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Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from March through November 2006

USFWS Report

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Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from March through November 2006

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Abstract.—We estimated that zero clipped and 221 unclipped Chinook salmon *Oncorhynchus tshawytscha* passed through the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder into upper Battle Creek between March 1 and August 1, 2006. It is difficult to precisely apportion these fish to individual runs of Chinook because of the overlap in migration timing between runs. However, based on a combination of information from migration timing, coded-wire tag recoveries, and genetic analyses, we estimated there were 1 winter Chinook, 154 spring Chinook, 66 fall Chinook, and zero late-fall Chinook. These passage estimates were made while the fish ladder was open, which encompassed nearly the entire spring Chinook migration period but only part of the migration period for winter, fall, and late-fall Chinook. Some salmonids are able to jump the weir and circumvent the fish ladder, especially at high flows. While the fish ladder was open, flows exceeded 2,000 cfs on ten days in March and April possibly allowing some Chinook and steelhead to pass upstream undetected. After the ladder was closed on August 1, flows remained low (<435 cfs MDF) through December 10 suggesting that few CNFH fall Chinook jumped the barrier weir in 2006. An additional 50 unclipped Chinook were passed above the barrier weir prior to March 1 by CNFH during their late-fall Chinook propagation program. While these 50 Chinook could have been from any of the four runs of Chinook, they were most likely late-fall Chinook. Based on stream survey redd counts (122 total redds), we estimate a spawning population of 244 spring Chinook.

We estimate that 1 clipped and 438 unclipped rainbow trout *Oncorhynchus mykiss* passed above the CNFH barrier weir in 2006. Of these, 249 unclipped rainbow trout were passed by the hatchery prior to March 1 during their steelhead propagation program.

Overall, water temperatures in 2006 were good for spring Chinook to successfully produce juveniles. Adult Chinook holding in Battle Creek over the summer were exposed to water temperatures categorized as good or fair. Fair water temperatures can lead to some mortality and infertility. Although some Chinook were exposed to some "fair" water temperatures, the duration and magnitude of exposure was reduced relative to previous years and negative impacts were much less than in 2001 through 2005. Holding conditions were better in 2006 because of wet water-year conditions and the Coleman Powerhouse was not operated from December 2005 to August 2006 leaving stream flows in Battle Creek downstream of South Fork river mile 2.5. Mean daily water temperatures at redds were categorized as excellent for 99.6% of the days during egg incubation, suggesting there was little or no temperature-related egg mortality.

Stream surveys corroborated other studies that suggested there is a nearly impassable natural barrier on the North Fork at rm 5.06. From 2001 through 2006, we did not observe live Chinook, carcasses, or redds above this barrier. In 2003 and 2006, we observed Chinook and steelhead carcasses lodged in the boulders of this barrier.

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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. 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, along with PG&E, is planning to fund 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 were increased to 30 cfs plus or minus 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 winter 2007-08). 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 current investigations were carried out in 2005 by the Red Bluff Fish and Wildlife Office (RBFWO) under a 5-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 northern Tehama and southern Shasta 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 2.8 (13.8 miles in length)(Figure 1). Eagle Canyon Dam and Coleman Diversion Dam were considered the upstream limits of anadromous salmonid distribution during the study because fish ladders on the dams were 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 1, 2006 and November 3, 2006. Chinook salmon and steelhead returning to Battle Creek were classified as either unclipped (having an adipose fin) or clipped (not having an adipose fin). 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, 2005 to March 1, 2006. During this period, fish were periodically directed into holding ponds at CNFH, where fall and late-fall Chinook and steelhead were used in propagation programs. Fish passage upstream of the barrier weir in Battle Creek was afforded from March 1 through August 1, 2006 by opening the fish ladder. Passage was monitored until June 16 using a live trap, followed by underwater videography until August 1. The fish ladder was closed on August 1, 2006.

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 was operated approximately 8 h a day, 7 d a week from March 1 through June 16, 2006. To decrease potential passage delays for Chinook, the hours of trap operation were progressively shifted earlier over the trapping season. We implemented two time shifts based on diel movement patterns observed in previous years: 0930-1730 from March 1-April 22 and 0430-1230 from April 23-June 16. During hours when the trap was not operated, fish were allowed to enter the trap, but the exit was closed blocking upstream passage. Prior to operation each morning, the trap was cleaned, weather conditions were noted, and water temperature and stream stage elevation were documented. Every 2 h, temperature and stage gauge levels were recorded. When water temperature exceeded 60°F, trapping was terminated for that day to minimize the handling effects. Trapping was terminated for the season and videography began when water temperatures exceeded 60°F for a majority of the daily trap operation period.

During operation, the trap was checked every 30 min. Non-target fish were identified to species, counted, and released upstream. Salmonids were netted from the trap and immediately transferred to a 250 to 400 gallon fish distribution tank. Water temperature in the fish distribution tank was maintained within 2°F of Battle Creek water temperatures. Sodium chloride (1.0%) and Poly Aqua™ (artificial slime coat; 1.0%) were added to the tank to reduce fish stress and preserve their slime coat. While in the fish tank, Chinook and rainbow trout were anesthetized with CO_2 if needed.

Salmonids were measured (fork length) to the nearest 0.5 cm, examined for scars and tissue damage, examined for the presence or absence of a mark (an adipose-fin clip or floy tag), and identified to gender when possible. A tissue sample was taken from unclipped Chinook 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 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 CWTs were sacrificed for tag recovery and all others were released upstream of the barrier weir. Anesthetized Chinook and rainbow trout were placed in a recovery tank then release upstream.

For each time shift, we evaluated the diel timing of Chinook and rainbow trout/steelhead entering the barrier weir trap by calculating the adjusted total catch (ATC) for each time slot (e.g., 0930, 1000, 1030, etc.). Calculating an adjusted total was necessary to standardize for times when the trap was temporarily closed due to high water temperatures. The equation used to calculate the adjusted total catch was

$$ATC_{ia} = \frac{TC_{ia}}{I_{ia}} \cdot TPI_a$$

where $ATC_{i\,a}$ = adjusted total catch at time *i* (e.g., at 1030) during time shift *a*, $TC_{i\,a}$ = total catch at time *i* during time shift *a*, $I_{i\,a}$ =number of trap inspections at time *i* during time shift *a*, and

TPI_a = number of total possible trap inspections at each half hour interval during time shift *a*. Data were summarized on an hourly basis by summing adjacent pairs of $ATC_{i\,a}$ (e.g., $ATC_{0930\,a}$ + ATC_{0100a}).

Video counts.—An underwater video camera (Lorex CVC-6991) was used to record Chinook, rainbow trout, and other non-target species as they passed through the fish ladder. The camera was placed in the modified fish trap at the upstream end of the fish ladder. Video monitoring of fish passage was conducted from June 17 through August 1. A lighting system allowed for 24-h monitoring. In 2006, we began using a digital video recorder (DVR, Honeywell Fusion DVR model HFDVR1612012) to record fish passage. The DVR was set to record 15 frames per second at the highest video quality setting. Each night the DVR was programmed to transfer and store the video data to a 1 terabyte external hard drive (Maxtor OneTouch™ III). In conjunction with the DVR, we also used a time-lapse analog video cassette recorder (VCR) as a backup incase the DVR computer crashed. The time mode on the video cassette recorder was set to 24 h, and 160-min VHS tapes were used. A time-date stamp was recorded on the video.

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.

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 accidently 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

$$P_{tu} = \sum_{i=1}^{16}\left(\left[\frac{u_i}{c_i + u_i} \cdot unk_i\right] + u_i\right)$$

and

$$P_{tc} = \sum_{i=1}^{16}\left(\left[\frac{c_i}{c_i + u_i} \cdot unk_i\right] + c_i\right)$$

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 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; 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

$$P_{vu} = \sum_{i=1}^{8}\left(\left[\frac{u_i}{c_i + u_i} \cdot unk_i\right] + u_i\right) \cdot \left(\frac{T_i}{V_i}\right)$$

and

$$P_{vc} = \sum_{i=1}^{8}\left(\left[\frac{c_i}{c_i + u_i} \cdot unk_i\right] + c_i\right) \cdot \left(\frac{T_i}{V_i}\right)$$

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 was 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

We conducted snorkel surveys on Battle Creek between August 28 and November 3, 2006. Four surveys were conducted in each reach during this period except for Reach 7. Reach 7, located below the barrier weir, was not surveyed in October or November due to the abundance of non-target fall Chinook. The primary purpose of these surveys was to collect data on the spatial and temporal distribution of spring Chinook and, to a lesser degree, rainbow trout. The 21.6 mile survey was divided into seven reaches (Table 7; Figure 1) 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, two or three snorkelers counted Chinook and rainbow trout, carcasses, and redds. Rainbow trout were divided into three size categories; small, medium, and large. The small size range was "larger than young-of-the-year" to 16 in. The medium size range was 16-22 in. And the large size range was >22 in. 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 and rainbow trout, 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 therefore 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. The gauging stations on the North Fork, South Fork, and mainstem Battle Creek 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 holding locations were documented using a hand held Global Positioning System (GPS) receiver. 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 Stowaway™ 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 marked in the field with flagging and given a unique identification number in order to differentiate between old and new redds. An attempt was made 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 Keir'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.

Using these thermal criteria, we evaluated the potential effect of water temperature on egg survival at each individual Chinook redd. 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 that (1) 1,850 Daily Temperature Units (DTU = $MDT_{°F}$ - $32_{°F}$) were required for egg incubation to time of emergence and (2) generally the redds were constructed the day preceding the survey when they were first observed. This redd construction (fertilization) date results in a "best-case-scenario" because choosing an earlier date would result in more exposure to higher temperatures in late summer. 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).

We measured spring Chinook redd dimensions, depths, water velocities and dominant substrate size. Redd dimensions included maximum length and maximum width. Redd area was calculated using the formula for an ellipse (area = π•½ width•½ length). Depth measurements were maximum depth (redd pit), minimum depth (redd tailspill), and pre-redd depth (measured immediately upstream of the redd). Mean column velocity was measured at the same location as the pre-redd depth. Velocity measurements were taken 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 T.E.N. buffer (Tris, EDTA, and NaCl) and one was dried and stored in a scale envelope (not collected from weir trap samples). One vial sample was sent to Hatfield Marine Science Center, Oregon State University, for genetic analyses by Dr. Michael Banks. The other samples were archived at the RBFWO. A new method of genetic analysis was used beginning in 2004 which was not used in previous years. The new method classifies individual fish as either spring, winter, fall, or late-fall Chinook. Each run assignment had an associated confidence probability. The individual run assessment technique was developed based on Central Valley Chinook.

In previous years, genetic analyses were preformed using two other techniques; "WHICHRUN" which identified individual salmon as either winter Chinook or non-winter Chinook and "Mixed Stock Analysis" which estimates the proportion of spring, winter, fall, and late-fall Chinook in a group but did not classify individual fish.

Age Structure

Age determination of returning spring Chinook was done 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. Scales were dried 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). Each scale was independently aged by two readers. 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.

Results

Coleman National Fish Hatchery Barrier Weir

Trapping.—A total of 302 Chinook were captured in the barrier weir trap between March 1 and June 16, 2006. Of these, 163 were clipped and 139 were unclipped (Table 9). We retrieved coded-wire tags (CWT) from 154 clipped Chinook captured in the trap. Tag codes revealed that 148 were late-fall run from CNFH, 5 were winter run from Livingston Stone National Fish Hatchery, and 1 was a spring run from Feather River Fish Hatchery (Table A.1). CWTed late-fall Chinook were captured as late as June 14, although their reported spawning period is finished by the end of April (Vogel and Marine 1991). CWTed winter Chinook were captured between March 2 and May 23. The single CWTed spring Chinook was captured on June 2.

The trap was closed on seven days due to high flows; March 6, April 3-5, April 12, and April 16-17. Mean daily flows causing trap closure ranged from 1,919 to 4,672 cfs

A total of 135 rainbow trout were captured in the barrier weir trap and 126 were released upstream (escapement). Of the 135 that were captured, 9 were clipped, 125 were unclipped, and 1 was unknown (Table 10). One clipped rainbow trout had a CWT and was from CNFH (brood year 2003). Other species captured in the trap and passed upstream included 7,745 Sacramento sucker *Catostomus occidentalis*, 46 Sacramento pikeminnow *Ptychocheilus grandis* , and 31 hardhead *Mylopharodon conocephalus*.

We documented that three Chinook and seven rainbow trout, which were passed above the barrier weir, fell back downstream of the weir and were recaptured in the trap. Of the rainbow trout, three were passed upstream of the weir by CNFH during their steelhead propagation program prior to March 1.

The hours of trap operation were 0930-1730 for the period March 1-April 22 and 0430-1230 for the period April 23-June 16. During the trapping period, the majority of clipped

Chinook were captured during the first time shift and the majority of unclipped Chinook were captured during the second time shift. During the first time shift, clipped Chinook were captured most frequently during the first trap check of the day (fish were allowed to enter and hold in the trap throughout the night) with a second peak in adjusted total catch (ATC) occurring in the afternoon between1600 and 1700 hours (Figures 2 and 3). Of the few unclipped Chinook captured during the first time shift, most passed after 1400 hours. During the second time shift, unclipped Chinook were captured most frequently during the first trap check of the day with a second peak in ATC occurring in the morning between 0700 and 0800 hours (Figures 2 and 3). Of the few clipped Chinook captured during the second time shift, peak passage was also between 0700 and 0800 hours.

Diel timing of rainbow trout entering the barrier weir trap showed some variation throughout the trapping season (Figures 4 and 5). During the first time shift, unclipped rainbow trout were captured most frequently between 1400 and 1500 hours whereas clipped rainbow trout were captured most frequently during the first trap check of the day and between 1600 and 1700 hours. During the second time shift, unclipped rainbow trout were captured most frequently between 1000 and 1100 hours.

Video counts.—A total of 80 Chinook were observed passing through the barrier weir fish ladder between June 17 and August 1, 2006. Of these, all were unclipped (Table 11). Extrapolation for poor picture quality or video equipment malfunction resulted in a passage estimate of 82 unclipped Chinook. Chinook were not observed passing above the barrier weir for a 9-day period from July 23 through July 31 (Figure 6). Similar periods of no fish passage from mid-July through early-August occurred in 2000-2005 (Brown and Newton 2002; Brown et al. 2005; Brown and Alston 2007; Alston et al. 2007; Newton et al. 2007). During the video monitoring period, 96% of the allowed passage was video recorded with a good or fair picture quality.

A total of 63 rainbow trout were observed passing through the barrier weir fish ladder during the video monitoring period. Of these, 62 were unclipped and 1 was clipped (Table 12). Extrapolation for poor viewing quality or equipment malfunction resulted in a passage estimate of 63 unclipped and 1 clipped rainbow trout. Other species observed passing upstream included 29 Sacramento sucker *Catostomus occidentalis*, 60 Sacramento pikeminnow *Ptychocheilus grandis* , 22 hardhead *Mylopharodon conocephalus*, 1 Pacific lamprey *Lampetra tridentata*, and 1 tule perch *Hysterocarpus traski*.

Diel timing of passage during video monitoring indicated that Chinook passed the barrier weir throughout the entire day with a slight peak in passage between 0600 and 0700 hours (Figures 2 and 3). Diel timing of rainbow trout passage indicated that passage occurred primarily during daylight hours (Figure 4). Rainbow trout passage peaked between 1700 and 1800 hours (Figure 5).

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 zero clipped and 221 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 1 and August 1, 2006 (Tables 9, 11, and 13). An additional 50 unclipped Chinook were released above the barrier weir by CNFH personnel prior to opening the barrier weir fish ladder on March 1 (Tables 1, 2, and 13). These 50 Chinook were diverted from lower Battle Creek into the hatchery as part of the late-fall Chinook propagation program. Because CNFH personnel attempt to mark 100% of their late-fall production with an adipose-fin clip and CWT, these 50 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 189 unclipped rainbow trout passed upstream of the barrier weir fish ladder between March 1 and August 1, 2006 (Tables 10, 12, and 13). An additional 249 unclipped rainbow trout were released above the barrier weir by CNFH prior to March 1 (Tables 1, 2, and 13). 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 13 and peaked the week of June 18-24 (Table 11, Figure 6). The middle 50% of the run passed between May 14 and June 19. Chinook did not appear to migrate above the weir during the nine days preceding the ladder closure on August 1, with the exception of one Chinook observed the morning of August 1.

The temporal distribution of clipped Chinook observed at the barrier weir is different from that of unclipped Chinook. Observations of clipped Chinook also began March 1, peaked during the first 2 weeks of trap operation and declined steadily through April, with an additional four fish passing in late May and early June (Figure 6).

Rainbow trout migrating past the barrier weir exhibited a bimodal migration pattern. The two periods of peak passage were March 1-11, when trap operation began, and June 18-July 1 (Figure 7).

Size, sex, and age composition.— Chinook captured in the barrier weir trap had a mean fork length of 73.3 cm and ranged in length from 41.0 to 101.5 cm (n = 303). The length-frequency distribution was continuous and was approximately normal with a mode at about 71-75 cm (Figure 8). Rainbow trout captured in the barrier weir trap had a mean fork length of 41.4 cm and ranged from 24.0 to 52.0 cm (n = 148). The length-frequency distribution for rainbow trout was continuous and was approximately normal with a mode at about 36-40 cm (Figure 9).

The ratio of male to female clipped Chinook captured in the barrier weir was 1:2.0 (n=163). 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 the majority of rainbow trout, the sex was undetermined.

Tagging records were used 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 = 108), 4-year-olds (n = 43), and 5-year-olds (n = 3). There were no tagged 2-year-olds recovered in 2006. There was overlap in fork length between Chinook of ages three through five (Figure 10, Table A.1). Age was not determined for unclipped Chinook.

Stream Surveys

Snorkel surveys in 2006 did not begin until August 28, about two or three months later than in previous years. Sustained high flows in Battle Creek during the spring and early summer prevented us from conducting snorkel surveys. For surveys conducted in reaches 1-6, observations of live adult Chinook peaked at 143 in late August (Tables 14 and 15). Also, we observed a total of 122 redds above the barrier weir, of which 17 were observed in September and 105 were in October. We observed a total of 54 carcasses above the barrier weir, of which 2 were observed in August, 8 in September, 40 in October, and 4 in November.

Small rainbow trout were the dominant size group in all the reaches (Table 16). Medium rainbow trout were most abundant in Reach 5. Large rainbow trout counts were ≤5 on all surveys of reaches 1-6 (Table 16). Reach 2 had the highest monthly mean rainbow trout counts, followed by Reach 1 (Table 17). The lowest monthly mean counts were observed in Reach 6.

Conditions for snorkel surveys were good. Stream flows were always <95 cfs on reaches 1-6a (Figures 11-13). Temperatures ranged from 46˚ to 68˚F. Average turbidity was 2.0 NTU with a range of 1.1 to 5.8 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 6, Table 14). Surveys indicated that most Chinook spawned in late September or early October (Table 14).

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 18). On the South Fork, the percentage of MDTs categorized as good ranged from 79% at the upstream most site to 55% at the downstream most site. On the North Fork, the percentage of MDTs categorized as good ranged from 90% at the upstream most site to 48% at the downstream most site. On the mainstem, the percentage of MDTs categorized as good ranged from 45% at the upstream most site to 28% at the downstream most site.

We identified two large holding pools where Chinook commonly congregated during the summer. These pools were informally named P.L. Pool and B. Pool. Estimated MDTs at P.L. Pool (Reach 3) were categorized as follows; 69% good and 31% fair. Estimated MDTs at B. Pool (Reach 4) were categorized as follows; 45% good and 55% fair.

The upstream most observation of a Chinook on the North Fork was a carcass observed on October 30 at rm 5.06, located in the rocks of a natural barrier identified as "nearly impassable by all fish at all flows (TRPA 1998, barrier NF5.14)." 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 75 redds in the North Fork, 23 in the South Fork, and 24 in the mainstem (Table 14). In the North Fork, South Fork, and mainstem Battle Creek, Chinook began spawning sometime between August 28 and September 18. Chinook likely finished spawning by the end of October because the numbers of new redds observed on our final survey (October 31) were greatly reduced (Table 14). 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). Unlike 2004 and 2005 we observed redds above Wildcat Dam on the North Fork (Reach 1). We observed 19 redds in Reach 1and the upstream-most redd was located at about rm 4.6. The upstream-most redd on the South Fork was located at about rm 2.5, immediately downstream of Coleman Diversion Dam which blocks fish passage.

We estimated MDT at each Chinook redd during the egg incubation period. On average, the incubation period lasted 111 days, based on an 1,850 DTU requirement. During the incubation period, the average percentage of days that redds were exposed to each temperature category were 99.6% excellent; 0.4% good; and 0% fair, poor, and very poor (Table 19, Table A.2). Temperature exposures were similar between survey reaches with a minimum of 95.4% of days classified as excellent for redds in Reach 5 (mainstem).

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, 2006. On the North Fork, the percentage of

MDTs categorized as good or excellent was 100% at the upstream-most and downstream-most sites (Table 20). On the South Fork, the percentage categorized as good or excellent was 100% at the upstream-most and downstream-most sites (Table 20). On the mainstem, the percentage categorized as good or excellent ranged from 100% at the upstream-most site to 91% at the downstream-most site (rm 9.3).

Measurements were taken on 73 spring Chinook redds (Table A.3). Redd area ranged from 11 to 328 square feet (ft^2) with an average of 89 ft^2. Redd depths (pre-construction) ranged from 0.5 to 4.2 ft with an average of 1.4 ft. Water velocities ranged from 0.4 to 4.1 ft/s with an average of 1.9 ft/s. All measurements of redd area, depth, and water velocity were within the ranges reported for stream type (spring run) Chinook (Healey 1991). Redd substrate particles had a median size range of 1-3 in, a minimum of 1 in, and a maximum range of 2-4 in.

Of the 54 Chinook carcasses observed during snorkel surveys, 41 were recovered and spawning status was determined for 17. Of the 17 carcasses, 15 were spawned and 2 were unspawned. Spawning status frequently could not be determined due an advanced state of decay or carcasses being partially eaten by scavengers.

Tissue Collection for Genetic Analyses

Genetic analysis was performed on tissue samples from 138 unclipped Chinook captured in the barrier weir trap (March 1 - June 16). Results indicated that 51% were spring run, 48% were fall run, 0% were late-fall run, and 1% (n=1) were winter run (M. A. Banks, Oregon State University, personal communication). The average confidence probabilities for spring-run and fall-run calls were 0.93 and 0.91 respectively. The confidence probability for the winter Chinook was 0.999. Individuals identified as fall run were captured throughout the entire trapping period although the reported migration period for fall Chinook does not begin until sometime between mid-June and mid-July (Vogel and Marine 1991), which is after the period when we collected the tissue samples.

In some cases, individuals had a secondary run call. For example, the primary run call might be fall run with an 0.80 confidence probability and the secondary call might be spring run with a 0.20 confidence probability. Of the 66 samples from the barrier weir trap which were classified as fall run, 29 had a secondary run call of spring run and 8 had a secondary run call of late-fall. Of the 71 samples classified as spring run, 25 had a secondary run call of fall run and 2 had a secondary run call of late-fall.

We collected 41 samples from the 54 Chinook carcasses observed during stream surveys from September 18 to November 2. Of these, six were genetically classified as spring run and six were classified as fall run. The quality of the remaining 29 samples was too poor to analyze.

Age Structure

Age was estimated from scale samples collected from carcasses sampled during snorkel surveys. In 2006, 43 readable scales were collected from Chinook during the spring run immigration and spawning period. Of the 43 samples, 4.7% were classified as 2-year-olds, 93.0% were 3-year-olds, and 2.3% were 4-year-olds.

Discussion

Chinook Salmon Population and Passage Estimates

We estimated that zero clipped and 221 unclipped Chinook passed the CNFH barrier weir between March 1 and August 1, 2006. We generally use 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 the Mixed Stock Analysis genetic methods which classifies proportions of a sample group as winter, spring, fall, or late-fall run (Brown and Newton 2002, Brown et al. 2005, Brown and Alston 2007). Recently, improved genetic analysis techniques became available which were capable of assigning individuals to a particular run. Based on this new technique, we estimated approximately 1 winter run, 154 spring run, 66 fall run, and zero late-fall run passed through the CNFH barrier weir ladder in 2006.

The 139 Chinook passing the weir during the trapping period (March 1-June 16) were assigned to a particular run according to genetic analysis results: 1 winter run, 72 spring run, and 66 fall run. This being said, we recognize that many of the fall run may actually be mis-classified spring or late-fall run. Vogel and Marine (1991) report that fall Chinook do not begin migrating past Red Bluff Diversion Dam on the Sacramento River until sometime between mid-June and mid-July which is after the trapping period. The Red Bluff Diversion Dam is 29 miles downstream from the mouth of Battle Creek. This suggests that they are not fall run. Analysis of genetic data and run timing from 1996 to 2006 suggests that the potentially mis-classified Chinook are more likely spring run than late-fall run. Chinook classified as fall run were evenly distributed throughout the trapping period and not just in the early trapping period when late-fall Chinook are much more numerous. Of the barrier weir trap samples collected from 2004 through 2006, 46% of the "fall" run had a secondary run assignment of spring run compared to 12% secondarily classified as late-fall run. Because of the temporal and spatial overlap in spawn timing between fall and spring Chinook in Battle Creek, some hybridization may have occurred, making it difficult to genetically differentiate these two runs. Furthermore, the genetic analysis did not include any Battle Creek spring Chinook as a baseline for comparison. It is possible that some of the "fall" run Chinook fish may be remnant Battle Creek spring Chinook (M. A. Banks, Oregon State University, personal communication).

Recommendation: We recommend further population genetic analyses with existing data or incorporation of phenotypic Battle Creek spring Chinook into the genetic baseline to help determine if genetically classified fall Chinook are mis-classified spring Chinook, spring-fall hybrids, or late-fall Chinook.

Five coded-wire tagged winter Chinook were captured in the barrier weir trap in 2006. In contrast, from 2001 through 2005 we did not capture any tagged winter Chinook, but the total winter run escapement to the Sacramento River was also lower in these years. Gauging from conditions in Battle Creek during recent years, which were not favorable to the natural production of winter Chinook salmon, we presume that any naturally produced winter Chinook adults present in Battle Creek are likely strays from the Sacramento River. Further, we presumed that hatchery and natural winter Chinook from the Sacramento River would likely stray into Battle Creek at the same rate. Based on the ratio of hatchery (e.g., tagged) to natural winter Chinook returning to the Sacramento River in 2006 (1:6.216, USFWS 2007), 31 natural winter Chinook would be expected to have entered Battle Creek in 2006. Genetic analysis identified only one natural winter Chinook as being passed upstream of the barrier weir during the trapping period in 2006. Based on escapement estimates of winter Chinook to the Sacramento River, the estimated stray rate into Battle Creek was 0.21% for hatchery-origin winter run and 0.01% for natural-origin winter run[1]. Although the 2006 stray rate of hatchery winter Chinook into Battle Creek appears to be higher than natural winter run, both stray rates are very low. Genetic analyses of unclipped Chinook sampled at the barrier weir trap from 2001 through 2005 identified only two natural winter Chinook in 2002 (Brown et al. 2005). The genetic analysis for winter Chinook has a very high probability of being correct.

We assumed that all 82 unclipped Chinook passing during the video monitoring period were spring Chinook. This assumption was made because the large majority of Chinook reported to migrate during this period are spring run (Vogel and Marine 1991). This assumption is consistent with run estimation methods used in previous annual reports.

The total escapement estimate for rainbow trout was much lower in 2006 than escapement estimates from 2001 through 2004 (Table 1). This decrease was largely due to a decision by the USFWS and CNFH to discontinue passing clipped CNFH steelhead upstream of the barrier weir. In recent years, CNFH has passed some clipped steelhead upstream to aid in the timely recovery of steelhead in upper Battle Creek. The decision to no longer pass clipped steelhead was made based on concerns of the CALFED Technical Review Panel and the Battle Creek Watershed Conservancy concerning possible negative impacts of hatchery fish on naturally-spawning populations with respect to fitness and productivity (Busack et al. 2004). Regarding escapement estimates for unclipped rainbow trout only, 2006 was about average for the period 2001-2006.

During the trapping period, high flows caused the closure of the trap on seven days. It is thought that adult salmonids can swim over the weir at these flows, circumventing the fish ladder. This suggests that escapement is underestimated more in years with higher flows, such as 2006. Most of the closure days occurred in April, an intermediate period between the typical end of the clipped Chinook migration (CNFH late-fall run) and the beginning of the unclipped Chinook migration (spring run). Because the closures mainly occurred during this intermediate period, the underestimate in our escapement estimates may have been small.

Following the 2003 sampling season, we recommended that the upstream fish ladder of the CNFH barrier weir be closed August 1 instead of August 31 in order to inhibit the passage of fall Chinook above the weir. Fall Chinook could potentially superimpose redds on spring Chinook redds or interbreed with spring Chinook. In most years that barrier weir passage has been monitored by underwater video, we have observed a decrease in passage followed by a gap of zero passage during July. In 2000 through 2003 video monitoring continued through August, and during these years we observed passage increasing in August after the gap in July. It is likely that these fish returning in August are fall Chinook returning to CNFH. State and

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[1]2006 winter Chinook escapement estimates for the upper Sacramento River produced by California Department of Fish and Game (CDFG) differ slightly from USFWS estimates and result in a hatchery to natural ratio of 1:6.514 and stray rates into Battle Creek of 0.22% for hatchery-origin and 0.01% for natural-origin winter Chinook (D. Killam, CDFG, personal communication).

federal fishery resource agencies agreed with the recommendation and the fish ladder was closed August 1 since 2004. Similar to previous years, we observed a 9-day gap in passage in late July, 2006.

In 2006 we continued investigating diel passage timing of salmonids through the barrier weir fish ladder. Similar to previous years, we observed clipped Chinook passing early in the season in the afternoon, with the exception of high numbers being caught in the first trap check of the day. The high numbers captured in the first trap check may have resulted from fish being allowed to congregate in the trap while it was not being operated. Unclipped fish primarily passed a few hours after sunrise later in the season. Operating the trap at an earlier time of day from late April through early June resulted in a reduced potential for delaying fish passage, lower water temperatures during trapping, less stress on trapped fish, and a longer trapping season.

Evaluation of a Digital Video Recorder (DVR)

In 2006, we began using a DVR as our primary device to record fish passage. Obtaining analog time-lapse VCRs, replacement parts, and services has become increasingly difficult in recent years. Reviewing video footage for fish passage using the DVR was more efficient than our traditional method of using a VCR. Using a DVR, 1 d (8 h) of staff time was required to review about 72 h of video footage. In comparison, a VCR required 1 d of staff time to review about 48 h or video footage. The increased efficiency using the DVR was a result of 1) the increased speed of maneuvering between fast forward, rewind, slow motion, and freeze frame playback modes and 2) improved picture clarity. Maneuvering between playback modes using a traditional VCR remote control requires time to mechanically rewind, stop, or change the speed of a cassette tape. Conversely, a DVR computer can instantaneously skip backward or forward or change playback speed with the click of a mouse. Reviewing analog footage in fast forward introduces distortion and horizontal lines across the picture. This distortion makes it more difficult for reviewers to distinguish fish from debris, causing them to stop, rewind, and slow down the tape speed when no fish was present. Digital video did not distort and it could be reviewed at a faster speed.

The process of archiving video clips of salmonid passage was also much more efficient using the DVR. Digital video is stored in computer folders which are labeled according to date and time for quick retrieval and export of video clips.

The DVR was reliable regarding its continuous operation during the video monitoring period. The DVR recorded 93% of the available time. This is the highest percentage of any years since 2001. Malfunctions of the DVR were related to power outages and DVR computer crashes (reasons unknown). Using a VCR as a backup device allowed us to record video during the times when the DVR computer crashed for a total coverage of 96% of the video monitoring period.

Recommendation: We recommend using a VCR as a backup device to record periods when the DVR malfunctions for reasons other than a power outage.

A typical video season at the barrier weir is approximately nine weeks. We estimate the staff time required to review the video record would be about 21 d using the DVR and 32 d using a VCR. The cost of our initial investment in digital video equipment ($6,570) would be recovered in less than two seasons by the reduction in personnel costs (personnel costs estimated as $350 per day).

Since 2003, we have selected a third of the video days to be viewed a second time for quality assurance (QA) purposes. An annual error rate was calculated for the primary viewers and the QA viewers as the percent of salmonids not seen. We used the combined data from both groups to estimate the total number of salmonids. The average error rate was 16% for the VCR (n=6) and 11% for the DVR (n=2).

> **Recommendation**: Because differences in error rates could be correlated with the experience level of crew members in any given year and not just video recording methods, we recommend comparing error rates between the VCR and DVR within the same year to determine if salmonids are more easily detected using a particular method. Video recorded in both formats for backup reasons could be reviewed in the future.

Evaluation and Adaptive Management of Battle Creek Stream Flow

Increase North Fork flows to test barrier hypothesis.—A potential low-flow barrier at rm 3.04 on the North Fork (Reach 1) was identified in 2001 and 2002 as potentially impassible to Chinook at 30 cfs (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). From 2001 through 2006, redds were observed above rm 3.04 only in 2003 (8% of all redds) and 2006 (14% of redds). Years 2003 and 2006 were unique during this period because (1) the total number of redds was higher than the other years (Table 5) and (2) they were relatively wet years and North Fork flows remained high into June in 2003 and July in 2006 as apposed to dropping to near summer base flows before late April in the other years. It appears that Chinook can pass this potential low-flow barrier during wet years such as 2006 but may have passage difficulties during normal or dry years.

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 steelhead 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. From 2001 through 2006, we did not observe live Chinook, carcasses, or redds above this barrier. In 2006, a Chinook carcass was found lodged in the boulders of this barrier (October 30). Also, in 2003, a Chinook carcass (July 8) and a rainbow trout/steelhead carcass (October 28) were found lodged between rocks of this barrier. Field notes and statements by crew members suggested that these fish appeared to have died while attempting to jump this barrier. Therefore, we believe this barrier may block salmonid passage at moderate and low flows. Alternatively, there is only 0.19 miles of anadromous fish habitat above this barrier up to Eagle Canyon Dam where passage is currently blocked. There is very little holding or spawning habitat in this short reach, possibly encouraging salmonids that may pass the barrier to drop back downstream to find suitable habitat.

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 2006, escapement of unclipped Chinook (March 1-August 1) was 2.4 times greater than 2004 and 3.0 times greater than 2005 (Table 3). The increased escapement in 2006 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.—On December 12, 2005, the Pacific Gas and Electric Company's Coleman Powerhouse hydroelectric facility sustain substantial internal damage causing the powerhouse to be shut down until about August 18, 2006. As a result Battle Creek flows were not diverted from the creek at Coleman Diversion Dam during this period leaving essentially all of the creek's flow instream in the lower South Fork (Reach 3) and the mainstem (Reaches 4-7). Water Year 2006 was one of the wettest on record for Battle Creek. The combination of these two situations in 2006 created better conditions for adult spring Chinook holding, relative to previous years. Water temperatures were cooler and holding pools were deeper and more prevalent potentially reducing otter predation on spring Chinook. Water temperature data has been collected since 1998 near a large spring-Chinook holding pool on the mainstem (rm 16.0). MDTs in 2006 at rm 16.0 were an average of 2.4˚F less than the average for the baseline period of 1998-2005 for the period June 1-August 17, the hottest time of the year. Also, holding temperatures for the period June 1-September 30 were categorized as nothing less than fair above river mile 12.2 on the mainstem (Table 18). Fair water temperatures can lead to some mortality and infertility. Although some Chinook were exposed to some "fair" water temperatures, the duration and magnitude of exposure was reduced relative to previous years and any negative impacts were much less than in 2001 through 2005.

Our temperature analysis of each individual redd indicated that Chinook egg incubation temperatures were excellent on 99.6% of the days. We feel that incubating eggs did not experience any adverse effects from water temperatures. This may be due to a combination of interim flows and wet water year conditions providing cooler water temperatures, spawners waiting until water temperatures were suitable for spawning, and spawners selecting upstream locations with cooler water temperatures.

In the past six years of stream surveys, Chinook redd density (redds/mile) was highest in Reach 2 (lower North Fork) with the exception of 2001 (Table 6). In 2006, the Reach 2 spawning density was at least 2.4 times greater than any other reach. Spawning density in Reach 1, located upstream of Reach 2, has been relatively low or nonexistent although it has the most suitable water temperatures for holding and spawning. Possible explanations as to why Chinook appear to utilize Reach 2 over Reach 1 include (1) proximity to large holding pools, (2) differences in the quantity and quality of spawning gravel, (3) potential passage problems at the six low-flow barriers in reaches 1 and 2 identified by TRPA (1998), and (4) potential passage problems at Wildcat Dam fish ladder. In 2006, increased observations of live Chinook and redds in Reach 1 documented that Chinook were using the Wild Cat Dam fish ladder although survey crews observed the ladder was blocked by debris at times. Debris removal and maintenance of this fish ladder is important until Wild Cat Dam is removed, possibly in 2008.

Recommendation: We recommend that all fish ladders be regularly maintained and cleared of debris by PG&E.

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Tables

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

Year	Late-fall Chinook		Steelhead	
	Clipped	Unclipped	Clipped	Unclipped
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

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 from March through August (Brown and Newton 2002, Brown et al. 2005, Brown and Alston 2007, Alston et al. 2007, Newton et al. 2007).

Year	Ladder Open (m/dd)	Chinook		Rainbow trout /steelhead	
		Clipped	Unclipped	Clipped	Unclipped
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

TABLE 3.—Multi-year summary of total estimated escapement in Battle Creek of winter, spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead passing upstream of the 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 Chinook and rainbow trout/steelhead passed through the barrier weir fish ladder (March-August). Maximum potential spring Chinook includes all unclipped salmon passed from March through August. Estimated spring Chinook escapement is a reduced estimate based on apportioning some Chinook to the winter, fall, or late-fall runs. Estimated late-fall Chinook escapement is all Chinook (unclipped) passed by CNFH plus a portion of Chinook passed through the fish ladder.

Year	Winter Chinook	Spring Chinook		Fall Chinook	Late-fall Chinook	Rainbow trout / steelhead	
		Maximum	Estimate			Clipped	Unclipped
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

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
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%
Average	64	9%	36%	55%

TABLE 5.—Multi-year summary of total Chinook redds (n) observed between August and November 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
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%
Average	82	50%	19%	31%

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
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

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
7	2.99	Barrier weir	5.83	Lower Rotary Screw Trap	2.84

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 captured at Coleman National Fish Hatchery barrier weir trap and associated passage estimates for 2006.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
March 1-4	73	2	0	0	2
March 5-11	36	1	0	0	1
March 12-18	16	0	0	0	0
March 19-25	15	0	0	0	0
March 26–April 1	13	1	0	0	1
April 2-8	1	3	0	0	3
April 9-15	2	2	0	0	2
April 16-22	1	1	0	0	1
April 23-29	2	6	0	0	6
April 30-May 6	0	15	0	0	15
May 7-13	0	20	0	0	20
May 14-20	0	22	0	0	22
May 21-27	1	12	0	0	12
May 28- June 3	2	11	0	0	11
June 4-10	0	22	0	0	22
June 11-16	1	21	0	0	21
Total	163	139	0	0	139

TABLE 10.—Rainbow trout/steelhead captured at Coleman National Fish Hatchery barrier weir trap and associated passage estimates for 2006.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
March 1-4	3	25	0	0	25
March 5-11	6	21	0	0	21
March 12-18	0	4	0	0	4
March 19-25	0	12	0	0	12
March 26–April 1	0	7	0	0	7
April 2-8	0	6	0	0	6
April 9-15	0	14	0	0	14
April 16-22	0	10	0	0	10
April 23-29	0	5	0	0	5
April 30-May 6	0	5	1	0	6
May 7-13	0	2	0	0	2
May 14-20	0	3	0	0	3
May 21-27	0	3	0	0	3
May 28- June 3	0	7	0	0	7
June 4-10	0	1	0	0	1
June 11-16	0	0	0	0	0
Total	9	125	1	0	126

TABLE 11.—Chinook salmon video recorded passing the Coleman National Fish Hatchery barrier weir fish ladder and associated passage estimates for 2006. Passage estimates include estimated passage during hours not video recorded.

Dates	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
Jun 17	10.3	10.3	0	13	0	0	13
June 18-24	168	165	0	27	0	0	27.5
June 25-July 1	168	166.3	0	19	0	0	19.2
July 2-8	168	165.6	0	12	0	0	12.2
July 9-15	168	160.3	0	6	0	0	6.3
July 16-22	168	138	0	2	0	0	2.4
July 23-29	168.0	168.0	0	0	0	0	0
July 30-August 1	57	57	0	1	0	0	1
Total	1075.3	1030.4	0	80	0	0	82

TABLE 12.—Rainbow trout/steelhead video recorded passing the Coleman National Fish Hatchery barrier weir fish ladder and associated passage estimates for 2006. Passage estimates include estimated passage during hours not video recorded.

Dates	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
Jun 17	10.3	10.3	0	3	0	0	3
June 18-24	168	165	1	17	0	1.0	17.3
June 25-July 1	168	166.3	0	20	0	0	20.2
July 2-8	168	165.6	0	13	0	0	13.2
July 9-15	168	160.3	0	3	0	0	3.1
July 16-22	168	138	0	3	0	0	3.7
July 23-29	168	168	0	3	0	0	3
July 30-August 1	57.0	57.0	0	0	0	0	0
Total	1075.3	1030.4	1	62	0	1	63

TABLE 13.—Total passage estimates for Chinook and rainbow trout/steelhead above the Coleman National Fish Hatchery (CNFH) barrier weir in 2006.

Passage Route	Chinook Passage: Clipped	Chinook Passage: Unclipped	Steelhead Passage: Clipped	Steelhead Passage: Unclipped
CNFH	0	50	0	249
Barrier Weir: Trap	0	139	0	126
Barrier Weir: Video	0	82	1	63
Total	0	271	1	438

TABLE 14.—Chinook salmon live adults, carcasses, and redds observed during the 2006 Battle Creek snorkel surveys.

Reach	Date	Chinook	Carcasses	Redds
1	8/28/06	16	0	0
1	9/18/06	23	4	8
1	10/2/06	13	2	10
1	10/30/06	0	4	1
2	8/29/06	4	1	0
2	9/19/06	5	0	2
2	10/3/06	35	11	49
2	10/31/06	0	14	5
3	8/29/06	29	0	0
3	9/19/06	25	2	2
3	10/3/06	20	5	16
3	10/31/06	2	3	5
4	8/30/06	90	1	0
4	9/20/06	40	2	5
4	10/4/06	13	1	17
4	11/2/06	0	3	0
5	8/30/06	2	0	0
5	9/20/06	2	0	0
5	10/4/06	1	0	1
5	11/2/06	0	1	0
6	8/31/06	2	0	0
6	9/21/06	0	0	0
6	10/6/06	0	0	1
6	11/3/06	0	0	0
7	9/1/06	16	0	0
Total (Reaches 1-6)			54	122

TABLE 15.—Counts of live Chinook observed on Battle Creek snorkel surveys in 2006. Totals only include reaches above the Colman National Fish Hatchery barrier weir (reaches 1-6).

Reach	**August** 8/28-9/1	**September** 9/18-21	**October** 10/2-6	**November** 10/30-11/3
1	16	23	13	0
2	4	5	35	0
3	29	25	20	2
4	90	40	13	0
5	2	2	1	0
6	2	0	0	0
7	16			
Total (Reaches 1-6)	143	95	82	2

TABLE 16.—Rainbow trout/steelhead observed during the 2006 Battle Creek snorkel survey. Small fish are larger than young-of-the-year up to 16 inches. Medium fish are from 16 to 22 inches. Large fish are greater than 22 inches.

Reach	Date	Small	Medium	Large	Total
1	8/28/06	479	6	1	486
1	9/18/06	563	2	1	566
1	10/2/06	404	2	0	406
1	10/30/06	184	1	0	185
2	8/29/06	630	2	0	632
2	9/19/06	444	3	0	447
2	10/3/06	377	1	0	378
2	10/31/06	220	1	0	221
3	8/29/06	421	10	2	433
3	9/19/06	262	7	1	270
3	10/3/06	169	11	1	181
3	10/31/06	431	28	2	461
4	8/30/06	547	21	5	573
4	9/20/06	323	5	0	328
4	10/4/06	147	3	0	150
4	11/2/06	269	3	0	272
5	8/30/06	194	38	1	233
5	9/20/06	225	39	1	265
5	10/4/06	94	8	1	103
5	11/2/06	152	16	1	169
6	8/31/06	180	13	1	194
6	9/21/06	106	6	0	112
6	10/06/06	81	8	1	90
6	11/3/06	82	8	1	91
7	9/1/06	56	12	5	73

TABLE 17.—Counts of rainbow trout/steelhead observed on Battle Creek snorkel surveys in 2006. Totals only include reaches above the Colman National Fish Hatchery barrier weir (reaches 1-6).

Reach	August 8/28-9/1	September 9/18-21	October 10/2-6	November 10/30-11/3	Reach Average
1	486	566	406	185	411
2	632	447	378	221	420
3	433	270	181	461	336
4	573	328	150	272	331
5	233	265	103	169	190
6	194	112	90	91	122
7	73				
Total (Reaches 1-6)	2551	1988	1308	875	

TABLE 18.—Number of days mean daily temperatures met Ward and Keir's (1999) suitability categories for spring Chinook holding from June 1 through September 30, 2006 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]	*50*[c]	*0*	*0*	*7*	*65*
Wildcat Dam	North Fork	2.5[a]	0	0	0	36	86
Wildcat Road Bridge	North Fork	0.9[a]	0	0	0	64	58
Above confluence of forks	North Fork	0.05[a]	0	0	0	63	59
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	26	96
Manton Road Bridge	South Fork	1.7[a]	0	0	0	38	84
Above confluence of forks	South Fork	0.1[a]	0	0	0	55	67
Below confluence of forks	Mainstem	16.0[b]	0	0	0	67	55
Reach 4 Upper	Mainstem	15.9[b]	*61*[c]	*0*	*0*	*23*	*38*
Reach 4 Lower	Mainstem	12.9[b]	0	0	0	83	37
Reach 5 Upper	Mainstem	12.2[b]	*61*[c]	*0*	*0*	*43*	*18*
Reach 5 Lower	Mainstem	9.3[b]	*28*[c]	*0*	*5*	*63*	*26*

[a] From confluence of the North Fork and South Fork Battle Creek

[b] From confluence with the Sacramento River

[c] Incomplete data set

TABLE 19.—Estimated percent of days that spring Chinook egg incubation fell within water temperature suitability categories in Battle Creek in 2006. Parentheses include the mean number of days redds were exposed to each category.

Reach	Location	n = (Redds)	Very Poor	Poor	Fair	Good	Excellent
1	North Fork	19	0%	0%	0%	0%	100% (102)
2	North Fork	56	0%	0%	0%	0.1% (<1)	99.9% (108)
3	South Fork	23	0%	0%	0%	0%	100% (123)
4	Mainstem	22	0%	0%	0%	1.4% (2)	98.6% (110)
5	Mainstem	1	0%	0%	0%	4.6% (5)	95.4% (103)
6	Mainstem	1	0%	0%	0%	1.8% (2)	98.2% (111)
7	Mainstem	0					
Total		122	0%	0%	0%	0.4% (<1)	99.6% (111)

TABLE 20.—Number of days mean daily temperatures met Ward and Keir's (1999) suitability categories for spring Chinook egg incubation from September 15 through October 31, 2006 at select monitoring sites in Battle Creek.

Site Name	Location	River Mile	No Data	Very Poor	Poor	Fair	Good	Excell-ent
Eagle Canyon Dam	North Fork	5.3[a]	0	0	0	0	0	47
Wildcat Dam	North Fork	2.5[a]	0	0	0	0	7	40
Wildcat Road Bridge	North Fork	0.9[a]	0	0	0	0	10	37
Above confluence of forks	North Fork	0.05[a]	0	0	0	0	9	38
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	0	0	47
Manton Road Bridge	South Fork	1.7[a]	0	0	0	0	0	47
Above confluence of forks	South Fork	0.1[a]	0	0	0	0	2	45
Below confluence of forks	Mainstem	16.0[b]	0	0	0	0	9	38
Reach 4 Upper	Mainstem	15.9[b]	0	0	0	0	15	32
Reach 4 Lower	Mainstem	12.9[b]	0	0	0	4	17	26
Reach 5 Upper	Mainstem	12.2[b]	0	0	0	7	17	23
Reach 5 Lower	Mainstem	9.3[b]	0	0	1	3	22	21
Total				0	1	14	108	441

[a] From confluence of the North Fork and South Fork Battle Creek
[b] From confluence with the Sacramento River

Figures

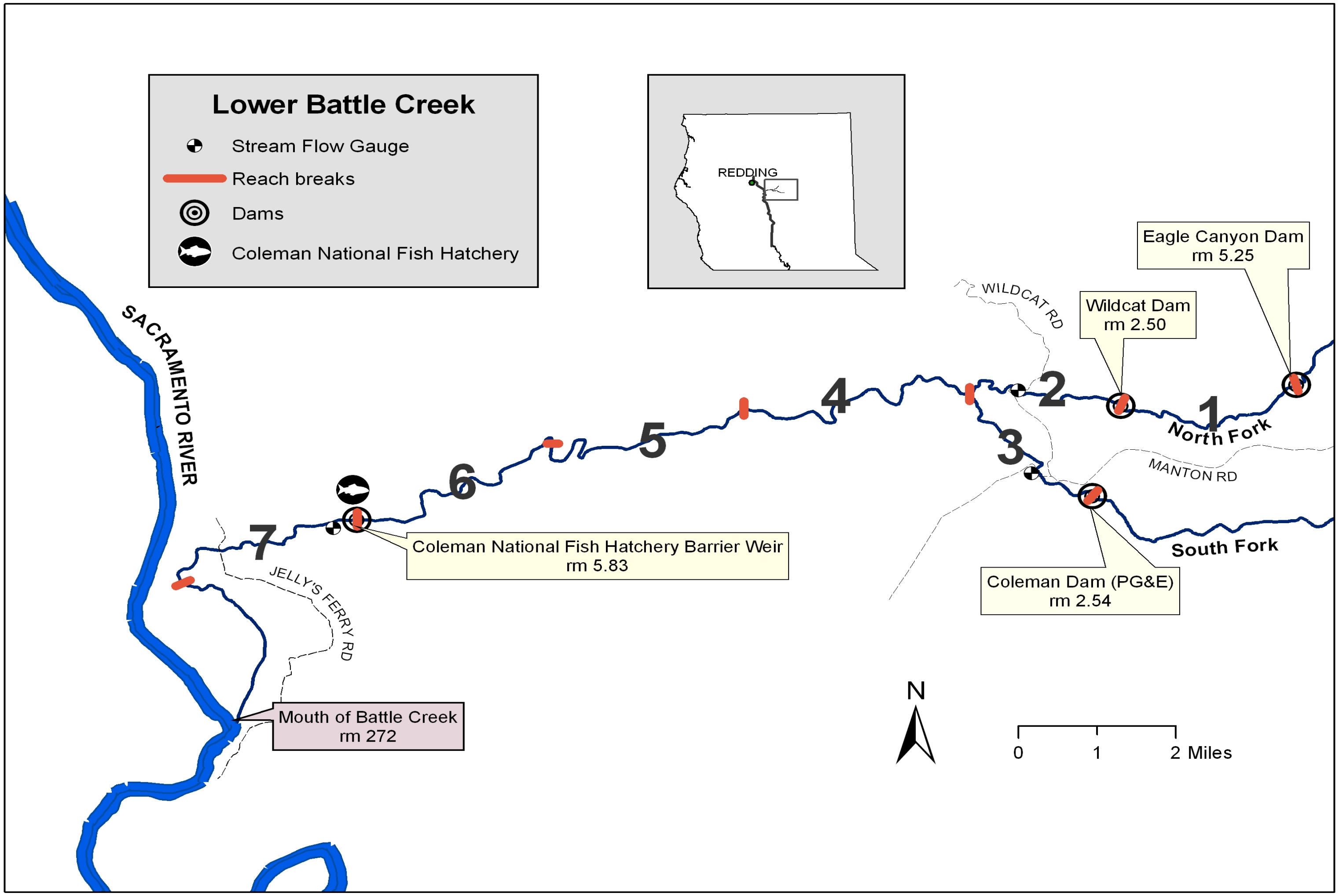

FIGURE 1.—Map of Battle Creek depicting the location of the Coleman National Fish Hatchery barrier weir and stream survey reaches.

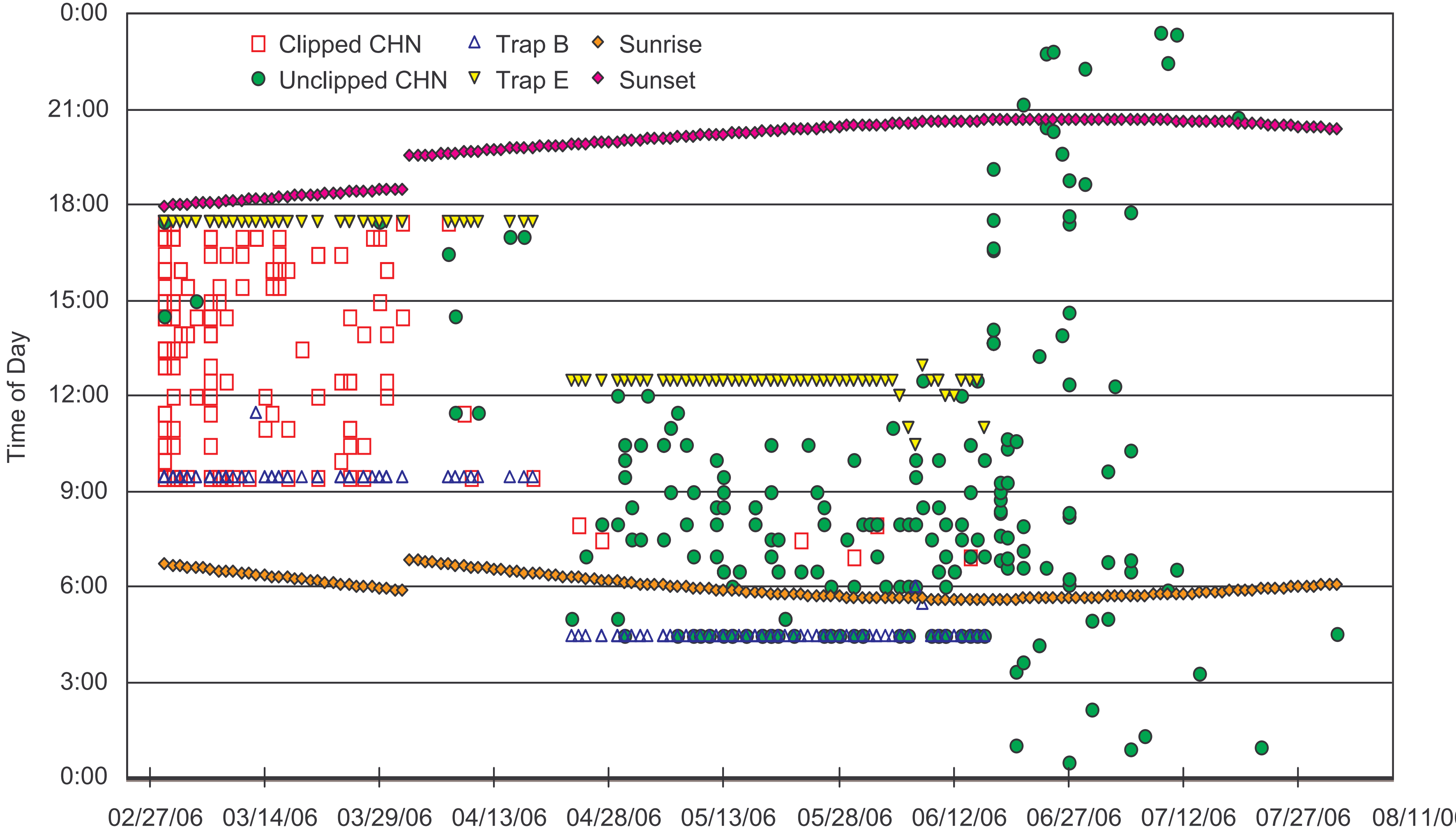

FIGURE 2.—Diel migration timing of Chinook salmon (CHN, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir during periods of tap operation (March 1-June 16) and video monitoring (June 17-August 1) in 2006. Also included are times of sunrise, sunset, beginning of trap operation (Trap B), and end of trap operation (Trap E).

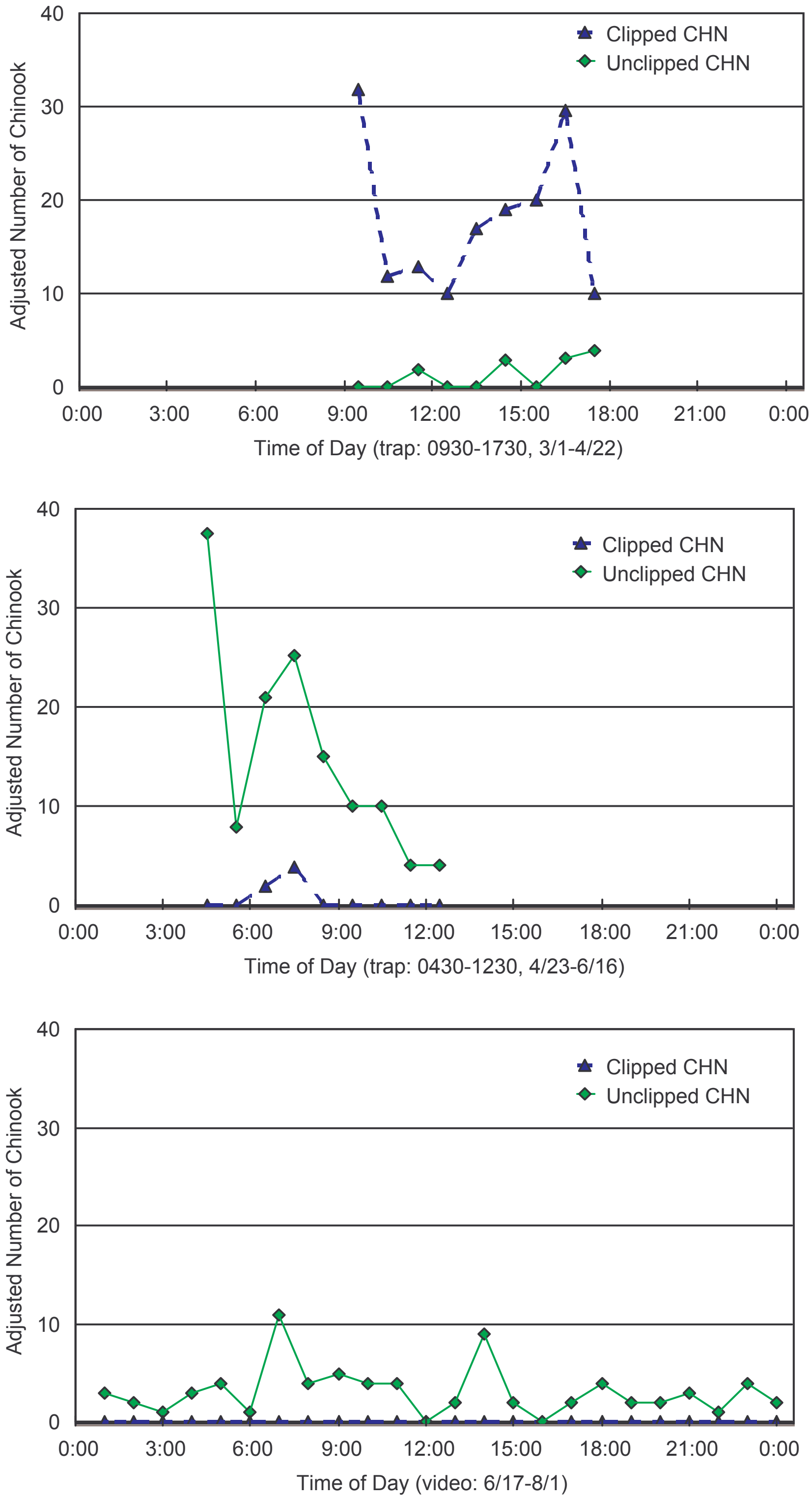

FIGURE 3.—Adjusted time-frequency distribution of Chinook (CHN, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir during periods of tap operation (March 1-June 16) and video monitoring (June 17-August 1) in 2006. Hours of trap operation were shifted to capture earlier passing unclipped Chinook. In addition, the shift coincided with lower water temperatures.

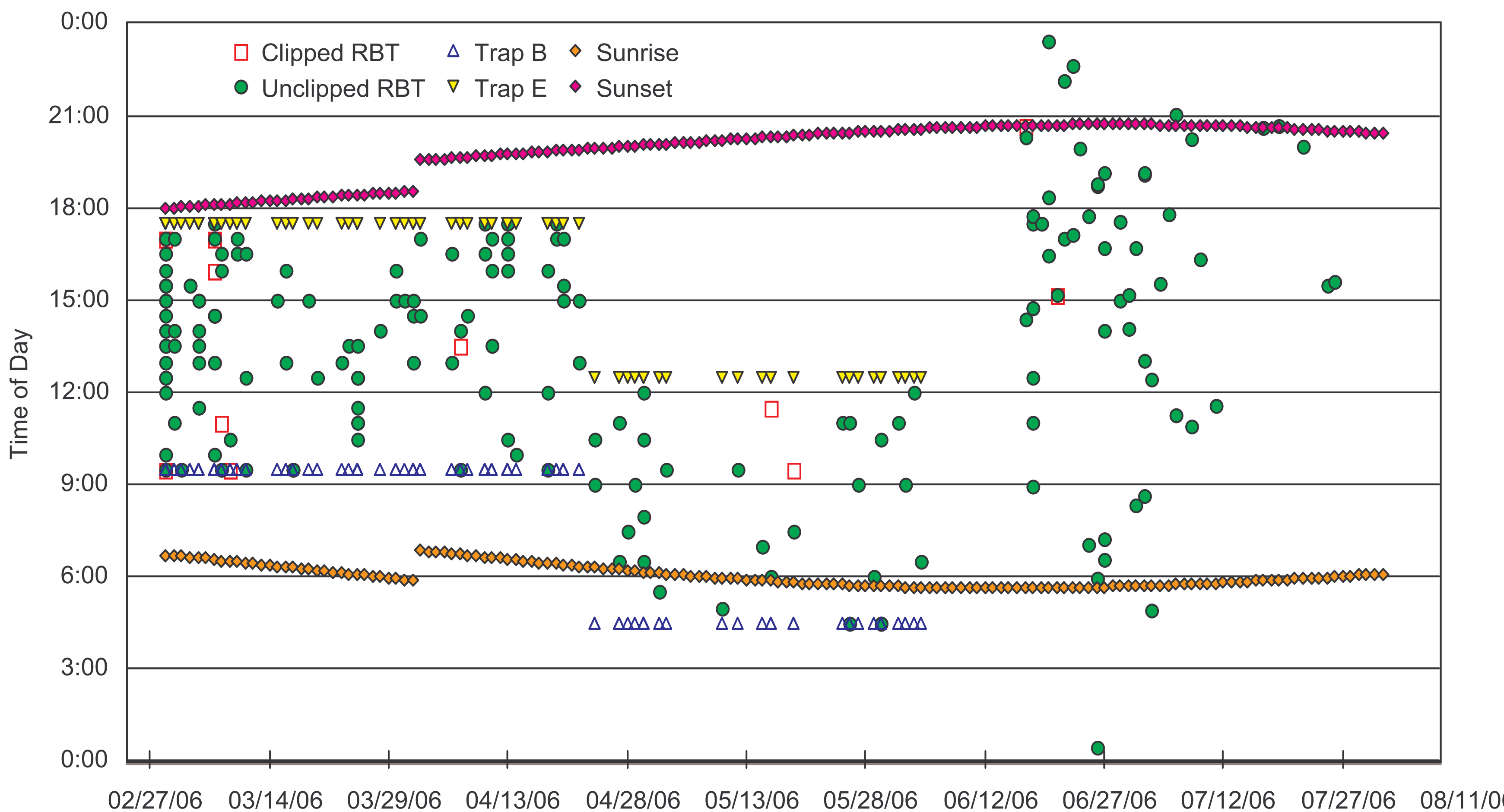

FIGURE 4.—Diel migration timing of rainbow trout/steelhead (RBT, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir during periods of tap operation (March 1-June 16) and video monitoring (June 17-August 1) in 2006. Also included are times of sunrise, sunset, beginning of trap operation (Trap B), and end of trap operation (Trap E).

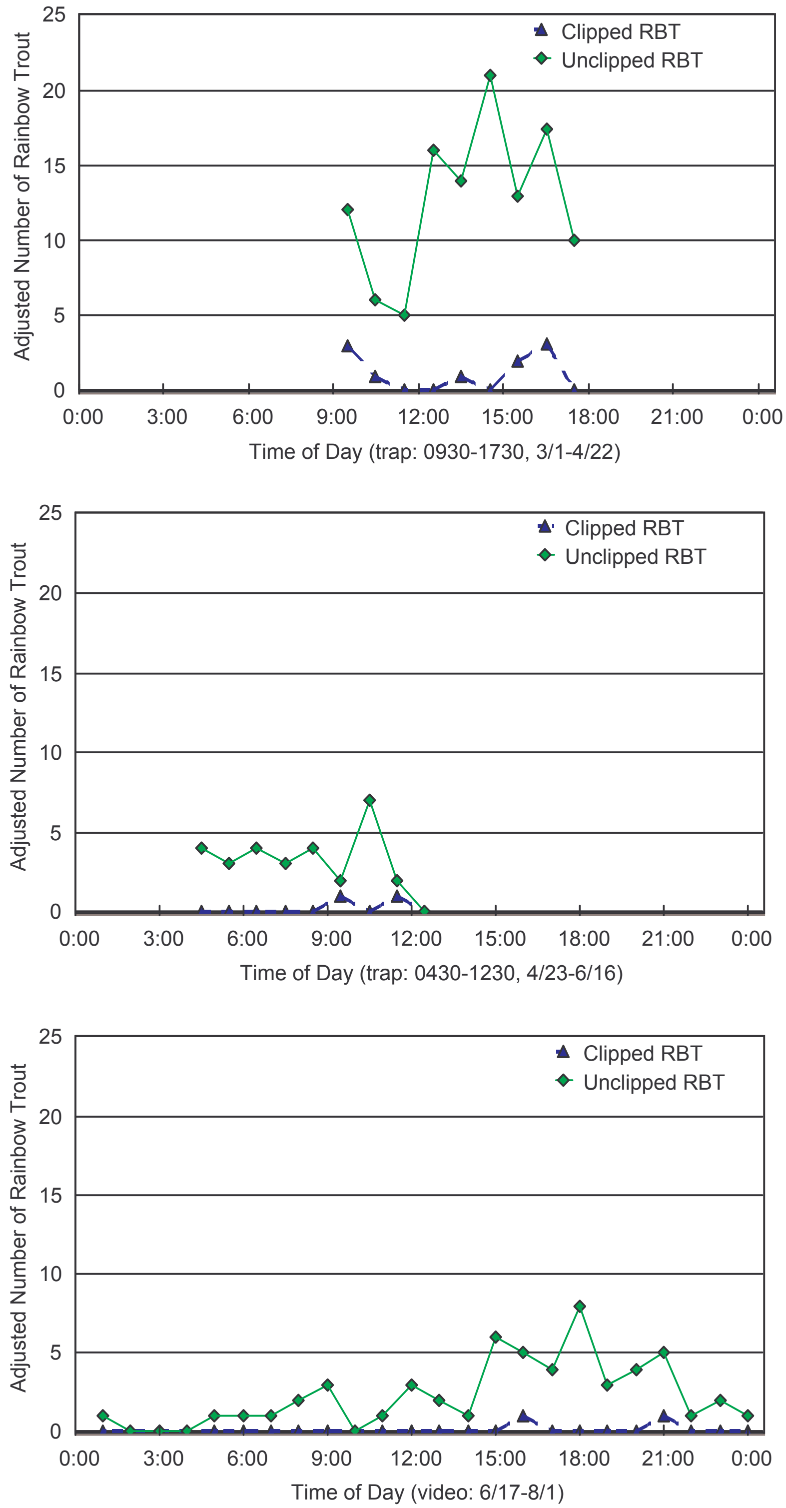

FIGURE 5.—Adjusted time-frequency distribution of rainbow trout/steelhead (RBT, clipped and unclipped) observed at the Coleman National Fish Hatchery barrier weir during periods of tap operation (March 1-June 16) and video monitoring (June 17-August 1) in 2006. Three graphs represent three different start times. These earlier times coincided with lower water temperatures.

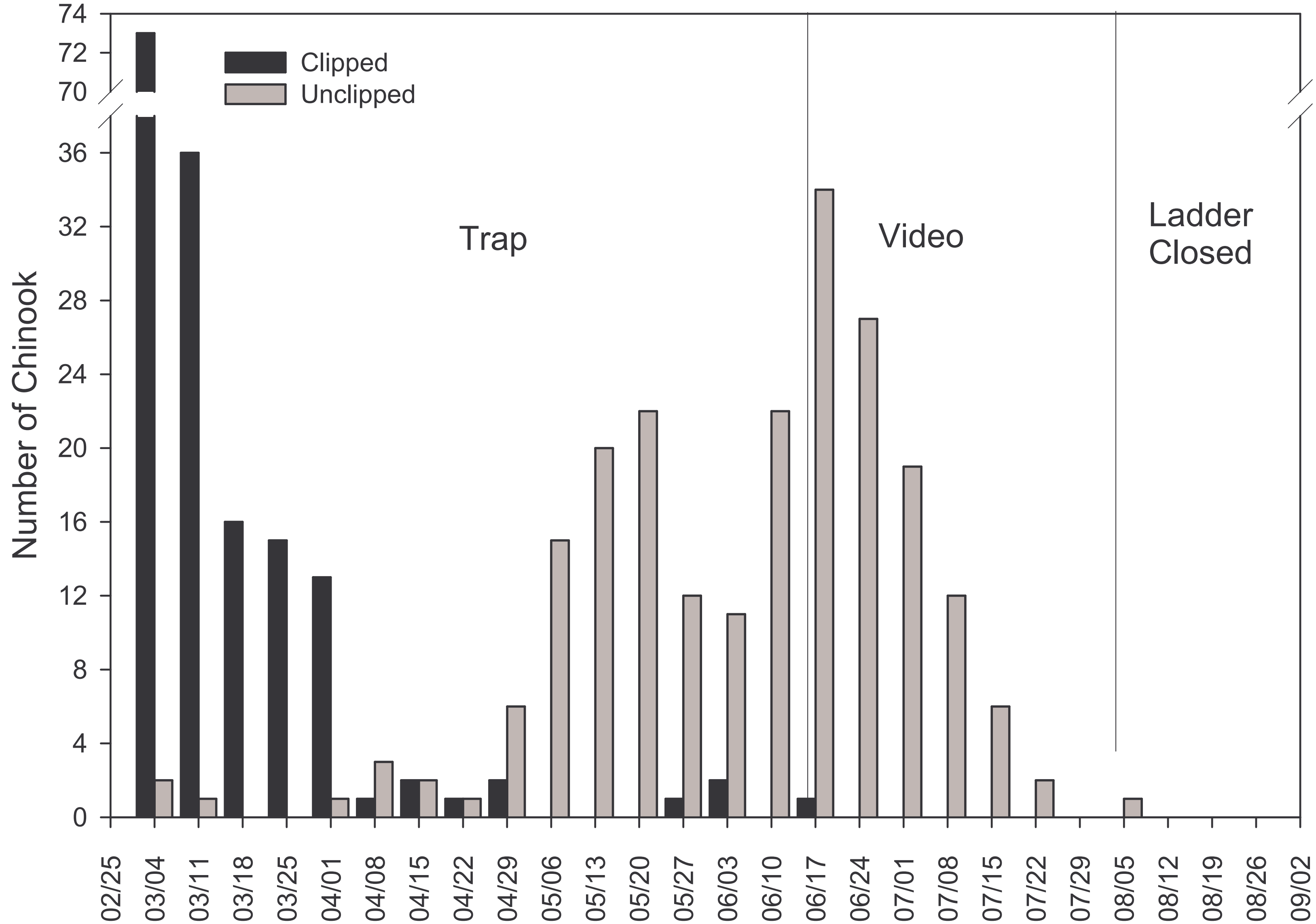

FIGURE 6.—Number of clipped and unclipped Chinook salmon observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2006, by week. Dates indicate the last day of the week.

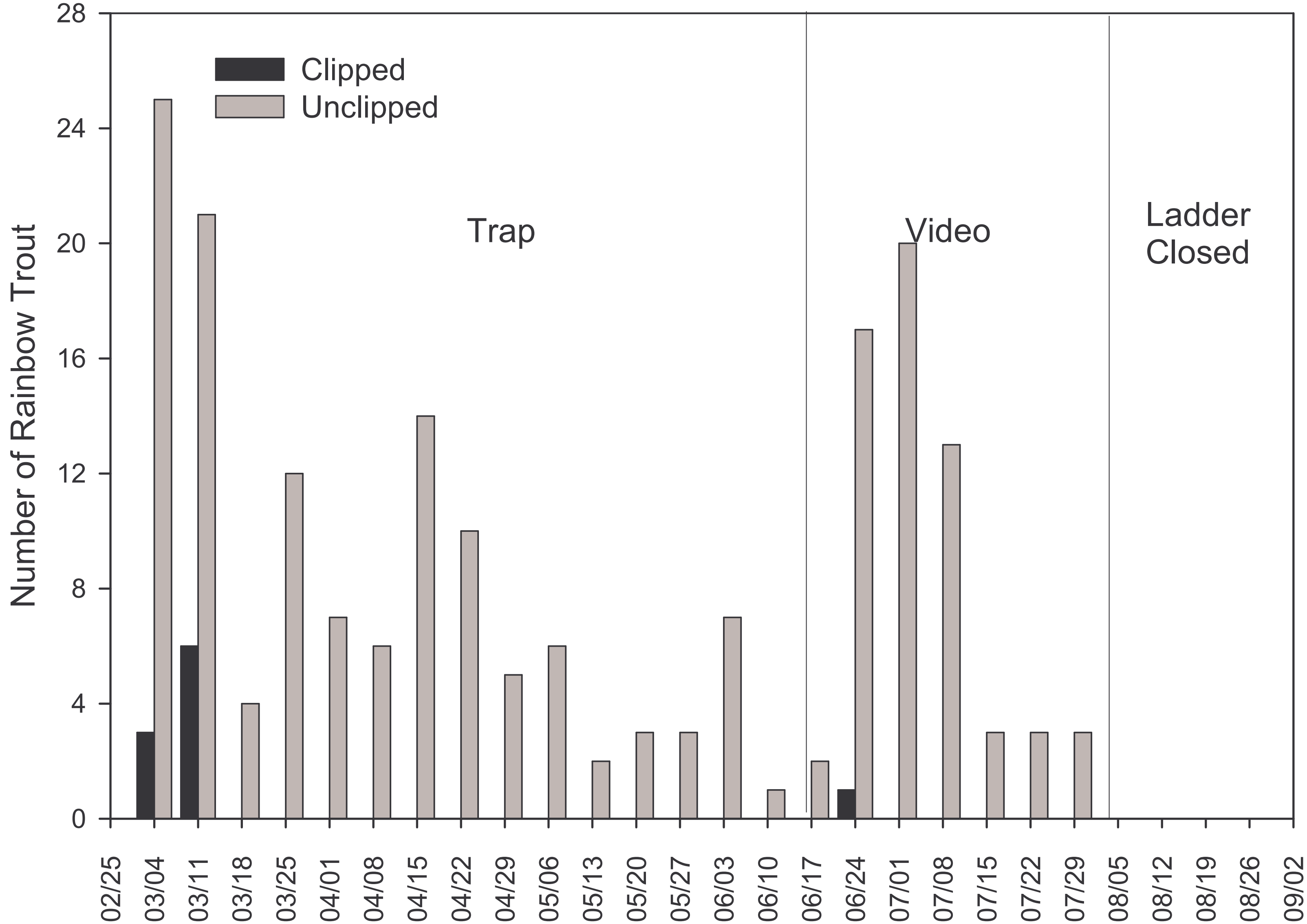

FIGURE 7.—Number of clipped and unclipped rainbow trout/steelhead observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2006, by week. Dates indicate the last day of the week.

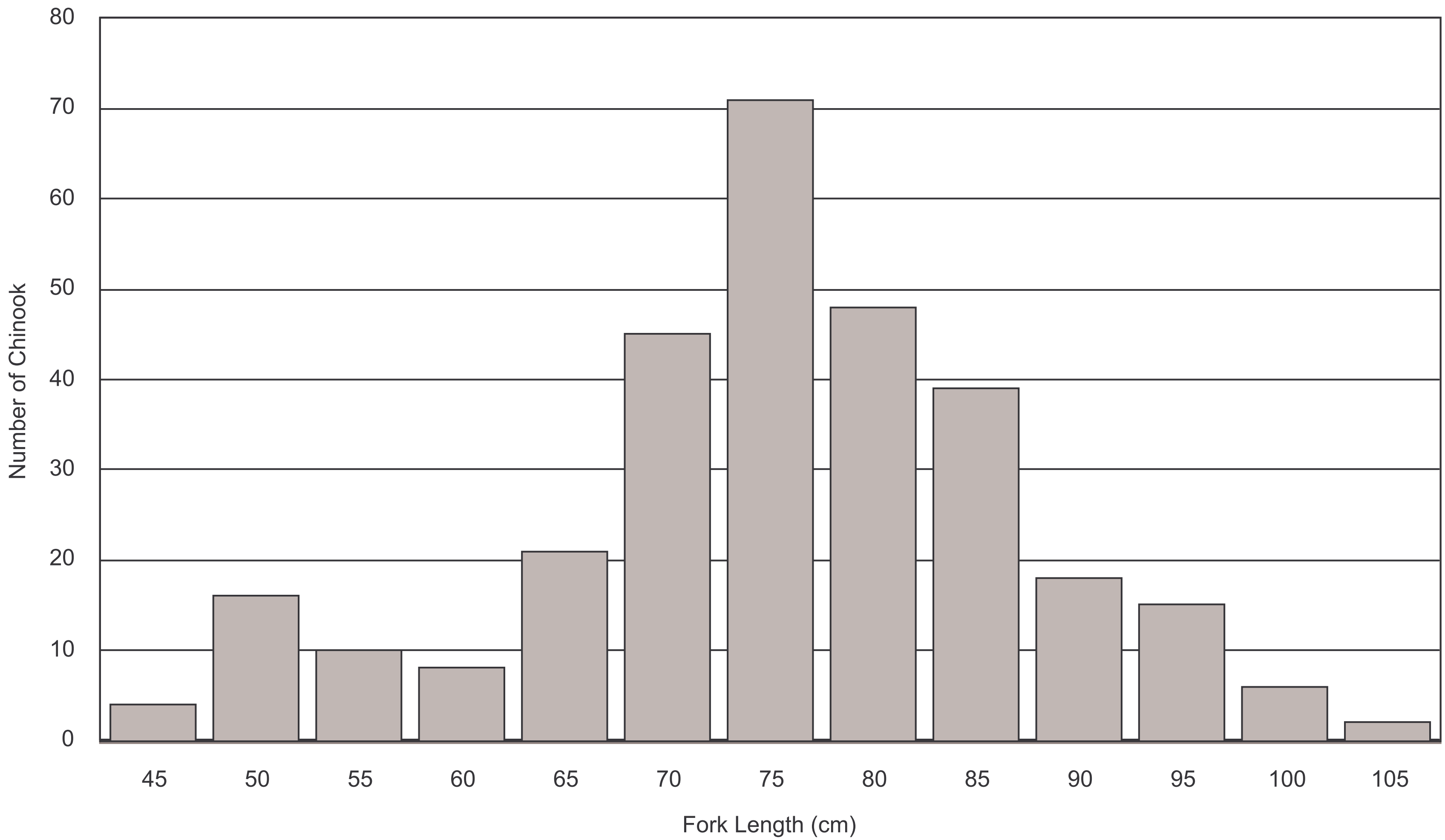

FIGURE 8.—Length-frequency distribution of Chinook captured in the Coleman National Fish Hatchery barrier weir fish trap in 2006. Fork length labels are the upper end of the size category.

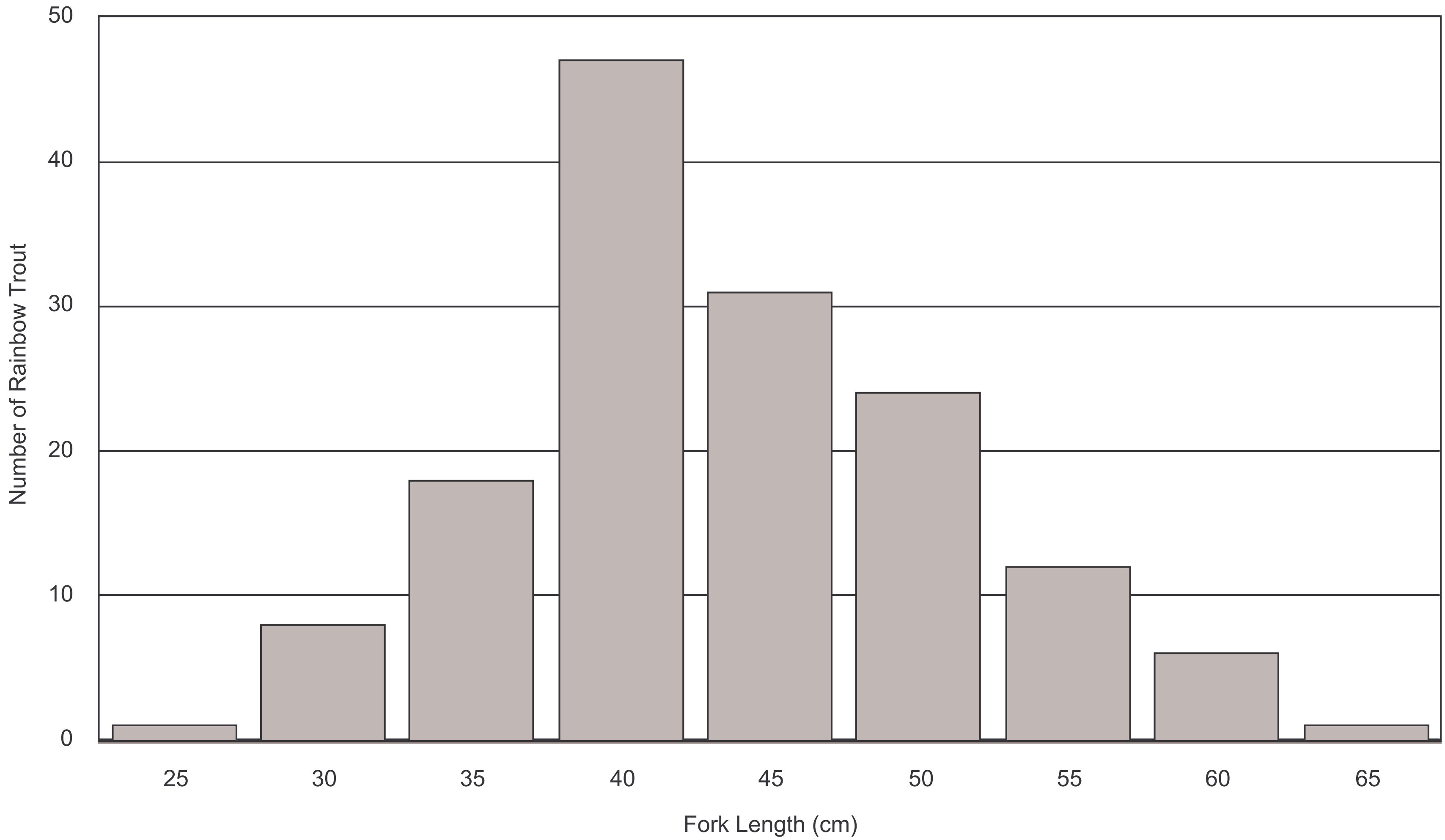

FIGURE 9.—Length-frequency distribution of rainbow trout/steelhead captured in the Coleman National Fish Hatchery barrier weir trap in 2006. Fork length labels are the upper end of the size category.

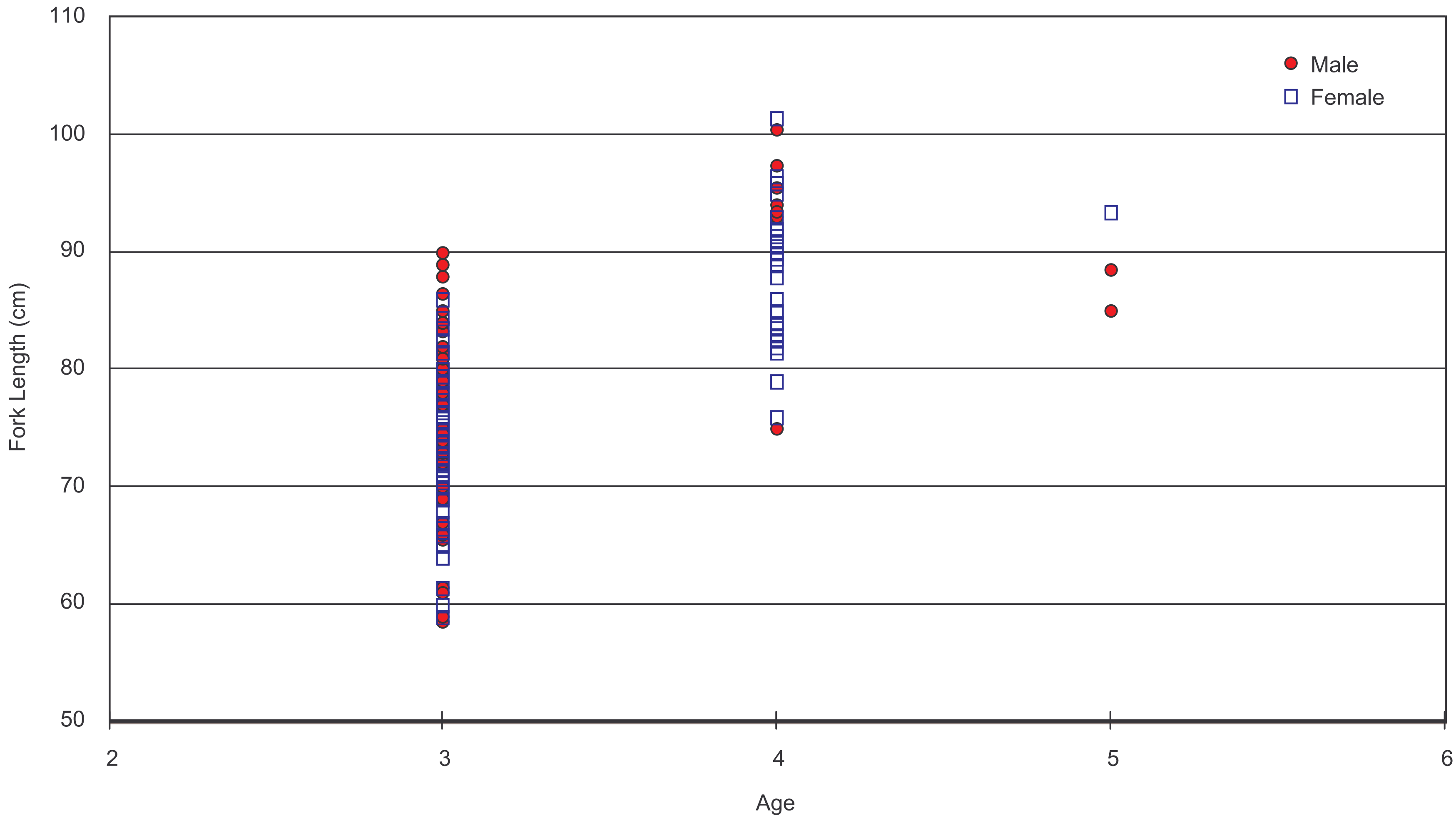

FIGURE 10.—Relationship between fork length and age for coded-wire tagged Chinook captured in the Coleman National Fish Hatchery barrier weir fish trap in 2006.

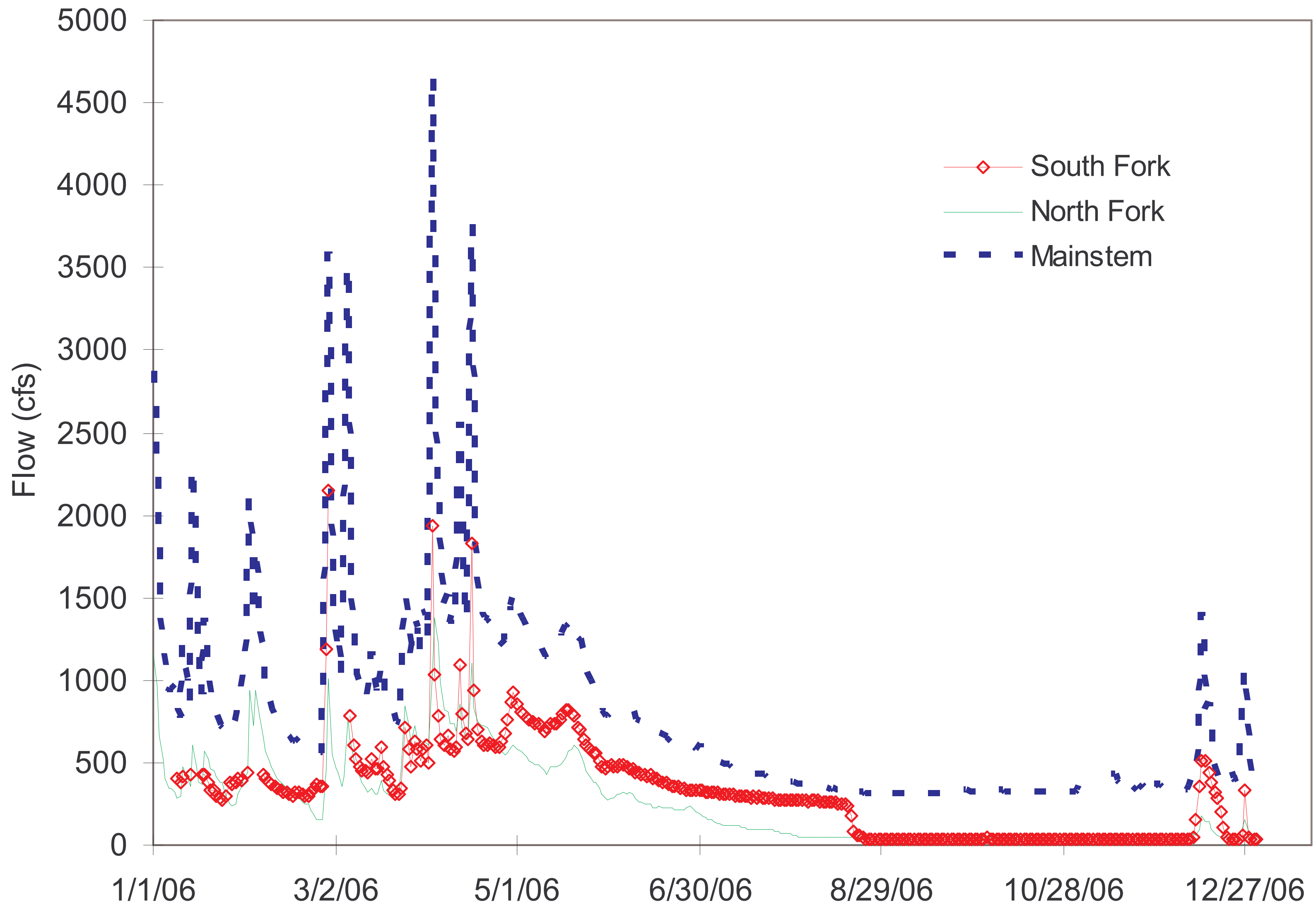

FIGURE 11.—Mean daily flows at the Coleman National Fish Hatchery barrier weir on the mainstem Battle Creek (rm 5.8), Wildcat Road Bridge on the North Fork (rm 0.9), and Manton Road Bridge on the South Fork (rm 1.7) in 2006.

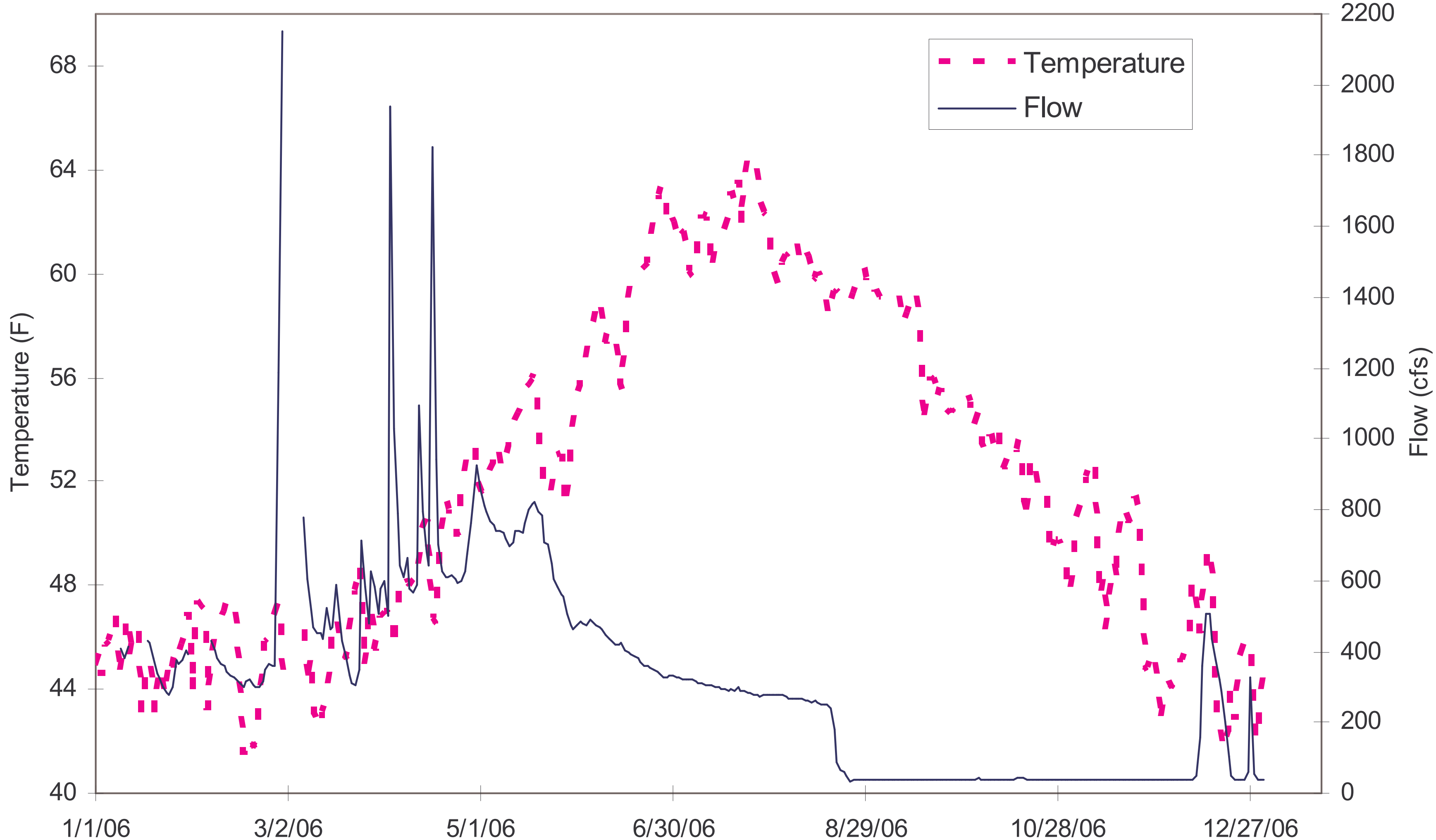

FIGURE 12.—South Fork Battle Creek Mean Daily Water Temperatures and Flows at Manton Road Bridge in 2006.

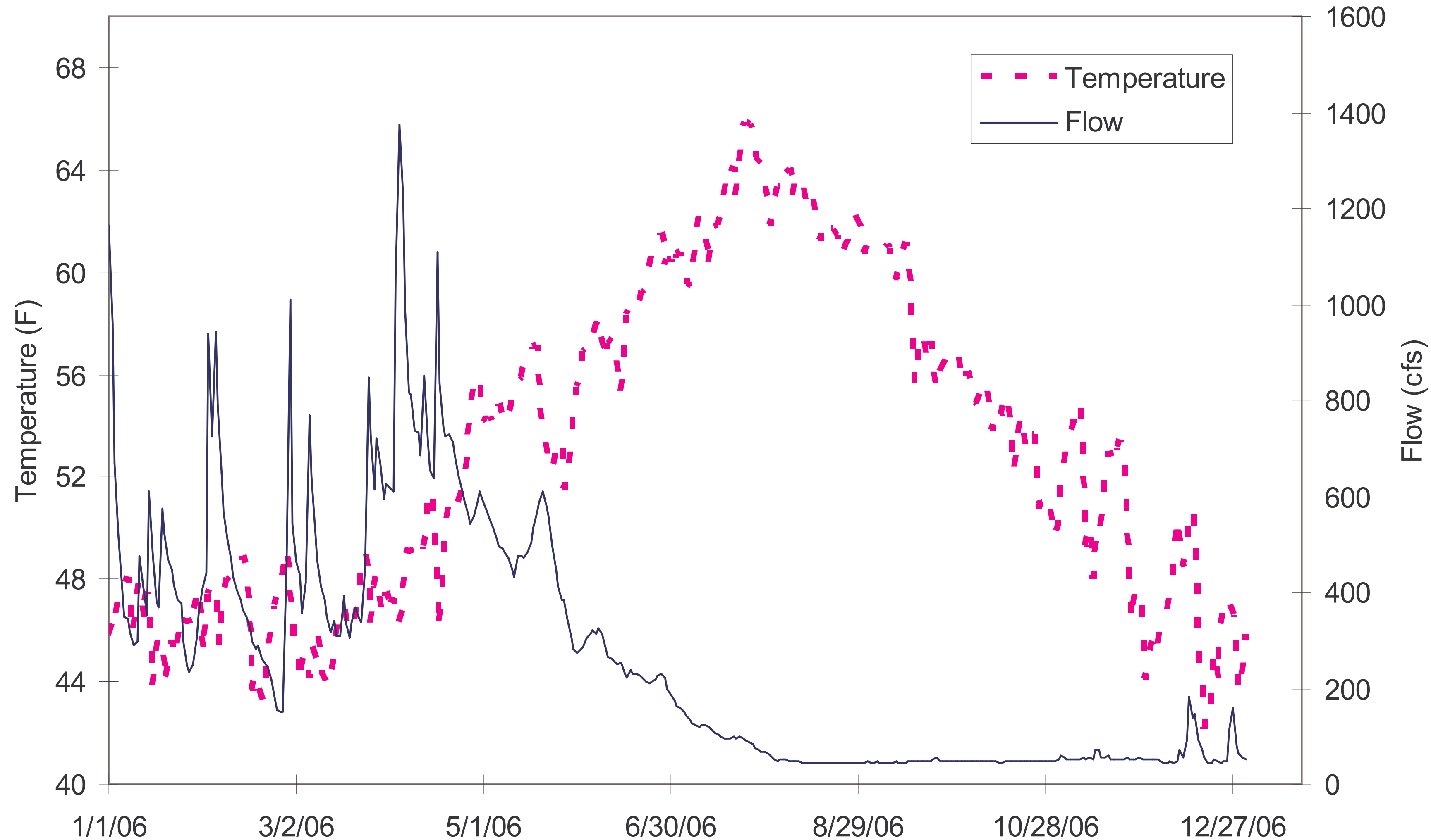

FIGURE 13.—North Fork Battle Creek Mean Daily Water Temperatures and Flows at Wildcat Road Bridge in 2006.

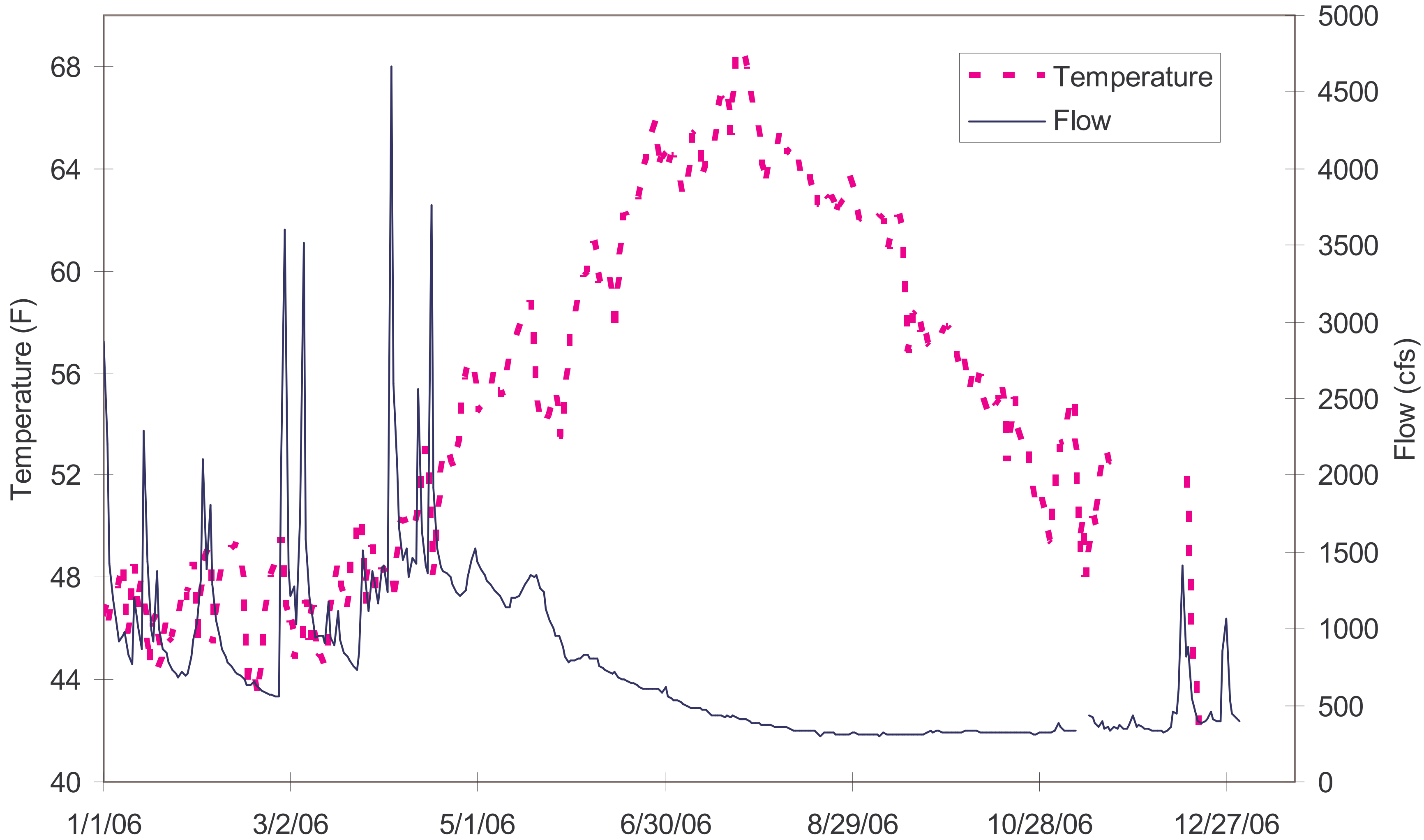

FIGURE 14.—Mainstem Battle Creek Mean Daily Water Temperatures and Flows at the Coleman National Fish Hatchery barrier weir in 2006.

Appendix

TABLE A.1.—Coded-wire tags recovered during Coleman National Fish Hatchery (CNFH) barrier weir trap monitoring in 2005.

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/1/2006	Barrier Weir Trap	Chinook	F	76	051776	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	84	051770	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	94	051164	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	M	70	051776	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	81	051767	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	74	051776	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	88	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	58.5	051776	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	98.5	**NTD**	—	—	—
3/1/2006	Barrier Weir Trap	Chinook	M	79	051770	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	101.5	051165	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	66	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	85	055138	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	83	051095	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	85	051094	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	76	051764	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	92	051091	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	67	051765	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	93	051099	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	M	67	051776	CNFH	Late Fall	2003

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/1/2006	Barrier Weir Trap	Chinook	F	66.5	051777	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	81.5	051095	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	60	051765	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	76.5	051770	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	74	051777	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	74.5	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	78	051764	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	82.5	051091	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	86	051164	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	73.5	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	74	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	M	61	051776	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	74.5	051766	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	77.5	051765	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	71.5	051768	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	74.5	051770	CNFH	Late Fall	2003
3/1/2006	Barrier Weir Trap	Chinook	F	88	051096	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	90	055139	CNFH	Late Fall	2002
3/1/2006	Barrier Weir Trap	Chinook	F	71	051776	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	92	055139	CNFH	Late Fall	2002

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/2/2006	Barrier Weir Trap	Chinook	F	71	051765	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	70	051766	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	84	051095	CNFH	Late Fall	2002
3/2/2006	Barrier Weir Trap	Chinook	M	84	051768	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	64	051775	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	M	59	051777	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	78	051997	**LSFH**	**WINTER**	2003
3/2/2006	Barrier Weir Trap	Chinook	M	79	051777	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	M	77	051699	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	72	051776	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	71	051765	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	66	051777	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	66	051777	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	86	051766	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	87	**LOST TAG**	—	—	—
3/2/2006	Barrier Weir Trap	Chinook	F	76	051769	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	80	051766	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	M	80	051776	CNFH	Late Fall	2003
3/2/2006	Barrier Weir Trap	Chinook	F	85	051095	CNFH	Late Fall	2002
3/2/2006	Barrier Weir Trap	Chinook	F	77	051699	CNFH	Late Fall	2003

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/3/2006	Barrier Weir Trap	Chinook	F	65	051777	CNFH	Late Fall	2003
3/3/2006	Barrier Weir Trap	Chinook	F	75	051767	CNFH	Late Fall	2003
3/3/2006	Barrier Weir Trap	Chinook	M	69	051775	CNFH	Late Fall	2003
3/3/2006	Barrier Weir Trap	Chinook	M	69	051775	CNFH	Late Fall	2003
3/3/2006	Barrier Weir Trap	Chinook	F	76	051099	CNFH	Late Fall	2002
3/3/2006	Barrier Weir Trap	Chinook	F	68	051766	CNFH	Late Fall	2003
3/3/2006	Barrier Weir Trap	Chinook	M	73	051770	CNFH	Late Fall	2003
3/4/2006	Barrier Weir Trap	Chinook	M	86.5	051777	CNFH	Late Fall	2003
3/4/2006	Barrier Weir Trap	Chinook	F	69	051776	CNFH	Late Fall	2003
3/4/2006	Barrier Weir Trap	Chinook	M	48	**NTD**	—	—	—
3/4/2006	Barrier Weir Trap	Chinook	M	73	051766	CNFH	Late Fall	2003
3/4/2006	Barrier Weir Trap	Chinook	F	72	051775	CNFH	Late Fall	2003
3/4/2006	Barrier Weir Trap	Chinook	F	72.5	051769	CNFH	Late Fall	2003
3/5/2006	Barrier Weir Trap	Chinook	F	79	051775	CNFH	Late Fall	2003
3/5/2006	Barrier Weir Trap	Chinook	F	70.5	051699	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	84.5	051770	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	M	89	051775	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	91.5	051096	CNFH	Late Fall	2002
3/7/2006	Barrier Weir Trap	Chinook	M	77	051699	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	84	051091	CNFH	Late Fall	2002

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/7/2006	Barrier Weir Trap	Chinook	M	77	051770	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	77	051965	LSFH	**WINTER**	2003
3/7/2006	Barrier Weir Trap	Chinook	F	78	051776	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	92	051095	CNFH	Late Fall	2002
3/7/2006	Barrier Weir Trap	Chinook	F	74	051776	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	79.5	051766	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	65	051776	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	M	82	051776	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	69	051775	CNFH	Late Fall	2003
3/7/2006	Barrier Weir Trap	Chinook	F	90	055139	CNFH	Late Fall	2002
3/7/2006	Barrier Weir Trap	Chinook	M	61.5	051776	CNFH	Late Fall	2003
3/8/2006	Barrier Weir Trap	Chinook	F	72	**LOST TAG**	—	—	—
3/8/2006	Barrier Weir Trap	Chinook	F	71	051770	CNFH	Late Fall	2003
3/8/2006	Barrier Weir Trap	Chinook	F	72	051770	CNFH	Late Fall	2003
3/8/2006	Barrier Weir Trap	Chinook	F	81.5	051766	CNFH	Late Fall	2003
3/8/2006	Barrier Weir Trap	Chinook	M	77	051766	CNFH	Late Fall	2003
3/8/2006	Barrier Weir Trap	**Rainbow**	U	44	054947	CNFH	winter	2003
3/8/2006	Barrier Weir Trap	Chinook	F	90.5	051096	CNFH	Late Fall	2002
3/8/2006	Barrier Weir Trap	Chinook	M	74	051766	CNFH	Late Fall	2003
3/9/2006	Barrier Weir Trap	Chinook	M	85	055135	CNFH	Late Fall	2001

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/9/2006	Barrier Weir Trap	Chinook	M	85	051776	CNFH	Late Fall	2003
3/9/2006	Barrier Weir Trap	Chinook	F	78	**NTD**	—	—	—
3/9/2006	Barrier Weir Trap	Chinook	F	75	051765	CNFH	Late Fall	2003
3/9/2006	Barrier Weir Trap	Chinook	F	81.5	051770	CNFH	Late Fall	2003
3/9/2006	Barrier Weir Trap	Chinook	F	76	051777	CNFH	Late Fall	2003
3/9/2006	Barrier Weir Trap	Chinook	M	95.5	051095	CNFH	Late Fall	2002
3/10/2006	Barrier Weir Trap	Chinook	F	79	051775	CNFH	Late Fall	2003
3/11/2006	Barrier Weir Trap	Chinook	F	79	051091	CNFH	Late Fall	2002
3/11/2006	Barrier Weir Trap	Chinook	F	70	051766	CNFH	Late Fall	2003
3/11/2006	Barrier Weir Trap	Chinook	F	72	**NTD**	—	—	—
3/12/2006	Barrier Weir Trap	Chinook	F	70.8	051775	CNFH	Late Fall	2003
3/13/2006	Barrier Weir Trap	Chinook	F	76	051765	CNFH	Late Fall	2003
3/13/2006	Barrier Weir Trap	Chinook	F	73	051766	CNFH	Late Fall	2003
3/14/2006	Barrier Weir Trap	Chinook	F	64	051776	CNFH	Late Fall	2003
3/14/2006	Barrier Weir Trap	Chinook	M	66	051766	CNFH	Late Fall	2003
3/15/2006	Barrier Weir Trap	Chinook	M	79	051775	CNFH	Late Fall	2003
3/15/2006	Barrier Weir Trap	Chinook	F	73.5	051766	CNFH	Late Fall	2003
3/15/2006	Barrier Weir Trap	Chinook	F	80	051775	CNFH	Late Fall	2003
3/15/2006	Barrier Weir Trap	Chinook	F	59	051766	CNFH	Late Fall	2003
3/16/2006	Barrier Weir Trap	Chinook	M	65.5	051770	CNFH	Late Fall	2003

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/16/2006	Barrier Weir Trap	Chinook	M	93.5	051164	CNFH	Late Fall	2002
3/16/2006	Barrier Weir Trap	Chinook	F	61.5	051765	CNFH	Late Fall	2003
3/16/2006	Barrier Weir Trap	Chinook	F	82.5	051766	CNFH	Late Fall	2003
3/17/2006	Barrier Weir Trap	Chinook	F	82.5	051095	CNFH	Late Fall	2002
3/17/2006	Barrier Weir Trap	Chinook	M	81	051765	CNFH	Late Fall	2003
3/17/2006	Barrier Weir Trap	Chinook	F	65	051776	CNFH	Late Fall	2003
3/19/2006	Barrier Weir Trap	Chinook	F	69	051768	CNFH	Late Fall	2003
3/21/2006	Barrier Weir Trap	Chinook	F	93	051095	CNFH	Late Fall	2002
3/21/2006	Barrier Weir Trap	Chinook	F	89	055139	CNFH	Late Fall	2002
3/21/2006	Barrier Weir Trap	Chinook	F	82	051092	CNFH	Late Fall	2002
3/21/2006	Barrier Weir Trap	Chinook	M	66	051776	CNFH	Late Fall	2003
3/24/2006	Barrier Weir Trap	Chinook	F	91	051092	CNFH	Late Fall	2002
3/24/2006	Barrier Weir Trap	Chinook	M	75	051095	CNFH	Late Fall	2002
3/24/2006	Barrier Weir Trap	Chinook	F	77	**NTD**	—	—	—
3/25/2006	Barrier Weir Trap	Chinook	M	83.3	051770	CNFH	Late Fall	2003
3/25/2006	Barrier Weir Trap	Chinook	F	75.5	051776	CNFH	Late Fall	2003
3/25/2006	Barrier Weir Trap	Chinook	M	72.5	**NTD**	—	—	—
3/25/2006	Barrier Weir Trap	Chinook	F	75.5	051765	CNFH	Late Fall	2003
3/25/2006	Barrier Weir Trap	Chinook	F	71	051774	CNFH	Late Fall	2003
3/25/2006	Barrier Weir Trap	Chinook	F	89.6	051164	CNFH	Late Fall	2002

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
3/25/2006	Barrier Weir Trap	Chinook	M	75	051776	CNFH	Late Fall	2003
3/27/2006	Barrier Weir Trap	Chinook	M	72	051775	CNFH	Late Fall	2003
3/27/2006	Barrier Weir Trap	Chinook	F	74.5	051777	CNFH	Late Fall	2003
3/27/2006	Barrier Weir Trap	Chinook	F	93.5	050769	CNFH	Late Fall	2001
3/28/2006	Barrier Weir Trap	Chinook	F	84	051093	CNFH	Late Fall	2002
3/29/2006	Barrier Weir Trap	Chinook	F	95	051164	CNFH	Late Fall	2002
3/29/2006	Barrier Weir Trap	Chinook	M	97.4	051092	CNFH	Late Fall	2002
3/30/2006	Barrier Weir Trap	Chinook	F	90.5	051091	CNFH	Late Fall	2002
3/30/2006	Barrier Weir Trap	Chinook	F	83.5	051164	CNFH	Late Fall	2002
3/30/2006	Barrier Weir Trap	Chinook	M	88.5	050764	CNFH	Late Fall	2001
3/30/2006	Barrier Weir Trap	Chinook	F	89.5	051091	CNFH	Late Fall	2002
3/30/2006	Barrier Weir Trap	Chinook	F	91.5	051095	CNFH	Late Fall	2002
4/1/2006	Barrier Weir Trap	Chinook	F	89.5	051091	CNFH	Late Fall	2002
4/1/2006	Barrier Weir Trap	Chinook	F	72.5	051775	CNFH	Late Fall	2003
4/7/2006	Barrier Weir Trap	Chinook	F	96	051095	CNFH	Late Fall	2002
4/9/2006	Barrier Weir Trap	Chinook	F	96	051091	CNFH	Late Fall	2002
4/10/2006	Barrier Weir Trap	Chinook	F	83.5	051777	CNFH	Late Fall	2003
4/18/2006	Barrier Weir Trap	Chinook	F	79.5	051995	LSFH	**WINTER**	2003
4/24/2006	Barrier Weir Trap	Chinook	M	81.5	051988	LSFH	**WINTER**	2003
4/27/2006	Barrier Weir Trap	Chinook	F	96.5	051091	CNFH	Late Fall	2002
5/23/2006	Barrier Weir Trap	Chinook	M	90	051997	LSFH	**WINTER**	2003

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (cm)	Tag code [a]	Hatchery or creek of origin [b]	Run	Brood year
5/30/2006	Barrier Weir Trap	Chinook	M	83	**NTD**	—	—	—
6/2/2006	Barrier Weir Trap	Chinook	M	69	062401	FRH	**SPRING**	2003
6/14/2006	Barrier Weir Trap	Chinook	M	100.5	051092	CNFH	Late Fall	2002

[a] NTD means No Tag Detected.

[b] Hatcheries include Coleman National Fish Hatchery (CNFH), Livingston Stone National Fish Hatchery (LSFH), and Feather River Fish Hatchery (FRH).

TABLE A.2.—Estimated number of days that egg incubation fell within the five water-temperature suitability categories for each spring Chinook redd in 2006. The incubation period was calculated using a cumulative total of 1,850 Daily Temperature Units (DTU).

Location	Reach	River mile	Date	Very poor	Poor	Fair	Good	Excell -ent	Total days
North Fork	1	4.63	9/18/2006	0	0	0	0	100	100
North Fork	1	4.13	9/18/2006	0	0	0	0	98	98
North Fork	1	3.91	9/18/2006	0	0	0	0	97	97
North Fork	1	3.80	9/18/2006	0	0	0	0	97	97
North Fork	1	3.78	9/18/2006	0	0	0	0	97	97
North Fork	1	3.61	9/18/2006	0	0	0	0	96	96
North Fork	1	3.37	9/18/2006	0	0	0	0	95	95
North Fork	1	3.29	9/18/2006	0	0	0	0	95	95
North Fork	1	4.22	10/2/2006	0	0	0	0	108	108
North Fork	1	3.89	10/2/2006	0	0	0	0	106	106
North Fork	1	3.79	10/2/2006	0	0	0	0	106	106
North Fork	1	3.79	10/2/2006	0	0	0	0	106	106
North Fork	1	3.43	10/2/2006	0	0	0	0	104	104
North Fork	1	3.28	10/2/2006	0	0	0	0	103	103
North Fork	1	3.28	10/2/2006	0	0	0	0	103	103
North Fork	1	3.21	10/2/2006	0	0	0	0	111	111
North Fork	1	2.96	10/2/2006	0	0	0	0	102	102
North Fork	1	2.73	10/2/2006	0	0	0	0	101	101
North Fork	1	3.29	10/30/200	0	0	0	0	114	114
North Fork	2	2.26	9/19/2006	0	0	0	5	88	93
North Fork	2	0.72	9/19/2006	0	0	0	4	99	103
North Fork	2	2.29	10/3/2006	0	0	0	0	102	102
North Fork	2	2.28	10/3/2006	0	0	0	0	110	110
North Fork	2	2.24	10/3/2006	0	0	0	0	102	102
North Fork	2	2.02	10/3/2006	0	0	0	0	103	103
North Fork	2	2.01	10/3/2006	0	0	0	0	103	103
North Fork	2	2.01	10/3/2006	0	0	0	0	103	103
North Fork	2	1.84	10/3/2006	0	0	0	0	104	104
North Fork	2	1.84	10/3/2006	0	0	0	0	104	104
North Fork	2	1.82	10/3/2006	0	0	0	0	105	105
North Fork	2	1.82	10/3/2006	0	0	0	0	105	105
North Fork	2	1.76	10/3/2006	0	0	0	0	105	105
North Fork	2	1.67	10/3/2006	0	0	0	0	105	105
North Fork	2	1.67	10/3/2006	0	0	0	0	105	105
North Fork	2	1.67	10/3/2006	0	0	0	0	105	105

TABLE A.2.—Continued

Location	Reach	River mile	Date	Very poor	Poor	Fair	Good	Excell -ent	Total days
North Fork	2	1.67	10/3/2006	0	0	0	0	105	105
North Fork	2	1.61	10/3/2006	0	0	0	0	106	106
North Fork	2	1.61	10/3/2006	0	0	0	0	107	107
North Fork	2	1.41	10/3/2006	0	0	0	0	107	107
North Fork	2	1.41	10/3/2006	0	0	0	0	107	107
North Fork	2	1.36	10/3/2006	0	0	0	0	108	108
North Fork	2	1.29	10/3/2006	0	0	0	0	108	108
North Fork	2	1.29	10/3/2006	0	0	0	0	108	108
North Fork	2	1.29	10/3/2006	0	0	0	0	108	108
North Fork	2	1.29	10/3/2006	0	0	0	0	108	108
North Fork	2	1.15	10/3/2006	0	0	0	0	108	108
North Fork	2	1.15	10/3/2006	0	0	0	0	109	109
North Fork	2	1.02	10/3/2006	0	0	0	0	109	109
North Fork	2	1.02	10/3/2006	0	0	0	0	109	109
North Fork	2	1.02	10/3/2006	0	0	0	0	109	109
North Fork	2	1.02	10/3/2006	0	0	0	0	109	109
North Fork	2	1.02	10/3/2006	0	0	0	0	110	110
North Fork	2	0.94	10/3/2006	0	0	0	0	110	110
North Fork	2	0.94	10/3/2006	0	0	0	0	110	110
North Fork	2	0.94	10/3/2006	0	0	0	0	110	110
North Fork	2	0.86	10/3/2006	0	0	0	0	110	110
North Fork	2	0.86	10/3/2006	0	0	0	0	110	110
North Fork	2	0.86	10/3/2006	0	0	0	0	110	110
North Fork	2	0.87	10/5/2006	0	0	0	0	112	112
North Fork	2	0.82	10/5/2006	0	0	0	0	112	112
North Fork	2	0.79	10/5/2006	0	0	0	0	112	112
North Fork	2	0.75	10/5/2006	0	0	0	0	112	112
North Fork	2	0.54	10/5/2006	0	0	0	0	113	113
North Fork	2	0.54	10/5/2006	0	0	0	0	113	113
North Fork	2	0.48	10/5/2006	0	0	0	0	113	113
North Fork	2	0.43	10/5/2006	0	0	0	0	113	113
North Fork	2	0.41	10/5/2006	0	0	0	0	113	113
North Fork	2	0.33	10/5/2006	0	0	0	0	114	114
North Fork	2	0.27	10/5/2006	0	0	0	0	114	114
North Fork	2	0.04	10/5/2006	0	0	0	0	115	115
North Fork	2	2.32	10/31/200	0	0	0	0	112	112
North Fork	2	2.02	10/31/200	0	0	0	0	114	114

TABLE A.2.—Continued

Location	Reach	River mile	Date	Very poor	Poor	Fair	Good	Excell -ent	Total days
North Fork	2	1.66	10/31/200	0	0	0	0	116	116
North Fork	2	1.48	10/31/200	0	0	0	0	117	117
North Fork	2	1.34	10/31/200	0	0	0	0	118	118
South Fork	3	2.09	9/19/2006	0	0	0	0	109	109
South Fork	3	2.09	9/19/2006	0	0	0	0	109	109
South Fork	3	2.53	10/3/2006	0	0	0	0	121	121
South Fork	3	2.53	10/3/2006	0	0	0	0	121	121
South Fork	3	2.21	10/3/2006	0	0	0	0	128	128
South Fork	3	2.17	10/3/2006	0	0	0	0	122	122
South Fork	3	2.17	10/3/2006	0	0	0	0	122	122
South Fork	3	2.12	10/3/2006	0	0	0	0	123	123
South Fork	3	1.93	10/3/2006	0	0	0	0	123	123
South Fork	3	1.93	10/3/2006	0	0	0	0	123	123
South Fork	3	1.85	10/3/2006	0	0	0	0	123	123
South Fork	3	1.79	10/3/2006	0	0	0	0	123	123
South Fork	3	1.69	10/3/2006	0	0	0	0	124	124
South Fork	3	1.69	10/3/2006	0	0	0	0	124	124
South Fork	3	1.69	10/3/2006	0	0	0	0	124	124
South Fork	3	1.13	10/3/2006	0	0	0	0	122	122
South Fork	3	0.72	10/3/2006	0	0	0	0	120	120
South Fork	3	0.72	10/3/2006	0	0	0	0	120	120
South Fork	3	2.15	10/31/200	0	0	0	0	132	132
South Fork	3	2.15	10/31/200	0	0	0	0	133	133
South Fork	3	1.94	10/31/200	0	0	0	0	133	133
South Fork	3	1.65	10/31/200	0	0	0	0	133	133
South Fork	3	0.20	10/31/200	0	0	0	0	129	129
Mainstem	4	16.50	9/20/2006	0	0	0	6	97	103
Mainstem	4	16.27	9/20/2006	0	0	0	6	97	103
Mainstem	4	16.24	9/20/2006	0	0	0	6	97	103
Mainstem	4	16.06	9/20/2006	0	0	0	6	97	103
Mainstem	4	15.43	9/20/2006	0	0	0	8	93	101
Mainstem	4	16.58	10/4/2006	0	0	0	0	117	117
Mainstem	4	16.14	10/4/2006	0	0	0	0	117	117
Mainstem	4	16.02	10/4/2006	0	0	0	0	117	117
Mainstem	4	15.98	10/4/2006	0	0	0	0	117	117
Mainstem	4	15.85	10/4/2006	0	0	0	0	117	117
Mainstem	4	15.85	10/4/2006	0	0	0	0	117	117

TABLE A.2.—Continued

Location	Reach	River mile	Date	Very poor	Poor	Fair	Good	Excell -ent	Total days
Mainstem	4	15.85	10/4/2006	0	0	0	0	117	117
Mainstem	4	15.40	10/4/2006	0	0	0	0	116	116
Mainstem	4	15.40	10/4/2006	0	0	0	0	116	116
Mainstem	4	15.40	10/4/2006	0	0	0	0	116	116
Mainstem	4	15.40	10/4/2006	0	0	0	0	116	116
Mainstem	4	14.82	10/4/2006	0	0	0	0	114	114
Mainstem	4	14.47	10/4/2006	0	0	0	0	113	113
Mainstem	4	14.38	10/4/2006	0	0	0	0	113	113
Mainstem	4	14.20	10/4/2006	0	0	0	0	112	112
Mainstem	4	14.03	10/4/2006	0	0	0	0	111	111
Mainstem	4	13.25	10/4/2006	0	0	0	2	107	109
Mainstem	5	11.94	10/4/2006	0	0	0	5	103	108
Mainstem	6	8.57	10/6/2006	0	0	0	2	111	113

TABLE A.3.—Chinook redd measurements taken during USFWS Battle Creek snorkel surveys in 2006.

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]
9/18/2006	1	7.92	4.42	27.46	2.08	2.46	1.58	1.43	2.3
9/18/2006	1	16.92	4.83	64.22	1.08	1.67	0.88	2.71	1.3
9/18/2006	1	5.25	3.33	13.74	0.75	1.17	0.67	2.3	1.2
9/18/2006	1	11.67	5	45.81	1	1.29	0.5	1.88	1.2
9/18/2006	1	16.67	3.83	50.18	1.33	1.63	1	1.34	2.3
9/18/2006	1	13.42	5.17	54.44	1.08	1.17	0.83	1.01	1.3
9/18/2006	1	14.17	4.17	46.36	0.92	1.33	0.42	2.53	1.2
9/18/2006	1	15.25	8.25	98.81	1	1.33	0.67	0.94	1.3
9/19/2006	2	12.25	4.67	44.9	1.83	1.67	0.67	0.61	1.3
9/19/2006	2	24.58	9.83	189.86	0.75	2.25	2	2.36	1.3
9/19/2006	3	11.92	4.25	39.78	0.75	1.42	1	1.1	1.3
9/19/2006	3	3.58	5.92	16.65	0.83	1.33	0.75	2.21	2.4
9/20/2006	4	7.42	4.25	24.76	1.25	1.58	0.83	1.99	1.2
9/20/2006	4	10.92	6.08	52.16	1.08	2.17	2	3.44	1.3
9/20/2006	4	6.17	3.08	14.93	1.67	2.33	1.33	2.51	1.2
9/20/2006	4	14.33	4	45.03	1.08	1.92	1.25	2.98	1
9/20/2006	4	4.58	3	10.8	1.92	2.42	1.67	2.13	1.3
10/2/2006	1	17	7.58	101.25	1.25	1.42	0.42	1.59	1.3
10/2/2006	1	14.58	5.67	64.9	0.83	1.25	0.63	2.23	1.2
10/2/2006	1	17.67	8.08	112.16	1.08	1.42	0.33	1.2	1.2
10/2/2006	1	10.5	8.83	72.85	1.75	2.08	1.42	1.41	1.3
10/2/2006	1	14.42	8.75	99.07	1	1.5	0.96	2.64	1.3
10/2/2006	1	5.83	4.17	19.09	0.83	1.17	0.83	2.29	2.4
10/2/2006	1	7.5	4.17	24.54	1.17	1.58	1.17	1.15	1.3
10/2/2006	1	9.17	4.17	30	1.25	1.5	1.42	2.6	1.3
10/3/2006	2	15.83	11.58	144.04	2.42	2.75	1.25	1.11	1.3
10/3/2006	2	9.67	6.75	51.25	0.92	1.75	1.33	1.46	1.3
10/3/2006	2	16.42	10.67	137.53	2.67	2.5	1.17	1.41	1
10/3/2006	2	10.58	2.5	20.78	1.17	1.75	1.17	2.92	1.2
10/3/2006	2	26.67	6.17	129.15	1.58	1.92	0.83	4.08	2.3
10/3/2006	2	15.92	5.92	73.96	0.83	1.25	0.42	3.52	2.3
10/3/2006	2	13.08	14.83	152.42	1.92	2.25	0.83	0.9	2.4
10/3/2006	2	16	12	150.8	1.25	2	0.75	1.58	1.2
10/3/2006	2	28.33	9.92	220.68	1.83	2.42	0.75	1.58	1.3
10/3/2006	2	16.42	8.33	107.45	1.92	2	0.75	1.88	2.3
10/3/2006	3	15	6.83	80.5	1.58	1.75	0.67	2.04	1.3
10/3/2006	3	18.33	6.67	95.99	0.58	1.08	0.33	3.5	1.3
10/3/2006	3	19.17	6	90.32	0.5	1	0.5	1.51	1.3

TABLE A.3.—Continued

Date	Reach	Max length (ft)	Max width (ft)	Area (ft²)	Depth: pre-redd (ft)	Depth: pit (ft)	Depth: tailspill (ft)	Velocity (ft/s)	Substrate code [a]
10/3/2006	3	15	8.33	98.17	1	1	0.25	3.5	1.3
10/3/2006	3	10.83	9.17	77.99	1.58	1.92	0.75	0.66	1.3
10/3/2006	3	10.83	6.67	56.72	0.83	1.58	0.67		1.3
10/3/2006	3	13.5	6.67	70.69	1.17	1.67	0.92		1.3
10/3/2006	3	14.58	6.5	74.45	0.83	1.25	0.67		2.4
10/3/2006	3	10.42	7.5	61.36	1.08	1.33	0.92	1.88	2.4
10/3/2006	3	8.58	5.42	36.52	1	1.17	0.58	2.18	1.3
10/4/2006	4	10.92	5.75	49.3	1.42	1.75	1	1.78	1.3
10/4/2006	4	15.58	6.33	77.51	0.83	1.42	0.5	0.37	1.2
10/4/2006	4	13.92	9.33	102.01	1.17	1.42	0.75	1.4	1.3
10/4/2006	4	17.58	13.5	186.43	1.08	1.58	0.58	1.54	1.2
10/4/2006	4	13	4.67	47.65	1.08	1.42	0.63	2.42	1.3
10/4/2006	4	20.17	9.67	153.11	1.17	1.75	0.75	2.19	1.3
10/4/2006	4	10.25	6.75	54.34	1.58	1.67	0.58	1.09	2.3
10/4/2006	4	17.33	7.83	106.64	0.83	1.17	0.46	3.32	1.3
10/4/2006	4	15.33	13.5	162.58	1.67	2.08	0.83	1.38	1.3
10/4/2006	4	15.33	10.92	131.47	4.17	4.67	2.83	1.22	1.3
10/4/2006	4	15.17	12.17	144.93	2.25	2.5	1.58	2.32	2.3
10/4/2006	4	16.25	12.33	157.41	1.67	2.17	0.5	1.61	1.3
10/4/2006	4	18.17	8	114.14	1.92	2.25	1.58	1.12	1.2
10/4/2006	5	17	19.25	257.02	2	2.17	0.92	1.27	1.3
10/5/2006	2	9.25	8.08	58.72	2.25	2.5	1.33	1.95	1.3
10/5/2006	2	15.17	8.58	102.24	2.42	2.5	1.25	1.49	1.3
10/5/2006	2	7	3	16.49	1.17	1.33	0.83	2.76	2.3
10/5/2006	2	27.5	15.17	327.58	1.75	2.42	0.67	1.33	2.3
10/5/2006	2	23.33	11.92	218.38	2.25	2.42	0.58	1.45	2.3
10/5/2006	2	9.67	6.25	47.45	2.25	2.5	0.75	2.18	2.3
10/5/2006	2	18.33	9.42	135.59	2.17	2.42	0.42	1.52	1.75
10/5/2006	2	20.83	9.42	154.08	2	2.5	0.75	1.79	1.2
10/5/2006	2	11.42	6.75	60.52	2.33	2.58	1.42	2.16	1.3
10/5/2006	2	13.67	4.42	47.41	1.5	1.75	0.46	0.96	1.3
10/6/2006	6	12.92	7.92	80.31	1	1.25	0.33	1.9	2.3
10/30/2006	1	7.92	4.17	25.91	1	1.33	0.58	1.45	1.3
10/31/2006	2	11.5	5.25	47.42	0.92	1.75	1.33	1.48	1.3
10/31/2006	2	22.92	8	143.99	0.58	1.67	0.75	2.4	1.2
Average		14.06	7.43	89.11	1.41	1.81	0.90	1.89	1.3[b]
Minimum		3.58	2.50	10.80	0.50	1.00	0.25	0.37	1
Maximum		28.33	19.25	327.58	4.17	4.67	2.83	4.08	2.4

[a] Dominant substrate codes are described by USFWS (2005) and are generally defined as follows; 1 = 1 in., 1.3 = 1-3 in., 2.4 = 2-4 in, etc.
[b] The median substrate code was used instead of an average.