# Adult Spring Chinook Salmon Monitoring in Clear Creek, California 2003-2004

USFWS Report

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*Abstract*.—Spring Chinook salmon *Oncorhynchus tshawytscha* are listed as a threatened species under the federal Endangered Species Act. Restoration actions on Clear Creek targeted for the recovery of this species include dam removal, increased instream flows, and spawning gravel supplementation. To evaluate the effectiveness of these actions, we used snorkel surveys to monitor adult spring Chinook in Clear Creek since 1999. This report summarizes results from 2003 and 2004. The number of live Chinook observed during August surveys was used as an index of annual adult spring-run abundance. August index survey counts were 25 in 2003 and 98 in 2004. The 2004 index was our highest on record with the second highest count being 66 in 2002. A temporary weir was installed from late August to early November 2003 and 2004, to spatially separate spring-run and fall-run Chinook. Monitoring results indicated that the weir was effective at separating the runs and preventing hybridization and redd superimposition between the runs. The minimum number of Chinook documented upstream of the weir was 30 in 2003 and 68 in 2004. The number of redds observed upstream of the weir was 53 in 2003 and 37 in 2004. Age was estimated by reading scales and the majority of spring Chinook were 3-year-olds in 2003 (78%) and 2-year-olds in 2004 (70%). Spawning began as early as September 9 and continued into October. The size of spring-run redds ranged from 11 to 392 $ft^2$ with an average of 92 $ft^2$. The median substrate size category for redds was 2-4 inches. Two coded-wire tags were recovered, identifying the salmon as wild spring Chinook from Butte Creek.

Water temperature monitoring results demonstrated that it is feasible, using managed flow releases, to provide suitable conditions between Whiskeytown Dam and the Igo gaging station for all life stages of spring Chinook. Over the two-year study period, maintaining temperatures $\leq$60˚F for adult holding and juvenile rearing from June 1 through mid-September required instream flows from 70 to 94 cfs. Flows >150 cfs were required to consistently meet the $\leq$56˚F spawning criteria in September.

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## Introduction

The U.S. Fish and Wildlife Service (USFWS) has conducted monitoring of adult spring Chinook *Oncorhynchus tshawytscha* in Clear Creek since 1999. This is the second report and summarizes results from the years 2003-2004. Newton and Brown (2004) summarized monitoring results for the years 1999-2002. The purpose of this monitoring is to determine spring Chinook population status and trends in Clear Creek, determine their spatial and temporal distribution, evaluate the effectiveness of past restoration actions and guide future restoration actions. The Clear Creek Restoration Program has five major elements (De Staso and Brown 2002), three of which directly target spring Chinook: increase stream flow (Brown 1996), remove Saeltzer Dam (DWR 1997, Hepler 2000), and supplement the spawning gravel supply which has been blocked by Whiskeytown Dam (McBain and Trush 2001).

The removal of Saeltzer Dam in 2000 in conjunction with increased cool water releases from Whiskeytown Dam provided an additional 11.6 river miles (RM) of anadromous salmonid habitat beginning in 2001. Monitoring results from 2003 and 2004 included initial spring-run adult returns from the first two brood years following dam removal (BY 2001 and 2002).

Newton and Brown (2004) showed that there was not a complete spatial or temporal separation between spring and fall Chinook spawning and the potential existed for hybridization of these runs. Hybridization could threaten efforts to restore spring Chinook to Clear Creek. As a result, a temporary weir was installed in 2003 and 2004 during the spawning period to spatially separate the runs. This report evaluates the effectiveness of the temporary weir.

## Study Area

Clear Creek, a westside tributary to the upper Sacramento River, enters the mainstem Sacramento River at RM 289 (river kilometer 465) near the south Redding city limits in Shasta County, California. The Clear Creek study area extends downstream from Whiskeytown Dam (RM 18.1; Table 1, Figure 1). Whiskeytown Dam is a complete barrier to fish passage and is the uppermost boundary of habitat available to anadromous salmon and steelhead. The study area ends at the USFWS' rotary screw trap (RM 1.7). The Anderson-Cottonwood Irrigation District (ACID) siphon and associated sheetpile dam is located downstream of the rotary screw trap (RST) at RM 1.3. Most salmonid spawning habitat is upstream of the ACID siphon. For this reason, the California Department of Fish and Game (CDFG) fall Chinook carcass survey also ends at the RST. The Clear Creek study area extends from an elevation of 1000 feet down to 440 feet above mean sea level.

The stream channel below Whiskeytown Dam can be divided into two predominant types at Clear Creek Road Bridge (RM 8.5). Upstream, the creek is mainly confined by steep canyon walls and is characterized by falls, high gradient riffles, and deep pools. The substrate is mainly bedrock, large boulders, and fine sand. Downstream from RM 8.5 is the alluvial reach with a much lower gradient and a much wider valley relatively unconstrained by bedrock. Substrate is mainly a mixture of cobble, gravel and sand.

## Methods

*Snorkel Surveys*

Snorkel surveys were used to monitor adult spring Chinook in Clear Creek beginning in

1999. Spring Chinook surveys were snorkel surveys conducted from late April through November. The survey included a16.4 mile-long section of Clear Creek starting at Whiskeytown Dam (RM 18.1) and extending downstream to the USFWS' rotary screw trap (RM 1.7). The survey was divided into six reaches (Figure 1, Table 2) and usually required five days to complete. Surveys began at the upstream most reach (Reach 1) and continued downstream on consecutive days. Moving downstream with the current, three snorkelers counted adult Chinook, Chinook carcasses, and Chinook redds. (Although not included in this report, rainbow trout were also counted and divided into three size categories.) Generally, snorkelers were adjacent to each other in a line perpendicular to the flow and would keep track of individual counts within their lane or area of the creek. As needed, snorkelers would confer with each other to make sure no salmon were missed or double counted and then sum and record their counts.

In 2003 and 2004, we generally conducted monthly surveys of reaches 1-6. Surveys were conducted twice a month in September and October to more accurately determine spawning timing. Surveys of Reach 6 were terminated in late September or early October due to the high abundance of fall Chinook.

Stream flow, water turbidity and water temperature can all influence the effectiveness of snorkel surveys (Thurow 1994). We collected data on these three parameters for each snorkel survey. Stream flow was recorded at the U.S. Geological Survey (USGS) gaging station near Igo (RM 10.9). Turbidity samples were taken at the beginning and end of each reach and analyzed the same day using a Hach Turbidimeter. We measured water temperature at the beginning and end of each survey reach with a hand-held submersible thermometer.

*Migration timing and spatial distribution of live Chinook*.— Snorkel surveys were used to document the migration timing and spatial distribution of Chinook in Clear Creek. The date and number of live Chinook observed per reach were recorded. Additionally, Chinook locations were documented using a hand-held Global Positioning System (GPS) receiver. Our annual spring Chinook population index was the highest number of Chinook observed during an August snorkel survey. We used GPS locations and Optic StowAway® temperature loggers deployed at 11 locations in Clear Creek (Figure 1) to evaluate exposure of adults to excessively high water temperatures.

*Time and spatial distribution of Chinook carcasses*.—Chinook carcass locations were also documented using a hand-held GPS receiver. Data gathered from carcasses included tissue and scale samples, fork length, gender, presence or absence of eggs, presence of an external tag (e.g. floy tag) and presence of an adipose fin. Heads were collected from all adipose-fin clipped carcasses and from carcasses where the presence of a fin clip could not be determined due to decomposition. Coded-wire tags (CWTs) were later extracted from heads in the laboratory. After sampling, we marked (e.g. removed the caudal fin) or removed the carcasses from the creek in order to not double count them on subsequent surveys.

Tissue samples for genetic analyses were taken in triplicate (2003) or quadruplicate (2004) usually from a fin (the operculum was sampled if the carcass was highly decayed). Two or three samples were placed in vials containing tris-glycine buffer then frozen and one was dried for 24 hours before storing in a small envelope. Samples are archived at the Red Bluff Fish and Wildlife Office (RBFWO).

*Spawning timing and spatial distribution of Chinook redds*.—Redd locations were also documented. All redds were marked by tying flagging to nearby vegetation in order to differentiate new redds from those observed during previous surveys. Documented redds needed to have both a clearly defined pit and tailspill. "Practice" or "test" redds lacking clear form were not classified as redds. We used GPS locations and StowAway® loggers deployed at 11 locations to evaluate exposure of incubating eggs to excessively high water temperatures. Minimum days of exposure was based on the criteria that 1) 1,600 Daily Temperature Units (DTU = "mean daily temperature" - 32) were required for egg incubation to time of emergence (Piper et al. 1982) and 2) the redds were constructed the day following the preceding survey (April-July) or the day preceding the current survey (August-November).

In order to evaluate spawning gravel supplementation projects, we recorded the origin of the gravel at redd locations as native, supplementation gravel, mixture of native and supplementation gravel, or unknown. Supplementation gravel was identified by tracer rock (chert not found in the Clear Creek watershed), size (2-4"), and shape (rounded edges).

We measured spring Chinook redd dimensions, depths, water velocities and dominant substrate size. Redd dimensions included maximum length and maximum width. Redd area was calculated using the formula for an ellipse (area = π•½ width•½ length). Depth measurements were maximum depth (redd pit), minimum depth (redd tailspill) and pre-redd depth (measured immediately upstream of the redd). Mean column velocity was measure at the same location as the pre-redd depth. Velocity measurements were taken with a General Oceanics model 2030 mechanical flow meter or a Marsh-McBirney model 201 meter. Dominant substrate size was classified using methods described by USFWS (2005).

*Age Structure*

Age determination of returning spring Chinook was done by reading scales collected from carcasses recovered upstream of the temporary picket weir (RM 8.09). Scales were removed from the left side of the fish and from the second or third row above the lateral line in the region bisected by a line drawn between the back of the dorsal fin and the front of the anal fin. Scales were dried for about 24 hours and stored in scale envelopes. Scales were prepared for reading by rehydrating and cleaning them in soapy water. Scales were mounted sculptured side up between two glass microscope slides held together with tape. A microfiche reader was used to count the number of annuli and the age was determined to be the number of annuli plus 1 (Borgerson 1998). Each scale was independently aged by two readers. If results were incongruent, the scale was read a third time cooperatively by the same two readers. After the third read, if an agreement was not reached, that scale was not included in our data set. Scale readers were trained using fall and late-fall Chinook of known age from Coleman National Fish Hatchery.

*Temporary Weir*

A temporary picket weir was installed at RM 8.09 (near the top of Reach 5) in order to spatially separate spawning spring-run from fall-run Chinook and prevent hybridization (Figure 2). Monitoring results described in Newton and Brown (2004) demonstrated that hybridization may threaten the recovery of spring Chinook in Clear Creek. In 2003, the weir was installed on September 2 and removed on November 3. In 2004, the weir was installed on August 26 and removed on November 1. Monitoring of the weir was conducted 7 days per week and included either snorkeling or walking a 100 foot reach immediately upstream of the weir and a 1000 foot reach immediately downstream of the weir. Snorkeling was generally done every-other or every-third day. Weir monitoring included count and location data for steelhead and rainbow trout, live Chinook, Chinook carcasses, and Chinook redds. Genetic samples and coded-wire tags (if present) were collected from carcasses. Since weir monitoring was conducted within our spring Chinook snorkel survey area, weir data such as carcass and redd counts were also included in the data set for the next snorkel survey of Reach 5a (upstream) or Reach 5b (downstream) for analysis purposes.

*Stream Flow and Temperature Conditions*

The suitability of stream temperatures for spring Chinook were evaluated based on the criteria stated in the Doubling Plan (USFWS 2001) and the Biological Opinion for the Central Valley Project (CVP) and State Water Project (SWP) operations (NMFS 2002). Generally, from June 1 to September 14, temperature criteria was ≤60˚F for holding of adults and rearing of juveniles. From September 15 to November 1, the criteria was ≤56˚F for egg incubation. The water temperature target location was at the USGS gaging station (RM 10.9). The transition date from ≤60˚ to ≤56˚F may have occurred slightly earlier in some years based on adaptive management recommendations of the Clear Creek Restoration Program Technical Team. In 2003 and 2004, criteria transitioned to ≤56˚F on September 13 and September 14 respectively.

## Results

*Snorkel Surveys*

The average number of spring Chinook snorkel surveys for reaches 1-6 was 10 in 2003 and 11 in 2004 (Table 3). We conducted snorkel surveys in flows ranging from 72 to 375 cfs with annual averages being 184 cfs in 2003 and 164 cfs in 2004 (Table 4). Turbidity ranged from 0.4 to 2.0 nephelometer turbidity units (NTU) with annual averages being 0.9 NTU in 2003 and 2004. Water temperatures ranged from 49˚ to 71˚F. Our spring Chinook August index surveys were conducted under better than average viewing conditions; flows were near their annual low and turbidity was near or below average levels (Table 4).

*Migration timing and spatial distribution of live Chinook*.— In 2003, our spring Chinook August index was 25 (Figure 3). During the immigration period for spring-run, monthly observations of Chinook began at zero in late April (reaches 4-6 were not surveyed due to a storm event), increased to 28 in July and declined to 23 in late August (Figure 4, Table A1). In August 72% of Chinook observed were located above the weir location. On September 2 the picket weir was installed and flow releases were increased. Subsequent surveys showed observations above the weir increased slightly throughout September and then declined in October and November. Conversely, observations below the weir substantially increased in September and October as the fall run immigration began.

In 2004, our spring Chinook August index was 98, the highest since surveys began in 1999 (Figure 3). Observations of Chinook began at 80 in late April. Previously, the highest late-April count was 6 in 2000. Following the April survey, observations of live Chinook increased to 111 in June and generally declined to 73 in early September (Figure 5, Table A2). By late September, large numbers of fall Chinook were observed and the Reach 6 survey was discontinued in October. The picket weir was installed on August 26 at which time 69% of Chinook were located upstream of the weir. Following the installation of the weir, live Chinook counts generally declined upstream and increased downstream of the weir. Counts increased upstream of the weir in late October corresponding to the weir collapsing from an unexpected 1010 cfs flow release from Whiskeytown Dam.

In 2003, 20 observations of Chinook were made at locations on days when the Mean

Daily Temperatures (MDT) exceeded 60˚F (1 in Reach 4, 3 in Reach 5 and 16 in Reach 6). These observations were made between July 14 and September 12 during which period 110 total observations of Chinook were made (Table 5). In 2004, 156 observations of Chinook were made at locations on days when the MDT exceeded 60˚F (42 in Reach 5 and 114 in Reach 6). These observations were made between June 14 and September 10 during which period 463 total observations of Chinook were made.

*Time and spatial distribution of Chinook carcasses*.—In 2003, Chinook carcasses were first observed during the early September survey, the same week the first spring Chinook redds were observed. Carcasses were recovered on each survey thereafter (Figure 4, Table A1). During the survey period, we encountered a total of 58 carcasses, two of which had an adipose-fin clip (Table A3). One of the clipped salmon was a wild spring Chinook from Butte Creek. The Butte Creek fish was from brood year (BY) 2000 of which CDFG tagged about 166,570 juveniles (Ward et al. 2002). The spring Chinook was collected October 1 on the stream bank about 2 yards downstream of the weir (Reach 5b). No tag was detected in the second clipped salmon which was collected on the upstream side of the weir. Tissue samples for genetic analyses were collected from 57 carcasses (Table 6). Genetic analyses are currently underway to identify the run status of individual fish. Possible run designations include Butte Creek spring-run, Mill-Deer Creek spring-run, fall-run, late fall-run, and winter-run.

In 2004, seven adult Chinook carcasses were recovered between June 29 and August 27, prior to the spring-run spawning period (Figure 5, Table A2). The first carcass was recovered on June 29 in Reach 6 and its sex and spawn status could not be determined. This first carcass was recovered about 2 miles downstream from a single redd observed on June 18 during the typical spawning period for winter Chinook. Future genetic analysis may determine the run status of this carcass. The other 6 early season carcasses were recovered in reaches 2 and 3. These carcasses were all incomplete fragments and sex, spawn status and length could not be determined. At least one showed strong signs of otter predation such as a cleaned skin with attached caudal peduncle turned inside out. Water temperatures in reaches 2 and 3 were always <60˚F, our criteria to protect holding spring-run. In 2004, we encountered a total of 87 carcasses, one of which had an adipose-fin clip (Table A3). The clipped salmon was a wild spring Chinook from Butte Creek. The Butte Creek fish was from BY 2002 of which CDFG tagged about 36,415 juveniles (Ward et al. 2004). The spring Chinook was collected October 14 on the upstream side of the temporary weir (Reach 5a). Tissue samples for genetic analyses were collected from 85 carcasses (Table 6). Genetic analyses are in progress but results are unavailable at this time.

*Spawning timing and spatial distribution of Chinook redds*.—In 2003, we observed a total of 53 redds in reaches 1-5a and 117 in reaches 5b-6 (Reach 6 was not surveyed following September) (Figure 4, Table A1). The first redds were observed during the week of September 10 in reaches 1, 3 and 4 (3 redds). These early season redds were constructed sometime after the week of August 27. Initial flow increases for spawning were implemented September 3. On the next survey, the week of September 24, redds counts peaked in reaches 1-5a and redds were observed in all reaches. Redd counts below the picket weir (Reach 5b) peaked the week of October 8. Spawning density within reaches 1-5a was highest in Reach 4 at 7 redds/mile, followed by Reach 2 at 6 redds/mile (Table 7). In 2003, 87 redds were exposed to MDTs exceeding 56˚F (but <59˚F) for an average minimum of 5 days (Table 5). Of the 87 redds, 86 were in Reach 6 and 1 was in Reach 4.

In 2004, we observed a total of 37 redds in reaches 1-5a and 90 in reach 5b-6 (Reach 6 was not surveyed following September) (Figure 5, Table A2). We observed one redd in Reach 6 on June 18. During the estimated egg incubation period, this early season redd was subjected to water temperatures >56˚F for a minimum of 49 days, >60˚F for 21 days, and a maximum MDT of 66˚F. The first spring Chinook redds were observed during the week of September 8 in reaches 4 and 5b (4 redds). These early season redds were constructed sometime after the week of August 25 and prior to initial spawning flow increases on September 10. On the next survey, the week of September 22, redds counts peaked in reaches 1-5a but, unlike previous years, redds were not observed in Reach 1 until early October. Redd counts below the picket weir (Reach 5b) were equal in late-September and early-October. Spawning density within reaches 1-5a was highest in Reach 5a at 13 redds/mile, followed by Reach 4 at 6 redds/mile (Table 7). In 2004, 70 redds were exposed to MDTs exceeding 56˚F (but <59˚F) for a average minimum of 6 days, excluding the June redd (Table 5). Of the 70 redds, 62 were in Reach 6, 5 were in Reach 5b and 3 were in Reach 4.

Supplemental spawning gravel for spring Chinook was placed in three locations upstream of the temporary weir (Figure 1); below Whiskeytown Dam (Reach 1), below Placer Road Bridge (Reach 4) and upper Reading Bar (Reach 5a). In 2003, 3 of 11 redds in Reach 1 and 5 of 16 redds in Reach 4 were in supplementation gravel. Reach 5a supplementation gravel was unavailable in 2003. In 2004, 0 of 6 redds in Reach 1, 7 of 15 redds in Reach 4 and 4 of 5 in Reach 5a were in supplementation gravel. The four redds in Reach 5a were at locations commonly used for spawning in years prior to gravel additions.

Measurements were taken on spring Chinook redds located in reaches 1 through 5a (above the temporary picket weir). Crews measured 45 redds in 2003 and 36 redds in 2004 (Table 8). Redd area ranged from 11 to 392 $ft^2$ with an average of 92 $ft^2$ (Table 8). Redd depths (pre-construction) ranged from 1.0 to 6.3 ft with an average of 2.5 ft. Water velocity ranged from 0.9 to 3.7 ft/s with an average of 2.3 ft/s. All measurements of redd area, depth and water velocity were within the ranges reported for stream type (spring-run) Chinook (Healey 1991). Redd substrate particles had a median size range of 2-4 inches, a minimum range of 1-2 inches and a maximum range of 4-6 inches.

*Age Structure*

The age structure of spring Chinook in 2003 and 2004 was estimated by aging scales. Returning adults ranged from age 2 to age 4. The dominant age class in 2003 was three-year-olds (BY 2000) comprising 78% of the sample (Table 9). The dominant age class was two-year-olds (BY 2002) in 2004 comprising 70% of the sample. Corresponding adult August population indices were 9, 0 and 66 for BY's 2000, 2001 and 2002 respectively. The 2004 age structure does not include carcasses collected above the temporary weir following its collapse on October 17 because most were probably fall-run. Additionally, the above age structure does not include the two CWT'ed Butte Creek spring-run; a 3-year-old in 2003 and a 2-year-old in 2004.

*Temporary Weir*

In 2003, monitoring results indicated the weir successfully blocked passage of fall Chinook from September 2 through November 3. Regular underwater inspections of the weir pickets indicated that there were no spaces through which salmon could pass. Counts of live salmon within a 1000 foot reach immediately downstream generally increased from zero on September 3 to a maximum of 11 on October 20 (Figure 6). Forty-seven percent of redds in Reach 5b were within 1000 ft of the weir (Figure 7). In contrast to data indicating passage was blocked, snorkel counts of live Chinook upstream of the weir increased from 20 on September 11 to 26 on September 25. This increase may represent the variability in the detection rate of live Chinook by snorkel survey and not a true increase in the number of fish.

In 2004, monitoring results indicated the weir successfully blocked passage of Chinook from August 26 through November 1 with the exception of October 18 and 19 when the weir collapsed due to high flows. Except for October 18 and 19, regular underwater inspections of the weir pickets indicated that there were no spaces through which salmon could pass. Counts of live salmon within a 1000 foot reach immediately downstream generally increased from zero on August 27 to a maximum of 35 on October 2 (Figure 6). Fifty-two percent of redds in Reach 5b were within 1000 ft of the weir (Figure 8).

On October 17, 2004, Whiskeytown Dam release gates malfunctioned and flows reached a peak of 1,010 cfs at the Igo gage. The high flows caused the weir to collapse late in the evening on October 17 allowing fish passage upstream of the weir. CDFG provided replacement parts and we reinstalled the weir around 4:00 pm on October 19. In the week prior to the collapse, snorkel observations of Chinook were declining from 35 to 31 and then to 14 (Figure 6). Following the reinstallation of the weir, only four Chinook were observed below the weir. Observations of live Chinook and carcass recoveries above the weir increased following the weir collapse (Figure 5). Although Chinook may have passed the weir, no new redds were observed upstream of the weir after its collapse. Of the carcasses recovered upstream of the weir following its collapse, 1 was female, 17 were male and 4 were unknown. The male to female sex ratio of 17:1 possibly explains the absence of new redds.

In 2003, a minimum of 30 Chinook occupied the spring-run habitat upstream of the weir based on live counts and carcass recoveries. A total of 53 redds were identified upstream of the weir. A rotary screw trap near the weir location is used to estimate juvenile production from these spring-run redds. The juvenile passage estimate for BY 2003 was 68,559 (Jim Earley, USFWS, unpublished data).

In 2004, a minimum of 68 Chinook occupied the spring-run habitat upstream of the weir. A total of 37 redds were identified upstream of the weir. Based on the rotary screw trap catch, the juvenile spring chinook passages estimate for BY 2004 was 86,194.

Permits for the temporary weir required that there could be no negative impacts to immigrating steelhead and that weir pickets must be raised to allow passage if more than 10 steelhead ($\geq$22 inches in length) were observed with 1000 feet of the weir. The maximum number of steelhead observed holding below the weir was 2 in 2003 and 3 in 2004. For rainbow trout between 16 and 22 inches, a maximum of 4 were observed in 2003 and 12 in 2004. Impacts to immigrating adult steelhead were negligible in both years.

The weir was useful for recovering spring Chinook carcasses and collecting tissue samples for genetic analysis. Of carcasses from reaches 1- 5a, the percentage recovered on the weir was 32% in 2003 and 75% in 2004.

Monitoring data suggested the timing of installation and removal of the weir appeared appropriate for the prevention of hybridization and redd superimposition between spring and fall-run Chinook. At the time of installation, the percentage of Chinook upstream of the weir location was about 72% in 2003 and 69% in 2004. In 2004, the installation date was one week earlier than 2003 to provide greater protection against the possibility of early arriving fall-run passing upstream of the weir location while still allowing adequate time for spring-run to migrate above the weir. In both years, the weir was installed before the large influx of fall Chinook coming into Reach 6 (Figures 4 and 5). Following the removal of the weir, November snorkel survey counts of live Chinook upstream of the weir location were 0 in 2003 and 9 or less in

2004. November surveys did not document any new redds upstream of the weir following its removal. Rotary screw trap juvenile catch data can be used in conjunction with water temperature data to roughly back-calculate when eggs were deposited in the gravel. This data can be used to determine if fall Chinook spawned upstream of the weir site in late November or December while spring-run eggs were incubating. Trap data showed no evidence of successful redds being constructed upstream of the weir in November and December in 2003 and only 1 or 2 successful redds in 2004 (Jim Earley, USFWS, unpublished data).

*Stream Flow and Temperature Conditions*

In 2003, Whiskeytown Dam releases were 200 cfs from April 1 to April 29 at which time there was an uncontrolled spill through the "Glory Hole" for seven days. During the spill, Mean Daily Flows (MDF) peaked at 3509 cfs with an instantaneous peak of 3620 cfs. Following the spill, flows remained at 200 cfs until May 28. Flows were ramped down to 140 cfs beginning May 28 and then to 90 cfs beginning June 27. Flows remained at 90 cfs until September 3. Flows releases for spring-run spawning were increased to 140 cfs on September 3, to 160 cfs on September 8 and to 200 cfs on September 12. We used the ≤60˚F criteria for the period of June 1 to September 13 and the ≤56˚F criteria from September 14 to November 1. MDTs at the Igo gage only slightly exceeded 60˚F on one day during the 105 day period and did not exceed 56˚F during the spawning period. The one day above 60˚F occurred on July 23 at a MDF of 94 cfs (Figure 7).

In 2004, Whiskeytown Dam releases were 200 cfs from April 1 to June 1. Flows were then ramped down to 150 cfs and then again to 90 cfs in early July. Throughout the summer low flow months adjustments were made four times with flows ranging from 70 to 90 cfs. Flow releases for spring-run spawning were increased to 125 cfs on September 10, down to 100 cfs on September 12, and then to 150 cfs on September 14. Flows were ramped up to 200 cfs beginning September 20 for the winter months. We used the ≤60˚F criteria for the period of June 1 to September 14 and the ≤56˚F criteria from September 15 to November 1. MDTs at the Igo gage did not exceed 60˚F but exceeded 56˚F on two days of the spawning period. The two days were September 15 and 16 at a release of 150 cfs (Figure 8).

In both years, MDT coming into lower Clear Creek from Whiskeytown Reservoir peaked in September at an annual maximum of about 54˚F.

## Discussion

*Snorkel Surveys*

Spring Chinook August population indexes for Clear Creek were 25 in 2003 and 98 in 2004. The 2004 index was our highest on record, with the second highest count being 66 in 2002. The annual installation of a temporary weir beginning in 2003 allowed for a second population index for spring-run although this index would not be comparable to previous survey years. This second index is the minimum number of documented spring Chinook above the weir which usually is the maximum survey count of live Chinook plus all carcasses recovered up through that date. Similar to the August index, the "above weir" index increased from 30 in 2003 to 68 in 2004. It is unclear to us why redd counts above the weir decreased in 2004. One possible explanation is that spring-run excavated more well-developed test redds in 2003 which were mis-classified as viable redds.

Juvenile production estimates for spring-run emigrating past the weir location, increased 26% from 2003 to 2004. This increase is most similar to the "above weir" index which increased 127%. The August index increased 292% and the above weir redd count decreased 30%. Possible explanations for why juvenile production did not increase at the same rate as escapement indices include 1) variable environmental conditions, 2) variable male to female sex ratio and 3) estimation error for escapement or juvenile production.

In 2004, spring-run immigration began earlier than in previous years with 80 Chinook being observed in late April compared to a previous maximum of 6 during the same time period. This immigration timing is more typical of Central Valley spring Chinook which return to their natal streams beginning in mid-March (Yoshiyama et al. 1998, CDFG 1998).

Aging of scales indicated that adults in 2004 were predominantly two-year-olds. Typically, the majority of spring-run spawn at age 3 (Fisher 1994) or 4 (Ward et al. 2004). Three-year-olds returning in 2004 would have been from BY 2001 for which our August index was zero, our lowest on record. Because escapement in 2001 was very low, expected returns from this year class would be low. Conversely, two-year-olds returning in 2004 were from BY 2002 for which our August index was 66, our highest on record up to that date. The unusually high percentage of two-year-olds in 2004 may indicate that, due to restoration efforts, spring Chinook are beginning to successfully reproduce in Clear Creek and return as adults to their natal stream.

We recovered two CWTs from adipose-fin clipped Chinook and both were wild spring-run from Butte Creek. This evidence of wild spring-run straying into Clear Creek is encouraging because restoration efforts depend exclusively on immigration of fish from other watersheds. Butte Creek spring-run are one of only three remaining independent populations of wild spring Chinook (Lindley et al. 2004). The occurrence of Butte Creek fish in Clear Creek suggests that strays from the other two remaining independent populations of spring Chinook, Mill and Deer creeks, may also be contributing to the recovery of spring-run in Clear Creek. Spring-run from Feather River Hatchery (FRH) were not recovered during Clear Creek spring Chinook surveys in 2003 and 2004 but they were recovered in the CDFG fall Chinook carcass survey in Reach 6 (C. Harvey-Arrison, CDFG, personal communication). The FRH spring-run apparently spawned at the same time and location as fall Chinook. CDFG does not consider the FRH fish to be true spring-run (CDFG 1998).

*Temporary Weir*

Snorkel survey and weir monitoring results showed that the temporary picket weir successfully separated spring and fall Chinook preventing hybridization and redd superimposition between the races. The weir operation period, from late August to early November, effectively balanced the need to allow enough time for late-arriving spring-run to immigrate above the weir while preventing fall-run from doing so. The weir remained in place long enough to cover the entire fall-run spawning period upstream of the weir location. Fall-run continue to spawn into December downstream in Reach 6. In 2004, the Clear Creek Technical Team considered installing the weir in early August to more closely match the closure date of the Battle Creek barrier weir fish ladder (also intended to prevent hybridization between spring and fall-run). But, snorkel surveys showed that only 45% of Chinook in Clear Creek had moved above the weir in early August and the decision was made to delay the installation for two weeks allowing about 69% to move above the weir.

The weir, by spatially segregating the runs, provided an opportunity to estimate juvenile spring-run production in Clear Creek. The USFWS began operating a second upstream rotary screw trap in 2003 in conjunction with the weir. This trap is about 0.2 miles upstream of the temporary weir location and has proven useful in providing the only estimates of spring Chinook production in Clear Creek (Brown and Earley 2004). Previously, one screw trap was operated near the mouth of Clear Creek but Brown and Earley (2004) demonstrated that the length-at-date method for differentiating fall and spring-run was inadequate and catch data could not accurately estimate spring-run production at this location.

*Stream Flow and Temperature Conditions*

*Attraction flows*.—Newton and Brown (2004) suggested that flows ≥150 cfs appeared to provide adequate passage for spring Chinook entering Clear Creek but suggested that flow experiments would be needed to determine optimal attraction flows. In 2003, a storm event in late April provided an un-managed spill release from Whiskeytown Reservoir, providing a pulse attraction flow. The spill occurred from April 29 to May 5, increasing dam releases from 200 cfs to MDFs ranging from 1235 to 3509 cfs. One week prior to the spill, we snorkel surveyed the upper three reaches (Reaches 1-3) and no Chinook were observed. Two weeks following the spill we surveyed all reaches and 18 Chinook were observed, 5 of which were in the upper 3 reaches. For comparison, snorkel counts in May in previous survey years ranged from 0 to 29 without a pulse attraction flow. Because population levels are variable among years, it is difficult to determine the direct effect of the pulse flow in regards to attracting spring Chinook into Clear Creek.

*Spawn timing and temperature effects*.—In 2003 and 2004, spring Chinook spawning began in early September and peaked in late September. Only four redds above the temporary weir were exposed to temperatures above the 56˚F target. These redds were in Reach 4 downstream of our temperature target location. Negative impacts to spring-run eggs appear negligible as MDTs were elevated for only a short duration (minimum estimate of 2 or 3 days) and were always <59˚F. Seymour (1956) found that Chinook egg mortality rates were drastically reduced for eggs incubated under declining temperature conditions and were low for eggs incubated at an initial temperature of 60˚F. In both years, stream flows were increased in early September for spawning but it is unknown if spawning was a direct response to flow. Previous surveys showed that spring-run began spawning in early September where temperatures were adequate, without an increase in flows (Newton and Brown 2004).

In 2004, we observed one potential winter-run Chinook redd on June18. We estimated that this redd was exposed to water temperatures >60˚F for a minimum of 21 days. The USFWS (1998) studied temperature tolerance specifically for Sacramento River winter-run Chinook. USFWS results showed that the temperature above which 50% of Chinook eggs die from temperature effects, when raised under constant temperature conditions ($LT_{50c}$), was between 58˚ and 60˚F for winter-run. Therefore, there may have been substantial egg mortality for this redd. Juvenile winter-run Chinook were not captured in the lower rotary screw trap in 2004, based on length-at-date analysis (J. Earley, USFWS, personal communication).

*Meeting temperature criteria*.—Temperature data from 1999-2002 showed that the ≤60˚F criteria for adult holding and juvenile rearing at the Igo gage required flows as high as 90 cfs and as low as 68 cfs (Newton and Brown 2004). Similar results were seen in 2003 and 2004 with the ≤60˚F criteria being met with flows ranging from 70 to about 94 cfs (criteria was slightly exceeded one day at 94 cfs). Also, data from 2003 and 2004 showed that flows >150 cfs were required to consistently meet the ≤56˚F criteria in September.

## Recommendations

Based on our findings, we make the following recommendation to enhance conditions in Clear Creek for the restoration and conservation of spring Chinook salmon and to improve the effectiveness of our future monitoring efforts.

1. Continue to install the temporary weir from the last week in August through the first week in November to spatially separate fall-run and spring-run Chinook.

## Acknowledgments

This monitoring project was funded by the CVPIA Restoration Fund. We gratefully acknowledge the hard work and dedication of our snorkel survey crew including Naseem Alston, Mike Berry (CDFG), Howard Brown (NMFS), Felipe Carrillo, Joseph Chigbrow, David Colby, Casey Del Real, James Earley, Shea Gaither, Jimmy Faukner, Tricia Hoffer, Sarah Giovannetti, Josh Grigg, Andrew Gross, Ethan Jankowski, Matt Johnson, Melissa Kleeman, Tim Loux, Matthew McCormack, Phil Moeller, Adam Ray, Laurie Stafford, Jon Sutliff, Brandon Thompson, Paul Walfoort and Lael Will. We are grateful to CDFG for providing, transporting and installing the temporary picket weir, specifically Wade Sinnin, Monty Currier and Jim Thompson. We thank the Whiskeytown National Recreation Area (NPS) and the Bureau of Land Management for providing creek access on public lands. We thank all those who reviewed and provided comments on drafts of this report.

## References

Borgerson, L.A. 1998. Scale analysis. Oregon Department of Fish and Wildlife, Fish Research Project F-144-R-09, Annual Progress Report, Portland.

Brown, M. R. 1996. Benefits of increased minimum instream flows on Chinook salmon and steelhead in Clear Creek, Shasta County, California 1995-6. USFWS Report. U.S. Fish and Wildlife Service, Northern Central Valley Fishery Resource Office, Red Bluff, California.

Brown, M. R., and J. T. Earley. 2004. Monitoring Juvenile Spring Chinook in Clear Creek, California, from October 2003 to July 2004. Draft USFWS Report. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California.

CDFG (California Department of Fish and Game). 1998. Report to the Fish and Game Commission: a status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. California Department of Fish and Game, Sacramento.

De Staso, J. and M. R. Brown. 2002. Clear Creek Restoration Program Annual Work Plan for fiscal year 2003. CVPIA program document.

http://www.usbr.gov./mp/cvpia/awp/2003/3406(b)12Clear Creek.pdf.

DWR (California Department of Water Resources). 1997. Saeltzer Dam Fish Passage Project on Clear Creek. Preliminary Engineering Technical Report. Division of Planning and Local Assistance. December 1997.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8(3):870-873.

Healey, M. C. 1991. Life history of Chinook salmon. Pages 313–393 in C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver, BC.

Hepler, T. E. 2000. Ten miles to Whiskeytown - the removal of Saeltzer Dam. U.S. Bureau of Reclamation, Denver, Colorado.

Lindley, S. T., R. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley basin. NOAA Technical Memorandum NMFS (NOAA-TM-NMFS-SWFSC-360). National Marine Fisheries Service, Southwest Region.

McBain and Trush. 2001. Lower Clear Creek Gravel Management Plan. Appendix D of Final report: geomorphic evaluation of lower Clear Creek downstream of Whiskeytown Dam, California. November 2001.

NMFS (National Marine Fisheries Service). 2002. Biological Opinion for the Central Valley Project (CVP) and State Water Project (SWP) operations, April 1, 2002 through March 31, 2004. National Marine Fisheries Service, Southwest Region.

Piper, P. G., and five coauthors. 1982. Fish Hatchery Management. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D. C.

Seymour, A. H. 1956. Effects of temperature upon young Chinook salmon. Doctoral thesis. University of Washington, Seattle.

Thurow, R. F. 1994. Underwater methods for study of salmonids in the Intermountain West. U.S. Forest Service General Technical Report, INT-GTR-307. Ogden, Utah.

USFWS (U.S. Fish and Wildlife Service). 1998. Effect of temperature on early-life survival of Sacramento River fall- and winter-run chinook salmon. USFWS Report. US. Fish and Wildlife Service, Northern Central Valley Fish and Wildlife Office, Red Bluff, California.

USFWS (U.S. Fish and Wildlife Service). 2001. Final Restoration Plan for the Anadromous Fish Restoration Program. A plan to increase natural production of anadromous fish in the Central Valley of California. Prepared for the Secretary of the Interior by the United States Fish and Wildlife Service with the assistance from the Anadromous Fish and

Restoration Program Core Group under authority of the Central Valley Project Improvement Act. Released as a revised draft on May 30,1997 and adopted as final on January 9, 2001.

USFWS (U.S. Fish and Wildlife Service). 2005. Monitoring of restoration projects in Clear Creek using 2-dimensional modeling methodology. Prepared by The Energy Planning and Instream Flow Branch, Sacramento Fish and Wildlife Office, California.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2002. Butte and Big Chico Creeks spring-run Chinook salmon, Oncorhynchus tshawytscha, life history investigation 2000-2001. California Department of Fish and Game, Sacramento Valley - Central Sierra Region, Rancho Cordova.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2004. Butte and Big Chico Creeks spring-run Chinook salmon, Oncorhynchus tshawytscha, life history investigation 2002-2003. California Department of Fish and Game, Sacramento Valley - Central Sierra Region, Rancho Cordova.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487-521.

**Tables**

TABLE 1.—Important locations on Clear Creek with associated river miles (RM). The river mile system was developed by the Red Bluff Fish and Wildlife Office using ortho-rectified aerial photos (Enplan Co., Redding, CA, 1997).

| Location name | RM |
|---|---|
| Confluence - Sacramento River | 289 (S.R.) |
| Confluence T.L. [a] | 0.69 |
| Highway 273 Bridge | 0.90 |
| A.C.I.D. siphon | 1.33 |
| USFWS Lower Rotary Screw Trap & T.L. | 1.73 |
| Restoration Grove T.L | 3.40 |
| Transmission Lines - Center Tower | 3.61 |
| Renshaw Riffle T.L. | 4.97 |
| Deepest Pool & T.L. | 5.95 |
| City of Redding Gravel Supplementation Site | 6.26 |
| Gorge Cascade & T.L. | 6.46 |
| Former McCormick-Saeltzer Dam Site | 6.47 |
| Temporary Picket Weir | 8.09 |
| USFWS Upper Rotary Screw Trap | 8.29 |
| Clear Creek Road Bridge & T.L. | 8.50 |
| Placer Road Gravel Supplementation Site | 10.58 |
| Placer Falls | 10.59 |
| Placer Road Bridge | 10.60 |
| Igo Gage & T.L. | 10.85 |
| South Fork Clear Creek | 10.99 |
| Two Tier Falls | 11.88 |
| Kanaka Creek & T.L | 13.04 |
| Need Camp Bridge & T.L. | 16.00 |
| Paige Boulder Creek | 16.27 |
| Peltier Valley Road Bridge | 16.90 |
| Whiskeytown Dam Gravel Supplementation Site | 18.04 |
| Whiskeytown Dam & T.L. | 18.11 |

[a] T.L. = Temperature Logger

TABLE 2.—Reach number, length and boundary locations with associated river miles (RM) for Clear Creek snorkel surveys.

| Reach | Reach length (miles) | Upstream | | Downstream | |
|---|---|---|---|---|---|
| | | Location | RM | Location | RM |
| 1 | 2.1 | Whiskeytown Dam | 18.1 | NEED Camp Bridge | 16.0 |
| 2 | 3.0 | NEED Camp Bridge | 16.0 | Kanaka Creek | 13.0 |
| 3 | 2.1 | Kanaka Creek | 13.0 | Igo Gage | 10.9 |
| 4 | 2.4 | Igo Gage | 10.9 | Clear Creek Rd. Bridge | 8.5 |
| 5 | 2.0 | Clear Creek Rd. Bridge | 8.5 | Saeltzer Dam Site | 6.5 |
| *5a* | *0.4* | *Clear Creek Rd. Bridge* | *8.5* | *Picket Weir* | *8.1* |
| *5b* | *1.6* | *Picket Weir* | *8.1* | *Saeltzer Dam Site* | *6.5* |
| 6 | 4.8 | Saeltzer Dam Site | 6.5 | Rotary Screw Trap | 1.7 |

TABLE 3.—Number of spring Chinook snorkel surveys conducted in Clear Creek by year and by reach.

| Year | Reach 1 | Reach 2 | Reach 3 | Reach 4 | Reach 5 | Reach 6 |
|---|---|---|---|---|---|---|
| 1999 | 1 | 1 | 1 | 3 | 4 | 22 |
| 2000 | 7 | 6 | 7 | 8 | 8 | 12 |
| 2001 | 8 | 8 | 8 | 8 | 8 | 10 |
| 2002 | 11 | 10 | 10 | 10 | 10 | 7 |
| **2003** | **12** | **10** | **10** | **9** | **9** | **7** |
| **2004** | **12** | **12** | **12** | **12** | **12** | **8** |

TABLE 4.—Stream flow, turbidity and temperature during spring Chinook snorkel surveys conducted during 2003 and 2004. The range and mean (in parentheses) for annual survey seasons and conditions during the August index survey (AIS) are given.

| Year | Flow ($ft^3/s$) | Turbidity (NTU) | Temperature (˚F) |
|---|---|---|---|
| 2003 | 93-375 (184) | 0.9-1.8 (0.9) | 49-69 |
| 2004 | 72-253 (164) | 0.4-2.0 (0.9) | 49-71 |
| AIS 2003 | 93 | 0.7-1.3 | 53-67 |
| AIS 2004 | 75 | 0.7-0.9 | 55-67 |

TABLE 5.—Snorkel survey observations of adult Chinook and Chinook redds in water temperatures exceeding criteria of MDTs ≤60˚F and ≤56˚F respectively. Adult exposure includes the number of observations in high MDTs, period during which exposures occurred, and percentage of adults observed in high MDTs within the exposure period. Redd exposures include percent of redds exposed to high temperatures from August through November and the average minimum days redds were exposed to high MDTs.

| Year | 1999 | 2000 | 2001 | 2002 | **2003** | **2004** |
|---|---|---|---|---|---|---|
| No. adults in water >60˚F | 44 | 35 | 5 | 45 | **20** | **156** |
| Adult exposure period | 6/15-8/30 | 5/25-9/28 | 6/18-9/13 | 7/15-8/16 | **7/14-9/12** | **6/14-9/10** |
| % Adults in water >60˚F | 24% | 48% | 11% | 35% | **18%** | **34%** |
| % Redds in water >56˚F (Aug.-Nov.) | 26.0% | 0.2% | 54.4% | 0.7% | **51.2%** | **63.1%** |
| Average minimum days of redds in >56˚F | 5 days | 2 days | 10 days | 3 days | **5 days** | **6 days** |

TABLE 6.—Total number of carcasses recovered, percent of carcasses sampled for genetic analysis, and percent of carcasses possessing coded-wire tags. Carcasses were recovered during annual spring Chinook snorkel surveys (1999-2004) and weir monitoring (2003 & 2004) conducted by the USFWS.

| Year | 1999 | 2000 | 2001 | 2002 | **2003** | **2004** |
|---|---|---|---|---|---|---|
| Total Carcasses | 92 | 39 | 96 | 124 | **58** | **87** |
| % Sampled | *37.0%*[a] | 12.8% | *42.7%*[a] | 63.7% | **98.3%** | **97.7%** |
| % CWT | 2.2% | 0% | 2.1% | 2.4% | **3.4%** | **1.1%** |

[a] Errata: These percentages are corrections of those reported by Newton and Brown (2004).

TABLE 7.—Redd density (redds per mile) by reach based on redds observed during Clear Creek spring Chinook snorkel surveys conducted from 1999 through 2004. Reach 6 is not included as it was not surveyed during the entire spawning period.

| Year | Reach 1 | Reach 2 | Reach 3 | Reach 4 | Reach 5 | *(Reach 5a)* | *(Reach 5b)* |
|---|---|---|---|---|---|---|---|
| 1999 | | | | 5 | 37 | | |
| 2000 | 1 | 2 | 0 | 1 | 1 | | |
| 2001 | 2 | 2 | 3 | 9 | 22 | | |
| 2002 | 20 | 10 | 14 | 13 | 48 | | |
| **2003** | **5** | **6** | **2** | **7** | **11** | **(5)** | **(12)** |
| **2004** | **3** | **3** | **1** | **6** | **14** | **(13)** | **(14)** |

TABLE 8.—Summary of spring Chinook redd measurements in reaches 1-5a of Clear Creek during the 2003 and 2004 snorkel survey seasons. Measurements include redd dimensions, depths, mean column water velocity, and median substrate code.

| | Length (ft) | Width (ft) | Area ($ft^2$) | Depth: pit (ft) | Depth: tailspill (ft) | Depth: Pre-redd (ft) | Velocity (ft/s) | Substrate Code |
|---|---|---|---|---|---|---|---|---|
| Mean | 14.4 | 7.3 | 91.9 | 2.8 | 1.8 | 2.5 | 2.3 | |
| Median | | | | | | | | 2.4 |
| Standard Deviation | 6.5 | 3.4 | 72.6 | 1.0 | 1.0 | 1.1 | 0.7 | |
| Minimum | 3.3 | 2.6 | 10.7 | 1.3 | 0.4 | 1.0 | 0.9 | 1.2 |
| Maximum | 27.3 | 18.3 | 392.4 | 6.2 | 4.5 | 6.3 | 3.7 | 4.6 |
| Count | 80 | 79 | 79 | 81 | 80 | 81 | 78 | 79 |

TABLE 9.—Population age structure for adult spring Chinook returning to Clear Creek in 2003 and 2004 (reaches 1-5a). Age determinations were made by scale reading. Included are total number of fish aged (n=) and the percentage of adults originating from brood years (BY) 1998-2002. Adult spring Chinook August index counts for each brood year are listed in parentheses.

| Escapement Year | n= | BY 2002 (66) | BY 2001 (0) | BY 2000 (9) | BY 1999 (35) | BY 1998 (N/A) |
|---|---|---|---|---|---|---|
| 2003 | 23 | | 13% | 78% | 9% | 0% |
| 2004 | 33 | 70% | 21% | 9% | 0% | |

**Figures**

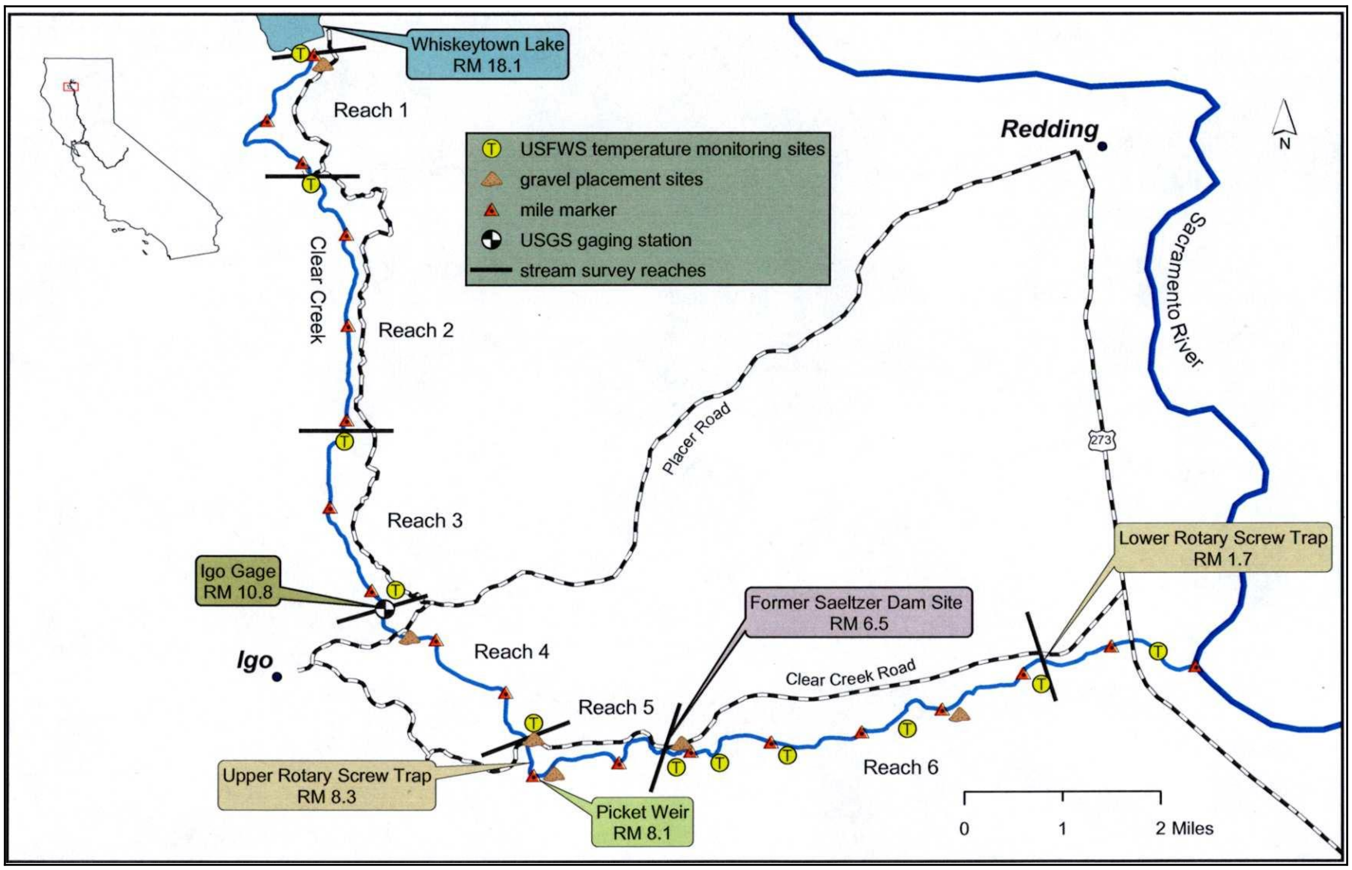


FIGURE 1.—Map of lower Clear Creek, Shasta County, California depicting USFWS spring Chinook snorkel survey reaches and monitoring sites.

FIGURE 2.—The Clear Creek temporary picket weir installed at river mile 8.09 during September and October, 2003 and 2004, to spatially separate spawning spring-run and fall-run Chinook .

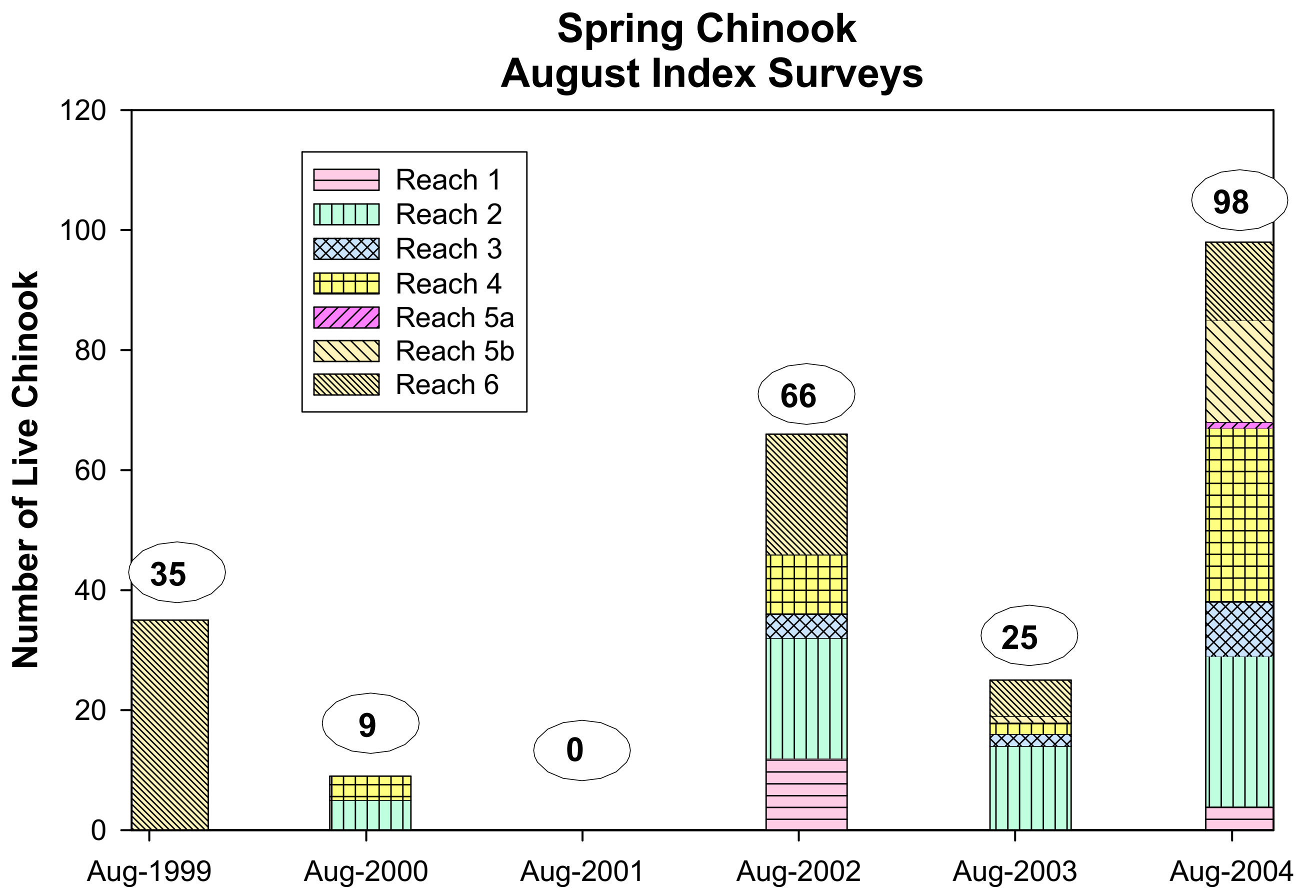


FIGURE 3.—Spring Chinook August index survey counts of live Chinook in Clear Creek downstream of Whiskeytown Dam from 1999-2004.

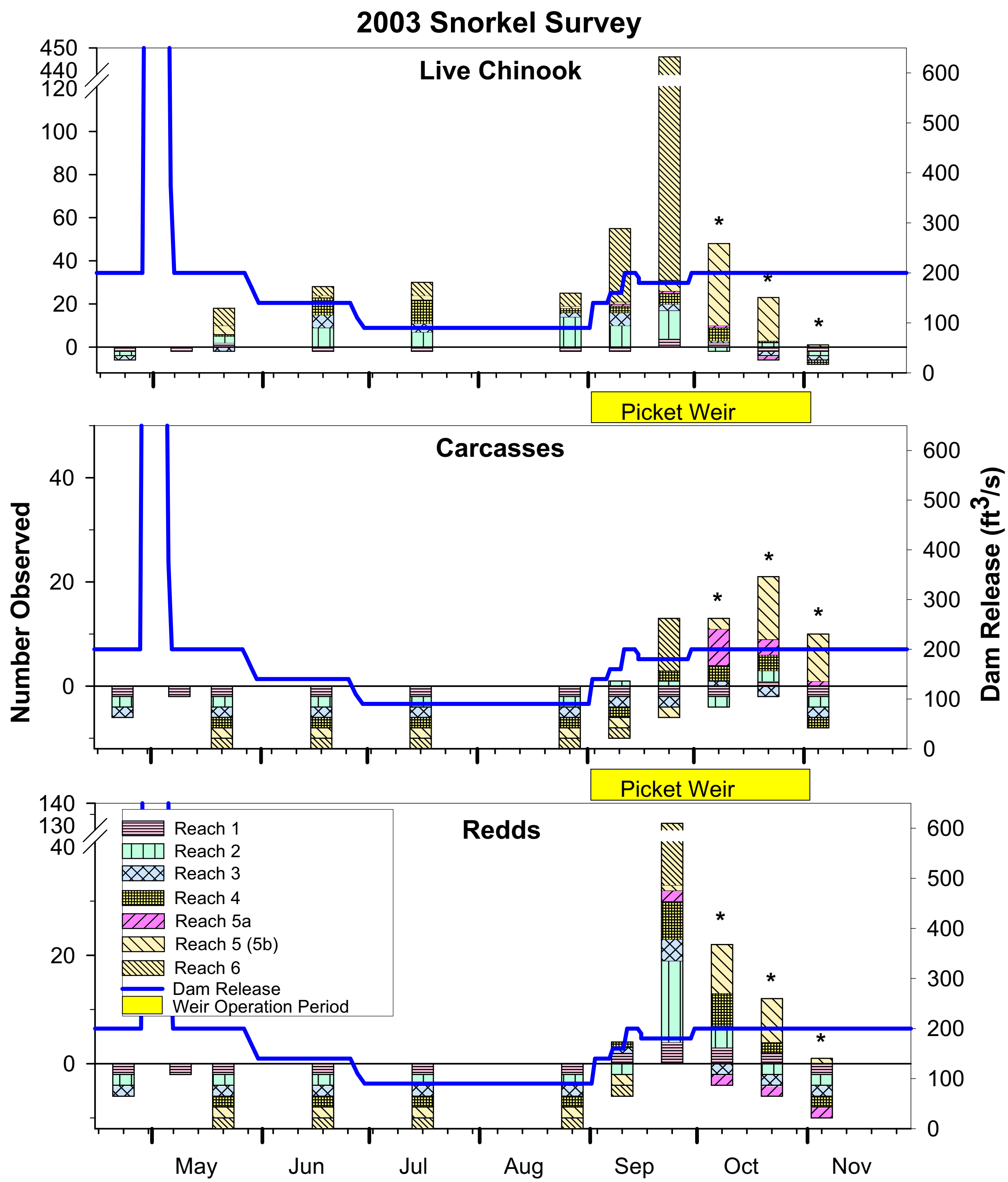


FIGURE 4.—Number of live adult Chinook, carcasses and redds observed during Clear Creek snorkel surveys in 2003 with water releases below Whiskeytown Dam ($ft^3/s$). Stacked bars <0 represent snorkel surveys with zero observations. Generally, each stack represents one week of surveys. Reach 6 was not surveyed in October and November (*) due to the very large number of fall-run Chinook.

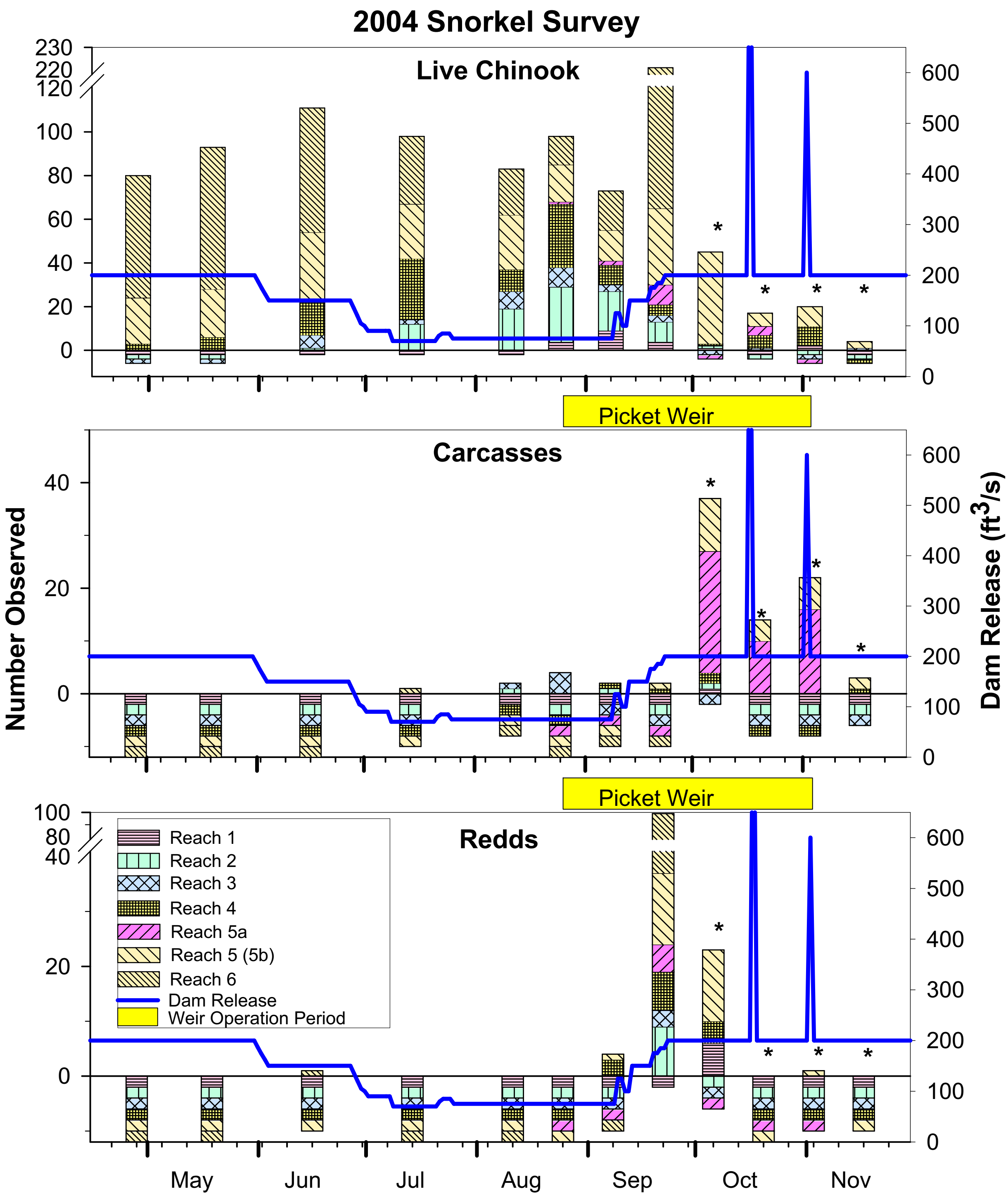


FIGURE 5.—Number of live adult Chinook, carcasses and redds observed during Clear Creek snorkel surveys in 2004 with water releases below Whiskeytown Dam ($ft^3/s$). Stacked bars <0 represent snorkel surveys with zero observations. Generally, each stack represents one week of surveys. Reach 6 was not surveyed in October and November (*) due to the very large number of fall-run Chinook.

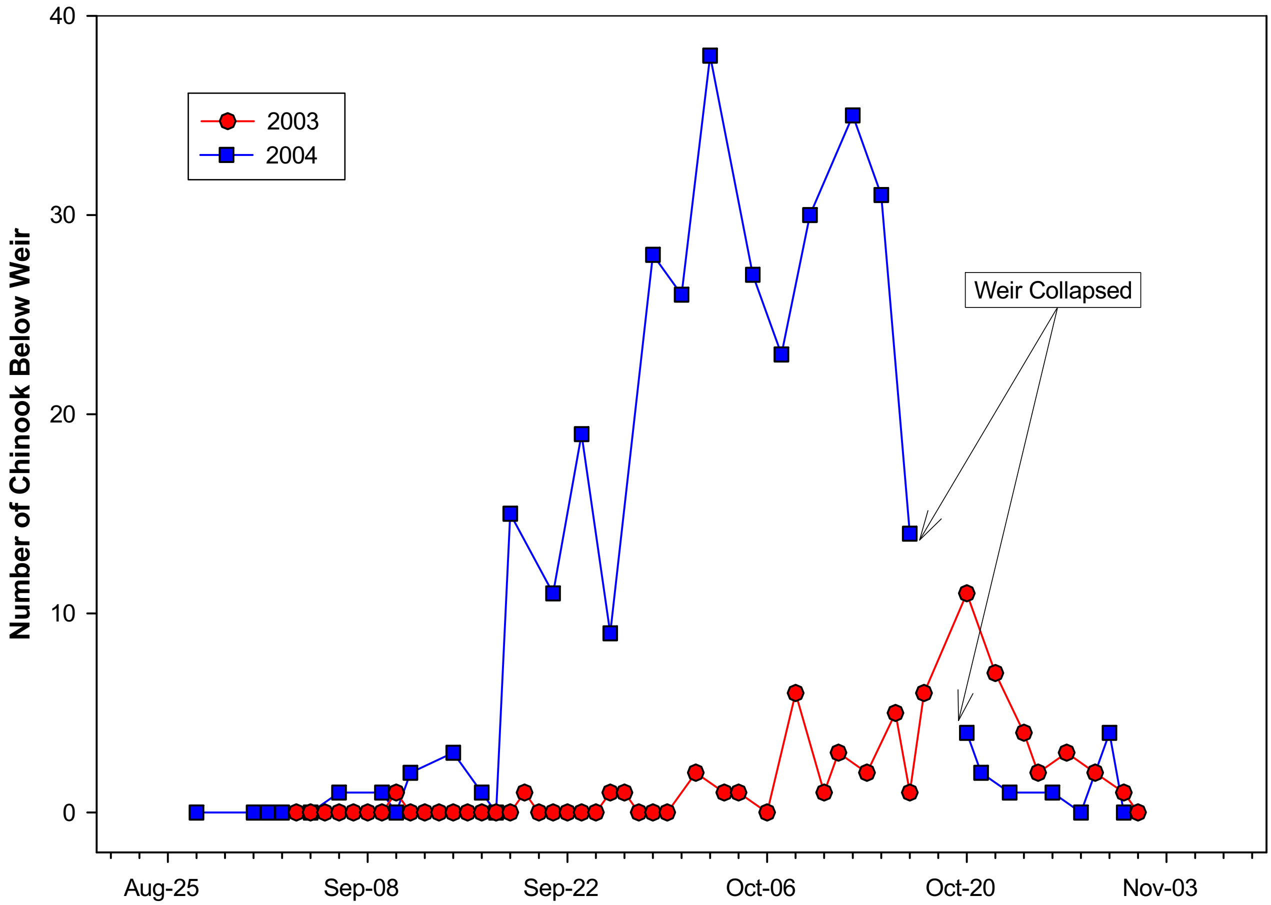


FIGURE 6.—The number of live adult Chinook observed within 1000 feet downstream of the Clear Creek temporary picket weir in 2003 and 2004.

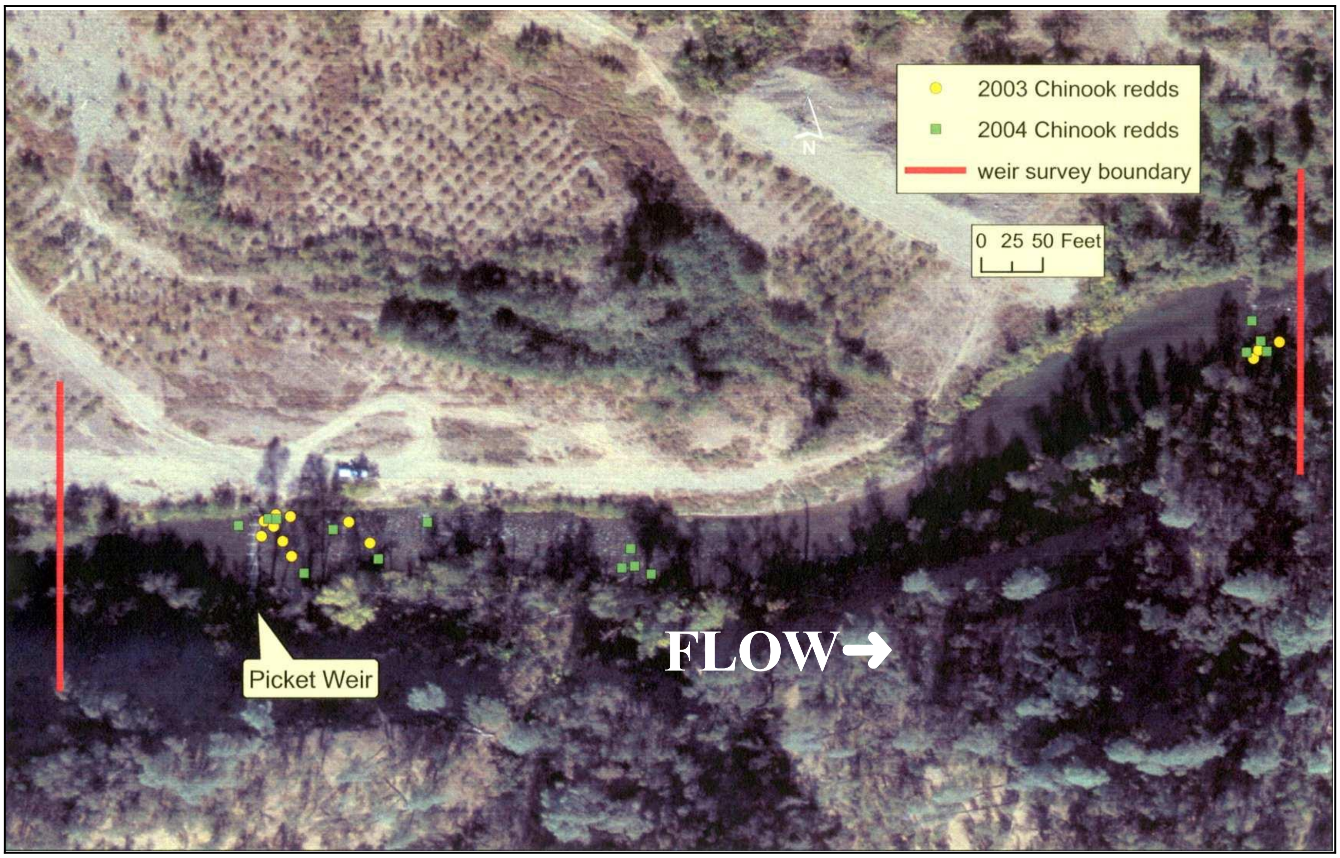


FIGURE 6.—Chinook redd locations in 2003 and 2004 within monitoring boundaries for the Clear Creek temporary picket weir.

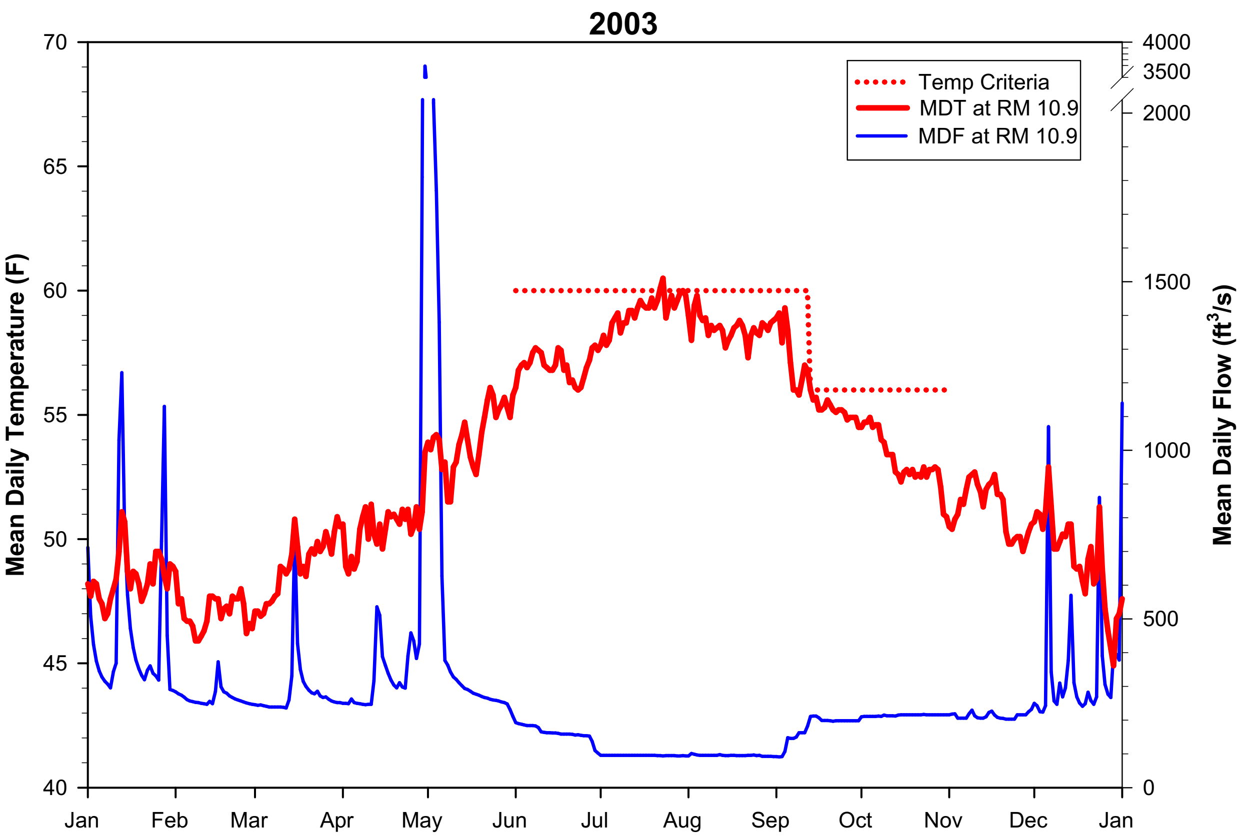


FIGURE 7.—Mean daily temperature (MDT) and mean daily flow (MDF) at the Igo Gage (RM 10.9) with temperature criteria for spring Chinook holding (≤60˚F) and egg incubation (≤56˚F) on Clear Creek in 2003.

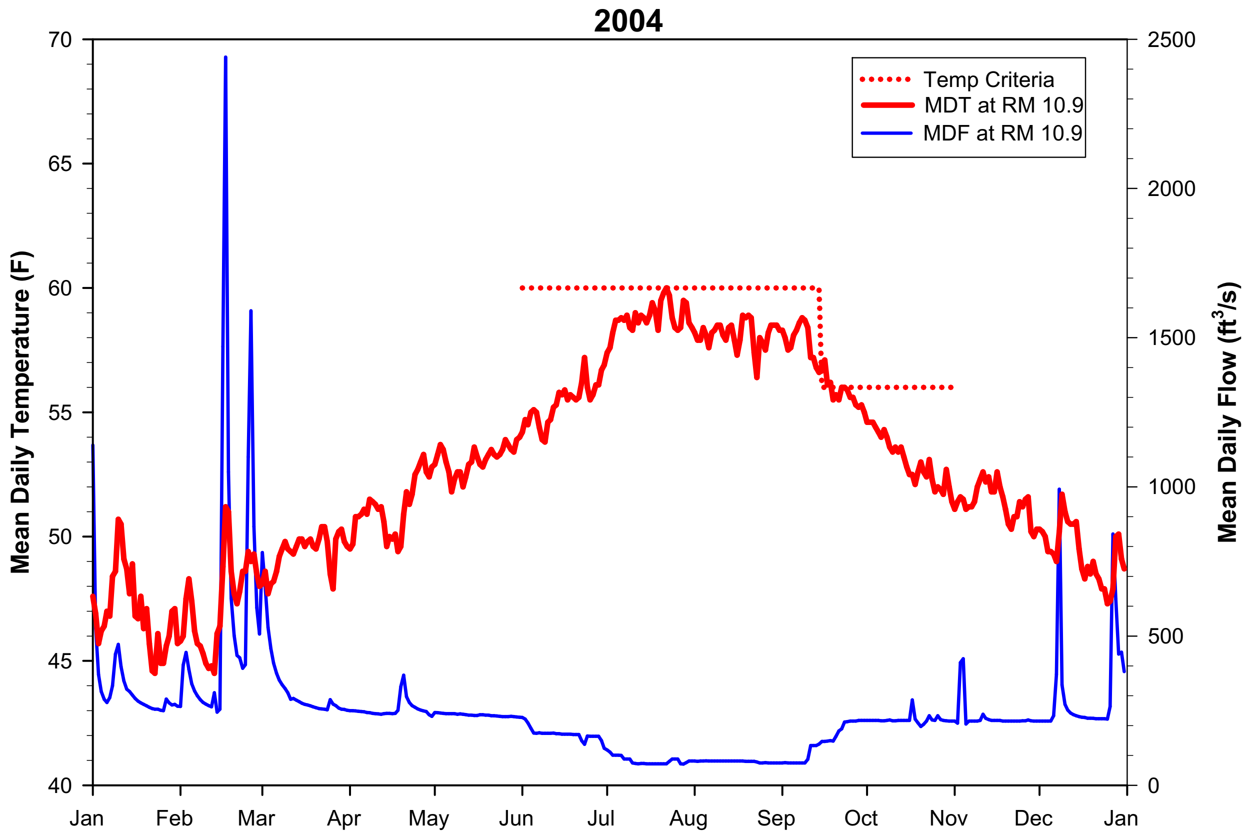


FIGURE 8.—Mean daily temperature (MDT) and mean daily flow (MDF) at the Igo Gage (RM 10.9) with temperature criteria for spring Chinook holding (≤60˚F) and egg incubation (≤56˚F) on Clear Creek in 2004.

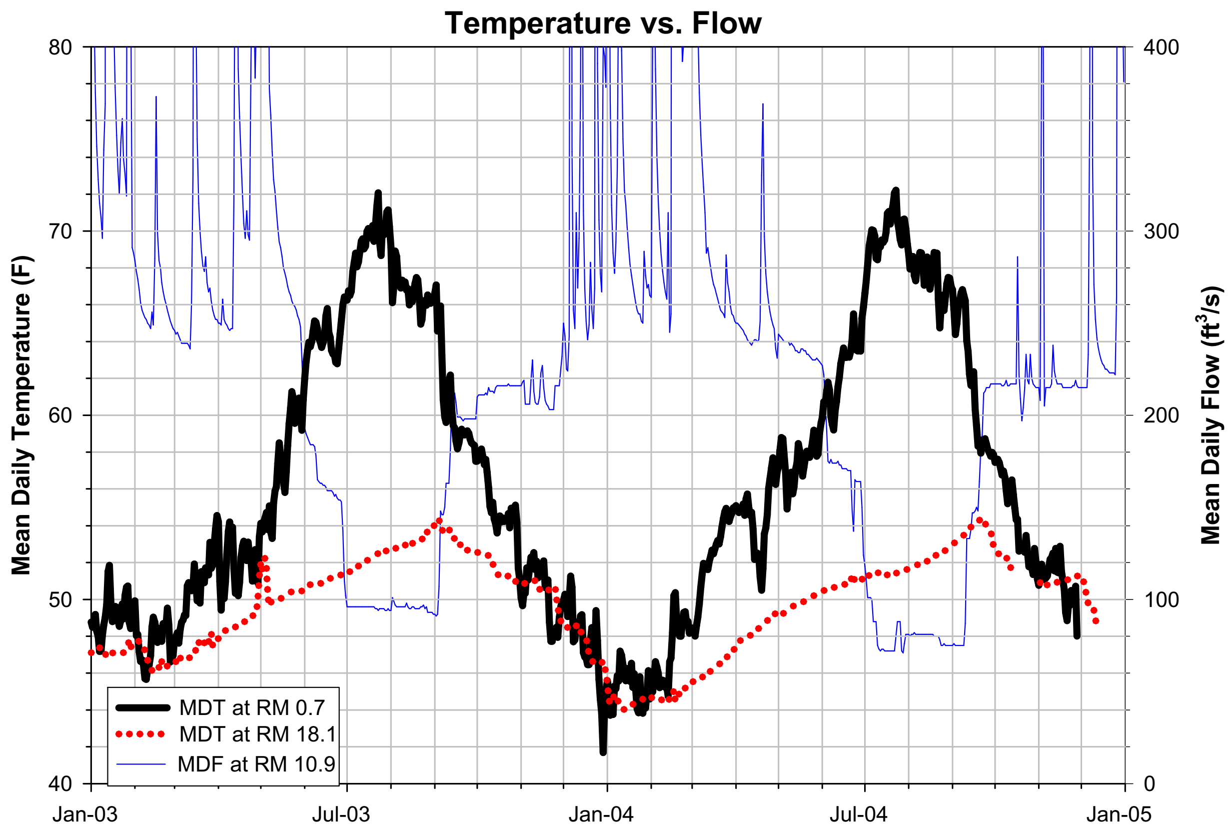


FIGURE 9.—Mean daily water temperatures (MDT) below Whiskeytown Dam (RM 18.1) and near the confluence with the Sacramento River (RM 0.7) plotted with mean daily flow (MDF) at the Igo gage (RM 10.9) for Clear Creek in 2003 and 2004.

**Appendices**

Table A1.—USFWS Clear Creek snorkel survey observations in 2003 of live adult Chinook, carcasses and new redds. Survey conditions include stream flow, average turbidity and average water temperature. Carcasses and new redds observed during weir monitoring were included in the next Reach 5 snorkel survey.

| Reach | Date | Chinook[a] | Carcasses | New redds | Flow ($ft^3/s$) | Turbidity (NTU) | Temp (˚F) |
|---|---|---|---|---|---|---|---|
| 1 | 04/21/03 | 0 | 0 | 0 | 320 | 1.3 | 49 |
| 1[b] | 05/09/03 | 0 | 0 | 0 | 333 | 1.8 | 52 |
| 1 | 05/19/03 | 2 | 0 | 0 | 267 | 1.4 | 52 |
| 1 | 06/16/03 | 0 | 0 | 0 | 152 | 0.8 | 54 |
| 1 | 07/14/03 | 0 | 0 | 0 | 96 | 0.8 | 55 |
| 1 | 08/25/03 | 0 | 0 | 0 | 95 | 0.7 | 53 |
| 1[b] | 08/26/03 | 0 | 0 | 0 | 96 | | 56 |
| 1 | 09/08/03 | 0 | 0 | 2 | 150 | 1.0 | 57 |
| 1 | 09/22/03 | 4 | 0 | 4 | 190 | 0.9 | 56 |
| 1 | 10/06/03 | 2 | 0 | 3 | 200 | 0.9 | 56 |
| 1 | 10/20/03 | 0 | 1 | 2 | 200 | 1.1 | 54 |
| 1 | 11/04/03 | 0 | 0 | 0 | 206 | 0.7 | 51 |
| *1* | *Totals* | | *1* | *11* | | | |
| 2 | 04/22/03 | 0 | 0 | 0 | 299 | 1.3 | 50 |
| 2 | 05/20/03 | 3 | 0 | 0 | 261 | 1.1 | 53 |
| 2 | 06/17/03 | 9 | 0 | 0 | 149 | 0.6 | 55 |
| 2 | 07/15/03 | 7 | 0 | 0 | 96 | 0.8 | 58 |
| 2 | 08/27/03 | 14 | 0 | 0 | 93 | 1.2 | 58 |
| 2 | 09/09/03 | 10 | 1 | 0 | 156 | 0.8 | 58 |
| 2 | 09/23/03 | 13 | 1 | 15 | 190 | 0.7 | 58 |
| 2 | 10/07/03 | 0 | 0 | 4 | 200 | 0.7 | 56 |
| 2 | 10/21/03 | 2 | 2 | 0 | 200 | 0.6 | 54 |
| 2 | 11/05/03 | 0 | 0 | 0 | 206 | 0.7 | 53 |
| *2* | *Totals* | | *4* | *19* | | | |
| 3 | 04/23/03 | 0 | 0 | 0 | 282 | 1.5 | 50 |
| 3 | 05/21/03 | 0 | 0 | 0 | 260 | 1.2 | 54 |
| 3 | 06/18/03 | 6 | 0 | 0 | 149 | 0.9 | 54 |
| 3 | 07/16/03 | 4 | 0 | 0 | 96 | 0.7 | 57 |
| 3 | 08/27/03 | 2 | 0 | 0 | 93 | 1.3 | 59 |
| 3 | 09/10/03 | 6 | 0 | 1 | 163 | | 58 |
| 3 | 09/24/03 | 3 | 0 | 4 | 190 | 0.9 | 56 |
| 3 | 10/08/03 | 1 | 1 | 0 | 200 | 0.7 | 55 |
| 3 | 10/22/03 | 0 | 0 | 0 | 200 | 0.8 | 53 |
| 3 | 11/06/03 | 0 | 0 | 0 | 206 | 0.7 | 52 |
| *3* | *Totals* | | *1* | *5* | | | |
| 4 | 04/24/03 | No Survey (high turbidity) | | | 375 | | |
| 4 | 05/22/03 | 1 | 0 | 0 | 258 | 1.2 | 53 |
| 4 | 06/19/03 | 8 | 0 | 0 | 150 | 0.6 | 58 |
| 4 | 07/17/03 | 11 | 0 | 0 | 96 | 0.6 | 60 |
| 4 | 08/28/03 | 2 | 0 | 0 | 93 | | 62 |
| 4 | 09/11/03 | 3 | 0 | 1 | 163 | 0.7 | 60 |
| 4 | 09/25/03 | 5 | 2 | 7 | 190 | 0.7 | 57 |
| 4 | 10/09/03 | 6 | 3 | 6 | 200 | 0.8 | 55 |
| 4 | 10/23/03 | 1 | 3 | 2 | 200 | 0.8 | 54 |
| 4 | 11/07/03 | 0 | 0 | 0 | 208 | 0.9 | 53 |
| *4* | *Totals* | | *8* | *16* | | | |
| 5 | 04/24/03 | No Survey (high turbidity) | | | 375 | | |
| 5 | 05/22/03 | 4 | 0 | 0 | 258 | 1.2 | 58 |
| 5 | 06/19/03 | 1 | 0 | 0 | 150 | 0.6 | 58 |
| 5 | 07/17/03 | 2 | 0 | 0 | 96 | 0.6 | 60 |
| 5 | 08/28/03 | 1 | 0 | 0 | 93 | | 62 |
| 5a[c] | 09/11/03 | 1 | 0 | 0 | 163 | 0.7 | 60 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5a | 09/25/03 | 1 | 0 | 2 | 190 | 0.7 | 57 |
| 5a | 10/10/03 | 1 | 7 | 0 | 200 | 0.8 | 56 |
| 5a | 10/24/03 | 0 | 3 | 0 | 200 | 0.8 | 55 |
| 5a | 11/07/03 | 0 | 1 | 0 | 208 | 0.9 | 53 |
| 5b | 09/11/03 | 1 | 0 | 0 | 163 | 0.7 | 60 |
| 5b | 09/25/03 | 5 | 0 | 1 | 190 | 0.7 | 57 |
| 5b | 10/10/03 | 38 | 2 | 9 | 200 | 0.8 | 56 |
| 5b | 10/24/03 | 20 | 12 | 8 | 200 | 0.8 | 55 |
| 5b | 11/07/03 | 1 | 9 | 1 | 208 | 0.9 | 53 |
| *5 all* | *Totals* | | *34* | *21* | | | |
| 6 | 04/25/03 | No Survey (high turbidity) | | | 439 | | |
| 6 | 05/23/03 | 8 | 0 | 0 | 255 | 1.2 | 59 |
| 6 | 06/20/03 | 4 | 0 | 0 | 149 | 0.7 | 62 |
| 6 | 07/18/03 | 6 | 0 | 0 | 96 | 0.9 | 69 |
| 6 | 08/29/03 | 6 | 0 | 0 | 93 | 1.1 | 67 |
| 6 | 09/12/03 | 34 | 0 | 0 | 182 | 1.2 | 63 |
| 6 | 09/26/03 | 415 | 10 | 98 | 190 | 0.8 | 60 |
| *6* | *Totals* | | *10* | *98* | | | |
| *5b-6* | *Totals* | | *33* | *117* | | | |
| *1-5a* | *Totals* | | *25* | *53* | | | |

[a] Counts may include multiple observations of the same salmon between surveys.
[b] Supplemental survey.
[c] A picket weir was installed in Reach 5 on 09/02/2003 and removed on 11/03/2003. Reach 5 was divided into 5a (upstream of weir) and 5b (downstream).

Table A2.—USFWS Clear Creek snorkel survey observations in 2004 of live adult Chinook, carcasses, and new redds. Survey conditions include stream flow, average turbidity, and average water temperature. Carcasses and new redds observed during weir monitoring were included in the next Reach 5 snorkel survey.

| Reach | Date | Chinook [a] | Carcasses | New redds | Flow (ft/s) | Turbidity (NTU) | Temp (˚F) |
|---|---|---|---|---|---|---|---|
| 1 | 04/26/04 | 0 | 0 | 0 | 253 | 1.6 | 50.0 |
| 1 | 05/17/04 | 0 | 0 | 0 | 240 | 1.2 | 51.6 |
| 1 | 06/15/04 | 0 | 0 | 0 | 173 | 0.9 | 54.0 |
| 1 | 07/12/04 | 0 | 0 | 0 | 72 | 0.6 | 55.5 |
| 1 | 08/09/04 | 0 | 0 | 0 | 82 | 0.8 | 57.0 |
| 1 | 08/23/04 | 4 | 0 | 0 | 82 | 0.8 | 55.3 |
| 1 | 09/07/04 | 9 | 0 | 0 | 75 | 1.1 | 57.5 |
| 1 | 09/20/04 | 4 | 0 | 0 | 182 | 0.8 | 54.5 |
| 1 | 10/04/04 | 1 | 1 | 6 | 217 | 1.0 | 55.5 |
| 1 | 10/18/04 | 0 | 0 | 0 | 189 | 0.8 | 54.0 |
| 1 | 11/01/04 | 2 | 0 | 0 | 215 | 0.6 | 53.5 |
| 1 | 11/15/04 | 0 | 0 | 0 | 217 | 0.6 | 51.5 |
| *1* | *Totals* | | *1* | *6* | | | |
| 2 | 04/27/04 | 0 | 0 | 0 | 250 | 1.5 | 53.0 |
| 2 | 05/18/04 | 0 | 0 | 0 | 236 | 0.9 | 54.0 |
| 2 | 06/15/04 | 1 | 0 | 0 | 173 | 1.2 | 57.0 |
| 2 | 07/13/04 | 12 | 0 | 0 | 72 | 0.6 | 56.0 |
| 2 | 08/10/04 | 19 | 1 | 0 | 82 | 0.6 | 59.0 |
| 2 | 08/24/04 | 25 | 0 | 0 | 75 | 0.9 | 57.0 |
| 2 | 09/07/04 | 18 | 1 | 0 | 75 | 0.9 | 57.0 |
| 2 | 09/21/04 | 9 | 0 | 9 | 181 | 1.1 | 56.8 |
| 2 | 10/07/04 | 1 | 1 | 0 | 217 | 1.9 | 56.0 |
| 2 | 10/20/04 | 0 | 0 | 0 | 197 | 0.8 | 51.5 |
| 2 | 11/01/04 | 0 | 0 | 0 | 215 | 0.9 | 52.0 |
| 2 | 11/16/04 | 0 | 0 | 0 | 217 | 0.7 | 53.0 |
| *2* | *Totals* | | *3* | *9* | | | |
| 3 | 04/28/04 | 0 | 0 | 0 | 250 | 1.3 | 51.5 |
| 3 | 05/19/04 | 0 | 0 | 0 | 236 | 1.4 | 52.8 |
| 3 | 06/16/04 | 6 | 0 | 0 | 170 | 0.8 | 56.5 |
| 3 | 07/14/04 | 2 | 0 | 0 | 74 | 0.4 | 55.5 |
| 3 | 08/11/04 | 8 | 1 | 0 | 82 | 0.7 | 56.0 |
| 3 | 08/25/04 | 9 | 4 | 0 | 75 | 0.7 | 60.5 |
| 3 | 09/08/04 | 3 | 0 | 0 | 75 | 0.7 | 57.5 |
| 3 | 09/22/04 | 3 | 0 | 3 | 182 | 1.0 | 55.5 |
| 3 | 10/07/04 | 0 | 0 | 0 | 217 | 0.9 | 52.5 |
| 3 | 10/21/04 | 1 | 0 | 0 | 194 | 1.0 | 49.0 |
| 3 | 11/01/04 | 0 | 0 | 0 | 215 | 0.8 | 49.5 |
| 3 | 11/17/04 | 1 | 0 | 0 | 217 | 0.8 | 52.0 |
| *3* | *Totals* | | *5* | *3* | | | |
| 4 | 04/29/04 | 3 | 0 | 0 | 225 | 1.2 | 52.5 |
| 4 | 05/20/04 | 6 | 0 | 0 | 236 | 1.0 | 55.5 |
| 4 | 06/17/04 | 16 | 0 | 0 | 170 | 0.9 | 58.0 |
| 4 | 07/15/04 | 28 | 0 | 0 | 72 | 0.6 | 61.0 |
| 4 | 08/12/04 | 10 | 0 | 0 | 82 | 0.7 | 60.5 |
| 4 | 08/26/04 | 29 | 0 | 0 | 75 | 0.7 | 60.5 |
| 4 | 09/09/04 | 9 | 1 | 3 | 75 | 0.9 | 62.5 |
| 4 | 09/22/04 | 5 | 1 | 7 | 182 | 1.4 | 57.5 |
| 4 | 10/08/04 | 1 | 2 | 4 | 217 | 2.0 | 54.3 |
| 4 | 10/21/04 | 6 | 0 | 0 | 194 | 0.9 | 53.0 |
| 4 | 11/02/04 | 9 | 0 | 0 | 215 | 1.1 | 50.5 |
| 4 | 11/18/04 | 0 | 1 | 0 | 216 | 0.5 | 52.5 |
| *4* | *Totals* | | *5* | *14* | | | |
| 5 | 04/29/04 | 21 | 0 | 0 | 225 | 1.2 | 52.5 |
| 5 | 05/20/04 | 22 | 0 | 0 | 236 | 1.0 | 55.5 |
| 5 | 06/17/04 | 31 | 0 | 0 | 170 | 0.9 | 58.0 |
| 5 | 07/15/04 | 25 | 0 | 0 | 72 | 0.6 | 61.0 |
| 5a [b] | 08/12/04 | 0 | 0 | 0 | 82 | 0.7 | 60.5 |
| 5a | 08/26/04 | 1 | 0 | 0 | 75 | 0.7 | 60.5 |
| 5a | 09/09/04 | 2 | 0 | 0 | 75 | 0.9 | 62.5 |
| 5a | 09/23/04 | 9 | 0 | 5 | 212 | 0.8 | 57.5 |
| 5a | 10/08/04 | 0 | 23 | 0 | 217 | 0.9 | 56.0 |
| 5a | 10/22/04 | 4 | 10 | 0 | 215 | 0.9 | 50.0 |
| 5a | 11/02/04 | 0 | 16 | 0 | 215 | 1.2 | 50.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5a | 11/18/04 | 0 | 0 | 0 | 216 | 0.5 | 52.5 |
| 5b | 08/12/04 | 25 | 0 | 0 | 82 | 0.7 | 60.5 |
| 5b | 08/26/04 | 17 | 0 | 0 | 75 | 0.7 | 60.5 |
| 5b | 09/09/04 | 14 | 0 | 0 | 75 | 0.9 | 62.5 |
| 5b | 09/23/04 | 35 | 1 | 13 | 212 | 0.8 | 57.5 |
| 5b | 10/08/04 | 42 | 10 | 13 | 217 | 0.9 | 56.0 |
| 5b | 10/22/04 | 6 | 4 | 0 | 215 | 0.9 | 50.0 |
| 5b | 11/02/04 | 9 | 6 | 1 | 215 | 1.2 | 50.0 |
| 5b | 11/18/04 | 3 | 2 | 0 | 216 | 0.5 | 52.5 |
| *5 all* | *Totals* | | *72* | *32* | | | |
| 6 | 05/01/04 | 56 | 0 | 0 | 250 | 1.3 | 56.5 |
| 6 | 05/21/04 | 65 | 0 | 0 | 236 | 1.0 | 59.0 |
| 6 | 06/18/04 | 57 | 0 | 1 | 170 | 0.8 | 63.5 |
| 6 | 07/16/04 | 31 | 1 | 0 | 72 | 0.6 | 70.5 |
| 6 | 08/13/04 | 21 | 0 | 0 | 82 | 0.8 | 68.0 |
| 6 | 08/27/04 | 13 | 0 | 0 | 75 | 0.7 | 66.5 |
| 6 | 09/10/04 | 18 | 0 | 0 | 82 | 0.8 | 67.5 |
| 6 | 09/24/04 | 156 | 0 | 62 | 212 | 0.9 | 58.5 |
| 6 | 11/30/04[c] | 276 | | 1419 | 215 | 0.8 | 50.0 |
| *6* | *Totals* | | *1* | *63* | | | |
| *5b-6* | *Totals* | | *24* | *90* | | | |
| *1-5a* | *Totals* | | *63* | *37* | | | |

[a] Counts may include multiple observations of the same salmon between surveys.
[b] A picket weir was installed in Reach 5 on 08/26/2004 and removed on 11/01/2004. Reach 5 was divided into 5a (upstream of weir) and 5b (downstream).
[C] A supplemental redd count survey following the spring-run survey period. Not included in reach total.

TABLE A3.—Information on adipose-fin clipped Chinook carcasses and coded-wire tags (CWT) recovered by the USFWS on Clear Creek in 2003 and 2004 including carcasses recovered on surveys other than the spring Chinook snorkel survey.[a]

| Survey | Date | Reach | CWT code [b] | Run | Origin [c] | Brood year | Sex | Fork length (mm) |
|---|---|---|---|---|---|---|---|---|
| Picket Weir | 10/01/03 | R5b | 601120406 | Spring | Butte Creek | 2000 | Female | 675 |
| Picket Weir | 10/17/03 | R5a | NTD | | | | Female | 760 |
| Picket Weir | 10/14/04 | R5a | 601000402 | Spring | Butte Creek | 2002 | unknown | 470 |
| Late-fall Carcass Survey | 01/09/03 | R6 | 55210 | Late-fall | CNFH | 1999 | Female | 820 |
| Late-fall Carcass Survey | 01/09/03 | R6 | 55207 | Late-fall | CNFH | 1999 | Male | 845 |
| Late-fall Carcass Survey | 01/17/03 | R6 | 55134 | Late-fall | CNFH | 1999 | Male | unknown |
| Late-fall Carcass Survey | 01/15/04 | R6 | 50397 | Late-fall | CNFH | 2000 | Female | 900 |
| Late-fall Carcass Survey | 01/15/04 | R6 | 50768 | Late-fall | CNFH | 2001 | Male | 740 |
| Late-fall Carcass Survey | 01/30/04 | R6 | 50768 | Late-fall | CNFH | 2001 | Female | 760 |
| Late-fall Carcass Survey | 12/16/04 | R6 | 51778 | Late-fall | CNFH | 2003 | unknown | 470 |
| Other | 02/06/03 | R6 | 55133 | Late-fall | CNFH | 1999 | Male | 870 |
| Other | 02/20/03 | R6 | 50467 | Late-fall | CNFH | 2000 | Female | unknown |
| Other | 12/02/04 | R6 | 64930 | Fall | MOK | 2001 | Male | 735 |

[a] Most CWT recoveries on Clear Creek are made by California Department of Fish and Game during their fall Chinook carcass survey and are not included in this report.
[b] NTD = No tag detected.
[c] Butte Creek = Butte Creek wild stock, CNFH = Coleman National Fish Hatchery, MOK = Mokelumne River Fish Installation.