Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from March through November 2008

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Abstract- The purpose of our monitoring project was to provide fisheries information for the adaptive management of anadromous salmonid restoration projects in Battle Creek including the Interim Flow Project and the Battle Creek Salmon and Steelhead Restoration Project. Our adult salmonid monitoring investigations included (1) salmonid escapement estimates at the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder and (2) stream surveys documenting salmonid spawning distributions upstream of the barrier weir. Monitoring activities occurred from March through November 2008.

In 2008, we estimated five clipped and 105 unclipped Chinook salmon *Oncorhynchus tshawytscha*, passed through the Coleman National Fish Hatchery barrier weir (rm 5.8) to the middle portion of Battle Creek, from March 1 to August 1. This passage number was lower than the previous two years and lower than the average passage from 2001-2007. We used the unclipped passage total to estimate the “maximum potential spring Chinook” escapement. It is likely that a proportion of this maximum estimate were actually winter, fall, and late-fall Chinook due to overlap in migration periods. Run-specific Chinook salmon population estimates presented in previous annual reports were based, in part, on genetic analyses, which classified proportions of a sample group as winter, spring, fall, or late-fall run. At the time of writing this report, genetic analysis had not yet been performed. CNFH personnel released an additional 19 unclipped Chinook above the barrier weir prior to opening the barrier weir fish ladder on March 1. While these 19 Chinook could have been from any of the four runs, they were most likely late-fall Chinook. Based on stream survey redd counts (40 total redds), we estimate a spawning population of 80 spring Chinook.

We estimated that one clipped and 120 unclipped rainbow trout passed upstream of the barrier weir fish ladder between March 1 and August 1, 2008. CNFH released an additional 159 unclipped rainbow trout above the barrier weir prior to March 1.

Unlike previous years, we used an instream video monitoring setup to count upstream migrating salmonids after our trapping season ended. We moved to this style of video monitoring due the CNFH Barrier Weir Improvement Project. The barrier weir was undergoing construction at the time of monitoring and we were unable to use our typical method.

Overall, water temperatures in 2008 were adequate for spring Chinook to successfully produce juveniles, but at a reduced number due to high temperatures during the spring Chinook holding period. During the holding period, 72% of mean daily water temperatures were categorized as fair or poor in the most utilized holding pool, which likely led to some reduced fertility and adult mortality. During the egg incubation period, mean daily water temperatures at redds were categorized as excellent for 88.8 to 96.3% of the days, suggesting there was little or no temperature-related egg mortality.

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Introduction

Battle Creek is important to the conservation and recovery of federally listed anadromous salmonids in the Central Valley of California. Restoration actions and projects, planned or underway in Battle Creek, focus on providing habitat for three federally listed species in the Central Valley Evolutionary Significant Unit (ESU); the endangered winter Chinook salmon *Oncorhynchus tshawytscha*, threatened spring Chinook salmon (Chinook), and threatened steelhead *Oncorhynchus mykiss*. Currently, the geographic range of the winter Chinook ESU is limited to a small area in the mainstem of the Sacramento River between Keswick Dam and Red Bluff, California, where it may be susceptible to catastrophic loss (Figure 1). Establishing a second population in Battle Creek could reduce the possibility of extinction. Battle Creek also has the potential to support significant, self-sustaining populations of spring Chinook and steelhead, which is crucial to their recovery.

Since the early 1900's, a hydroelectric power generating system of dams, canals, and powerhouses, now owned by Pacific Gas and Electric Company (PG&E), has operated in the Battle Creek watershed in Shasta and Tehama Counties, California. The hydropower system has had severe impacts upon anadromous salmonids and their habitat (Ward and Kier 1999). In 1992, the Central Valley Project Improvement Act (CVPIA) federally legislated efforts to double populations of Central Valley anadromous salmonids. The CVPIA Anadromous Fisheries Restoration Program outlined several actions necessary to restore Battle Creek, including the following: “to increase flows past PG&E’s hydropower diversions in two phases; to provide adequate holding, spawning, and rearing habitat for anadromous salmonids (USFWS 2001a).”

The Ecological Restoration Program (ERP) of the federal and State of California interagency program known as CALFED, PG&E, and other contributors funded the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). The Restoration Project will provide large increases in minimum instream flows in Battle Creek, remove five dams, and construct fish ladders and fish screens at three other dams. Planning, designing, and permitting of the Restoration Project have taken longer than originally anticipated.

PG&E is required under its current Federal Energy Regulatory Commission (FERC) license to provide minimum instream flows of 3 cubic feet per second (cfs) downstream of diversions on the North Fork Battle Creek (North Fork) and 5 cfs downstream of diversions on the South Fork Battle Creek (South Fork). Beginning in 1995, the CVPIA Water Acquisition Program (1995 to 2000) and ERP (2001 to present) contracted with PG&E to increase minimum instream flows in the lower Reaches of the North Fork and South Fork. In general, flows are increased to 30 cfs +/- 5 cfs below Eagle Canyon Dam on the North Fork and below Coleman Diversion Dam on the South Fork. Increased flows were not provided on the South Fork in 2001 and most of 2002, due in part to lack of funds. Based on an agreement in 2003, flows can be redistributed between the forks to improve overall conditions for salmonids, based on water temperatures and the distribution of live Chinook and redds.

The ERP funded Interim Flow Project will continue until the Restoration Project construction begins (currently scheduled for early spring 2010). The intent of the Interim Flow Project is to provide immediate habitat improvement in the lower Reaches of Battle Creek to sustain current natural salmonid populations while implementation of the more comprehensive Restoration Project moves forward.

The goal of our monitoring project is to provide fisheries information for the adaptive management of anadromous salmonid restoration in Battle Creek including the Interim Flow

Project and the Restoration Project when it comes online. The Red Bluff Fish and Wildlife Office (RBFWO) carried out the current investigations in 2008, under a 3-year grant from ERP. This grant was designed to support most of the monitoring needs of the Restoration Project's Adaptive Management Plan (Terraqua Inc. 2004). Our monitoring investigations included (1) salmonid escapement estimates at the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder, (2) stream surveys documenting salmonid spawning distributions upstream of the barrier weir, and (3) juvenile salmonid production estimates (not included in this report). Tables summarizing data from previous years are included in this report (Tables 1-6).

Study Area

Battle Creek is located in southern Shasta and northern Tehama counties, California, and is fed by the volcanic slopes of Lassen Peak in the southern Cascade Range and numerous springs (Figure 1). Battle Creek eventually enters the Sacramento River (river mile (rm) 272) east of the town of Cottonwood, California. Battle Creek is comprised of the North Fork (approx. 29.5 miles in length from head waters to confluence), the South Fork (approx. 28 miles in length from headwaters to confluence), the mainstem Battle Creek (16.6 miles from the confluence of the north and south forks to the Sacramento River), and many tributaries. Battle Creek has been identified as having high potential for fisheries restoration because of its relatively high and consistent flow of cold water. It has the highest base flow (dry-season flow) of any tributary to the Sacramento River between the Feather River and Keswick Dam (Ward and Kier 1999). Our study areas were at the CNFH barrier weir on the mainstem Battle Creek (rm 5.8), the North Fork below Eagle Canyon Dam (5.3 miles in length), the South Fork below Coleman Diversion Dam (2.5 miles in length), and the mainstem Battle Creek above rm 5.8 (10.8 miles in length)(Figure 2). Eagle Canyon Dam and Coleman Diversion Dam are considered the upstream limits of anadromous salmonid distribution during the study because fish ladders on the dams are closed.

Methods

We used the CNFH barrier weir fish trap and video counts along with stream surveys to monitor adult salmonids in Battle Creek between March and November. Chinook salmon and steelhead returning to Battle Creek were classified as either unclipped (adipose fin present) or clipped (adipose fin absent). We considered all clipped Chinook and rainbow trout to be hatchery-origin and unclipped Chinook to be either natural-origin or hatchery-origin (not all hatchery Chinook are clipped). We considered all unclipped rainbow trout to be natural-origin as CNFH has clipped 100% of their steelhead production since 1998. It is likely that unclipped Chinook returning to Battle Creek during our monitoring period are mostly spring Chinook. However, it is possible that some unclipped Chinook are late-fall, winter, or fall run due to overlapping periods of migration. Therefore, we chose not to classify all unclipped Chinook as spring run. We use the term "rainbow trout" to refer to all *Oncorhynchus mykiss,* including anadromous steelhead, because of the difficulties in differentiating the anadromous and resident forms in the field.

Coleman National Fish Hatchery Barrier Weir

Operation of the CNFH barrier weir (the barrier weir) blocked upstream passage of fish through the fish ladder from August 1, 2007 to March 1, 2008. During this period, fish were periodically directed into holding ponds at CNFH, where fall and late-fall Chinook and rainbow trout were used in propagation programs. Upstream passage at the Battle Creek barrier weir was allowed from March 1 through August 1, 2008 by opening the fish ladder. We initially monitored upstream fish passage from March 1 through August 1 by using a live trap and later switched to underwater videography.

In 2008, the CNFH was in the second year of the construction on the Barrier Weir Improvement Project (BWIP). In 2007, our operations were not modified. Whereas, in 2008, adjustments were made in order to avoid interference with the construction project. Our methods were the same for weir trapping but not for the video monitoring.

Trapping.—A false bottom fish trap, located at the upstream end of the fish ladder, was used to capture Chinook, rainbow trout, and other non-target species as they migrated upstream. The trap operated approximately 8-h a day, 7-d a week. To decrease potential passage delays for Chinook, we implemented two time shifts based on diel movement patterns observed in previous years: 0930-1730 (PST) from March 1 to mid-April and 0430-1230 (PDT) from mid-April until May 16, when video monitoring began. During hours when the trap was not operated, fish were allowed to enter the trap, but the exit remained closed blocking upstream passage. Prior to operation each morning, the trap was cleaned, weather conditions were noted, and water temperatures were documented. Every 2 h, water temperature was recorded. When water temperature exceeded 60ºF, we stopped trapping for that day to minimize the stress caused by handling fish at high temperatures. Trapping was terminated for the season and videography began when water temperatures exceeded 60ºF for a majority of the daily trap operation period.

During operation, the trap was checked every 30 min. We identified non-target fish species, counted, and released native fish upstream and non-native fish downstream. We netted salmonids from the trap and immediately transferred them to a holding trough, where we collected biological data. Water temperature in the holding trough was maintained within 2ºF of Battle Creek water temperatures.

Salmonids were measured (fork length) to the nearest 0.5 cm, identified as male or female when possible, and examined for scars and tissue damage. Salmonids were also examined for the presence of a mark such as an adipose-fin clip, Floy tag, or Visible Implant Elastomer (VIE) tag. A tissue sample was taken from unclipped Chinook and rainbow trout for genetic analysis. All clipped Chinook were sacrificed and coded-wire tags (CWTs) extracted and decoded to determine run designation, hatchery of origin, and age. Since only a fraction of the clipped rainbow trout are tagged with a CWT, they were first scanned using a V-detector or a handheld wand detector (Northwest Marine Technology). Clipped trout with a CWT were sacrificed for tag recovery. Clipped trout without a CWT were transported live to a CNFH raceway. The CNFH has a program where they recondition, VIE tag and release steelhead kelts into lower Battle Creek. If reconditioned kelts were captured in the trap, they were released downstream.

Video counts.—Due to construction of the at the CNFH barrier weir, video monitoring could not take place at the typical location. Previously we installed an underwater camera at the weir trap. Instead, we installed a temporary weir to guide fish through an 8-foot-wide center opening and used overhead and underwater cameras to monitor fish passage. The temporary weir was installed approximately 50 yards upstream of the CNFH barrier weir.

California Fish and Game assisted us in the setup of a video monitoring system. The same style of video weir is used for fall Chinook monitoring on lower Battle, Cottonwood, and Cow Creeks (Killam 2006, Killam 2007, and Killam 2008). The weir directed fish to pass through a viewing area. In the viewing area, we installed two 4 ft by 10 ft white high-density polyethylene (HDPE) sheets to create a platform on the streambed, to increase visibility of passing fish. This platform also had a fish-measuring device on it, so the video readers could determine if the fish that passed were greater than 16 inches. One wing of the weir was an Alaska-style picket weir. The other wing was constructed with panels created out of 1 $^{1/8}$ horizontal steel pipe (Killam 2006, Killam 2007, and Killam 2008).

A black and white camera, used for fish detection was suspended above the viewing area (Killam 2006, Killam 2007, and Killam 2008). This camera's viewing extent covered downstream of the platform, the entire platform and upstream of the platform. Three underwater wide-angle color cameras were setup on the white viewing platform. One was on the river left side at the downstream edge of the platform, another was across on the river right downstream edge of the platform, and the last one was placed in the middle of the board above the measuring device facing river right. These three cameras were used for species identification. All four cameras where then fed into a four-channel DVR (Supercircuits type QS-29), which merged the four images onto on monitor (Killam 2008). We used three field DVRs and switched them out on a 7-d rotation. The video record from the field DVRs was then played through our Honeywell Fusion DVR (Newton et al. 2007) for storage and viewing. A lighting system allowed for 24-h monitoring.

Recording of fish passage began on May 16 and continued to August 1. On June 20, a thunderstorm caused a seven minute power outage and lightening struck our overhead camera, resulting in the discontinued use of it. We continued recording with the three underwater cameras, until June 24. At this point we installed an interim overhead camera that was not ideal for night recording. On July 3, we received and installed the replacement camera. The 8-d period prior to the installation of the replacement camera had night video that was very difficult to view.

Digital video footage was later viewed in fast-forward mode until a fish was observed, then reviewed at slow playback speed or "freeze frame" mode to assist in species identification and mark detection. The certainty of the observation was rated as good, fair, or poor. A good rating signified complete confidence in determining species and the presence or absence of an adipose fin; fair suggested confidence in determining species and the presence or absence of an adipose fin but additional review was needed; and poor suggested uncertainty in determining species and the presence or absence of an adipose fin.

Picture quality was also rated as good, fair, or poor. Good signified a clear picture; fair indicated that objects were discernable but extra review was needed; and poor indicated that some objects were indistinguishable. Passage was estimated for periods of poor picture quality based on passage rates during adjacent periods of good and fair picture quality.

Five-second clips of all Chinook and rainbow trout passing the barrier weir were recorded onto a DVD, which was reviewed by more experienced personnel to confirm species identification and the presence or absence of an adipose fin. The total number of clipped and unclipped Chinook and rainbow trout observed was recorded. If the adipose fin was unidentifiable, then Chinook and rainbow trout were classified as unknown clip status.

Additionally, the hours of possible fish passage and the hours of video-recorded fish passage were logged.

For quality assurance (QA) purposes, every third day of video monitoring was viewed a second time by a separate staff member. Annual error rates were calculated for primary viewers and QA viewers as the percent of salmonids not seen. We used the combined observations from both groups to derive the estimated total number of salmonids seen. QA measures were used to identify training needs and give a general indication amount of negative bias in our passage estimates during the video monitoring period. Observations from the QA process were included in official counts for those days but error rates were not used as correction factors for non-QA days.

Passage estimation.—We estimated the number of clipped and unclipped Chinook and rainbow trout passing through the barrier weir fish ladder. For each week of trapping, total passage of clipped and unclipped salmonids was estimated by apportioning unknown clip status Chinook or rainbow trout counts (e.g., fish that accidentally escaped the trap prior to being examined for an adipose fin) according to the proportion of clipped and unclipped fish captured during the same week. For each week of video monitoring, total passage was estimated by apportioning any unknown clip status fish and then expanding observed counts according to the amount of time passage was allowed, but not recorded due to poor video quality or equipment malfunction. Total passage was calculated by summing weekly passage estimates at the barrier weir as well as the number of clipped and unclipped Chinook and rainbow trout released into upper Battle Creek by CNFH prior to March 1. The equations used for estimating passage during barrier weir trapping were

$$P_{tu} = \sum_{i=1}^{n} \left(\left[\frac{u_i}{c_i + u_i} \cdot unk_i \right] + u_i \right)$$

and

$$P_{tc} = \sum_{i=1}^{n} \left(\frac{c_i}{c_i + u_i} \cdot unk_i \right)$$

where P_{tu} = passage estimate for unclipped Chinook or rainbow trout during barrier weir fish trap operation; P_{tc} = passage estimate for clipped Chinook or rainbow trout during barrier weir fish trap operation; c_i = actual number of clipped Chinook or rainbow captured at the barrier weir during week *i* (not passed upstream); u_i = actual number of unclipped Chinook or rainbow trout observed passing the barrier weir during week *i*; and unk_i = actual number of unknown clip status Chinook or rainbow trout observed passing the barrier weir during week *i*. The equations used for estimating passage during barrier weir video counting were

$$P_{vu} = \sum_{i=1}^{n} \left(\left[\frac{u_i}{c_i + u_i} \cdot unk_i \right] + u_i \right) \cdot \left(\frac{T_i}{V_i} \right)$$

and

$$P_{vc} = \sum_{i=1}^{n} \left(\left[\frac{c_i}{c_i + u_i} \cdot unk_i \right] + c_i \right) \cdot \left(\frac{T_i}{V_i} \right)$$

where P_{vu} = passage estimate for unclipped Chinook or rainbow trout during barrier weir video monitoring; P_{vc} = passage estimate for clipped Chinook or rainbow trout during barrier weir video monitoring; c_i = actual number of clipped Chinook or rainbow trout observed passing the barrier weir during week i; u_i = actual number of unclipped Chinook or rainbow trout observed passing the barrier weir during week i; unk_i = actual number of unknown clip status Chinook or rainbow trout observed passing the barrier weir during week i; T_i = number of hours of unrestricted fish passage at the barrier weir during week i; and V_i = number of hours of actual good and fair video recorded fish passage at the barrier weir during week i.

Migration timing.—Migration timing past the barrier weir was determined using fish trap and video counting data. The number of clipped and unclipped Chinook and rainbow trout passing the barrier weir was summed weekly and plotted. Peak as well as onset and termination of migration were noted.

Size, sex, and age composition.—We recorded fork length and sex of Chinook and rainbow trout captured in the barrier weir fish trap and from Chinook carcasses retrieved during stream surveys. Length-frequency distributions were developed and male to female sex ratios were calculated. The age of returning Chinook was determined for coded-wire tagged fish and length-at-age plots were developed.

Stream Surveys

The annual spring-Chinook snorkel surveys were scheduled to occur in June, and then twice a month from September to November. The primary purpose of these surveys was to collect data on the spatial and temporal distribution of live spring Chinook and spawning habitat. The 18.6-mile survey was divided into six Reaches upstream of the barrier weir (Table 7; Figure 2) and usually required 4 d to complete, depending on personnel availability and flow conditions. Surveys were scheduled on consecutive weekdays beginning at the uppermost reaches and working downstream.

While moving downstream with the current, three snorkelers counted Chinook, carcasses, and redds. Generally, snorkelers were adjacent to each other in a line perpendicular to the flow. When entering large plunge pools where Chinook could be concealed below bubble curtains, one snorkeler would portage around and enter at the pool tail to count Chinook, while the other two snorkelers would enter at the head of the pool through the bubble curtain. When groups of Chinook were encountered, snorkelers would confer with each other to make sure salmon were not missed or double counted.

When survey personnel encountered carcasses, they would collect tissue for genetic analyses, scales for age determination, and record biological information such as fork length, sex, egg retention, and presence or absence of a tag and 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 or lack of a complete carcass. Coded-wire tags were later extracted from heads in the laboratory.

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 measured at three gauging stations operated by California Department of Water Resources (DWR) or the US Geological Survey (USGS). The gauging stations on the North Fork (BNF), South Fork (BAS), and mainstem Battle Creek (BAT) were at Wildcat Road Bridge (rm 0.9), Manton Road Bridge (rm 1.7), and CNFH (rm 5.8), respectively. Turbidity samples were taken at the beginning and end of each reach and analyzed the same day using a Model 2100 Hach Turbidimeter. An average turbidity value was calculated for each survey day. For surveys when only one turbidity sample was taken, we used that value. Water temperatures were measured at the beginning and end of each reach using a hand held submersible thermometer.

Holding location.—We located holding areas of Chinook through snorkel surveys. The date and number of Chinook observed per reach were recorded and exact coordinates of these locations were documented using a hand held Global Positioning System (GPS) receiver (Garmin Etrex or Trimble GeoXH). We used thermal criteria presented by Ward and Kier (1999) to evaluate the suitability of water temperatures in Battle Creek for adult spring Chinook holding from June 1 through September 30. We labeled Ward and Kier's four categories as good, fair, poor, and very poor. Continuous water temperature data was collected at three locations on the South Fork (Reach 3), four locations on the North Fork (Reaches 1 and 2), and five locations on the mainstem (Reaches 4-6). Temperature data was obtained from Onset HOBO Water Pro V2™ temperature loggers installed and maintained by the RBFWO and from two DWR gauging stations located at the Manton Road Bridge on the South Fork and the Wildcat Road Bridge on the North Fork. Evaluating temperatures at these sites provided a range of conditions Chinook may have been exposed to when holding in Battle Creek.

Spawning location and timing.—We located Chinook spawning areas and estimated time of spawning. The number of redds per reach and the date each redd was first observed were recorded. Coordinates of redds were documented using a GPS receiver. All redds were aged and marked in the field with flagging and given a unique identification number in order to differentiate between old and new redds. Redd age categories were 1) clearly visible and clean; 2) older with flattened tailspill, fine sediment in pit, or algae growth; 3) old and hard to discern; and 4) redd no longer visible. Based on redd ages and the number of redds, we attempted to determine the beginning, peak, and end of Chinook spawning.

We used thermal criteria modified from Ward and Kier (1999) to evaluate the suitability of water temperatures in Battle Creek for spring Chinook egg incubation. We added an additional category of 56°F to Ward and Kier's four-category system for water temperatures (Table 8). This additional category was added because other Central Valley streams have 56°F as a temperature target for Chinook egg incubation (NMFS 2002, USFWS 2001a). We labeled the five categories as excellent, good, fair, poor, and very poor.

We evaluated the potential effect of water temperature on egg survival at each individual Chinook redd by estimating the number of days eggs that were exposed to each temperature category. Mean daily temperatures (MDTs) at redd locations were estimated by plotting daily temperature monitoring data (X-axis = river mile, Y-axis = MDT) and using the equation of a straight line connecting two adjacent monitoring sites to interpolate MDT for a redd at a given river mile. Estimated days of exposure to each temperature category was based on the criteria where 1,850 Daily Temperature Units (DTU = $MDT_{°F}$ - $32_{°F}$) were required for egg incubation to time of emergence. The 1,850 DTU requirement is within the reported range for juvenile Chinook (Heming 1982, Murray and McPhail 1988) and was estimated specifically for Battle Creek based on rotary screw trap catch data and stream survey data (Earley and Brown 2004). The best-case scenario was calculated based on a redd construction date of the day preceding the survey when the redd was first observed. The worst-case scenario was calculated based on a redd construction date of the day following the preceding survey because water temperatures are generally warmer earlier in the spawning season.

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 = $\pi \bullet \frac{1}{2}$ width $\bullet \frac{1}{2}$ 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 measured at the same location as the pre-redd depth. We collected velocity measurements with a General Oceanics model 2030 mechanical flow meter. Dominant substrate size was classified using methods described by USFWS (2005).

Tissue Collection for Genetic Analyses

Tissue samples were collected from unclipped Chinook captured at the fish trap and from carcasses collected during stream surveys. We used either scissors or a hole punch to obtain four small pieces of fin tissue. Three pieces were stored in small vials containing ethanol and one was dried and stored in a scale envelope (not collected from weir trap samples). Samples were archived at the RBFWO. At the time this report was written, genetic results were not available. Future genetic analyses will classify individual fish as spring, winter, fall, or late-fall Chinook.

Age Structure

We determined the age of returning spring Chinook by reading scales collected from carcasses recovered upstream of the CNFH barrier weir. 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. We dried the scales for about 24 h 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. The age was determined to be the number of annuli plus one (Borgerson 1998). Two readers independently aged each scale. If results were different, the scale was read a third time cooperatively by the same two readers. 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 CNFH.

Spring Chinook Population Trend Analysis

Passage of adult spring Chinook into upper Battle Creek has been monitored for 14 consecutive years (1995-2008). We used simple linear regression to determine the population trend for this period. Year was treated as the independent (predictor) variable and the annual total number of unclipped Chinook (a.k.a., maximum potential spring run) was treated as the dependent (response) variable. The slope of the regression line can be taken as a measure of trend.

Results

Coleman National Fish Hatchery Barrier Weir

Trapping.—A total of 203 Chinook were captured in the barrier weir trap between March 1 and May 16, 2008. Of these, 175 were clipped and 28 were unclipped (Table 9). We retrieved coded-wire tags (CWT) from 162 clipped Chinook captured in the trap. Out of the 162 tags recovered, 161 fish were late-fall Chinook from CNFH and one was a spring Chinook from

Feather River Hatchery (Appendix A1). The spring Chinook was captured in the trap on May 5, and was a 4-year-old fish.

A total of 154 rainbow trout were captured in the barrier weir trap and 98 unclipped trout and three unknown clip status fish were released upstream (escapement). Of the 154 that were captured, 47 were clipped, 104 were unclipped, and three were unknown clip status (Table 10). There were six unclipped rainbow trout mortalities and one clipped rainbow trout mortality. Other species captured in the trap and passed upstream included 6,389 Sacramento sucker (*Catostomus occidentalis*), 55 Sacramento pikeminnow (*Ptychocheilus grandis),* and 120 hardhead (*Mylopharodon conocephalus).*

We documented two rainbow trout that passed above the barrier weir fell back downstream of the weir, and were recaptured in the trap. One fish was initially passed upstream during the CNFH rainbow trout propagation program before March 1 and the second fish was passed during our trapping operations after March 1.

Video counts.—A total of 82 Chinook were observed passing through the video monitoring weir between May 16 and August 1, 2008. Of these, 55 were unclipped, 4 were clipped, and 23 were of unknown clip status (Table 9). Extrapolation for poor picture quality or video equipment malfunction resulted in a passage estimate of 77 unclipped and 5 clipped Chinook. We observed no Chinook passing above the barrier weir for a 21-day period starting on July 11 until the closing of the weir on August 1 (Table 9, Figure 8). Similar periods of no fish passage from mid-July through early August occurred in 2000-2006 (Brown and Newton 2002; Brown et al. 2005; Brown and Alston 2007; Alston et al. 2007; Newton et al. 2007, Newton et al. 2008).

We observed a total 20 rainbow trout passing through the barrier weir fish ladder during the video monitoring period. Of these, 16 were unclipped, 1 was clipped, and 3 were of unknown clip status (Table 10). Extrapolation for poor viewing quality or equipment malfunction resulted in a passage estimate of 18 unclipped and 1 clipped rainbow trout. Other species observed passing upstream; included 1,072 Sacramento suckers, 226 Sacramento pikeminnow, 161 hardhead, 10 Pacific lamprey (*Lampetra tridentate),* 5 smallmouth bass, and 229 unknown species.

The DVR successfully recorded 99% of the monitoring period. The 1% of the monitoring period was lost due to a power outage. The cause for the power outage was a thunderstorm, which shorted one of our video cameras, and the DVR stopped recording. During the actual time that video was recorded, 99% of the footage was recorded with a good or fair picture quality. The remaining 1% of poor quality footage was due to high turbidity related to snowmelt.

Typically, every third day of video monitoring was selected to be viewed a second time by a separate staff member for quality assurance (QA) purposes. In 2008, we did QA on one third of the days but the order was less systematic due to initial budget constraint early in the reviewing process. QA checks showed that the average error rates (i.e., percent not seen) for primary and QA viewers were 7.9% for Chinook, 20.0% for rainbow trout, and 9.3% for Chinook and rainbow trout combined.

Video data showed that unclipped Chinook preferred certain times of day to migrate past the CNFH barrier weir (χ^2= 59.95, P<0.001). The pattern of diel passage timing seen in 2008 (Figure 4) was similar to ten years of aggregated data from 1998-2007 (Figure 5). Passage frequency increased after 2200, peaked around midnight, and continued through the morning. Passage returned to low levels in the morning after 0800. In 2008, 81% of passage occurred during 33% (8 h) of the day (2200-0600). Chinook passage frequency began increasing after dark when water temperatures began to fall. Passage frequency returned to base levels about two hours after sunrise while temperatures were still at their lowest levels of the day.

Video data showed that rainbow trout also preferred certain times of day to migrate past the CNFH barrier weir. The pattern of diel passage timing seen in 2008 (Figure 6) was not similar to ten years of aggregated data from 1998-2007 (Figure 7). Typically, passage frequency increased after sunrise, peaked in the afternoon (1200-1600), and returned to a low level by dark. In 2008, 70% of passage occurred during 33% (8 h) of the day (2200-0600).

Passage estimation. — Passage estimates for unclipped salmonids are higher than actual numbers observed due to estimates made for periods of poor video quality. We estimated that 5 clipped and 105 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 1 and August 1, 2008 (Table 9). CNFH personnel released an additional 19 unclipped Chinook above the barrier weir prior to opening the barrier weir fish ladder on March 1 (Table 1). These 19 Chinook were diverted from lower Battle Creek into the hatchery as part of the late-fall Chinook propagation program. Since CNFH personnel attempt to mark 100% of their late-fall production with an adipose-fin clip and CWT, these 19 Chinook were considered natural-origin and were released into Battle Creek upstream of the barrier weir to spawn naturally.

We estimated that 1 clipped and 120 unclipped rainbow trout passed upstream of the barrier weir fish ladder between March 1 and August 1, 2008 (Table 2 and 10). CNFH released an additional 159 unclipped rainbow trout above the barrier weir prior to March 1 (Table 1). These rainbow trout were taken into the hatchery as part of the steelhead propagation program, but were not used as brood stock.

Migration timing.— The migration of unclipped Chinook past the barrier weir began March 2 and peaked the week of May 11 (Table 9, Figure 8). The middle 50% (including unknown clip-status fish) of the run passed between May 15 and May 28. The last Chinook to migrate before the weir closure on August 1 passed on July 10.

The temporal distribution of clipped Chinook observed at the barrier weir is different from that of unclipped Chinook. Observations of clipped Chinook began March 1, peaked during the first 3 weeks of trap operation and declined steadily through June (Figure 8). We observed the last clipped Chinook on June 24.

Rainbow trout migrating past the barrier weir exhibited a similar migration pattern to previous years. In previous years, we observed a bi-modal pattern, with low passage in April and May. In 2008, we witnessed low passage during the month of May, but the secondary peak was lower than the previous years. The lower secondary peak was during the video monitoring period and could be attributed to the difficulty of accurately identifying trout (Figure 9).

Size, sex, and age composition.— Chinook captured in the barrier weir trap had a mean fork length of 76.6 cm and ranged in length from 42.0 to 100.0 cm (n =203). The length-frequency distribution was continuous and was approximately normal with a mode at about 76-80 cm (Figure 10). Rainbow trout captured in the barrier weir trap had a mean fork length of 46.3 cm and ranged from 30.0 to 70.0 cm (n = 157). The length-frequency distribution for rainbow trout was continuous and was approximately normal with a mode at about 46 to 50 cm (Figure 11).

The ratio of male to female clipped Chinook captured in the barrier weir was 1:1.25 (n=175). The sex ratio for unclipped Chinook was not determined due to the difficulty in determining the sex of spring Chinook before the appearance of secondary sex characteristics.

For clipped rainbow trout the sex ratio was 1:1.4 (n=53) and for unclipped rainbow trout it was 1:2.2 (n=103).

We used tagging records to determine the age of most coded-wire tagged Chinook captured in the barrier weir trap. The ages of tagged Chinook included, 3-year-olds (n = 155), 4-year-olds (n = 6), and a 6-year-old (n=1). There was overlap in fork length for Chinook ages three and four (Figure 12, Table A1). Age was not determined for unclipped Chinook.

Stream Surveys

Our snorkel surveys were conducted June-November. Our June survey was a Chinook distribution survey and was completed from June 17-June 20, 2008. There was no July survey due to warm water temperatures. We restarted our snorkel surveys on August 25 and continued through November 14. We conducted surveys once a month, except for October, when two surveys were completed. For surveys conducted in Reaches 1-6, observations of live adult Chinook peaked at 18 in October (Tables 11 and 12). In addition, we observed 40 redds above the barrier weir, of which two were observed in September and 38 in October. We observed eight carcasses above the barrier weir from August to November.

Conditions for snorkel surveys were good. The average creek flows on the north fork (Reach 1-2) during surveys was 41 cfs (Figures 14 and 16). On the south fork (Reach 3) the average flow was 36 cfs (Figures 14 and 17). Stream flows were always <85 cfs on Reaches 4-6a (Figure 15). Temperatures ranged from 49º to 69ºF. Average turbidity was 2.1 NTU with a range of 0.8 to 4.3 NTU. The presence or absence of an adipose fin usually could not be determined for Chinook seen during our surveys.

Holding location.—Barrier weir counts and snorkel survey observations of live Chinook and redds indicated that most spring Chinook held in Battle Creek for 3 to 5 months (between early May and late September) prior to spawning (Figure 8, Table 11). Surveys indicated that most Chinook spawned in late September to mid October (Table 11).

Using the Ward and Kier (1999) thermal criteria for holding (Table 8), we evaluated MDTs for the holding period at three locations on the South Fork, four locations on the North Fork and five locations on the mainstem (Table 13). On the South Fork, the percentage of MDTs categorized as good ranged from 50.0% at the upstream-most site to 29.5% at the downstream-most site. On the North Fork, the percentage of MDTs categorized as good ranged from 100% at the upstream-most site to 26.2% at the downstream-most site. On the mainstem, the percentage of MDTs categorized as good ranged from 27.0 % at the upstream-most site to 9.8% at the downstream-most site.

We identified one large holding pool where Chinook commonly congregated during the summer. This pool is informally named B. Pool, and is located on the mainstem. Estimated MDTs at B. Pool (Reach 4) were categorized as follows; 27.0% good and 69.7% fair and 3.2% poor.

The upstream-most observation of a Chinook on the North Fork was a live fish observed on June 16 at rm 4.25. This is below a potential natural barrier identified as "nearly impassable by all fish at all flows (TRPA 1998, barrier NF5.14)" (Figure 2). The upstream-most observation of a live Chinook on the South Fork was immediately below Coleman Diversion Dam, which blocks fish passage.

Spawning location and timing.— We observed 11 redds in the North Fork, 10 in the South Fork, and 19 in the mainstem (Tables 5 and 11). In both the forks and mainstem Battle Creek, Chinook began spawning sometime between August 27 and September 16. Chinook likely finished spawning by the middle of October because we observed no new redds on our final survey, the week of November 10 (Table 11). On the North Fork, an open fish ladder allowed Chinook to pass above Wildcat Dam (rm 2.50) and potentially continue up as far as Eagle Canyon Dam (rm 5.25). Similar to 2006 and 2007 we observed redds above Wildcat Dam on the North Fork (Reach 1). We observed four redds in Reach 1 and the upstream-most redd was located at approximately rm 3.6. The upstream-most redd on the South Fork was located at about rm 2.2, downstream of Coleman Diversion Dam.

We estimated MDT at each Chinook redd during the egg incubation period. In the best-case scenario, the incubation period averaged approximately 105 days, based on a 1,850 DTU requirement. During the incubation period, the average percentage of days that redds were exposed to each temperature category were 96.3% excellent; 2.4% good, 1.1% fair, and 0.2% poor and no days at very poor (Table 14, Table A3). The worst-case scenario had more days in the good, fair, poor, and very poor categories, with average exposure being 88.8% excellent, 5.6% good, 4.2% fair, and 1.2% poor, and 0.2% very poor. When looking at both the best-case and worst-case scenarios, temperature exposures were worse in reaches that had redds observed during the two September surveys. Reach 5 (mainstem), had a minimum of 93.7% of days classified as excellent in the best-case scenario and 78.4% in the worst-case scenario.

In addition to estimating water temperatures at each redd, we also evaluated spawning temperatures at our fixed sites. We used spawning criteria modified from Ward and Kier (1999) for the dates of September 15 through October 31, 2008. On the North Fork, the percentage of MDTs categorized as good or excellent was 100% at the 2 upstream-most sites and above 80.0% at the downstream sites (Table 15). On the South Fork, the percentage categorized as good or excellent was above 84.0% at all three sites (Table 15). On the mainstem, the percentage categorized as good or excellent ranged from 83.0% at the upstream-most site to 55.0% at the downstream-most site (rm 5.9).

Measurements were taken on 29 spring Chinook redds (Table A2). Redd area ranged from 10.5 to 280.7 square feet (ft^2) with an average of 85.1 ft^2. Redd depths (pre-construction) ranged from 0.75 to 1.92 ft with an average of 1.25 ft. Water velocities ranged from 0.20 to 3.57 ft/s with an average of 1.67 ft/s. Redds that were built in 2007 had the same average water velocity. 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 1-3 in, a minimum of 1 in, and a maximum range of 3-5 in.

Of the nine Chinook carcasses observed during surveys, eight were recovered and spawning status was determined for one. The one carcass was an unspawned female, which was actually collected in May on our video weir. We cannot frequently determine the spawning status due to the advanced state of decay or carcasses being partially eaten by scavengers.

Tissue Collection for Genetic Analyses

We collected 33 Chinook salmon genetic samples, 25 of the samples being from the Barrier Weir trap and the remaining eight samples from snorkel surveys. The samples are currently stored at the RBFWO facility. Once a contract is initiated, the samples will be analyzed and results will be presented at that time. We also collected 109 rainbow trout samples, with 104 collected during the trapping season.

Age Structure

Estimated age was obtained from scale samples collected from adult Chinook carcasses recovered on snorkel surveys. There were six scale samples collected in 2008, of which all were readable. We classified the ages as the following: 50% were 3-year-olds, and 50% were 4-year-olds.

Spring Chinook Population Trend Analysis

We used simple linear regression to measure the spring Chinook population trend from 1995 to 2008. The slope of the regression line was 9.32 indicating that, on average, the population increased by about 9 Chinook per year (Figure 13). The 95% confidence interval for the slope estimate was -0.79 to 19.42. There was not a significant difference (P=0.067) between in the population trend and zero. There was some evidence that two of the standard assumptions for simple linear regression were not met; that population estimates were (1) independent and (2) had constant variance. Data diagnostics gave some indication that population estimates were autocorrelated (i.e., 2-year-lag negative autocorrelation) and had increasing variance over time.

Discussion

Chinook Salmon Population and Passage Estimates

We estimated that five clipped and 105 unclipped Chinook passed the CNFH barrier weir between March 1 and August 1, 2008. This number for unclipped Chinook was less than half the escapement of the two previous years and less than the average escapement for the previous 13 years (average = 136). It is important to note that a majority of these fish would be returning as 3-year-olds from 2005 (Fisher 1994). The low escapement in 2008 may have been a result of the low escapement of the 2005 parent generation (n = 73). Also, in the winter of 2005-2006, the CNFH used an unscreened intake for their water supply (Intake 2) due to emergency operational changes to the PG&E hydroelectric system. This may have caused fish to be entrained into the intake and never successfully migrate out of Battle Creek. This reduction in out-migrating juvenile Chinook may have caused lower than average returns for 2008.

We generally use the unclipped passage total to estimate the “maximum potential spring Chinook” escapement. Based on run timing (Vogel and Marine 1991) and genetic results from previous years, the majority of these unclipped Chinook are likely spring run with a minority possibly being winter, fall, or late-fall Chinook due to overlap in migration periods. Run-specific Chinook salmon population estimates presented in previous annual reports were based, in part, on Genetic Stock Identification analyses (Brown and Newton 2002, Brown et al. 2005, Brown and Alston 2007). Genetic results were not available in time for this report. We will make run-specific escapement estimates when genetic results become available.

The five clipped Chinook that passed during video monitoring were likely late returning CNFH late-fall Chinook but may have also been spring Chinook from Feather River Hatchery or Butte Creek (natural-origin fish, McReynolds et al. 2007). In previous years, we have captured clipped CNFH late-fall Chinook as late as June 14. Of the four known clipped Chinook in 2008, all passed prior to July 1.

The total escapement estimate for rainbow trout was lower in 2008 than escapement estimates from 2001 through 2004 (Table 1). This decrease was largely due to the continuation of clipped rainbow trout not being released in the upper watershed. Regarding escapement estimates for unclipped rainbow trout only, 2008 was slightly below the average for the period 2001-2008.

With the trap installed in March, there is always the possibility for storms and associated high flow events. In flow events higher than 2,000 cfs, we cannot safely check the trap; therefore, we have to temporarily shut down our operation. Adult salmonids can swim over the weir at higher flows, circumventing the fish ladder. This suggests that escapement is underestimated in years with higher flows. In spring of 2008, there were no high flow events; therefore, there was no time when we closed the trap. Since, the trap was not closed our passage estimate should be highly accurate.

In 2008, we continued investigating diel passage timing of salmonids through the barrier weir fish ladder during the trap operation period. Similar to previous years, we observed a majority of clipped Chinook passing early in the season in the afternoon, with the exception of fish caught in the first trap check of the day. The Chinook captured in the first trap check may have resulted from fish congregating in the trap while it was not being operated. Unclipped Chinook primarily passed a few hours after sunrise later in the trap operation period. Operating the trap at an earlier time of day from late April through early May resulted in a reduced potential for delaying fish passage, lower water temperatures during trapping, less stress on trapped fish, and a longer trapping season.

Video monitoring data showed that unclipped Chinook preferred to migrate past the CNFH barrier weir at night and early morning when water temperatures were falling (but not at their lowest levels). The 8 h period with the most passage was 2200-0600 PDT. In 2008, 1400-2100, appeared to be the unfavourable time for fish migration. The first day of video passage was not evaluated in the above analysis due to the trap door being closed over night and fish holding until we opened the door at the start of our video monitoring. The first several days of video monitoring had higher flows and turbidity due to snowmelt in the upper watershed, which may have triggered fish movement. Prior to the video monitoring period, we operated a fish trap for 8 h/d and prevented passage the rest of the day. Unclipped Chinook generally start migrating past the weir around middle or late April. Shifting our hours of trap operation to 0430-1230 after April 21 included the hours of peak passage for unclipped Chinook (0400-0800) and minimized the delay for those attempting to pass during the period 0000-0400.

Video monitoring from May through July showed rainbow trout preferred to migrate during evening hours. The 8 h period with the most passage was the same for Chinook, 2200-0600 PDT. This differed from previous years when trout passed mainly during daylight hours. One reason for this difference may have been the difficulty in identifying trout at our new temporary video station. For example, trout may have been misidentified as other species more frequently during daylight than at night, but this is uncertain.

Trout passing during the video monitoring period are likely resident trout as opposed to the anadromous form, the threatened steelhead trout. Central Valley steelhead are considered winter steelhead that mature in the ocean and spawn shortly after river entry (McEwan 2001, Moyle 2002). Typically, steelhead spawning occurs from December through April with peaks from January through March. From March 1 through April 21, we operated the trap during the hours 1030-1830 PDT, which encompasses the peak passage hours for rainbow trout in the summer. We are uncertain if passage patterns for rainbow trout in the summer are similar to steelhead patterns in the spring. If they are similar, our hours of trap operation during this period minimized any delay for steelhead passage.

Different Video monitoring system

The video monitoring setup was completely different from the typical procedure. Our typical setup involves a small corridor for fish to swim passed an underwater camera. The viewing area is small and usually all fish are observed unless it is turbid or if there was a power outage. This year involved a larger viewing area that was not necessarily covered by all the underwater cameras. Also, the overhead camera only allowed for the viewer to see the top of the fish. Therefore, this presented us with a few unexpected challenges. Although there were three underwater cameras, we experienced a harder time identifying rainbow trout. Identifying the clip status on salmonids was also more difficult than other years. Lastly, the viewing area was larger, which made viewing more difficult when the water was turbid.

In 2008, we observed 20 rainbow trout during our video monitoring. From 2001-2007 we averaged approximately 60 rainbow trout passing during video monitoring. We count fish that are greater than 12 in. in length. It is possible that fish greater than 12 in. but smaller than 15 in. migrated through the viewing area were observed in the overhead camera, but not in the underwater cameras. These rainbow trout may have been mistakenly identified as another species or marked as an unknown species. We also observed more rainbow trout at night, whereas in previous years we observed a majority of fish during the day. This year's setup may have been better for observing fish during the evening due to less ambient light. There is no cover to prevent daylight in the viewing area, which may have made it more difficult to identify the species of fish. When a viewing area has a cover, it reduces the sun's glare on the water surface and from shining in the water, creating bright spots where it is difficult to discern what passes through. As a result of these factors, our 2008 rainbow trout escapement estimate may be biased low.

This low bias in salmonid escapement estimates is demonstrated by our error rate calculations. Every season we calculate an error rate (i.e., percent of salmonids not observed) for our video monitoring based on our QA/QC readings. In 2006, our error rates were 2.8% for Chinook and 9.6% for rainbow trout, with a combined salmonid error rate of 5.8%. In 2007, our error rates for Chinook, rainbow trout and combined salmonids were 3.9%, 13.6%, and 8.5%, respectively. This year our error rates in all three categories were higher then the previous two years. The error rates were 7.9% for Chinook, 20.0% for rainbow trout and 9.3% for combined salmonids. The reason for the increased error rate was likely due to the increased difficulty of reviewing video footage from our temporary video system. In addition to the challenges listed above, viewers had to watch four video images simultaneously on a single computer monitor. In contrast, our typical video system required the viewing of only one image and fish were confined to a much smaller passage area.

This year we observed more unknown clip status Chinook than previous years. We counted 23 unknown clip status Chinook. Again, the video setup may have been the reason for this. The underwater cameras were low in the water and it was difficult to view the area of the adipose fin. Another reason may have been the speed that the Chinook passed. Fish that quickly moved through may have been easily identified as a Chinook, but it was too hard to determine the clip status. Typically, we observe zero unknown clip status Chinook, except in 2001, we observed two and in 2007 we observed one. Apportioning a large number of unknown clip status Chinook to the categories of clipped or unclipped may have led to slight inaccuracies in our escapement estimates. However, the 2008 ratio of clipped to unclipped Chinook was within the range observed from 2001 through 2007.

Overall, one of the greatest challenges with the setup was turbidity. The period of time that we observed 82% of our unknown clip status Chinook was during the highest flows of the monitoring period. Higher flows usually mean higher turbidity, creating a non-ideal viewing environment. In normal years, we guided fish through a small opening that would allow them to be close to the camera, which helped in identification of fish in turbid conditions. Although, this year we had underwater cameras, the fish did not necessarily need to swim past them. It is likely that, during the high flow events, the fish swam over the underwater cameras and we only observed these fish from the overhead camera.

Evaluation and Adaptive Management of Battle Creek Stream Flow

Increase North Fork flows to test barrier hypothesis.— A potential low-flow barrier (Figures 2 and 3B) at rm 3.04 on the North Fork (Reach 1) was identified in 2001 and 2002 as potentially impassible to Chinook at about 30 cfs, the current interim flow level (Brown and Newton 2002; Brown et al. 2005). This raised concern as to whether it would be impassable at the future Restoration Project flow level of 35 cfs from May through November (NMFS et al. 1999). Since 2001, there has been four years (2003, 2006, 2007, and 2008) in which redds have been observed above this potential barrier. In 2007, we hypothesized that the number of fish influenced the spatial distribution of redds. Years 2003, 2006 and 2007 were unique because the total number of redds over all reaches was higher than the other years (Table 5), possibly causing fish to spawn farther upstream (Newton et al. 2008). This did not appear to be the case in 2008, since we observed only 40 redds and had a maximum potential population of 105 fish.

In the 2006 report (Newton et al. 2007), we hypothesized that fish were only able to pass the potential low-flow barrier in 2003 and 2006 because of relatively high spring flows in those years. However, in 2007 (Newton et al.2008) noted that flows in 2007 were low similar to 2001 and 2002, yet Chinook passed above this location. However, 2007 flows were higher in April, when early upstream migration may have occurred. This evidence suggested that the cascade at rm 3.04 is not a complete barrier to all spring Chinook at low flows near 30 cfs but it may limit fish passage, as evidenced by the low percentage of upstream redds (4%) in conjunction with a record high population estimate in 2007. In 2008, this again appeared to be the case. From March 1-August 1, average flows on the North Fork were 51.9 cfs in 2007 and 48.0 cfs in 2008. Unlike 2007, April flows in 2008 were relatively low, but there was an eight-day increase in flow during May (Figures 14 and 16). This flow increase also coincided with fish passage at the CNFH barrier weir and it is possible that the fish moved through the system rather quickly. As the population increases better information will become available as to whether this cascade is impeding passage.

In a survey of fish barriers in Battle Creek, Thomas R. Payne and Associates (TRPA) identified a nearly impassable barrier on the North Fork at rm 5.06. TRPA (1998) suggested this barrier may be passable to rainbow trout and spring Chinook in good condition at flows >88 cfs. Also in the Final Restoration Plan for the Anadromous Fish Restoration Program (USFWS 2001), actions identified to increase natural production of anadromous fish in Battle Creek included improving fish passage at this natural barrier. As in previous years, we did not observe live Chinook or redds above this barrier in 2008. Therefore, we continue to believe this barrier may block salmonid passage at moderate and low flows.

The effect of Interim Flows on South Fork Battle Creek.— In 2001 and most of 2002, interim flows of 30 cfs were not provided in the South Fork which resulted in higher water temperatures during the spring Chinook holding and early spawning periods. Coincidentally, in

2001 and 2002, an above average proportion of Chinook held and spawned in the South Fork (Tables 4 and 5). Since most spring Chinook return as 3-year-olds and some as 4-year-olds (Fisher 1994), most of the progeny from these two year classes would be expected to have returned in 2004 and 2005. In 2007, escapement of unclipped Chinook (March 1-August 1) was 3.2 times greater than 2004 and 3.2 times greater than 2005 (Table 3). In 2008, the escapement of unclipped Chinook was 1.2 times greater than 2004, 1.4 times greater than 2005. This increase in escapement in 2007 and 2008 may be a beneficial result of providing interim flows of 30 cfs in both the North Fork and South Fork.

Holding and spawning water temperatures.—Water temperature data has been collected since 1998 near a large spring-Chinook holding pool on the mainstem (rm 16.0). MDT at rm 16.0 for the period June 1-August 17, the hottest time of the year, was an average of 0.1 ºF warmer than the average of 1998-2005. Due to warm water and air temperatures, we did not conduct a July snorkel survey. Holding temperatures for the period June 1-September 30 were categorized as "poor" and "fair" for more than 60% of the time in the lower sections of the forks and in the mainstem (Table 13). Poor water temperatures could lead to no successful spawning and fair water temperatures may lead to some mortality and infertility. Reach 5 and 6 were the two sections that had the most days in the "poor" category. There were fish observed in this section of the creek, but typically, the majority of the fish were observed holding above this section. The downstream portions of the forks had no more than two days in the "poor" category. Exposure to unsuitably high water temperatures by adult Chinook prior to spawning likely led to some reduction in reproductive success. The reduction in reproductive success may have been minimal because (1) the duration of exposure to "poor" temperatures may have been short because spring Chinook could have migrated upstream past these areas and (2) the negative impact of exposure to "fair" temperatures may be small.

Our temperature analysis of each individual redd indicated that Chinook egg incubation temperatures under our worst-case-scenario were categorized as "excellent" for 88.8% of the days, on average. The range of "excellent" days for individual redds ranged from 99.0% to 73.4%. The data indicates that incubating eggs experienced minimal adverse effects from water temperatures. Even though water temperatures were higher than other years, the spawners possibly waited until water temperatures were suitable before spawning or selected more upstream locations where there were cooler water temperatures. We only observed two early redds, and the rest were observed at the in October (Table 11 and Appendix A2).

In the past eight years of stream surveys, Chinook redd density (redds/mile) was highest in Reach 2 (lower North Fork) with the exception of 2001 and 2008 (Table 6). In 2008, less than 20% of the redds were observed in Reach 2 (43% of the redds were in Reach 4). Since 2002 the percent of redds in Reach 2 ranged from 25.6% to 71.4%. In 2001 the percent of redds in Reach 2 was 21.9% and in 2008 it was 17.5%. We analyzed flow and temperature data from 2001-2008 and found no correlation between the number of redds in Reach 2 and water flows and temperature. At this time, it remains unclear why the amount of redds in Reach 2 were lower in 2008 compared to previous years.

Spring Chinook Population Trend Analysis

Linear regression techniques indicated that the population of spring Chinook in Battle Creek increased by about nine fish per year, on average, from 1995 to 2008. This suggests that environmental conditions in Battle Creek have been suitable to maintain and lead to a modest increase in the population. Interim flows, provided by PG&E, CVPIA, and CALFED since

1995, have likely been a primary contributing factor to this increase.

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Tables

TABLE 1-Multi-year summary of the number of adult late-fall Chinook and steelhead trout released upstream of Coleman National Fish Hatchery (CNFH) barrier weir during the CNFH broodstock collection and spawning program (R. Null, US Fish and Wildlife, unpublished data). Late-fall Chinook are generally passed from late December through February and steelhead from October through February.

	Late-fall Chinook [a]		Steelhead	
Year	Clipped	Unclipped	Clipped	Unclipped
1994-**1995**	0	0	0	
1995-**1996**	0	0	276 [b]	
1996-**1997**	0	0	295 [b]	
1997-**1998**	0	0	418 [b]	
1998-**1999**	0	0	1163 [b]	
1999-**2000**	0	0	1416 [b]	
2000-**2001**	0	98	1352	131
2001-**2002**	0	216	1428	410
2002-**2003**	0	57	769	416
2003-**2004**	0	40	314	179
2004-**2005**	0	23	0	270
2005-**2006**	0	50	0	249
2006-**2007**	0	72	0	132 [c]
2007-**2008**	0	19	0	159

[a] All juvenile late-fall Chinook produced at Coleman NFH were adipose-fin clipped beginning in 1992.
[b] All juvenile steelhead produced at Coleman NFH were adipose-fin clipped beginning in 1998, therefore, differentiation between natural and hatchery adults based on mark status was not entirely possible until the 2001-2002 return year.
[c] Revised number based on corrections provided by R. Null.

TABLE 2-Multi-year summary of estimated escapement in Battle Creek of clipped and unclipped Chinook salmon and rainbow trout/steelhead passing upstream through the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder between March and August.

Year	Ladder Open (m/dd)	Chinook		Rainbow trout /steelhead	
		Clipped	Unclipped	Clipped	Unclipped
1995	3/30-6/30	74	66	34 [a]	127 [a]
1996	3/26-7/01	151	35	1 [a]	40 [a]
1997	3/05-7/01	130	107	0 [a]	49 [a]
1998	3/04-7/01	40	178	0 [a]	51 [a]
1999	3/09-7/01	3	73	6 [a]	100 [a]
2000	3/07-9/01	7	78	18 [a]	86 [a]
2001	3/03-8/31	5	111	30	94
2002	3/01-8/30	0	222	14	183
2003	3/03-8/29	13	221	3	118
2004	3/02-8/01	2	90	15	125
2005	3/01-8/01	0	73	0	74
2006	3/01-8/01	0	221	1	189
2007	3/01-8/01	5	291	3	216
2008	3/01-8/01	5	105	1	120

[a] A comprehensive marking program for juvenile steelhead produced at Coleman NFH began in 1998, therefore, differentiation between natural and hatchery adults based on mark status was not entirely possible until the 2001-2002 return year.

TABLE 3-Multi-year summary of total estimated escapement in Battle Creek of all four runs of Chinook salmon and rainbow trout/steelhead passing upstream of Coleman National Fish Hatchery (CNFH) barrier weir. Total estimated escapement includes Chinook salmon and steelhead passed during the CNFH broodstock collection and spawning program prior to March and fish passed through the barrier weir fish ladder between March 1 and August 31 (period of ladder operation was shorter in some years). Maximum potential spring Chinook includes all unclipped salmon passed during the ladder operation period. Estimated spring Chinook escapement is a reduced estimate based on apportioning some Chinook to the winter, fall, and late-fall runs.

Year	Winter Chinook	Spring Chinook		Fall Chinook	Late-fall Chinook	Rainbow trout / steelhead	
		Maximum	Estimate			Clipped	Unclipped
1995		66				161[a]	
1996		35				317[a]	
1997		107				344[a]	
1998		178				469[a]	
1999		73				1263[a]	
2000		78				1520[a]	
2001	0+	111	100	9 to 14	98 to 102	1382	225
2002	3	222	144	42	249	1442	593
2003	0	221	100	130	61	772	534
2004	0	90	70	20	42	329	304
2005	0	73	67	6	23	0	344
2006	1	221	154	66	50	1	438
2007		291			N/A[b]	3	346
2008		105			N/A[b]	1	279

[a] Clip status was not used to differentiate hatchery- and natural-origin adult steelhead until 2001 because Coleman National Fish Hatchery did not begin marking all of their production until brood year 1998.

[b]Genetic samples have not been analyzed to determine the total estimate of Late-fall Chinook

TABLE 4-Multi-year summary of total live Chinook (n) observed in August and their distribution among the North Fork, South Fork, and mainstem Battle Creek. Observations were made during August snorkel surveys.

Year	n =	North Fork	South Fork	Mainstem
1995	15	27%	0%	73%
1996	10	40%	0%	60%
1997	4	50%	0%	50%
1998	16	19%	50%	31%
1999	-	-	-	-
2000	-	-	-	-
2001	27	0 %	63 %	37 %
2002	88	0 %	58 %	42 %
2003	94	7 %	33 %	60 %
2004	26	0 %	8 %	92 %
2005	6	33%	33%	33%
2006	143	14%	20%	66%
2007	33	9%	49%	42%
2008	8	37.5%	25%	37.5%

TABLE 5-Multi-year summary of total Chinook redds (n) observed between August and November[a] and their distribution among the North Fork, South Fork, and mainstem Battle Creek. Observations were made during spring Chinook snorkel surveys.

Year	n =	North Fork	South Fork	Mainstem
1995 [b]	13	46%	54%	0%
1996 [c]	21	52%	0%	48%
1997	66	53%	15%	32%
1998	247	33%	34%	33%
1999 [d]	-	-	-	-
2000	-	-	-	-
2001	32	34%	38%	28%
2002	78	35%	21%	45%
2003	176	45%	15%	40%
2004	34	73%	9%	18%
2005	47	51%	13%	36%
2006	122	61%	19%	20%
2007	132	59%	16%	25%
2008	40	27.5%	25%	47.5%

[a] Some redds were observed prior to August in 1995, 1996, 1997, and 2003 and are not included in this table.
[b] In 1995, surveys were not conducted after the last week of September.
[c] In 1996, surveys were not conducted in Reach 6 after August.
[d] In 1999, only one survey was conducted in Reaches 1-3 in September.

TABLE 6-Multi-year summary of Chinook redd density (redds/mile) in Battle Creek snorkel survey reaches.

Year	North Fork (Reaches 1-2)	South Fork (Reach 3)	Mainstem (Reaches 4-6)	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
1995 [a]	-	-	-	-	-	-	-	-	-
1996	2	0	1	0	4	0	2	0	1
1997	7	4	2	5	8	4	4	1	1
1998	15	33	8	12	19	33	13	4	6
1999 [a]	-	-	-	-	-	-	-	-	-
2000 [a]	-	-	-	-	-	-	-	-	-
2001	2	5	1	1	3	5	1	1	1
2002	5	6	3	3	8	6	4	4	2
2003	15	10	7	5	26	10	12	3	5
2004	5	1	1	0	10	1	2	0	0
2005	5	2	2	0	10	2	3	2	<1
2006	14	9	2	7	22	9	6	<1	<1
2007	15	8	3	2	29	8	7	2	0
2008	2	4	2	1	3	4	4	<1	<1

[a] Survey frequency was inadequate to obtain a total count of redds.

TABLE 7-Reach numbers and locations with associated river miles (rm) for Battle Creek stream surveys.

Reach	Reach length (miles)	Upstream		Downstream	
		Location	rm	Location	rm
1 (North Fork)	2.75	Eagle Canyon Dam	5.25	Wildcat Dam	2.50
2 (North Fork)	2.50	Wildcat Dam	2.50	Confluence of forks	0.00
3 (South Fork)	2.54	Coleman Diversion Dam	2.54	Confluence of forks	0.00
4	3.82	Confluence of forks	16.61	Mt. Valley Ranch	12.79
5	3.47	Mt. Valley Ranch	12.79	Ranch road	9.32
6	3.49	Ranch road	9.32	Barrier weir	5.83

TABLE 8-Temperature criteria used to evaluate the suitability of Battle Creek water temperatures for Spring Chinook. Criteria are modified from Ward and Kier (1999).

Life Stage	Mean Daily Water Temperature (°F)	Response	Suitability Category
Adult Holding	≤60.8	Optimum	Good
	>60.8 to 66.2	Some Mortality and Infertility	Fair
	>66.2	No Successful Spawning	Poor
	≥80	Lethal	Very Poor
Egg Incubation	≤56	Optimum	Excellent
	>56 to ≤58	<8% Mortality	Good
	>58 to ≤60	15 to 25% Mortality	Fair
	>60 to ≤62	50 to 80% Mortality	Poor
	>62	100% Mortality	Very Poor

TABLE 9-**Chinook salmon** video-recorded passing the Coleman National Fish Hatchery barrier weir and associated passage estimated for 2008. Passage estimates include estimated passage during hours not video recorded.

Dates	Week number	Monitoring method	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
March 1	1	Trap			23	0	0	0	0
March 2-8	2	Trap			40	1	0	0	1
March 9-15	3	Trap			71	4	0	0	4
March 16-22	4	Trap			19	1	0	0	1
March 23-29	5	Trap			11	0	0	0	0
March 30-April 5	6	Trap			6	4	0	0	4
April 6-12	7	Trap			3	2	0	0	2
April 13-19	8	Trap			1	1	0	0	1
April 20-26	9	Trap			0	0	0	0	0
April 27-May 3	10	Trap			0	5	0	0	5
May 4-10	11	Trap			1	3	0	0	3
May 11-15	12	Trap			0	7	0	0	7
May 16-17	12	Video	40.7	40.1	1	18	10	1.5	27.9
May 18-24	13	Video	168.0	167.3	1	13	9	1.7	21.5
May 25-31	14	Video	168.0	168.0	0	6	0	0.0	6.0
June 1-7	15	Video	168.0	168.0	0	6	1	0.0	7.0
June 8-14	16	Video	168.0	168.0	0	2	1	0.0	3.0
June 15-21	17	Video	168.0	167.9	1	1	0	1.0	1.0
June 22-28	18	Video	168.0	167.9	1	6	1	1.1	6.9
June 29-July 5	19	Video	168.0	168.0	0	2	1	0.0	3.0
July 6-12	20	Video	168.0	168.0	0	1	0	0.0	1.0
July 13-19	21	Video	168.0	167.8	0	0	0	0.0	0.0
July 20-26	22	Video	168.0	167.8	0	0	0	0.0	0.0
July 27-August 1	23	Video	129.8	129.7	0	0	0	0.0	0.0
Totals			1850.5	1848.4	179	83	23	5	105

TABLE 10-**Rainbow trout/steelhead** video-recorded passing the Coleman National Fish Hatchery barrier weir fish ladder and associated passage estimates for 2008. Passage include passage during hours not video recorded.

Dates	Week number	Monitoring method	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
March 1	1	Trap			20	42	0	0	36
March 2-8	2	Trap			14	19	1	0	20
March 9-15	3	Trap			8	18	1	0	19
March 16-22	4	Trap			0	5	0	0	5
March 23-29	5	Trap			1	5	1	0	6
March 30-April 5	6	Trap			3	2	0	0	2
April 6-12	7	Trap			1	4	0	0	4
April 13-19	8	Trap			0	3	0	0	3
April 20-26	9	Trap			0	0	0	0	0
April 27-May 3	10	Trap			0	2	0	0	2
May 4-10	11	Trap			0	2	0	0	2
May 11-15	12	Trap			0	2	0	0	2
May 16-17	12	Video	40.7	40.1	0	1	0	0.0	1.0
May 18-24	13	Video	168.0	167.3	0	3	0	0.0	3.0
May 25-31	14	Video	168.0	168.0	0	2	1	0.0	3.0
June 1-7	15	Video	168.0	168.0	0	3	1	0.0	4.0
June 8-14	16	Video	168.0	168.0	1	5	1	1.2	5.8
June 15-21	17	Video	168.0	167.9	0	1	0	0.0	1.0
June 22-28	18	Video	168.0	167.9	0	0	0	0.0	0.0
June 29-July 5	19	Video	168.0	168.0	0	0	0	0.0	0.0
July 6-12	20	Video	168.0	168.0	0	1	0	0.0	1.0
July 13-19	21	Video	168.0	167.8	0	0	0	0.0	0.0
July 20-26	22	Video	168.0	167.8	0	0	0	0.0	0.0
July 27-August 1	23	Video	129.8	129.7	0	0	0	0.0	0.0
Totals			1850.5	1848.4	48	120	6	1	120

TABLE 11-Chinook salmon live adults, redds and carcasses observed during the 2008 Battle Creek stream surveys.

Reach	Date	Chinook	Redds	Carcasses
1	6/17/08	4	0	0
1	8/25/08	2	0	1
1	9/16/08	0	1	0
1	9/29/08	0	3	0
1	10/14/08	0	0	0
1	10/27/08	0	0	0
1	11/10/08	0	0	0
2	6/17/08	0	0	0
2	8/25/08	1	0	0
2	9/17/08	0	0	0
2	9/30/08	0	0	0
2	10/14/08	2	7	0
2	10/28/08	0	0	1
2	11/12/08	0	0	0
3	6/18/08	5	0	0
3	8/26/08	2	0	0
3	9/17/08	0	0	0
3	10/1/08	10	7	1
3	10/15/08	2	3	2
3	11/12/08	0	0	0
4	6/18/08	3	0	0
4	8/27/08	3	0	0
4	9/18/08	1	1	0
4	10/1/08	6	11	0
4	10/15/08	1	4	2
4	11/13/08	0	0	0
5	6/19/08	2	0	0
5	8/28/08	0	0	0
5	9/18/08	0	0	0
5	10/2/08	1	1	0
5	10/16/08	0	0	0
5	11/14/08	0	0	0

Table 11-Continued

Reach	Date	Chinook	Redds	Carcasses
6	6/20/08	1	0	0
6	8/28/08	0	0	0
6	9/19/08	0	0	0
6	10/3/08	1	2	0
6	10/16/08	1	0	0
6	10/30/08	0	0	1
6	11/14/08	0	0	0
Totals			**40**	**9**[a]

[a] One additional carcass is added to this count. An unspawned, adipose present female Chinook was found on the video weir on 5/19/08 (Reach 6).

TABLE 12-Total monthly counts of live Chinook observed on the 2008 Battle Creek Stream Surveys.

	June	**August**	**September (1st)**	**September (2nd)**	**October (1st)**	**October (2nd)[a]**	**November**
Reach 1-6	6/17-6/20	8/25-8/28	9/16/-9/19	9/29-10/3	10/14-10/16	10/27-10/30	11/10-11/14
1	4	2	0	0	0	0	0
2	0	1	0	0	2	0	0
3	5	2	0	10	2	0	0
4	3	3	1	6	1	0	0
5	2	0	0	1	0	0	0
6	1	0	0	1	1	0	0
Totals	**15**	**8**	**1**	**18**	**6**	**0**	**0**

[a] Only Reaches 1, 2 and 6 were surveyed

TABLE 13-Number of days mean daily temperatures met Ward and Kier's (1999) suitability categories for spring Chinook holding from June 1 through September 30, 2008 at select monitoring sites in Battle Creek.

Site Name	Location	River Mile	No Data	Very Poor	Poor	Fair	Good
Eagle Canyon Dam	North Fork	5.3[a]	0	0	0	0	122
Wildcat Dam	North Fork	2.5[a]	0	0	0	32	90
Wildcat Road Bridge	North Fork	0.9[a]	0	0	0	89	33
Above confluence of forks	North Fork	0.05[a]	0	0	0	90	32
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	61	61
Manton Road Bridge	South Fork	1.7[a]	15	0	0	70	37
Above confluence of forks	South Fork	0.1[a]	0	0	2	84	36
Below confluence of forks	Mainstem	16.0[b]	0	0	4	85	33
Reach 4 Lower	Mainstem	12.9[b]	0	0	17	86	19
Reach 5 Lower	Mainstem	9.3[b]	0	0	46	68	8
Reach 6 Lower (UBC RST)[c]	Mainstem	5.9[b]	0	0	65	45	12

[a] From confluence of the North Fork and South Fork Battle Creek
[b] From confluence with the Sacramento River
[c] This logger is located below the Coleman Powerhouse and Tailrace

TABLE 14-Estimated range for percent of days that incubating spring Chinook eggs fell within water temperature suitability categories in Battle Creek in 2008. The left and right numbers of the range represent the average for the worst-case scenario and the best-case scenario respectively. Presented in the parentheses are the ranges of average number of days that redds were exposed to each temperature category based on the worst and best-case scenarios.

Reach	Location	n = (Redds)	Very Poor	Poor	Fair	Good	Excellent
1	North Fork	3	0%	0%	2.0-0.5% (2-<1)	9.0-6.0% (8-5)	89.0-93.4% (78-89)
2	North Fork	7	0%	0%	0.5-0% (<1-0)	1.8-0% (2-0)	97.7-100.0% (101-108)
3	South Fork	10	0%	0%	0.4-0.1% (<1)	5.4-0.9% (5-1)	94.3-99.0% (99-114)
4	Mainstem	17	0.4-0% (6-0)	2.0-0.5% (30-2)	8.7-2.1% (127-2)	7.1-3.7% (104-3)	81.8-93.7% (74-94)
5	Mainstem	1	0%	4.6-0% (4-0)	13.6-3.0% (12-3)	3.4-3% (6-3)	78.4-94.0% (69-95)
6	Mainstem	2	0%	7.7-0% (14-0)	5.4-1.9% (10-4)	3.3-2.9% (3)	83.6-95.2% (153-196)
Total		40	0.2-0% (<1-0)	1.2-0.2% (2-<1)	4.2-1.1% (4-1)	5.5-2.4% (5-2)	88.8-96.3% (86-102)

TABLE 15-Number of days mean daily temperatures met Ward and Kier's (199) suitability categories for spring Chinook egg incubation from September 15 through October 31, 2008 at the select monitoring sites in Battle Creek.

Site Name	Location	River Mile	No Data	Very Poor	Poor	Fair	Good	Excellent
Eagle Canyon Dam	North Fork	5.3[a]	0	0	0	0	3	44
Wildcat Dam	North Fork	2.5[a]	0	0	0	0	12	35
Wildcat Road Bridge	North Fork	0.9[a]	0	0	0	7	14	26
Above confluence of forks	North Fork	0.05[a]	0	0	0	9	14	24
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	3	8	36
Manton Road Bridge	South Fork	1.7[a]	0	0	0	3	10	34
Above confluence of forks	South Fork	0.1[a]	0	0	0	7	11	29
Below confluence of forks	Mainstem	16.0[b]	0	0	1	7	13	26
Reach 4 Lower	Mainstem	12.9[b]	0	0	5	13	6	23
Reach 5 Lower	Mainstem	9.3[b]	0	3	11	8	2	23
Reach 6 Lower (UBC RST)[c]	Mainstem	5.9[b]	0	3	9	9	3	23

[a] From confluence of the North Fork and South Fork Battle Creek
[b] From confluence with the Sacramento River
[c] This logger is located below the Coleman Powerhouse and Tailrace

Figures

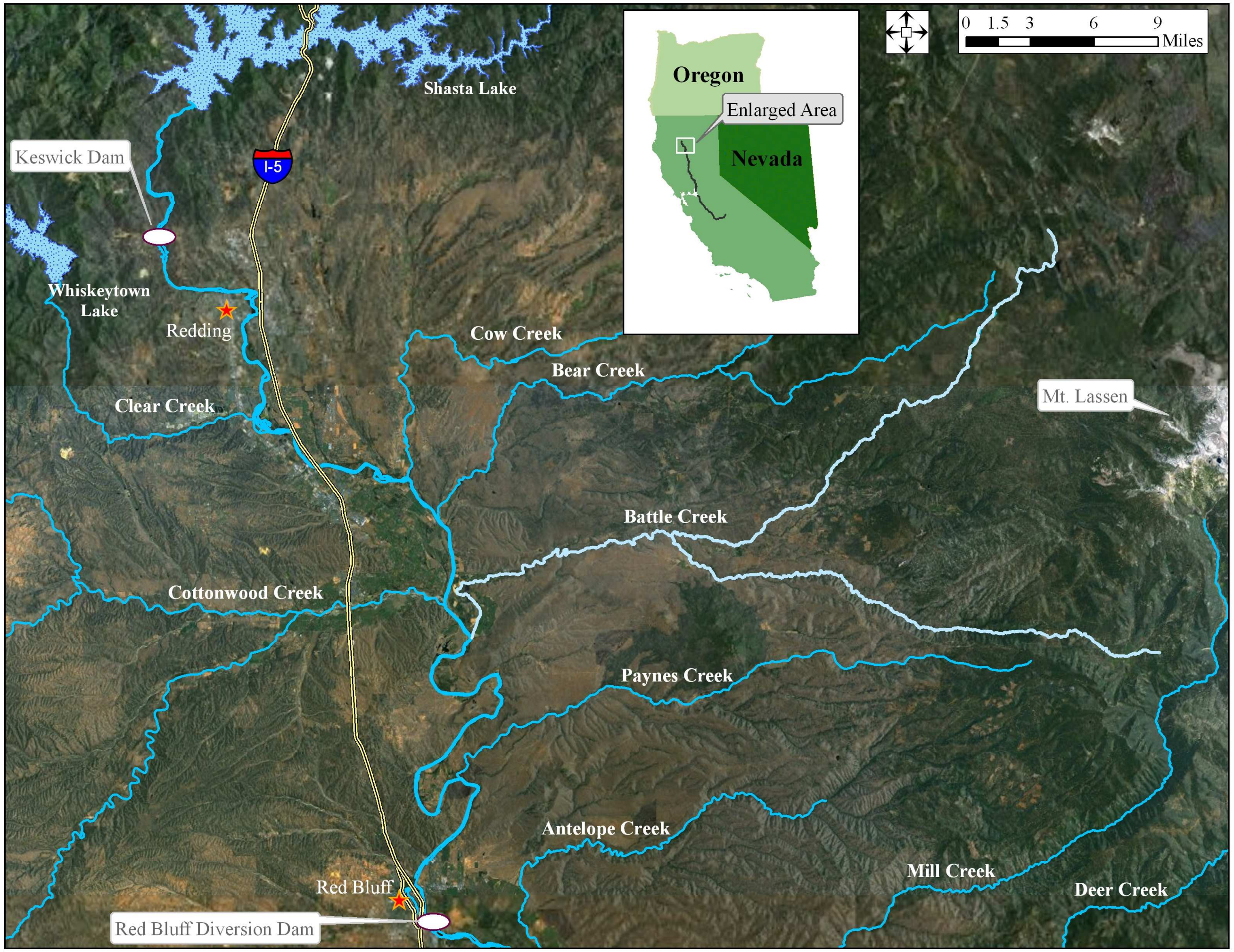

FIGURE 1-Map of the Sacramento River and it's tributaries (including Battle Creek) between Keswick Dam and Red Bluff, California.

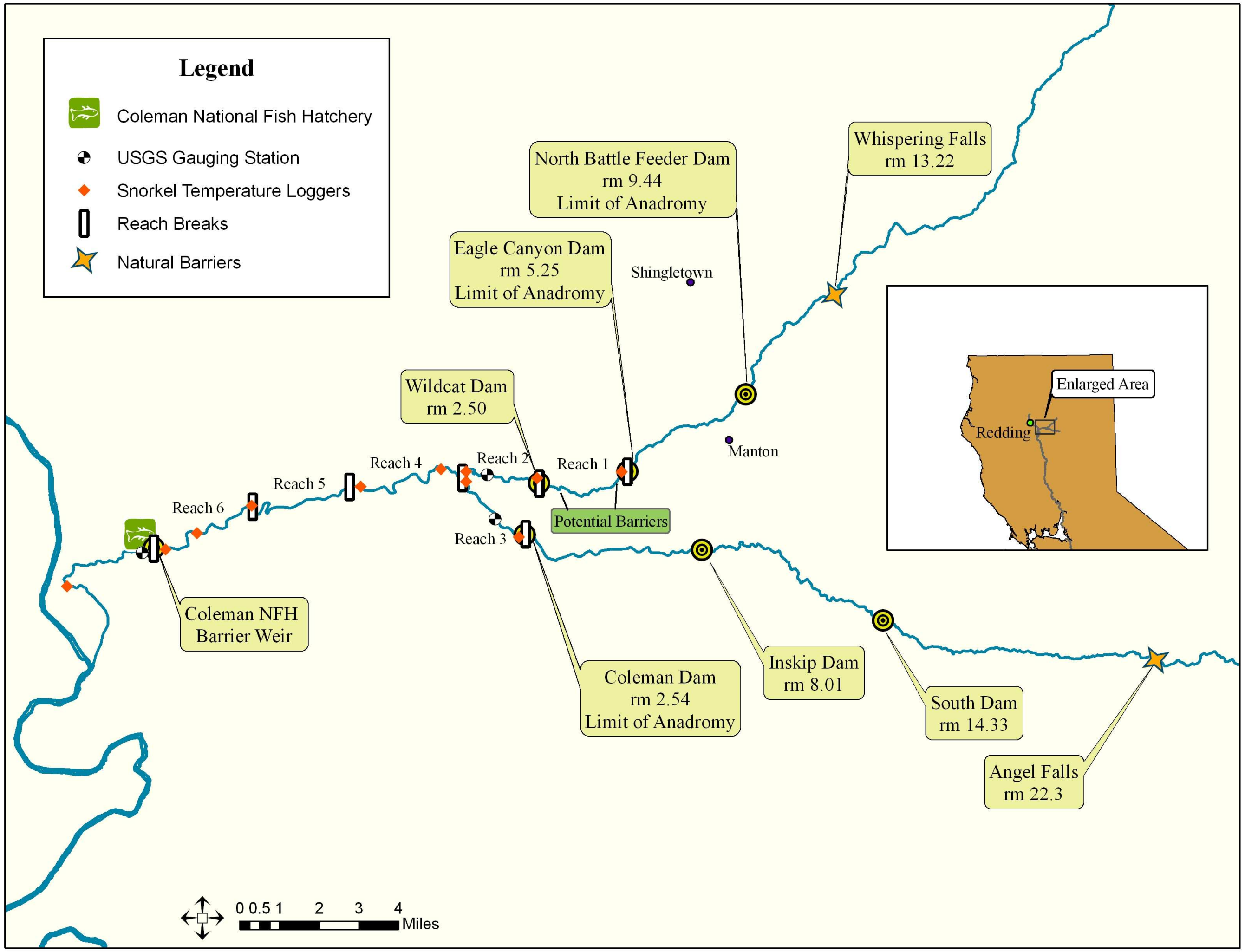

FIGURE 2-Map of Battle Creek depicting the location of the Coleman National Fish Hatchery barrier weir and stream survey reaches.

FIGURE 3-Above pictures show the upper and lower potential barriers on the North Fork of Battle Creek. Picture A, is the upper barrier at rm 5.41 and picture B is the lower (low-flow) barrier at rm 3.04.

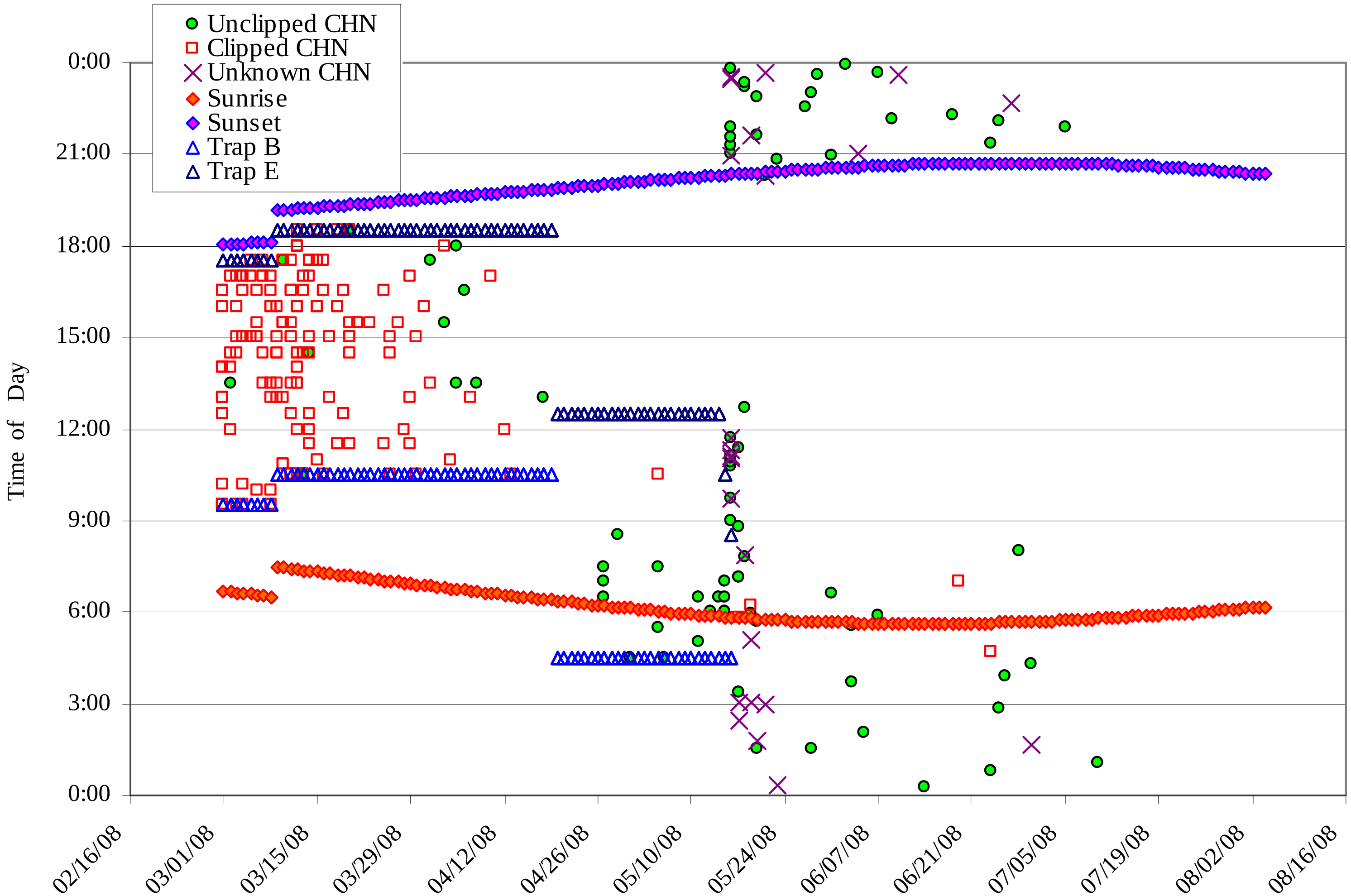

FIGURE 4-Diel migration of Chinook (CHN, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir periods of trap operation (March 1-May 16) and video monitoring (May 16-August 1) in 2008. Also included are times of sunrise, sunset, beginning of trap operation (Trap B) and end of trap operation (Trap E).

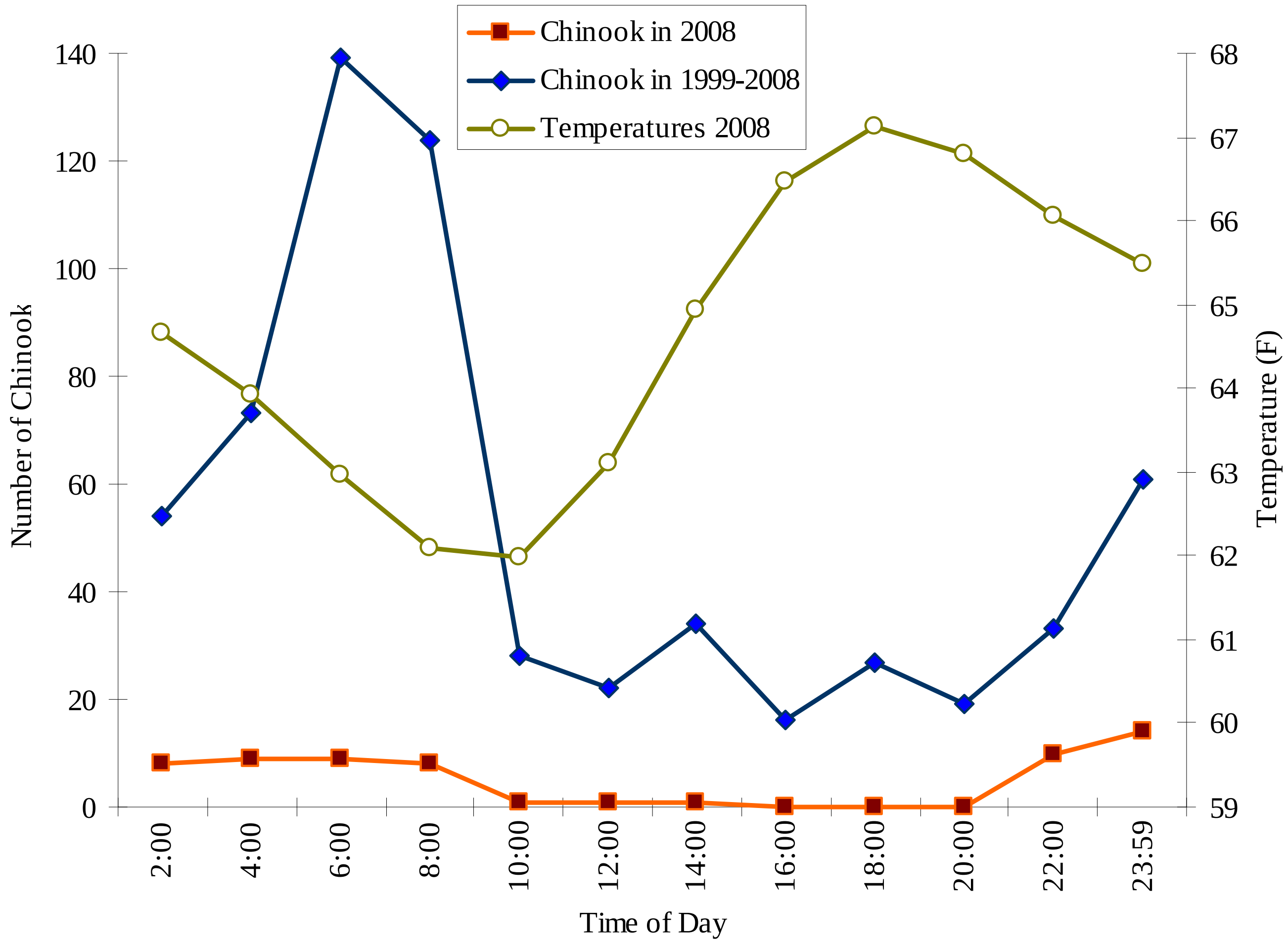

FIGURE 5-Diel migration of unclipped Chinook (CHN) salmon observed at the Coleman National Fish Hatchery barrier weir during periods of video monitoring. Data include Chinook passing in 2008 for May 17-July 31, the ten-year sum of Chinook passing from May or June (depending on the year) through July 31, and the average temperature per time category for May 17-July 31, 2008.
*Note: To show the normal distribution May 16 data was not included in this graph.

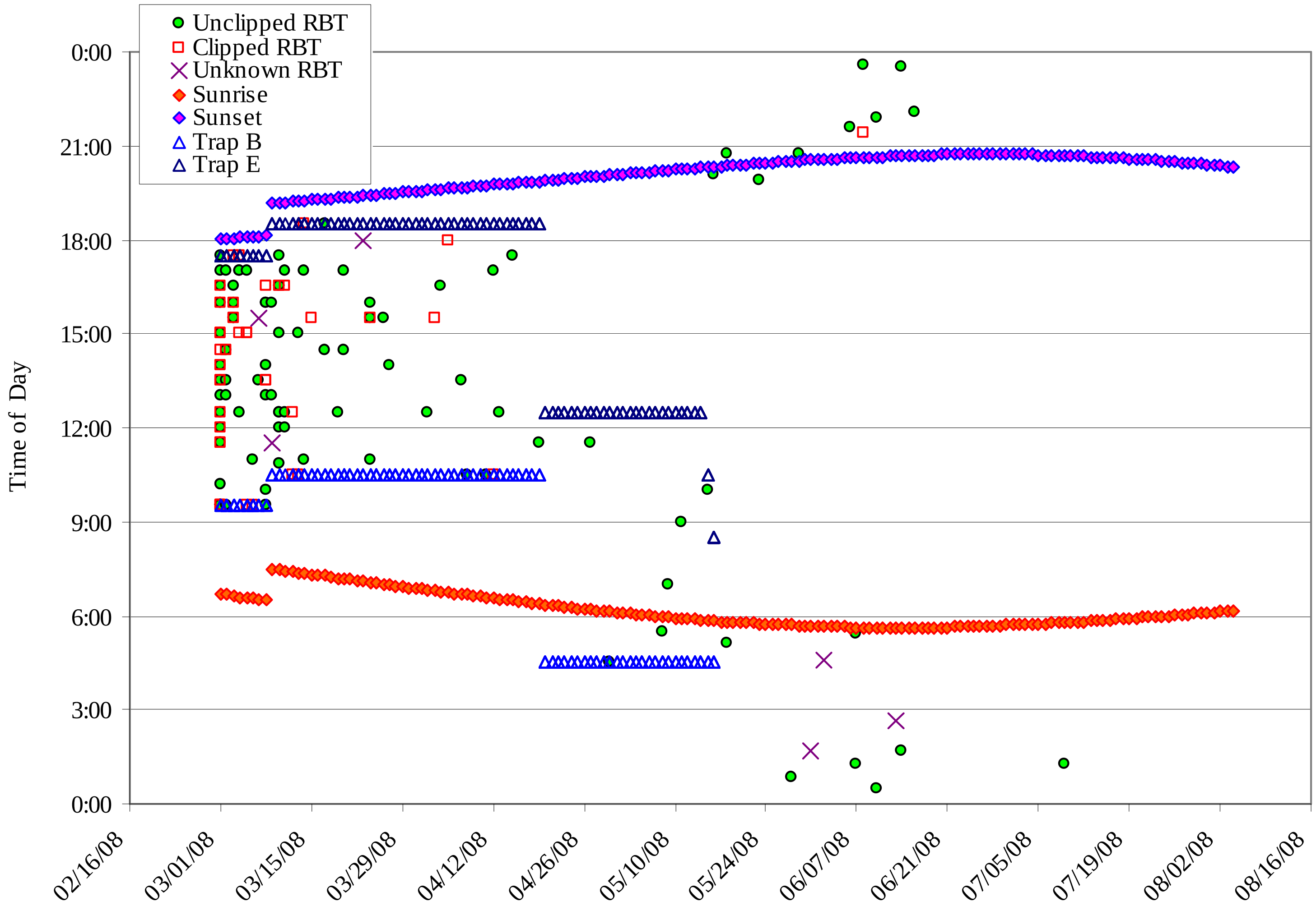

FIGURE 6-Diel migration of rainbow trout/steelhead (RBT, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir during periods of trap operation (March 1-May 16) and video monitoring (May 16-August 1) in 2008. Also included are times of sunrise, sunset, beginning of trap operation (Trap B) and end of trap operation (Trap E).

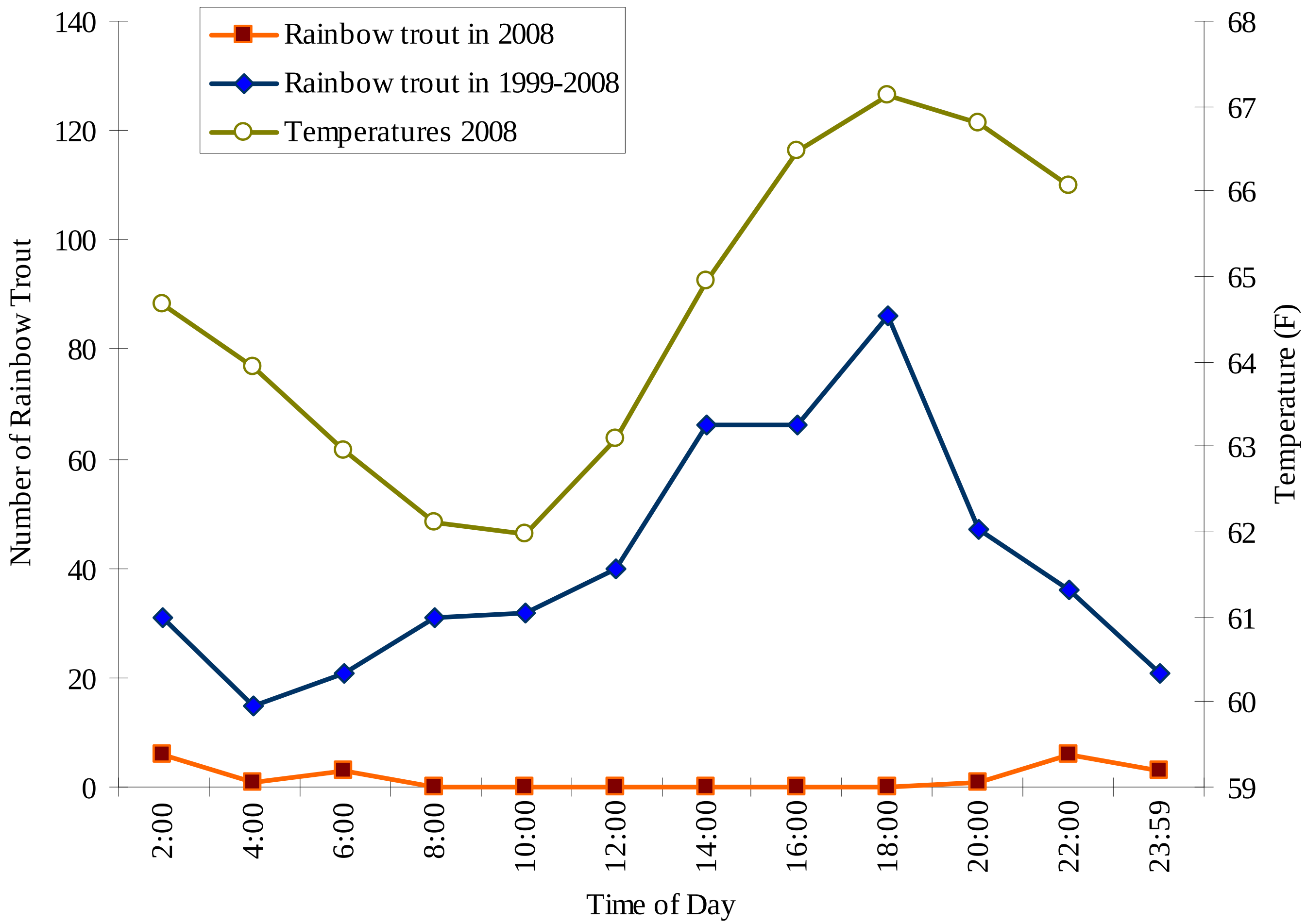

FIGURE 7-Diel migration of rainbow trout/steelhead observed at the Coleman National Fish Hacthery barrier weir during periods of video monitoring. Data includes rainbow trout/steelhead passing in 2008 for May 16-July 31, the ten-year sum of rainbow trout passing from May or June (depending on the year) through July 31, and the average temperature per time category for May 16-July 31, 2008. Labels are the upper end of the two-hour time categories.

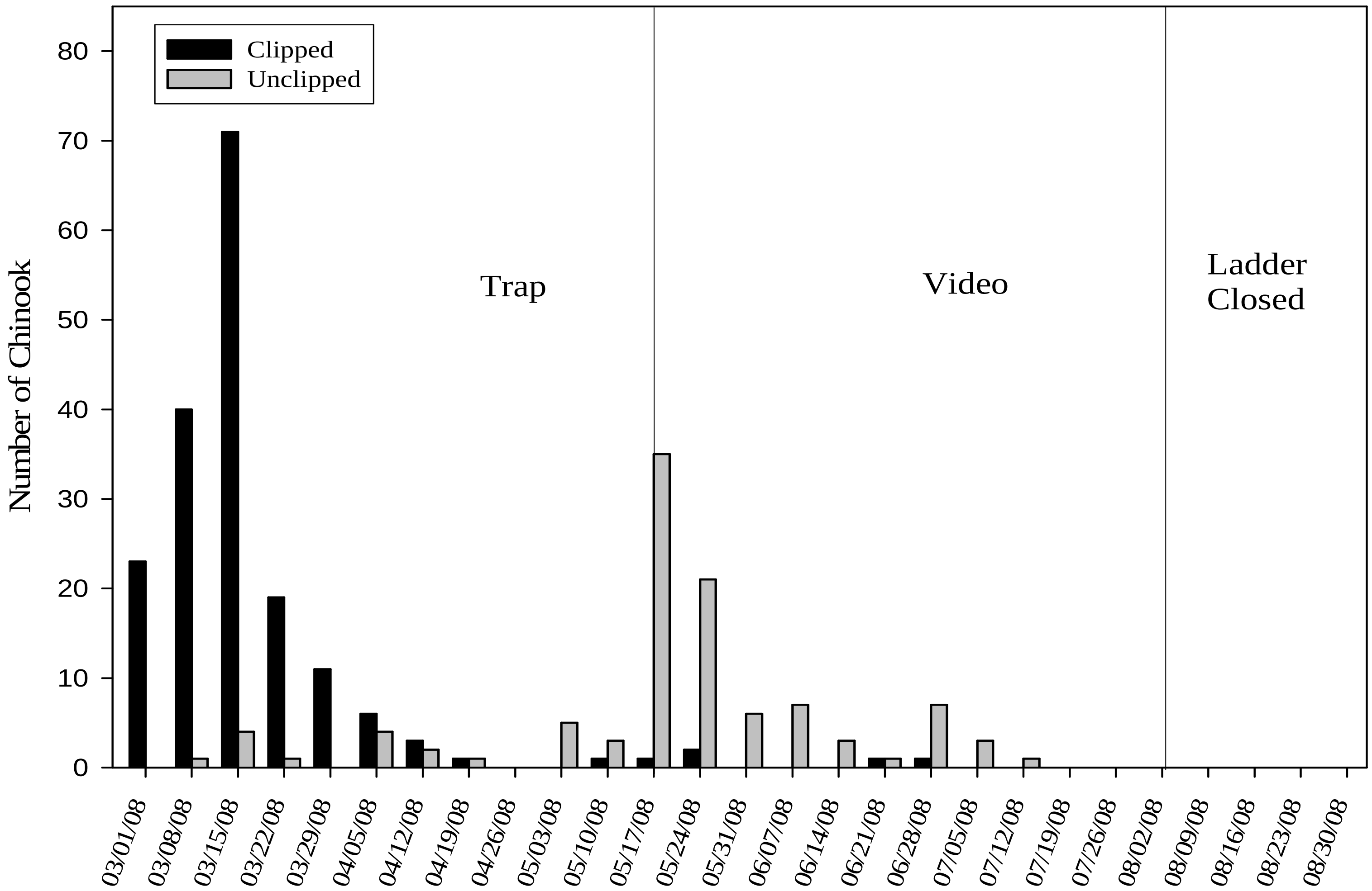

FIGURE 8-Number of clipped and unclipped Chinook salmon observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2008, by week. Dates indicate the last day of the week. The first week is a partial week.

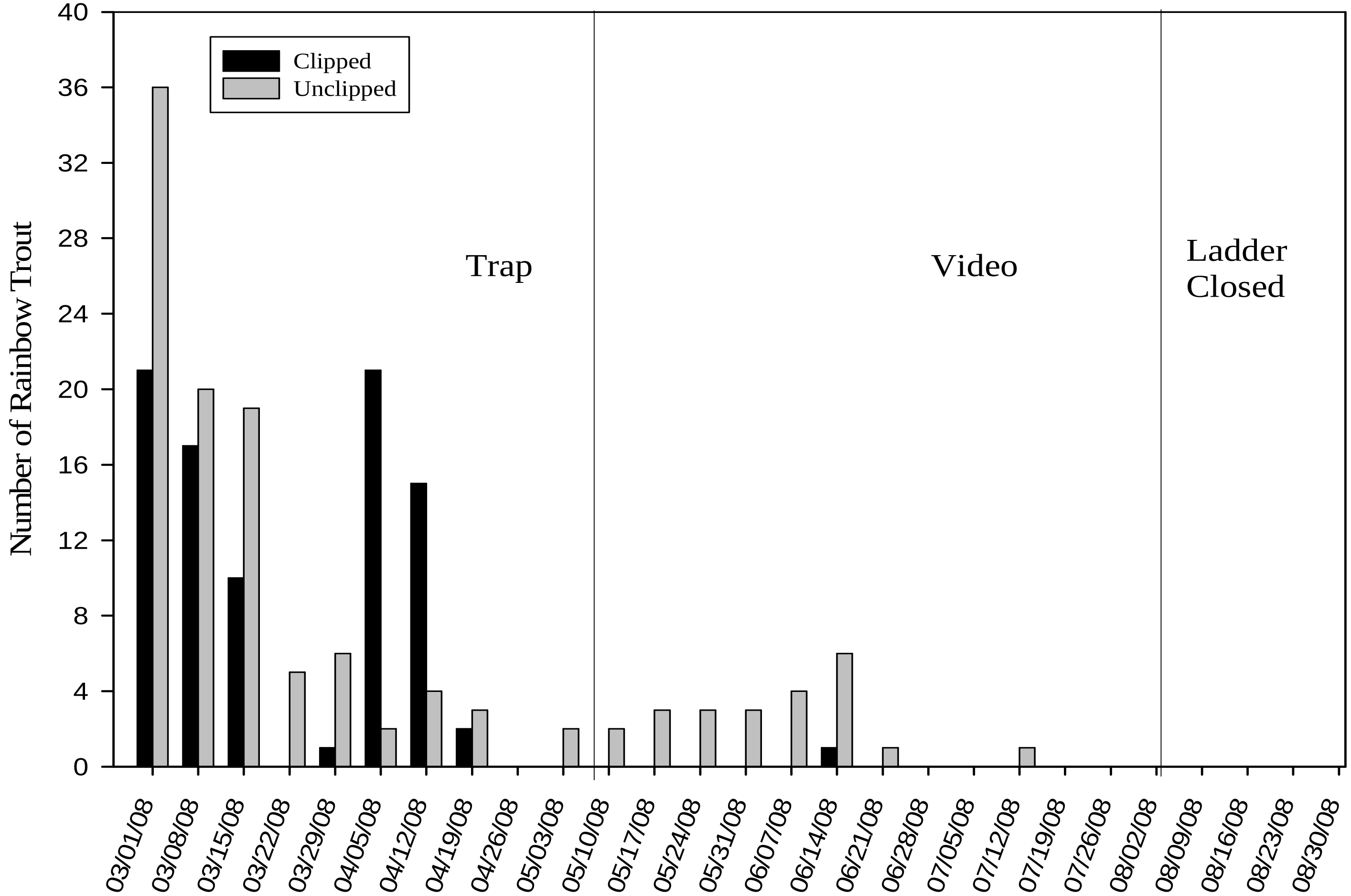

FIGURE 9-Number of clipped and unclipped rainbow trout/steelhead observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2008, by week. Dates indicate the last day of the week. The first week is a partial week.

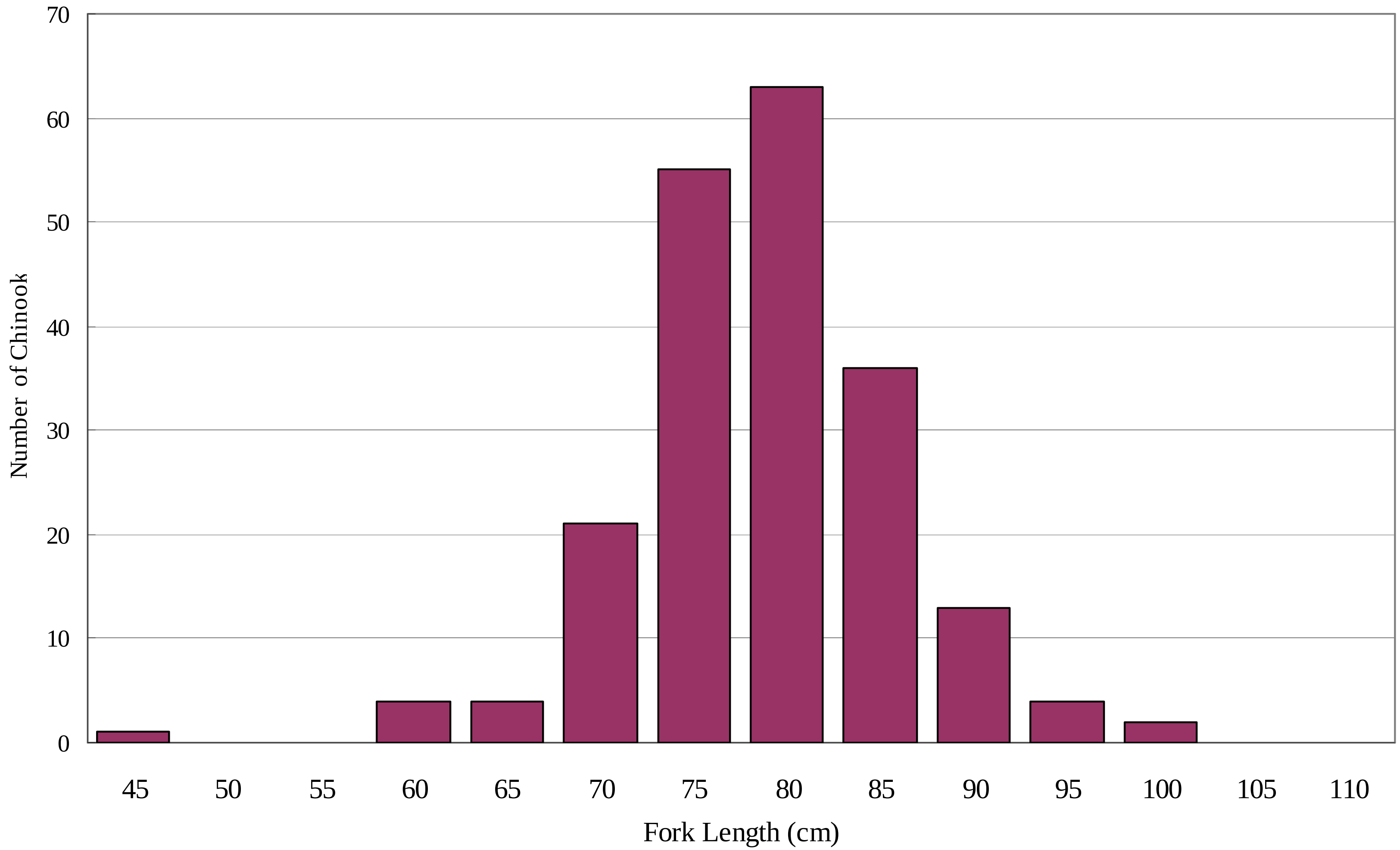

FIGURE 10-Length-frequency distribution of Chinook captured in the Coleman National Fish Hatchery barrier weir in 2008. Fork length labels are the upper end of the size category.

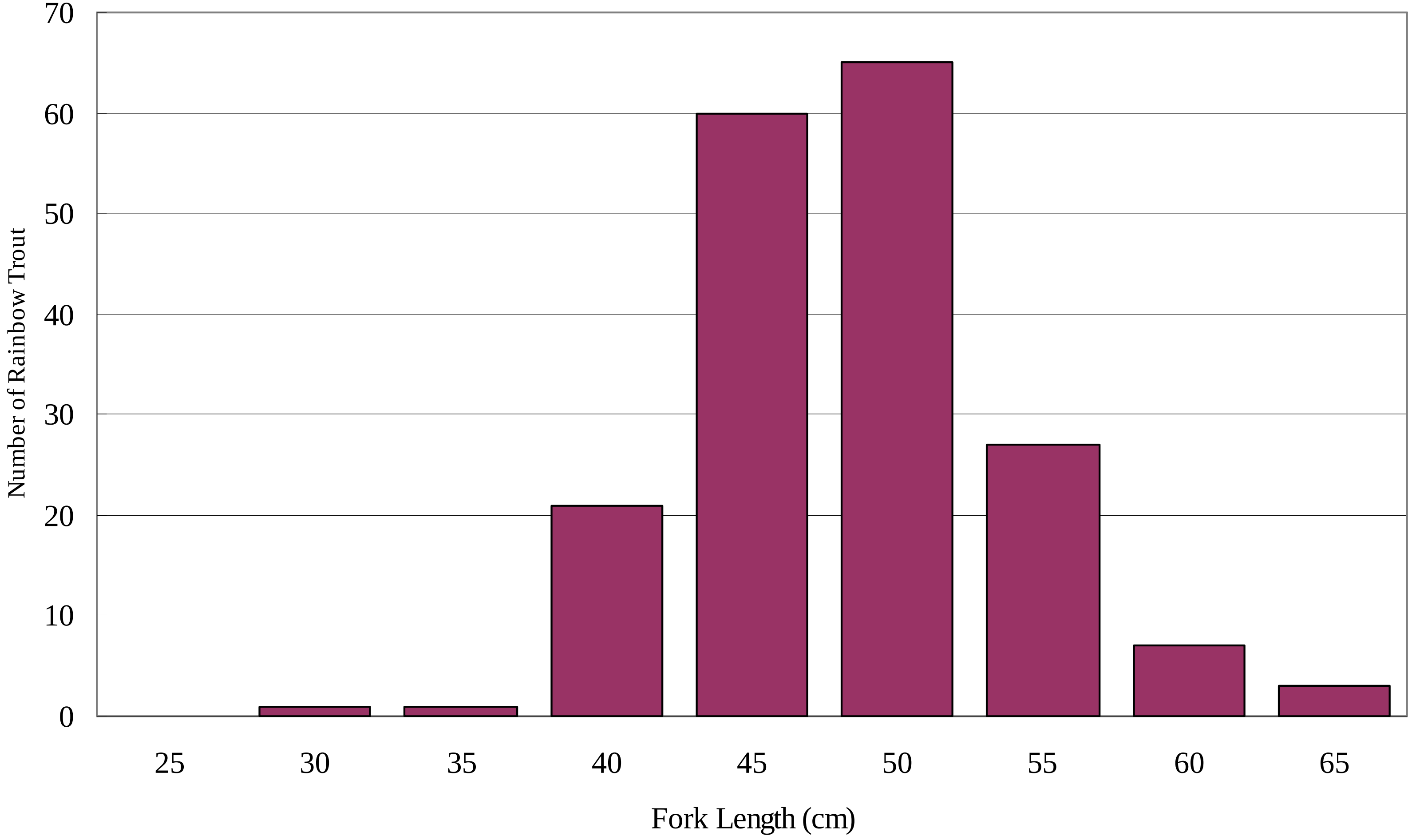

FIGURE 11-Length-frequency distribution of rainbow trout/steelhead captured in Coleman National Fish Hatchery barrier weir trap in 2008. Fork length labels are the upper end of the size category.

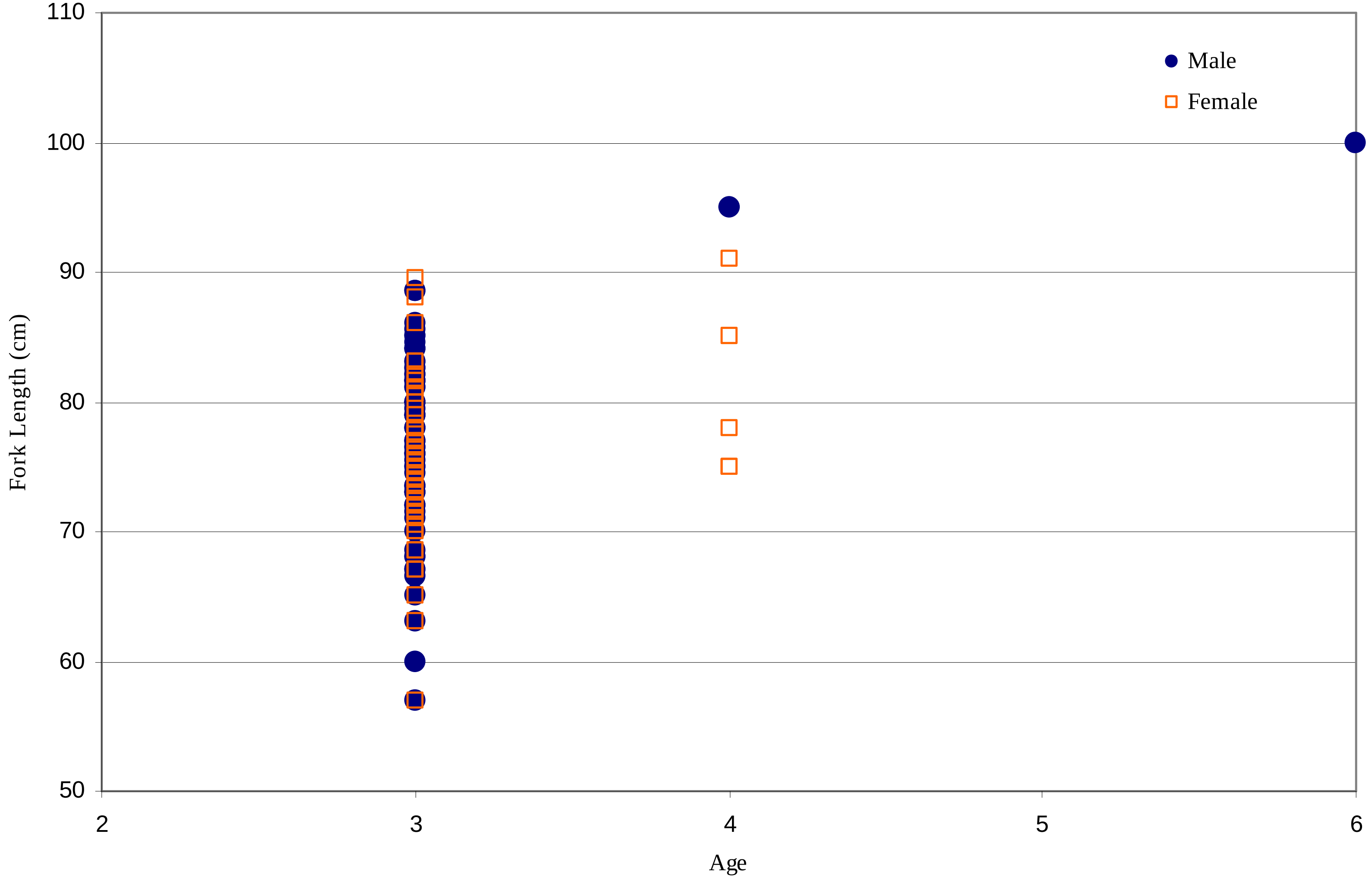

FIGURE 12-Relationship between fork length and age for coded-wire tagged Chinook captured in the Coleman National Fish Hatchery barrier weir trap in 2008.

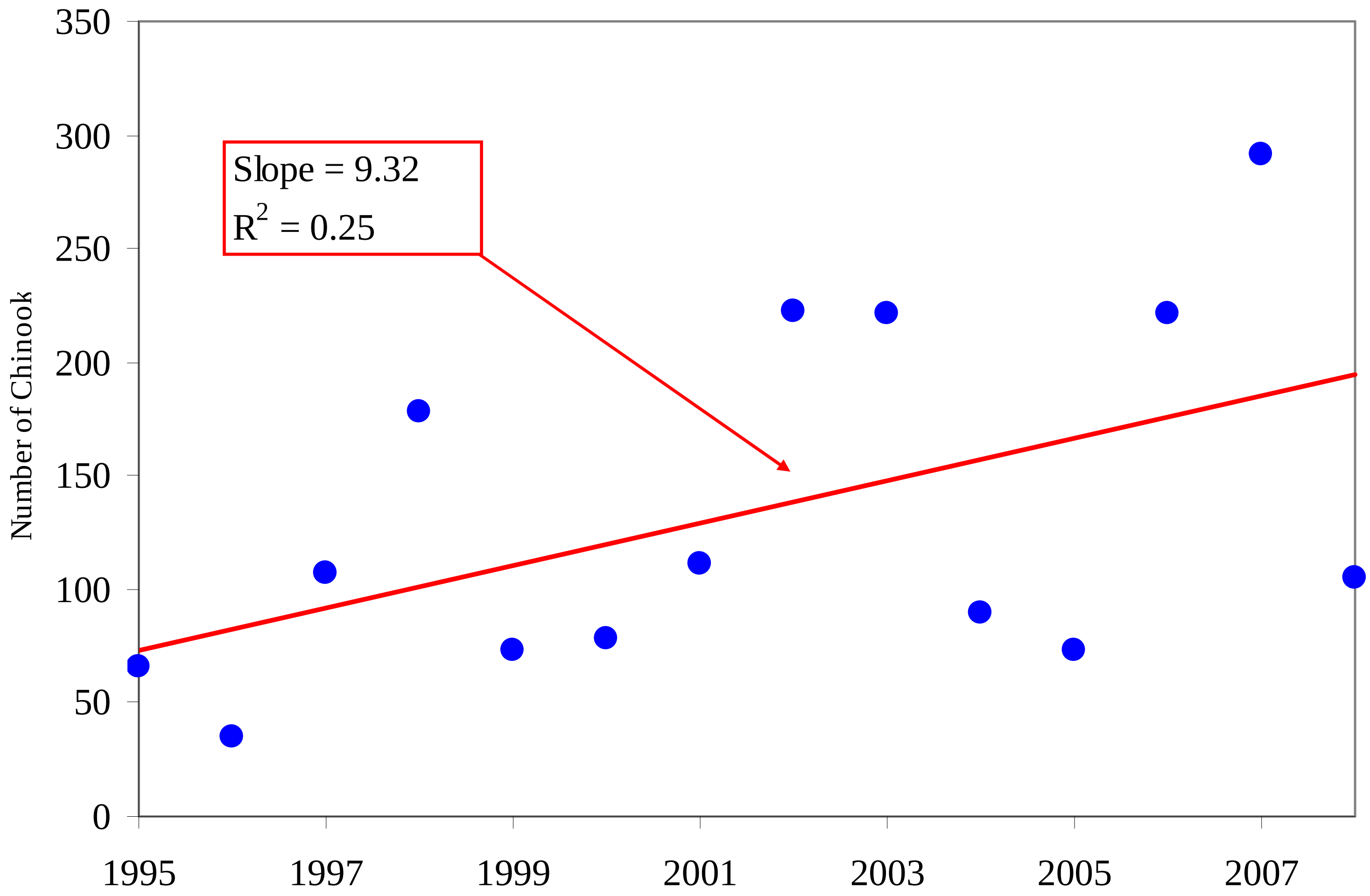

FIGURE 13-The annual total number of unclipped Chinook (i.e., maximum potential spring Chinook) passed above the Coleman National Fish Hatchery barrier weir on Battle Creek from 1995 to 2008. The simple linear regression line describes the population trend for this period.

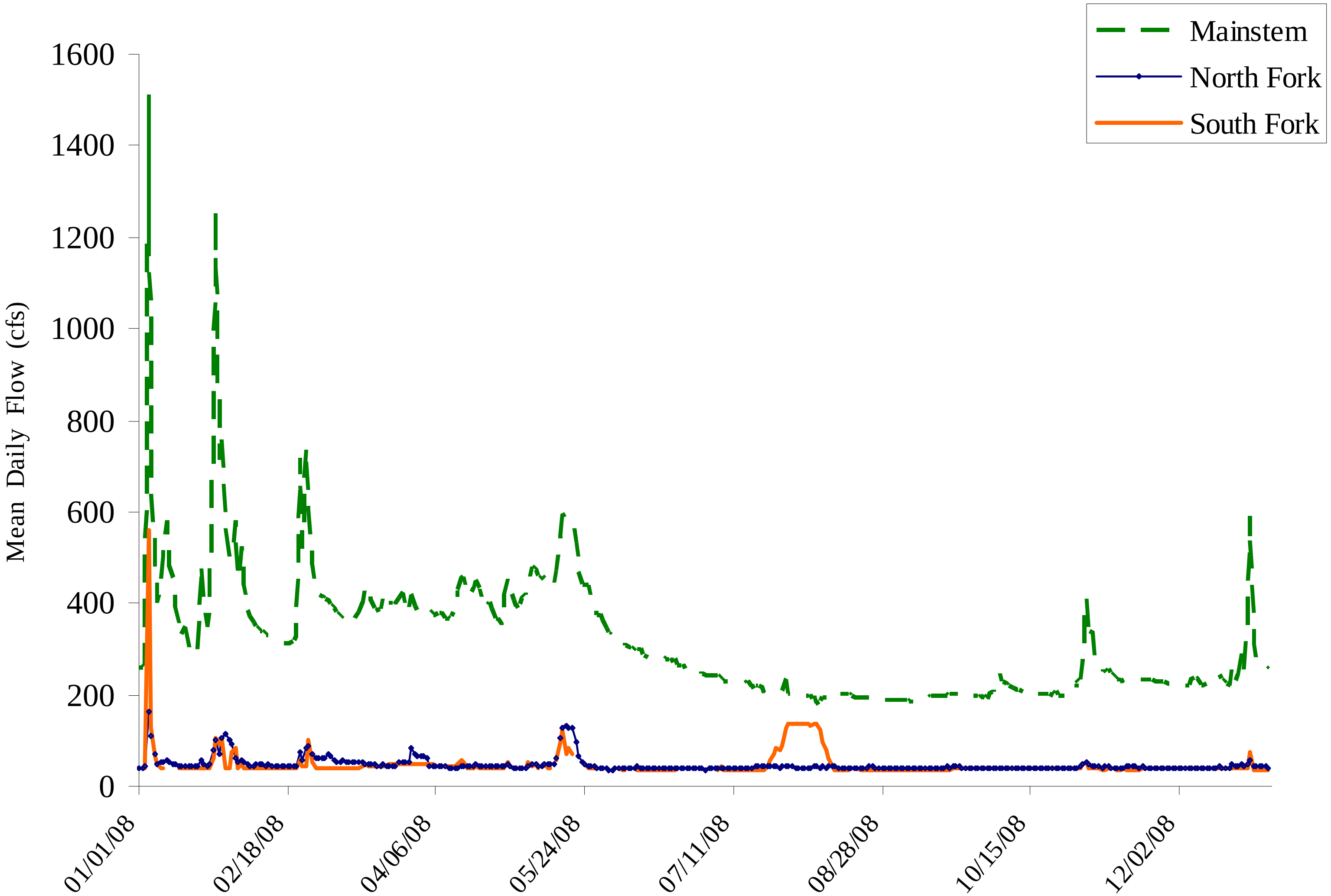

FIGURE 14-The 2008 mean daily flows (MDF) at the Coleman National Fish Hatchery barrier weir on the mainstem (rm 5.8), Wildcat Road Bridge on the North Fork (rm 0.9), and Manton Road Bridge on the South Fork (rm 1.7) of Battle Creek.

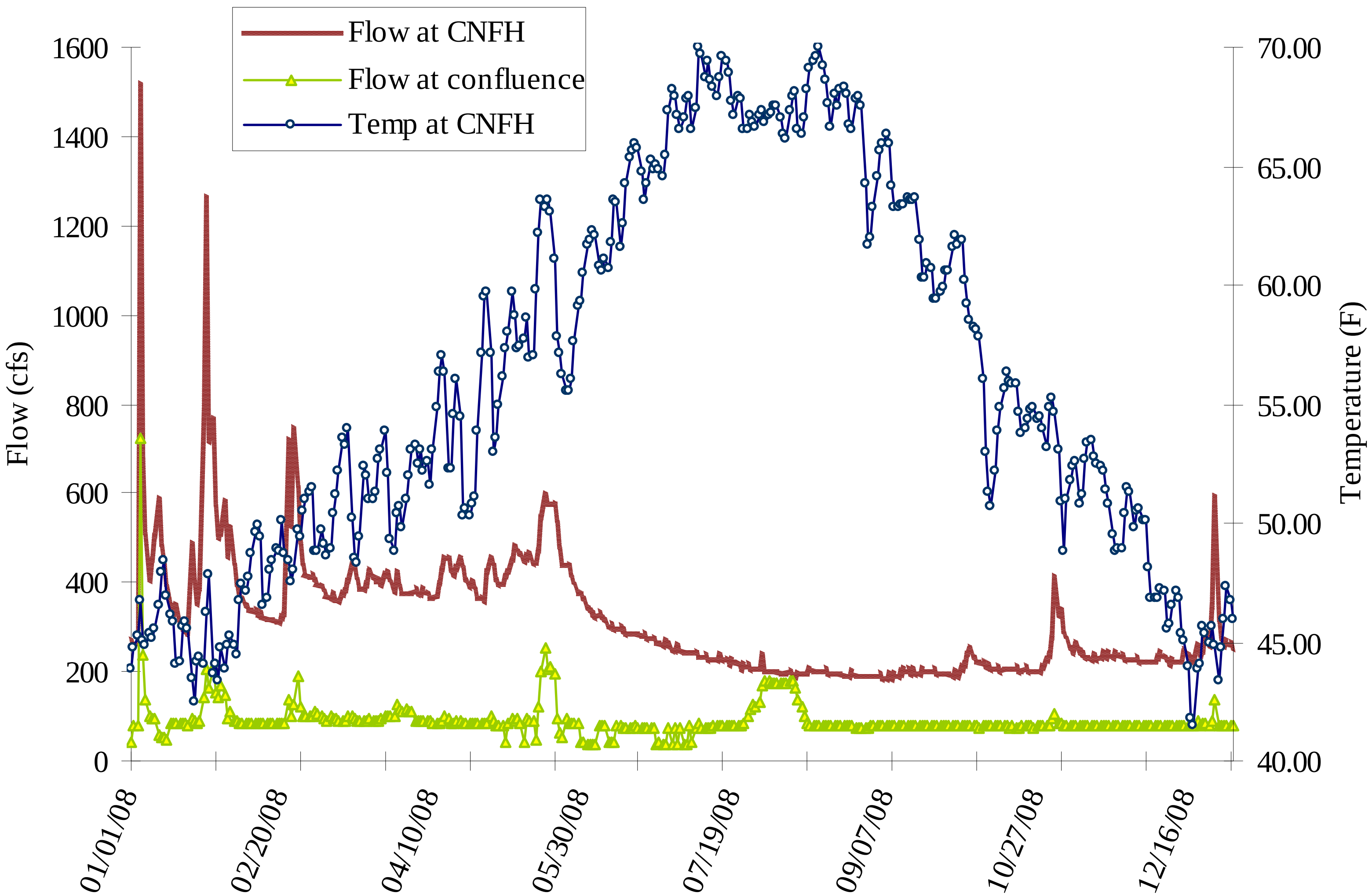

FIGURE 15-The 2008 mean daily flow (MDF) and water temperature (MDT) at the Coleman National Fish Hatchery barrier weir on the mainstem and the flow at the confluence of the forks on Battle Creek.

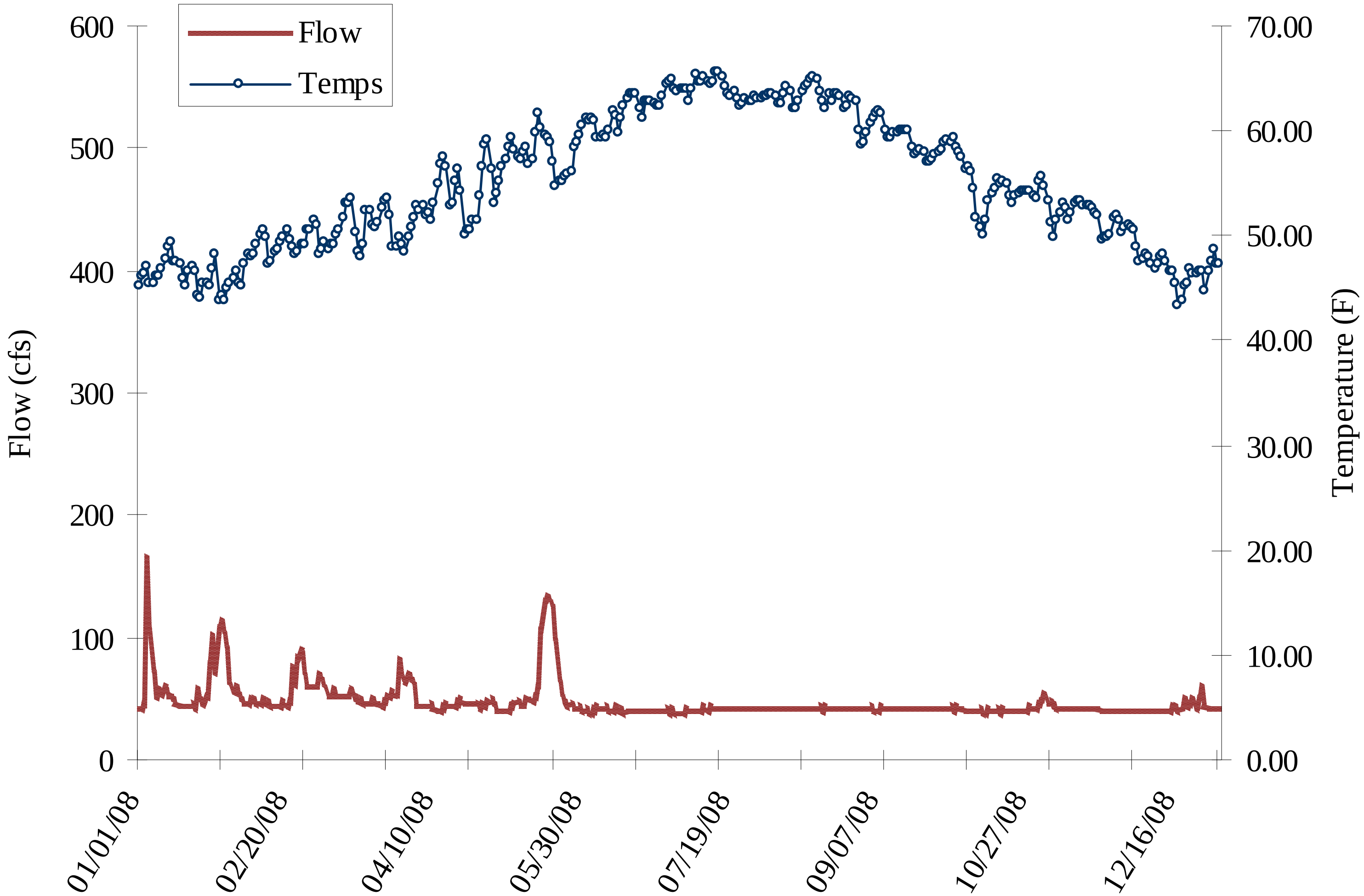

FIGURE 16-The 2008 mean daily flow (MDF) and water temperature (MDT) at Wildcat Road Bridge on the North Fork of Battle Creek.

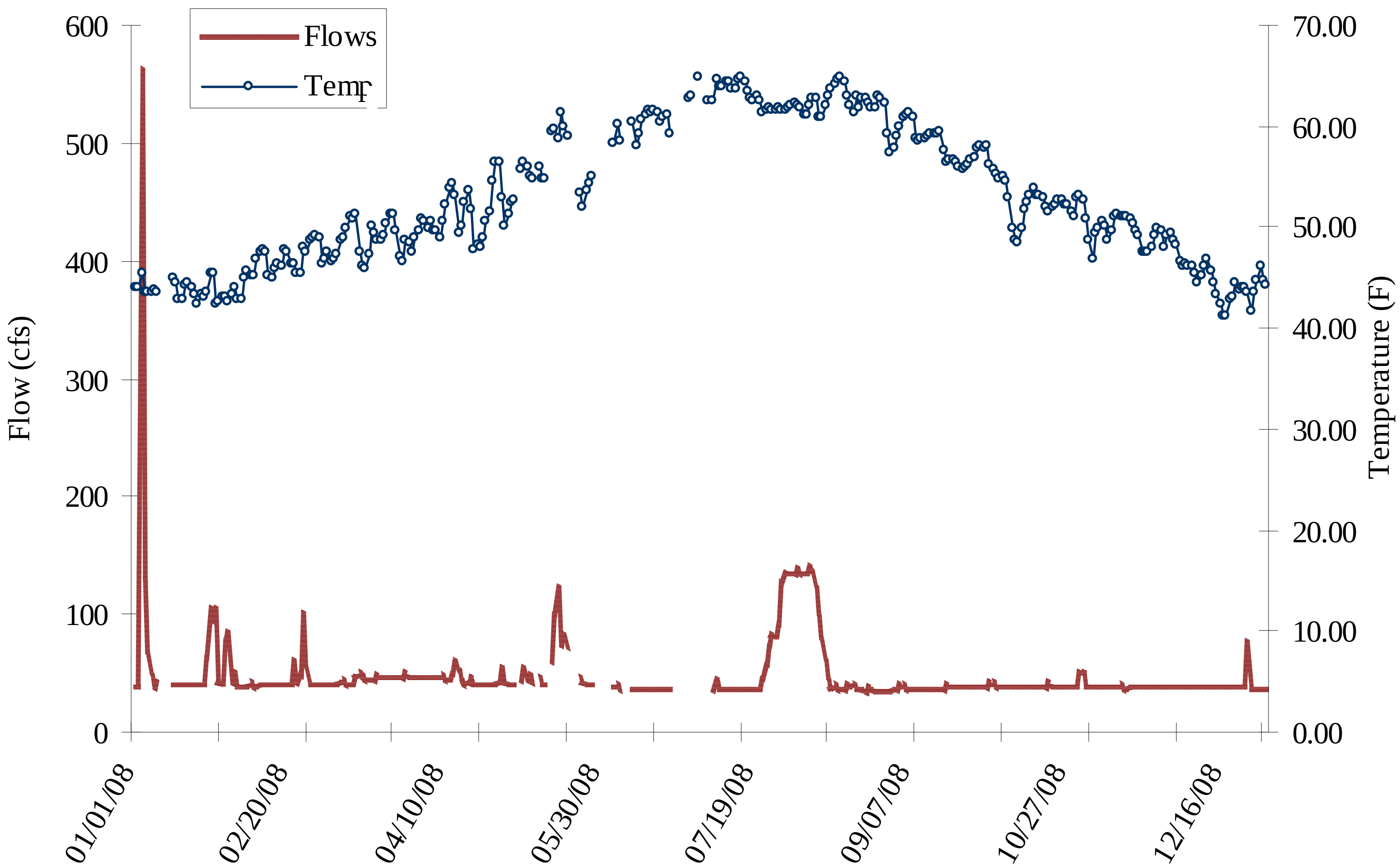

FIGURE 17-The 2008 mean daily flow (MDF) and water temperature (MDT) at Manton Road Bridge on the South Fork of Battle Creek.

Appendix A

APPENDIX A1-Coded-wire tags recovered during Coleman National Fish Hatchery (CNFH) barrier weir trap monitoring in 2008.

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/1/2008	Barrier Weir Trap	Chinook	M	84.0	052869	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	65.0	052783	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	85.0	052868	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	68.0	052867	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	70.0	052785	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	81.0	052780	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	81.0	052866	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	77.0	052782	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	72.0	052782	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	76.0	052794	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	73.0	NTD			
3/1/2008	Barrier Weir Trap	Chinook	F	76.0	052782	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	67.0	052868	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	68.5	052783	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	72.5	052869	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	68.5	0501021511	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	76.5	052870	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	82.5	052783	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	60.0	052783	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/1/2008	Barrier Weir Trap	Chinook	F	77.5	052792	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	80.0	052866	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	M	73.5	052865	CNFH	Late-fall	2005
3/1/2008	Barrier Weir Trap	Chinook	F	88.0	052866	CNFH	Late-fall	2005
3/2/2008	Barrier Weir Trap	Chinook	M	80.0	052866	CNFH	Late-fall	2005
3/2/2008	Barrier Weir Trap	Chinook	M	73.0	052782	CNFH	Late-fall	2005
3/2/2008	Barrier Weir Trap	Chinook	F	77.0	052866	CNFH	Late-fall	2005
3/2/2008	Barrier Weir Trap	Chinook	F	76.0	052782	CNFH	Late-fall	2005
3/3/2008	Barrier Weir Trap	Chinook	F	77.0	NTD			
3/3/2008	Barrier Weir Trap	Chinook	F	73.0	052783	CNFH	Late-fall	2005
3/3/2008	Barrier Weir Trap	Chinook	F	81.0	052867	CNFH	Late-fall	2005
3/3/2008	Barrier Weir Trap	Chinook	M	73.5	052782	CNFH	Late-fall	2005
3/3/2008	Barrier Weir Trap	Chinook	M	72.0	052864	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	M	77.0	052866	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	M	67.0	052870	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	F	75.0	052782	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	F	72.0	052783	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	M	73.5	052780	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	F	81.5	052866	CNFH	Late-fall	2005
3/4/2008	Barrier Weir Trap	Chinook	M	79.0	052866	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/4/2008	Barrier Weir Trap	Chinook	M	71.0	NTD			
3/5/2008	Barrier Weir Trap	Chinook	F	83.0	052864	CNFH	Late-fall	2005
3/5/2008	Barrier Weir Trap	Chinook	F	80.5	052783	CNFH	Late-fall	2005
3/5/2008	Barrier Weir Trap	Chinook	F	79.5	052869	CNFH	Late-fall	2005
3/6/2008	Barrier Weir Trap	Chinook	F	73.0	052870	CNFH	Late-fall	2005
3/6/2008	Barrier Weir Trap	Chinook	F	76.5	052782	CNFH	Late-fall	2005
3/6/2008	Barrier Weir Trap	Chinook	M	85.5	052866	CNFH	Late-fall	2005
3/6/2008	Barrier Weir Trap	Chinook	M	79.0	052782	CNFH	Late-fall	2005
3/6/2008	Barrier Weir Trap	Chinook	M	73.0	052870	CNFH	Late-fall	2005
3/7/2008	Barrier Weir Trap	Chinook	M	86.0	052782	CNFH	Late-fall	2005
3/7/2008	Barrier Weir Trap	Chinook	F	80.5	052865	CNFH	Late-fall	2005
3/7/2008	Barrier Weir Trap	Chinook	M	76.5	Lost Tag			
3/7/2008	Barrier Weir Trap	Chinook	M	72.0	0501021511	CNFH	Late-fall	2005
3/7/2008	Barrier Weir Trap	Chinook	M	88.5	052783	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	F	76.0	052783	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	M	81.5	052782	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	F	80.5	052782	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	M	71.5	052864	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	M	72.0	052794	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	F	75.0	052865	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/8/2008	Barrier Weir Trap	Chinook	F	72.0	052783	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	F	81.0	052783	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	F	79.0	052866	CNFH	Late-fall	2005
3/8/2008	Barrier Weir Trap	Chinook	M	68.0	052795	CNFH	Late-fall	2005
3/9/2008	Barrier Weir Trap	Chinook	F	66.5	NTD			
3/9/2008	Barrier Weir Trap	Chinook	M	84.5	052782	CNFH	Late-fall	2005
3/9/2008	Barrier Weir Trap	Chinook	F	72.0	052782	CNFH	Late-fall	2005
3/9/2008	Barrier Weir Trap	Chinook	F	78.0	052866	CNFH	Late-fall	2005
3/9/2008	Barrier Weir Trap	Chinook	M	74.5	052782	CNFH	Late-fall	2005
3/9/2008	Barrier Weir Trap	Chinook	F	74.0	052866	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	F	71.5	052783	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	80.0	052866	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	81.5	052866	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	F	78.0	052866	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	72.0	Lost Tag			
3/10/2008	Barrier Weir Trap	Chinook	F	74.0	052783	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	F	75.0	052782	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	77.0	052782	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	79.0	NTD			
3/11/2008	Barrier Weir Trap	Chinook	M	78.0	NTD			
3/11/2008	Barrier Weir Trap	Chinook	M	84.0	052866	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/11/2008	Barrier Weir Trap	Chinook	M	81.0	052864	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	67.0	052794	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	74.5	052782	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	75.5	052864	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	78.0	052866	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	M	75.0	052783	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	M	68.5	052783	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	80.0	NTD			
3/11/2008	Barrier Weir Trap	Chinook	M	80.0	052782	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	65.0	052866	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	75.0	052287	CNFH	Late-fall	2004
3/11/2008	Barrier Weir Trap	Chinook	M	83.0	052868	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	82.0	052866	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	82.0	052783	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	77.0	052866	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	89.5	052866	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	74.0	052783	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	81.0	052866	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	78.0	052868	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	75.0	052865	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	71.5	052864	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/12/2008	Barrier Weir Trap	Chinook	F	80.5	052783	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	73.0	052782	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	75.5	052866	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	83.0	052785	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	M	66.5	052783	CNFH	Late-fall	2005
3/10/2008	Barrier Weir Trap	Chinook	F	82.0	052866	CNFH	Late-fall	2005
3/11/2008	Barrier Weir Trap	Chinook	F	77.0	052780	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	79.5	052783	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	M	81.5	052783	CNFH	Late-fall	2005
3/12/2008	Barrier Weir Trap	Chinook	F	73.5	052865	CNFH	Late-fall	2005
3/13/2008	Barrier Weir Trap	Chinook	M	76.5	052873	CNFH	Late-fall	2005
3/13/2008	Barrier Weir Trap	Chinook	F	78.0	052278	CNFH	Late-fall	2004
3/13/2008	Barrier Weir Trap	Chinook	F	72.5	052782	CNFH	Late-fall	2005
3/13/2008	Barrier Weir Trap	Chinook	M	88.5	052866	CNFH	Late-fall	2005
3/13/2008	Barrier Weir Trap	Chinook	F	78.0	052782	CNFH	Late-fall	2005
3/13/2008	Barrier Weir Trap	Chinook	M	80.0	NTD			
3/13/2008	Barrier Weir Trap	Chinook	M	78.0	052782	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	M	57.0	052782	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	M	63.0	052783	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	F	67.0	052866	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	M	76.0	052782	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/14/2008	Barrier Weir Trap	Chinook	F	75.0	052279	CNFH	Late-fall	2004
3/14/2008	Barrier Weir Trap	Chinook	M	72.0	NTD			
3/14/2008	Barrier Weir Trap	Chinook	M	75.0	052782	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	F	74.5	052866	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	F	78.0	052782	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	M	70.0	052866	CNFH	Late-fall	2005
3/14/2008	Barrier Weir Trap	Chinook	M	67.0	052782	CNFH	Late-fall	2005
3/15/2008	Barrier Weir Trap	Chinook	F	74.0	052783	CNFH	Late-fall	2005
3/15/2008	Barrier Weir Trap	Chinook	F	79.0	052782	CNFH	Late-fall	2005
3/15/2008	Barrier Weir Trap	Chinook	M	85.0	052867	CNFH	Late-fall	2005
3/15/2008	Barrier Weir Trap	Chinook	F	77.0	052782	CNFH	Late-fall	2005
3/15/2008	Barrier Weir Trap	Chinook	F	86.0	052866	CNFH	Late-fall	2005
3/16/2008	Barrier Weir Trap	Chinook	F	72.0	052783	CNFH	Late-fall	2005
3/16/2008	Barrier Weir Trap	Chinook	F	70.0	052783	CNFH	Late-fall	2005
3/16/2008	Barrier Weir Trap	Chinook	F	75.0	052782	CNFH	Late-fall	2005
3/17/2008	Barrier Weir Trap	Chinook	F	78.0	052866	CNFH	Late-fall	2005
3/17/2008	Barrier Weir Trap	Chinook	F	70.0	052782	CNFH	Late-fall	2005
3/18/2008	Barrier Weir Trap	Chinook	M	76.0	052783	CNFH	Late-fall	2005
3/18/2008	Barrier Weir Trap	Chinook	M	77.0	052866	CNFH	Late-fall	2005

Collection Date	Barrier Weir Trap	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/18/2008	Barrier Weir Trap	Chinook	F	83.0	052864	CNFH	Late-fall	2005
3/18/2008	Barrier Weir Trap	Chinook	F	74.0	052783	CNFH	Late-fall	2005
3/19/2008	Barrier Weir Trap	Chinook	F	81.5	052782	CNFH	Late-fall	2005
3/19/2008	Barrier Weir Trap	Chinook	M	82.5	052783	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	M	81.5	052783	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	M	71.0	052782	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	M	76.5	052783	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	F	77.0	052782	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	M	82.0	0501021511	CNFH	Late-fall	2005
3/20/2008	Barrier Weir Trap	Chinook	F	79.0	0501021510	CNFH	Late-fall	2005
3/21/2008	Barrier Weir Trap	Chinook	M	73.0	052783	CNFH	Late-fall	2005
3/21/2008	Barrier Weir Trap	Chinook	F	75.0	NTD			
3/23/2008	Barrier Weir Trap	Chinook	F	85.0	052294	CNFH	Late-fall	2004
3/25/2008	Barrier Weir Trap	Chinook	M	79.0	052866	CNFH	Late-fall	2005
3/25/2008	Barrier Weir Trap	Chinook	F	74.5	052780	CNFH	Late-fall	2005
3/26/2008	Barrier Weir Trap	Chinook	F	57.0	052866	CNFH	Late-fall	2005
3/26/2008	Barrier Weir Trap	Chinook	M	79.0	052782	CNFH	Late-fall	2005
3/26/2008	Barrier Weir Trap	Chinook	F	70.5	052783	CNFH	Late-fall	2005
3/27/2008	Barrier Weir Trap	Chinook	M	84.0	052782	CNFH	Late-fall	2005

APPENDIX A1-Continued

Collection Date	Collection location and method	Species	Sex	Fork Length (cm)	Tag code[a]	Hatchery or Creek of origin[b]	Run	Brood Year
3/28/2008	Barrier Weir Trap	Chinook	F	63.0	052864	CNFH	Late-fall	2005
3/29/2008	Barrier Weir Trap	Chinook	F	78.0	NTD			
3/29/2008	Barrier Weir Trap	Chinook	F	71.0	052783	CNFH	Late-fall	2005
3/29/2008	Barrier Weir Trap	Chinook	F	74.5	052782	CNFH	Late-fall	2005
3/30/2008	Barrier Weir Trap	Chinook	M	80.0	052782	CNFH	Late-fall	2005
3/30/2008	Barrier Weir Trap	Chinook	F	71.0	052782	CNFH	Late-fall	2005
3/31/2008	Barrier Weir Trap	Chinook	F	76.0	052868	CNFH	Late-fall	2005
4/1/2008	Barrier Weir Trap	Chinook	F	71.0	052866	CNFH	Late-fall	2005
4/3/2008	Barrier Weir Trap	Chinook	F	76.0	052864	CNFH	Late-fall	2005
4/4/2008	Barrier Weir Trap	Chinook	M	100.0	051095	CNFH	Late-fall	2002
4/7/2008	Barrier Weir Trap	Chinook	F	76.0	052783	CNFH	Late-fall	2005
4/10/2008	Barrier Weir Trap	Chinook	F	76.0	052782	CNFH	Late-fall	2005
4/12/2008	Barrier Weir Trap	Chinook	F	91.0	052278	CNFH	Late-fall	2004
4/13/2008	Barrier Weir Trap	Chinook	F	75.5	052782	CNFH	Late-fall	2005
5/5/2008	Barrier Weir Trap	Chinook	M	95.0	062443	FRH	Spring	2004

[a] NTD means No Tag Detected
[b] Hatcheries include Coleman National Fish Hatchery (CNFH), Livingston Stone National Fish Hatchery (LSFH), and Feather River Hatchery (FRH).

APPENDIX A2-Chinook redd measurements taken during USFWS Battle Creek snorkel surveys in 2008.

Date	Reach	Max Length (ft)	Max Width (ft)	Area (ft^2)	Depth: Pre-redd (ft)	Depth: Pit (ft)	Depth: Tailspill (ft)	Velocity (ft/s)	Substrate code[a]
9/16/2008	1	6.67	4.92	25.74	1.42	1.83	1.17	1.37	2.4
9/18/2008	4	5.00	2.67	10.47	1.33	1.83	1.25	2.86	1.3
9/29/2008	1	11.00	12.17	105.11	1.42	3.50	0.75	1.62	2.3
9/29/2008	1	5.92	7.00	32.53	0.83	1.08	0.33	1.02	1
9/29/2008	1	6.08	4.08	19.51	1.42	2.00	1.58	2.06	3.4
10/1/2008	3	20.33	7.08	113.12	1.50	2.00	0.67	1.08	2.4
10/1/2008	3	15.08	6.67	78.98	1.42	1.75	0.75	1.60	2.4
10/1/2008	3	10.75	5.92	49.95	0.83	1.25	0.33	1.31	2.4
10/1/2008	4	18.00	9.17	129.59	0.92	1.58	0.75	1.39	1.3
10/1/2008	4	5.33	3.58	15.01	0.92	1.08	0.83	1.14	1.3
10/1/2008	4	19.83	9.00	140.19	0.92	1.25	0.67	1.07	1.3
10/1/2008	4	18.17	12.08	172.41	1.92	2.25	1.42	2.52	2.4
10/1/2008	4	19.75	9.58	148.65	0.75	1.00	0.50	0.71	1.3
10/1/2008	4	5.58	3.92	17.18	0.75	1.04	0.38	1.52	1.2
10/1/2008	4	9.33	5.08	37.26	1.67	2.00	1.33	1.83	2.4
10/2/2008	5	16.33	7.67	98.35	1.08	1.67	0.50	2.18	1.3
10/3/2008	6	11.25	4.33	38.29	1.83	2.33	1.58	0.20	2.4
10/3/2008	6	12.67	10.00	99.48	0.83	2.25	0.75	1.76	1.3
10/14/2008	2	12.42	7.00	68.26	1.08	1.75	0.83	3.37	1.3
10/14/2008	2	7.08	2.92	16.23	1.50	1.83	1.33	1.88	2.3
10/14/2008	2	19.50	18.33	280.78	1.25	1.83	0.75	1.38	1.3
10/14/2008	2	14.92	14.58	170.85	1.33	1.58	0.50	2.42	1.3
10/14/2008	2	16.25	8.50	108.48	1.58	2.00	0.75	2.19	1.3
10/14/2008	2	16.42	5.17	66.62	1.08	1.50	0.75	3.57	2.3
10/15/2008	3	10.67	7.58	63.53	1.42	1.79	1.08	1.09	1.3
10/15/2008	3	14.25	6.42	71.81	1.42	1.67	1.00	1.73	3.5
10/15/2008	4	28.00	7.58	166.77	1.08	1.50	0.83	1.69	2.4
10/15/2008	4	20.42	5.42	86.86	1.50	1.75	1.00	0.42	1.3
10/15/2008	4	9.33	4.83	35.43	1.33	1.83	1.17	1.50	2.4
Average		1.24	1.73	0.85	13.35	7.39	85.43	1.65	1.3[b]
Minimum		0.75	1.00	0.08	5.00	2.67	10.47	0.20	1
Maximum		1.92	3.50	1.58	28.00	18.33	280.78	3.57	3.5

[a] Dominant substrate codes are described by USFWS (2005)and are generally defined as follows; 1=1 in., 2.3= 2-3 in., 3.5=3-5 in., etc.

[b] The median substrate code was used instead of average.

APPENDIX A3-Estimated number of days that egg incubation fell within the five water-temperature suitability categories for each spring Chinook redd in 2008. The incubation period was calculated using a cumulative 1,850 Daily Temperature Unit (DTU). Days listed under 'B' and 'W' are the best-case scenarios and worst-case scenarios, respectively.

				Very Poor		Poor		Fair		Good		Excellent		Total Days	
Location	Reach	River Mile	Date	B	W	B	W	B	W	B	W	B	W	B	W
North Fork	R1	3.57	9/16/2008	0	0	0	0	2	7	13	18	70	56	**85**	**81**
North Fork	R1	3.53	9/29/2008	0	0	0	0	0	0	3	4	95	87	**98**	**91**
North Fork	R1	3.50	9/29/2008	0	0	0	0	0	0	3	4	95	87	**98**	**91**
North Fork	R1	3.16	9/29/2008	0	0	0	0	0	0	4	6	94	85	**98**	**91**
North Fork	R2	1.76	10/14/2008	0	0	0	0	0	0	0	1	108	103	**108**	**104**
North Fork	R2	1.15	10/14/2008	0	0	0	0	0	0	0	1	112	107	**112**	**108**
North Fork	R2	1.01	10/14/2008	0	0	0	0	0	0	0	1	113	108	**113**	**109**
North Fork	R2	0.92	10/14/2008	0	0	0	0	0	0	0	1	114	109	**114**	**110**
North Fork	R2	0.88	10/14/2008	0	0	0	0	0	1	0	3	103	95	**103**	**99**
North Fork	R2	0.88	10/14/2008	0	0	0	0	0	1	0	3	103	95	**103**	**99**
North Fork	R2	0.48	10/14/2008	0	0	0	0	0	2	0	3	104	94	**104**	**99**
South Fork	R3	2.22	10/1/2008	0	0	0	0	0	0	1	7	112	95	**113**	**102**
South Fork	R3	2.16	10/1/2008	0	0	0	0	0	0	1	8	112	94	**113**	**102**
South Fork	R3	2.11	10/1/2008	0	0	0	0	0	0	1	8	112	94	**113**	**102**
South Fork	R3	2.10	10/1/2008	0	0	0	0	0	0	1	8	112	94	**113**	**102**
South Fork	R3	2.10	10/1/2008	0	0	0	0	0	0	1	8	112	94	**113**	**102**
South Fork	R3	1.92	10/1/2008	0	0	0	0	0	0	1	8	113	94	**114**	**102**
South Fork	R3	0.11	10/1/2008	0	0	0	0	1	4	2	10	109	86	**112**	**100**
South Fork	R3	2.17	10/15/2008	0	0	0	0	0	0	0	0	121	114	**121**	**114**
South Fork	R3	2.10	10/15/2008	0	0	0	0	0	0	0	0	121	114	**121**	**114**
South Fork	R3	0.34	10/15/2008	0	0	0	0	0	0	2	0	111	120	**113**	**120**
Mainstem	R4	16.26	9/18/2008	0	6	1	13	11	14	8	5	68	33	**88**	**74**
Mainstem	R4	16.58	10/1/2008	0	0	1	4	3	12	6	6	83	61	**93**	**83**
Mainstem	R4	16.58	10/1/2008	0	0	1	4	3	12	6	6	83	61	**93**	**83**
Mainstem	R4	16.51	10/1/2008	0	0	1	4	3	12	5	5	86	63	**95**	**84**
Mainstem	R4	16.27	10/1/2008	0	0	1	1	2	10	4	8	93	69	**100**	**88**
Mainstem	R4	16.57	10/1/2008	0	0	0	0	1	4	3	12	101	78	**105**	**94**
Mainstem	R4	16.05	10/1/2008	0	0	0	0	2	9	4	9	97	74	**103**	**92**
Mainstem	R4	16.01	10/1/2008	0	0	0	0	2	7	4	5	97	86	**103**	**98**
Mainstem	R4	15.57	10/1/2008	0	0	0	0	2	10	5	9	95	72	**102**	**91**
Mainstem	R4	14.82	10/1/2008	0	0	1	1	2	11	4	7	94	71	**101**	**90**
Mainstem	R4	14.79	10/1/2008	0	0	1	1	2	11	4	7	94	71	**101**	**90**
Mainstem	R4	14.06	10/1/2008	0	0	1	2	2	11	4	6	93	70	**100**	**89**
Mainstem	R4	13.80	10/15/2008	0	0	0	0	0	3	2	5	98	87	**100**	**95**
Mainstem	R4	13.80	10/15/2008	0	0	0	0	0	0	0	3	111	102	**111**	**105**
Mainstem	R4	13.25	10/15/2008	0	0	0	0	0	0	0	3	112	103	**112**	**106**
Mainstem	R4	14.13	10/15/2008	0	0	0	0	0	1	0	5	109	97	**109**	**103**
Mainstem	R5	11.93	10/2/2008	0	0	0	4	3	12	3	3	95	69	**101**	**88**

APPENDIX A3-Continued

Location	Reach	River Mile	Date	Very Poor		Poor		Fair		Good		Excellent		Total Days	
				B	W	B	W	B	W	B	W	B	W	B	W
Mainstem	R6	7.29	10/3/2008	0	0	0	6	2	3	3	3	98	83	**103**	**95**
Mainstem	R6	7.23	10/3/2008	0	0	0	8	2	7	3	3	98	70	**103**	**88**