State of California
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DEPARTMENT OF FISH AND GAME

BUTTE AND BIG CHICO CREEKS SPRING-RUN CHINOOK SALMON, ONCORYHNCHUS TSHAWYTSCHA LIFE HISTORY INVESTIGATION 2005-2006

By

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North Central 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 2005 through December 2006.

For Butte Creek, there were 25,454 juvenile Chinook salmon captured near Chico of which 16,139 were held and subsequently coded-wire tagged. The adult spring-run Chinook salmon escapement estimate using the snorkel survey methodology was 4,579. An alternate estimate based upon the modified Schaefer model carcass survey methodology was 6,303. A Schaefer model carcass survey was also conducted to evaluate pre-spawning mortality with an estimated 244 fish that died prior to spawning. Combined, the carcass surveys recovered 62 Butte Creek coded-wire tagged adults from BY 02 (22) and BY 03 (40). Based upon tag recoveries and an adjustment for release group size, the year 2006 population contained an estimated 25% age-3, and 75% age-4 fish. Comparing the expanded recovery rate of ocean catch and inland escapement of BY 02 catch during 2005-2006 suggests an ocean catch rate of approximately 59%.

A modified Schaefer model carcass survey of Butte Creek fall-run Chinook salmon estimated the population to be 1,920. There were 2 coded-wire tagged recoveries during the fall-run survey. Both recovered tags were from fall-run Chinook salmon natal to other watersheds.

For Big Chico Creek, the adult spring-run Chinook salmon escapement was 299 based upon the snorkel methodology.

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INTRODUCTION

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.

This is the eighth 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 seven previous reports, Hill and Webber (1999), Ward and McReynolds (2004), Ward et al. (2004a,b,c), McReynolds et al. (2005), and McReynolds et al. (2006), summarized project results through December 2005.

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 and enters the Sacramento River, west 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.

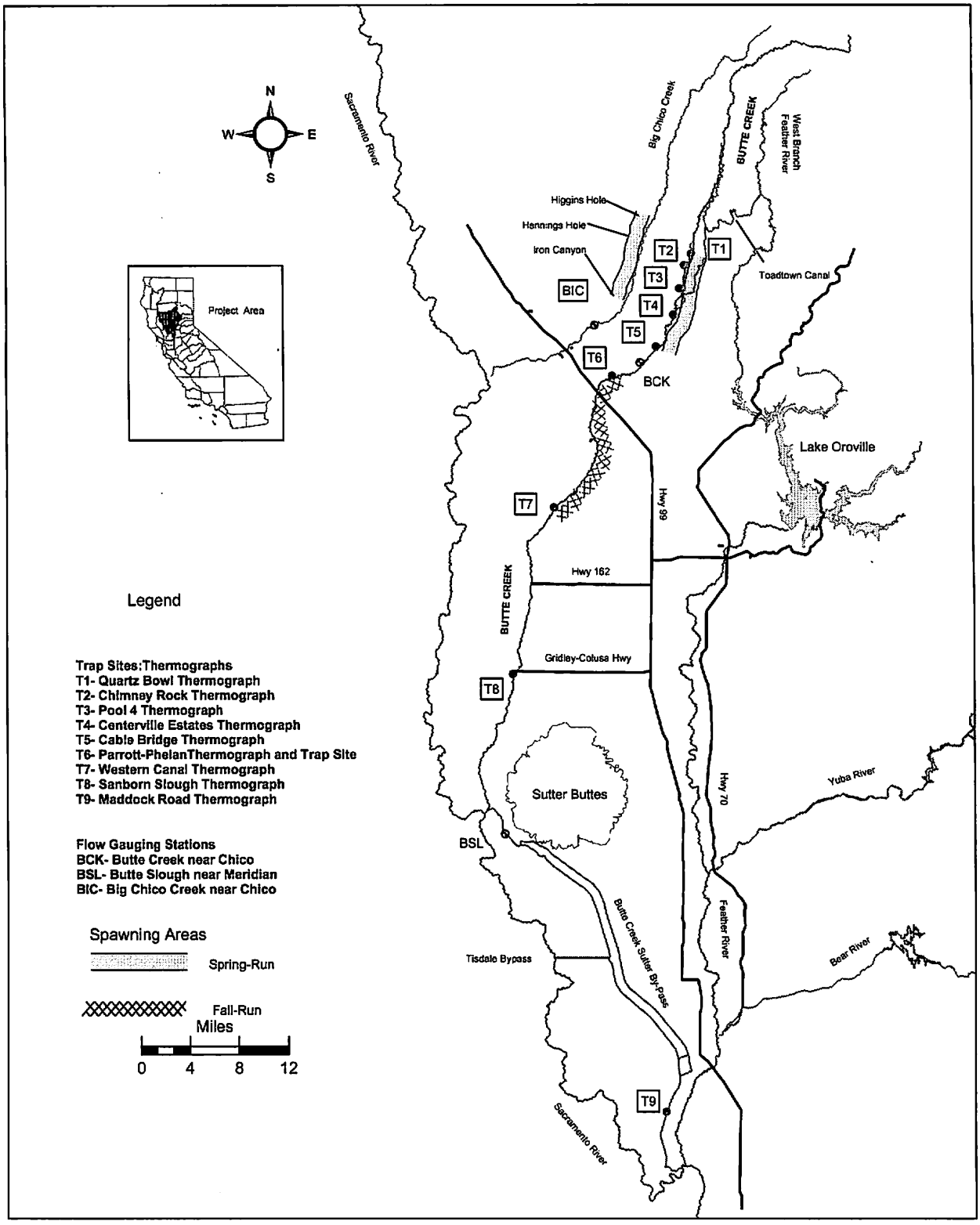
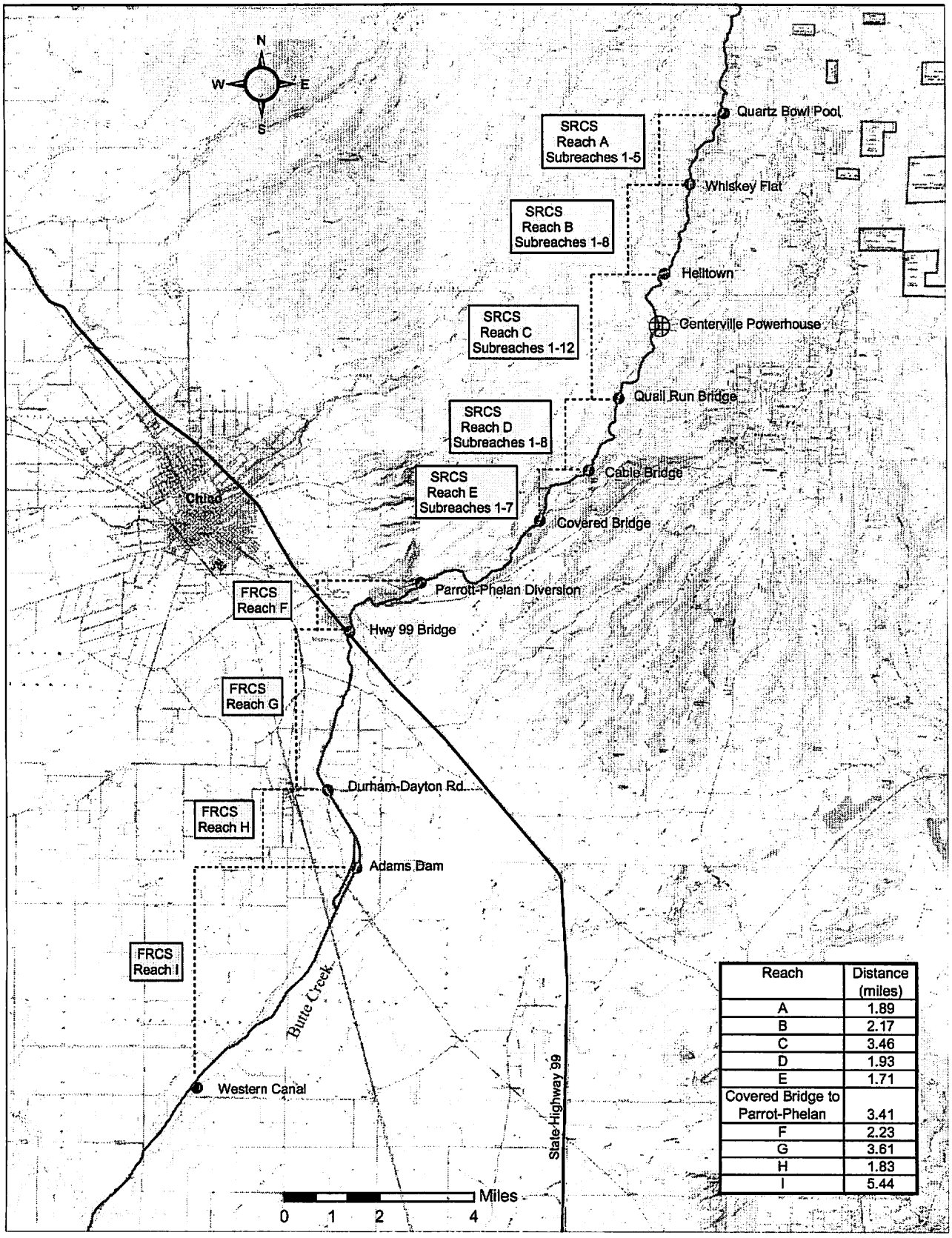


Figure 1. Butte Creek and Big Chico Creek watersheds with trap locations, gauging stations, and salmon spawning areas indicated.



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 a 2.4 m diameter (8 ft) rotary screw trap manufactured by EG Solutions (Eugene, Oregon). The 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 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

The four physical measurements taken daily were: water velocity, screw trap revolutions, water temperature and turbidity. 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.

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.

Salmon were transported in aerated buckets to the BCY, approximately two miles downstream of the PPDD site. Fish were coded-wire 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 SRCS Escapement

Each summer adult SRCS escapement estimates are developed by conducting snorkel surveys on Butte and Big Chico Creeks. Adults are counted while holding prior to spawning and before the possibility of pre-spawn mortality. On Butte Creek, the snorkel survey extended from the Quartz Bowl Pool (QBP) to PPDD (Figures 1 and 2). On Big Chico Creek, the survey was from Higgins Hole to Iron Canyon (Figure 1). On Butte Creek, the survey was conducted over three days (July 24-26, 2006) each covering a discrete reach, and on one day (July 17, 2006) 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 SRCS 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, through September 14, 2006 as follows:

$$E = N_{ij} = R_{ij}(T_iC_j/R_iR_j) - T_i$$

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 Carcass Survey

The primary goals of the survey were to recover CWT's from adults tagged and released as juveniles in Butte Creek during previous years; to provide an alternative adult escapement estimate; and to estimate the proportion taken in the ocean sport /commercial harvest. Adult spawning surveys using the modified Schaefer model were completed for both SRCS and FRCS populations during 2006 which is the sixth year an intensive mark-recapture carcass survey was conducted.

The 2006 SRCS spawning survey was conducted from September 19, through October 26, 2006. 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 2006, there was 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

The 2006 FRCS carcass survey was conducted from October 31, 2006 through December 21, 2006. 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 2005-2006

The 2005-2006 trapping season began at the PPDD when the diversion trap was installed on October 27, 2005. The diversion trap was operated until June 28, 2006. The rotary screw trap was installed on November 1, 2005 and removed on June 19, 2006. During the trapping season, there were occasions when one or more of the traps were removed due to high stream flows or excessive debris. Trapping was suspended periodically for both the screen trap and screw trap during this survey period. Between mid-November and January the screen trap was suspended for 46 days and the rotary screw trap was suspended for a total of 79 days. (Tables 1, 2, and Appendix A, Figure 1).

A total of 25,454 juvenile salmon including yearlings were captured in all traps; 4,959 in the diversion screen trap and 20,495 in the screw trap(s) (Tables 1 and 2). Of the total captured, 16,139 were coded-wire tagged and released at the BCY (Table 3).

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, 2005 to June 28, 2006; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
10/16/05	10/31/05	93	-	93	93	1	5
11/1/05	11/15/05	36	19.1	30	125	41	15
11/16/05	11/30/05	-	-	-	-	-	0
12/1/05	12/15/05	-	-	-	-	-	0
12/16/05	12/31/05	34	1.6	31	38	210	2
1/1/06	1/15/06	35	1.6	30	38	266	11
1/16/06	1/31/06	35	3.8	31	129	1,635	16
2/1/06	2/15/06	35	1.8	31	60	781	15
2/16/06	2/28/06	35	2.1	31	62	688	13
3/1/06	3/15/06	40	18.7	32	149	167	15
3/16/06	3/31/06	38	14.0	32	143	370	16
4/1/06	4/15/06	37	8.5	34	89	42	15
4/16/06	4/30/06	52	13.9	34	76	12	15
5/1/06	5/15/06	71	11.8	35	99	64	15
5/16/06	5/31/06	71	10.0	33	97	470	16
6/1/06	6/15/06	80	7.2	52	99	199	15
6/16/06	6/30/06	76	9.8	52	89	13	14
					Total	4,959	198

Table 2. Semi-monthly catch summary of juvenile Butte Creek spring-run Chinook salmon caught in the screw trap at Parrott-Phelan Diversion Dam from November 1, 2005 to June 19, 2006; yearling captures are included.

Trapping Period		Mean FL (mm)	Standard Deviation	Range FL (mm)		Total No. Captured	No. Trapping Days
11/1/05	11/15/05	43	69.1	28	149	87	15
11/16/05	11/30/05	45	89.7	30	135	415	15
12/1/05	12/15/05	36	107.3	30	121	3,794	13
12/16/05	12/31/05	35	1.5	31	38	771	3
1/1/06	1/15/06	35	3.8	30	105	703	10
1/16/06	1/31/06	35	3.2	31	119	4,134	16
2/1/06	2/15/06	35	1.8	31	59	4,666	15
2/16/06	2/28/06	35	1.8	31	48	2,104	13
3/1/06	3/15/06	-	-	-	-	-	0
3/16/06	3/31/06	36	2.3	32	62	2337	9
4/1/06	4/15/06	-	-	-	-	-	0
4/16/06	4/30/06	-	-	-	-	-	0
5/1/06	5/15/06	70	10.0	35	101	323	8
5/16/06	5/31/06	73	7.2	36	115	896	15
6/1/06	6/15/06	81	9.6	56	126	240	15
6/16/06	6/30/06	83	12.6	55	120	25	4
					Total	20,495	151

Table 3. Summary of coded-wire tagged juvenile Butte Creek spring-run Chinook salmon released at Baldwin Construction site from January 17, to March 22, 2006.

Tag Code	Release Date		Mean FL (mm)	Range FL (mm)		Total No. Released
06-01-00-07-05	01/17/06	02/22/06	35	33	65	6,229
06-02-01-01-09	02/01/06	03/22/06	35	32	65	9,910
					Total	16,139

Table 4. Recaptures of juvenile Butte Creek spring-run Chinook salmon bearing coded-wire tags by other research projects during 2006.

Recovery Date	Tag Code*	Recovery FL (mm)	Recapture Location	Days at Large
5/10/06	06-02-01-01-09	84	Chipps Island	74
5/14/06	06-02-01-01-09	84	Chipps Island	78

* All fish were from BY 2005 and tagged at Baldwin Construction Yard.

Juvenile Emigration 2005-2006

YOY and yearling juvenile SRCS outmigrants were delineated based upon the FL of juvenile salmon captured at PPDD. During this 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 and emigrated later in the spring.

During the trapping period, 83 yearling SRCS were captured. The first yearling SRCS was captured on October 27, 2005 and the last on June 20, 2006 (Table 1 and 2; Appendix B, Figure 1). Length-frequency histograms for the entire period continue to show a bi-modal, and sometimes tri-modal distributions that generally appear to delineate YOY and yearling SRCS and also late fall-run Chinook salmon (LFRCS) (Appendix B, Figure 1).

Adult Escapement 2006

Snorkel Escapement Survey

The 2006 SRCS adult escapement estimate based upon the snorkel survey method was 4,579 (Table 5).

Pre-spawning Mortality Carcass Survey

This was the fourth year that an intensive mark recapture survey was conducted during the adult SRCS holding period to assess pre-spawn mortalities (Ward et al., 2004d; Ward et al., 2006a,b,c). During the SRCS pre-spawn mortality survey (June 27, 2006 through September14, 2006) 181 carcasses were examined (72% female, 28% male) and three CWT's were recovered. Since recoveries of marked salmon were too low to calculate an estimate using the modified Schaefer model, an expansion factor developed from the subsequent spawning carcass survey of F = 1.35 (Appendix C) was applied to generate an estimated total pre-spawning mortality of 244. 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.

Carcass Survey

During this study period, the sixth intensive survey directed at recovering CWT's from previous release groups was conducted. A spawning carcass survey was begun on September 19, 2006 and continued through October 26, 2006 covering the 17.7 km (11 mi.) SRCS spawning area (Figures 1 and 2). Additionally, significant spawning activity was noted in the reach below the CCB and below the normal survey area. To provide some assessment of this activity, 484 carcasses were counted and chopped during three surveys that covered that reach.

Based upon the spawning carcass survey there were an estimated 6,303 adult SRCS that spawned during 2006. A total of 4,747 carcasses were examined, including those from below the CCB, with a total of 59 CWT's recovered: BY 02 (21) and BY 03 (38) (Appendix D, Table 2). For SRCS carcasses and CWT recoveries below the CCB, an expansion factor of F = 1.35 was calculated as previously described for the pre-spawn mortality estimate. In addition to the Butte Creek carcass recoveries, 26 CWT's were recovered in the ocean fishery (Appendix D, Table 1).

Subsequent to the SRCS carcass survey, a survey of the FRCS spawning area (Figure 1 and 2) was conducted from October 31 through December 21, 2006. Two CWT's were recovered (Appendix D, Table 3) from 1,116 carcasses that were examined. An expansion factor of F = 1.72 was calculated based upon the modified Schaefer model population estimation methodology as described for the pre-spawn mortality estimate (Appendix C).

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

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 – July 28, 2005
2006	4,579	July 24 – July 26, 2006

Water Temperatures 2005-2006

Thermal recording data loggers were installed at the five sites within the SRCS holding and spawning reach of Butte Creek (Figure 1). Recorded mean daily temperatures during the period June through October ranged as high as 21.9° C on July 25, at the Pool 4 location (Table 6; Appendix E, Figures 1 - 5). Average daily temperatures at all sites were above 15.0° C until early-September 2006.

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	6/1/06 to 10/31/06	88	21	0
Chimney Rock	6/1/06 to 10/31/06	86	37	4
Pool 4	6/1/06 to 10/31/06	92	61	11
Centerville Estates	6/1/06 to 10/31/06	94	45	4
Cable Bridge	6/1/06 to 10/31/06	98	63	11

Big Chico Creek

Adult Escapement 2006

The Big Chico Creek spawning escapement survey was conducted July 17, 2006. The estimate was 299 based upon the snorkel survey method (Table 7). Of the estimated adults that returned to spawn, 83% (248) were above the Iron Canyon Fish Ladder.

Table 7. Annual snorkel estimates of adult spring-run Chinook salmon escapement in Big Chico Creek.

Year	Estimate	Survey Date
1998	369	August 1998
1999	27	September 10, 1999
2000	27	August 8, 2000
2001	39	August 8, 2001
2002	0	August 8, 2002
2003	81	August 11, 2003
2004	0	August 11 & 13, 2004
2005	37	August 10, 2005
2006	299*	July 17, 2006

* Survey was conducted in July to avoid any potential pre-spawn mortalities.

DISCUSSION

Juvenile Emigration

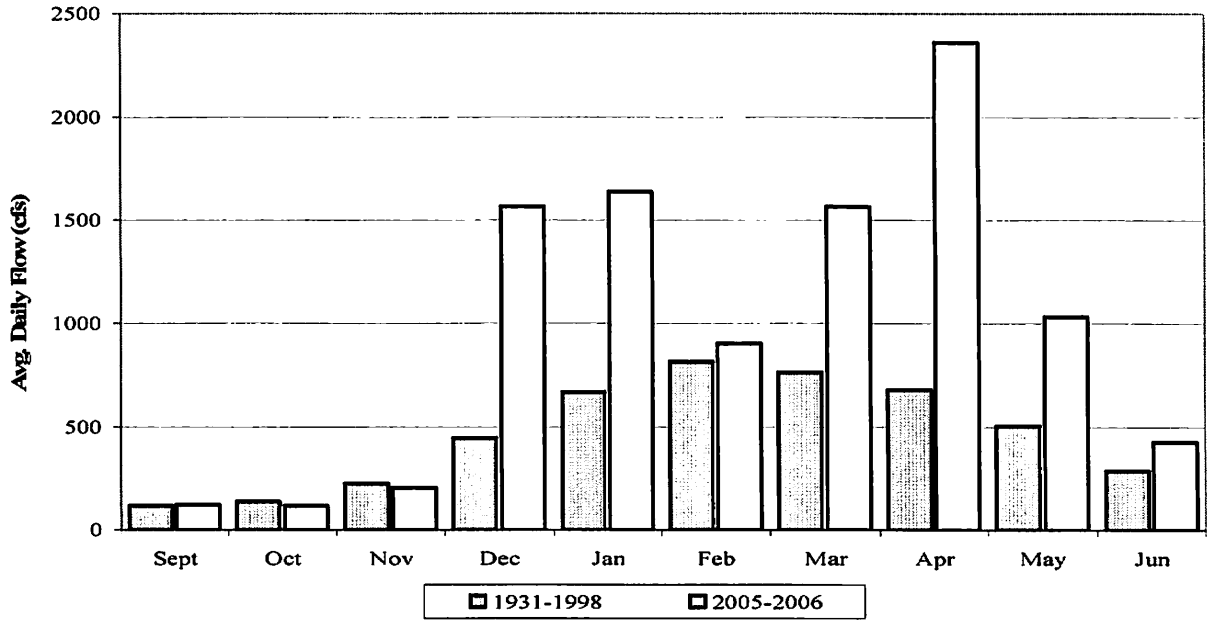
During this study period, emphasis was focused on trapping and tagging juvenile SRCS at the PPDD, as well as recovering tags from returning adults. As with previous studies, short periods of elevated uncontrolled flows and heavy debris required cessation of trapping (Appendix A, Figure 1) to protect personnel and gear. The juvenile trapping effort at PPDD for the screw trap and diversion screen trap was suspended a total of 79 and 46 trap days, respectively, of the 247-day trapping season.

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 past two study periods more than 90% of the total catch emigrated by the end of February. However, during the 2005-06 season, the total season catch was 25,454, significantly lower than other sampling periods. Of the total catch, 78% had occurred by the end of February. Above average historical flows for December and January contributed to the relative low number of juveniles captured (Figure 3). On December 31st 2005, Butte Creek flows peaked at 13,700cfs.

During periods of high flows, traps are pulled for personnel safety, protection of trapping equipment and to decrease potential mortality of juvenile salmon. Past study reports

(McReynolds, et al. 2006) have shown that increased flows in Butte Creek during peak juvenile emigration (January-February), result in increased juvenile salmon numbers passing PPDD. It is likely that large numbers of salmon emigrated past PPDD this season when traps were pulled.

Figure 3. Comparison of Butte Creek average flows as measured at Butte Creek near Chico Gage (USGS #11390000) during 2005-06 with average flows during the period 1931-1998 (CDWR, 2002).



Emerged fry were captured at PPDD from November 2005 through June 2006 (Appendix B, Figure 1). As with previous years (McReynolds et al., 2005), recently emerged fry captured at PPDD beginning in early April (Appendix B, Figure 1) were assumed to be LFRCS. Again, FRCS were observed spawning above PPDD after mid-October 2006, 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. During this survey period 83 yearling salmon were captured at PPDD compared to 11 yearling salmon the previous study year. These results continue to support the conclusion that the majority of Butte Creek SRCS migrate as YOY.

Adult Escapement

During this study period, three discrete surveys were completed to develop an estimate of adult SRCS escapement. A standard swimming snorkel survey was conducted July 24-26, 2006. The snorkel survey has been performed consistently since 1991 and serves as a population index. The 2006 snorkel survey was conducted during July in an attempt to develop a better estimate prior to any significant pre-spawn mortality. There were an estimated 11 pre-spawn mortalities prior to the snorkel survey.

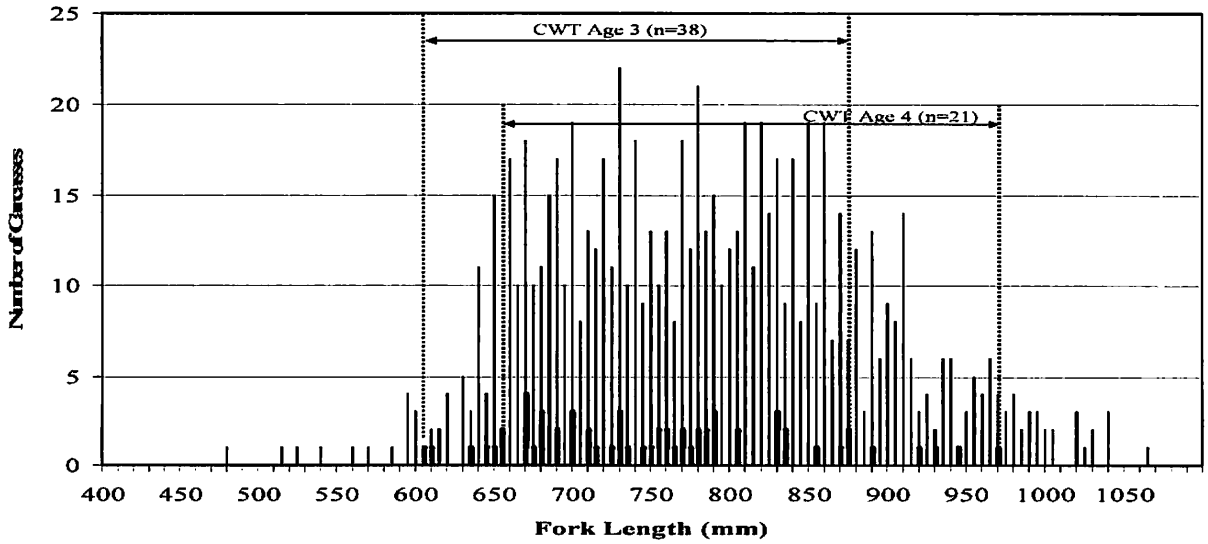
Previous project findings have shown that snorkel surveys significantly underestimate salmon abundance (McReynolds et al., 2006). As an alternative, a standard modified Schaefer model spawning carcass survey was initiated beginning in 2001. Based upon significant pre-spawn

mortalities observed during 2002, an additional modified Schaefer model survey was completed during 2003, 2004, and 2005 to account for those adults that died prior to spawning. The 2006 escapement estimate based upon the snorkel survey was 4,579 with a range of 3,880 to 5,362. The combined pre-spawn and spawning Schaefer model carcass survey results from 2006 estimated a larger population of 6,547; 244 that died prior to spawning and 6,303 which survived to spawn (Appendix C, Table 1).

During previous surveys (2001-2004) SRCS spawning was almost exclusively confined to reaches above the CCB, with only a small number observed below. However, as in 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, four single day surveys to record and chop spawned carcasses were completed during September and October. There were 484 carcasses counted and chopped. Among those that survived to spawn, there were 4,747 carcasses examined including those from the reach below CCB, of which 800 fresh carcasses (57% female, 43% male) were marked, with a subsequent recovery of 476 (60%).

Based upon snorkel surveys and adults returning as three year olds, the 2006 escapement estimate represents a 1.04 cohort replacement rate (4579/4398). However, Butte Creek CWT recoveries continue to demonstrate that a proportion of Butte Creek SRCS return to spawn at age-4. Of the 59 CWT's recovered on the spawning survey, 38 were age-3 and 21 were age-4 (Figure 4). Based upon tag recoveries adjusted for release group size the population contained approximately 25% age-3, and 75% age-4 fish. However, analysis of length frequency data shows a smaller average fork length for recovered CWT salmon and may bring this conclusion into question.

Figure 4. Length frequency distribution of 800 spawned adult Butte Creek spring-run Chinook salmon carcasses measured and marked for abundance estimate between September 19 and October 26, 2006.



This was the fourth season a fully funded pre-spawning mortality survey was completed starting on June 27 and ending on September 14, 2006 at onset of spawning. Mortalities were low throughout the study period. There was a total of 181 carcasses examined of which 91 were

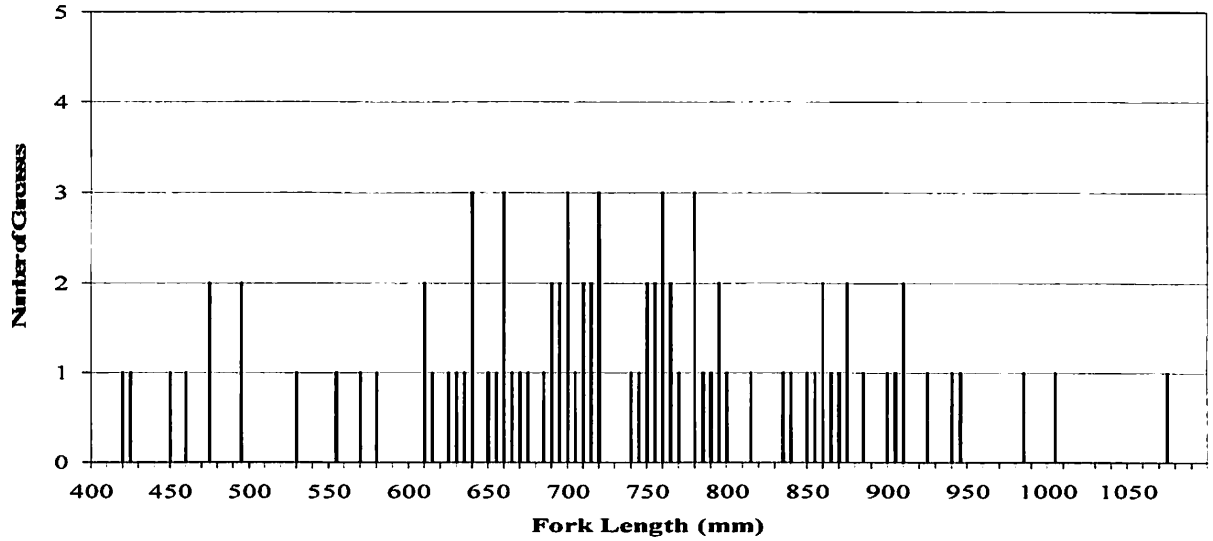
measured and identified by sex (72% female, 28% male). Of the 91 fish examined for gender, 22 were marked for possible recovery and only one was recovered during the 13 week survey. Due to the low number of marks and recoveries it was not possible to generate a modified Schaefer model estimate of total pre-spawn mortality. Instead, an expansion factor (F = 1.35) 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 244 (181 x 1.35).

For the measured sub-sample of adult Butte Creek SRCS the average size of both males and females was similar to 2003 , and significantly larger than observed during 2001, 2002, 2004 and 2005. (Table 8, Figure 4, 5). Based upon CWT analysis and adjusting for CWT release size groups, 2006 and 2003 age-4 fish dominate the age composition (75% and 69% respectively) which would result in the larger average size.

Table 8. Fork lengths of adult Butte Creek spring-run Chinook salmon that spawned during 2001- 2006 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
2006	458	57%	972	562	762	342	43%	1065	478	817
2005	609	55%	895	518	706	495	45%	1090	435	771
2004	376	54%	962	490	723	324	46%	973	429	765
2003	378	60%	979	494	802	252	40%	1110	423	844
2002	416	49%	910	574	708	440	51%	1091	349	754
2001	784	52%	910	340	709	711	48%	1020	402	760

Figure 5. Length frequency distribution of 91 adult Butte Creek spring-run Chinook salmon pre-spawn mortalities measured between June 27, and September 14, 2006.



Ocean recoveries during 2006 (Appendix D, Table 1) extended from April through September, and all were taken from south of Monterey, California to California/Oregon border. For the 2006 recovery year, no Butte Creek fish were recovered and/or reported in the Oregon ocean fisheries. Based upon the current ocean-aging convention that assigns SRCS to the next age class on May

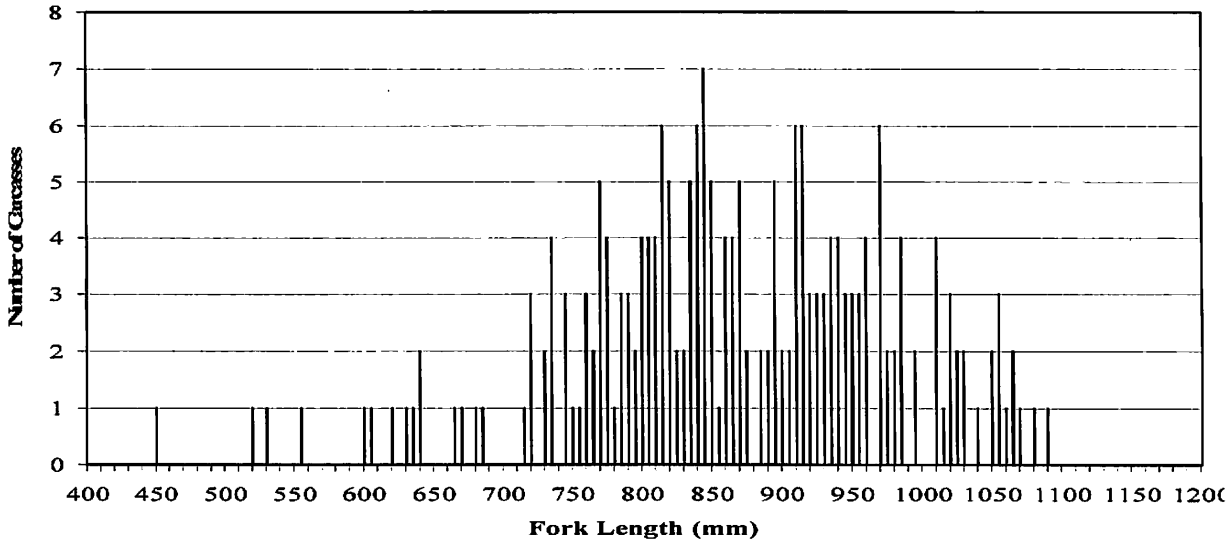
1 (Viele et al., 2004), there were 1 age-3, and 25 age-4 recoveries. Comparing the expanded BY 02 ocean and inland recoveries (Table 9; Appendix D, Table 1) suggests a 59% ocean sport/commercial catch rate. This is the highest catch rate for any BY, and substantially higher than the 40% ocean sport/commercial catch rate for BY01 and BY00.

Table 9. Brood Year 2002 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	2	3	9		33	
Sport	3	4	2		3	
Commercial	3	3	1		4	
Commercial	3	4	21		74	
Spawn	3			34		47
Spawn	4			22		30
Sacramento River	4			2		2
Clear Creek	2			1		1
Total			33	58	114	80

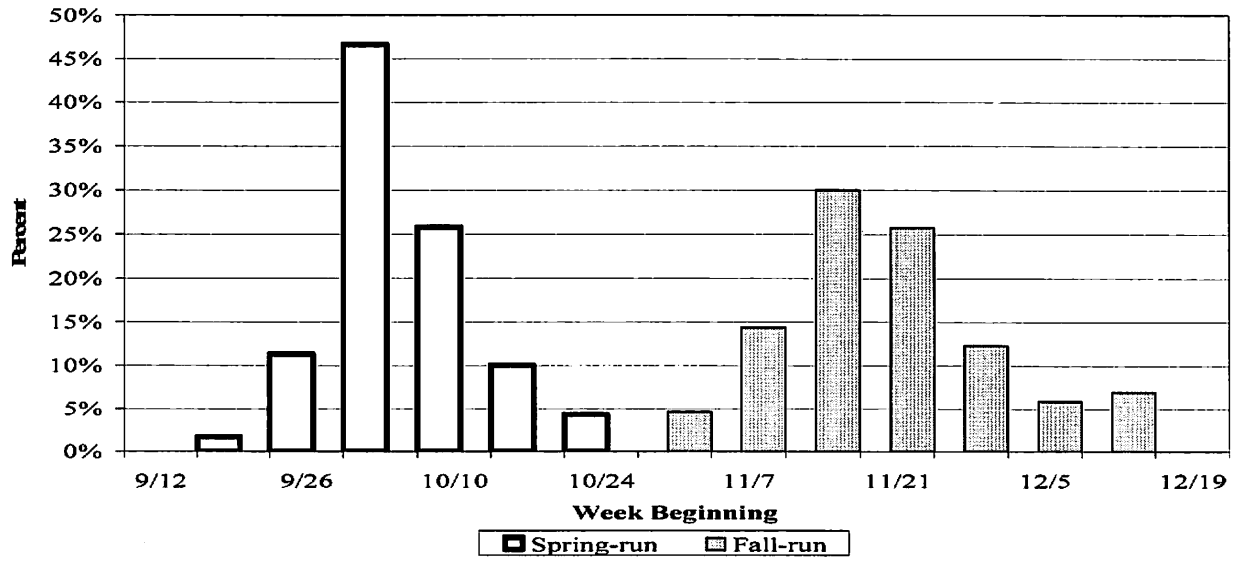
Subsequent to the SRCS carcass survey, a FRCS carcass survey was initiated on October 31, and continued through December 21, 2006. The FRCS survey covered the reaches of Butte Creek downstream of the PPDD (Figure 1 and 2). For the fourth consecutive year, a bar rack was placed in the fish ladder at the PPDD during the last week of September, to reduce the number of FRCS that spawn upstream of this site. A small number of FRCS ascended and spawned above the bar rack. The bar rack was removed during the first week of December. Using the modified Schaefer model, 1,116 carcasses were examined, with 214 of the fresh carcasses marked of which 111 were subsequently recovered. For 2006, the modified Schaefer model estimate for FRCS was 1920 fish which spawned in the reach downstream of the PPDD (Appendix C, Table 2). The mean FL of the measured sub-sample of 215 Butte Creek FRCS was 862 mm (Figure 6). There was a total of two CWT marked carcasses recovered during the FRCS carcass survey (Figure 6; Appendix D, Table 2). Both of the recovered CWT's were from FRCS natal to other watersheds; the Feather and Merced River.

Figure 6. Length frequency distribution of 215 adult fall-run Chinook salmon carcasses measured and marked for abundance estimate between October 31, and December 21, 2006.



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, 2006. 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 19, through December 21, 2006.



Adult Straying

The results from the 2005-2006 study period continue to support Butte Creek SRCS as a distinct and sustaining population with little evidence to date of significant introgression from other watersheds. To date, there have been 189 (expanded to 313 for sampling effort) CWT Butte Creek SRCS recovered in Butte Creek and six (no expansion) in other watersheds.

During this reporting period, two Butte Creek adult CWT SRCS were recovered in the Sacramento River fall-run carcass survey near Redding. Although most juveniles are assumed to be SRCS when captured at PPDD, there is potential for some FRCS juveniles to be sampled and tagged. However, these recoveries were found when traditional spawning of SRCS occurs in Butte Creek. A female at 790mm with tag code 0601000402 was recovered on 10/5/2006. Additionally, a second female at 780mm with tag code 0601000401 was recovered on 10/24/2006. Both fish were from BY 2002 and released at BCY. Release dates for these tag codes ranged from 2/13/2003 through 3/27/2003. It is difficult to assess the magnitude of Butte Creek SRCS straying into other Central Valley watersheds due to the lack of uniform effort to recover CWT fish, particularly among SRCS.

Water Temperature

Butte Creek water temperatures have historically exceeded ideal temperatures as reported for holding and spawning SRCS (Appendix E, Figures 1-5). In general, temperatures for holding adult SRCS should not exceed 15°C (59°F) (Hinze, 1959; Boles, 1988; CDFG, 1998). There are five locations within the summer holding habitat of Butte Creek that have continuously recording data loggers (Figure 1). Average daily temperatures exceeded 15°C at all sites from late-June until 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 2005-06 season to include Chris Bennett, Mitch Azevedo, Jeff Humble, Kyle Thompson, and Dave Lunsford.

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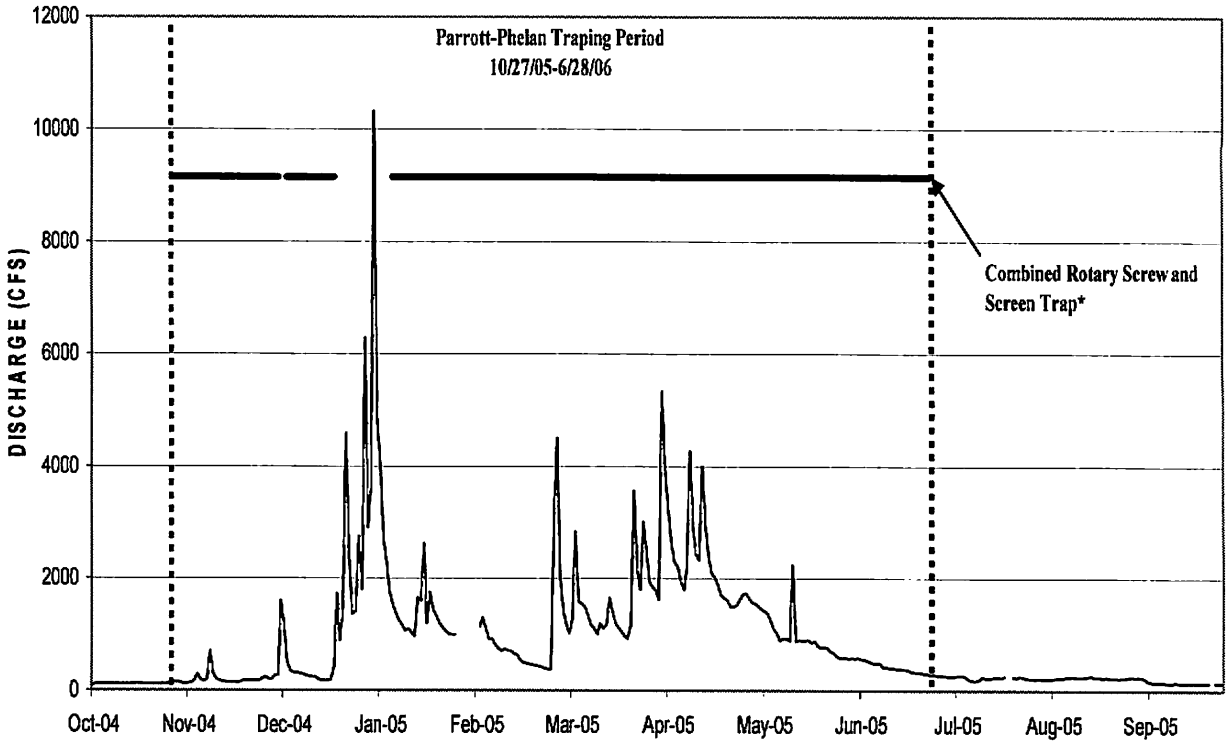
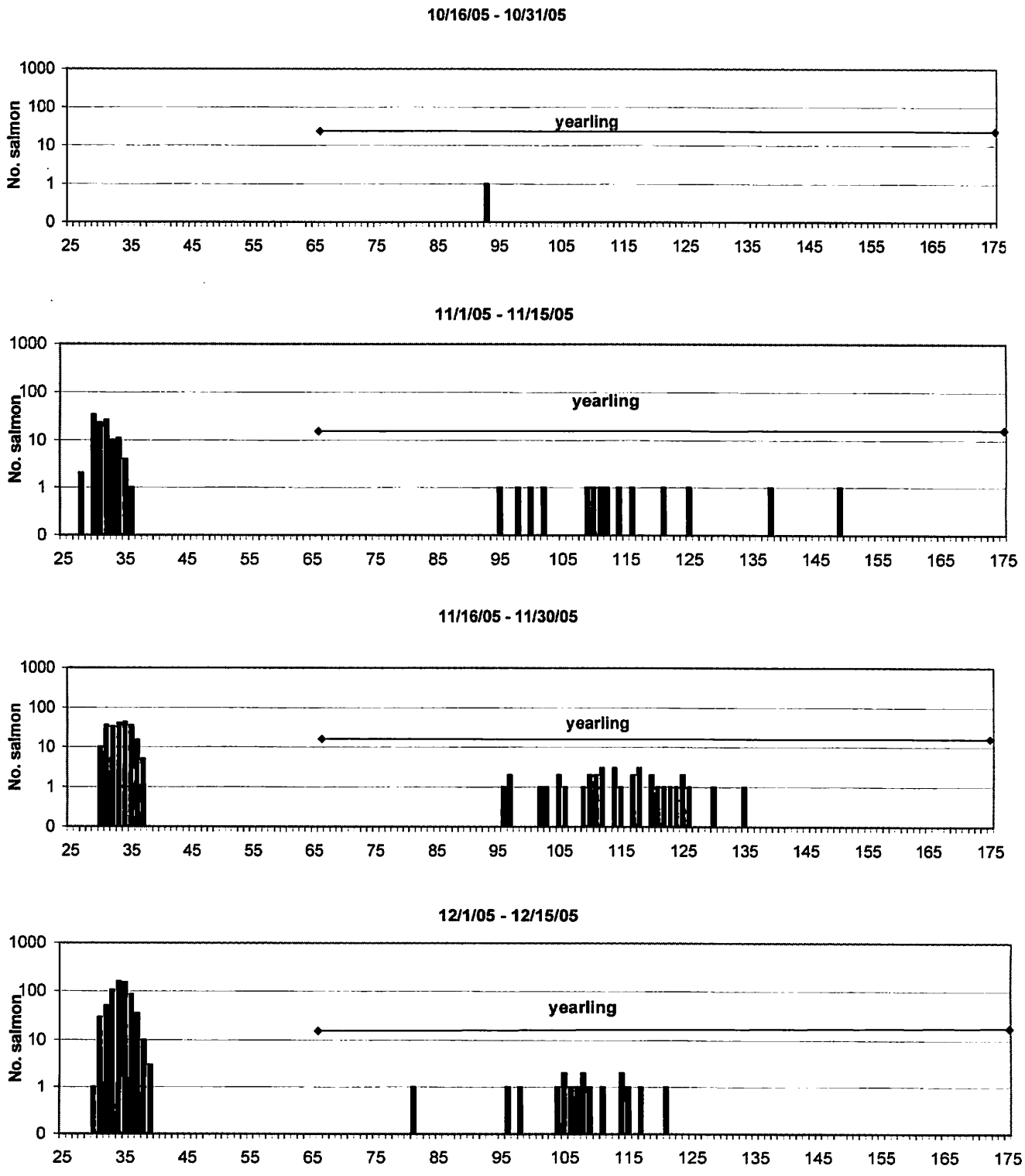
APPENDIX A, (Figure 1). Butte Creek flow at Butte Creek near Chico Gage (USGS - #11390000), water year 2005-06, with trapping period shown. Flow data are provisional and subject to revision.

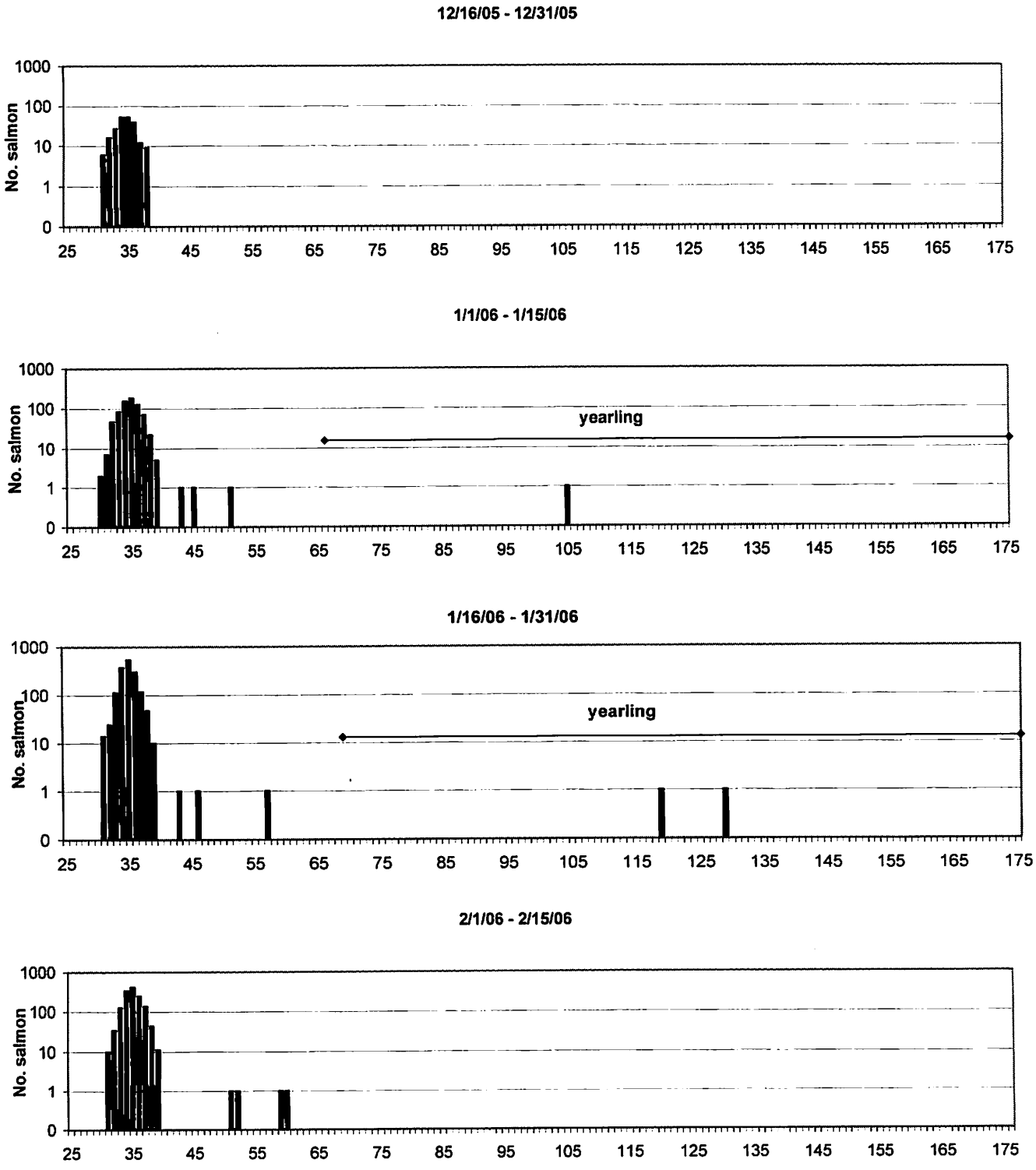


*Breaks in horizontal line indicate periods of time when the trap(s) were not fishing.

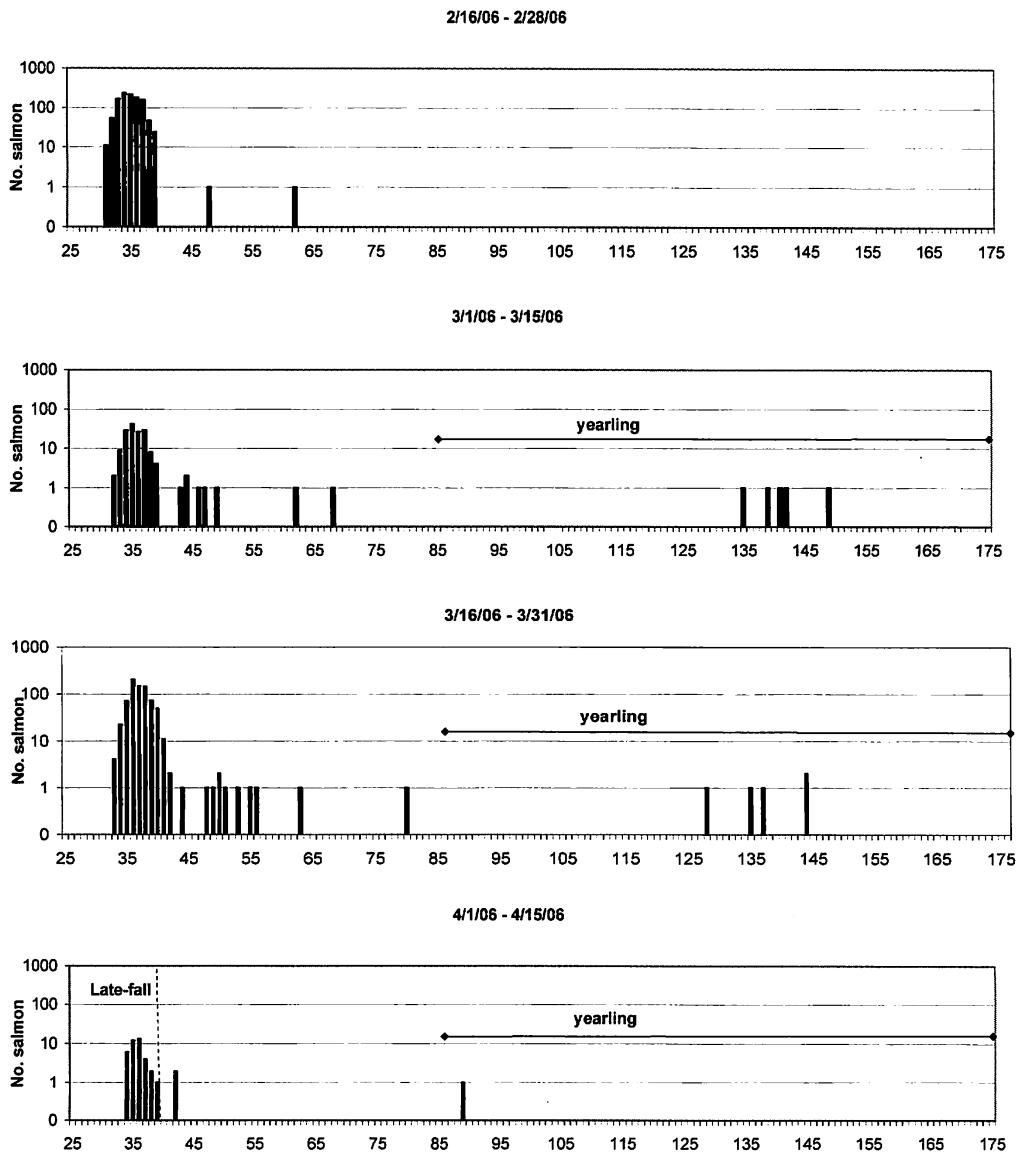
APPENDIX B, Figure 1. Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2005 through June 28, 2006. All fish are assumed to be spring-run Chinook salmon except where indicated.



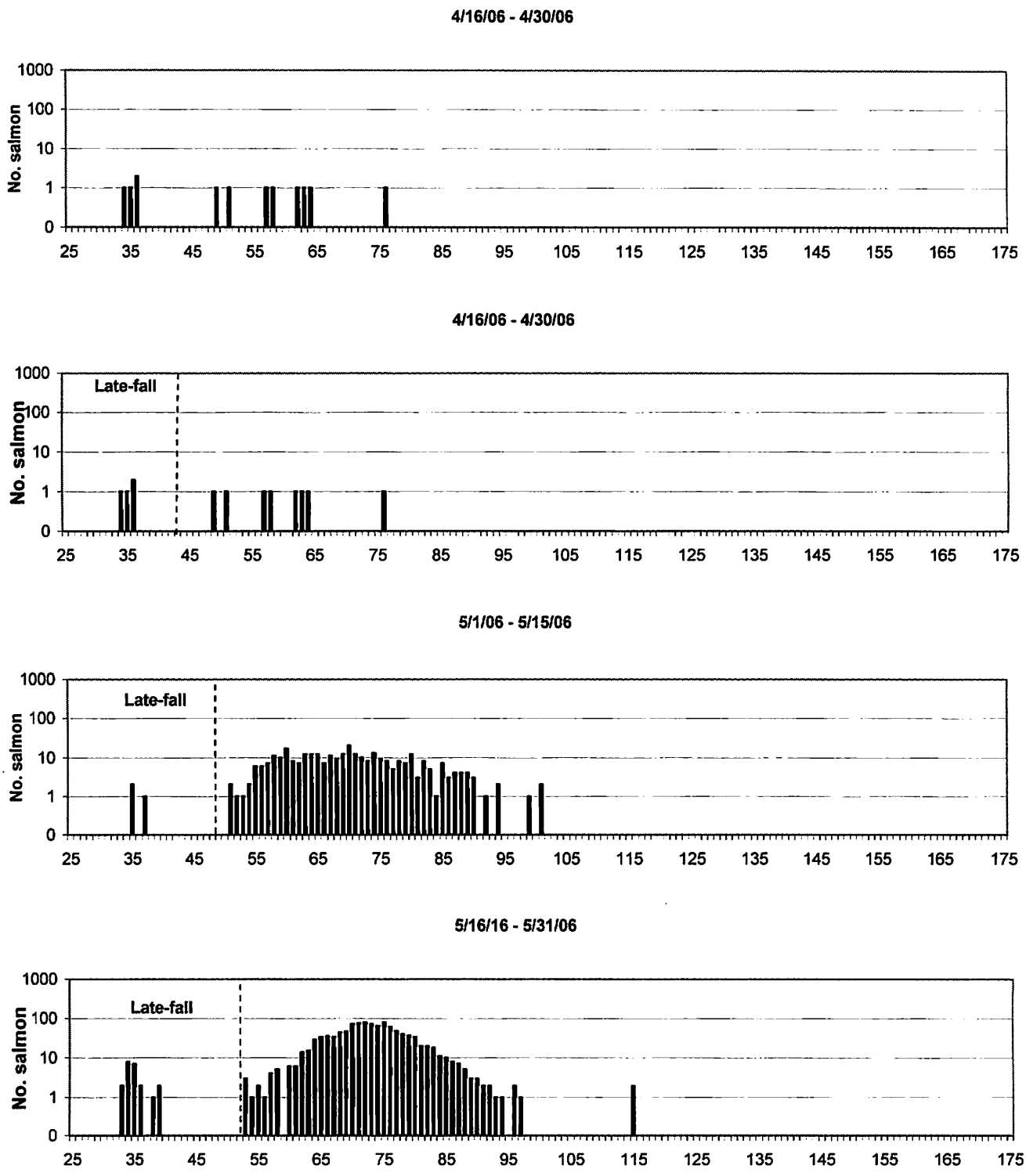
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2005 through June 28, 2006. All fish are assumed to be spring-run Chinook salmon except where indicated.



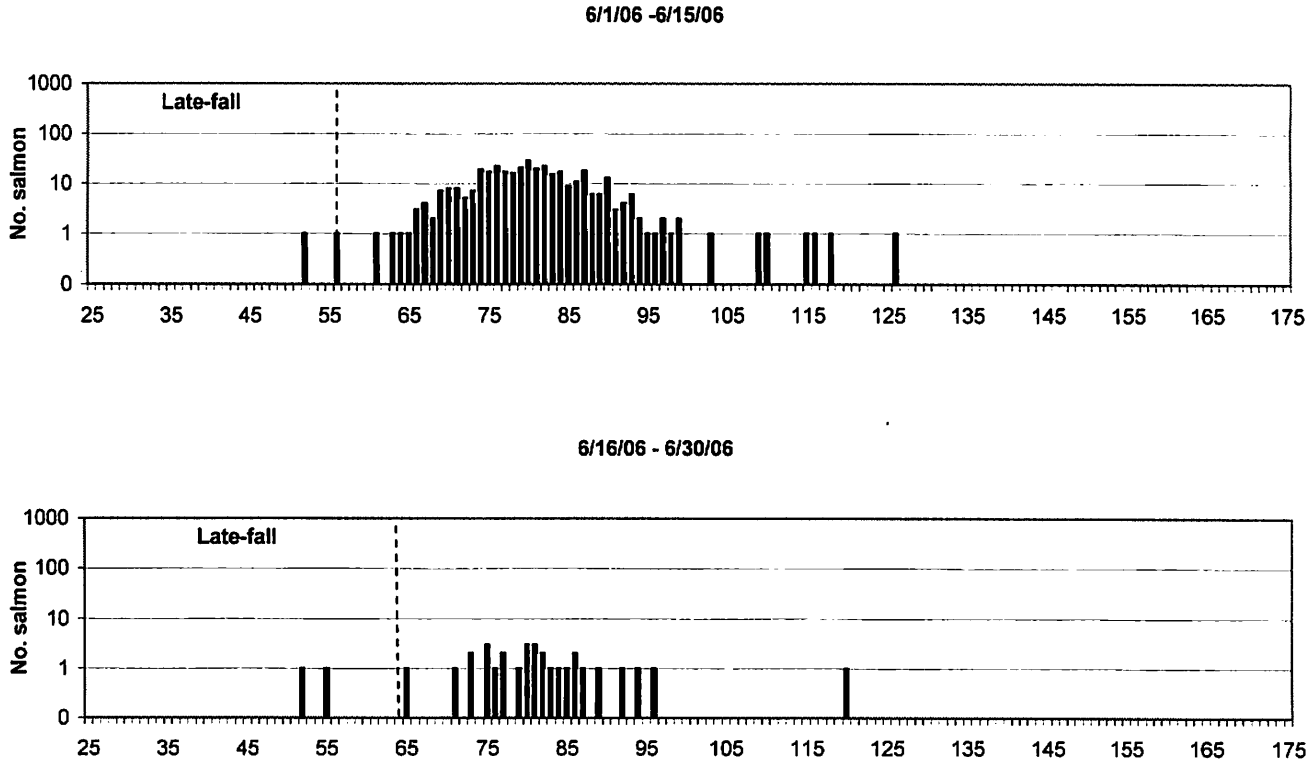
APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2005 through June 28, 2006. All fish are assumed to be spring-run Chinook salmon except where indicated.



APPENDIX B, Figure 1. (continued) Frequency distribution of lengths of juvenile Chinook salmon caught and released at Parrott-Phelan Diversion Dam from October 16, 2005 through June 20, 2006. 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, 2005 through June 28, 2006. 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 2006 using modified Schaefer Model.

Week of Recovery $R_{(i)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$					Tags Recovered $R_{(i)}$	Carcasses Counted $C_{(i)}$	Population Estimate $E_{(i)}$
	1	2	3	4	5			
	Sept. 19-21	Sept. 26-28	Oct. 3-5	Oct. 10-12	Oct. 17-19			
1 Sept. 26-28	13	-	-	-	-	13	305	649
2 Oct. 3-5	2	91	-	-	-	93	1672	2606
3 Oct. 10-12	1	16	206	-	-	223	1164	1575
4 Oct. 17-19	0	9	40	56	-	105	472	534
5 Oct. 24-26	0	1	10	13	18	42	225	244
Tag Recovery $R_{(i)}$	16	117	256	69	18		Total	5608
Tagged $M_{(i)}$	30	185	383	146	56	Carcasses chopped first period (Sept. 19-21, Reaches A-E)		42
							Total Population Estimate Surveyed Reaches A-E = E	5650
							*Plus Chops from Covered Bridge to Parrott Diversion (484) adjusted by F = 1.35	653
							Total Population Estimate	6303

* Expansion factor for reaches with incomplete survey and for CWT recoveries F = 1.35

APPENDIX C, Table 2. Butte Creek fall-run Chinook spawning escapement estimate for 2006 using modified Schaefer Model

Week of Recovery $R_{(i)}$	$R_{(ij)}$ Week of Tagging $T_{(i)}$						Tags Recovered $R_{(i)}$	Carcasses Counted $C_{(i)}$	Population Estimate
	1	2	3	4	5	6			
	Oct.31 Nov.2	Nov. 7-9	Nov. 14-16	Nov. 20-22	Nov. 28-30	Dec. 5-7			
1 Nov. 7-9	4	-	-	-	-	-	4	120	600
2 Nov. 14-16	0	29	-	-	-	-	29	229	492
3 Nov. 20-22	0	6	26	-	-	-	32	272	401
4 Nov. 28-30	0	0	9	15	-	-	24	210	237
5 Dec. 5-7	0	1	0	8	12	-	21	114	115
6 Dec. 12-14	0	0	0	0	1	0	1	3	3
7 Dec. 19-21	0	0	0	0	0	0	0	46	46
Tag Recovery $R_{(i)}$	4	36	35	23	13	0		Total	1894
Tagged $M_{(i)}$	20	71	53	36	27	8	Carcasses chopped first period (Nov. 2-4)		18
								Total Population Estimate	1920**

* Expansion factor for CWT recoveries F = 1.72

** Total includes 8 fish not recovered from week 6

* 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 2005 and 2006. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/17/03-1/22/03	2002	06-01-00-03-02	9/14/06	786	1.35	Butte Cr.-Reach E	Inland Pre-Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/03/06	759	1.35	Butte Cr.-Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/03/06	833	1.35	Butte Cr.-Reach B	Inland Spawn
1/30/03-2/13/03	2002	06-01-00-04-00	10/03/06	656	1.35	Butte Cr.-Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/04/06	759	1.35	Butte Cr.-Reach CO	Inland Spawn
1/22/03-1/27/03	2002	06-01-00-03-03	10/05/06	776	1.35	Butte Cr.-Reach C	Inland Spawn
1/30/03-2/13/03	2002	06-01-00-04-00	10/05/06	734	1.35	Butte Cr.-Reach C	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/05/06	832	1.35	Butte Cr.-Reach C	Inland Spawn
1/22/03-1/27/03	2002	06-01-00-03-03	10/05/06	753	1.35	Butte Cr.-Reach C	Inland Spawn
2/13/03-2/24/03	2002	06-01-00-04-01	10/05/06	834	1.35	Butte Cr.-Reach C	Inland Spawn
1/30/03-2/13/03	2002	06-01-00-04-00	10/05/06	971	1.35	Butte Cr.-Reach C	Inland Spawn
1/30/03-2/13/03	2002	06-01-00-04-00	10/05/06	857	1.35	Butte Cr.-Reach E	Inland Spawn
1/30/03-2/13/03	2002	06-01-00-04-00	10/05/06	947	1.35	Butte Cr.-Reach D	Inland Spawn
1/22/03-1/27/03	2002	06-01-00-03-03	10/05/06	932	1.35	Butte Cr.-Reach B	Inland Spawn
3/5/03-3/27/03	2002	06-01-00-04-02	10/10/06	874	1.35	Butte Cr.-Reach B	Inland Spawn
1/17/03-1/22/03	2002	06-01-00-03-02	10/10/06	831	1.35	Butte Cr.-Reach E	Inland Spawn
1/22/03-1/27/03	2002	06-01-00-03-03	10/12/06	832	1.35	Butte Cr.-Reach E	Inland Spawn
1/22/03-1/27/03	2002	06-01-00-03-03	10/12/06	709	1.35	Butte Cr.-Reach E	Inland Spawn
2/13/03-2/24/03	2002	06-01-00-04-01	10/19/06	921	1.35	Butte Cr.-Reach D	Inland Spawn
3/5/03-3/27/03	2002	06-01-00-04-02	10/19/06	804	1.35	Butte Cr.-Reach C	Inland Spawn
2/13/03-2/24/03	2002	06-01-00-04-01	10/19/06	889	1.35	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 2005 and 2006. 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	10/19/06	784	1.35	Butte Cr.-Reach D	Inland Spawn
3/5/03-3/27/03	2002	06-01-00-04-02	10/05/06	790	1.00	Main-stem Sac. River	Inland Recovery
2/13/03-2/24/03	2002	06-01-00-04-01	10/24/06	780	1.00	Main-stem Sac. River	Inland Recovery
1/31/04-2/2/04	2003	06-01-00-08-03	4/9/06	678	5.07	Monterey	Ocean Sport
1/12/04-1/16/04	2003	06-01-00-04-03	5/31/06	718	3.13	Princeton	Ocean Commercial
2/1/04-2/2/04	2003	06-01-00-05-00	6/4/06	701	3.05	San Francisco	Ocean Sport
2/1/04-2/2/04	2003	06-01-00-04-09	7/1/06	741	3.7	Fort Bragg	Ocean Sport
1/16/04-1/20/04	2003	06-01-00-05-07	7/1/06	734	4.21	Sausalito	Ocean Sport
1/13/04-1/16/04	2003	06-01-00-05-06	7/2/06	699	4.21	Sausalito	Ocean Sport
1/13/04-1/16/04	2003	06-01-00-05-06	7/3/06	656	4.21	Bodega Bay	Ocean Sport
2/2/04-2/3/04	2003	06-01-00-03-06	7/9/06	718	3.7	Fort Bragg	Ocean Sport
2/2/04-2/4/04	2003	06-01-00-03-07	7/29/06	825	3.17	Bodega Bay	Ocean Commercial
1/27/04-1/28/04	2003	06-01-00-04-06	7/29/06	751	3.17	San Francisco	Ocean Commercial
2/2/04-2/4/04	2003	06-01-00-05-02	8/8/06	730	2.95	Fort Bragg	Ocean Commercial
1/13/04-1/16/04	2003	06-01-00-05-06	8/17/06	655	1.35	Butte Cr.-Reach D	Inland Pre-Spawn
1/13/04-1/16/04	2003	06-01-00-05-06	8/23/06	755	2.73	Fort Bragg	Ocean Commercial
1/12/04-1/16/04	2003	06-01-00-04-03	9/1/06	765	1.51	Fort Bragg	Ocean Commercial
1/12/04-1/16/04	2003	06-01-00-04-03	9/1/06	729	1.51	Fort Bragg	Ocean Commercial
1/28/04-1/29/04	2003	06-01-00-04-07	9/3/06	731	4.5	Eureka	Ocean Sport
1/20/04-1/23/04	2003	06-01-00-05-09	9/14/06	772	1.35	Butte Cr.-Reach D	Inland Pre-Spawn
2/3/04-2/5/04	2003	06-01-00-05-03	9/14/06	755	2.5	Bodega Bay	Ocean Commercial
1/29/04-2/1/04	2003	06-01-00-08-01	9/21/06	732	1.35	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 2005and 2006. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/12/04-1/16/04	2003	06-01-00-04-03	9/27/06	699	1.35	Butte Cr.-Reach CO	Inland Spawn
1/26/04-1/28/04	2003	06-01-00-04-05	9/27/06	646	1.35	Butte Cr.-Reach CO	Inland Spawn
2/4/04-2/6/04	2003	06-01-00-05-04	9/28/06	729	1.35	Butte Cr.-Reach CO	Inland Spawn
1/6/04-1/12/04	2003	06-01-00-03-05	9/28/06	700	1.35	Butte Cr.-Reach E	Inland Spawn
1/16/04-1/20/04	2003	06-01-00-05-08	9/28/06	669	1.35	Butte Cr.-Reach C	Inland Spawn
1/26/04-1/28/04	2003	06-01-00-04-05	9/28/06	671	1.35	Butte Cr.-Reach D	Inland Spawn
1/23/04-1/26/04	2003	06-01-00-04-04	9/28/06	668	1.35	Butte Cr.-Reach E	Inland Spawn
12/31/03-1/6/04	2003	06-01-00-03-04	9/28/06	651	1.35	Butte Cr.-Reach E	Inland Spawn
1/26/04-1/28/04	2003	06-01-00-04-05	9/28/06	604	1.35	Butte Cr.-Reach C	Inland Spawn
2/3/04-2/5/04	2003	06-01-00-05-03	10/3/06	692	1.35	Butte Cr.-Reach B	Inland Spawn
12/31/03-1/6/04	2003	06-01-00-03-04	10/3/06	729	1.35	Butte Cr.-Reach B	Inland Spawn
1/23/04-1/26/04	2003	06-01-00-04-04	10/4/06	753	1.35	Butte Cr.-Reach CO	Inland Spawn
1/20/04-1/23/04	2003	06-01-00-06-00	10/4/06	678	1.35	Butte Cr.-Reach CO	Inland Spawn
2/2/04-2/4/04	2003	06-01-00-05-02	10/4/06	711	1.35	Butte Cr.-Reach CO	Inland Spawn
1/12/04-1/16/04	2003	06-01-00-04-03	10/4/06	789	1.35	Butte Cr.-Reach CO	Inland Spawn
1/23/04-1/27/04	2003	06-01-00-06-01	10/4/06	763	1.35	Butte Cr.-Reach CO	Inland Spawn
1/27/04-1/28/04	2003	06-01-00-04-06	10/4/06	678	1.35	Butte Cr.-Reach CO	Inland Spawn
1/31/04-2/2/04	2003	06-01-00-08-03	10/4/06	612	1.35	Butte Cr.-Reach CO	Inland Spawn
2/1/04-2/2/04	2003	06-01-00-04-09	10/5/06	634	1.35	Butte Cr.-Reach C	Inland Spawn
1/29/04-2/1/04	2003	06-01-00-08-01	10/5/06	752	1.35	Butte Cr.-Reach C	Inland Spawn
1/31/04-2/2/04	2003	06-01-00-08-03	10/5/06	792	1.35	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 2005 and 2006. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
2/1/04-2/2/04	2003	06-01-00-05-00	10/5/06	782	1.35	Butte Cr.-Reach E	Inland Spawn
1/29/04-2/1/04	2003	06-01-00-08-01	10/5/06	676	1.35	Butte Cr.-Reach E	Inland Spawn
1/20/04-1/23/04	2003	06-01-00-05-09	10/5/06	712	1.35	Butte Cr.-Reach C	Inland Spawn
1/6/04-1/12/04	2003	06-01-00-03-05	10/5/06	669	1.35	Butte Cr.-Reach C	Inland Spawn
1/16/04-1/20/04	2003	06-01-00-05-07	10/5/06	779	1.35	Butte Cr.-Reach C	Inland Spawn
1/20/04-1/23/04	2003	06-01-00-06-00	10/5/06	715	1.35	Butte Cr.-Reach C	Inland Spawn
1/28/04-1/29/04	2003	06-01-00-04-08	10/11/06	689	1.35	Butte Cr.-Reach CO	Inland Spawn
1/28/04-1/29/04	2003	06-01-00-04-08	10/12/06	804	1.35	Butte Cr.-Reach D	Inland Spawn
2/2/04-2/4/04	2003	06-01-00-05-02	10/12/06	744	1.35	Butte Cr.-Reach D	Inland Spawn
12/31/03-1/6/04	2003	06-01-00-03-04	10/12/06	681	1.35	Butte Cr.-Reach C	Inland Spawn
1/28/04-1/29/04	2003	06-01-00-04-08	10/12/06	670	1.35	Butte Cr.-Reach C	Inland Spawn
1/26/04-1/28/04	2003	06-01-00-04-05	10/12/06	791	1.35	Butte Cr.-Reach E	Inland Spawn
1/20/04-1/23/04	2003	06-01-00-05-09	10/12/06	770	1.35	Butte Cr.-Reach D	Inland Spawn
1/6/04-1/12/04	2003	06-01-00-03-05	10/12/06	724	1.35	Butte Cr.-Reach E	Inland Spawn
1/12/04-1/16/04	2003	06-01-00-04-03	10/12/06	869	1.35	Butte Cr.-Reach B	Inland Spawn
1/12/04-1/16/04	2003	06-01-00-04-03	10/19/06	876	1.35	Butte Cr.-Reach E	Inland Spawn
1/25/05-1/27/05	2004	06-02-01-00-00	6/3/06	510	3.05	Berkeley	Ocean Sport
1/13/05-1/15/05	2004	06-01-00-08-04	6/11/06	513	3.05	Bodega Bay	Ocean Sport
1/27/05-1/29/05	2004	06-02-01-00-03	6/11/06	430	3.05	Berkeley	Ocean Sport
1/13/05-1/16/05	2004	06-01-00-08-06	6/15/06	514	3.05	Princeton	Ocean Sport
1/10/05-1/13/05	2004	06-01-00-07-00	6/16/06	466	3.28	Bodega Bay	Ocean Sport

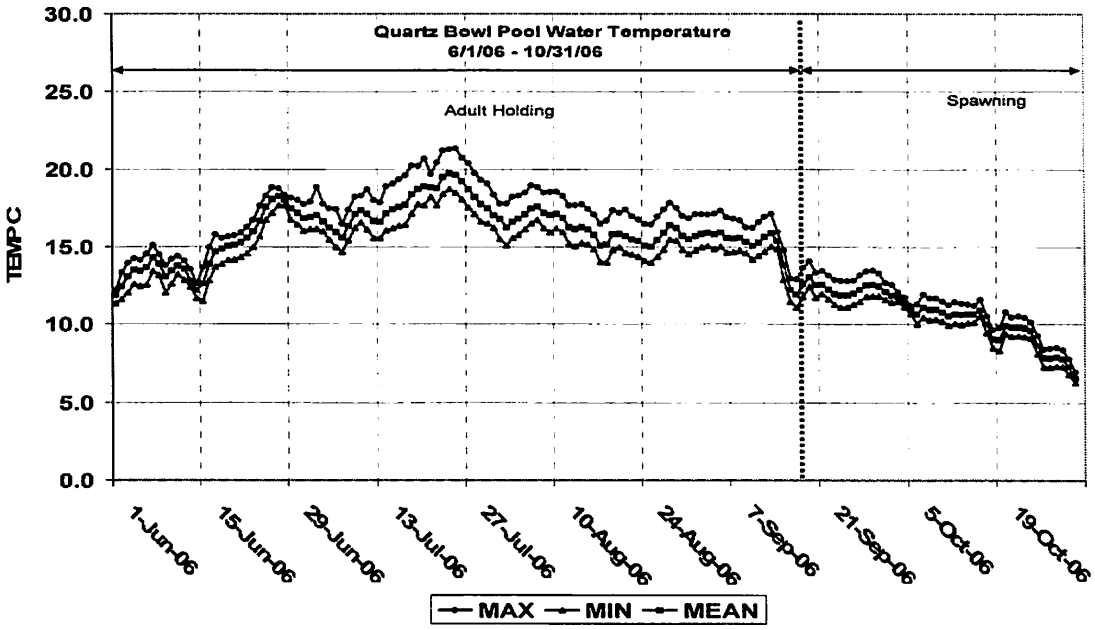
APPENDIX D, Table 1. (continued) Recoveries of Butte Creek adult spring-run Chinook salmon carcasses bearing coded-wire tags during 2005 and 2006. All fish were tagged at Baldwin Construction Yard.

Release Date	Brood Year	Tag Code	Recovery				
			Date	FL (mm)	Expansion	Site	Method
1/17/05-1/22/05	2004	06-01-00-09-00	7/2/06	525	4.21	Berkeley	Ocean Sport
1/17/05-1/20/05	2004	06-01-00-09-01	7/3/06	509	4.21	Berkeley	Ocean Sport
1/26/05-1/28/05	2004	06-02-01-00-02	7/4/06	492	3.7	Fort Bragg	Ocean Sport
1/26/05-1/28/05	2004	06-02-01-00-02	7/26/06	585	3.25	Bodega Bay	Ocean Sport
1/25/05-1/27/05	2004	06-01-00-09-09	8/19/06	646	2.73	Bodega Bay	Ocean Commercial

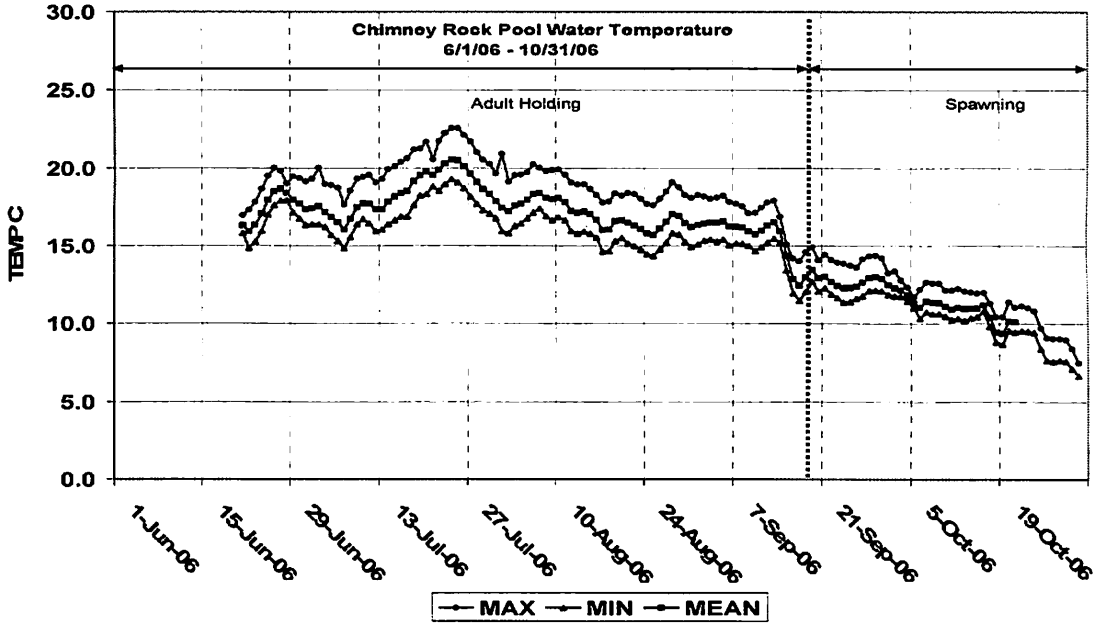
APPENDIX D, Table 2. Recoveries of adult fall-run Chinook salmon carcasses bearing coded-wire tags in Butte Creek during 2006.

Release				Recovery			
Stock	Brood Year	Tag Code	Site	Date	FL (mm)	Expansion	Butte Creek Reach
Feather River	2004	062429	West Sacramento	11/09/06	721	1.72	I
Merced River	2004	064700	Jersey Pt.	11/22/06	594	1.72	I

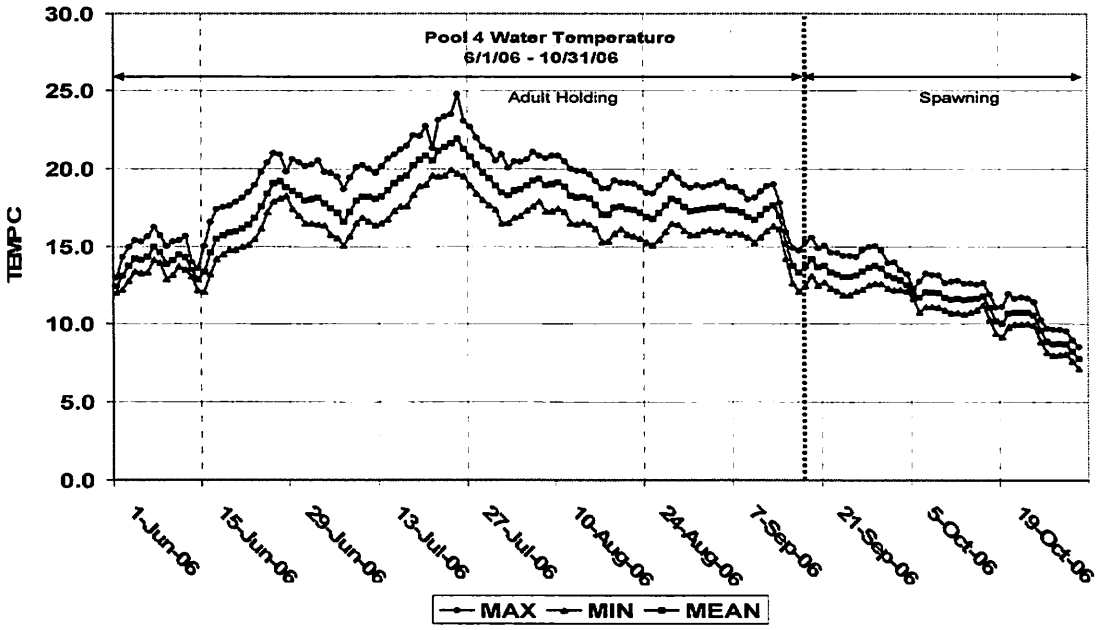
APPENDIX E, (Figure 1). Butte Creek water temperature at Quartz Bowl pool.



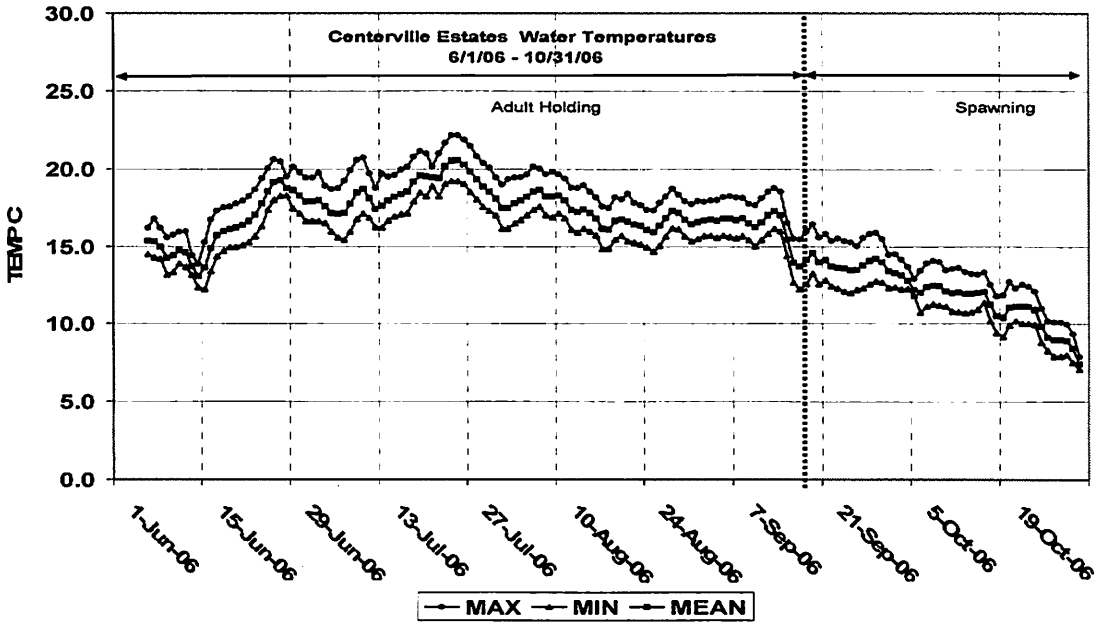
APPENDIX E, (Figure 2). Butte Creek water temperature at Chimney Rock pool.



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.