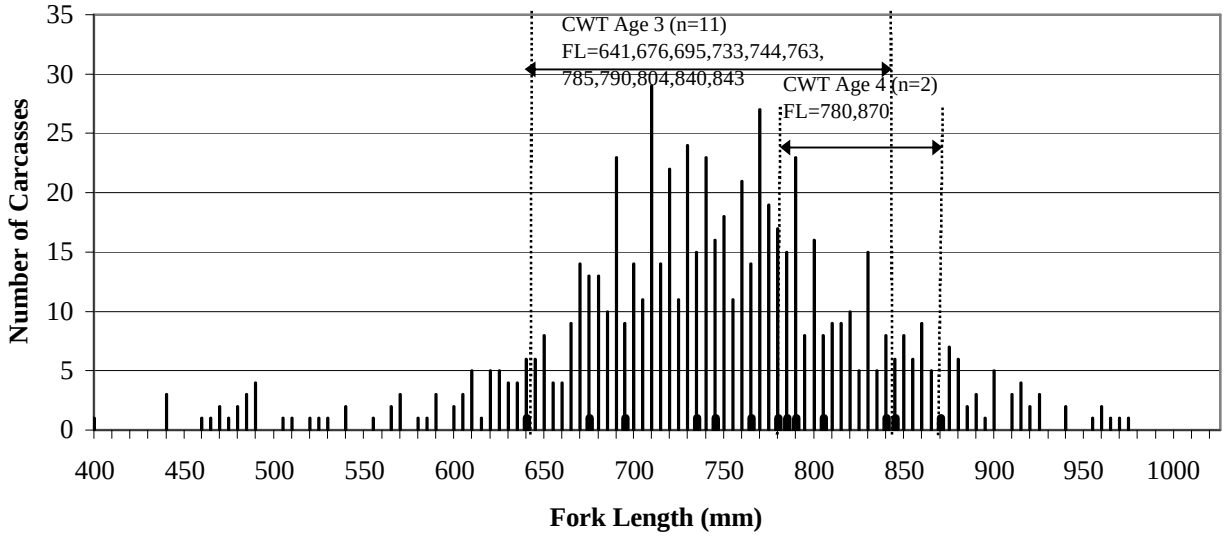


Figure 5. Length frequency distribution of 700 spawned adult Butte Creek spring-run Chinook salmon carcasses measured and marked for abundance estimate between September 21, and October 22, 2004.



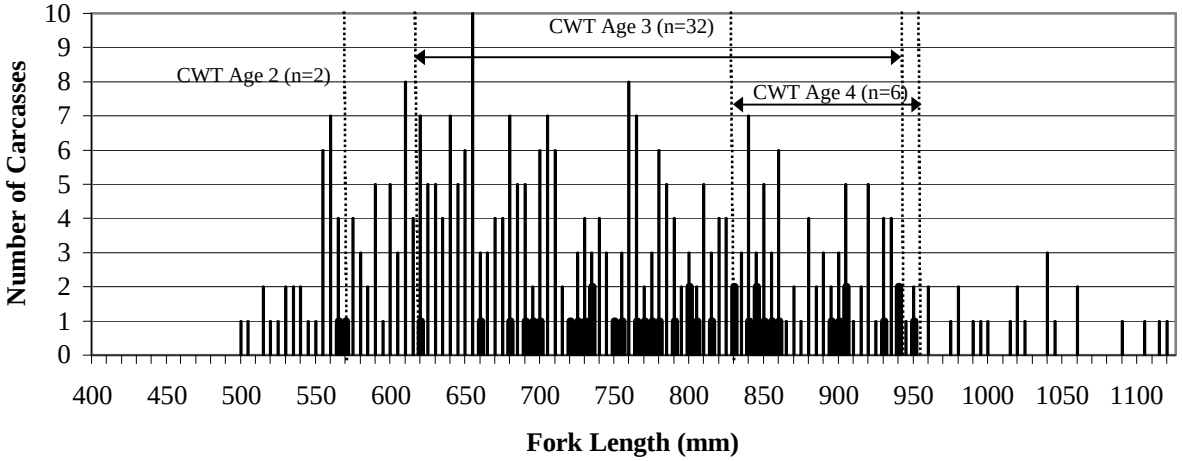
Ocean recoveries during 2004 (Appendix F, Table 1) extended from March through September, and all were taken from south of Monterey, California to Depoe Bay, Oregon. Based upon the current ocean-aging convention that increments spring-run salmon to the next age class on May 1, there was 11 age-3 and 2 age-4. Comparing the expanded BY 00 ocean and inland recoveries (Table 12; Appendix F, Table 1) suggests a 43% ocean sport/commercial catch rate ($O_s + O_c/(O_s + O_c + I_{Total\ Escapement}$), similar to the 43% ocean sport/commercial catch rate for BY 99 and slightly lower than the BY 98 rate of 48%.

Table 12. Brood Year 2000 ocean and inland recoveries of adult Butte Creek spring-run Chinook salmon tagged and released at Baldwin Construction Yard.

Source	Inland Age	Ocean Age	Number Recovered		Expanded Number Recovered	
			Ocean	Inland	Ocean	Inland
Sport	2	3	2		9	
Sport	3	4	2		8	
Commercial	3	3	1		4	
Commercial	3	4	5		15	
Spawn	3			8		12
Spawn	4			2		4
Pre-Spawn	3			14		30
Local	3			1		1
Total			10	25	36	47

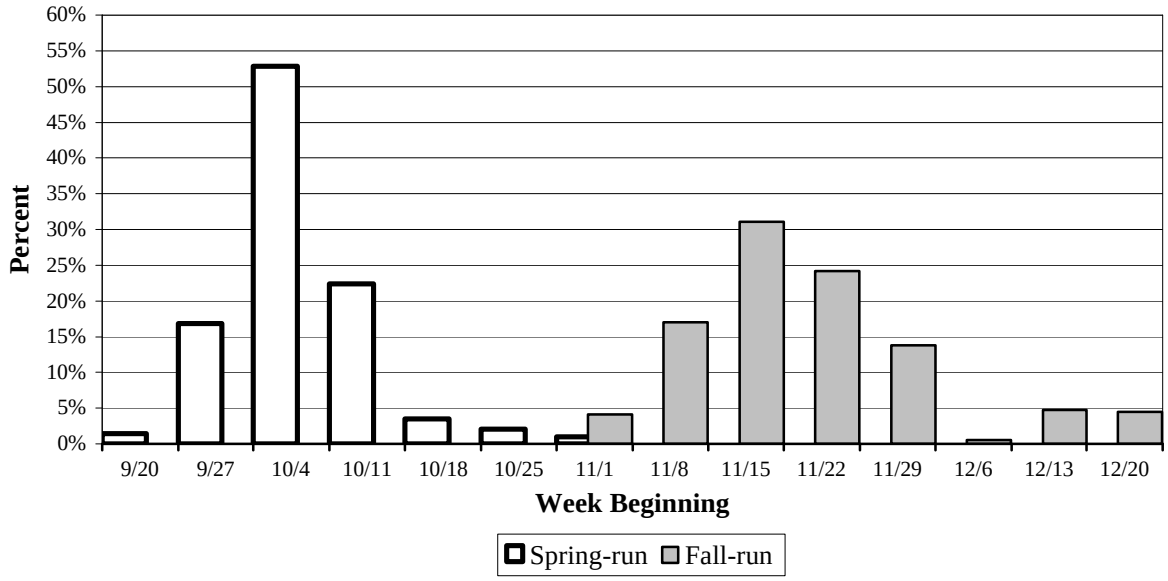
Subsequent to the SRCS carcass survey, a FRCS carcass survey was initiated on November 3rd and continued through December 23, 2004. The FRCS survey covered the reaches of Butte Creek downstream of the PPDD (Figure 1). For the third consecutive year, a bar rack was placed in the fish ladder at the PPDD 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 last week of December. Using the technique of the modified Schaefer Model, 1,636 carcasses were examined, with 346 of the fresh carcasses marked with colored ribbons of which 189 were subsequently recovered. For 2004, the Schaefer model estimate for FRCS was 2,456 fish which spawned in the reach downstream of the PPDD. A kayak survey was conducted to assess the spawning upstream of the PPDD. It was estimated that a minimum of 60 FRCS spawned upstream. There was a total of 40 CWT marked carcasses recovered during the FRCS carcass survey (Figure 6; Appendix F, Table 2). All of the recovered CWT's were from salmon natal to other watersheds, with a majority from the Merced and Mokelumne rivers .

Figure 6. Length frequency distribution of 346 adult fall-run Chinook salmon carcasses measured and marked for abundance estimate between November 3, and December 16, 2004.



Comparison of Butte Creek SRCS and FRCS spawning timing (Figure 7) continues to show little overlap, with peak SRCS spawning occurring during the week of October 4; for FRCS the peak occurred during the week of November 15, 2004. All of Butte Creek SRCS spawned above PPDD (Figure 1), while the vast majority of FRCS spawned downstream of that site. The results from the 2003-2004 study period continue to support Butte Creek SRCS as a distinct and sustaining population with little evidence to date of introgression from other watersheds.

Figure 7. Percent of carcasses of spawned Butte Creek spring- and fall-run Chinook salmon recovered for period September 21, 2004 through December 23, 2004.



Adult Spring-run Straying

During this reporting period, there were two recoveries of Butte Creek adult CWT SRCS in other watersheds. The first (BY 01) was recovered from Battle Creek at the barrier weir on April 20, 2004. This Butte Creek stray (Tag # 06-01-00-02-08) was sacrificed at the barrier weir. There was no expansion factor for this sampling. The second recovery (BY 02) was recovered from Clear Creek on October 14, 2004. This Butte Creek stray (Tag # 06-01-00-04-02) was found upstream of the picket weir (Appendix F, Table 1). The Clear Creek picket weir was installed from August 26 to November 2, 2004 to spatially isolate SRCS from FRCS. Since there was no systematic SRCS spawning survey in Clear Creek, no expansion factor for sampling effort was determined. Thus 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 89 (expanded to 176 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 F, 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 June 21st and exceeded 20°C for two days during the holding period at Quartz Bowl Pool.

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 2003-04 season to include Chris Bennett, Mitch Azevedo, Jeff Humble, Adam Geyer, Kyle Thompson, Sam Plemons, and Dave Vigil.

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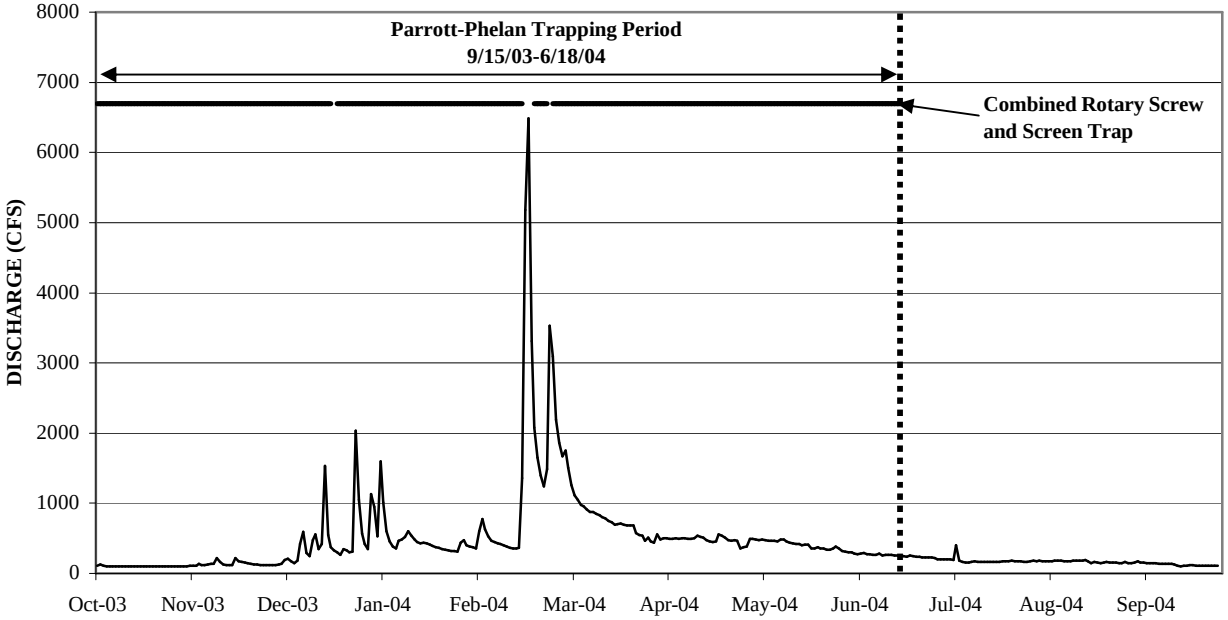
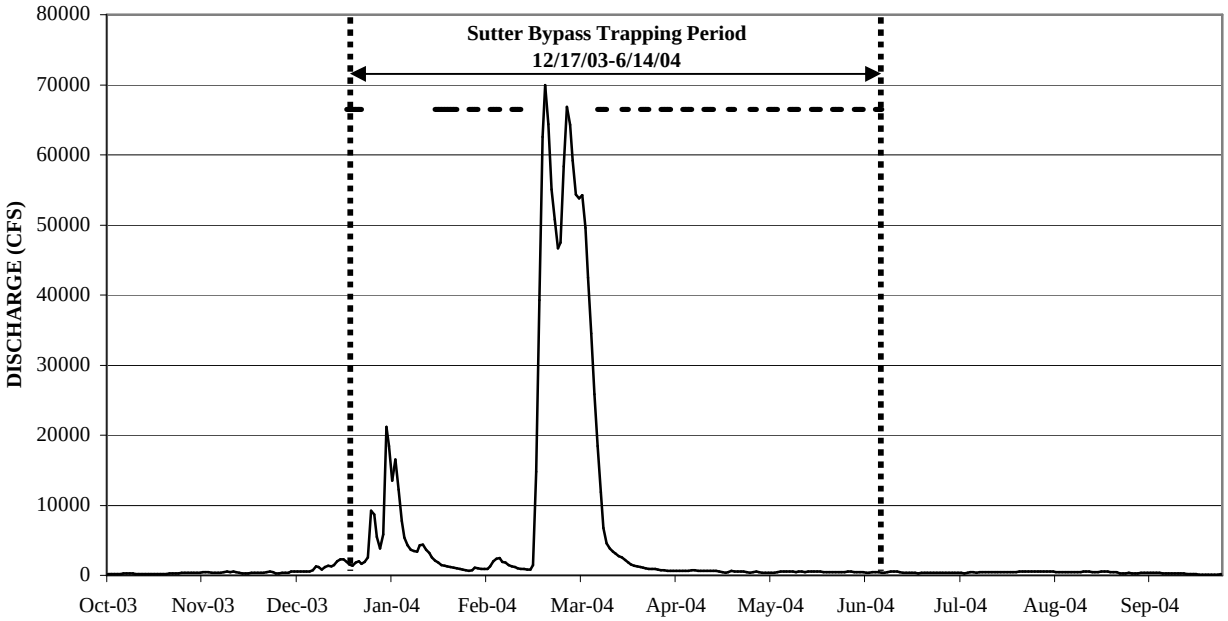
APPENDIX A, Figure 1. Butte Creek flow at Butte Creek near Chico Gage (USGS - #11390000), water year 2003-04, with trapping period shown. Flow data are provisional and subject to revision.

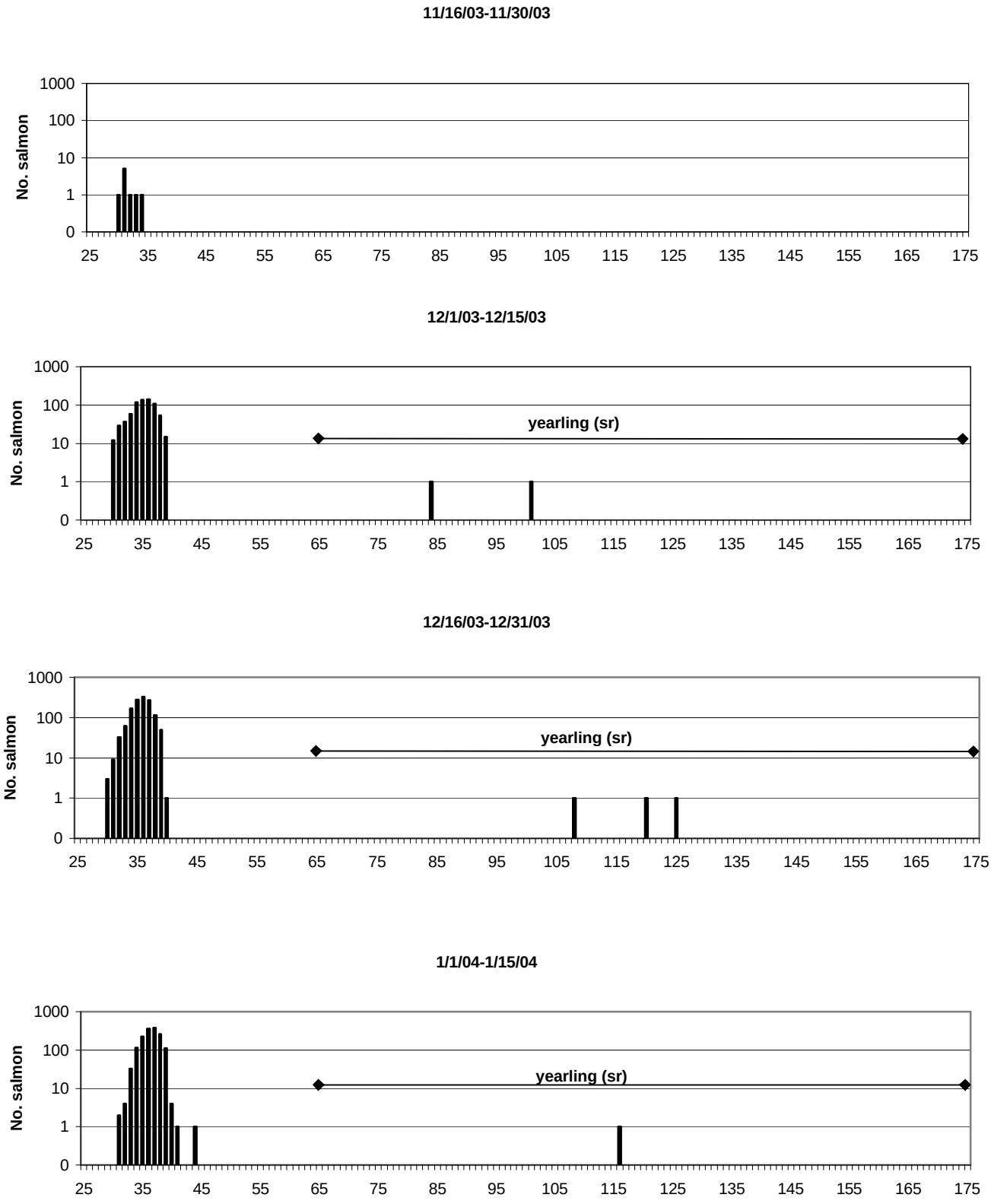


APPENDIX A, Figure 2. Butte Creek flow at Sutter Bypass Butte Slough near Meridian Gage (DWR A20972), water year 2003-04, with trapping period shown. Flow data are provisional and subject to revision.

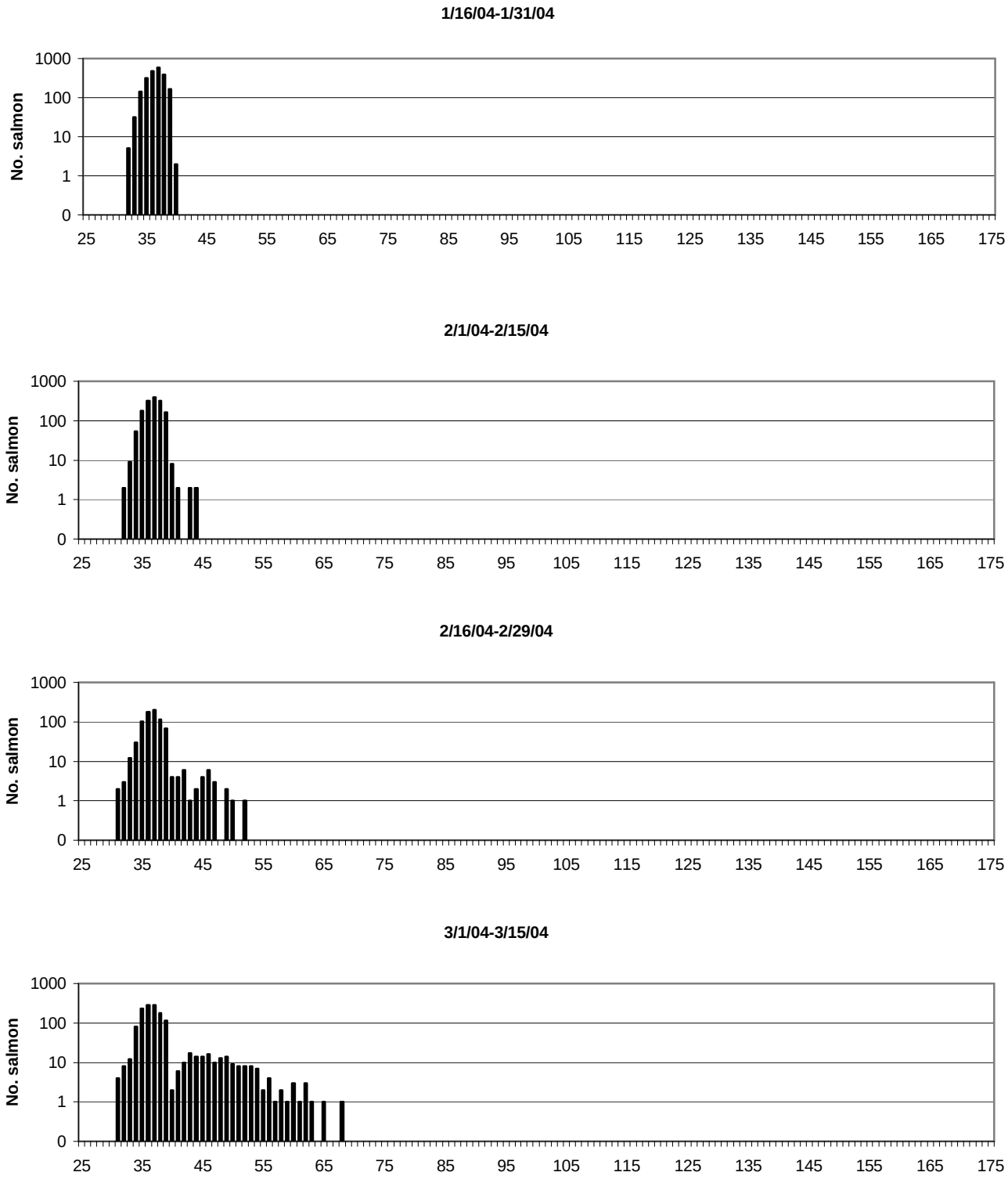


*Breaks in horizontal line indicate periods of time when the trap(s) were not fishing.

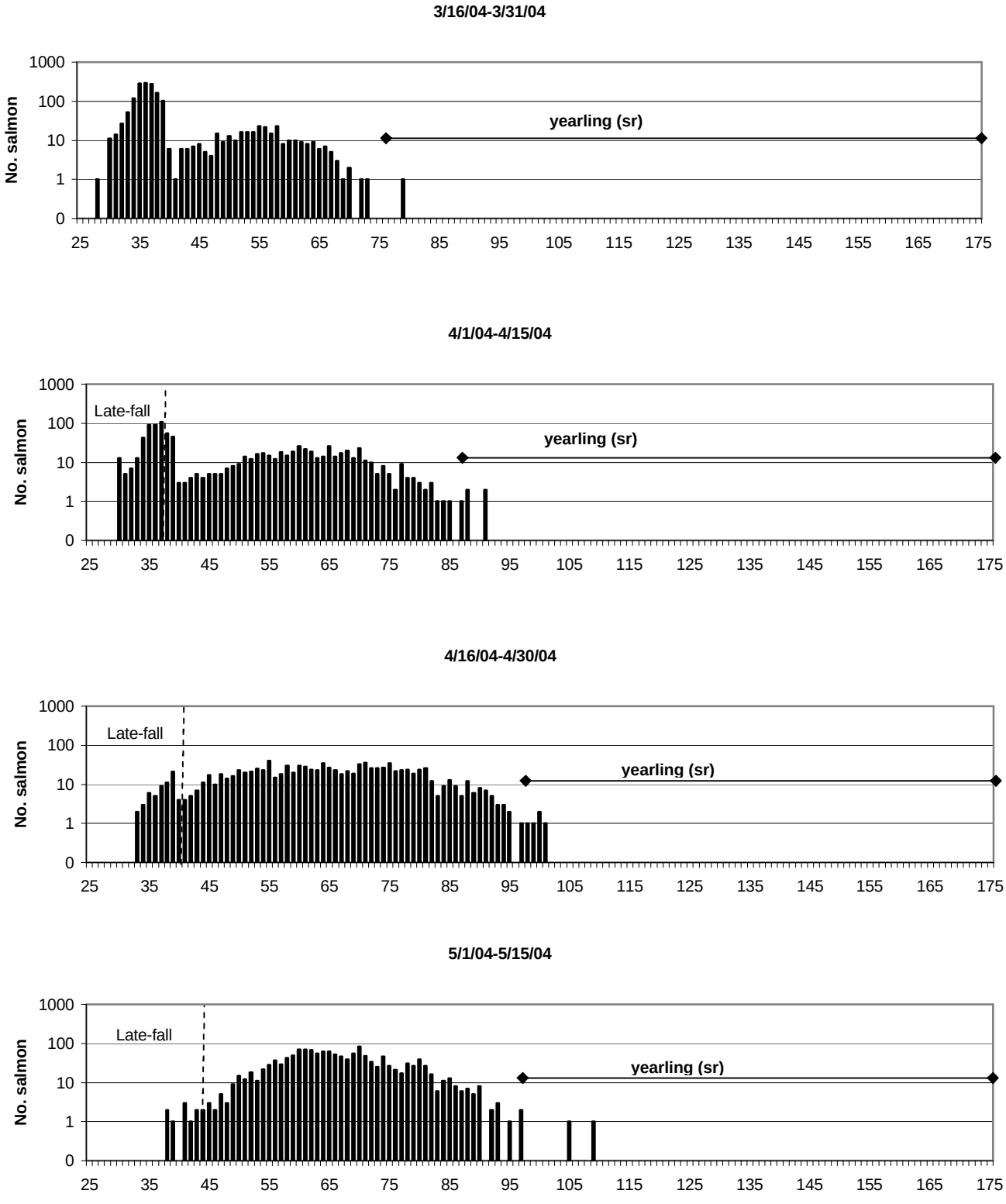
APPENDIX B, Figure 1. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from November 16, 2003 through June 16, 2004. All fish are assumed to be spring-run Chinook salmon except where indicated.



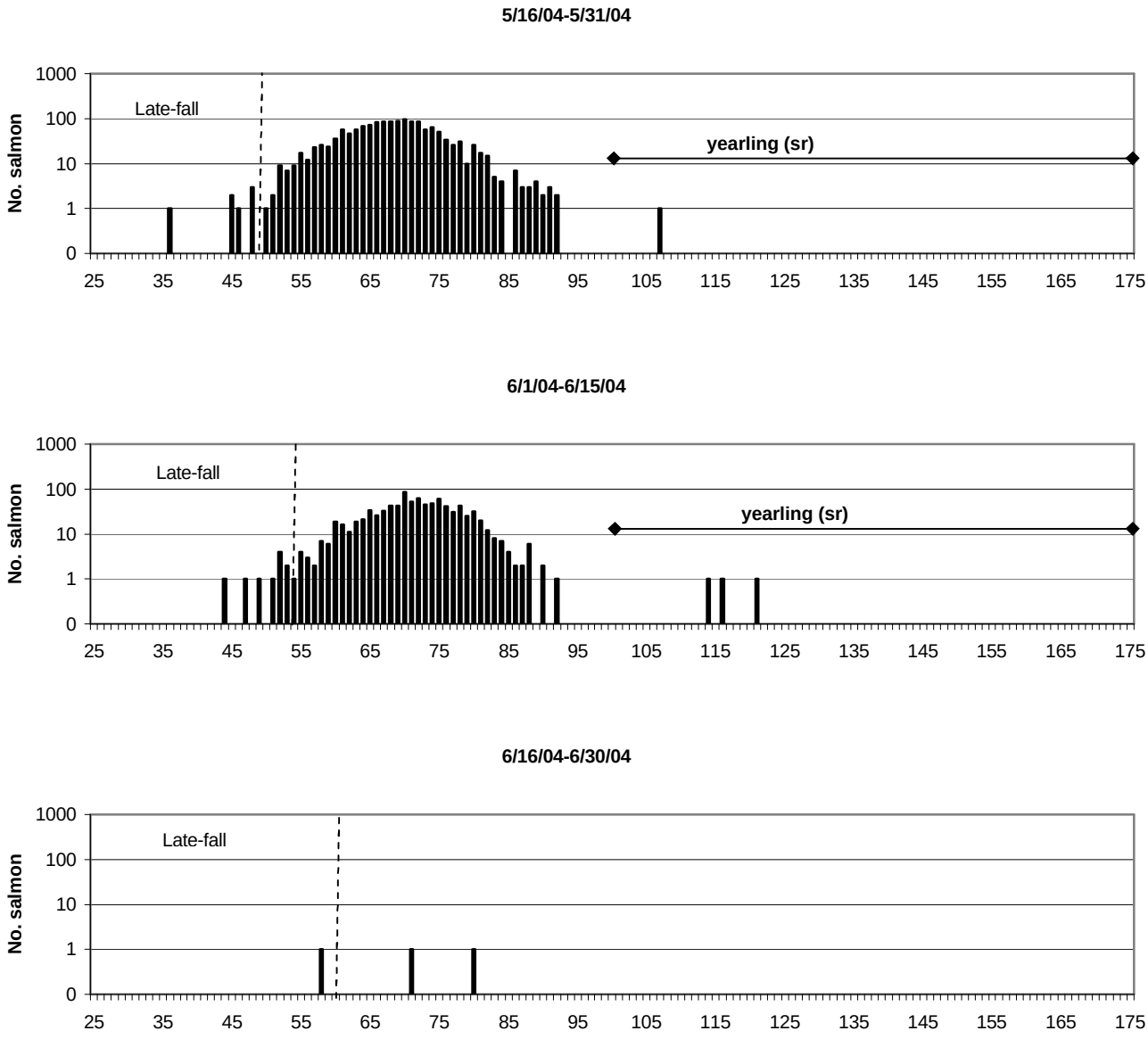
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from November 16, 2003 through June 16, 2004. All fish are assumed to be spring-run Chinook salmon except where indicated.



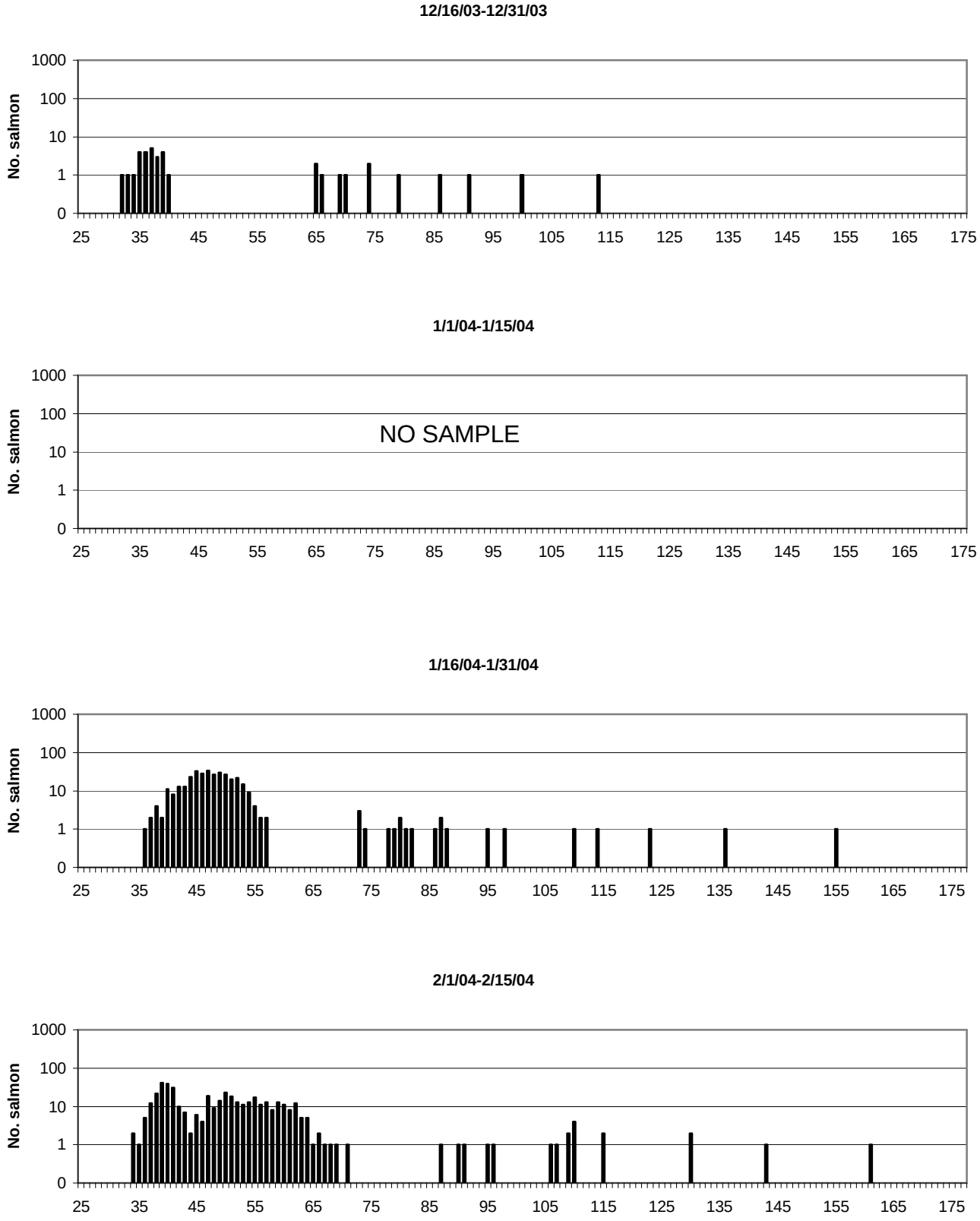
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from November 16, 2003 through June 16, 2004. All fish are assumed to be spring-run Chinook salmon except where indicated.



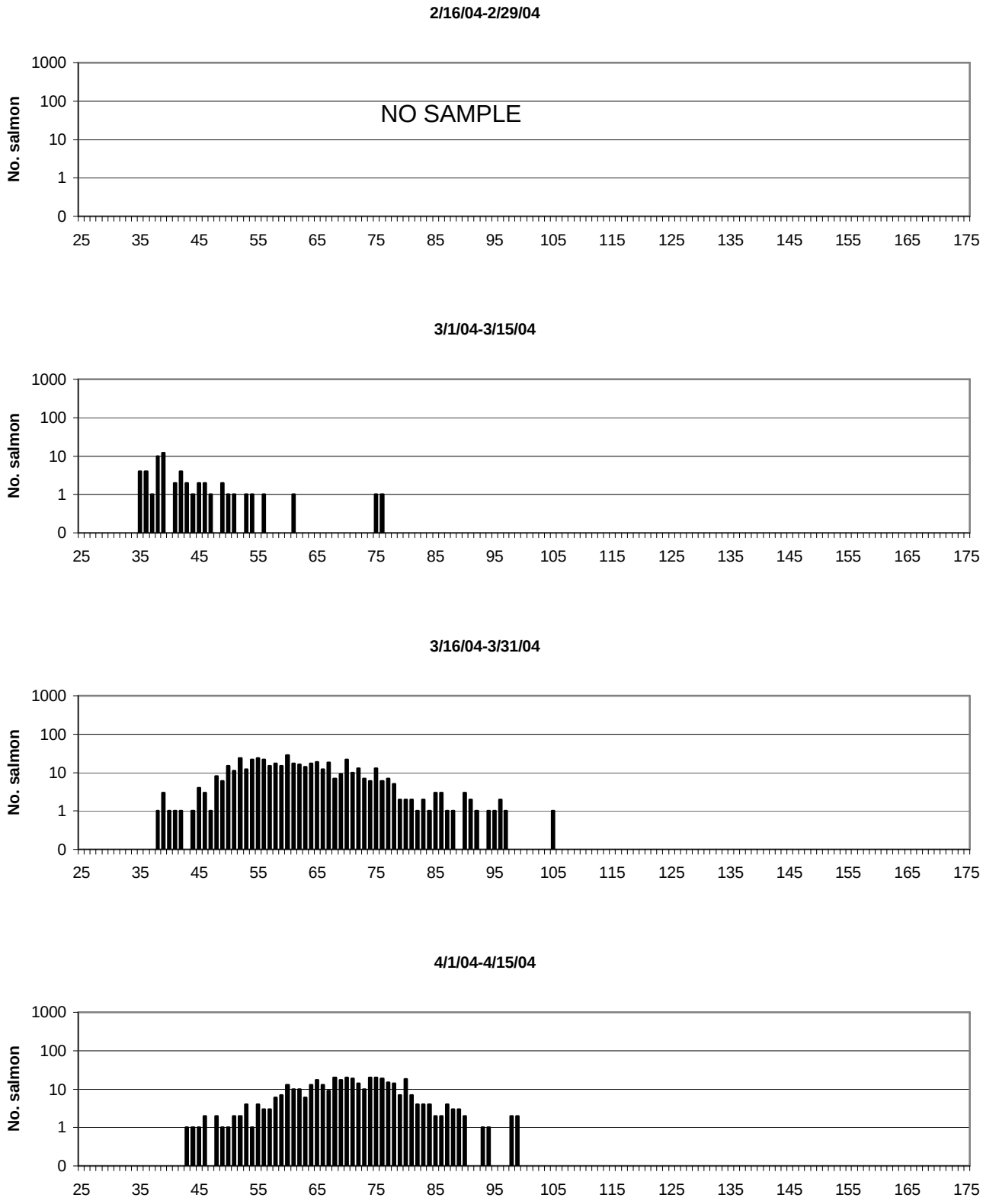
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from November 16, 2003 through June 16, 2004. All fish are assumed to be spring-run Chinook salmon except where indicated.



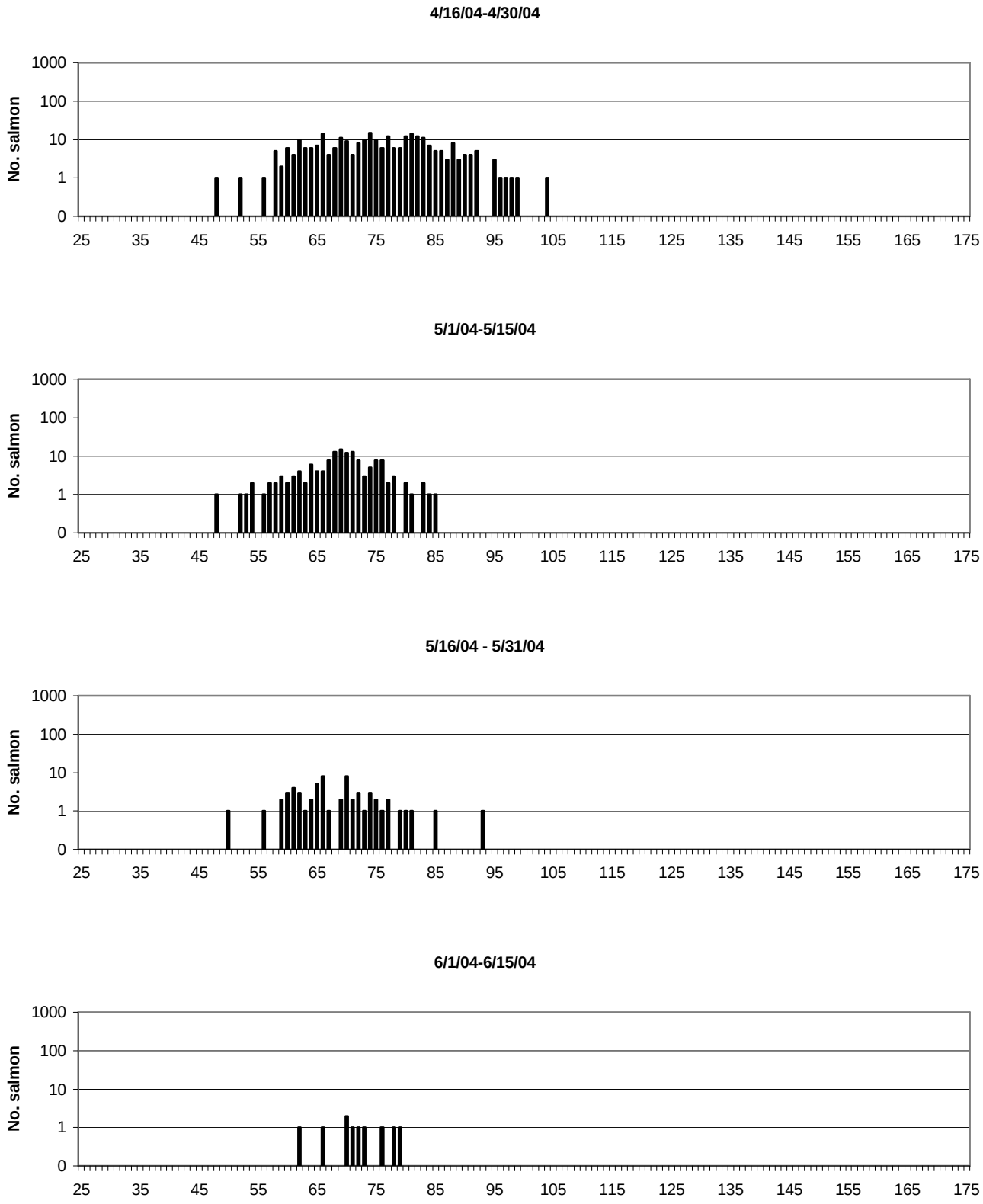
APPENDIX B, Figure 2. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Maddock Road in the Sutter Bypass from December 18, 2003 through June 2, 2004.



APPENDIX B, Figure 2. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Maddock Road in the Sutter Bypass from December 18, 2003 through June 2, 2004.



APPENDIX B, Figure 2. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Maddock Road in the Sutter Bypass from December 18, 2003 through June 2, 2004.



APPENDIX C, Table 1. Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags in the Sutter Bypass at Maddock Rd. All fish were from BY 2003 and tagged at Baldwin Construction Yard.

Tag code 06-01-00-03-04					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/26/2004	78	83	4/2/2004	70	90

Tag code 06-01-00-03-05					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
1/21/2004	40	12	3/25/2004	91	76
2/13/2004	48	35			

Tag code 06-01-00-03-07					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/25/2004	75	51			

Tag code 06-01-00-04-03					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
1/21/2004	38	7	4/14/2004	76	90
3/25/2004	78	70	4/14/2004	89	90
3/26/2004	81	71			

Tag code 06-01-00-04-04					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/25/2004	64	60			

Tag code 06-01-00-04-05					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/4/2004	37	8	3/30/2004	70	63

APPENDIX C, Table 1. (continued) Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags in the Sutter Bypass at Maddock Rd. All fish were from BY 2003 and tagged at Baldwin Construction Yard.

Tag code 06-01-00-04-06					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/5/2004	37	8	4/1/2004	75	64
3/19/2004	64	51			

Tag code 06-01-00-04-08					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/4/2004	36	6	3/30/2004	70	61
3/25/2004	73	56	4/1/2004	64	63

Tag code 06-01-00-04-09					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/13/2004	41	11	3/31/2004	76	58

Tag code 06-01-00-05-00					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/25/2004	73	52	3/26/2004	64	53
3/25/2004	66	52	3/26/2004	70	53

Tag code 06-01-00-05-01					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/12/2004	39	7	3/19/2004	60	43
2/12/2004	37	7			

Tag code 06-01-00-05-02					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/25/2004	65	51			

APPENDIX C, Table 1. (continued) Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags in the Sutter Bypass at Maddock Rd. All fish were from BY 2003 and tagged at Baldwin Construction Yard.

Tag code 06-01-00-05-03					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/10/2004	38	6	3/23/2004	60	48

Tag code 06-01-00-05-04					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
4/2/2004	79	57			

Tag code 06-01-00-05-06					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/25/2004	83	70	3/30/2004	72	75

Tag code 06-01-00-05-07					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
1/27/2004	35	9	3/17/2004	70	59

Tag code 06-01-00-05-08					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
1/21/2004	34	3	3/25/2004	72	67
2/10/2004	45	23	4/7/2004	78	80
2/13/2004	48	26			

Tag code 06-01-00-05-09					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
1/27/2004	38	5	3/25/2004	75	63
3/19/2004	52	57	4/1/2004	72	70

Tag code 06-01-00-06-00					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/30/2004	78	68	4/1/2004	75	70

APPENDIX C, Table 1. (continued) Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags in the Sutter Bypass at Maddock Rd. All fish were from BY 2003 and tagged at Baldwin Construction Yard.

Tag code 06-01-00-06-01					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/4/2004	35	10	3/30/2004	77	65
2/5/2004	36	11	4/1/2004	79	67
2/12/2004	44	18			

Tag code 06-01-00-08-00					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
3/19/2004	60	50	3/26/2004	74	57
3/25/2004	72	56			

Tag code 06-01-00-08-01					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/11/2004	39	11	3/30/2004	71	59
3/26/2004	73	55	4/2/2004	85	62

Tag code 06-01-00-08-02					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/6/2004	34	6	4/23/2004	73	83
3/26/2004	72	55			

Tag code 06-01-00-08-03					
Recovery Date	Recovery FL (mm)	Days at Large	Recovery Date	Recovery FL (mm)	Days at Large
2/13/2004	39	12			

APPENDIX D, Table 1. Recovery of juvenile Chinook salmon tagged and released by USFWS during 2003-2004 season. Salmon were recovered in the Sutter Bypass at Maddock Rd.

Tag Code	Race[1]	Source[2]	Release Site[2]	Release Date	Avg. FL at Release	Recovery Date	FL at Recovery	Days at Large
51764	LFR	CNFH	CNFH	01/02/04	134	1/22/2004	153	20
51768	LFR	CNFH	CNFH	01/02/04	130	1/21/2004	134	19
51768	LFR	CNFH	CNFH	01/02/04	130	2/12/2004	159	41
51776	LFR	CNFH	CNFH	01/02/04	128	2/6/2004	178	35
501021514	FR	CNFH	RBDD	02/17/04	47	3/19/2004	70	31
501021514	FR	CNFH	RBDD	02/17/04	47	3/19/2004	69	31
501021514	FR	CNFH	RBDD	02/17/04	47	3/19/2004	61	31
501021514	FR	CNFH	RBDD	02/17/04	47	3/25/2004	77	37
501021514	FR	CNFH	RBDD	02/17/04	47	3/25/2004	69	37
501021514	FR	CNFH	RBDD	02/17/04	47	3/25/2004	68	37
501021514	FR	CNFH	RBDD	02/17/04	47	3/30/2004	72	42
501021514	FR	CNFH	RBDD	02/17/04	47	4/6/2004	71	49
501021514	FR	CNFH	RBDD	02/17/04	47	4/15/2004	99	58

[1] Race designation, LFR = late-fall run Chinook salmon, FR – fall run Chinook salmon.
[2] Source and Release Site designation include Coleman National Fish Hatchery on Battle Creek (CNFH), and Red Bluff Diversion Dam (RBDD)

APPENDIX E, Table 1. Butte Creek spring-run Chinook spawning escapement estimate for 2004 using modified Schaefer Model.

Week of Recovery $R_{(j)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$					Tags Recovered $R_{(i)}$	Carcasses Counted $C_{(j)}$	Population Estimate
	1	**2**	**3**	**4**	**5**			
	Sept. 21-23	Sept. 28-30	Oct. 5-7	Oct. 12-14	Oct. 21-22			
1 Sept. 28-30	4	-	-	-	-	4	571	2345
2 Oct. 5-7	2	118	-	-	-	120	2444	4674
3 Oct. 12-14	0	18	141	-	-	159	1162	1955
4 Oct. 21-22	0	0	13	6	-	19	180	995
5 Oct. 25-29	0	0	4	3	2	9	112	152
6 Nov. 2-4	0	0	3	1	1	5	53	53
Recovery $R_{(i)}$	6	136	161	10	3		Total	10174
Tagged $M_{(i)}$	23	265	293	105	14	Carcasses from Sept. 21-23		47
							Population Estimate	10221

APPENDIX E, Table 2. Butte Creek fall-run Chinook spawning escapement estimate for 2004 using modified Schaefer Model

Week of Recovery $R_{(j)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$					Tags Recovered $R_{(i)}$	Carcasses Counted $C_{(j)}$	Population Estimate
	1	**2**	**3**	**4**	**5**			
	Nov. 3-5	Nov. 9-11	Nov. 16-18	Nov. 22-24	Nov. 30-Dec. 16			
1 Nov. 9-11	13	-	-	-		13	204	359
2 Nov. 16-18	3	58	-	-		61	461	578
3 Nov. 22-24	0	0	75	-		75	418	524
4 Nov. 30-Dec. 16	1	1	7	24		33	275	827
5 Dec. 21-23	0	0	0	2	5	7	75	126
Recovery $R_{(i)}$	17	59	82	26	5		Total	2415
Tagged $M_{(i)}$	26	88	109	110	13	Carcasses from Nov. 3-5		41
							Population Estimate	2456

APPENDIX F, Table 1. Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2003 and 2004. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/29/01-2/02/01	2000	06-01-12-04-08	10/7/04	780	2.08	Butte Cr. – Reach C	Inland Spawn
1/16/01-1/19/01	2000	06-01-12-04-02	10/14/04	870	2.08	Butte Cr. – Reach C	Inland Spawn
2/11/02-2/13/02	2001	06-01-00-01-00	3/13/04	666	3.53	Fort Bragg	Ocean Sport
2/13/02-2/15/02	2001	06-01-00-01-02	4/9/04	623	4.69	Monterey	Ocean Sport
2/05/02-2/07/02	2001	06-01-00-02-08	4/20/04	700	1.00	Battle Creek	Inland Recovery
2/05/02-2/07/02	2001	06-01-00-01-05	5/26/04	687	3.64	Bodega Bay	Ocean Sport
1/11/02-1/17/02	2001	06-01-00-00-08	7/14/04	735	3.37	Monterey	Ocean Commercial
1/07/02-1/11/02	2001	06-01-00-00-07	9/30/04	733	2.08	Butte Cr. – Reach C	Inland Spawn
1/11/02-1/17/02	2001	06-01-00-00-08	10/5/04	804	2.08	Butte Cr. – Reach B	Inland Spawn
1/07/02-1/11/02	2001	06-01-00-00-07	10/5/04	744	2.08	Butte Cr. – Reach B	Inland Spawn
2/05/02-2/07/02	2001	06-01-00-02-08	10/5/04	843	2.08	Butte Cr. – Reach B	Inland Spawn
2/18/02-2/27/02	2001	06-01-00-01-06	10/7/04	695	2.08	Butte Cr. – Reach C	Inland Spawn
1/11/02-1/17/02	2001	06-01-00-00-08	10/7/04	641	2.08	Butte Cr. – Reach C	Inland Spawn
1/29/02-1/31/02	2001	06-01-00-02-06	10/7/04	785	2.08	Butte Cr. – Reach C	Inland Spawn
1/11/02-1/17/02	2001	06-01-00-00-08	10/7/04	676	2.08	Butte Cr. – Reach D	Inland Spawn
1/07/02-1/11/02	2001	06-01-00-00-07	10/7/04	840	2.08	Butte Cr. – Reach E	Inland Spawn
2/07/02-2/12/02	2001	06-01-00-02-09	10/7/04	790	2.08	Butte Cr. Reach E	Inland Spawn
1/07/02-1/11/02	2001	06-01-00-00-07	10/14/04	763	2.08	Butte Cr. Reach C	Inland Spawn
2/13/03-2/24/03	2002	06-01-00-04-01	6/27/04	618	5.07	Fort Bragg	Ocean Sport
1/22/03-1/27/03	2002	06-01-00-03-03	7/4/04	496	4.31	Bodega Bay	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-03-02	7/12/04	530	2.95	Depoe Bay OR - Sport 4	Ocean Sport

APPENDIX F, Table 1. (continued) Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2003 and 2004. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/30/03-2/13/03	2002	06-01-00-04-00	7/11/04	595	3.26	Winchester Bay OR-Sport 5	Ocean Sport
1/30/03-2/13/03	2002	06-01-00-04-00	7/27/04	551	5.28	Monterey	Ocean Sport
1/30/03-2/13/03	2002	06-01-00-04-00	8/7/04	521	3.22	Bodega Bay	Ocean Sport
1/30/03-2/13/03	2002	06-01-00-04-00	8/21/04	511	1.95	Florence OR-Sport 5	Ocean Sport
1/30/03-2/13/03	2002	06-01-00-04-00	9/5/04	625	2.7	Winchester Bay OR – Sport 5	Ocean Sport
1/17/03-1/22/03	2002	06-01-00-03-02	9/11/04	534	3.81	Eureka	Ocean Sport
1/16/01-1/19/01	2002	06-01-00-04-02	10/14/04	470	1.00	Clear Creek	Inland Recovery

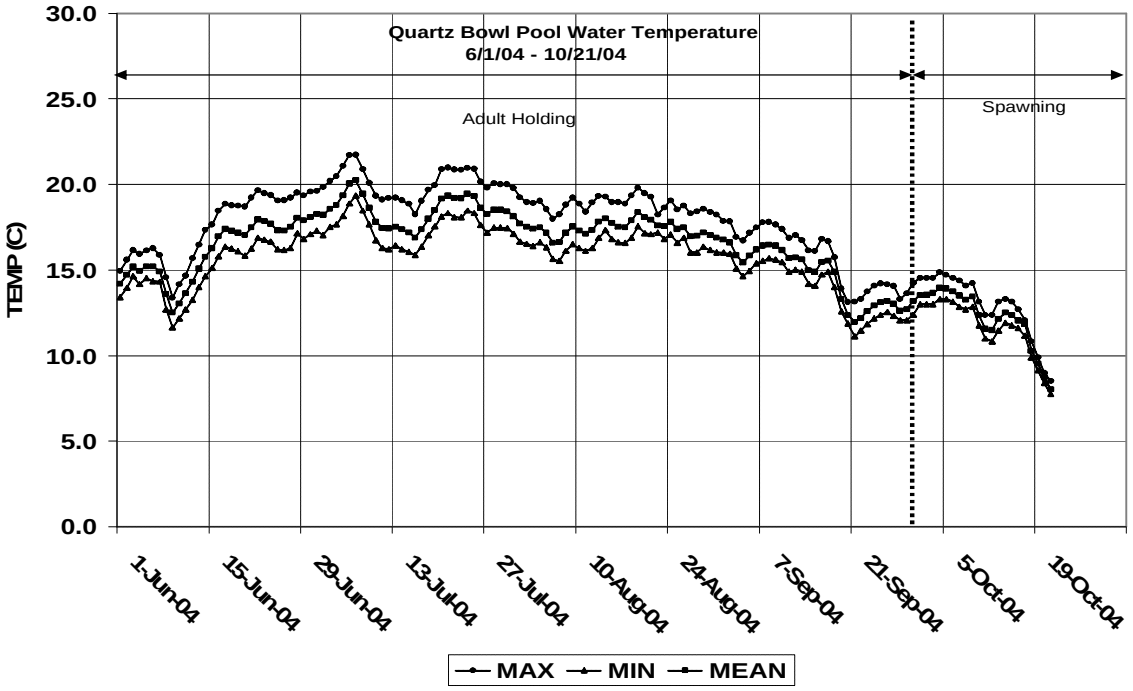
APPENDIX F, Table 2. Recoveries of adult fall-run Chinook salmon carcasses bearing coded-wire tags in Butte Creek during 2004.

Release				Recovery			
Stock	Brood Year	Tag Code	Site	Date	FL (mm)	Expansion	Butte Creek Reach
American River	2000	065459	Wickland	11/18/04	843	1.54	H
American River	2000	065459	Wickland	11/18/04	952	1.54	I
Coleman	2000	0501030502	RBDD	11/11/04	830	1.54	I
Feather River	2000	062665	Wickland	11/5/04	828	1.54	H
Feather River	2001	062090	Wickland	11/11/04	849	1.54	I
Feather River	2001	062090	Wickland	11/11/04	789	1.54	I
Feather River	2001	062090	Wickland	11/11/04	899	1.54	I
Feather River	2001	062090	Wickland	11/16/04	727	1.54	G
Feather River	2001	062091	Wickland	11/16/04	771	1.54	G
Feather River	2001	062091	Wickland	11/18/04	693	1.54	I
Feather River	2001	062090	Wickland	11/18/04	854	1.54	I
Feather River	2001	062091	Wickland	11/24/04	620	1.54	I
Merced River	2001	064458	Mossdale	11/11/04	737	1.54	I
Merced River	2001	064481	S.J. River Jersey Pt.	11/11/04	688	1.54	I
Merced River	2000	064435	S.J. River Jersey Pt.	11/16/04	928	1.54	F
Merced River	2001	064460	S.J. River Jersey Pt.	11/16/04	781	1.54	F
Merced River	2001	064460	S.J. River Jersey Pt.	11/18/04	798	1.54	H
Merced River	2001	064480	S.J. River Jersey Pt.	11/18/04	773	1.54	H
Merced River	2001	064480	S.J. River Jersey Pt.	11/18/04	753	1.54	H
Merced River	2001	064481	S.J. River Jersey Pt.	11/18/04	804	1.54	I
Merced River	2002	062751	S.J. River Jersey Pt.	11/18/04	569	1.54	I
Merced River	2001	064460	S.J. River Jersey Pt.	11/18/04	733	1.54	I
Merced River	2001	064460	S.J. River Jersey Pt.	11/18/04	842	1.54	I
Merced River	2001	064480	S.J. River Jersey Pt.	11/18/04	817	1.54	I
Merced River	2002	062744	S.J. River Jersey Pt.	11/18/04	563	1.54	I
Merced River	2001	064460	S.J. River Jersey Pt.	11/22/04	719	1.54	F
Merced River	2001	064459	S.J. River Jersey Pt.	11/23/04	731	1.54	G
Merced River	2000	064435	S.J. River Jersey Pt.	11/24/04	941	1.54	H

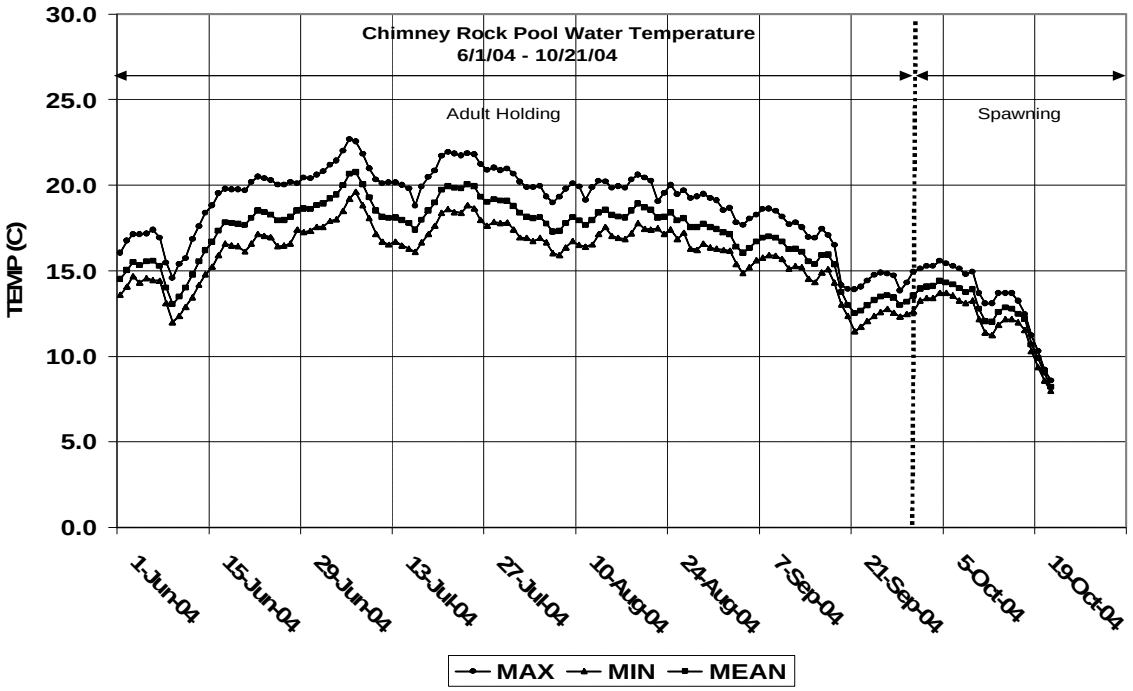
APPENDIX F, Table 2. (continued) Recoveries of adult fall-run Chinook salmon carcasses bearing coded-wire tags in Butte Creek during 2004.

Release				Recovery			
Stock	Brood Year	Tag Code	Site	Date	FL (mm)	Expansion	Butte Creek Reach
Merced River	2001	064460	S.J. River Jersey Pt.	12/2/04	942	1.54	I
Merced River	2001	064480	S.J. River Jersey Pt.	12/2/04	904	1.54	I
Mokelumne River	2001	064453	S.J. River Jersey Pt.	11/18/04	699	1.54	I
Mokelumne River	2001	064931	Sherman Isl.	11/23/04	798	1.54	G
Mokelumne River	2001	062723	S.J. River Jersey Pt.	11/24/04	751	1.54	H
Mokelumne River	2001	064928	Sherman Isl.	11/24/04	893	1.54	I
Mokelumne River	2001	064929	Sherman Isl.	11/24/04	661	1.54	I
Mokelumne River	2001	062722	S.J. River Jersey Pt.	11/30/04	904	1.54	F
Mokelumne River	2001	064931	Sherman Isl.	12/2/04	764	1.54	I
Mokelumne River	2001	064929	Sherman Isl.	12/16/04	861	1.54	H
Mokelumne River	2001	064929	Sherman Isl.	12/16/04	845	1.54	I
Mokelumne River	2001	064924	Staten Isl.	12/23/04	681	1.54	I

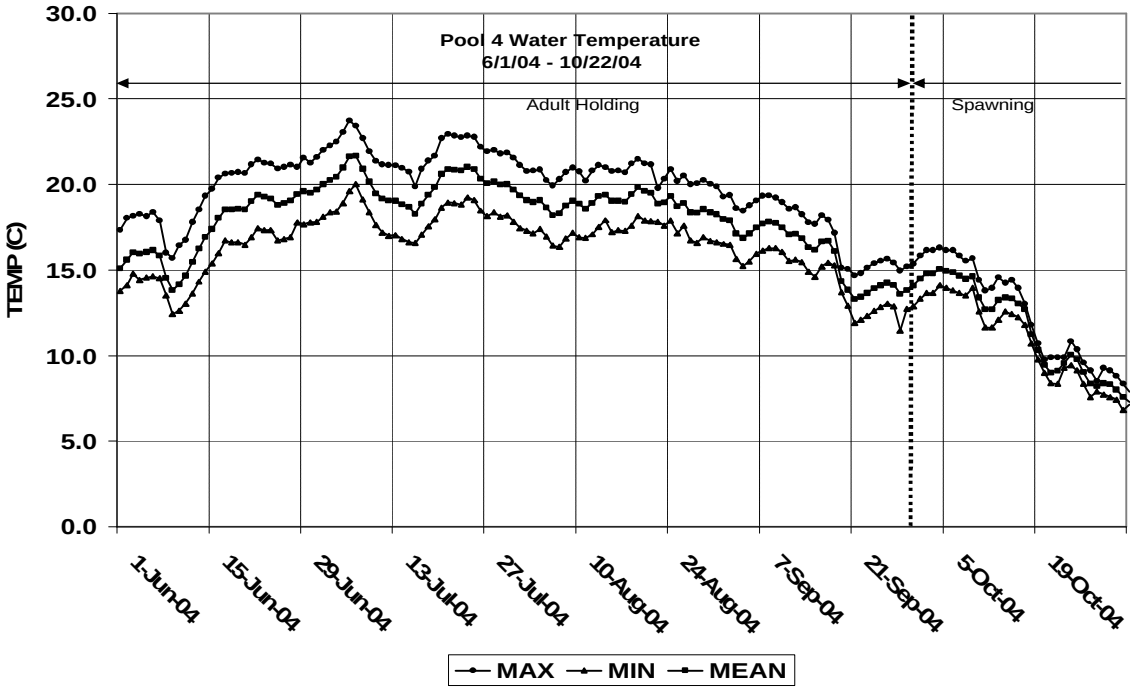
APPENDIX G, Figure 1. Butte Creek water temperature at Quartz Bowl pool.



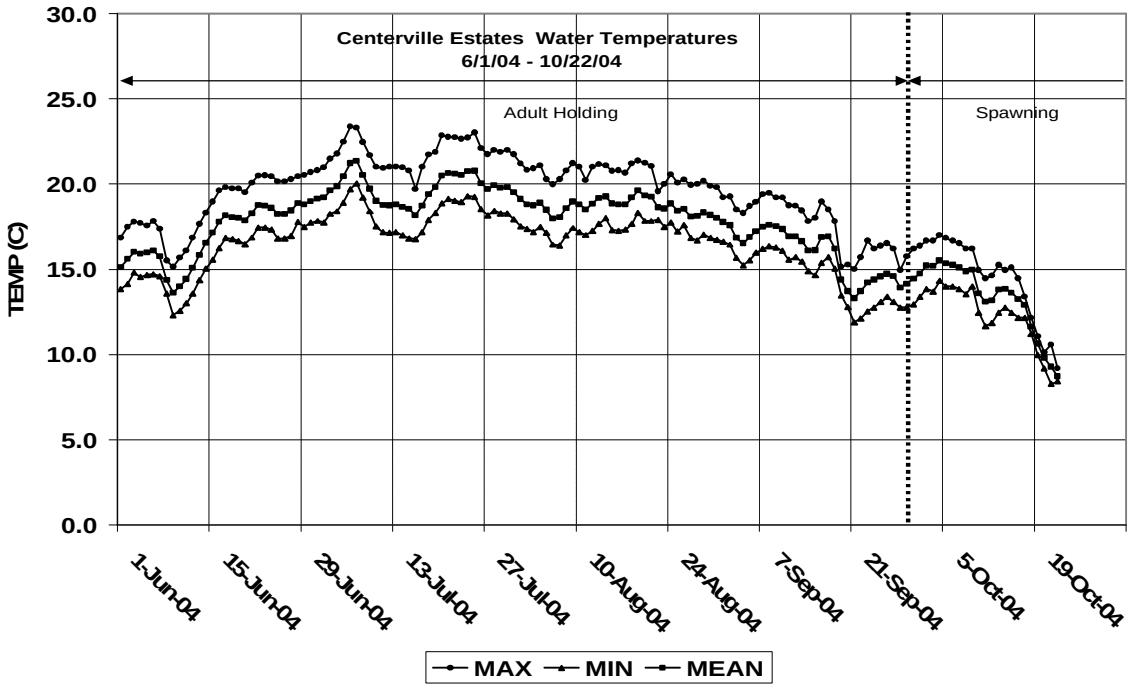
APPENDIX F, Figure 2. Butte Creek water temperature at Chimney Rock pool.



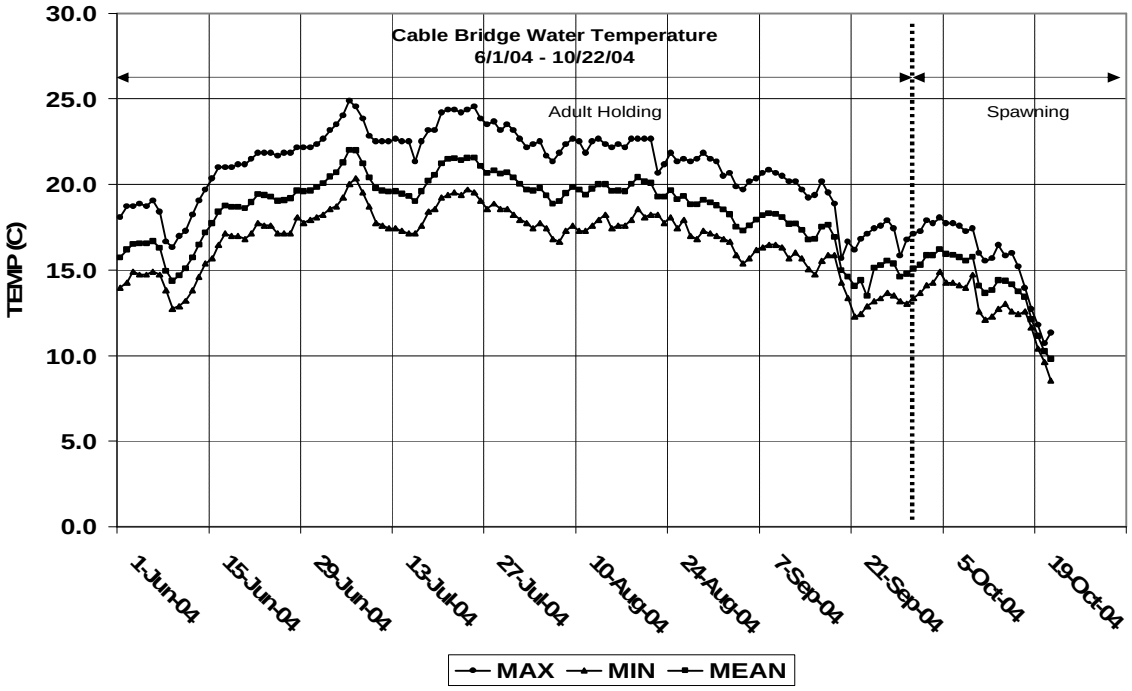
APPENDIX G, Figure 3. Butte Creek water temperature at Pool 4.



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



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



APPENDIX H. Measurement of Butte Creek SRCS redds during spawning season 2004.

Redd#	Date	Sub-Reach	Length Ft.	Width Ft.	Sq. Ft.	Redd#	Date	Sub-Reach	Length Ft.	Width Ft.	Sq. Ft.
1	9/17/04	C1	8.7	5.5	37.6	28	9/20/04	C5	6.9	5.0	27.1
2	9/17/04	C5	5.7	6.6	29.5	29	9/20/04	C5	5.7	4.7	21.0
3	9/17/04	C5	13.3	8.4	87.7	30	9/20/04	C5	5.9	4.9	22.7
4	9/17/04	C7	8.2	4.9	31.5	31	9/20/04	C5	5.6	4.0	17.6
5	9/20/04	B7	8.9	10.0	69.9	32	9/20/04	C6	6.4	4.1	20.6
6	9/20/04	B7	5.6	7.2	31.6	33	9/20/04	C6	6.2	3.9	18.0
7	9/20/04	B7	14.9	6.4	74.9	34	9/20/04	C12	6.4	4.8	24.1
8	9/20/04	B7	12.4	5.1	49.6	35	9/20/04	C12	6.4	4.5	22.6
9	9/20/04	B7	8.7	3.3	22.5	36	9/20/04	C12	9.5	5.4	40.3
10	9/20/04	B7	10.8	4.9	41.5	37	9/27/04	D1	5.9	9.1	42.2
11	9/20/04	B7	11.1	6.0	52.3	38	9/27/04	D1	9.2	3.3	23.8
12	9/20/04	B6	9.4	4.9	36.2	39	9/27/04	D1	7.5	3.4	20.0
13	9/20/04	B6	4.6	3.3	11.9	40	9/27/04	D1	6.2	4.6	22.4
14	9/20/04	B6	6.8	4.7	25.1	41	9/27/04	D1	6.8	5.7	30.4
15	9/20/04	B6	8.7	5.9	40.3	42	9/27/04	D2	8.9	3.9	27.2
16	9/20/04	B7	5.9	5.7	26.4	43	9/27/04	D1	5.8	4.5	20.5
17	9/20/04	B7	6.1	3.7	17.7	44	9/27/04	D2	6.2	4.7	22.9
18	9/20/04	B7	6.5	4.2	21.4	45	9/27/04	D2	10.4	5.0	40.8
19	9/20/04	B7	3.7	3.2	9.3	46	9/27/04	D2	8.3	4.4	28.7
20	9/20/04	B7	5.7	4.9	21.9	47	9/27/04	D2	6.2	4.5	21.9
21	9/20/04	B7	5.9	4.5	20.8	48	9/27/04	D2	5.2	4.0	16.3
22	9/20/04	C5	6.9	4.0	21.7	49	9/27/04	C1	6.9	5.8	31.4
23	9/20/04	C5	5.6	4.8	21.1	50	9/27/04	C1	6.8	6.0	32.0
24	9/20/04	C5	7.1	3.0	16.7	51	9/27/04	C1	6.4	4.0	20.1
25	9/20/04	C5	6.8	4.8	25.6	52	9/27/04	E1	5.9	4.0	18.5
26	9/20/04	C5	6.8	5.5	29.4	53	9/27/04	E1	5.9	2.9	13.4
27	9/20/04	C5	7.1	4.8	26.8						