Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from November 2003 through November 2004

USFWS Report

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Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from November 2003 through November 2004

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Abstract.—We estimate that 2 clipped and 90 unclipped Chinook salmon *Oncorhynchus tshawytscha* passed through the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder into upper Battle Creek between March 2 and August 1, 2004. 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 0 winter Chinook, 70 spring Chinook, 20 fall Chinook, and 2 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 were relatively low making it difficult to jump the weir and Chinook likely took the easier route through the fish ladder and our counting station. After the ladder was closed on August 1, flows remained low through late December suggesting that few CNFH fall Chinook jumped the barrier weir in 2004. An additional 40 unclipped Chinook were passed above the barrier weir prior to March 2 by CNFH during their late-fall Chinook propagation program. While these 40 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 (34 total redds), we estimate a spawning population of 68 spring Chinook.

Overall, water temperatures in 2004 were adequate for spring Chinook to successfully produce juveniles but at a reduced number due to high temperatures during the spring Chinook holding period. We documented unsuitably high water temperatures in the most utilized holding pool which likely led to some reduced fertility or adult mortality. Mean daily water temperatures at redds were categorized as excellent for 96% of the days during egg incubation, suggesting there was little or no temperature-related egg mortality.

We estimate that 329 clipped and 304 unclipped rainbow trout *Oncorhynchus mykiss* passed above the CNFH barrier weir in 2004 for a total of 633 rainbow trout. Of these, an estimated 314 clipped and 179 unclipped rainbow trout were passed by the hatchery prior to March 2 during their steelhead propagation program.

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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 of 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 spring 2007). 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 2004 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 November 25, 2003 and November 12, 2004. 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 30, 2003 to March 2, 2004. 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 2 through August 1, 2004 by opening the fish ladder. Passage was monitored until June 1 using a live trap, followed by underwater videography until August 1. The fish ladder was closed on August 1, 2004.

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 10 h a day, 7 d a week from March 2 through June 1, 2004. To decrease potential passage delays for Chinook, the hours of trap operation were progressively shifted earlier over the trapping season. We implemented three time shifts based on diel movement patterns observed in previous years: 0900-1900 from March 2-April 3, 0530-1530 from April 4-April 30, and 0400-1400 from May 1-June 1. 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.

Anesthetized salmonids were measured (fork length) to the nearest 1 mm, 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 (Northwest Marine Technology, Field Sampling Detector FSD-I). 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 or placed in the creek in a 38 x 10 inch (in) aluminum tube until they could swim out on their own.

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. 0900, 0930, 1000, 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

$$ATC_{ia} = \frac{TC_{ia}}{I_{ia}} \times TPI_a ,$$

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., $ATC_{0900\,a}$ + ATC_{0930a}).

Video counts.—An underwater video camera (ProVideo) 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 1 through August 1. A lighting system allowed for 24-h monitoring. A time-lapse video recorder was used to reduce maintenance and viewing time. The time mode on the video cassette recorder was set to 24 h, and 160-minVHS tapes were used. A time-date stamp was recorded.

In conjunction with video equipment, we installed a VAKI infrared fish counter as a backup system and to test its effectiveness for monitoring fish passage in our situation, especially during periods of high turbidity. The VAKI was used to investigate the accuracy of our video counts.

Video tapes were later viewed 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 presence or absence of an adipose fin; fair suggested confidence in determining species and presence or absence of an adipose fin but additional review was needed; and poor suggested uncertainty in determining species and 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.

All Chinook and rainbow trout passing the barrier weir were recorded onto a file tape which was reviewed by more experienced personnel to confirm species identification and 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 in 2004. 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 for 2004 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 2. The equations used for estimating passage during barrier weir trapping were

$$P_{tu} = \sum_{i=1}^{14} \left(\left[\left(\frac{u_i}{(c_i + u_i)} \right) * unk_i \right] + u_i \right)$$

and

$$P_{tc} = \sum_{i=1}^{14} \left(\left[\left(\frac{c_i}{(c_i + u_i)} \right) * unk_i \right] + c_i \right)$$

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

$$P_{vu} = \sum_{i=1}^{9} \left(\left[\left(\frac{u_i}{(c_i + u_i)} \right) * unk_i \right] + u_i \right) * \left(\frac{T_i}{V_i} \right)$$

and

$$P_{vc} = \sum_{i=1}^{9} \left(\left[\left(\frac{c_i}{(c_i + u_i)} \right) * unk_i \right] + c_i \right) * \left(\frac{T_i}{V_i} \right)$$

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.

Jumpers. —In 2004, we conducted a monitoring study to evaluate the number of fall Chinook circumventing the weir (i.e. jumping over) after the fish ladder was closed on August 1. This study helped determine the potential for hybridization and redd superimposition between fall and spring Chinook as well as helped interpret juvenile production estimates from an associated USFWS study. We attached cameras to a boom mounted over the fish ladder aiming directly across the barrier weir for better views of "jumpers". We monitored the barrier weir during daylight hours from August through November. Instantaneous flow was recorded at the time of each successful jump. Tape viewers rated days as good, fair, or poor viewing quality. Poor was used for any period that viewing was not possible due to lighting, camera obstruction, or other factors. Fair was used for any partial viewing difficulty, but still with moderate certainty of viewing accuracy. Good was used for good viewing conditions.

Stream Surveys

We conducted bi-monthly snorkel surveys on Battle Creek from May 6 to November 12, 2004. 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. Bi-monthly surveys were scheduled on consecutive weekdays beginning at the uppermost reaches and working downstream. Reach 7, located below the barrier weir, was not surveyed in October or November due to the abundance of non-target fall Chinook.

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 gaging stations operated by California Department of Water Resources (DWR) or the US Geological Survey. The gaging 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 gaging 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 - 32) were required for egg incubation to time of emergence and (2) 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).

Winter steelhead redd surveys.—We conducted winter steelhead redd surveys on Battle Creek between November 25, 2003 and April 8, 2004. Steelhead in the upper Sacramento Valley typically spawn from early winter through early spring. Steelhead redd surveys were scheduled twice a month but were frequently canceled due to storms and high flow conditions. Inflatable kayaks (Hyside®) were used to conduct surveys on the mainstem. Kayak surveys were preferred over snorkel surveys in the winter because of high stream flows, elevated turbidities (2-5 NTU), and low water temperatures (44-52˚F). For optimal viewing conditions, observers wore polarized sunglasses, kneeled on pontoons, or stood up in the kayak. Moving downstream with the current, three kayakers, spanning the width of the creek, documented the location and number of redds. We conducted snorkel surveys on the North and South Forks because flows were generally too low to operate kayaks. A GPS reading was taken at each redd and redds were flagged and labeled with a unique number.

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 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 and 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 124 Chinook were captured in the barrier weir trap between March 2 and June 1, 2004. Of these, 61 were clipped and 63 were unclipped (Table 9). We retrieved coded-wire tags (CWT) from 60 clipped Chinook captured in the trap. Tag codes revealed that 58 were CNFH late-fall Chinook, 1 was a wild Butte Creek spring Chinook, and 1 tag was unreadable (Table A.1). We did not recover any coded-wire tagged winter Chinook. One clipped Chinook had no tag detectable and no tags were lost during removal.

A total of 70 rainbow trout were captured in the barrier weir trap and 69 were released upstream (escapement). Of the 70 that were captured, 8 were clipped and 62 were unclipped (Table 10). Only one clipped rainbow trout had a CWT and it was sacrificed for tag extraction. Unfortunately the tag was lost during the extraction process.

The hours of trap operation were progressively shifted earlier over the trapping season. Three time shifts were implemented which began at 0900, 0530, and 0400. Within these three time shifts, diel timing of Chinook entering the barrier weir trap showed some variation throughout the 2004 trapping season (Figure 2). Early in the season, clipped Chinook were trapped throughout the hours of trap operation with a primary peak of ATC occurring in late morning and a secondary peak in late afternoon (Figure 3). Ninety percent of all clipped Chinook were trapped in the first time shift (March 2- April 3). Unclipped Chinook were trapped more in the morning hours with a peak of ATC occurring from 0600-0730 hours (Figure 3). Sixty percent of unclipped Chinook were trapped during the third time shift (May 1-June 1).

Diel timing of rainbow trout entering the barrier weir trap also showed some variation throughout the trapping season (Figure 4). During the first time shift, rainbow trout were trapped throughout the hours of trap operation with a slight peak of ATC occurring at 1600 hours (Figure 5). During second and third time shifts, rainbow trout were trapped most frequently at 1400-1430 hours. Seventy one percent of rainbow trout passed during the first time shift.

We operated the trap 24 hours per day from April 27 through April 29 in order to further investigate diel movement patterns of spring Chinook through the trap. Ten Chinook were captured during this period, however only one was captured outside normal trapping times (1930). Four rainbow trout were captured but only one was captured outside normal trapping times (0400). Water temperatures were above the 60˚F cutoff for about 25% of the 3-day period during which time the trap was shut down.

Video counts.—A total of 24 Chinook were observed passing through the barrier weir fish ladder between June 1 and August 1, 2004. Of these, 2 were clipped and 22 were unclipped (Table 11). Extrapolation for poor picture quality or video equipment malfunction resulted in a passage estimate of 27 unclipped Chinook. Extrapolation added 5 unclipped Chinook. From July 13 through August 1, no Chinook were observed passing (Figure 6). Similar periods of no fish passage from mid-July through early-August occurred in 2000-2003. During the video monitoring period, 78% (1134 h) of the afforded passage was video recorded with a good or fair picture quality. However, subtracting out the final 2 weeks results in 84% of total video recording. During the final 2 weeks, the VAKI infrared fish counter did not detect any fish passing through the video monitoring station and Chinook generally do not pass during this period.

A total of 56 rainbow trout were observed on video tape passing through the barrier weir fish ladder. Of these, 6 were clipped and 50 were unclipped (Table 12). Extrapolation for poor viewing quality or equipment malfunction resulted in a passage estimate of 71 rainbow trout. Extrapolation added 2 clipped and 13 unclipped rainbow trout to the passage estimate.

Diel timing of passage during video monitoring indicated that the average hourly passage rate for Chinook was highest between 0100 hours and 0700 hours, lower between 0800 hours and 1800 hours, and lowest (zero) between 1900 hours and 2400 hours (Figure 7). Also, 50% of Chinook passed during dark hours (Figure 7). Diel timing of rainbow trout passage during video monitoring peaked at approximately 1700 hours with 82% of passage occurring between 1300 and 1900 hours. Only 6% of rainbow trout passed during dark hours (Figures 8 and 9).

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 2 clipped and 90 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 2 and August 1, 2004 (Tables 9 and 11). An additional 40 unclipped Chinook were released above the barrier weir by CNFH personnel prior to opening the barrier weir fish ladder on March 2 (Tables 1, 2, and 13). These 40 Chinook were diverted from lower Battle Creek into the hatchery as part of the late-fall Chinook propagation program. Because CNFH personnel mark 100% of their late-fall production with an adipose-fin clip and CWT, these 40 Chinook were considered natural-origin and were released into Battle Creek upstream of the barrier weir to spawn naturally.

We estimated that 15 clipped and 125 unclipped rainbow trout passed upstream of the barrier weir fish ladder between March 2 and August 1, 2004 (Tables 10 and 12). An additional 314 clipped and 179 unclipped rainbow trout were released above the barrier weir by CNFH prior to March 2 (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 8 and peaked between May 1 and June 19. The middle 50% of the run passed between April 25 and June 12 (Figure 10). Chinook did not appear to migrate above the weir during the 2 weeks preceding the ladder closure on August 1.

The temporal distribution of clipped Chinook observed at the barrier weir is different from that of unclipped Chinook. The migration of clipped Chinook also began March 3, peaked during the first 2 weeks of trap operation and declined steadily until May, with an additional two fish passing in early June (Figure 10).

Rainbow trout migrating past the barrier weir exhibited a bimodal migration pattern (Figure 11). Passage of rainbow trout was greatest during the first 2 weeks of trap operation (March 3-15), after which weekly counts of rainbow trout gradually declined until May 29 when counts began rising again. A secondary peak of rainbow trout passage occurred the week of May 30-June 5.

Size, sex, and age composition.— Chinook captured in the barrier weir trap had a mean fork length of 76.1 cm and ranged in length from 41.5 to 107.0 cm (n = 125). The length-frequency distribution was continuous and was approximately normal with a mode at about 75 cm (Figure 12).

Rainbow trout captured in the barrier weir trap had a mean fork length of 41.4 cm and ranged from 18.0 to 65.5 cm (n = 65). The length-frequency distribution for rainbow trout was continuous and was approximately normal with a mode at about 40 cm (Figure 13).

The ratio of male to female clipped Chinook captured in the barrier weir was 1:2.2 (n=60). 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 = 27), 4-year-olds (n = 27), and 5-year-olds (n = 6). There were nearly equal numbers of males and females in the largest age categories (3 and 4-year-olds), but all 5-year-olds were female. There was overlap in fork length between Chinook of different ages (Figure 14). Age was not determined for unclipped Chinook.

Jumpers.— During video monitoring of jumpers at the barrier weir, we observed 19 Chinook jumping or swimming over the weir during daylight hours. Monitoring began August 1 and ended November 30, 2004. Ninety-five percent of the successful jumps occurred between 1330 and 1845 hours (Table 14). The average instantaneous flow during successful jumps was 250 cfs with the lowest flow being 223 cfs and the highest being 407 cfs. Of the 116 days recorded on video tape, 52% were classified as good days, 13% were fair, and 35% were poor in regard to picture quality.

Stream Surveys

During snorkel surveys conducted from May through November in reaches 1-6, observations of live adult Chinook peaked at 39 in late July (Tables 15 and 16). Also, we observed a total of 34 redds above the barrier weir, of which 18 were observed in September and 16 were in October. We recovered a total of 14 carcasses: 1 in July, 1 in August, 1 in September, 9 in October, and 2 in November. Small rainbow trout were the dominant size group in all the reaches. Medium rainbow trout were most abundant in Reach 4. Large rainbow trout counts were ≤5 on all reaches (Table 17). Reach 1 had the highest monthly mean rainbow trout counts, followed by Reach 2 (Table 18). The lowest monthly mean counts were observed in reaches 6 and 7.

Conditions for snorkel surveys were good to excellent. Stream flows were stable and were always <250 cfs on the mainstem (Figures 15-18). Temperatures ranged from 48˚ to 72˚F. Average daily turbidity was low and ranged from 0.5 to 2.7 NTU. The presence or absence of an adipose fin usually could not be determined for Chinook seen during our surveys.

Holding location.—Snorkel survey results indicated that some spring Chinook held in Battle Creek for at least 4.5 months (May through late September) prior to spawning. Surveys indicated that most Chinook spawned from the end of September through mid-October (Table 15). Therefore, we considered survey observations made from June through early September to be during the holding period for spring Chinook in 2004.

Chinook numbers and distribution remained relatively unchanged throughout the holding period. In June, the distribution was 21% in the North Fork, 11% in the South Fork, and 68% in the mainstem. In early September, the distribution was 24% in the North Fork, 10% in the South Fork, and 66% in the mainstem.

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 19). On the South Fork, the percentage of MDTs categorized as good ranged from 66% at the upstream most site to 22% at the downstream most site. On the North Fork, the percentage of MDTs categorized as good ranged from 98% at the upstream most site to 5% at the downstream most site. On the mainstem, the percentage of MDTs categorized as good ranged from 20% at the upstream most site to 11% at the downstream most site (rm 9.3).

We identified two primary holding pools where Chinook tended to congregate during the summer. Estimated MDTs at Pool #1 (Reach 3) were categorized as follows; 66% good, 34% fair, and 0% poor and very poor. Estimated MDTs at Pool #2 (Reach 4) were categorized as follows; 26% good, 66% fair, 8% poor, and 0 % very poor.

Spawning location and timing.—We observed 25 redds in the North Fork, 3 in the South Fork, and 6 in the mainstem (Table 15). In the North Fork, South Fork, and mainstem Battle Creek, Chinook began spawning between September 15 and 30, and finished spawning by October 14 (Table 15). The three redds in the South Fork were located at the top of Reach 3 immediately below Coleman Diversion Dam where the fish ladder was impassable. 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). In 2004, there were no redds observed above Wildcat Dam and only one live Chinook, even though in previous years redds were observed above Wildcat Dam. Because of the lack of Chinook above Wildcat Dam in 2004 along with above average flows through June, we were unable to further investigate a potential natural low-flow barrier to fish passage at rm 3.05 which was identified in previous annual reports (Brown and Newton 2002, Brown et al. 2005).

We estimated MDT at each Chinook redd during the egg incubation period. On average, the incubation period lasted 104 days, based on an 1,850 DTU requirement. During the incubation period, the average percentage of days redds were exposed to each temperature category were 95.7% excellent, 3.9% good, 0.4% fair, and 0% poor and very poor (Table 20, Table A.2). Temperature exposures were similar between survey reaches with a minimum of 92.0% of days classified as excellent for redds in Reach 4 (upper mainstem Battle Creek).

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, 2004. On the North Fork, the percentage of

MDTs categorized as good or excellent ranged from 100% at the upstream most site to 97% at the downstream most site. On the South Fork, the percentage categorized as good or excellent ranged from 98% at the upstream most site to 91% at the downstream most site (Table 21). On the mainstem, the percentage categorized as good or excellent ranged from 85% at the upstream most site to 51% at the downstream most site (rm 9.3).

Measurements were taken on 35 spring Chinook redds (Table A.3). Redd area ranged from 29 to 317 square feet (ft^2) with an average of 98 ft^2. Redd depths (pre-construction) ranged from 0.5 to 2.6 ft with an average of 1.5 ft. Water velocities ranged from 0.4 to 3.4 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 range of 1-2 in and a maximum range of 3-4 in.

Spawning status was determined for 4 of the 10 Chinook carcasses recovered during stream surveys. Of the four carcasses, three were spawned (recovered in the North Fork) and one was unspawned (recovered in the mainstem). Spawning status frequently could not be determined due an advanced state of decay, carcasses being partially eaten by scavengers, or apparent skinning and fileting by poachers.

Winter steelhead redd surveys.—The number of steelhead redd surveys completed per reach ranged from three to six (Table 22). High stream flows and high turbidities limited our ability to complete surveys. We observed a total of 32 rainbow trout/steelhead redds upstream of the CNFH barrier weir. Of the 32 redds, 43.8% were in the North Fork, 15.6% were in the South Fork, and 40.6% were in the mainstem. We observed 11 redds the week of January 16-23, our only complete survey that included all reaches. Prior to this survey, no redds were observed on the reaches surveyed. An additional 21 redds were observed throughout the creek from February through April (Table 22).

Measurements were taken on 15 rainbow trout/steelhead redds (Table A.4). Redd area ranged from 5 to 50 ft^2 with an average of 27 ft^2. Redd depths (pre-construction) ranged from 0.5 to 2.0 ft with an average of 1.2 ft. Water velocity ranged from 0.8 to 3.0 ft/s with an average of 1.5 ft/s. Redd substrate particles had a median size range of 1-2 in, with a minimum of 1 in and a maximum range of 2-4 in.

Tissue Collection for Genetic Analyses

Genetic analysis was performed on tissue samples from all 63 unclipped Chinook captured in the barrier weir trap (March 2 - June 1). Results indicated that 65% were spring run, 32% were fall run, 3% were late-fall run, and 0% were winter run (M. A. Banks, Oregon State University, personal communication). Of the spring run, all but one individual had an associated confidence probability of >95%. Of the fall run, almost half had an associated confidence probability of <95%, with two as low as 53%. The average confidence probabilities for spring-run and fall-run calls were 0.98 and 0.86 respectively. 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 many 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 20 Chinook classified as fall run, 10 had a secondary run call of spring run and 3 had a secondary run call of late-fall. Of the 41 samples classified as spring run, 8 had a secondary run call of fall run and 1 had a secondary run call of late-fall.

We collected 14 samples from Chinook carcasses encountered during stream surveys. Of these, one was genetically classified as a late-fall run and three were classified as fall run. The quality of the remaining 10 samples was too poor to analyze. The late-fall run sample was collected on August 20 and the fall Chinook samples were collected between October 13 and November 9.

Age Structure

Age was estimated from scale samples collected from carcasses sampled during the 2001 through 2004 snorkel surveys. In all years the dominant age class was three-year-olds (Figure 19). In 2004, the number of readable scales was eleven which is likely too few to be representative of the entire population. The number of readable scales collected each year averaged 23 and ranged from 5 in 2001 to 58 in 2003 (Figure 19).

Discussion

Chinook Salmon Population and Passage Estimates

We estimated that 2 clipped and 90 unclipped Chinook passed the CNFH barrier weir between March 2 and August 1, 2004. We generally use the unclipped passage total (90 in 2004) to estimate the "maximum potential spring Chinook" escapement. It is likely that a proportion of this maximum estimate are 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 MSA genetic analysis 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 zero winter run, 70 spring run, 20 fall run, and 2 late-fall run passed through the CNFH barrier weir ladder in 2004.

The 63 Chinook passing the weir during the trapping period (March 2-June 1) were assigned to a particular run according to genetic analysis results: 41 spring run, 20 fall run, and 2 late-fall run. This being said, we recognize that many of the fall run may actually be mis-classified spring or late-fall run. Genetic analysis results had more uncertainty associated with fall run assignments (i.e. lower confidence probabilities) compared to spring run assignments. Half of the fall run had a secondary run assignment of spring run with associated secondary confidence probabilities ranging from .03 to 0.47. 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. Additionally, 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. The Red Bluff Diversion Dam is 29 miles downstream from the mouth of Battle Creek.

We assumed that all 27 unclipped and 2 clipped 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 (June 1-August 1) are spring run (Vogel and

Marine 1991). This assumption is consistent with run estimation methods used in previous annual reports. We classified the two clipped Chinook, passing the barrier weir on June 2 and June 12, as spring run because (1) they passed near the peak of the spring run migration period and we occasionally capture clipped spring run from the Feather River Hatchery and Butte Creek, (2) it had been 5 weeks since we captured the last clipped CNFH late-fall Chinook, and (3) they passed prior to the reported fall run migration period and we did not observe additional clipped Chinook pass as the fall run migration period approached.

A total of seven Chinook and four rainbow trout/steelhead were detected passing upsteam of the barrier weir by the VAKI infrared fish counter which were missed by video viewers. This indicates that there is some error and a negative bias in passage estimates based on video monitoring methods alone. We did not include these numbers in the escapement estimates because the VAKI was not used in previous years and passage estimates would not be comparable if these fish were included.

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 continuing in August after the gap in July. It is likely that these fish returning in August are fall Chinook returning to CNFH. State and federal fishery resource agencies agreed with the recommendation and the fish ladder was closed August 1 in 2004. As seen in previous years, we observed the same 2-week gap in passage in late July,2004.

In 2004 we continued investigating diel passage timing of salmonids through the barrier weir fish ladder. Our observations in 2004 were similar to patterns observed in 2003 of clipped fish moving in the afternoon, early in the season; unclipped fish moving during the night, later in the season; and unclipped fish moving a few hours after daybreak, late in the season. Operating the trap at progressively earlier times of day from March through May resulted in lower water temperatures during trapping, potentially less stress on trapped fish, and a longer trapping season.

There are some uncertainties in accurately determining Chinook population estimates because the CNFH barrier weir is not considered fish tight. During August through March when the ladder to upstream Battle Creek is closed to passage, there is the potential for salmonids to escape upstream by jumping or swimming over the barrier weir. The ability of salmonids to successfully jump or swim over the weir may be affected by flow, concentration of salmonids below the weir, or other factors (USFWS 2001b). In 2004, our video monitoring of “jumpers” confirmed that some fall Chinook jump over the weir at flows as low as 223 cfs. More study is needed to accurately relate the number of Chinook jumping the weir to flow.

Evaluation and Adaptive Management of Battle Creek Stream Flow

Increase North Fork flows to test barrier hypothesis.—North Fork flows remained relatively high from mid-February through March. There were additional high flow events over 100 cfs in mid-April and flows were frequently over 60 cfs through May because of late season storms. A natural barrier at rm 3.04 (Reach 1) was identified in 2001 and 2002 as potentially impassible to Chinook at 30 cfs (current interim flow level) which raised concern as to whether it would be impassable at the future Restoration Project flow level of 35 cfs during this time period (NMFS et al. 1999). Because North Fork flows remained high for much of the spring Chinook immigration period in 2004, future monitoring is still needed to determine if Restoration Project flows are sufficient for passage at this temporary barrier and recommendation six and seven in Brown and Alston (2006) are still appropriate:

> Recommendation Six: If Chinook are blocked by the natural barrier at RM 3.05 on the North Fork, increase flows from 30 to 35 cfs on the North Fork for a week in September, to determine if Restoration Project minimum flows will be sufficient to allow Chinook passage at the barrier. Subsequent North Fork flows could be reduced by 1.25 cfs for 4 weeks in October to offset the cost of the increased flows.
>
> Recommendation Seven: Develop methods to quickly increase flows once a decision for a flow increase has been made. Both flow increases in the South Fork in 2002 were delayed from the point that recommendations were made by the Interim Flow Project Science Team to actual implementation. Administrative roles and methods could be better defined and streamlined to ensure quicker changes in flow.

The effect of Interim Flows on South Fork Battle Creek.—In 2001, interim flows of 30 cfs were not provided in the South Fork Battle Creek which resulted in higher water temperatures during the spring Chinook holding and early spawning periods. Coincidentally, in 2001, a relatively large proportion of Chinook held and spawned in the South Fork (Tables 4 and 5). Since most spring Chinook return as 3-year-olds (Fisher 1994), a low 2004 escapement estimate for unclipped Chinook relative to the 2001 estimate may indicate negative impacts of low flows in the South Fork in 2001. Our 2004 estimate for unclipped Chinook was 90 and our 2001 estimate was 98, excluding 13 Chinook which passed in August (August passage was allowed in 2001 but not in 2004). Additionally, many other factors outside of Battle Creek influence escapement.

We also estimated the number of juveniles produced per unclipped female Chinook to explore differences in environmental condition between 2001 and 2004. Annual juvenile production estimates upstream of the CNFH barrier weir were made by an associated RBFWO monitoring project using rotary screw traps (K. S. Whitton, USFWS, unpublished data). We estimated the annual number of adult female Chinook by dividing the unclipped escapement estimate by two. Juvenile production per unclipped female Chinook was 387 in 2001 and 640 in 2004. This difference may be a result of less suitable holding and spawning conditions in 2001 compared to 2004.

Holding and Spawning Water Temperatures.—The largest and most utilized holding pool for spring Chinook was in the upper mainstem Battle Creek (Reach 4). As many as 26 adult Chinook were observed holding in this pool during the summer of 2004. Mean daily water temperatures in this pool were classified as fair 66% of the days and poor 8% of the days from June 1 to September 30. Fair water temperatures can lead to some mortality and infertility and poor temperatures can result in unsuccessful spawning. Although we could not quantify exposure time for individual Chinook, it is likely that water temperatures at this location had negative impacts on holding adults prior to their spawning. The Restoration Project will increase instream flows in spring-fed Baldwin Creek, a tributary to upper mainstem Battle Creek, reducing water temperatures in the vicinity. The current Interim Flow Agreement does not include increased flows from Baldwin Creek.

Recommendation: We recommend the Interim Flow Science Team explore the benefits of increased instream flows from Baldwin Creek (until implementation of Restoration Project flows) for holding temperatures in the mainstem, through stream temperature modeling.

Our temperature analysis of each individual redd indicated that Chinook egg incubation temperatures were excellent on the large majority of days. We feel that incubating eggs did not experience any adverse effects from water temperatures. This may be a combination of interim flows 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 four years of stream surveys, Chinook redd density (redds/mile) was highest in the North Fork with the exception of 2001 (Table 6). The higher redd density in the North Fork may be the result of the North Fork having the most miles of habitat with highly suitable water temperatures. Other important factors which were not examined include the quantity and quality of spawning gravel and the quantity of habitat with suitable water depth and velocity for spawning.

Winter steelhead redd surveys.—Pilot steelhead redd surveys were initiated in 2002 to explore the feasibility of using a combination of kayak and snorkel methods to determine the number and distribution of redds. In 2004, steelhead surveys were infrequent due to high flows and turbidities. Storm events, in between surveys, may have smoothed out redds making them undetectable. Data were somewhat useful to document some spawning locations (e.g., Reach 2 on the lower North Fork) but were not useful as a population abundance index or as a precise indicator of spawn timing. In years when viewing conditions are favorable, this type of survey may be useful to produce a spawning frequency index (e.g.., number of redds per steelhead passing above the barrier weir).

Scale Collection and Age Composition

Adult spring Chinook generally return at ages 2, 3, and 4 with the majority typically returning at age 3 (Fisher 1994). Annual percentages in each age category vary from year to year (Ward et al. 2002, Ward et al. 2004). Although our scale aging results fit the pattern typical of spring Chinook, the number of scales recovered is often too small to accurately estimate the annual age structure. For example, in 2004 we were only able to age 11 fish. Without accurate age structure data, it is difficult to precisely estimate escapement for each brood year, in turn making it more difficult to associate the success of a particular year class with annual environmental conditions and restoration efforts. In the absence of accurate age structure data, we make the general assumption that all returning adults are 3-year-olds in order to evaluate the success of particular year classes.

Recommendation: We recommend taking scale samples from spring Chinook captured in the CNFH barrier weir fish trap if permits can be obtained or installing temporary picket weirs on the North Fork and South Fork to catch carcasses drifting downstream.

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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

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).

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

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

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 %
Average	59	2%	41%	58%

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 %
Average	80	47%	21%	33%

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

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 2004.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
2-6 March	25	0	0	0	0
7-13 March	15	2	0	0	2
14-20 March	6	0	0	0	0
21-27 March	5	9	0	0	9
28 March-3 April	4	3	0	0	3
4-10 April	0	1	0	0	1
11-17 April	2	1	0	0	1
18-24 April	2	1	0	0	1
25 April-1 May	2	10	0	0	10
2-8 May	0	10	0	0	10
9-15 May	0	9	0	0	9
16-22 May	0	5	0	0	5
23-29 May	0	8	0	0	8
30 May-1 June	0	4	0	0	4
Total	61	63	0	0	63

TABLE 10.—Rainbow trout/steelhead captured at Coleman National Fish Hatchery barrier weir trap and associated passage estimates for 2004. The clipped rainbow trout/steelhead captured the week of May 16-22 was sacrificed for coded-wire tag retrieval.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
2-6 March	1	15	0	1	15
7-13 March	5	18	0	5	18
14-20 March	0	5	0	0	5
21-27 March	0	4	0	0	4
28 March-3 April	0	5	0	0	5
4-10 April	0	3	0	0	3
11-17 April	0	1	0	0	1
18-24 April	0	1	0	0	1
25 April-1 May	1	4	0	1	4
2-8 May	0	4	0	0	4
9-15 May	0	1	0	0	1
16-22 May	1	1	0	0	1
23-29 May	0	0	0	0	0
30 May-1 June	0	0	0	0	0
Total	8	62	0	7	62

TABLE 11.—Chinook salmon video recorded passing the Coleman National Fish Hatchery barrier weir fish ladder and associated passage estimates for 2004. 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
1-5 June	103.5	89.6	1	4	0	1	5
6-12 June	168.0	140.0	1	4	0	1	5
13-19 June	168.0	132.6	0	8	0	0	10
20-26 June	168.0	110.9	0	0	0	0	0
27 June-3 July	168.0	125.0	0	2	0	0	3
4-10 July	168.0	147.8	0	2	0	0	2
11-17 July	168.0	131.7	0	2	0	0	3
18-24 July	168.0	105.3	0	0	0	0	0
25-1 August	175.8	151.4	0	0	0	0	0
Total	1455.3	1134.3	2	22	0	2	27

TABLE 12.—Rainbow trout/steelhead video recorded passing the Coleman National Fish Hatchery barrier weir fish ladder and associated passage estimates for 2004. 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
1-5 June	103.5	89.6	4	13	0	5	15
6-12 June	168.0	140.0	0	11	0	0	13
13-19 June	168.0	132.6	0	7	0	0	9
20-26 June	168.0	110.9	1	6	0	2	9
27 June-3 July	168.0	125.0	1	4	0	1	5
4-10 July	168.0	147.8	0	4	0	0	5
11-17 July	168.0	131.7	0	2	0	0	3
18-24 July	168.0	105.3	0	2	0	0	3
25-1 August	175.8	151.4	0	1	0	0	1
Total	1455.3	1134.3	6	50	0	8	63

TABLE 13.—Total passage estimates for Chinook and rainbow trout/steelhead above the Coleman National Fish Hatchery (CNFH) barrier weir in 2004.

Passage Route	Chinook Passage: Clipped	Chinook Passage: Unclipped	Steelhead Passage: Clipped	Steelhead Passage: Unclipped
CNFH	0	40	314	179
Barrier Weir: Trap	0	63	7	62
Barrier Weir: Video	2	27	8	63
Total	2	130	329	304

TABLE 14.—Date, time, and stream flow for adult Chinook observed jumping over the Coleman National Fish Hatchery barrier weir (n=19). Video monitoring was conducted during daylight hours from August 1 to November 30, 2004.

	Jump #1		Jump #2		Jump #3		Jump #4	
Date of Successful Jumps	Flow (cfs)	Time	Flow (cfs)	Time	Flow (cfs)	Time	Flow (cfs)	Time
9/24/04	245	1700	252	1900				
9/26/04	252	1400	236	1500	249	1600		
9/27/04	245	1800	245	1800	245	1800		
9/28/04	191	1600						
9/29/04	249	1400	245	1600	245	1800	245	1800
9/30/04	226	1800						
10/1/04	407	1400						
10/4/04	223	0900	239	1900				
10/12/04	245	1700	245	1700				

TABLE 15.—Chinook salmon live adults, carcasses, and redds observed during the 2004 Battle Creek snorkel surveys.

Reach	Date	Chinook	Carcasses	Redds
1	5/13/04	0	0	0
1	5/25/04	0	0	0
1	6/7/04	0	0	0
1	6/22/04	0	0	0
1	7/6/2004	1	1	0
1	7/20/04	0	0	0
1	8/17/04	0	0	0
1	9/14/04	0	0	0
1	9/28/04	0	0	0
1	10/12/04	0	0	0
1	10/27/04	0	0	0
1	11/08/04	0	0	0
2	5/14/04	0	0	0
2	5/26/04	0	0	0
2	6/8/04	1	0	0
2	6/23/04	4	0	0
2	7/7/04	0	0	0
2	7/21/04	0	0	0
2	8/18/04	0	0	0
2	9/15/04	1	0	0
2	9/29/04	7	0	11
2	10/13/04	5	6	13
2	10/27/04	1	0	0
2	11/09/04	0	0	0
3	5/9/04	1	0	0
3	5/26/04	0	0	0
3	6/8/04	0	0	0
3	6/23/04	2	0	0
3	7/7/04	1	0	0
3	7/22/04	6	0	0
3	8/18/04	2	0	0
3	9/15/04	1	0	0
3	9/29/04	3	0	2
3	10/13/04	4	1	1
3	11/3/04	0	0	1
3	11/09/04	0	0	0
4	5/6/04	0	0	0
4	5/27/04	3	0	0
4	6/9/04	7	0	0
4	6/24/04	12	0	0

TABLE 15.—Continued

Reach	Date	Chinook	Carcasses	Redds
4	7/8/04	31	0	0
4	7/22/04	33	0	0
4	8/19/04	22	0	0
4	9/16/04	28	0	0
4	9/30/04	19	1	4
4	10/14/04	3	1	2
4	10/28/04	0	1	0
4	11/10/04	0	0	0
5	5/6/04	0	0	0
5	5/27/04	0	0	0
5	6/9/04	1	0	0
5	6/24/04	0	0	0
5	7/8/04	0	0	0
5	7/22/04	0	0	0
5	8/19/04	1	0	0
5	9/16/04	0	0	0
5	9/30/04	0	0	0
5	10/14/04	0	0	0
5	10/28/04	0	0	0
5	11/10/04	0	0	0
6	6/10/04	0	0	0
6	6/25/04	0	0	0
6	7/9/04	0	0	0
6	7/23/04	0	0	0
6	8/20/04	1	1	0
6	9/17/04	0	0	0
6	10/01/04	0	0	0
6	10/15/04	1	0	0
6	10/29/04	0	0	0
6	11/12/04	2	1	0
7	6/10/04	0	0	0
7	6/25/04	1	0	0
7	7/9/04	1	0	0
7	7/23/04	2	0	0
7	8/20/04	2	0	0
7	9/17/04	195	0	0
7	10/01/04	4203	1	17
Total			13	34

TABLE 16.—Counts of live Chinook observed on Battle Creek snorkel surveys in 2004. Totals only include reaches above the Colman National Fish Hatchery barrier weir (reaches 1-6).

Reach	May 6-14	May 25-27	June 7-10	June 22-25	July 6-9	July 20-23	Aug. 17-20	Sept. 14-17	Sept. 28-1	Oct. 12-15	Oct. 27-29	Nov. 8-12
1	0	0	0	0	1	0	0	0	0	0	0	0
2	0	0	1	4	0	0	0	1	7	5	1	0
3	1	0	0	2	1	6	2	1	3	4	0	0
4	0	3	7	12	31	33	22	28	19	3	0	0
5	0	0	1	0	0	0	1	0	0	0	0	0
6			0	0	0	0	1	0	0	1	0	2
7			0	1	1	2	2	195	4203			
Total (Reaches 1-6)	1	3	9	18	33	39	26	30	29	13	1	2

TABLE 17.—Rainbow trout/steelhead observed during the 2004 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	5/13/04	482	3	0	485
1	5/25/04	714	0	0	714
1	6/7/04	94	0	0	94
1	6/22/04	454	0	0	454
1	7/6/2004	494	2	0	496
1	7/20/04	688	1	0	689
1	8/17/04	938	0	0	938
1	9/14/04	731	0	0	731
1	9/28/04	779	0	0	779
1	10/12/04	750	0	0	750
1	10/27/04	102	0	0	102
1	11/08/04	284	0	0	284
2	5/14/04	431	0	0	431
2	5/26/04	373	0	0	373
2	6/8/04	516	0	0	516
2	6/23/04	502	0	0	502
2	7/7/04	718	1	0	719
2	7/21/04	541	6	0	547
2	8/18/04	451	2	0	453
2	9/15/04	867	0	0	867
2	9/29/04	413	0	0	413
2	10/13/04	350	0	0	350
2	10/27/04	119	0	0	119
2	11/09/04	367	0	0	367
3	5/9/04	73	6	0	79
3	5/26/04	220	23	0	243
3	6/8/04	464	16	0	480
3	6/23/04	245	9	0	254
3	7/7/04	274	10	0	284
3	7/22/04	337	2	0	339
3	8/18/04	361	7	0	368
3	9/15/04	373	9	0	382
3	9/29/04	476	15	0	491
3	10/13/04	298	7	0	305
3	11/3/04	95	1	0	96
3	11/09/04	207	3	0	210
4	5/6/04	32	0	0	32
4	5/27/04	220	1	0	221
4	6/9/04	365	20	0	385
4	6/24/04	456	29	0	485

TABLE 17.—Continued

Reach	Date	Small	Medium	Large	Total
4	7/8/04	443	46	0	489
4	7/22/04	601	19	0	620
4	8/19/04	317	23	4	344
4	9/16/04	556	16	0	573
4	9/30/04	456	21	0	477
4	10/14/04	482	21	0	503
4	10/28/04	267	12	0	279
4	11/10/04	439	6	0	445
5	5/6/04	13	2	5	20
5	5/27/04	70	6	0	76
5	6/9/04	119	22	0	141
5	6/24/04	206	13	0	219
5	7/8/04	327	33	0	360
5	7/22/04	280	56	3	339
5	8/19/04	70	3	0	73
5	9/16/04	183	6	0	189
5	9/30/04	397	20	0	417
5	10/14/04	273	8	0	281
5	10/28/04	132	7	0	139
5	11/10/04	107	3	0	110
6	6/10/04	11	0	0	11
6	6/25/04	32	3	0	35
6	7/9/04	41	6	2	49
6	7/23/04	51	3	0	54
6	8/20/04	27	1	0	28
6	9/17/04	68	1	1	70
6	10/01/04	14	0	0	14
6	10/15/04	35	0	2	37
6	10/29/04	23	0	1	24
6	11/12/04	18	1	0	19
7	6/10/04	31	4	0	35
7	6/25/04	8	5	1	14
7	7/9/04	55	16	5	76
7	7/23/04	39	10	3	52
7	8/20/04	38	9	2	49
7	9/17/04	9	15	3	27
7	10/01/04	23	26	6	55

TABLE 18.—Counts of rainbow trout/steelhead observed on Battle Creek snorkel surveys in 2004. Totals only include reaches above the Colman National Fish Hatchery barrier weir (reaches 1-6).

Reach	May 6-14	May 25-27	June 7-10	June 22-25	July 6-9	July 20-23	Aug. 17-20	Sept. 14-17	Sept. 28-1	Oct. 12-15	Oct. 27-29	Nov. 8-12	Reach Average
1	485	714	94	454	496	689	938	731	779	750	102	284	543
2	431	373	516	502	719	547	453	867	413	350	119	367	471
3	79	243	480	254	284	339	368	382	491	305	96	210	294
4	32	221	385	485	489	620	344	573	477	503	279	445	404
5	20	76	141	219	360	339	73	189	417	281	139	110	197
6			11	35	49	54	28	70	14	37	24	19	34
7			35	14	76	52	49	27	55				44
Total (Reaches 1-6)	1047	1627	1627	1949	2397	2588	2204	2812	2591	2226	759	1435	

TABLE 19.—Number of days mean daily temperatures met Ward and Keir's (1999) suitability categories for spring Chinook holding from June 1 through September 30, 2004 at select monitoring sites in Battle Creek.

Site Name	Location	River Mile	No Data	Very Poor	Poor	Fair	Good
Eagle Canyon Dam	North Fork	5.3[a]	0	0	0	3	119
Wildcat Dam	North Fork	2.5[a]	29	0	0	32	61
Wildcat Road Bridge	North Fork	0.9[a]	0	0	3	89	30
Above confluence of forks	North Fork	0.05[a]	44	0	3	69	6
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	41	81
Manton Road Bridge	South Fork	1.7[a]	0	0	0	51	71
Above confluence of forks	South Fork	0.1[a]	24	0	6	65	27
Below confluence of forks	Mainstem	16.0[b]	0	0	13	85	24
Reach 4 Upper	Mainstem	15.9[b]	0	0	10	80	32
Reach 4 Lower	Mainstem	12.9[b]	0	0	39	64	19
Reach 5 Upper	Mainstem	12.2[b]	0	0	29	73	20
Reach 5 Lower	Mainstem	9.3[b]	0	0	50	58	14
Total			97	0	153	710	504

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

TABLE 20.—Estimated percent of days that spring Chinook egg incubation fell within water temperature suitability categories in Battle Creek in 2004. 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	0					
2	North Fork	24	0%	0%	0.1% (<1)	3.8% (4)	96.1% (98)
3	South Fork	4	0%	0%	0%	0.8% (1)	99.2% (119)
4	Mainstem	6	0%	0%	1.6% (2)	6.4% (7)	92.0% (96)
5	Mainstem	0					
6	Mainstem	0					
7	Mainstem	0					
Total		34	0%	0%	0.4% (<1)	3.9% (4)	95.7% (100)

TABLE 21.—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, 2004 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	1	46
Wildcat Dam	North Fork	2.5[a]	1	0	0	0	12	34
Wildcat Road Bridge	North Fork	0.9[a]	0	0	1	12	10	24
Above confluence of forks	North Fork	0.05[a]	16	0	0	1	10	20
Coleman Diversion Dam	South Fork	2.5[a]	0	0	0	1	5	41
Manton Road Bridge	South Fork	1.7[a]	0	0	0	5	17	25
Above confluence of forks	South Fork	0.1[a]	0	0	0	4	19	24
Below confluence of forks	Mainstem	16.0[b]	0	0	1	6	18	22
Reach 4 Upper	Mainstem	15.9[b]	0	0	2	11	13	21
Reach 4 Lower	Mainstem	12.9[b]	0	0	3	17	10	17
Reach 5 Upper	Mainstem	12.2[b]	0	0	2	16	10	19
Reach 5 Lower	Mainstem	9.3[b]	0	2	6	15	7	17
Totals			17	2	15	88	132	310

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

[b] From confluence with the Sacramento River

TABLE 22.—Number of rainbow trout/steelhead redds observed upstream of Coleman National Fish Hatchery barrier weir during winter steelhead redd surveys on Battle Creek from November 25, 2003 through April 8, 2004.

Date	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Week Totals
11/25/03				0	0		0
1/5/04-1/6/04	0		0	0	0	0	0
1/16/04-1/23/04	5	6	0	0	0	0	11
2/4/04		0		0	0		0
2/13/04				2	1	8	11
3/9/04-3/16/04			1			0	1
3/17/04-3/23/04				2	0	0	2
4/6/04-4/8/04	0	3	4				7
Total	5	9	5	4	1	8	32

Figures

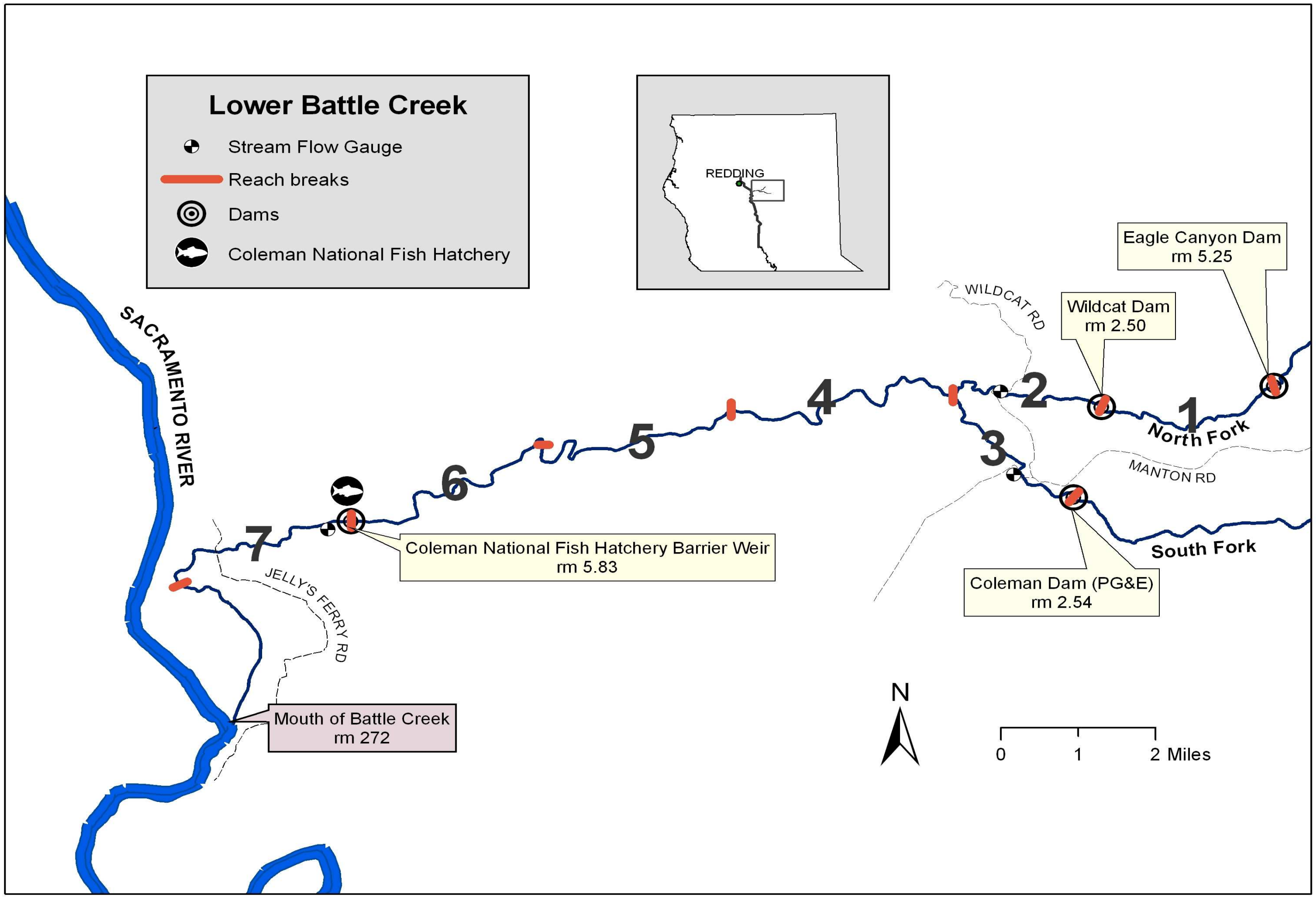

FIGURE 1.—Map of Battle Creek depicting the location of the Coleman National Fish Hatchery barrier weir and stream survey reaches for 2004.

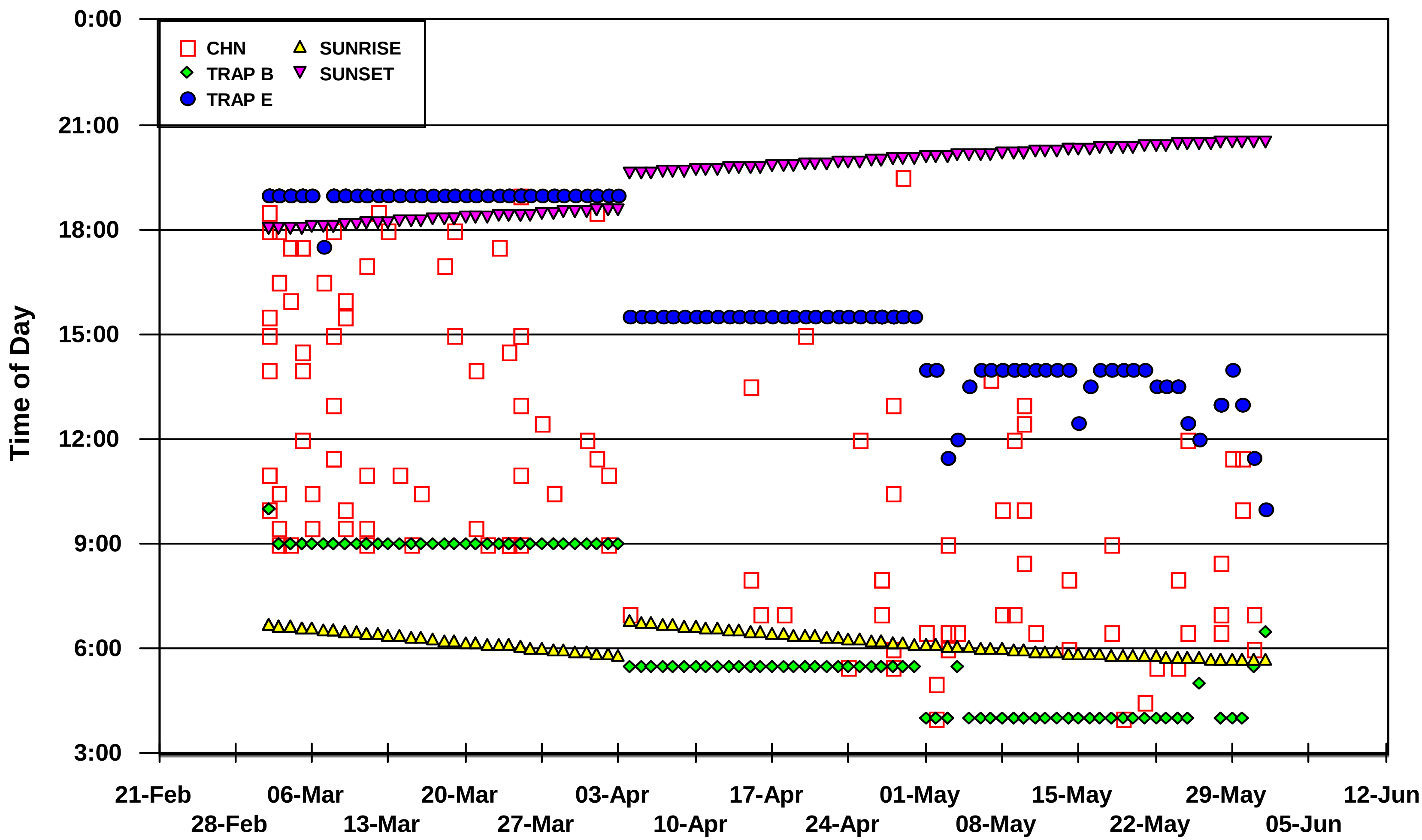

FIGURE 2.—Diel migration timing of Chinook (CHN) caught in the Coleman National Fish Hatchery barrier weir trap in 2004. Also included are times of sunrise, sunset, beginning of trap operation (Trap B), and end of trap operation (Trap E).

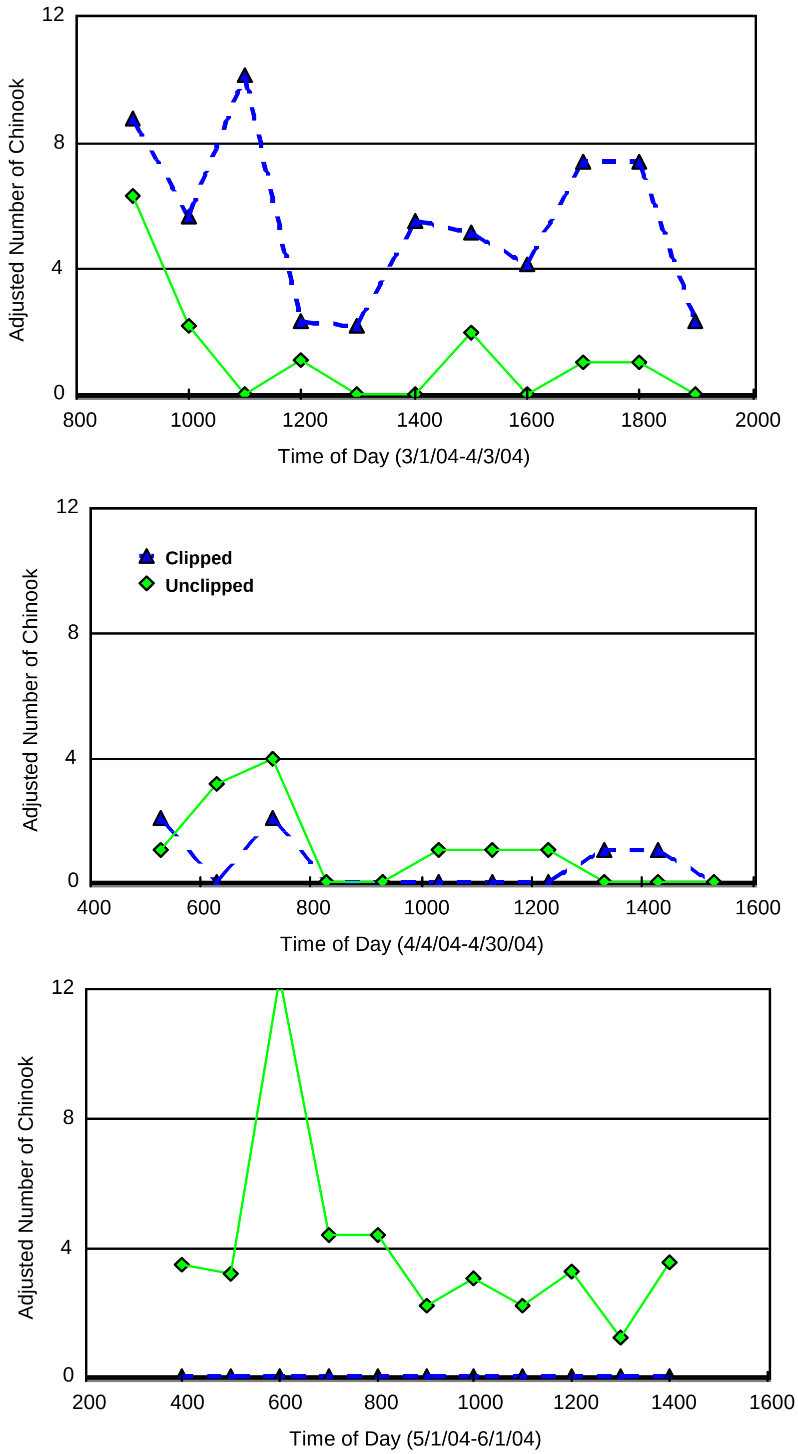

FIGURE 3.—Adjusted time-frequency distribution of Chinook caught in the Coleman National Fish Hatchery barrier weir trap in 2004. Three graphs represent three different start times. Start times were shifted to capture earlier passing Chinook. In addition, these earlier times coincided with lower water temperatures.

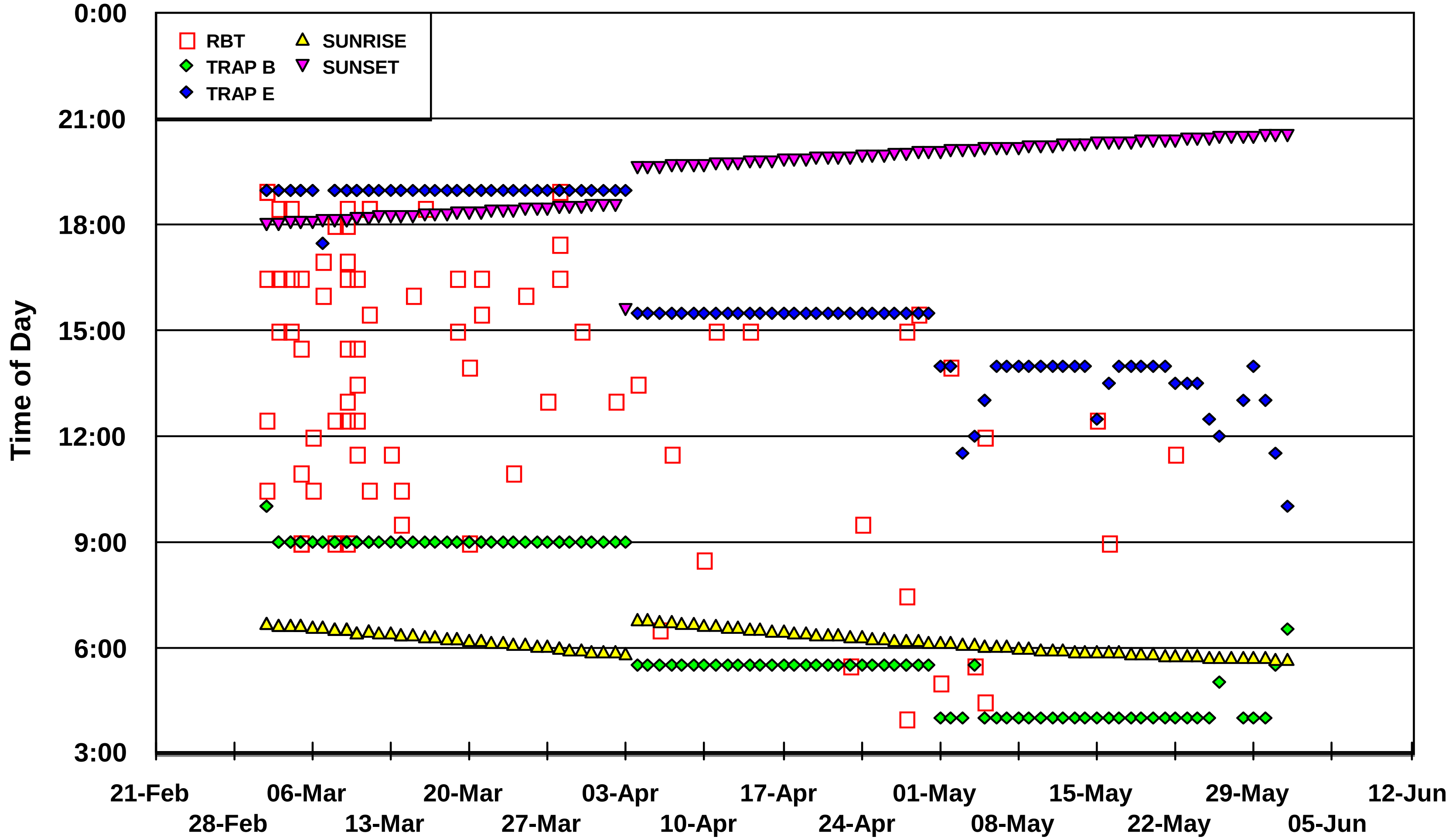

FIGURE 4.—Diel migration timing of rainbow trout/steelhead (RBT) caught in the Coleman National Fish Hatchery barrier weir trap in 2004. Also included are times of sunrise, sunset, beginning of trap operation (Trap B), and end of trap operation (Trap E).

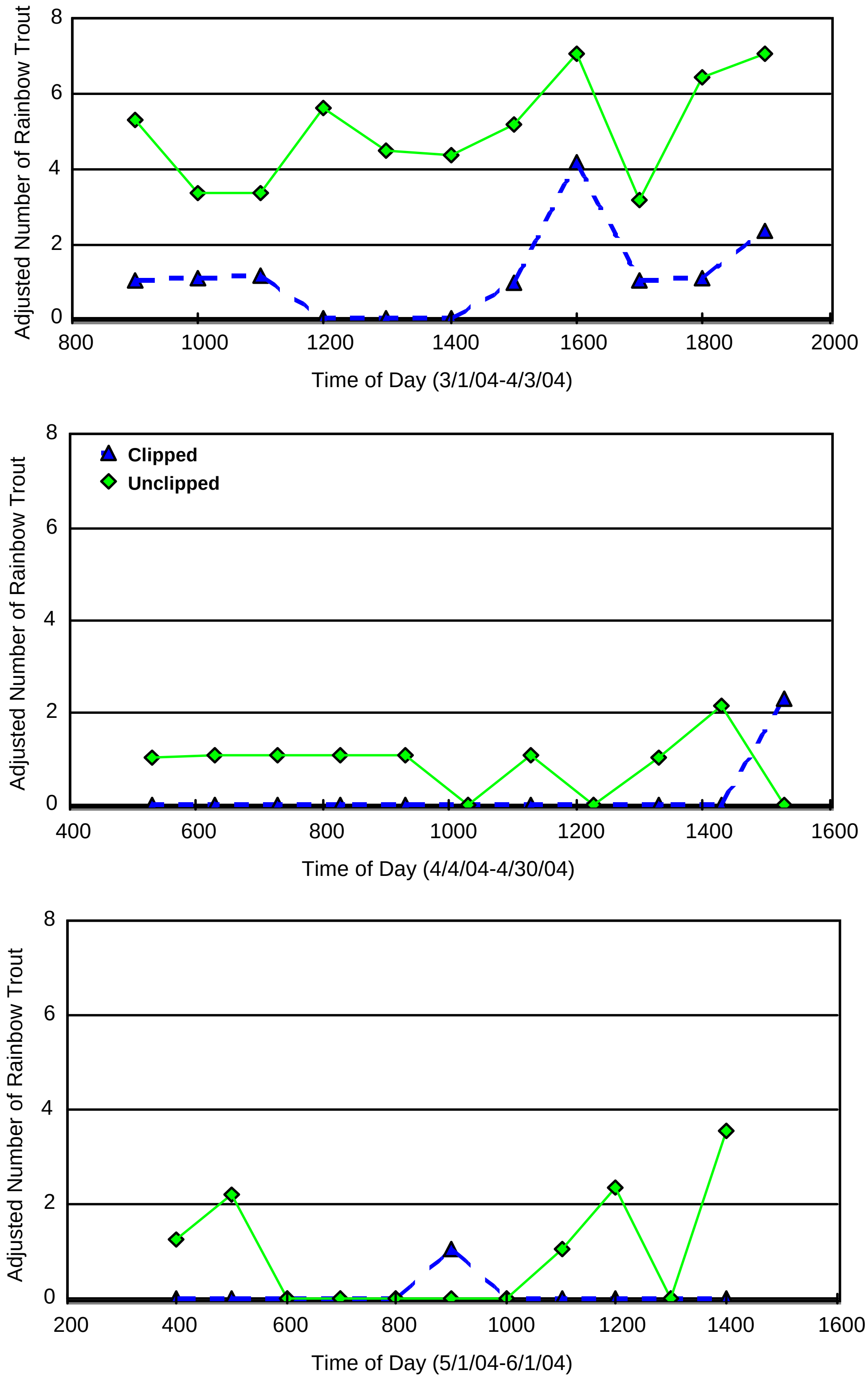

FIGURE 5.—Adjusted time-frequency distribution of rainbow trout/steelhead caught in the Coleman National Fish Hatchery barrier weir trap in 2004. Three graphs represent three different start times. These earlier times coincided with lower water temperatures.

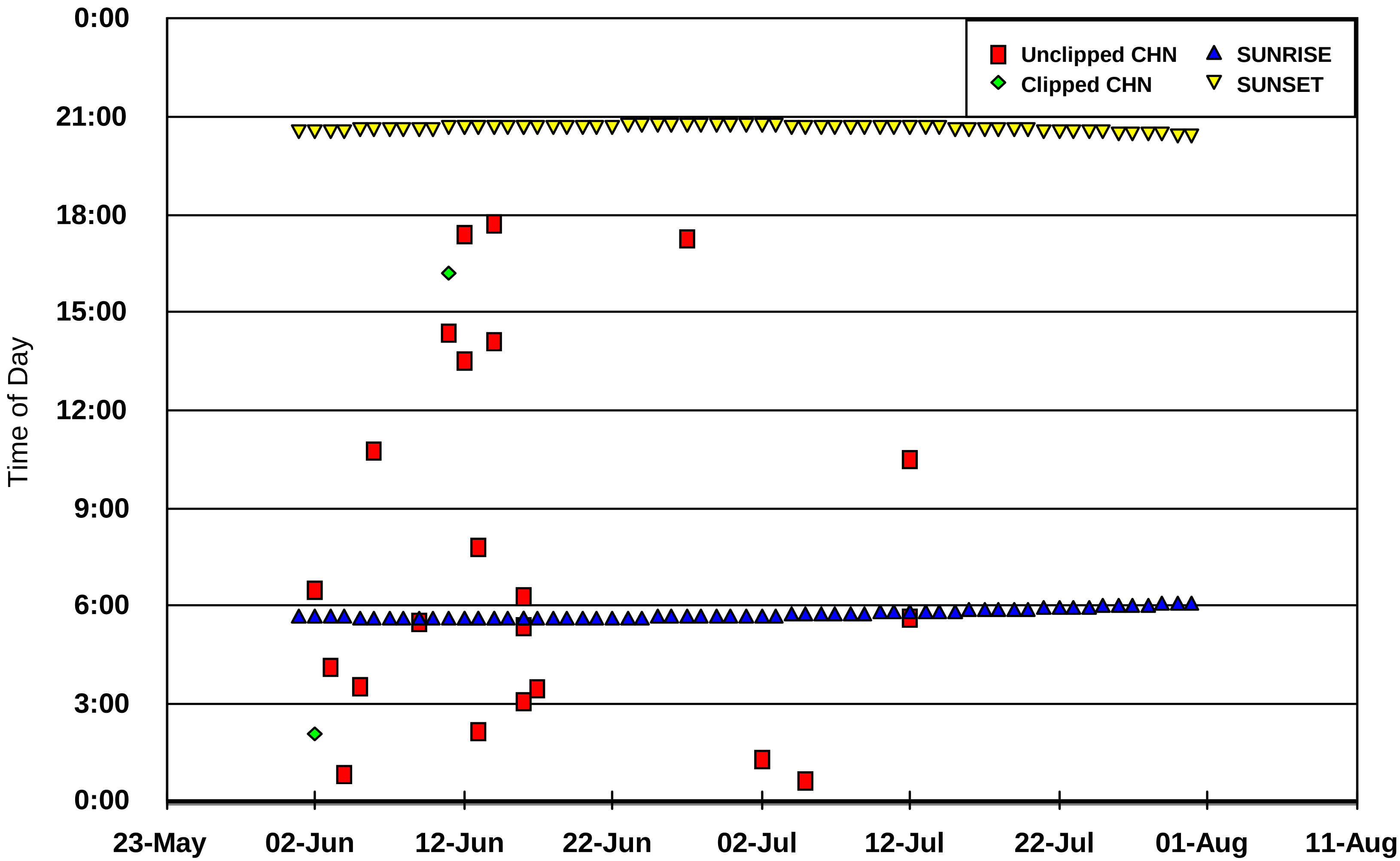

FIGURE 6.—Diel migration timing of Chinook (CHN) video taped passing the Coleman National Fish Hatchery barrier weir between June 1 and August 1, 2004.

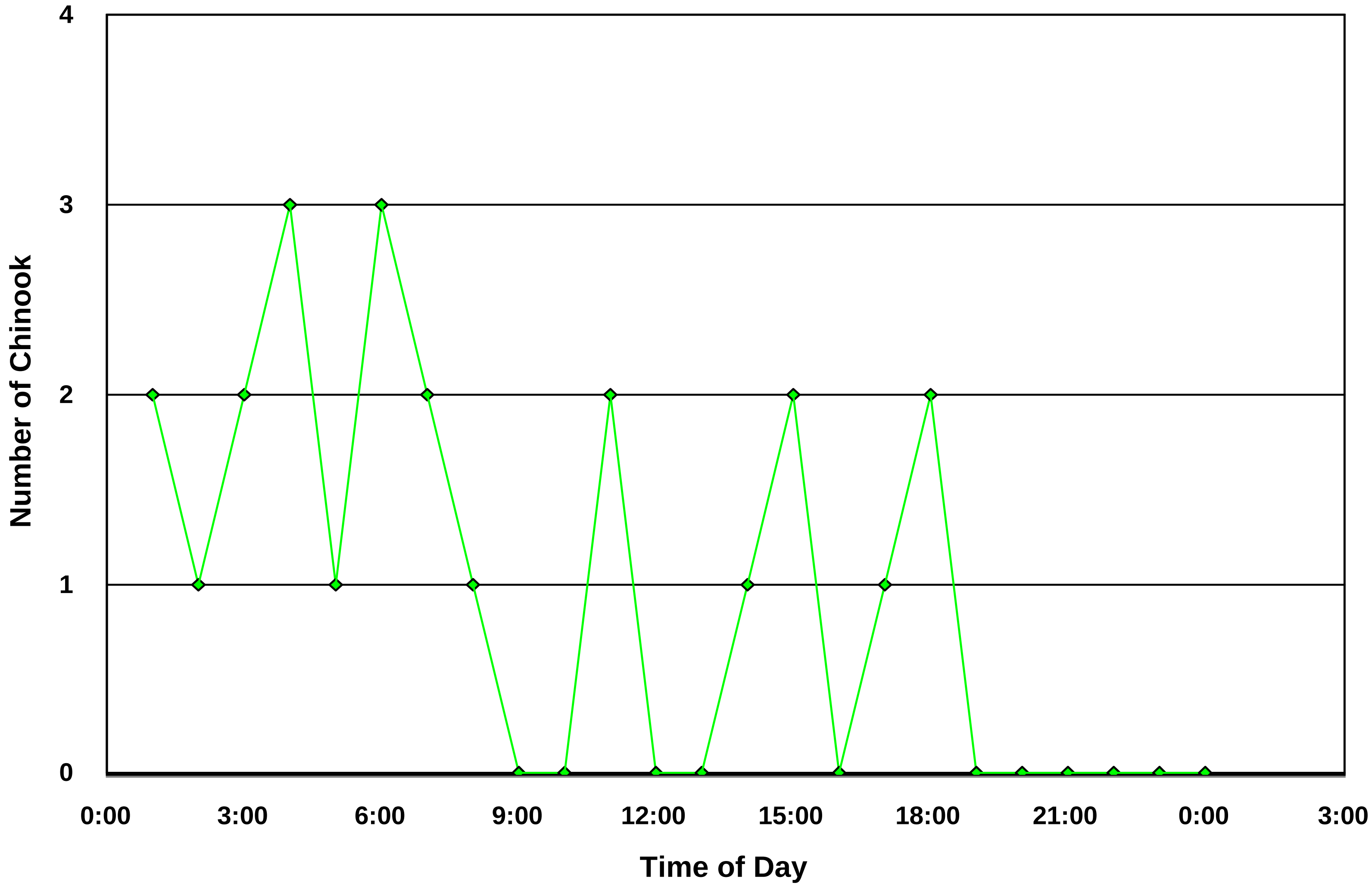

FIGURE 7.—Time-frequency distribution of Chinook video taped passing the Coleman National Fish Hatchery barrier weir between June 1 and August 1, 2004.

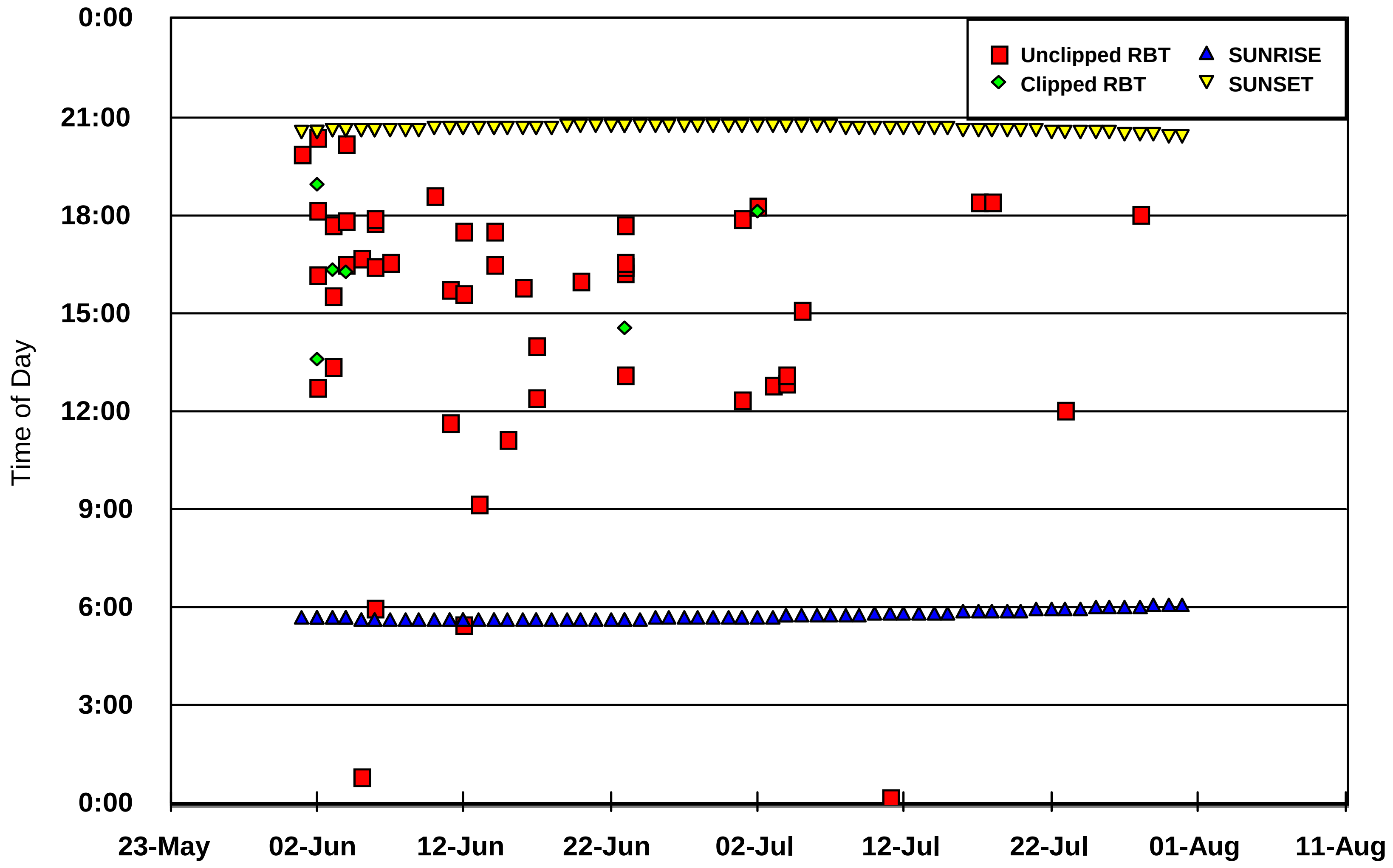

FIGURE 8.—Diel migration timing of rainbow trout/steelhead (RBT) video taped passing the Coleman National Fish Hatchery barrier weir between June 1 and August 1, 2004.

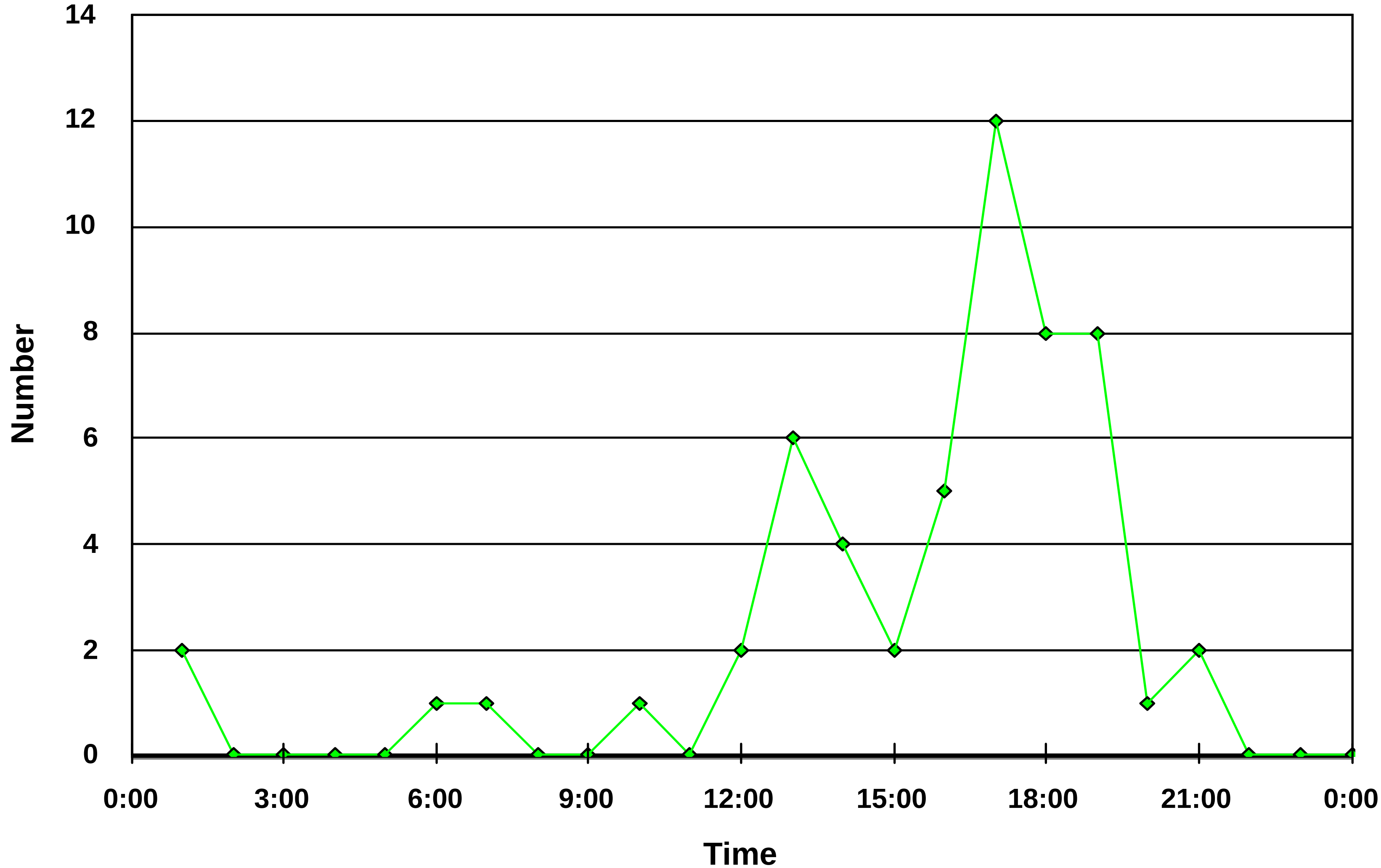

FIGURE 9.—Time-frequency distribution of rainbow trout/steelhead video taped passing the Coleman National Fish Hatchery barrier weir between June 1 and August 1, 2004.

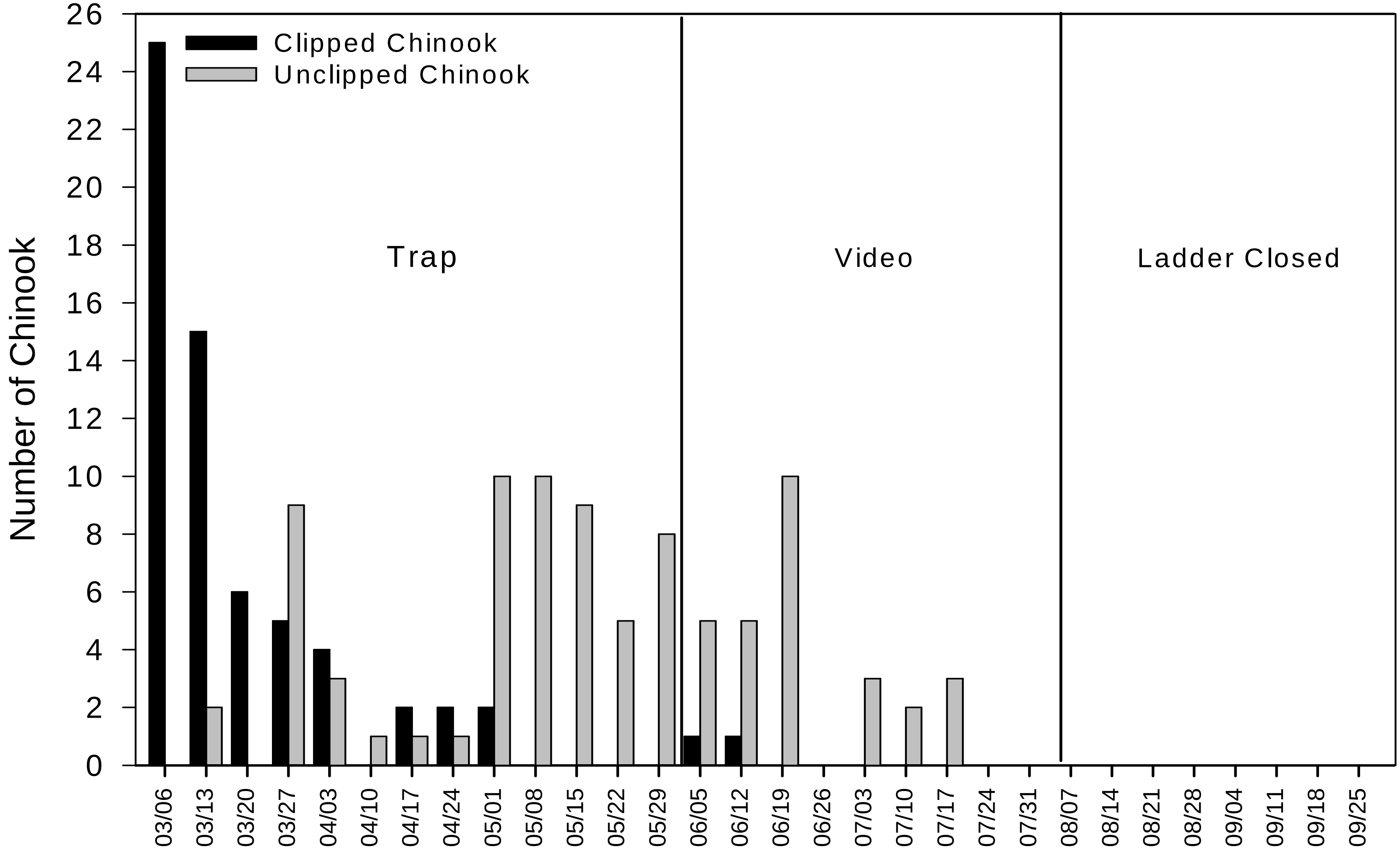

FIGURE 10.—Number of clipped and unclipped Chinook salmon observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2004, by week. Dates indicate the last day of the week.

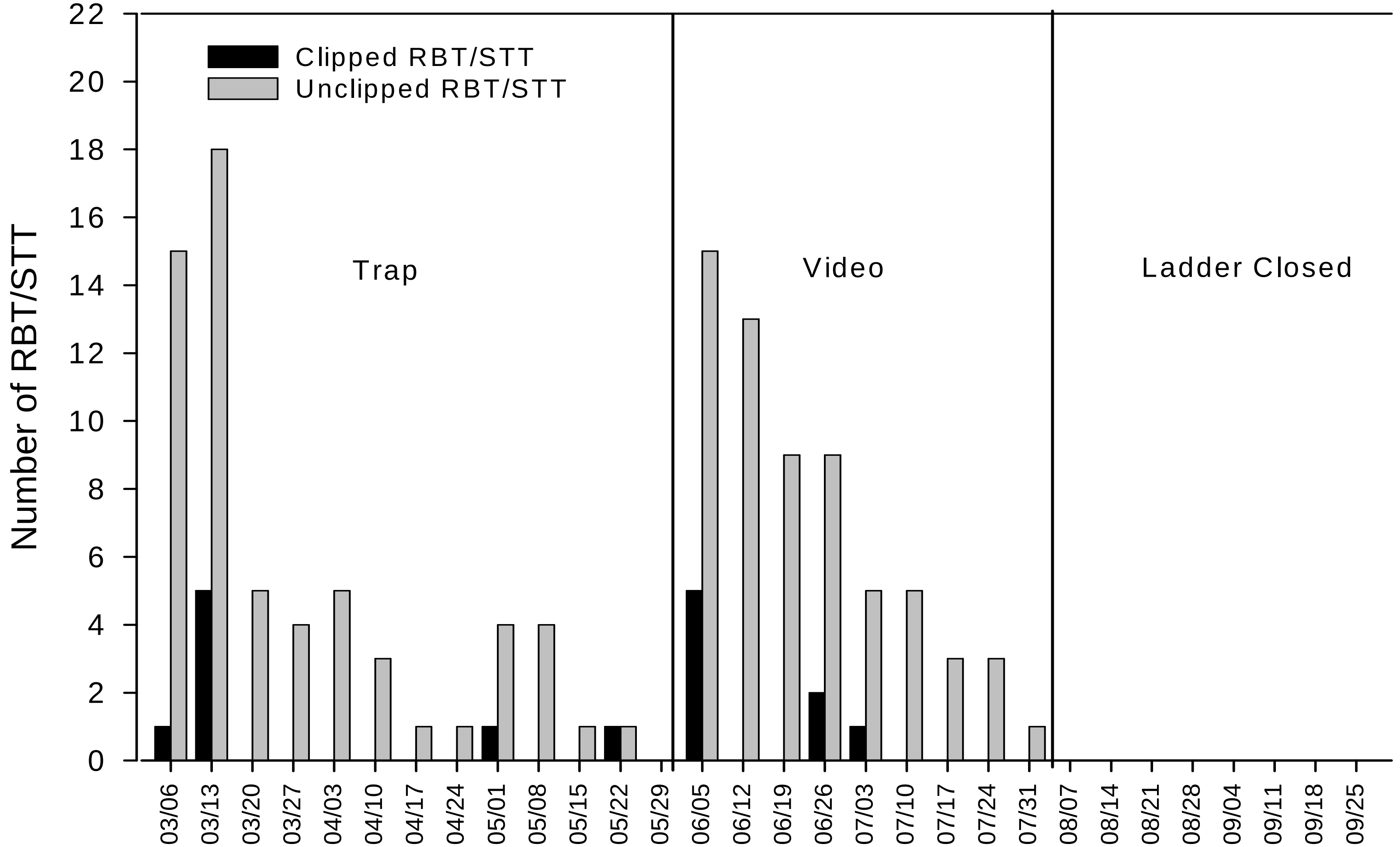

FIGURE 11.—Number of clipped and unclipped rainbow trout/steelhead (RBT/STT) observed at the Coleman National Fish Hatchery barrier weir fish ladder in 2004, by week. Dates indicate the last day of the week.

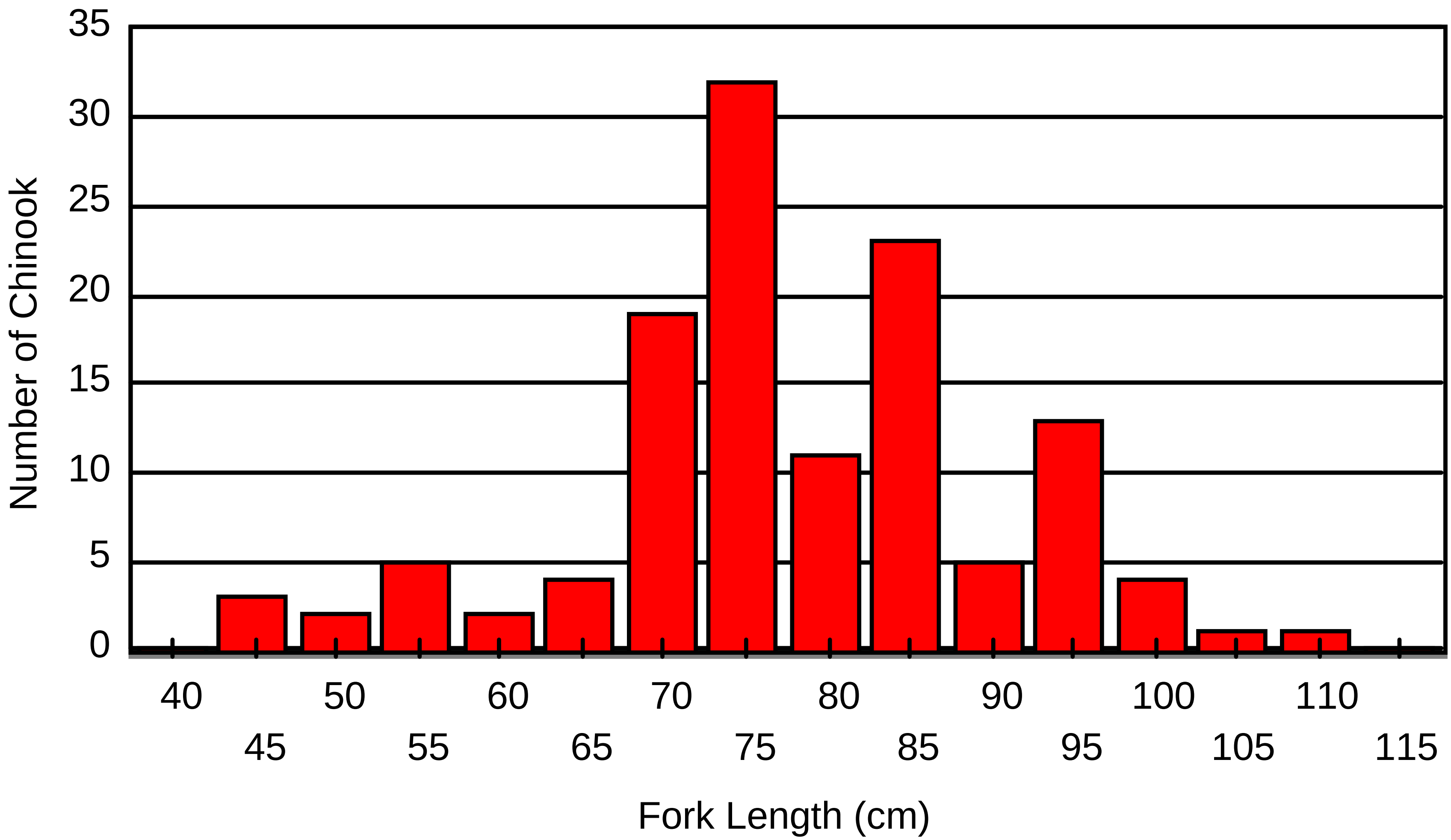

FIGURE 12.—Length-frequency distribution of Chinook captured in the Coleman National Fish Hatchery barrier weir fish trap in 2004. Fork length labels are the upper end of the size category.

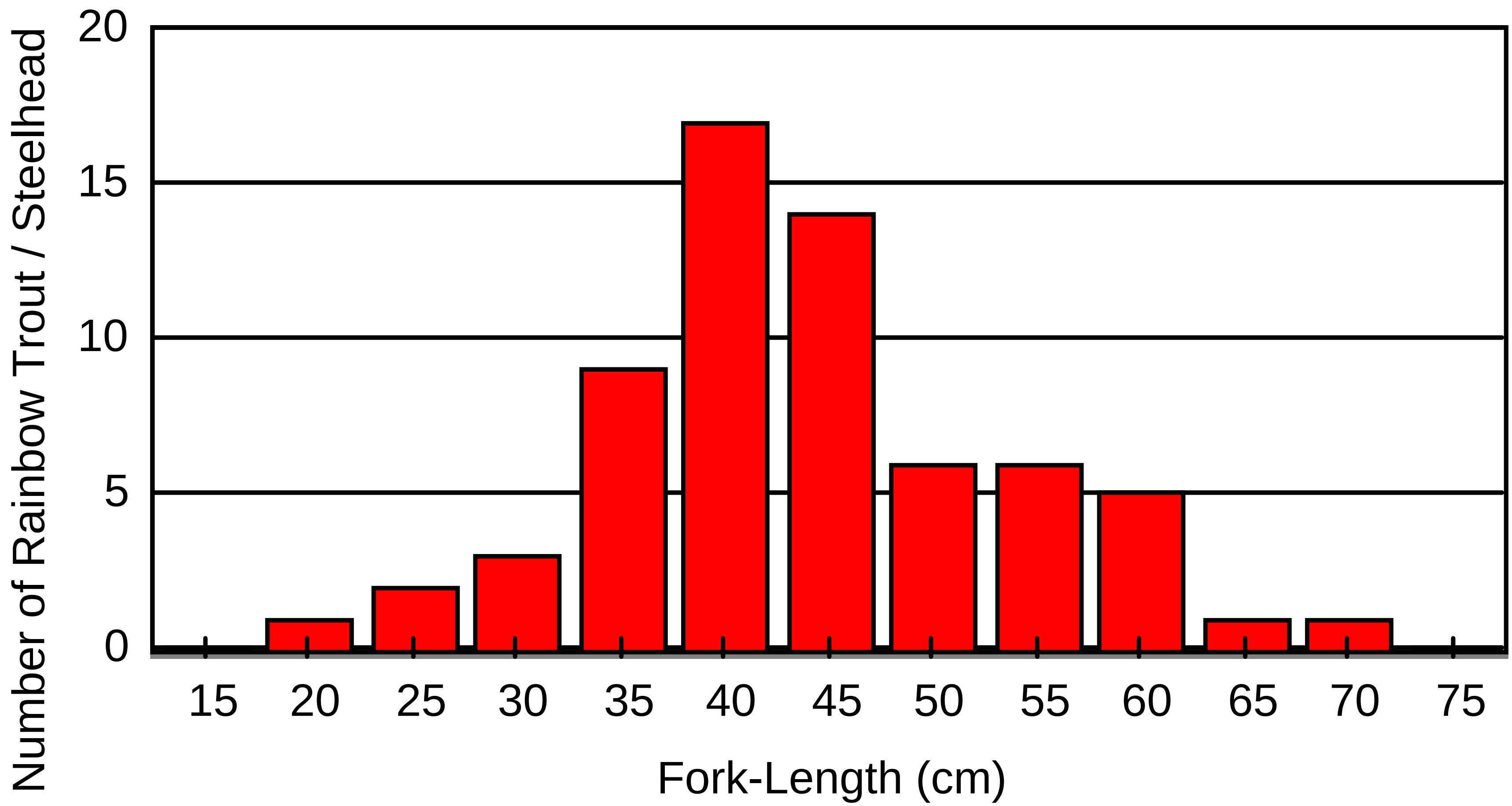

FIGURE 13.—Length-frequency distribution of rainbow trout/steelhead captured in the Coleman National Fish Hatchery barrier weir trap in 2004. Fork length labels are the upper end of the size category.

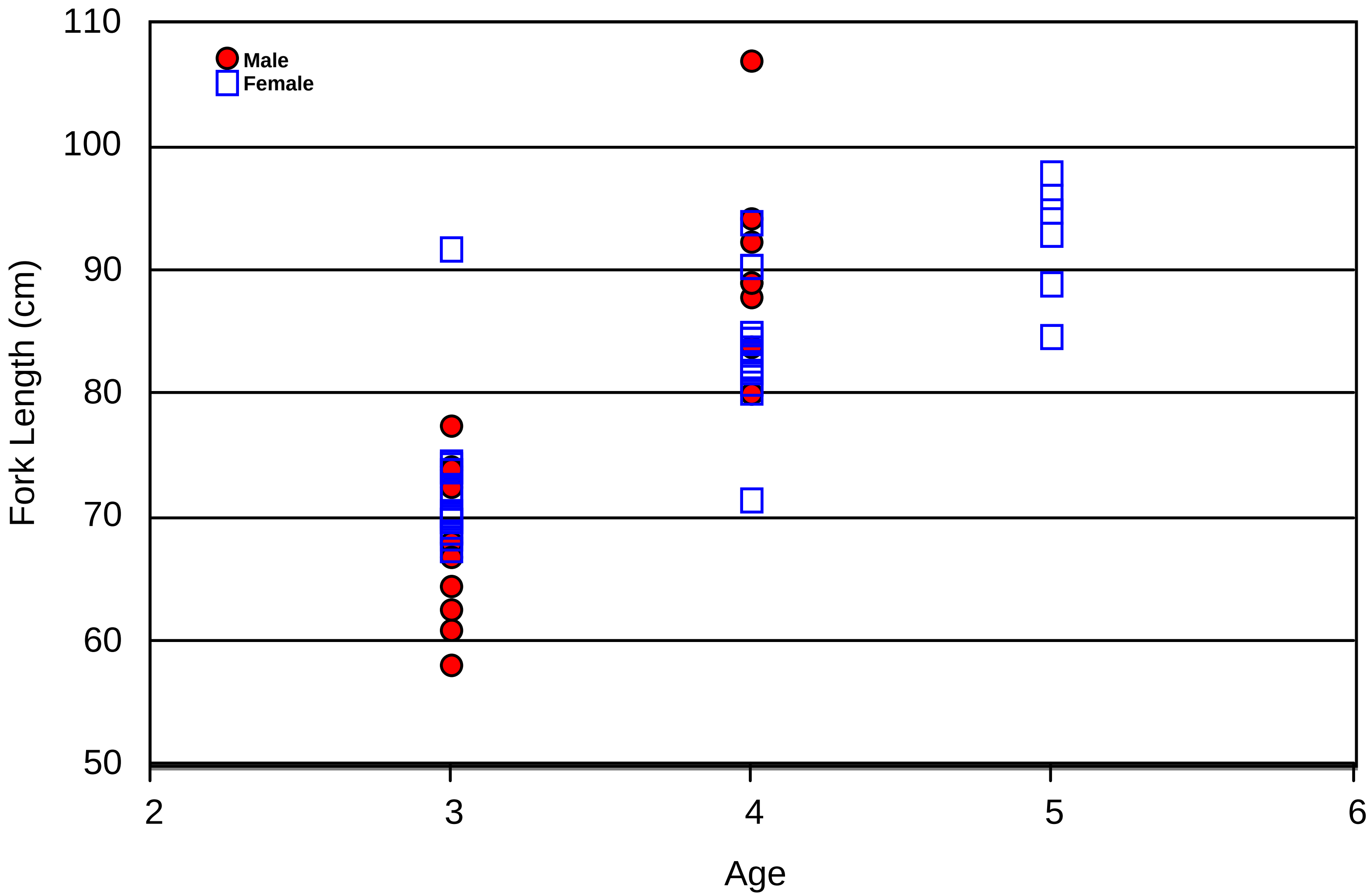

FIGURE 14.—Relationship between fork length and age for coded-wire tagged Chinook captured in the Coleman National Fish Hatchery barrier weir fish trap in 2004.

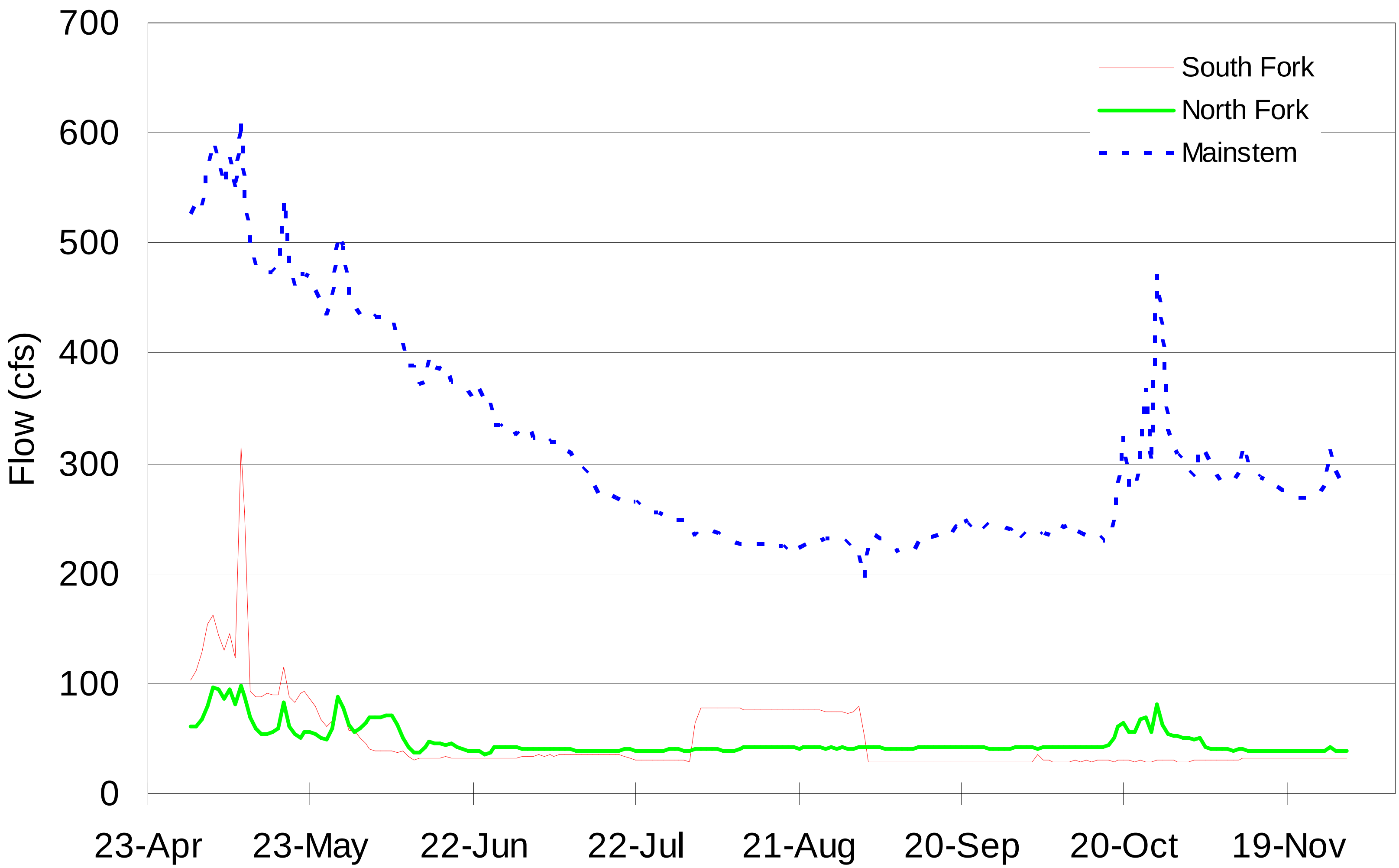

FIGURE 15.—Mean daily flows at the Coleman National Fish Hatchery barrier weir on the mainstem Battle Creek (rm 5.8), Wildcat Road Bridge on the North Fork (rm 0.9), and Manton Road Bridge on the South Fork (rm 1.7) in 2004.

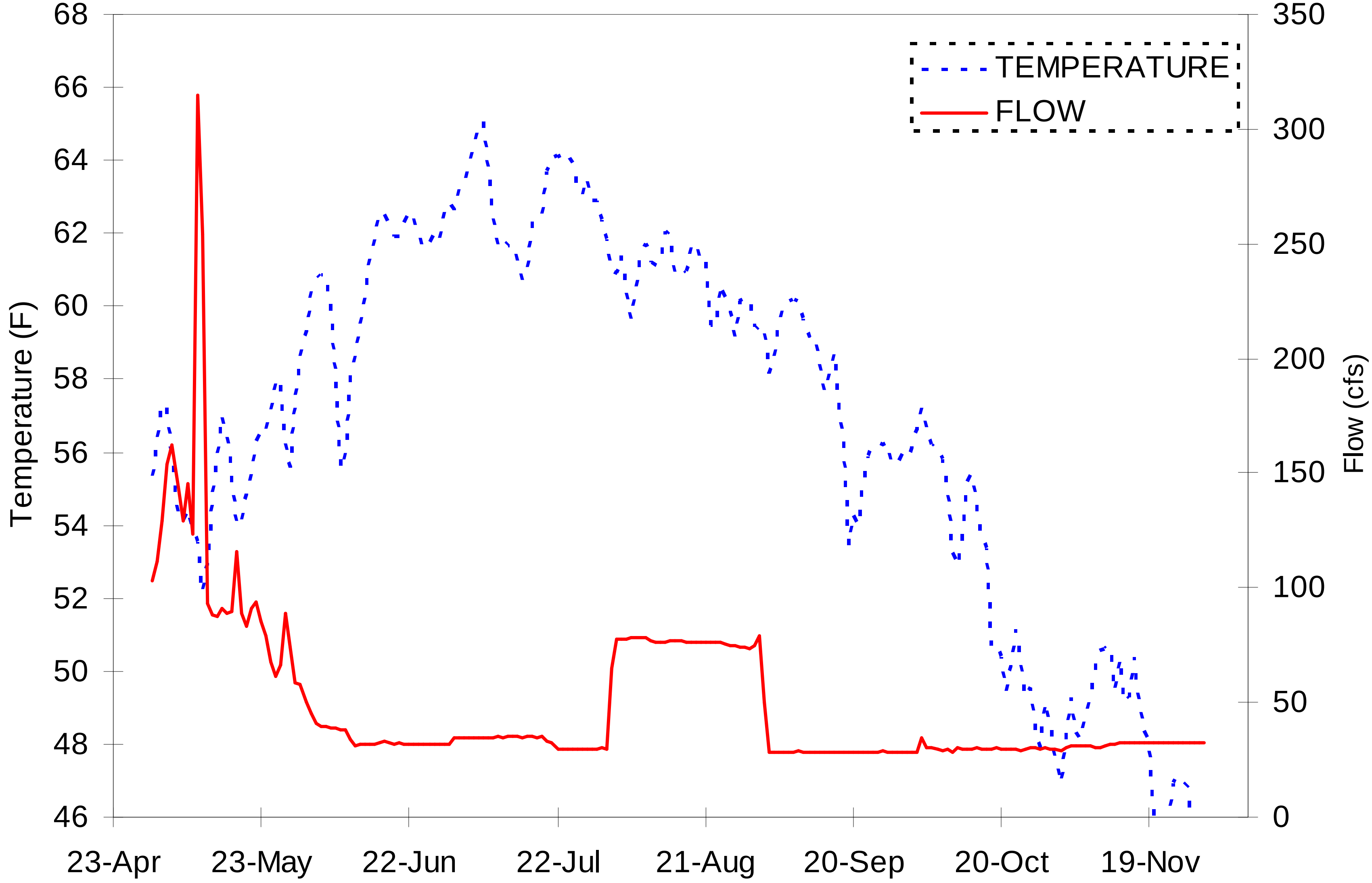

FIGURE 16.—South Fork Battle Creek Mean Daily Water Temperatures and Flows at Manton Road Bridge in 2004.

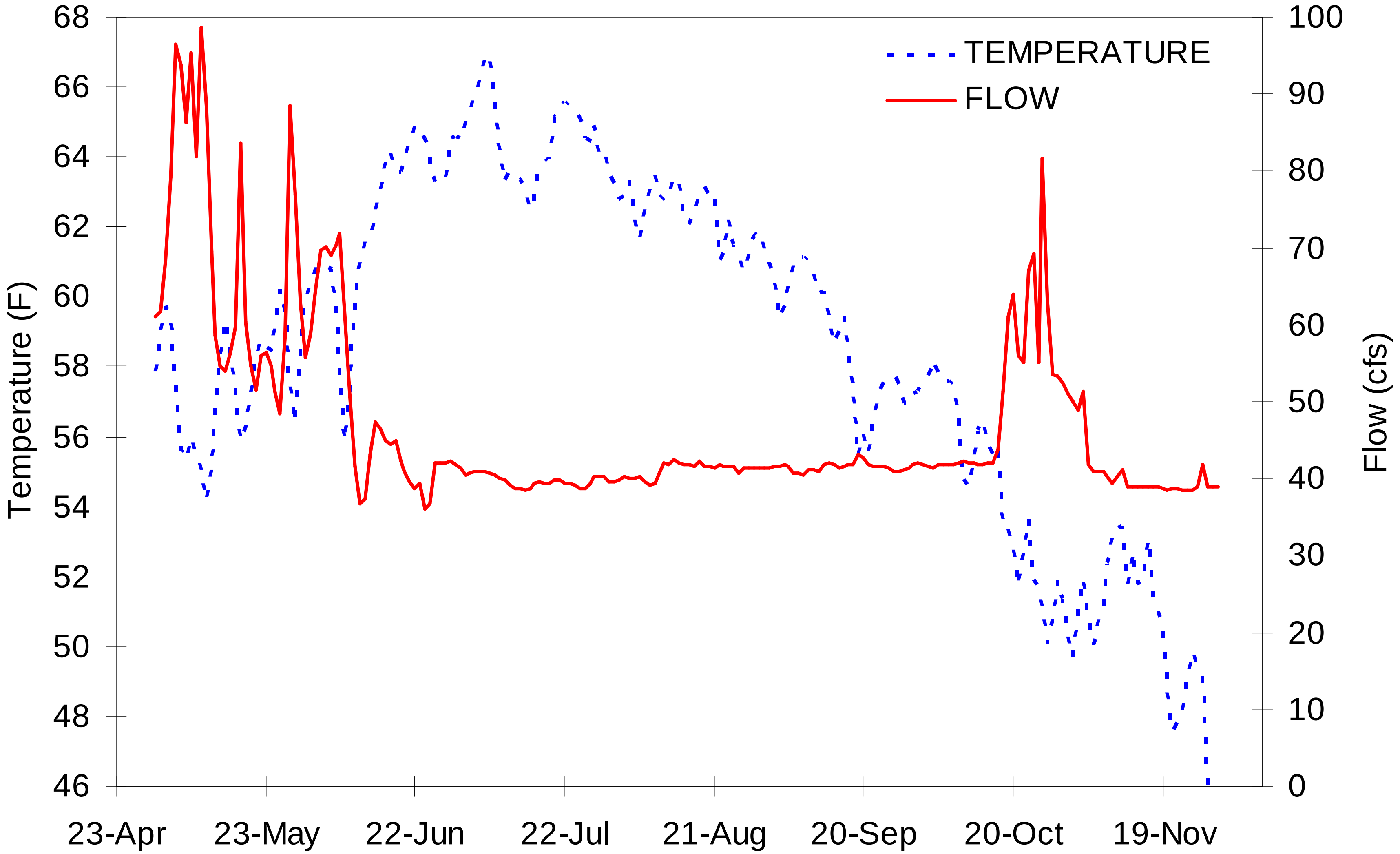

FIGURE 17.—North Fork Battle Creek Mean Daily Water Temperatures and Flows at Wildcat Road Bridge in 2004.

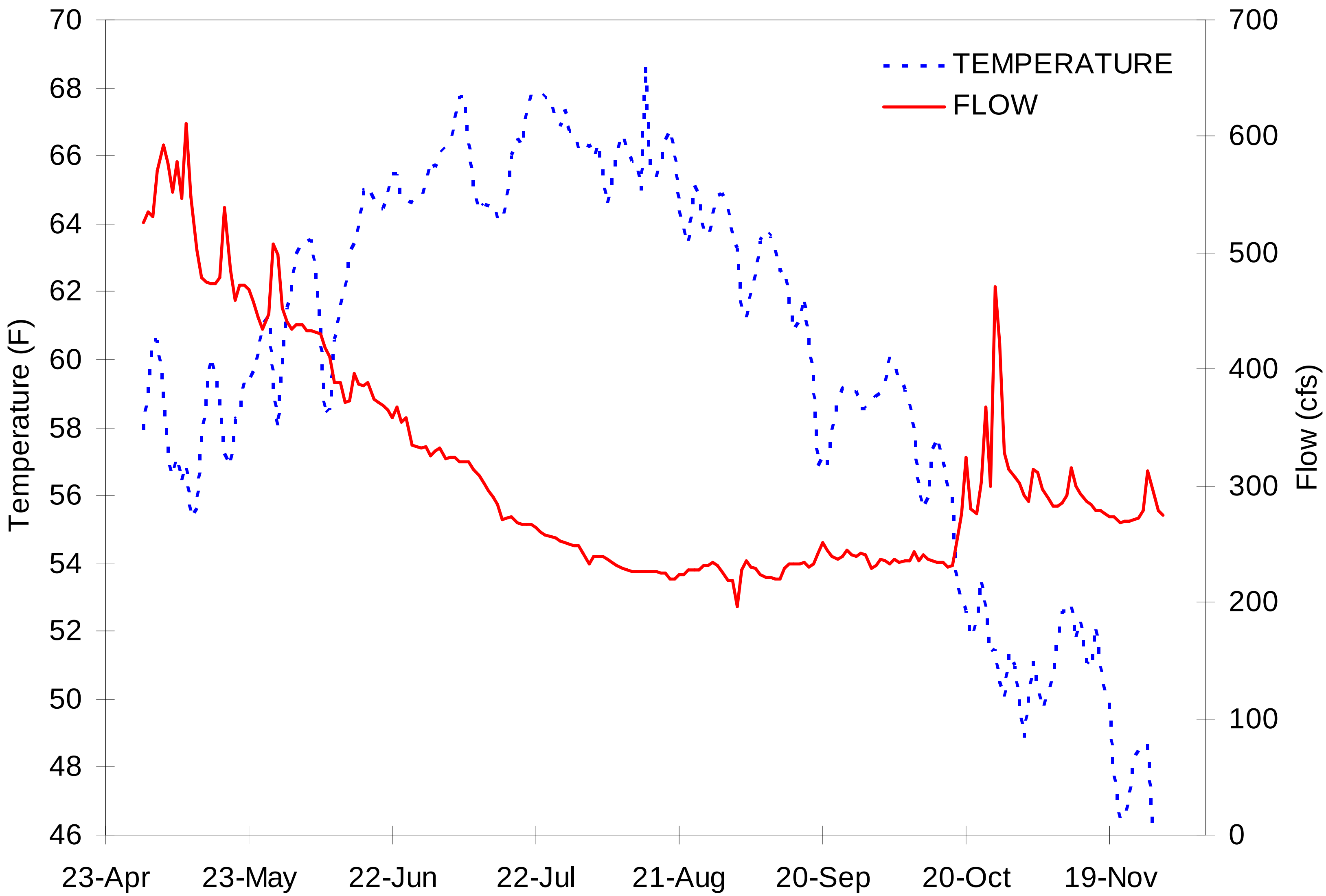

FIGURE 18.—Mainstem Battle Creek Mean Daily Water Temperatures and Flows at the Coleman National Fish Hatchery barrier weir in 2004.

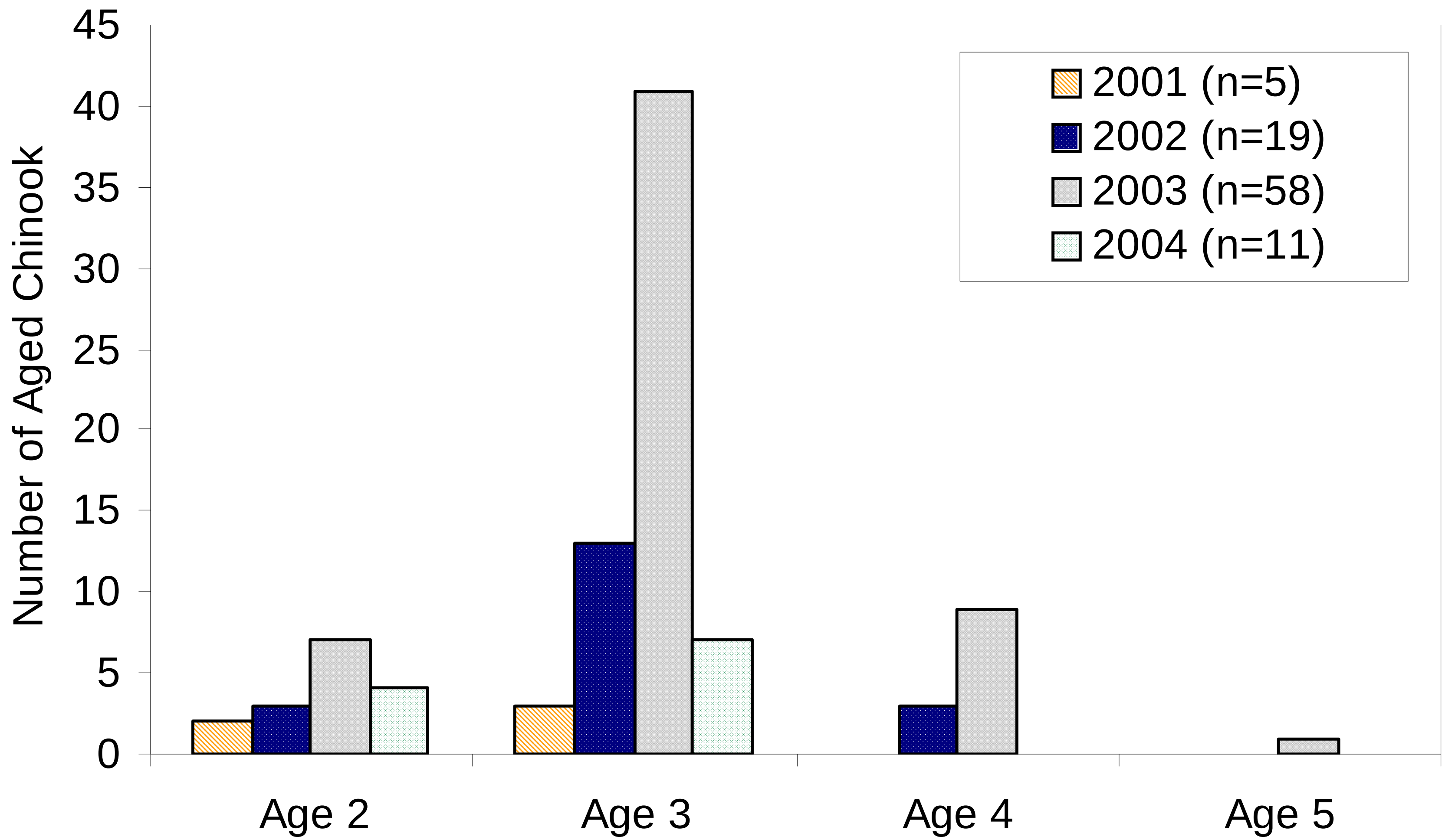

FIGURE 19.—Age determination of returning spring Chinook was done by reading scales collected from carcasses recovered upstream of the Coleman National Fish Hatchery barrier weir from 2001 through 2004.

Appendix

TABLE A.1.—Coded-wire tags recovered during Coleman National Fish Hatchery barrier weir trap monitoring in 2004. On 04/20/04 a coded-wire tagged wild spring Chinook from Butte Creek was captured in the trap.

Collection date	Collection location and method	Species	Sex	Fork length (in)	Tag code	Hatchery or creek of origin	Run	Brood year
03/02/04	Barrier Weir Trap	Chinook	Male	37.1	050469	CNFH	Late Fall	2000
03/02/04	Barrier Weir Trap	Chinook	Male	25.4	050774	CNFH	Late Fall	2001
03/02/04	Barrier Weir Trap	Chinook	Female	36.2	050774	CNFH	Late Fall	2001
03/02/04	Barrier Weir Trap	Chinook	Female	33.4	055209	CNFH	Late Fall	1999
03/02/04	Barrier Weir Trap	Chinook	Female	29.1	050764	CNFH	Late Fall	2001
03/02/04	Barrier Weir Trap	Chinook	Female	37.9	055210	CNFH	Late Fall	1999
03/02/04	Barrier Weir Trap	Chinook	Female	26.6	050764	CNFH	Late Fall	2001
03/02/04	Barrier Weir Trap	Chinook	Female	27.8	055135	CNFH	Late Fall	2001
03/03/04	Barrier Weir Trap	Chinook	Female	31.9	050466	CNFH	Late Fall	2000
03/03/04	Barrier Weir Trap	Chinook	Male	22.9	055135	CNFH	Late Fall	2001
03/03/04	Barrier Weir Trap	Chinook	Female	27.7	050772	CNFH	Late Fall	2001
03/03/04	Barrier Weir Trap	Chinook	Female	29.4	050773	CNFH	Late Fall	2001
03/03/04	Barrier Weir Trap	Chinook	Female	27.5	055135	CNFH	Late Fall	2001
03/04/04	Barrier Weir Trap	Chinook	Female	29.1	050773	CNFH	Late Fall	2001
03/04/04	Barrier Weir Trap	Chinook	Female	37.0	050397	CNFH	Late Fall	2000
03/04/04	Barrier Weir Trap	Chinook	Male	29.1	050766	CNFH	Late Fall	2001
03/04/04	Barrier Weir Trap	Chinook	Male	36.4	050470	CNFH	Late Fall	2000
03/05/04	Barrier Weir Trap	Chinook	Male	24.7	050774	CNFH	Late Fall	2001
03/05/04	Barrier Weir Trap	Chinook	Male	35.0	050470	CNFH	Late Fall	2000
03/05/04	Barrier Weir Trap	Chinook	Female	27.2	050766	CNFH	Late Fall	2001
03/05/04	Barrier Weir Trap	Chinook	Female	32.3	050469	CNFH	Late Fall	2000
03/05/04	Barrier Weir Trap	Chinook	Female	37.4	055213	CNFH	Late Fall	1999
03/05/04	Barrier Weir Trap	Chinook	Male	34.6	050470	CNFH	Late Fall	2000
03/06/04	Barrier Weir Trap	Chinook	Female	33.3	050398	CNFH	Late Fall	2000
03/06/04	Barrier Weir Trap	Chinook	Female	35.0	055209	CNFH	Late Fall	1999
03/07/04	Barrier Weir Trap	Chinook	Female	35.6	050466	CNFH	Late Fall	2000
03/08/04	Barrier Weir Trap	Chinook	Female	32.8	050468	CNFH	Late Fall	2000
03/08/04	Barrier Weir Trap	Chinook	Male	28.5	050766	CNFH	Late Fall	2001
03/08/04	Barrier Weir Trap	Chinook	Female	29.3	055135	CNFH	Late Fall	2001
03/08/04	Barrier Weir Trap	Chinook	Female	32.3	050470	CNFH	Late Fall	2000
03/08/04	Barrier Weir Trap	Chinook	Female	27.6	050770	CNFH	Late Fall	2001
03/09/04	Barrier Weir Trap	Chinook	Female	35.6	050465	CNFH	Late Fall	2000

TABLE A.1.—Continued

Collection date	Collection location and method	Species	Sex	Fork length (in)	Tag code	Hatchery or creek of origin	Run	Brood year
03/09/04	Barrier Weir Trap	Chinook	Female	36.6	055212	CNFH	Late Fall	1999
03/09/04	Barrier Weir Trap	Chinook	Female	28.5	050774	CNFH	Late Fall	2001
03/09/04	Barrier Weir Trap	Chinook	Female	38.6	055213	CNFH	Late Fall	1999
03/11/04	Barrier Weir Trap	Chinook	Female	27.0	055135	CNFH	Late Fall	2001
03/11/04	Barrier Weir Trap	Chinook	Male	26.4	050774	CNFH	Late Fall	2001
03/11/04	Barrier Weir Trap	Chinook	Female	29.1	NTD			
03/11/04	Barrier Weir Trap	Chinook	Female	33.0	050470	CNFH	Late Fall	2000
03/13/04	Barrier Weir Trap	Chinook	Female	33.3	050467	CNFH	Late Fall	2000
03/14/04	Barrier Weir Trap	Chinook	Female	27.2	050766	CNFH	Late Fall	2001
03/15/04	Barrier Weir Trap	Chinook	Female	33.5	050468	CNFH	Late Fall	2000
03/16/04	Barrier Weir Trap	Chinook	Male	31.5	050466	CNFH	Late Fall	2000
03/18/04	Barrier Weir Trap	Chinook	Male	26.8	055135	CNFH	Late Fall	2001
03/19/04	Barrier Weir Trap	Chinook	Female	33.5	050469	CNFH	Late Fall	2000
03/19/04	Barrier Weir Trap	Chinook	Male	35.0	050469	CNFH	Late Fall	2000
03/21/04	Barrier Weir Trap	Chinook	Male	51.0	050469	CNFH	Late Fall	2000
03/24/04	Barrier Weir Trap	Chinook	Female	31.7	050470	CNFH	Late Fall	2000
03/25/04	Barrier Weir Trap	Chinook	Female	32.4	050468	CNFH	Late Fall	2000
03/25/04	Barrier Weir Trap	Chinook	Male	29.3	050766	CNFH	Late Fall	2001
03/25/04	Barrier Weir Trap	Chinook	Female	33.1	050466	CNFH	Late Fall	2000
03/31/04	Barrier Weir Trap	Chinook	Female	27.7	050766	CNFH	Late Fall	2001
04/01/04	Barrier Weir Trap	Chinook	Male	24.0	050766	CNFH	Late Fall	2001
04/01/04	Barrier Weir Trap	Chinook	Male	33.1	050482	CNFH	Late Fall	2000
04/02/04	Barrier Weir Trap	Chinook	Female	32.5	050470	CNFH	Late Fall	2000
04/15/04	Barrier Weir Trap	Chinook	Male	30.5	050766	CNFH	Late Fall	2001
04/15/04	Barrier Weir Trap	Chinook	Female	28.2	050468	CNFH	Late Fall	2000
04/18/04	Barrier Weir Trap	Chinook	Male	31.5	050468	CNFH	Late Fall	2000
04/20/04	Barrier Weir Trap	Chinook	Female	27.6	0601000208	BUTTE	Spring	2001
04/28/04	Barrier Weir Trap	Chinook	Female	33.3	050470	CNFH	Late Fall	2000
04/28/04	Barrier Weir Trap	Chinook	Female	28.5	055135	CNFH	Late Fall	2001
05/16/04	Barrier Weir Trap	Rainbow Trout	Male	19.1	Lost Tag			

TABLE A.2.—Estimated number of days that egg incubation fell within the five water-temperature suitability categories for each spring Chinook redd in 2004. 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	Excellent	Total days
North Fork	2	2.27	9/29/2004	0	0	0	1	98	99
North Fork	2	2.20	9/29/2004	0	0	0	3	96	99
North Fork	2	1.52	9/29/2004	0	0	0	9	89	98
North Fork	2	1.52	9/29/2004	0	0	0	9	89	98
North Fork	2	1.52	9/29/2004	0	0	0	9	89	98
North Fork	2	1.49	9/29/2004	0	0	0	9	89	98
North Fork	2	1.40	9/29/2004	0	0	0	10	88	98
North Fork	2	1.35	9/29/2004	0	0	0	10	88	98
North Fork	2	1.15	9/29/2004	0	0	0	10	87	97
North Fork	2	0.47	9/29/2004	0	0	1	11	85	97
North Fork	2	0.17	9/29/2004	0	0	2	10	85	97
North Fork	2	2.25	9/29/2004	0	0	0	0	105	105
North Fork	2	1.92	10/13/2004	0	0	0	0	105	105
North Fork	2	1.90	10/13/2004	0	0	0	0	105	105
North Fork	2	1.73	10/13/2004	0	0	0	0	105	105
North Fork	2	1.73	10/13/2004	0	0	0	0	105	105
North Fork	2	1.73	10/13/2004	0	0	0	0	105	105
North Fork	2	1.66	10/13/2004	0	0	0	0	105	105
North Fork	2	1.01	10/13/2004	0	0	0	0	104	104
North Fork	2	1.01	10/13/2004	0	0	0	0	104	104
North Fork	2	1.01	10/13/2004	0	0	0	0	104	104
North Fork	2	1.00	10/13/2004	0	0	0	0	104	104
North Fork	2	0.61	10/13/2004	0	0	0	1	104	105
North Fork	2	0.54	10/13/2004	0	0	0	1	104	105
South Fork	3	2.19	9/29/2004	0	0	0	1	114	115
South Fork	3	1.93	9/29/2004	0	0	0	3	112	115
South Fork	3	2.11	10/13/2004	0	0	0	0	124	124
South Fork	3	1.92	11/3/2004	0	0	0	0	125	125
Mainstem	4	14.88	9/30/2004	0	0	2	10	96	108
Mainstem	4	14.88	9/30/2004	0	0	2	10	96	108
Mainstem	4	14.67	9/30/2004	0	0	3	9	95	107
Mainstem	4	14.43	9/30/2004	0	0	3	9	94	106
Mainstem	4	16.26	10/14/2004	0	0	0	1	97	98
Mainstem	4	16.26	10/14/2004	0	0	0	1	97	98

TABLE A.3.—Chinook redd measurements taken during USFWS Battle Creek snorkel surveys in 2004.

Date[a]	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
9/29/2004	2	10.33	10.67	86.57	2.00	2.33	0.83	1.12	1.3
9/29/2004	2	17.50	8.50	116.83	2.42	2.50	1.42	1.35	2.4
9/29/2004	2	14.00	8.67	95.29	1.29	1.75	0.75	1.35	1.2
9/29/2004	2	12.50	8.00	78.54	0.88	1.42	0.83	2.54	1.3
9/29/2004	2	12.92	11.33	114.97	1.42	1.67	0.75	0.61	1.3
9/29/2004	2	13.17	9.42	97.38	2.58	2.92	0.50	1.21	2.4
9/29/2004	2	18.17	11.00	156.95	1.67	1.92	0.33	1.31	2.4
9/29/2004	2	9.58	4.83	36.38	1.83	2.58	1.33	1.90	2.4
9/29/2004	2	16.25	9.83	125.50	1.58	1.83	0.25	1.47	1.3
9/29/2004	2	9.42	6.25	46.22	1.33	1.75	0.58	2.62	2.4
9/29/2004	3	8.04	8.25	52.11	1.25	1.29	0.75	0.92	1.3
9/29/2004	3	14.42	6.75	76.43	0.54	1.04	0.42	0.44	3.4
9/30/2004	4	15.00	4.67	54.98	1.50	2.00	1.42	3.10	1.3
9/30/2004	4	11.42	6.17	55.29	1.33	1.83	0.96	3.11	1.3
9/30/2004	4	13.00	6.75	68.92	2.00	2.17	1.08	2.63	2.4
9/30/2004	4	18.75	8.58	126.40	1.58	2.38	1.25	2.42	2.4
10/1/2004	7	20.00	8.92	140.06	1.00	1.17	0.13	2.15	1.3
10/1/2004	7	19.00	8.25	123.11	1.25	1.75	0.83	2.86	2.4
10/1/2004	7	20.75	12.33	201.00	1.33	1.92	0.67	2.36	1.3
10/13/2004	2	21.83	11.50	197.20	1.58	2.46	0.42	2.25	2.4
10/13/2004	2	8.58	4.42	29.77	1.50	2.08	1.25	2.07	1.3
10/13/2004	2	16.25	9.75	124.44	1.46	1.83	1.00	1.33	1.3
10/13/2004	2	10.42	9.50	77.72	1.33	1.88	0.75	1.83	1.3
10/13/2004	2	16.75	12.83	168.83	1.25	2.25	1.00	1.52	1.3
10/13/2004	2	9.83	3.75	28.96	1.17	2.00	1.00	2.51	1.3
10/13/2004	2	7.67	5.75	34.62	1.54	2.17	1.13	2.35	1.3
10/13/2004	2	12.08	5.08	48.24	2.00	2.33	1.42	1.85	1.2
10/13/2004	2	22.83	17.67	316.82	1.33	2.54	0.63	2.16	1.2
10/13/2004	2	8.58	4.25	28.65	1.50	2.00	0.92	1.62	1.2
10/13/2004	2	14.58	5.00	57.27	1.08	2.33	0.92	1.99	1.3
10/13/2004	2	27.92	10.33	226.57	1.42	2.00	1.08	1.77	1.2
10/13/2004	3	10.42	6.33	51.81	1.04	1.25	0.46	0.75	2.4
10/14/2004	4	9.17	9.33	67.20	1.50	1.92	1.33	1.69	2.4
10/14/2004	4	13.00	6.75	68.92	1.42	1.75	0.67	3.39	2.4
11/3/2004	3	10.92	6.17	52.87	1.08	1.17	0.58	1.34	1.3
Average		14.14	8.22	98.08	1.46	1.95	0.85	1.88	1.3[b]
Minimum		7.67	3.75	28.65	0.54	1.04	0.13	0.44	1.2
Maximum		27.92	17.67	316.82	2.58	2.92	1.42	3.39	3.4

[a] There were two redds (9/19/2004 and 10/13/2004) that were not measured.

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

TABLE A.4.—Rainbow trout/steelhead redd measurements taken during USFWS winter steelhead redd surveys on Battle Creek from November 25, 2003 through April 8, 2004.

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
1/16/2004[a]	6	5.00	3.08	12.11	1.00	1.58	0.67	0.86	1.2
1/21/2004	1	7.42	8.00	46.60	1.42	1.42	0.42	1.08	1.2
1/21/2004	1	3.75	6.42	18.90	1.17	1.08	0.50	1.10	2.3
1/21/2004	1	5.25	3.75	15.46	1.25	1.42	0.50	1.75	1
1/21/2004	1	5.00	5.08	19.96	1.92	2.00	1.25	1.38	1
1/22/2004	2	11.17	5.75	50.43	0.92	1.33	0.58	0.88	1
1/22/2004	2	9.75	4.92	37.65	1.08	1.25	0.58	0.80	1.3
1/22/2004	2	5.25	2.83	11.68	0.67	1.08	0.42	0.95	1.2
1/22/2004	2	4.33	3.00	10.21	1.58	1.92	0.92	0.98	1.3
1/23/2004	2	8.08	5.25	33.33	1.33	1.67	0.67	1.22	1.2
1/23/2004	2	9.75	5.17	39.56	0.75	1.42	0.50	2.99	2.3
2/13/2004	4	4.17	1.58	5.18	1.00	1.58	0.92	1.70	2.4
2/13/2004	4	10.00	4.00	31.42	1.08	1.33	0.83	2.39	1.2
2/13/2004	5	9.33	4.50	32.99	0.50	0.83	0.33	1.17	1.3
3/23/2004	4	7.17	4.00	22.51	2.00	2.50	1.83	2.92	1.2
Average		*7.17*	4.59	26.85	1.19	1.49	0.73	1.52	1.2[b]
Minimum		*3.75*	*1.58*	*5.18*	*0.50*	*0.83*	*0.33*	*0.80*	*1*
Maximum		*11.17*	*8.00*	*50.43*	2.00	*2.50*	*1.83*	*2.99*	*2.4*

[a] Unknown species. Not included in average.
[b] The median substrate code was used instead of an average.