Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from March through November 2002

USFWS Report

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Abstract.—We estimate that zero adipose-fin clipped (clipped) and 222 unclipped Chinook (*Oncorhynchus tshawytscha*) passed through the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder into upper Battle Creek between March 1 and August 30, 2002. It is difficult to precisely apportion these fish to individual runs of Chinook because of overlaps in migration timing between runs. However, based on a combination of information from migration timing, coded-wire tag recoveries, and genetic analyses, the following estimates were made: 33 were late-fall Chinook, 3 were winter Chinook, 144 were spring Chinook, and 42 were fall Chinook. We believe relatively few fall Chinook were able to jump over the barrier weir and avoid detection at the fish ladder monitoring station, due to low flows in 2002. Low flows probably made jumping the weir more difficult and salmonids would have likely taken the easier route through the open fish ladder. These passage estimates were made while the fish ladder into Battle Creek was open which included almost the entire spring Chinook migration period, but did not include the entire migration period for winter, fall, and late-fall Chinook. When the fish ladder into Battle Creek was closed, an unknown number of salmonids may have jumped the barrier weir. Therefore estimates of winter, fall, and late-fall Chinook may be partial counts of salmon entering the watershed above the barrier weir. An additional 216 unclipped Chinook were passed above the barrier weir prior to March 1 by CNFH personnel during their late-fall Chinook propagation program. While these 216 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 (78 total redds), we estimate a spawning population of 156 spring and fall Chinook.

Overall, water temperatures in 2002 were adequate for spring Chinook to successfully produce juveniles but was likely at a reduced number due to temperature-related spawner and egg mortality. During holding periods, all Chinook that we observed were subjected to water temperatures which could result in some mortality and reduced fertility. Some incubating Chinook eggs experienced high water temperatures in the South Fork, upper mainstem Battle Creek, and potentially in the North Fork. Spring Chinook appeared to delay spawning until temperatures were more suitable.

We estimate that 1,442 clipped and 593 unclipped rainbow trout (*O. mykiss*) passed above the CNFH barrier weir in 2002 for a total of 2,035 rainbow trout. Of these, we estimate that 1,428 clipped, and 410 unclipped rainbow trout were passed by the hatchery prior to March 1, during 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 (*O. mykiss*). The geographic range of the current winter Chinook ESU is limited to a small area in the mainstem of the Sacramento River between the Keswick Dam and Red Bluff, Ca., 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 run Chinook and steelhead 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. 2001).

From 1995 until 2001, the CVPIA Water Acquisition Program contracted with PG&E to increase minimum stream flow in the lower reaches of the North Fork of Battle Creek (North Fork) and South Fork of Battle Creek (South Fork). This initial flow augmentation project provided flows between 25 and 35 cfs below Eagle Canyon Dam on the North Fork and below Coleman Diversion Dam on the South Fork.

The federal and State of California interagency program known as the CALFED Bay-Delta Program (CALFED), along with PG&E, has funded the Battle Creek Salmon and Steelhead Restoration Project (Restoration Project). The Restoration Project may result in large increases in minimum instream flows in Battle Creek, removal of 5 dams, and construction of fish ladders and fish screens at 3 other dams.

Planning, designing, and permitting of the Restoration Project has taken longer than originally anticipated. Funds for increased minimum flows in Battle Creek from the CVPIA Water Acquisition Program ran out in 2001. Therefore, in 2001, CALFED funded the Battle Creek Interim Flow Project to purchase 30 cfs from PG&E for use in the North Fork downstream of Eagle Canyon Dam. These CALFED funded flows began in 2001 and will continue until the Restoration Project construction begins (currently scheduled for 2004). The intent of the Interim Flow Project is to provide immediate habitat improvement in the lower reaches of Battle Creek to sustain current natural populations while implementation of the more comprehensive Restoration Project moves forward.

PG&E currently has a requirement under its Federal Energy Regulatory Commission license to provide minimum instream flows of 3 cfs downstream of diversions on the North Fork and 5 cfs downstream of diversions on the South Fork. Under the Interim Flow Project, PG&E would increase instream flows up to 30 cfs through reductions in their hydropower diversions from May through October. The interim project was funded to provide 30 cfs in the North Fork, with no funds available for additional flows on the South Fork, however an agreement was reached which allows for changing flows on either of the forks based on environmental conditions. Relevant environmental conditions include water temperatures, numbers and locations of live Chinook and redds. In 2001, increased flows were provided only on the North Fork in part based on observations of higher Chinook spawning on the North Fork than on the South Fork. For instance, redd counts from 1995 to1998 indicated that 39% of Chinook spawning occurred in the North Fork versus 23% in the South Fork (RBFWO. unpublished data).

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 2002 by the Red Bluff Fish and Wildlife Office (RBFWO) under a three-year contract from the CALFED Bay Delta Program. This grant was designed to support most of the monitoring needs of the Restoration Project Adaptive Management Plan.

Between 1995 and 2000, the RBFWO Hatchery Evaluation Program performed similar fisheries investigations that studied the effects of the Fish and Wildlife Service winter Chinook propagation program that was formerly located at Coleman National Fish Hatchery (CNFH) on Battle Creek. The RBFWO intends on reporting not only the results of adult salmonid monitoring efforts from 1995 to the present, but also the results of juvenile salmonid monitoring efforts from 1998 to the present. The interpretation of the accumulated adult and juvenile monitoring data is beyond the scope of this one-year report.

In 2002, the Interim Flow Project increased flows on the South Fork from 5 cfs to 10 cfs on June 27, and from 10 cfs to 25 cfs on October 21. North Fork flows were decreased from 30 to 25 cfs on June 27.

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 specific areas of study (Figure 1) were at the Coleman National Fish Hatchery (CNFH) barrier weir on the mainstem Battle Creek (rm 5.8) and on 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). Eagle Canyon Dam (on the North Fork) and Coleman Diversion Dam (on the South Fork) were considered the upstream limits of salmonid distribution during the study because fish ladders on the dams were closed.

Methods

We used the CNFH barrier weir fish trap and video counts along with stream surveys to monitor adult salmonids in Battle Creek between March 1 and November 15, 2002. Chinook salmon and steelhead returning to Battle Creek were identified as either having an adipose fin (unclipped) or not having an adipose fin (clipped). We considered all clipped Chinook and rainbow trout to be hatchery-origin and unclipped Chinook to be either natural 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, unclipped Chinook could also be late-fall, winter, or fall run due to overlapping periods of migration. Therefore, we chose not to explicitly classify all unclipped Chinook as spring run. We use the term "rainbow trout" to refer to all *Oncorhynchus mykiss*, including anadromous steelhead, due to the difficulties in visually differentiating the anadromous and non-anadromous forms in the field.

Coleman National Fish Hatchery Barrier Weir

The CNFH barrier weir (the barrier weir) blocked upstream passage of fish through the fish ladder (rm 5.8) from September 1, 2001 through March 1, 2002. During this period, fish were directed into holding ponds at CNFH, to collect fall and late-fall Chinook and steelhead broodstock for the propagation programs. Passage of fishes upstream of the barrier weir in Battle Creek was afforded from March 1 through August 30, 2002 by opening the fish ladder. Fish passage was monitored using live trapping until May 27 followed by underwater videography until August 30.

Trapping.—A false bottom fish trap was used to capture Chinook, rainbow trout, and other non-targeted species as they passed through the fish ladder at the barrier weir. The trap was placed in the upstream end of the vertical slot fish ladder. Personnel from the RBFWO operated the trap approximately 7 ½ hours a day, 7 days a week from March 1 through May 27, 2002 (0730-1500 hours - March 1-April 18; 0530-1300 hours - April 19-May 5; 0430-1200 hours - May 6-May 27). During hours when the trap was not operated (e.g.1500 - 0730 hours), fish were allowed to enter the trap, but the exit was closed blocking fish passage. Prior to operation each morning, the trap was cleaned, and weather conditions, water temperature and stage gauge levels were documented. Every two hours temperatures and stage gauge levels were recorded. When water temperature exceeded 60°F, trapping for that day was terminated to reduce the effects of handling. Trapping was terminated for the season and videography began when water temperatures exceeded 60°F (as determined by Optic Stowaway® Temp Loggers) for a majority of the trap operation period in a day.

The trap was checked every 30 minutes. 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 temperature. Sodium chloride (1.0%) and Poly Aqua™ (artificial slime coat; 1.0%) were added to the tank to reduce fish stress and preserve their protective slime coat layer. While in the fish tank, Chinook and rainbow trout were anesthetized with CO_2.

Anesthetized salmonids were measured (fork length) to the nearest millimeter, 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. All clipped Chinook were sacrificed and coded-wire tags (CWT) were recovered and decoded to determine run, 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 possessing a CWT were sacrificed for tag recovery and all others were released upstream of the barrier weir. After taking a tissue sample for genetic analysis, unclipped Chinook and rainbow trout without a CWT were placed in either a 96 x 25 cm aluminum tube for recovery from anesthetization until they could swim out on their own, upstream of the barrier weir, or placed into a recovery tank, then released into the creek with a dip net when fully recovered.

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 at the barrier weir. The camera was placed in a modified weir at the upstream end of the fish ladder. Video monitoring of fish passage was conducted from May 27 through August 30. A lighting system allowed for 24 hour 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 hours, and 120 minute-8 mm tapes were used. Beginning June 24 we switched to 160 minute-VHS tapes. A time-date stamp was recorded. Tapes were viewed until a fish was observed, then reviewed at slow playback speed or "freeze frame" mode to assist in 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 viewing was needed to classify the fish; and “poor” suggested uncertainty in determining species and presence or absence of an adipose fin.

The quality of the picture was also rated as good, fair, or poor. Good signified a clear picture; fair indicated that objects were discernable but extra viewing was needed; and poor indicated that some objects were indistinguishable. Observations during poor periods are not included in passage estimates and instead, interpolated estimates are provided. The interpolated estimates were compared to the fish observations during poor periods to ensure credibility. The interpolated estimates were similar to the fish observations during poor periods, in this study.

All Chinook and rainbow trout passing the barrier weir were recorded onto a file tape and the tape 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 2002. 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 2002 was calculated by summing weekly passage estimates at the barrier weir as well as the number of clipped and unclipped Chinook and rainbow trout released into upper Battle Creek by CNFH prior to March 1. The equations used for estimating passage during barrier weir trapping were:

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

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

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 = actual number of clipped Chinook or rainbow trout observed passing the barrier weir during the week i;

u = actual number of unclipped Chinook or rainbow trout observed passing the barrier weir during the week i;

unk = actual number of unknown clip status Chinook or rainbow trout observed passing the barrier weir during the week i;

The equations used for estimating passage during barrier weir video counting were:

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

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

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 = actual number of clipped Chinook or rainbow trout observed passing the barrier weir during the week i;

u = actual number of unclipped Chinook or rainbow trout observed passing the barrier weir during the week i;

unk = actual number of unknown clip status Chinook or rainbow trout observed passing the barrier weir during the week i;

T = number of hours of unrestricted fish passage at the barrier weir during the week i; and,

V = number of hours of actual good and fair video recorded fish passage at the barrier weir during the 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. The number of fish captured per hour was calculated and plotted for Chinook and rainbow trout.

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. Age vs. length plots were developed for tagged Chinook.

Stream Surveys

We conducted bi-monthly stream surveys of Battle Creek from May 6 to November 15, 2002. The 21.6 mile survey area was divided into 7 reaches (Table 1; Figure 1) and usually required 4 days 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.

Snorkel type surveys were used on all reaches, except for Reach 3. 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 (we did not count young-of-the-year). We categorized rainbow trout with parr marks as “small”, rainbow trout with no parr marks but less than 22 inches long as “medium”, and rainbow trout greater than 22 inches as “large”. 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.

In Reach 3, our only survey reach in the South Fork, two surveyors walked upstream through the stream and along banks. Regular snorkel surveys were not possible due to the extremely shallow water in the South Fork during the summer of 2002 (stream flows were approximately 12 cfs), although we did snorkel in pools throughout the reach. On Reach 3, survey personnel counted Chinook, large and medium size rainbow trout, carcasses, and redds but did not count small-size rainbow trout.

When survey personnel encountered carcasses, they would collect tissue and scale samples, and record biological information such as fork length, sex, retention of eggs, presence or absence of a tag, and presence or absence of an adipose fin. Heads were collected from all adipose-fin clipped carcasses and from carcasses where the presence of a fin clip could not be determined due to decomposition or lack of a complete carcass. Coded-wire tags were extracted from heads in the laboratory.

Stream flow, water turbidity, and water temperature can all influence the effectiveness of snorkel surveys (Thurow. 1994). We collected data on these three parameters for each snorkel survey. Stream flow was measured at three California Department of Water Resources (DWR) gaging stations. 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. Stream flows are presented as mean daily flow in cubic feet per second (cfs). 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 then assigned to each survey day. (In the cases where only one 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 stream 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 for spring Chinook holding in Battle Creek (Table 2) from June 1 through September 30. We labeled Ward and Kier's four categories as good, fair, poor, and very poor. Water temperature data was collected at three locations on the South Fork (reach 3), three locations on the North Fork (reaches 1 and 2), and four locations on the mainstem (reaches 4-6). Temperature data was obtained from Optic Stowaway® Temp Loggers installed and maintained by the RBFWO and from two Department of Water Resources (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 provide 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 date of first observance and number of redds per reach were recorded and exact coordinates of redds were documented using a GPS receiver. All redds were marked in the field with flagging 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 (Table 2), presented by Ward and Kier (1999) to evaluate the suitability of water temperatures in Battle Creek for spring Chinook holding and egg incubation to the eyed-egg stage (Table 3 and 4). Development to the eyed-egg stage would take approximately 17 days at 58˚F (Piper et al. 1982). We labeled Kier's four categories as good, fair, poor, and very poor. Using these criteria we evaluated water temperature data at three sites on the South Fork (Reach 3), three on the North Fork Reach (Reaches 1-2), and four on the mainstem Battle Creek (Reach 4-6) from September 15 through October 31. Evaluating temperatures at these sites provide a range of conditions Chinook eggs may have been exposed to in each of these three creek segments.

Tissue Collection for Genetic Analyses

Tissue samples were collected from unclipped Chinook captured at the fish trap and from carcasses collected during stream surveys. Either scissors or a hole puncher were used to obtain three small pieces of fin tissue. Two 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 sample was sent to Bodega Marine Laboratory (BML) for genetic analyses and the other two samples were archived at the RBFWO. At BML, DNA was extracted and amplified using the Puregene method and individuals were genotyped at 7 loci (Hedgecock et al. 2001). Two methods were then used to analyze the genetic information; mixed stock analysis (MSA) and individual assignment (WHICHRUN). MSA does not assign a run to individual fish but assigns proportions of a mixed stock to specific runs. MSA has a minimum sample size requirement of approximately 100. WHICHRUN is used to clasify an individual fish is a winter Chinook or non-winter Chinook.

Results

Coleman National Fish Hatchery Barrier Weir

Trapping.—A total of 295 Chinook were captured in the barrier weir trap between March 1 and May 27, 2002. Of these, 166 were clipped and 129 were unclipped (Table 5).

We retrieved CWTs from 144 clipped Chinook captured in the trap. Tag codes indicated all 144 were from late-fall Chinook from CNFH (Appendix A). We did not recover any coded-wire tagged winter Chinook. Fourteen clipped Chinook had no tag detectable, and 8 tags were lost during removal.

Diel timing of Chinook entering the barrier weir trap showed some variation throughout the trapping season (Figures 2, 3 and 4). To investigate potential impacts of the barrier weir trap operation, trap opening and closing times were altered. Trapping began with a 0730 hours starting time and continued until April 19, then changed to a 0530 hours starting time, and then changed again on May 6 to 0430 hours start time. Early in the season clipped Chinook were trapped more frequently in the afternoon, whereas in late April and May, more Chinook were trapped in the morning and they were unclipped. Most of the late April and May Chinook were trapped within the first hour of trap operation, with a secondary peak trapped from 0700 to 0800 hours.

A total of 117 rainbow trout were captured in the barrier weir trap. Of these, 14 were clipped, 98 were unclipped, and 5 escaped prior to being examined for an adipose fin (Table 6). The escaped rainbow trout were approximately 10 inches in length. They escaped through a small opening that only became accessible as the false bottom of the trap is raised. The small opening was subsequently sewn shut. We designated the 5 unknown clip status rainbow trout as unclipped, based on the proportion of clipped and unclipped observed for that particular week (or surrounding weeks). Clipped rainbow trout without a CWT detected were released upstream of the weir. observed, one was detected with a CWT and was sacrificed. The tag code indicated that it came from CNFH. We released the rest of the clipped rainbow trout upstream of the weir as they did not have coded-wire tags.

Diel timing of rainbow trout entering the barrier weir trap also showed some variation throughout the trapping season (Figure 5). During the 0730 hours start time trapping period, rainbow trout were trapped most frequently at the beginning of trap operation (87.2% -102 out of 117), with a secondary peak at 1330 hours (Figure 6, Figure 7). Only 5.1% (6 out of 117) of the total rainbow trout passed during the 0530 start time trapping period, with no apparent pattern with timing. Only 7.7% (9 out of 117) rainbow trout passed during the 0430 hours start time trapping period, with peaks at 0630 and 1030 hours.

Video counts.—A total of 77 Chinook were observed passing through the barrier weir fish ladder between May 27 and August 30, 2002. Of these, none were clipped and 77 were unclipped (Table 7). For a period of 25 days from July 11 through August 4, no Chinook were observed (Figure 8 and 12). During the video monitoring period, 84% (1906 hours) of the afforded passage was video recorded with a good or fair picture quality (Table 7). Although we video monitored 84% of total passage, we probably monitored 90% of the actual Chinook passage past the barrier weir, since there were probably no fish passing during the mid-summer period.

We extrapolated for periods that were missed due to poor picture quality, caused by turbidity or video equipment malfunction. This resulted in a total passage estimate of 93 Chinook. Extrapolation between May 27 - June 15 added 12 Chinook to the passage estimate. Extrapolation between August 18-30, added 4 Chinook to the passage estimate. Extrapolation between July 14-27 added zero Chinook to the passage estimate. No Chinook were observed passing 10 days prior and 8 days following this July period of equipment malfunction.

A total of 54 rainbow trout were observed passing through the barrier weir fish ladder. Of these, 1 was clipped and 53 were unclipped (Table 8 and Figure 13). Extrapolation for poor viewing quality or equipment malfunction, between May 27-June 15, added 27 rainbow trout to the passage estimate.

Diel timing of Chinook passage during video monitoring had peaks at 0300 and 0700 hours. Chinook passing between 0100 hours and 0800 hours represented 69% of total passage. Also, 58% of Chinook passed during dark hours (Figure 9). Diel timing of rainbow trout passage during video monitoring had no apparent pattern, with 42% of passage occurring during dark hours (Figure 10), and a slight peak in passage at 2200 hours (Figure11).

Passage estimation.—Passage estimates for unclipped salmonids are higher than actual numbers observed due to estimates made during periods of poor video quality. We estimate zero clipped and 222 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 1 and August 30, 2002. An additional 216 unclipped Chinook were released above the barrier weir by CNFH personnel prior to opening the barrier weir fish ladder on March 1 (Table 9). These 216 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 coded-wire tag, these 216 Chinook were considered natural-origin and were released into Battle Creek, upstream of the barrier weir, to spawn naturally.

We estimate that 14 clipped and 183 unclipped rainbow trout passed through the barrier weir fish ladder between March 1 and August 30, 2002. An additional 1,428 clipped and 410 unclipped rainbow trout were released above the barrier weir by CNFH prior to March 1 (Table 9). 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 1 (the first day the fish ladder was open) and peaked the week of May 12-18. The middle 50% of the run passed between April 23 and May 25 (Figure 12). There was a continuous 25 day period (July 11 through August 4) in which Chinook did not appear to migrate above the weir. Following this period, migration of unclipped Chinook were observed during the final 4 weeks of barrier weir fish ladder operation.

The temporal distribution of clipped Chinook observed at the barrier weir is different from that of unclipped Chinook (Figure 12). The migration of clipped Chinook also began March 1, peaked during the first two weeks of trap operation and declined steadily into May.

Rainbow trout migrating past the barrier weir showed primary and secondary peaks in passage numbers (Figure 13). Passage of rainbow trout was greatest during the first two weeks of trap operation (March 3-9), after which, weekly counts of rainbow trout gradually declined until May 27 when counts began rising again. A smaller secondary peak of rainbow trout passage occurred the week of June 2-8. Following the secondary peak, weekly counts of rainbow trout again declined.

Size, sex, and age composition.— Chinook captured in the barrier weir trap had a mean fork-length of 80 cm and ranged in length from 45 cm to 107 cm (n=295). The length-frequency distribution was continuous and was approximately normal with a mode of 86-90 cm (Figure 14).

Rainbow trout captured in the barrier weir trap had a mean fork length of 46 cm and ranged from 33 to 68 cm (n=117). The length-frequency distribution for rainbow trout was continuous and was approximately normal with a mode of 45-48 cm (Figure 15).

The sex ratio of male to female Chinook captured in the barrier weir trap was different for clipped and unclipped fish. The male:female ratio for clipped Chinook (which were all late-fall run) was 1:3.7 (n=166). The male:female ratio for unclipped Chinook was 1:4.6 (n=39, plus an additional 90 were in the unknown sex category for a total of n=129). For rainbow trout, the ratio of male to female was 1:1 (n=58, an additional 59 were in the unknown sex category for a total of n=117).

Age was determined from tagging records for most coded-wire tagged Chinook captured in the barrier weir trap. The ages of tagged Chinook included 3-year-olds (n=34), 4-year-olds (n=102), and 5-year-olds (n=1). There was overlap in fork length between Chinook of different ages (Figure 16). Age was not determined for unclipped Chinook. Also, age was determined for only one rainbow trout, as only one had a coded-wire tag (3-year-old).

Stream Surveys

During regularly scheduled bi-monthly stream surveys, we observed 11 adult Chinook in May, 51 in June, 71 in July, 88 in August, 74 in September, 54 in October, and 2 in November (Table 10 and 11). During regular bi-monthly surveys (and supplemental surveys), we observed a total of 78 redds above the barrier weir: 1 in September, and 77 in October. We recovered a total of 35 carcasses: 1 in May, 1 in June, 2 in July, 1 in August, 6 in September, 23 in October, and 1 in November.

Small rainbow trout were the dominant size group in the North Fork (reaches 1 and 2). While small and medium rainbow trout were nearly equal in the remaining four reaches (Table 12). Large rainbow trout were most common in the lowest reach (Reach 7). Monthly mean rainbow trout numbers by reach (Table 13) show that Reach 4 had the greatest abundance (542) followed by Reach 1 (385). The fewest rainbow trout were observed in Reach 6 and 7.

Conditions for snorkel type surveys (all reaches except Reach 3) were good to excellent: stream flows were stable (Figure 17), temperatures ranged from 46˚ to 78˚F, and average daily turbidity was low (0.7 to 2.8 NTU). Conditions for walking surveys of Reach 3 were excellent as creek flows were low (approximately 16-19 cfs) and average daily turbidity was usually low (0.9 to 3.8 NTU- average was 1.6 NTU). The presence or absence of an adipose fin usually could not be determined for Chinook seen during our surveys.

Compared to 2001, flows in 2002 were increased in the South Fork below Coleman Dam when less flow was diverted into the Coleman Canal (Table 14 and 15, Figure 18). We compared water temperatures between years at two sites on the South fork: immediately below Coleman Dam (rm 2.5) and at Manton Road Bridge (rm 1.7). During the holding period (June 1-September 30) water temperatures at Coleman Dam averaged 60.6˚F in 2001, with 7 cfs, and averaged 60.9˚F in 2002, with 16 cfs. During the holding period at Manton Bridge, water temperatures averaged 65.6˚F in 2001, with 7 cfs, and averaged 63.1˚F in 2002, with and 16 cfs. During the egg incubation period (September 15-October 31) at Coleman Dam, temperatures averaged 55.7˚F with 8 cfs in 2001, and averaged 54.5˚F in 2002, with 19 cfs. During the egg incubation period at Manton Bridge temperatures averaged 57.9˚F in 2001, with 8 cfs, and averaged 55.1˚F in 2002, with 19 cfs.

In 2002, along with the increased flows in the South Fork came decreased flows in the North Fork. We compared water temperatures between years at the Wildcat Bridge site. During the holding period, temperatures averaged 62.2˚F in 2001 with 41cfs, and averaged 62.7˚F in 2002 with 38 cfs. During the egg incubation period temperatures averaged 57.0˚F in 2001 with 43 cfs, and averaged 55.9˚F in 2002 with 37 cfs.

Holding location.—Monitoring results indicate Chinook held in Battle Creek for about four months (from early June through early October) prior to spawning. Barrier weir monitoring showed that 75% of unclipped Chinook migrating into Battle Creek had passed the weir by June 15. Stream surveys indicated that most Chinook did not spawn until early October (see below). Therefore, we considered survey observations made during June, July, August, and September to be during the holding period for spring Chinook in 2002.

From June through September, Chinook numbers and proportions among the North Fork, South Fork and Mainstem steadily changed throughout the holding period (Table 10 and 11). For example, in June, 2% were in the North Fork, 87% in the South Fork and 11% in the mainstem, and in September, 1% were in the North Fork, 35% in the South Fork and 64% in the mainstem.

Monthly maximum counts of Chinook in the South Fork were 2 in May, 41 in June, 48 in July, 51 in August, 25 in September, 19 in October, and zero in November. Chinook numbers increased from two on May 7 to 34 on June 4, after a large increase and then decrease in flow, associated with annual maintenance outage of the PG&E hydropower system. The annual maintenance increased flows in the South Fork on May 20 from 64 cfs to 297 cfs. Flows decreased to 51 cfs on June 2, to 16 cfs on June 3, and to 11 cfs on June 4. Our May 21 survey of the South Fork was precluded by high flows. Surveys were considered unsafe and ineffective during the outage. Throughout the survey period, we repeatedly observed Chinook holding in a few pools, primarily between rm 1.7 and 2.5. However, by September they were all holding in one pool below Coleman Diversion Dam (rm 2.5). The dam was the upper limit to fish migration on the South Fork, due to the impassable fish ladder.

Monthly maximum counts of Chinook in the mainstem were nine in May, five in June, 23 in July, 37 in August, 46 in September, 28 in October and two in November (Table 10 and 11). We observed the majority of the Chinook repeatedly in a large deep pool in Reach 4. We observed the other Chinook in changing locations throughout the summer.

Using the Ward and Kier (1999) thermal criteria for holding of spring Chinook from June 1 through September 30 (Table 2), we evaluated South Fork water temperatures at three sites. Mean daily temperatures were classified as good, fair, poor, or very poor (Table 3). Coleman Diversion Dam (rm 2.5), had 70 days of fair (57%), and 52 days of good (43%) temperatures. Manton Road Bridge (rm 1.7) had 19 days of poor (16%), 71 days of fair (58%) and 32 days of good (26%) temperatures. The confluence had 71 days of poor (58%), 41 days of fair (34%) and 10 days of good (8%) temperatures (Figure 19). Chinook holding in the South Fork were located primarily at Coleman Dam.

We used the same criteria to classify temperatures in the North Fork where we evaluated holding temperatures. Wildcat Dam had 24 days of no data available, 48 days of fair (49%), and 50 days of good (51%) temperatures. Wildcat Road had three days of poor (2.5%), 89 days of fair (73%), and 30 of days good (24.5%) temperatures. The confluence (rm 0.1) had 14 days of poor (11.5%), 80 days of fair (65.5%) and 28 days of good (23%) temperatures (Figure 20). Fish were not able to pass above Eagle Canyon Dam.

We evaluated mainstem Battle Creek holding temperatures near the confluence of the two forks (rm 16.0)- 46 days poor (38%), 59 days fair (48%), and 17 days good (14%), and upper section of reach 4, 26 days had no data available, 32 days poor (33%), 45 days fair (47%), and 19 days good (14%), the lower section of reach 4, had 53 days no data, 32 days poor (46%), 29 days fair (42%), and 8 days good (12%), and reach 5, 25 days no data, 53 days poor (55%), 36 days fair (37%), and 8 days good (8%) (Table 3).

Spawning location and timing.—We observed 16 redds in the South Fork, 27 in the North Fork, and 35 in the mainstem (Table 10). In the South Fork, Chinook began spawning by October 1 (1 redd), constructed the majority of their redds in the first two weeks of October, and finished spawning by October 29 (Table 10). Our last survey on the South Fork was on November 13. In the North Fork, Chinook began spawning September 18 and finished by October 29. Our last survey on the North Fork was November 13. In the mainstem, Chinook began spawning in between our surveys on October 2 and October 31. Our last survey on the mainstem was November 15, and one redd was observed during this final survey, therefore the end of spawning is approximately November 15.

Fifty-five percent of Chinook redds were located in the North Fork and South Fork of Battle Creek. Most of the redds in the South Fork were either just downstream of the Coleman Diversion Dam pool, or just downstream of the next pool below the 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) where the fish ladder was closed. We observed redds above Wildcat Dam, but only as far up as rm 3, which is downstream of a narrow high-velocity cascading waterfall (roughly 4 feet high and 4 feet long). Downstream of the waterfall, the observed redds were located on the first four available spawning riffles. The same pattern was observed in 2001, where redds were found as far upstream as rm 3, but not beyond the waterfall. However, one Chinook was observed above rm 3 on two separate surveys this year, on May 23 and September 3, both of these dates corresponded with higher flows.

We were unable to determine the spawning status of 26 of the 34 carcasses because of several potential factors: advanced state of consumption by scavengers, skinning and fileting by poachers, and decomposition. Carcasses may have remained hidden under rocks, in large woody debris or in turbid pools, and then flushed out later. In the North Fork, all 11 carcasses were of unknown spawning status. In the South Fork 1 was unspawned, 1 was spawned, and 8 were of unknown spawning status. In the mainstem, 1 was unspawned, 5 were spawned, and 7 were of unknown spawning status. One of the mainstem carcasses was a coded wire tagged late-fall from CNFH and is not used in calculations involving possible spring run spawned and unspawned carcasses.

Spawning survey results, apportioned to either the North Fork, South Fork or mainstem, were compared between 2001 and 2002 (Table 16). During the holding period, the percentage of adults observed was similar in both 2001 and 2002, for North Fork, South Fork and Mainstem. During the spawning period, the percentage of redds was higher in the mainstem and lower in the South Fork, in 2002 than in 2001. Also during the 2002 spawning period, the percentage of carcasses was higher in the mainstem and North Fork and lower in the South Fork, in than in 2001.

Using the Ward and Kier (1999) thermal criteria for egg incubation from September 15 through October 31 (Table 2), we evaluated South Fork temperatures. Coleman Diversion Dam had five days of fair (11%) and 42 days of good (89%) temperatures. Manton Bridge had two days of poor (4.3%), 11 days of fair (23.4%), and 34 days of good (72.3%) temperatures. The confluence had nine days of very poor (19%), nine days of poor (19%), nine days of fair (19%) and 20 days of good (43%) temperatures.

North Fork temperatures were also evaluated. Wildcat Dam had three days of fair (6%), and 44 days of good (94%) temperatures. Wildcat Road had one day of poor (2%), 12 days of fair (26%), and 34 days of good (72%) temperatures. The confluence had three days of poor (6.4%), 10 days of fair (21.3%), and 34 days of good (72.3%) temperatures.

Mainstem Battle Creek water temperatures were also evaluated. Below the confluence had seven days of no data available, 10 days of poor (25%), eight days of fair (20%), and 22 days of good (55%) temperatures. The upper section of reach 4 had nine days of poor (19%), nine days of fair (19%), and 29 days of good (62%) temperature. The lower section of reach 4 had four days of very poor (9%), nine days of poor (19%), nine days of fair (19%) and 25 days of good (53%) temperatures. Reach 5 had four days of very poor (9%), nine days of poor (19%), nine days of fair (19%), and 25 of days good (53%) temperatures (Table 4).

Tissue Collection for Genetic Analyses

Samples from 129 Chinook from barrier weir trapping were analyzed by BML (Vanessa Rashbrook. personal communication). Using the WHICHRUN individual run assignment methodology (Hedgecock et al. 2001), two were winter-run based on the criteria of LOD>1which has been used in previous analyses of Battle Creek weir trap genetic samples (Appendix B). MSA results indicated that 0.9% were winter Chinook, 73.7% were spring Chinook, 17.5% were fall Chinook and 7.9% were late fall Chinook. We collected 31 samples from carcasses encountered during stream surveys. These samples have not been analyzed.

Discussion

Impact of barrier weir operations

In 2002 we changed the hours of the barrier weir operation to investigate impacts of trap closure on salmonid passage. We observed three diel peaks in Chinook passage: 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. The earlier hours of trap operation resulted in lower water temperatures during trapping, potentially less stress on trapped fish, and a longer trapping season.

Barrier weir trap operations potentially create an avoidable delay in adult salmonid passage as the upstream exit of the trap is closed for 16 hours a day (USFWS. 2002). Data from 1996 to 2000 (USFWS RBFWO. unpublished data), indicated that many fish were caught in the initial trapping period. This occurrence leads to two possible hypotheses: 1) that fish move upstream throughout the day and night and upon arriving at the closed trap, they are delayed until the trap opens; or 2) that crepuscularly moving fish are trapped during their morning activity period. In 2002 we explored these two hypotheses by opening the trap before daybreak (Figure 3). For the first "all 24 hours" hypothesis, we predicted that a large number of fish would be caught in the initial trapping period regardless of the time of day we opened the trap. In the second "crepuscular" hypothesis, fish may be delayed if they are moving before the trap opens in the morning or if they are moving in the afternoon after the trap has closed. We predicted that if we opened the trap in the morning before fish were moving, then we would trap fewer fish in the initial period than after daybreak. However, we also predicted that closing the trap earlier, before fish passed during the afternoon crepuscular period, could result in a larger number of fish in the trap in the initial period. We assumed that fish stayed in the trap and are currently testing the assumption by videotaping fish behavior in the trap while the trap is closed.

To test these hypotheses, opening and closing times were altered two times, to begin at 0730, 0530 and 0430 hours. Diel timing of Chinook entering the barrier weir trap varied during the trapping season. Early in the season clipped Chinook were trapped more frequently in the afternoon, whereas in late April and May, more Chinook were trapped in the morning, and they were unclipped (Figure 2). Most of the late April and May Chinook were trapped within the first hour of trap operation, with a secondary peak trapped from 0700 to 0800 hours (Figure 3).

Diel timing of rainbow trout entering the barrier weir trap also showed some variation throughout the trapping season (Figure 5). During the 0730 hours start time trapping period, rainbow trout were trapped most frequently at trap opening, with a secondary peak at 1330 hours (Figure 6).

Therefore, it appears that the second "crepuscular" hypothesis was at least partially correct, in that clipped Chinook and unclipped rainbow trout were caught crepuscularly during the afternoon of the 0730 hours opening and unclipped Chinook and rainbow trout moved after daybreak in the 0430 hours opening period. However, it appears that the first "all 24 hours" hypothesis is also true, because a large number of fish were in the initial catch for unclipped Chinook in 0530 and 0430 hours and unclipped rainbow trout in 0730 hours.

In addition to 2002, trap data from 2000 also suggests that a secondary peak of fish were trapped in the afternoon, and 1998 and 1999 also show this to some degree, again suggesting that fish were moving crepuscularly before dark. Earlier video tape data suggested that in some years fish were moving at night but not in other years. Diel timing of fish passage may be significantly different during video tape operation than in trap operations because of differences in stream flow, storm frequency, water temperature and turbidity, fish density, abilities or motivation of various stocks to move upstream, and video camera lighting (USFWS. 2003).

In 2002, our earlier hours of trap operation probably decreased the impact of handling Chinook by trapping during the 8 coolest hours of the day, generally from 0400 to 1200 hours.

Running the trap during the coolest 8 hours of the day delayed the date at which water temperature exceed 60˚ F during trapping, which is the criteria for stopping the trapping operations for the year. Therefore, by changing the hours of trap operation, we were able to run the trapping operations longer during the 2002 season.

Based on these results, in 2003 we changed the operation of the barrier weir:1) later, during the afternoon, early in the season, to collect more of the late afternoon arriving fish, to prevent potential delay, and to better determine when the afternoon peak in passage occurred; and 2) earlier in the morning, later in the season, to collect more of the morning arriving fish, and to operate during lower water temperatures, to reduce stress on fish, and increase the trapping season; and 3) for longer hours during the day, to potentially collect both more morning and late afternoon arriving fish.

Chinook Salmon Population estimates

Passage estimates based on weir counts, stream survey redd counts and genetic analysis.—We estimated passage of approximately 33 late fall run, three winter run, 144 spring run, and 42 fall run Chinook passed through the CNFH barrier weir ladder during the barrier weir monitoring period. These estimates will be refined in the future if improved differentiation of run based on genetic analysis becomes available. We made a few simplifying assumptions to develop these estimates, based upon reasons given below:

MSA results suggested that during the barrier weir trapping period, Chinook were 17.5% (n=23) fall run and 7.9% (n=10) late fall run, but we assumed all 33 were late fall Chinook for two reasons. It is unlikely that many fall Chinook pass during the period of March through May. There is a high likelihood that late fall fish were incorrectly identified as fall run (Dennis Hedgecock, BML, UC Davis. personal communication to Kevin Niemela to Matthew R. Brown).

WHICHRUN designated two winter Chinook during the barrier weir trapping period while MSA designated only one winter run Chinook. We used the more accurate WHICHRUN result in our estimates. During the video monitoring period, one winter Chinook was extrapolated based on the winter Chinook proportion during trapping, for a total of three winter Chinook.

MSA results suggested that during the barrier weir trapping period, Chinook were 73.7% (n=95) spring run Chinook. To be consistent with the WHICHRUN results, we reassigned one spring run as a winter run resulting in 94 spring Chinook during trapping. Spring Chinook passage was just beginning when trapping was completed and free passage with video monitoring began. We estimated that 50 of the 51 Chinook passing during the first half of video monitoring (May 27 to July 10) were spring run, yielding a total of 144 spring run.

We assumed all Chinook passing during the second half of video monitoring were fall run although they may have been either spring or fall run. Conversely, some of the Chinook passing in the first half of the video period may have been fall Chinook. The second half of the video monitoring period (July 10 through August 30) began with 30 consecutive days during which Chinook did not pass above the barrier weir and ended with a pulse of an estimated 42 Chinook (all un-clipped) passing from August 9-30. The distinct and prolonged temporal separation between the first and second migration periods suggests that these fish are spring and fall run respectively. Alternatively, water temperatures at the mouth of Battle Creek during July and early August averaged 70˚F and may have created a thermal barrier, discouraging Chinook from entering Battle Creek and delaying the migration of some spring run.

Based on redd counts (78 total redds), we estimate a spawning population of 156 Chinook. This estimate assumes a 1:1 sex ratio, each female constructed one redd, all redds were observed, and that no redds were constructed following the conclusion of the stream survey. A 1:1 sex ratio has been used to estimate spring Chinook spawning populations based on redd counts on Mill Creek (Harvey Arrison. 2001) and on Battle Creek (Brown and Newton. 2002). Two live Chinook were seen during the final stream survey, and these fish may have spawned subsequent to the survey. A cohort replacement rate could not be developed using a redd-based spawning population estimate because stream surveys did not occur in 1999.

Differences between population estimates.—The difference between the spawning estimate of 156 Chinook and the barrier weir passage count of 222 suggests one or more of the following: 1) not all of the fish that entered the watershed spawned due to pre-spawning mortality; 2) not all redds were detected; 3) some Chinook may have been late-fall or winter run and their redds were not detected due to their spawning prior to our first survey in May; 4)Chinook may have fallen back below the dam due to natural exploration, confusion due to the lack of hatchery odors above the weir, or due to handling in the weir trap; and 5) Extrapolation of video passage estimate by 16 Chinook, for periods of poor tape quality, may have been an overestimate. Some of these ideas are explored below. Chinook passing in August should also be added to the spring Chinook estimate for a combined spring and fall Chinook estimate for a more appropriate comparison to the redd estimates, since the redd estimates include both spring and fall Chinook. Therefore the 156 spawners (78 redds times 2) should be compared to 186 fall and spring Chinook passed.

Pre-spawning mortality.—Pre-spawning mortality may have been significant during the long summer holding period when water temperatures were high, and fish were exposed to these temperatures for a long period of time. Possible causes of mortality include predation, poaching, high water temperatures, and increased stress due to crowding combined with elevated temperatures. Fourteen of the 34 (41%) carcasses were observed prior to redd construction in that reach of the survey. Although we would have had a high likelihood of seeing redds during our surveys in this low flow year with better than average viewing conditions, that occurred at least every two weeks, we may not have detected all redds because of complexity of habitat, inexperience of some crew members. Of these 14 carcasses, two were pre-spawning mortalities (based on unspent eggs), and 12 were of undetermined spawning status. A total of six post-spawning mortalities were documented but only after redds were constructed in the reach the carcass was observed.

Twice we observed two fishermen at the major holding pool on the mainstem. We likely missed many pre-spawned carcasses during our surveys because they can be difficult to find and because they may have disappeared quickly due to scavengers or predators. We only found 10 carcasses out of the 51 live Chinook observed in the South Fork, and only 2 of these carcasses were identifiable to spawning status. Otters ate many Chinook on the South Fork, where remains of most of the carcasses were in small pieces. It seemed likely that carcasses would have been quickly devoured. Salmon remains were regularly found associated with otter scat at the main Chinook holding pool on the South Fork. In this pool, an otter was observed by the snorkel crew with a whole salmon in its mouth.

Fall backs and jumpers.—Some Chinook and rainbow trout included in the barrier weir counts, may have fallen back below the dam. Chinook and rainbow trout may have entered the system due to natural exploration, then fell back to continue exploration below the dam, or to find more desirable conditions. Chinook may have been attracted to hatchery odors that were present in their natal stream, then confusion due to the lack of hatchery odors above the weir may have caused them to return to the area below the dam. In addition, handling at the weir trap may have contributed to some Chinook falling back below the dam. There was no visible confirmation of Chinook falling back down over the dam after handling. None of the 129 Chinook trapped were recaptures that had already been passed. However, one steelhead was recaptured in the weir trap, that had been passed by weir trap operations, and in the winter of 2002-2003, 172 steelhead were recaptured by CNFH personnel out of 1,185 released above the weir by CNFH operations (Bob Null, RBFWO. personal communication).

We believe relatively few fall Chinook were able to jump over the barrier weir and avoid detection at the fish ladder monitoring station, due to low flows in 2002. Low flows probably made jumping the weir more difficult and salmonids would have likely taken the easier route through the open fish ladder. These passage estimates were made while the fish ladder into Battle Creek was open which included almost the entire spring Chinook migration period, but did not include the entire migration period for winter, fall, and late-fall Chinook. When the fish ladder into Battle Creek was closed, an unknown number of salmonids may have jumped the barrier weir. Therefore estimates of winter, fall, and late-fall Chinook may be partial counts of salmon entering the watershed above the barrier weir.

Sex ratio.— In 2001, male to female sex ratios were 1:1.8 (n=14) for clipped Chinook, and 1:28 (n=30) for unclipped Chinook. One explanation for the lower clipped ratio is that sex determination is easier with the clipped late-fall Chinook. In March and April, late-fall Chinook are ready to spawn, have readily expressed sex products when gently squeezed, and have fully developed, secondary-sex characteristics, such as a hooked jaw and large teeth, which are easily identifiable as male. In March through May, spring Chinook are not ready to spawn, are not expressing sex products, and are not yet showing secondary-sex characteristics. This possibility for mis-identifying males as females was previously identified in 2001 barrier weir operations (Brown and Newton. 2002). In 2002, in an effort to avoid misidentification, bright Chinook were labeled as "unknown sex", if no secondary-sex characteristics were present, or no sex products expressed.

Nonetheless, in 2002 the male to female sex ratio for clipped Chinook was 1:3.7 (n=166), and the unclipped Chinook 1:4.6 (n=39, an additional 90 were of unknown sex). Clipped Chinook were all sacrificed in 2002, were late-fall, and gender was verified (as was the case in 2001). The higher proportion of female late-fall Chinook is not surprising given that the clipped fish represent the end of the run which peaks in late December or January, and the end of the run may consist of more females than males (looking for reference). Gender estimates should have been more accurate in 2002 because of larger sample sizes.

Evaluation and Adaptive Management of Battle Creek Stream Flow

Success of pilot flow program.—Barrier weir population estimates for 1999 have not yet been developed and redd surveys were not conducted in 1999 for a redd based population estimate. Therefore a cohort replacement rate could not be developed to assist in evaluating the pilot flow program. A cohort replacement rate will be developed as part of a report planned to incorporate RBFWO Battle Creek sampling from 1995 to the present.

Comparison of temperature conditions in 2001 and 2002.—Flows were successfully increased in the South Fork in 2002 over 2001, to reduce the impact of high water temperatures on Chinook during holding and spawning periods. Annual differences in weather and air temperature can make analysis of the effect of flow on water temperature difficult. To reduce the uncertainty associated with these differences, we suggest using PG&E temperature model to estimate temperature benefits of increased flows versus un-improved flow conditions.

Nonetheless, South Fork water temperatures in 2001 and 2002 are compared in Table 15 using thermal criteria (Ward and Kier. 1999). While water temperatures at Coleman Dam did not appear to improve in 2002, water temperatures at Manton Bridge were better than in 2001. At Coleman Dam in both years water temperatures were never classified as "poor", but at Manton Bridge water temperatures were poor 76% of days monitored in 2001 and 20% in 2002. Improved water temperatures at Manton Bridge may be more important than at Coleman Dam to successful adult holding and juvenile production. Manton Bridge temperatures are more similar to temperatures Chinook would have experienced spawning in the South Fork. Coleman Dam is 2.5 rm from the confluence of mainstem Battle Creek, whereas Manton Bridge is 1.7 rm from the confluence.

The North Fork of Battle Creek was also evaluated because, in order to increase flows on the South Fork in 2002, flows were decreased on the North Fork (Table 15). Temperatures were not increased by the decrease in flow at both Eagle Canyon and Wildcat Bridge.

Don't decrease North Fork Flows to Increase South Fork flows.—There may be Chinook in the North Fork during the holding period that we do not detect because of differences in the viewing conditions between the South and North Forks. North Fork conditions included higher flows, higher turbidity, and more complex geomorphology of complex rock and stream channel formations with clusters of large boulders, narrower canyon walls which cast shadows, a steeper gradient resulting in more bubble curtains and more turbulence, and more safety distractions for snorkelers. South Fork surveys were in lower flows, involved walking along stream banks and in the stream channel. These conditions created easier viewing for long distances, giving us a better chance of seeing Chinook before they saw us. There were more pools, and generally lower turbidity. In addition, the flatter landscape creates less turbulence, and there were fewer safety distractions.

Increase North Fork flows to test barrier hypothesis.—Our results confirm that Interim Flow Project flows may be insufficient for fish passage on the North Fork. Flows were 30 cfs during the spring Chinook migration periods studied in 2001 and 2002. As in 2001, all spawning occurred downstream of a narrow high-velocity waterfall, identified as a natural barrier in 2001, at rm 3.05 (Reach 1) on the North Fork. The barrier was not identified in a survey of fish passage barriers conducted in 1988, 1989, and 1990 (TRPA. 1998). The reach upstream of the barrier is 40% of the current anadromous salmonid habitat in the North Fork. Seven redds were located on the first four available spawning riffles downstream of the waterfall. One live Chinook was seen above the natural barrier on May 23, 2002, and again on September 3, but was not seen again and may have passed during higher flows at the beginning of the summer.

Future monitoring is needed to determine if Restoration Project (35 cfs during the corresponding migration period; NMFS et al. 1999) flows are sufficient for passage at this temporary barrier. Increasing stream flow above 30 cfs, at least periodically, would likely allow Chinook to pass this potential barrier. The cost associated with increasing North Fork flows to the Restoration Project level for one week could be offset by reducing flows by 1.25 cfs for four weeks in October when water temperatures are no longer limiting.

Delays in implementing increased flows on the South Fork.—Flows were increased in the South Fork twice after some delay 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.

Planned power outage and associated flow increase.— The increase in Chinook numbers in the South Fork from 2 on May 7 to 34 on June 4, may have been due to the large increase in flow associated with annual maintenance outage of the PG&E hydropower system. A large proportion of the Battle Creek spring Chinook were in the South Fork, and were subjected to harmful high water temperatures after the annual maintenance. Our observations before and after this planned power outage, as well as the outages in May 2001, suggest four different, but non-exclusive ways that Chinook could have been attracted into the South Fork:

a) Chinook were falsely attracted by high flows during the power outage. This alternative was not supported by data from 2001, when under similar conditions, fish were not present after high flows.

b) Chinook were attracted into their natal stream during high flows. This alternative supports the notion that 1998 and 1999 were successful at producing spring Chinook in the South Fork.

c) Chinook were falsely attracted by North Fork water that is mixed into the South Fork below the Inskip Powerhouse. In this alternative Chinook were attracted to water from the North Fork which would have been the natal stream. This doesn't seem as likely, if it is true that few Chinook returned to the North Fork.

d) Chinook were attracted into their natal stream during low flows. Poor stream conditions should have dissuaded them, so this is not a probable reason. This alternative supports the notion that 1998 and 1999 were successful at producing spring Chinook in the South Fork.

Although we had been working with PG&E to coordinate our field work with previous outages, we were caught unawares that the May outage was going to occur. If we had known that the outage was going to occur, we would have rescheduled the stream survey to occur just before the outage, instead of 13 days before the outage. The longer time between the survey and the outage increases the uncertainty of when Chinook entered the South Fork and therefore whether they were attracted by the outage. We recommend better communication between the PG&E and FWS before future outages.

Recommendations

Some of the following recommendations were previously presented in our report "Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from March through October 2001" (Brown and Newton. 2002), and are presented here with italicized notes about their implementation. Of the 16 recommendations from 2001, 14 have been initiated. Recommendations 17 through 18 are new for the current report.

1. Consider closing the CNFH barrier weir fish ladder earlier in August to inhibit the passage of fall Chinook above the weir and the possibility of fall Chinook interbreeding with spring Chinook.

2. Consider reinstalling the trap in August to collect genetic data to determine run and assess the genetic risks of passing Chinook during August. If genetic techniques capable of quickly determining whether or not an individual Chinook is a spring run become available, selectively passing only spring Chinook could also be considered.

3. Collect tissue samples from unclipped Chinook released above the barrier weir during the CNFH late-fall spawning season for genetic analyses to determine run. *The RBFWO Hatchery Evaluation Program collected these samples in 2002-2003. Results are pending.*

4. Analyze tissue samples from unclipped Chinook collected in 2001 and previous years using newly developing genetic techniques capable of determining if individual fish are spring Chinook or non-spring Chinook. *Two of Three possible geneticists that may be able to genetically analyze our tissue samples have been contacted. Possibilities are promising.*

5. Study the effectiveness of the CNFH barrier weir in blocking Chinook passage while the fish ladder is closed. Relate the number of Chinook jumping over the weir to flow. *Our feasibility study using video taping to count salmonids jumping the barrier weir, was initiated in September 2002.* **Preliminary results indicate that while we did not detect any successful jumps during low flows in the Fall, we did document successful jumps during storm flow periods in 2003.**

6. Study the impact of barrier weir trap operation on the passage of salmonids through the fish ladder. *Operations in 2002 were modified to both reduce potential impacts and determine potential for impacts.* **Results presented in the current report were used to justify an amendment request to CALFED for funds to reduce potential impacts of trap closure. In 2003 we reduced the potential for impacts by I) running the trap for more hours of the day, which allows more fish to pass, II) shifting trap operations to peak passage periods during the day, III) shifting trap operations to hours of cooler water temperatures; we also installed a video camera on the trap to monitor behavior of fish during trapping**.

7. Evaluate the rate of salmonid recapture in the barrier weir trap using a caudal fin clip during genetic tissue sampling as the identifying mark. *In 2002, we began using the genetic-tissue fin-clip for recapture analysis. The very low recapture rate was discussed in the current report.*

8. When feasible, increase summer flows in the South Fork Battle Creek below Coleman Diversion Dam to provide more suitable water temperatures for Chinook holding. *In 2002, summer flows in the South Fork were increased to provide more suitable temperatures for Chinook. It is anticipated that flows will be increased during the entire summer of 2003 to 25 or 30 cfs using funding from the Interim Flow Project.*

9. If increased flows cannot be provided throughout the summer in the South Fork, do not attract Chinook into the creek in May during annual maintenance on Coleman Powerhouse. This can be achieved by requesting PG&E to re-schedule the annual maintenance or by physically blocking fish passage using a weir. *PG&E and the agencies have been discussing methods for reducing the fisheries impact of annual canal maintenance. According to an email from Angela Risdon on October 1, 2002,*

> *"PG&E is proposing to keep our planned 4-week outage as scheduled from May 5 through May 29, but PG&E will just perform the powerhouse related work. The spill during this outage will occur at the forebay and Intake 1 will not be available to the Hatchery. On August 4 through August 7, PG&E is proposing to schedule a four day outage for canal work. During the 4 day outage the spill will occur at the Coleman Diversion Dam. Coleman Powerhouse will be shutdown along with the canal, and Intake 1 will not be available to the Hatchery".*

Under this scenario, additional flows will not be released into the South Fork during annual maintenance during May. A much shorter duration release will occur in August. Therefore, it may be prudent to install a barrier weir at the mouth of the South Fork from August 4 through August 7, if flows are not increased on the South Fork in 2003. If water temperature and available spawning habitat are adequate in August due to increased flows, a barrier may not be desirable.

10. Begin stream surveys in early May to detect possible winter Chinook spawning and recover carcasses for genetic analysis. *Stream surveys were initiated on May 6 in 2002 to better detect winter Chinook spawning. No redds were detected. Genetic analysis of the 5 carcasses collected during potential winter Chinook spawning from May through August 31 (the carcasses may alternatively have been spring or fall chinook), will be discussed when results become available.*

11. Continue stream surveys through November to more accurately determine the beginning, peak, and end of spring and fall Chinook spawning. *Stream surveys in 2002 continued through the week of November 15th, during which only 2 live Chinook were detected. The frequency of surveys during spawning periods was increased to biweekly. Therefore, spawning timing was more accurately determined.*

12. Increase frequency of stream surveys from May through November to twice a month to improve: 1) carcass recovery for genetic analysis and coded-wire tag recovery; 2) run determination; 3) redd based spawner population estimates; 4) evaluation of the effects of water temperature and water flow on spawning location, spawning timing, and egg survival; 5) monitoring of the spatial and temporal separation of threatened spring Chinook and fall Chinook; 6) assessment of the fish-tightness of the barrier weir; 7) detection of hydropower system induced flow fluctuations which could attract salmonids and potentially induce spawning in inappropriate locations; and 8) response time for adaptive management of flows. *The frequency of surveys during spawning periods was increased to biweekly.*

13. Investigate the feasibility of monitoring steelhead spawning populations in Battle Creek by conducting stream surveys from December through April. *The RBFWO initiated a winter steelhead survey beginning in December 2002 to determine the feasibility of counting redds and live salmonids.* **We used kayaks for most of the survey to count redds and collect carcasses in reaches 4 to 7 in 2003. In 2004 we are attempting to survey reaches 1 to 3, either on foot or by snorkeling, because we could not effectively use kayaks under low flow conditions. These three reaches may be kayaked under higher flow conditions.**

14. Investigate the feasibility of performing replicate stream surveys to develop confidence intervals for counts of live Chinook, carcasses, and redds. *We investigated the feasibility of improving our stream surveys by researching the literature and conversing with our colleagues in the other fisheries' agencies including Dave Hankin, a recognized expert in the field of statistical and field sampling techniques for salmonids. Information from the Steelhead Project Work Team and the Escapement Project Work Team has also been useful. We have concluded that replicate stream surveys for adult Chinook are cost-prohibitive and are not performed in other watersheds.*

15. Continue to monitor potential fish barriers on the North Fork Battle Creek and consider releasing short term pulse flows below Eagle Canyon Dam to provide improved passage routes for Chinook and steelhead. *In 2002, we took note of potential fish barriers during our stream surveys, in particular the two which were mentioned in the 2001 report. Only one fish was seen above the lower barrier and it was seen a few days after precipitation increased flows 2.5 fold in the North Fork.* **If Chinook are blocked again, it is recommended flows be increased 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.**

16. Install water temperature recording devices at the downstream boundary of stream survey reaches 4 and 5 to better evaluate temperature effects on Chinook adults and egg survival. *The additional temperature recording devices were installed in June 2002.* **In 2003, a system of 22 temperature monitoring devices was installed in the Battle Creek watershed, replacing the one set up in 1998 by the Department of Water Resources.**

17. Develop methods to readily increase flows once decision for flow increase has been approved by Interim Flow Project Science Team (IFPST). Both flow increases in the South Fork were delayed in 2002, after. Administrative roles and methods could be better defined and streamlined to ensure quicker changes in flow.

18. Analyze the impact of annual variation in air temperature on water temperatures achieved under various flows. Use PG&E temperature model to estimate temperature benefits of increased flows versus un-improved flow conditions, to reduce the uncertainty associated with annual differences in weather and air temperature which can make analysis of the effect of flow on water temperature difficult.

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Tables

TABLE 1. Reach numbers and locations with associated river miles (RM) for Battle Creek spawning ground surveys in 2002.

	Upstream		Downstream	
Reach	Location	RM	Location	RM
1 (North Fork)	Eagle Canyon Dam	5.25	Wildcat Dam	2.50
2 (North Fork)	Wildcat Dam	2.50	Confluence of forks	*0.00*
3 (South Fork)	Coleman Diversion Dam	2.54	Confluence of forks	*0.00*
4	Confluence of forks	*16.61*	Mt. Valley Ranch	12.79
5	Mt. Valley Ranch	12.79	Ranch road	9.32
6	Ranch road	9.32	Barrier weir	5.83
7	Barrier weir	5.83	Lower Rotary Screw Trap	2.84

TABLE 2. Temperature criteria used to evaluate the suitability of Battle Creek water temperatures for Spring Chinook. Criteria are taken 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 to the Eyed-egg Stage	≤ 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 3. Number of days mean daily temperatures fell within the four suitability categories for holding spring Chinook from June 1 through September 30. River miles for the mainstem begin at Sacramento River and river miles for the forks begin at their confluence.

Location	River Mile	No Data	Very Poor	Poor	Fair	Good
Battle C. below NFSF confluence	16.8	0	0	46	59	17
MS R4 Upper	16.3	26	0	32	45	19
MS R4 Lower (Barn)	12.9	53	0	32	29	8
MS R5	12	25	0	53	36	8
NF Battle (Wildcat Dam)	2.5	24	0	0	48	50
NF Wildcat Road	0.9	0	0	3	89	30
NF Battle (Confluence)	0.02	0	0	14	80	28
SF Battle (Coleman Diversion Dam)	2.6	0	0	0	70	52
SF Manton Bridge	1.7	0	0	19	71	32
SF Battle (Confluence)	0.02	0	0	71	41	10
Totals		128	0	270	568	254

TABLE 4. Number of days mean daily temperatures fell within the four suitability categories for egg incubation from September 15 through October 31. River miles for the mainstem begin at Sacramento River and river miles for the forks begin at their confluence.

Location	River Mile	No Data	Very Poor	Poor	Fair	Good
Battle C. below NFSF confluence	16.8	7	0	10	8	22
MS R4 Upper	16.3	0	0	9	9	29
MS R4 Lower (Barn)	12.9	0	4	9	9	25
MS R5	12	0	4	9	9	25
NF Battle (Wildcat Dam)	2.5	0	0	0	3	44
NF Wildcat Road	0.9	0	0	1	12	34
NF Battle (Confluence)	0.02	0	0	3	10	34
SF Battle (Coleman Diversion Dam)	2.6	0	0	0	5	42
SF Manton Bridge	1.7	0	0	2	11	34
SF Battle (Confluence)	0.02	0	9	9	9	20
Totals		7	17	52	85	309

TABLE 5. Chinook captured at CNFH barrier weir trap and associated passage estimates for 2002. Note that all clipped Chinook captured in the trap were sacrificed for coded-wire tag recovery.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
1-2 March	18	1	0	0	1
3-9 March	83	8	0	0	8
10-16 March	43	4	0	0	4
17-23 March	14	0	0	0	0
24-30 March	4	2	0	0	2
31March-6 April April	3	11	0	0	11
7-13 April	0	9	0	0	9
14-20 April	0	4	0	0	4
21-27 April	0	24	0	0	24
28 April-4 May	0	10	0	0	10
5-11 May	1	14	0	0	14
12-18 May	0	27	0	0	27
19-25 May	0	13	0	0	13
26-27 May	0	2	0	0	2
Totals	166	129	0	0	129

TABLE 6. Rainbow trout / steelhead captured at CNFH barrier weir trap and associated passage estimates for 2002. Passage estimates include unknown rainbow trout / steelhead apportioned relative to the proportion of clipped and unclipped observed for that particular week (or surrounding weeks). One clipped rainbow trout / steelhead captured the week of March 17-23 was sacrificed for the retrieval of a present coded-wire tag.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
1-2 March	0	6	0	0	6
3-9 March	3	20	1	3	21
10-16 March	0	19	0	0	19
17-23 March	6	19	1	5	20
24-30 March	3	7	1	3	8
31March-6 April	1	9	0	1	9
7-13 April	0	4	1	0	5
14-20 April	0	0	1	0	1
21-27 April	1	1	0	1	1
28 April-4 May	0	1	0	0	1
5-11 May	0	3	0	0	3
12-18 May	0	6	0	0	6
19-25 May	0	3	0	0	3
26-27 May	0	0	0	0	0
Totals	14	98	5	13	103

TABLE 7. Chinook salmon video recorded passing the CNFH barrier weir fish ladder and associated passage estimates for 2002. Passage estimate calculations include apportioned unclipped and clipped Chinook during hours not taped.

Dates	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
27 May-1 June	131	94	0	19	0	0	26
2-8 June	168	71	0	3	0	0	7
9-15 June	168	113	0	3	0	0	4
16-22 June	168	167	0	9	0	0	9
23-29 June	168	163	0	1	0	0	1
30 June-6 July	168	167	0	3	0	0	3
7-13 July	168	164	0	1	0	0	1
14-20 July	168	154	0	0	0	0	0
21-27 July	168	60	0	0	0	0	0
28 July-3 Aug	168	166	0	0	0	0	0
4-10 August	168	167	0	11	0	0	11
11-17 August	168	168	0	2	0	0	2
18-24 August	168	130	0	11	0	0	14
25-30 August	130	122	0	14	0	0	15
Totals	2277	1906	0	77	0	0	93

TABLE 8. Rainbow trout / steelhead video recorded passing the CNFH barrier weir fish ladder and associated passage estimates for 2002. Passage estimate calculations include apportioned unclipped and clipped rainbow trout / steelhead during hours not taped.

Dates	Hours of passage	Hours of taped passage	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
27 May-1 June	131	94	1	8	0	1	11
2-8 June	168	71	0	15	0	0	35
9-15 June	168	113	0	8	0	0	12
16-22 June	168	167	0	9	0	0	9
23-29 June	168	163	0	1	0	0	1
30 June-6 July	168	167	0	2	0	0	2
7-13 July	168	164	0	2	0	0	2
14-20 July	168	154	0	1	0	0	1
15-27 July	168	60	0	0	0	0	0
28 July-3 Aug	168	166	0	3	0	0	3
4-10 Aug	168	167	0	0	0	0	0
11-17 Aug	168	168	0	3	0	0	3
18-24 Aug	168	130	0	1	0	0	1
25-30 Aug	130	122	0	0	0	0	0
Totals	2277	1906	1	53	0	1	80

TABLE 9. Total passage estimates for Chinook and rainbow trout / steelhead above CNFH barrier weir in 2002.

Passage route	Chinook passage: clipped	Chinook passage: unclipped	Steelhead passage: clipped	Steelhead passage: unclipped
CNFH	0	216	1428	410
Barrier weir: trap	0	129	13	103
Barrier weir: video	0	93	1	80
Total passage	0	438	1442	593

TABLE 10. Chinook salmon live adults, carcasses, and redds observed during the 2002 Battle Creek spawning ground survey. Monthly counts may included multiple observations of the same live salmon. Starting in September, fall run Chinook begin returning to lower Battle Creek, and are no longer counted during snorkel surveys.

Reach	Date	Chinook	Carcasses	Redds
1	05/06/02	0	0	0
1	05/23/02	1	0	0
1	06/03/02	0	0	0
1	06/10/02	0	0	0
1	06/24/02	0	0	0
1	07/08/02	0	0	0
1	07/22/02	0	0	0
1	08/19/02	0	0	0
1	09/03/02	1	1	0
1	09/17/02	0	0	0
1	09/30/02	0	0	0
1	10/21/02	0	3	0
1	10/28/02	0	1	7
1	11/12/02	0	0	0
2	05/07/02	0	0	0
2	05/23/02	0	0	0
2	06/04/02	2	0	0
2	06/12/02	0	0	0
2	06/25/02	1	1	0
2	07/09/02	0	0	0
2	07/23/02	0	1	0
2	08/20/02	0	0	0
2	09/04/02	0	0	0
2	09/18/02	1	0	1
2	10/01/02	7	0	6
2	10/16/02	1	2	12
2	10/29/02	0	2	1
2	11/13/02	0	0	0
3	05/07/02	2	0	0

3	06/04/02	34	0	0
3	06/13/02	45	0	0
3	06/25/02	41	0	0
3	07/09/02	42	0	0
3	07/23/02	48	0	0
3	08/20/02	51	1	0
3	09/04/02	40	1	0
3	09/18/02	25	3	0
3	10/01/02	19	2	2
3	10/10/02	12	0	10
3	10/16/02	2	2	3
3	10/29/02	0	1	1
3	11/04/02	0	0	0
3	11/13/02	0	0	0
4	05/08/02	4	0	0
4	05/22/02	0	0	0
4	06/05/02	13	0	0
4	06/26/02	4	0	0
4	07/10/02	19	0	0
4	07/24/02	23	1	0
4	08/21/02	30	0	0
4	09/05/02	27	0	0
4	09/19/02	35	0	0
4	10/02/02	17	1	0
4	10/17/02	0	0	10
4	10/30/02	0	2	5
4	11/14/02	2	1	0
5	05/08/02	1	0	0
5	05/22/02	1	0	0
5	06/05/02	1	0	0
5	06/26/02	0	0	0
5	07/10/02	0	0	0
5	07/24/02	0	0	0
5	08/22/02	0	0	0
5	09/05/02	0	0	0
5	09/19/02	0	1	0
5	10/02/02	1	0	1
5	10/17/02	2	3	12
5	10/30/02	0	2	0
5	11/14/02	0	0	0
6	05/09/02	0	0	0
6	05/28/02	6	0	0
6	06/06/02	1	0	0
6	06/27/02	1	0	0
6	07/11/02	0	0	0

6	07/25/02	0	0	0
6	08/23/02	4	0	0
6	09/06/02	6	0	0
6	09/20/02	11	0	0
6	10/03/02	10	0	5
6	10/18/02	3	0	1
6	10/31/02	6	2	1
6	11/15/02	0	0	0
7	05/09/02	4	0	0
7	05/28/02	1	1	0
7	06/06/02	0	0	0
7	06/27/02	0	0	0
7	07/11/02	0	0	0
7	07/25/02	0	0	0
7	08/23/02	3	0	0
7	09/06/02	168	0	0
7	09/20/02	7500	0	0
		Totals	35	78

TABLE 11. Total number of live adult Chinook observed during the 2002 Battle Creek stream surveys. Returning Coleman Hatchery fall run Chinook in September are not counted in total. In addition to the below surveys, Reach 3 only was surveyed on October 10 (12 Chinook observed) and November 4 (zero Chinook observed).

Date	May	May	June	June	June	July	July	Aug.	Sept.	Sept.	Oct.	Oct.	Oct.	Nov.
Reach 1-7	6-9	22,23 & 28	3-6	10-13	24-27	8-11	22-25	19-23	3-6	17-20	28-03	16-21	28-31	12-15
1	0	1	0	0	0	0	0	0	1	0	0	0	0	0
2	0	0	2	0	1	0	0	0	0	1	7	1	0	0
3	2	X	34	39	41	42	48	51	40	25	19	2	0	0
4	4	0	13	X	4	19	23	30	27	35	17	0	0	2
5	1	1	1	X	0	0	0	0	0	0	1	2	0	0
6	0	6	1	X	1	0	0	4	6	11	10	3	6	0
7	4	1	0	X	0	0	0	3	168	7500	X	X	X	X
Total	11		51		47	61	71	88	74	72	54	8	6	2

TABLE 12. Rainbow trout / steelhead observed during the 2002 Battle Creek stream survey. Size categories are as follows: small fish bear parr marks and are older than young-of-the-year. Medium fish lack parr marks and are less than 22 inches in length. Large fish are greater than 22 inches.

Reach	Date	Small	Medium	Large	Total
1	05/06/02	297	7	0	304
1	05/23/02	419	26	0	445
1	06/03/02	176	5	0	181
1	06/10/02	411	64	0	472
1	06/24/02	200	70	0	270
1	07/08/02	574	56	1	631
1	07/22/02	793	194	0	987
1	08/19/02	561	168	0	632
1	09/03/02	413	211	0	624
1	09/17/02	965	285	0	1250
1	09/30/02	374	82	0	456
1	10/21/02	379	107	0	486
1	10/28/02	544	420	0	964
1	11/12/02	179	27	1	207
2	05/07/02	151	18	0	169
2	05/23/02	164	14	0	178
2	06/04/02	176	29	0	205
2	06/12/02	305	57	0	362
2	06/25/02	275	72	0	347
2	07/09/02	410	104	0	514
2	07/23/02	335	113	2	450
2	08/20/02	324	89	0	413
2	09/04/02	472	242	0	714
2	09/18/02	1216	226	0	1442
2	10/01/02	428	75	0	503
2	10/16/02	1081	351	0	1432
2	10/29/02	805	179	0	984
2	11/13/02	168	14	0	182
3	05/07/02	104	51	0	155
3	06/04/02	-	20	0	20
3	06/13/02	-	16	2	18
3	06/25/02	-	20	0	20
3	07/09/02	-	15	5	20
3	07/23/02	-	32	0	32
3	08/20/02	-	43	0	43
3	09/04/02	-	50	0	50
3	09/18/02	-	54	0	54
3	10/01/02	-	59	0	59
3	10/10/02	-	0	0	0
3	10/16/02	-	10	0	10

3	10/29/02	-	0	0	0
3	11/04/02	-	10	2	12
3	11/13/02	0	0	0	0
4	05/08/02	146	81	0	227
4	05/22/02	12	5	0	17
4	06/05/02	161	150	4	315
4	06/26/02	253	339	3	595
4	07/10/02	227	453	10	690
4	07/24/02	422	447	**na**	869
4	08/21/02	473	540	0	1013
4	09/05/02	493	394	5	892
4	09/19/02	431	238	1	670
4	10/02/02	760	718	3	1481
4	10/17/02	360	243	8	611
4	10/30/02	361	233	0	594
4	11/14/02	366	179	2	547
5	05/08/02	47	31	0	78
5	05/22/02	10	3	0	13
5	06/05/02	89	92	0	181
5	06/26/02	67	52	4	123
5	07/10/02	158	156	3	317
5	07/24/02	151	225	0	376
5	08/22/02	189	156	0	345
5	09/05/02	174	177	0	351
5	09/19/02	272	252	2	526
5	10/02/02	241	240	0	481
5	10/17/02	222	103	0	325
5	10/30/02	74	75	0	149
5	11/14/02	121	33	4	158
6	05/09/02	11	18	0	29
6	05/28/02	6	11	0	17
6	06/06/02	28	11	0	39
6	06/27/02	19	11	0	30
6	07/11/02	23	30	0	53
6	07/25/02	73	29	0	102
6	08/23/02	25	27	0	52
6	09/06/02	64	34	0	98
6	09/20/02	45	30	0	75
6	10/03/02	60	83	0	143
6	10/18/02	39	25	2	66
6	10/31/02	14	21	3	38
6	11/15/02	15	4	30	49
7	05/09/02	8	17	3	28
7	05/28/02	1	1	5	7
7	06/06/02	2	5	0	7

7	06/27/02	0	21	4	25
7	07/11/02	14	14	16	44
7	07/25/02	51	33	25	109
7	08/23/02	49	37	7	93
7	09/06/02	40	68	31	139
7	09/20/02	7	30	13	50

TABLE 13. Rainbow trout / steelhead totals by month and by reach (all sizes) for the 2002 Battle Creek stream snorkel survey.

Date Reach 1-7	May 6-9	May 22,23 & 28	June 3-6	June 10-13	June 24-27	July 8-11	July 22-25	Aug. 19-23	Sept. 3-6	Sept. 17-20	Oct. 28-03	Oct. 16-21	Oct. 28-31	Nov. 12-15	Mean Totals
1	304	445	181	472	270	321	987	632	624	NU	456	486	NU	207	384.64
2	169	178	205	362	347	514	450	413	714	NU	503	NU	984	182	358.64
4	227	17	315	NA	595	690	869	1013	892	670	NU	611	594	547	541.54
5	78	13	181	NA	123	317	376	345	351	NU	481	325	149	158	222.85
6	29	17	39	NA	30	53	102	52	98	75	143	66	38	49	60.85
7	28	7	7	NA	25	44	109	93	139	50	NA	NA	NA	NA	55.78
Total	835	677	928	NA	1390	1939	2893	2548	2818	2219		2362		1143	1624.3

NA (not available) due to the reach not being surveyed
NU (Not used) for totals due to not passing quality control. Totals for these weeks are composites of two surveys.

TABLE 14. Comparison of 2001 and 2002, percent of time that South Fork water temperatures met Restoration Plan thermal criteria.

2001 number of days (percent)	Good	Fair	Poor	Very Poor	Ave Flow
Holding					
Coleman Dam	73 (60%)	49 (40%)	0	0	7cfs
Manton Bridge	12 (10%)	46 (38%)	58 (48%)	0	7cfs
Egg Incubation					
Coleman Dam	41 (87%)	6 (13%)	0	0	8cfs
Manton Bridge	27 (57%)	7 (15%)	7 (15%)	6 (13%)	8cfs
2002 number of days (percent)					
Holding					
Coleman Dam	52 (43%)	70 (57%)	0	0	16cfs
Manton Bridge	32 (26%)	71 (58%)	19 (16%)	0	16cfs
Egg Incubation					
Coleman Dam	42 (89%)	5 (11%)	0	0	19cfs
Manton Bridge	34 (72%)	11 (23%)	2 (4%)	0	19cfs

TABLE 15. Comparison of 2001 and 2002, average temperatures and flows during the holding and egg incubation time periods, on the North and South Forks of Battle Creek.

LOCATION	2001	2002
	°F (cfs)	°F (cfs)
Coleman Dam (SF)		
Holding (June 1-Sept 30)	60.6 (7)	60.9 (16)
Egg Incubation (Sept 15-Oct 31)	55.7 (8)	54.5 (19)
Manton Bridge (SF)		
Holding (June 1-Sept 30)	65.6 (7)	63.1 (16)
Egg Incubation (Sept 15-Oct 31)	57.9 (8)	55.1 (19)
Wildcat Road (NF)		
Holding (June 1-Sept 30)	62.2 (41)	62.7 (38)
Egg Incubation (Sept 15-Oct 31)	57.0 (43)	55.9 (37)
Eagle Canyon Dam (NF)		
Holding (June 1-Sept 30)	58.2 (41)	58.1 (38)
Egg Incubation (Sept 15-Oct 31)	55.3 (43)	54.5 (37)

TABLE 16. Comparison of adult Chinook, redds, and carcasses during snorkel surveys in 2001 and 2002.

2001 Number (Percent)	**North Fork**	**South Fork**	**Mainstem**
Adults During Holding	0 (0%)	17 (63%)	10 (37%)
Adults During Spawning	2 (7%)	13 (46.5%)	13 (46.5%)
Redds	11 (34.5%)	12 (37.5%)	9 (28%)
Carcasses	0 (0%)	6 (75%)	2 (25%)

2002 Number (Percent)	**North Fork**	**South Fork**	**Mainstem**
Adults During Holding	0 (0%)	51 (58%)	37 (42%)
Adults During Spawning	7 (13%)	19 (34%)	29 (53%)
Redds	27 (34.5%)	16 (20.5%)	35 (45%)
Carcasses	11 (31%)	10 (29%)	14 (40%)

Figures

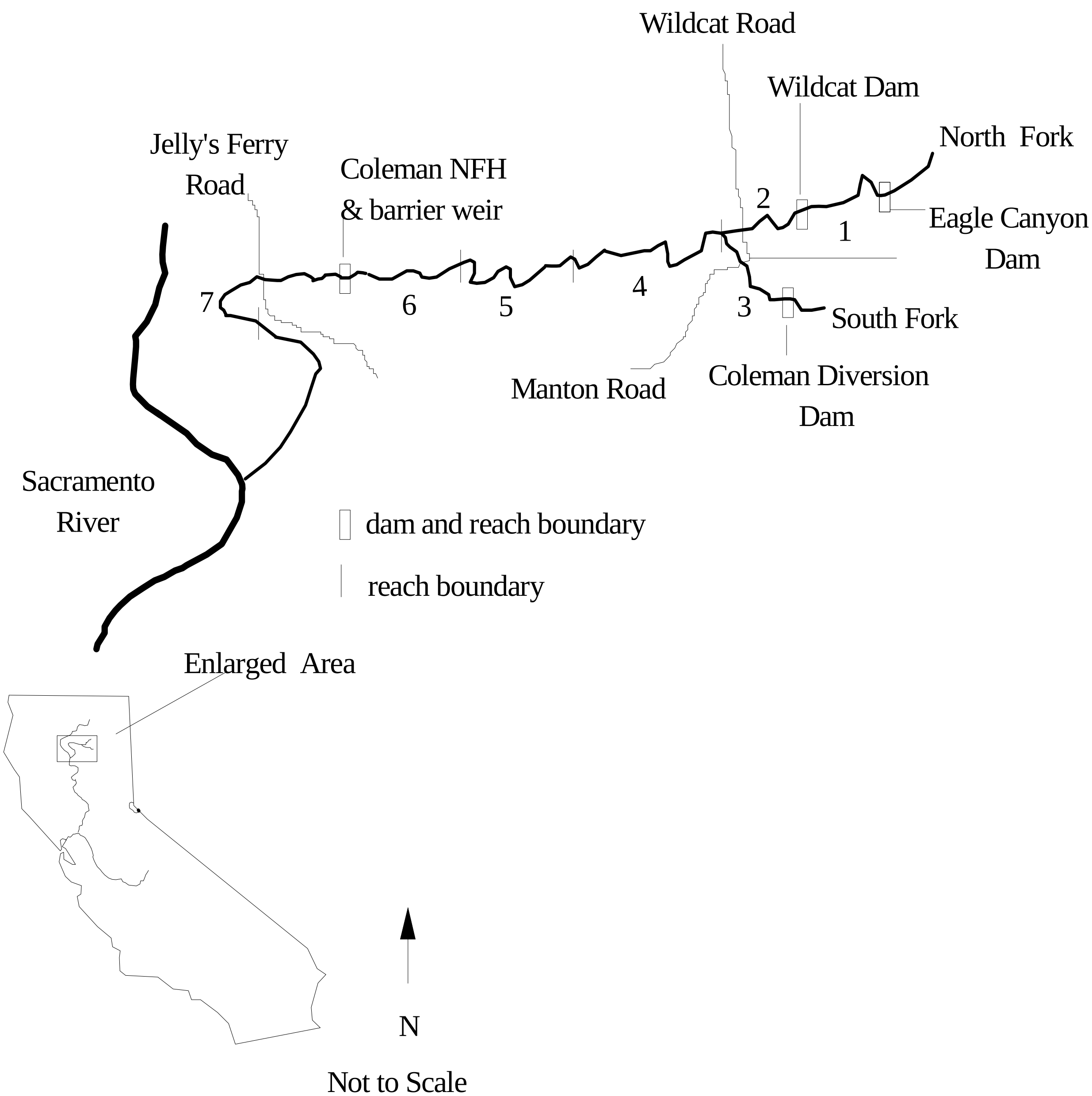

FIGURE 1. Map of Battle Creek depicting location of the Coleman National Fish Hatchery barrier weir and stream survey reaches for 2002.

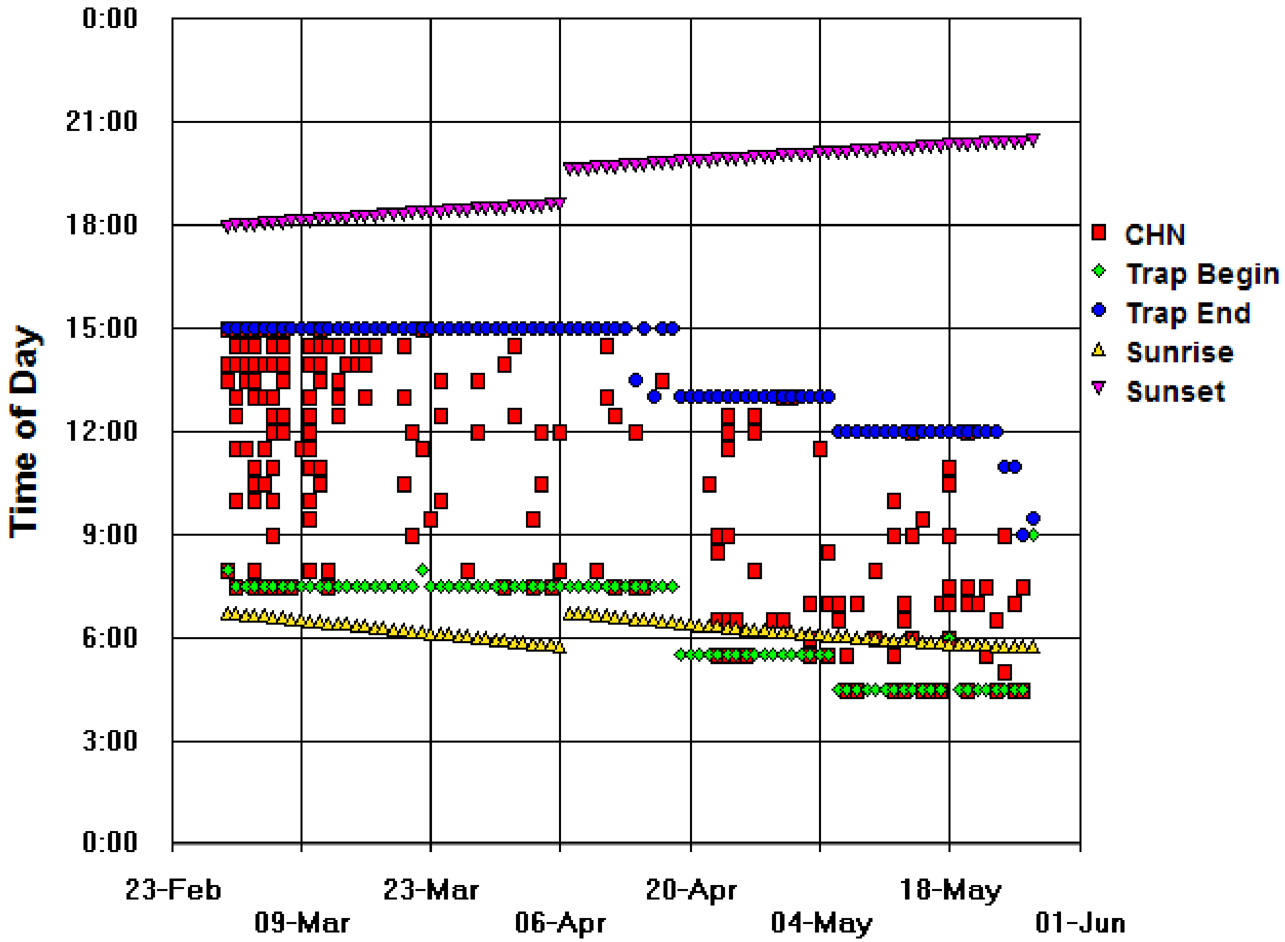

FIGURE 2. Diel timing of Chinook passing the Battle Creek barrier weir during trapping in 2002.

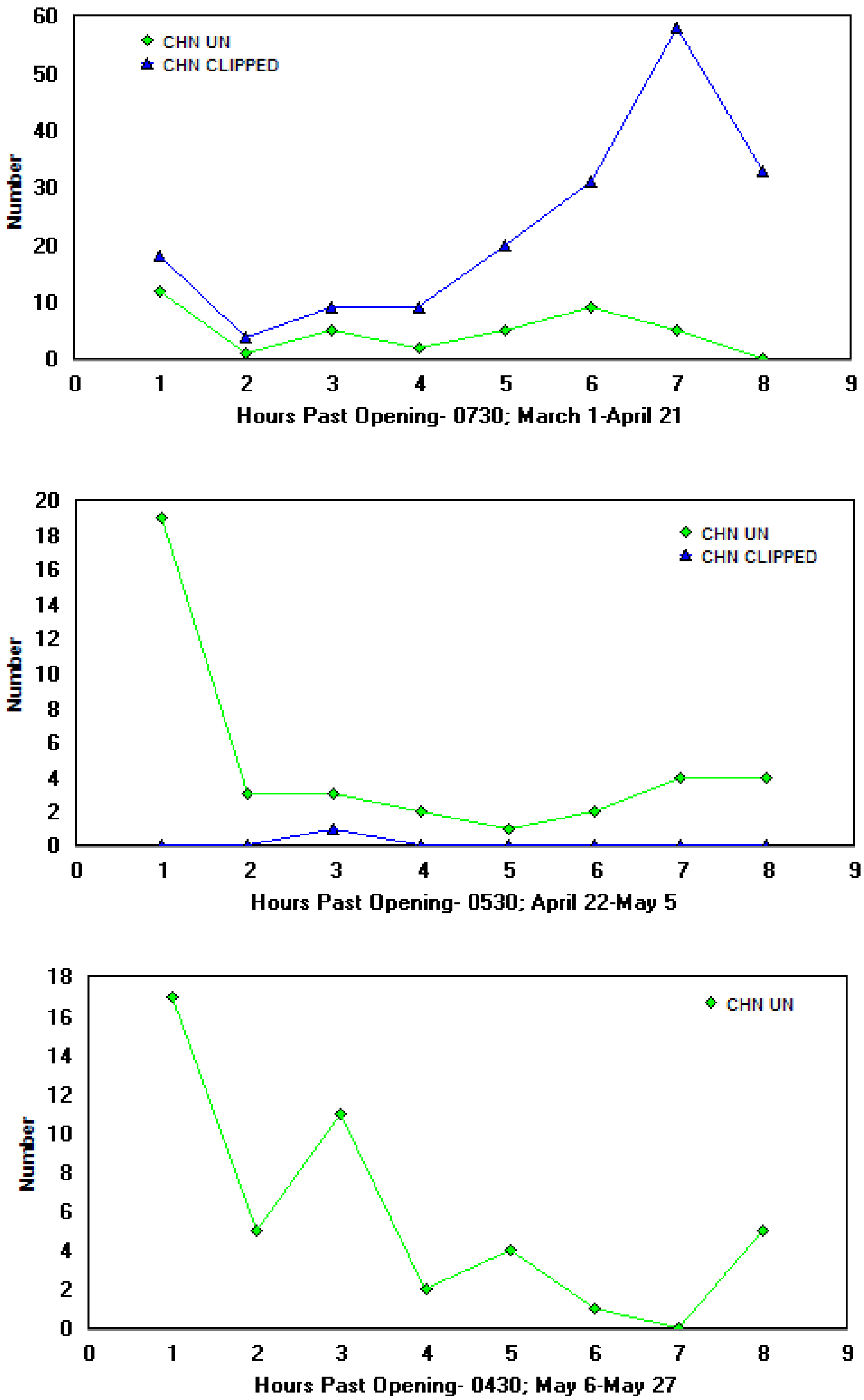

FIGURE 3. Adjusted time frequency of Chinook captured at weir trap reflects the hourly rate of capture. Three graphs represent three different start times. Start times were shifted to capture earlier passing Chinook. In addition these earlier times coincided with lower water temperatures.

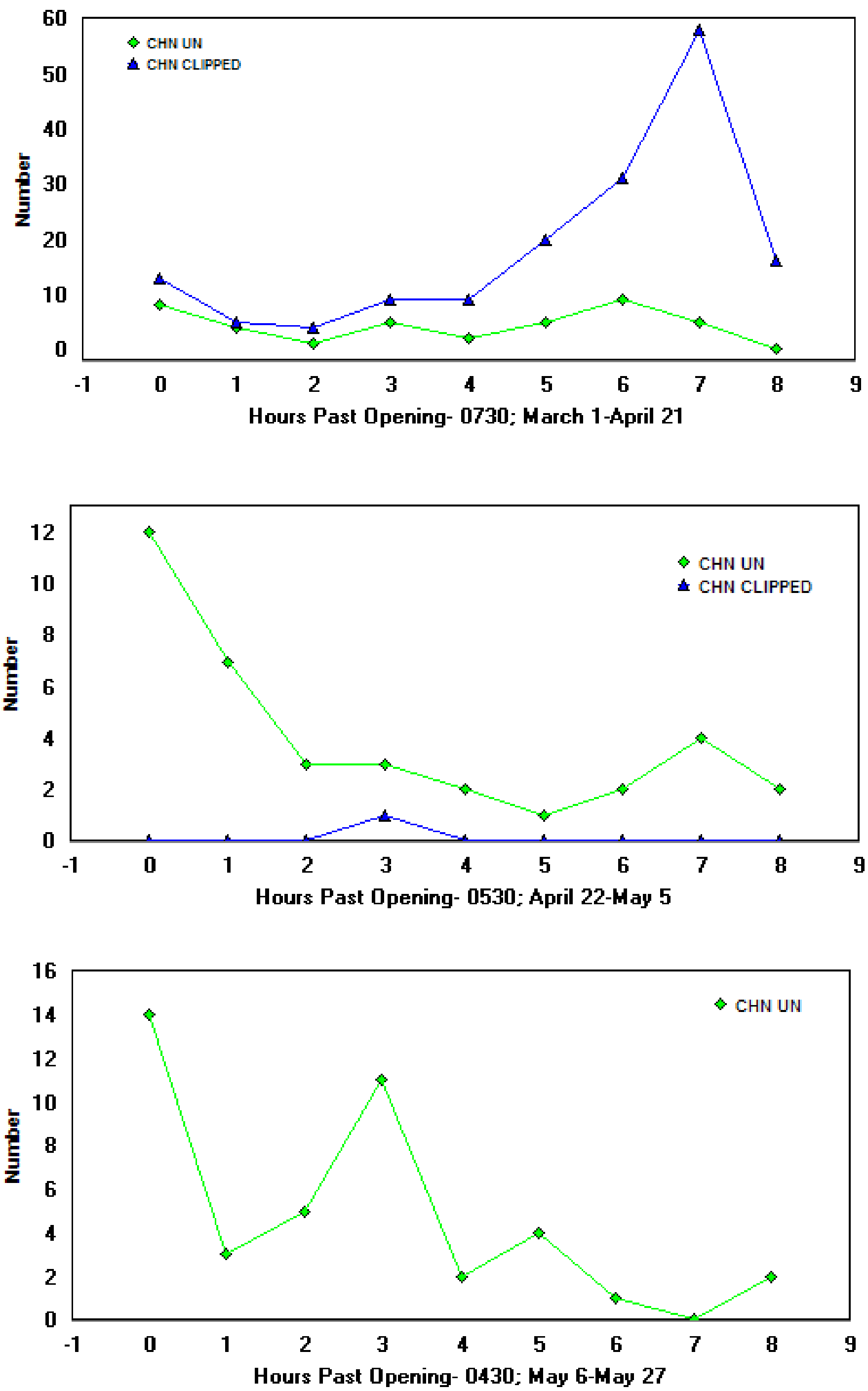

FIGURE 4. Time frequency of Chinook captured at weir trap. Three graphs represent three different start times. Start times were shifted to capture earlier passing Chinook. In addition these earlier times coincided with lower water temperatures.

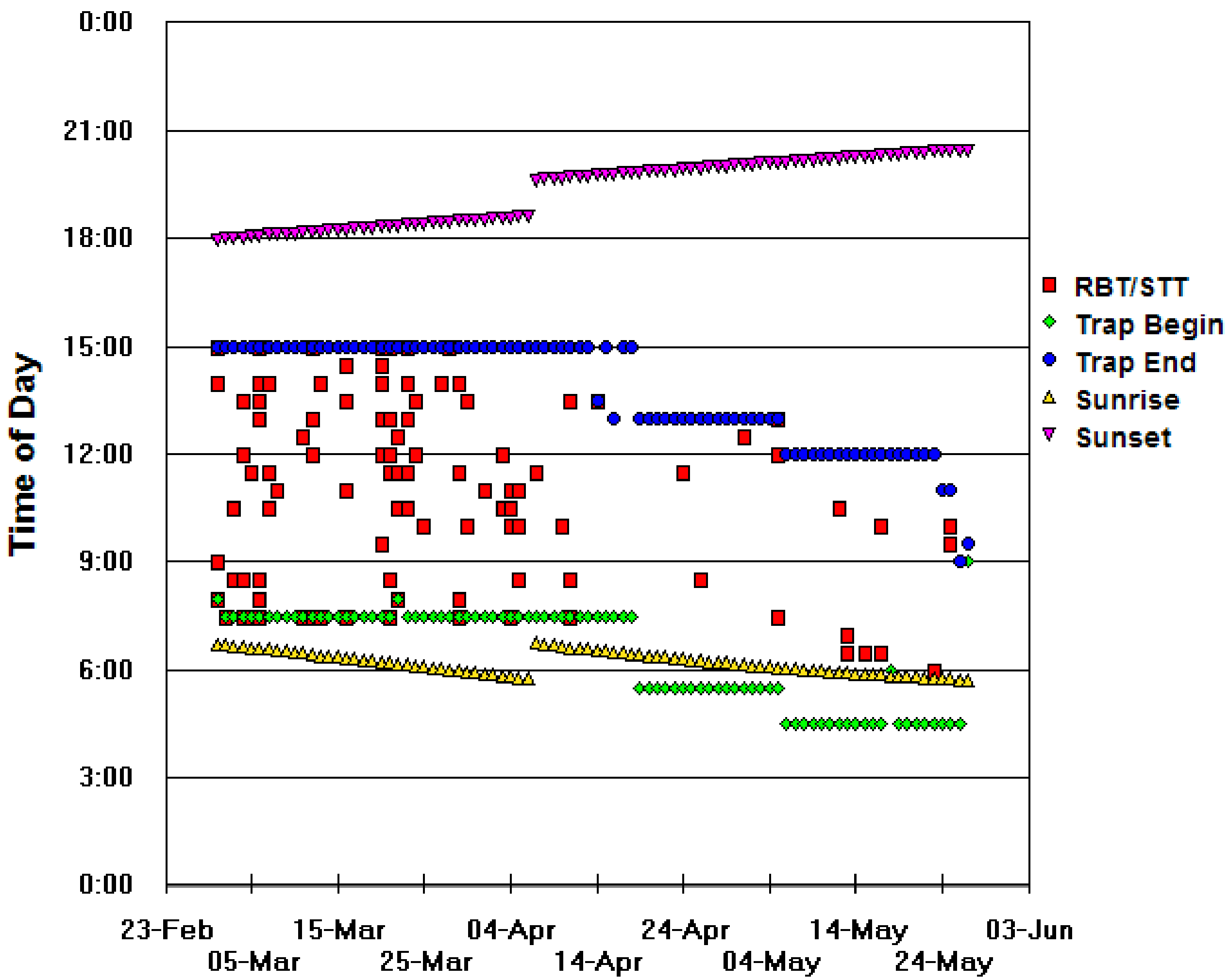

FIGURE 5. Diel timing of rainbow trout passing the Battle Creek barrier weir during trapping in 2002.

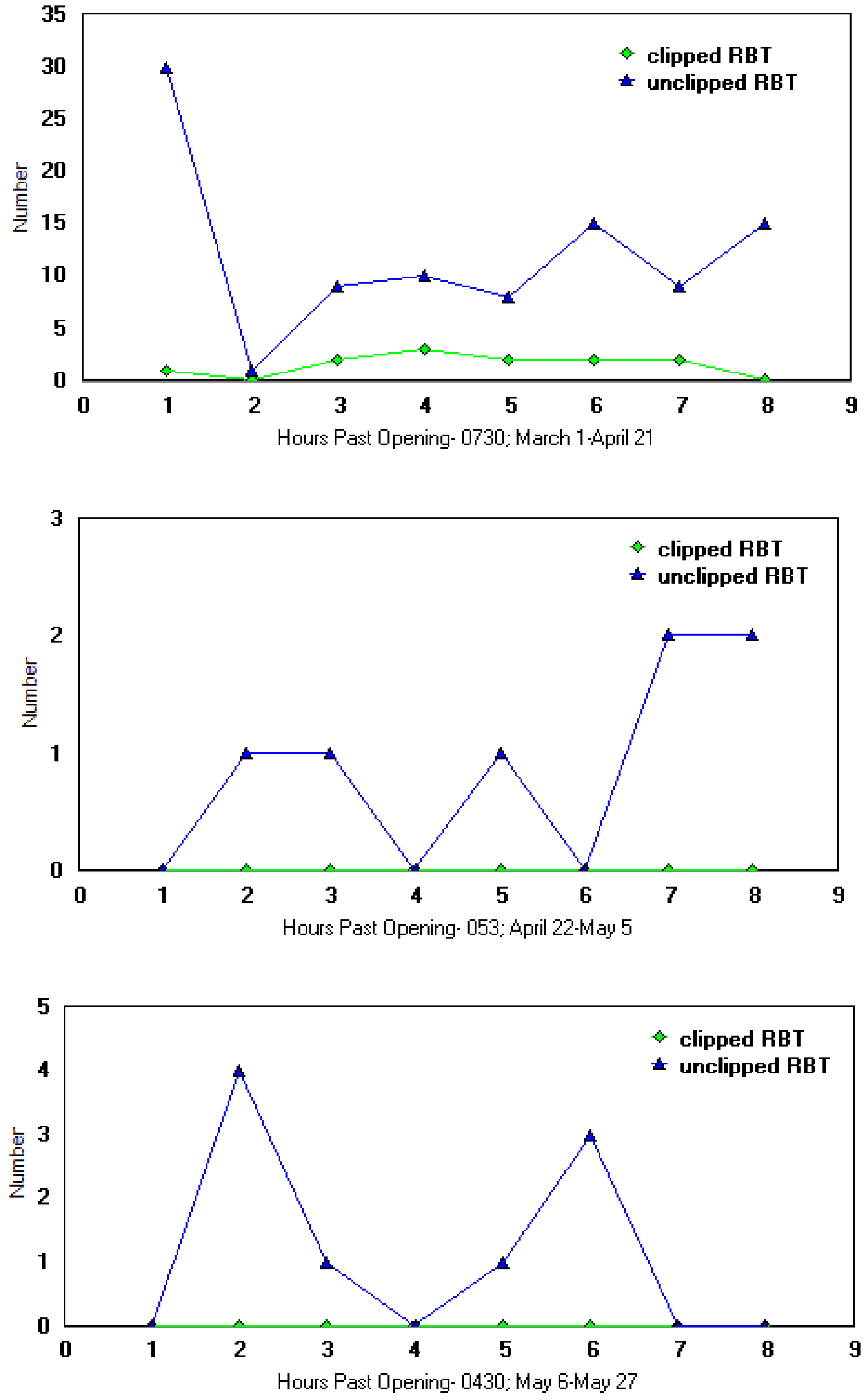

FIGURE 6. Adjusted time frequency of rainbow trout captured at weir trap reflects the hourly rate of capture. Three graphs represent three different start times. Start times were shifted to capture earlier passing rainbow trout. In addition these earlier times coincided with lower water temperatures.

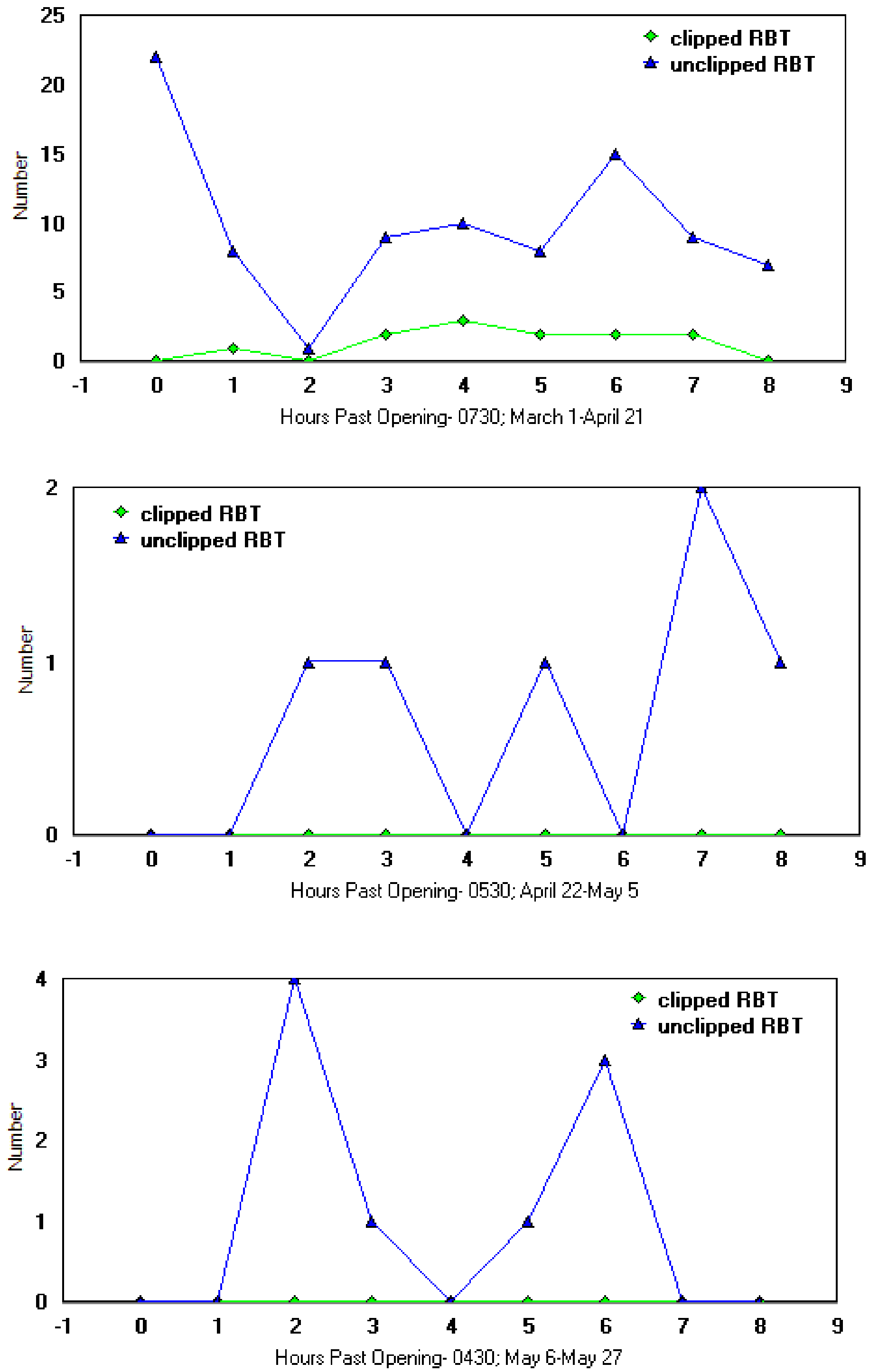

FIGURE 7. Time frequency of rainbow trout captured at weir trap. Three graphs represent three different start times. Start times were shifted to capture earlier passing rainbow trout. In addition these earlier times coincided with lower water temperatures.

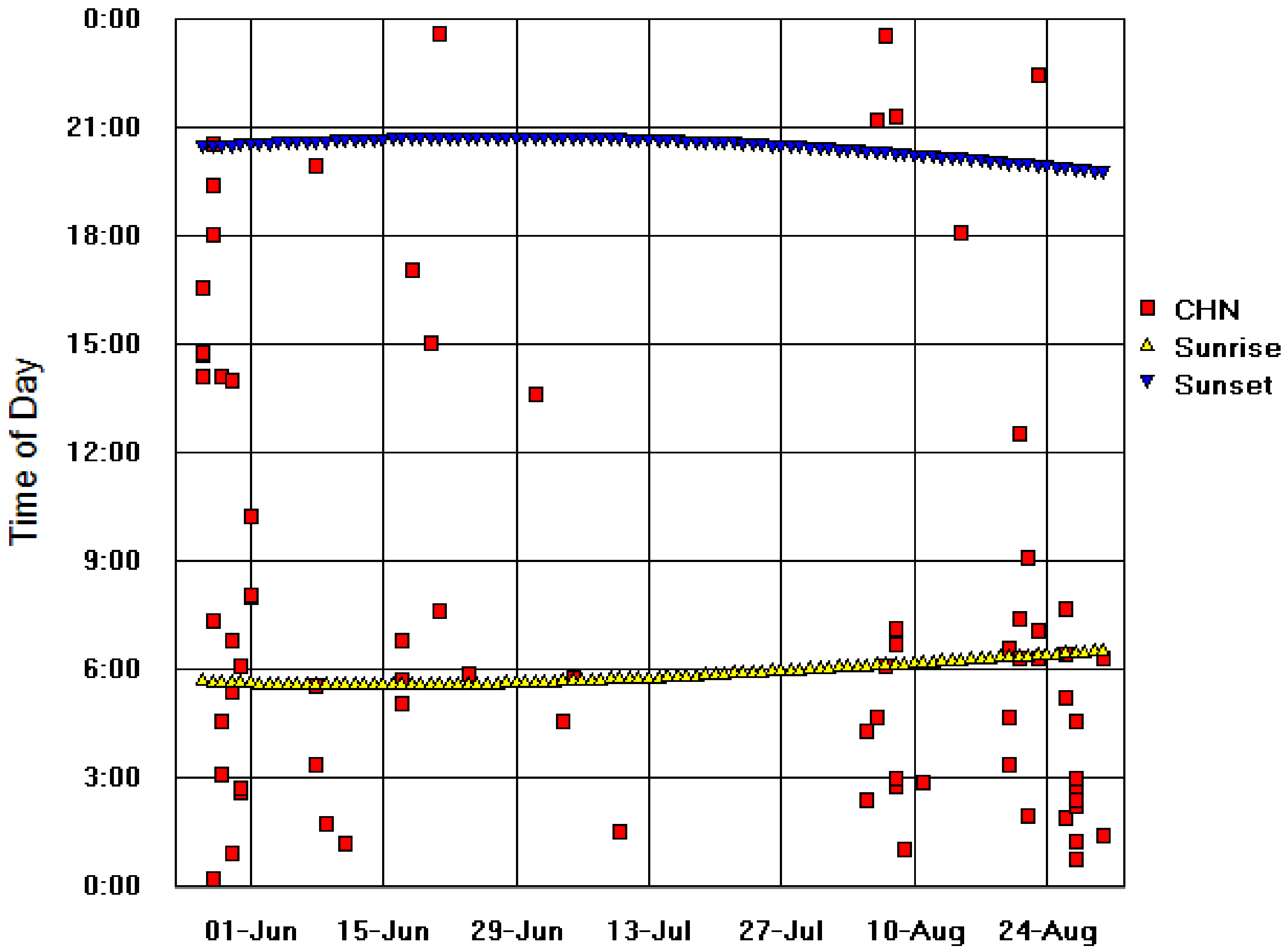

FIGURE 8. Diel migration timing of Chinook videotaped passing Battle Creek barrier weir in 2002.

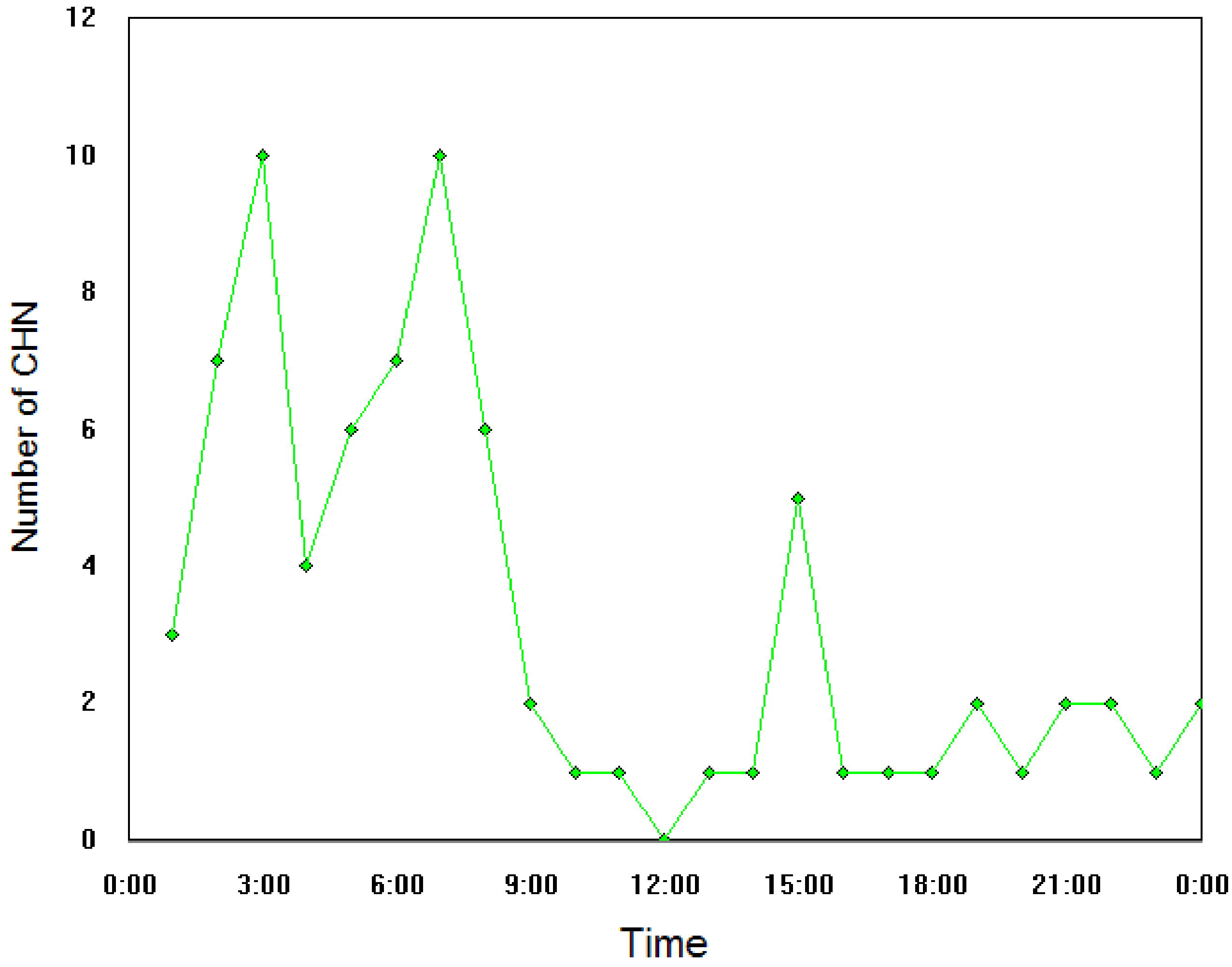

FIGURE 9. Time of day Chinook passed during underwater video monitoring.

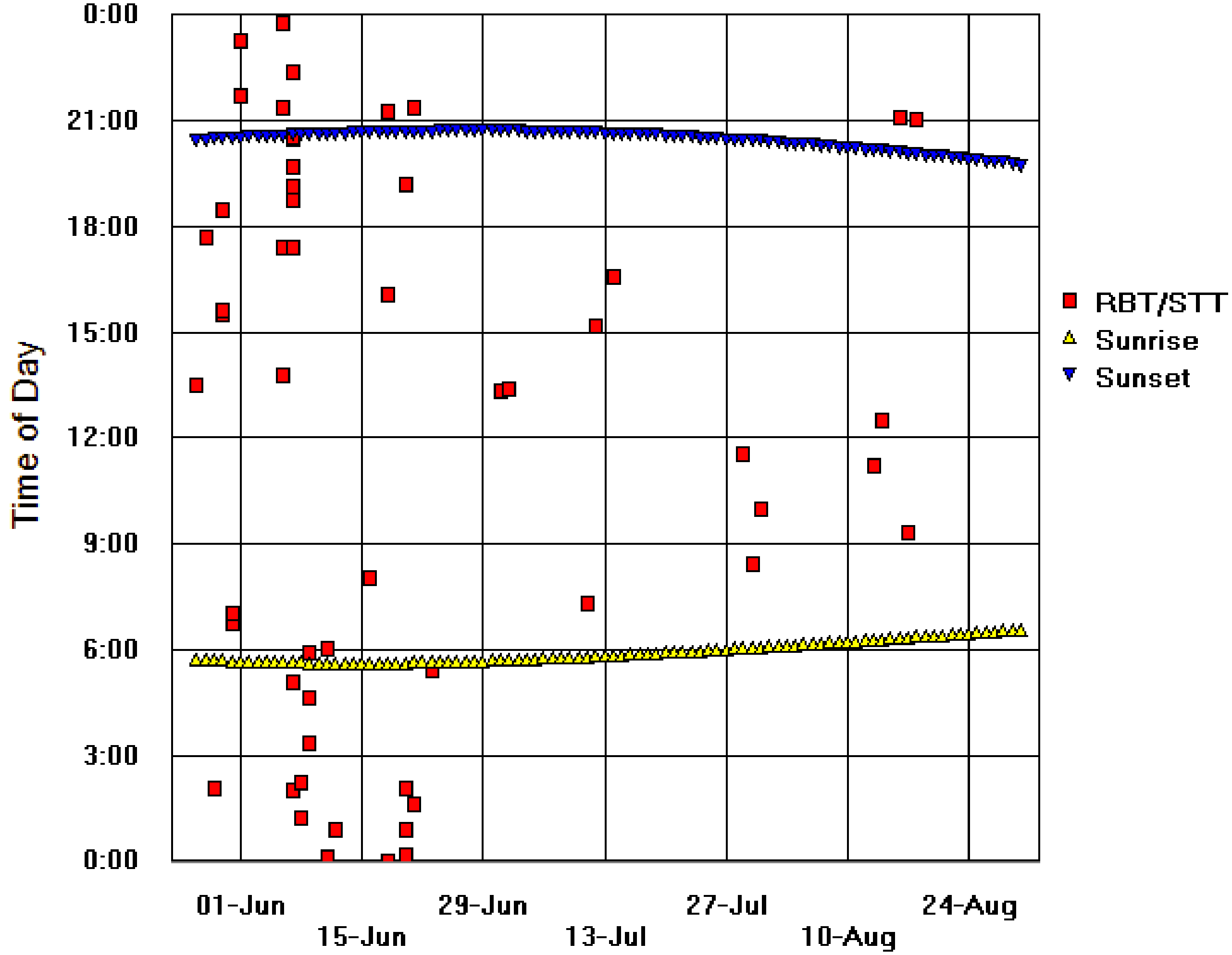

FIGURE 10. Diel migration timing of rainbow trout videotaped passing Battle Creek barrier weir in 2002.

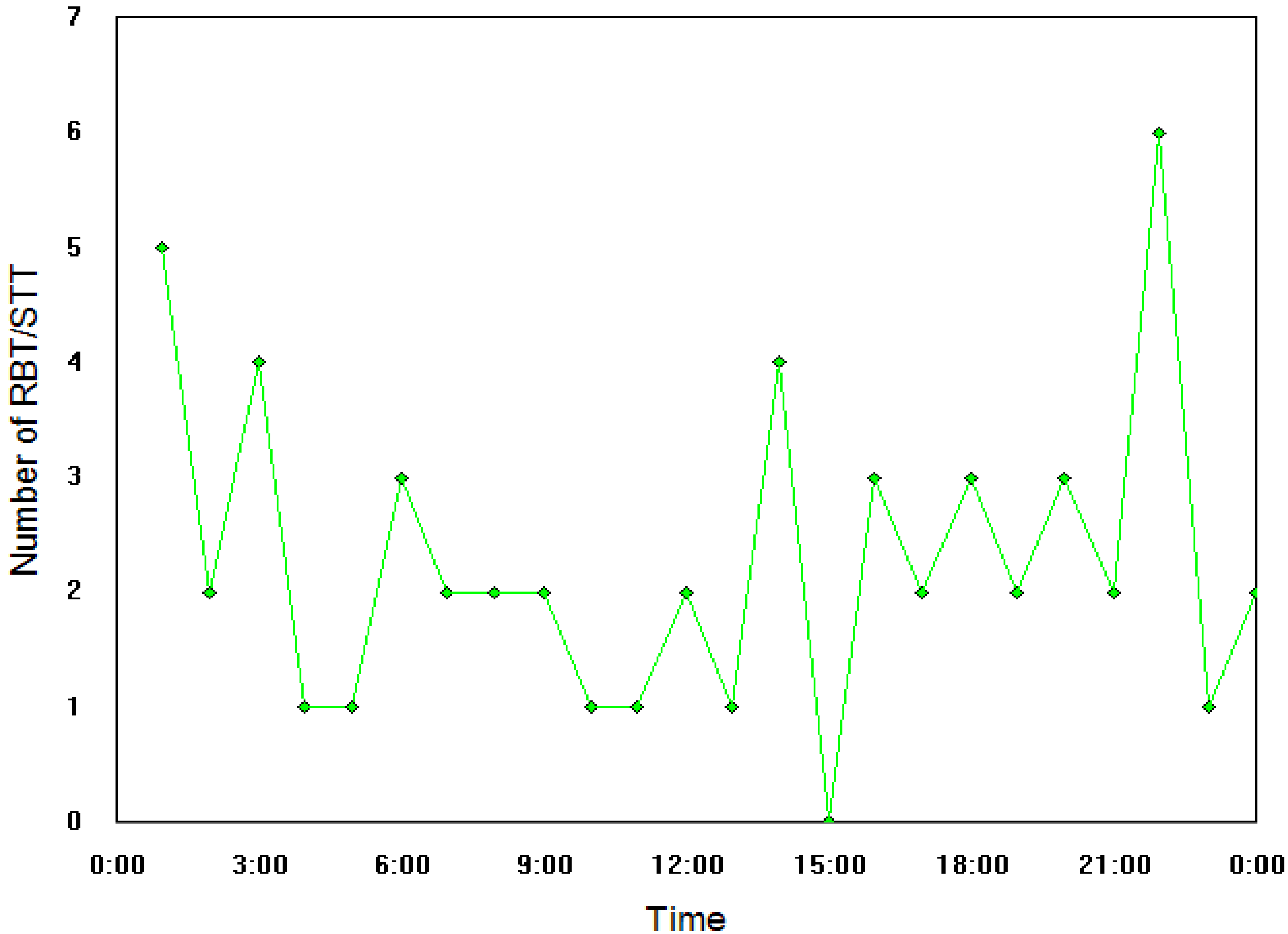

FIGURE 11. Time of day rainbow trout passed during underwater video monitoring.

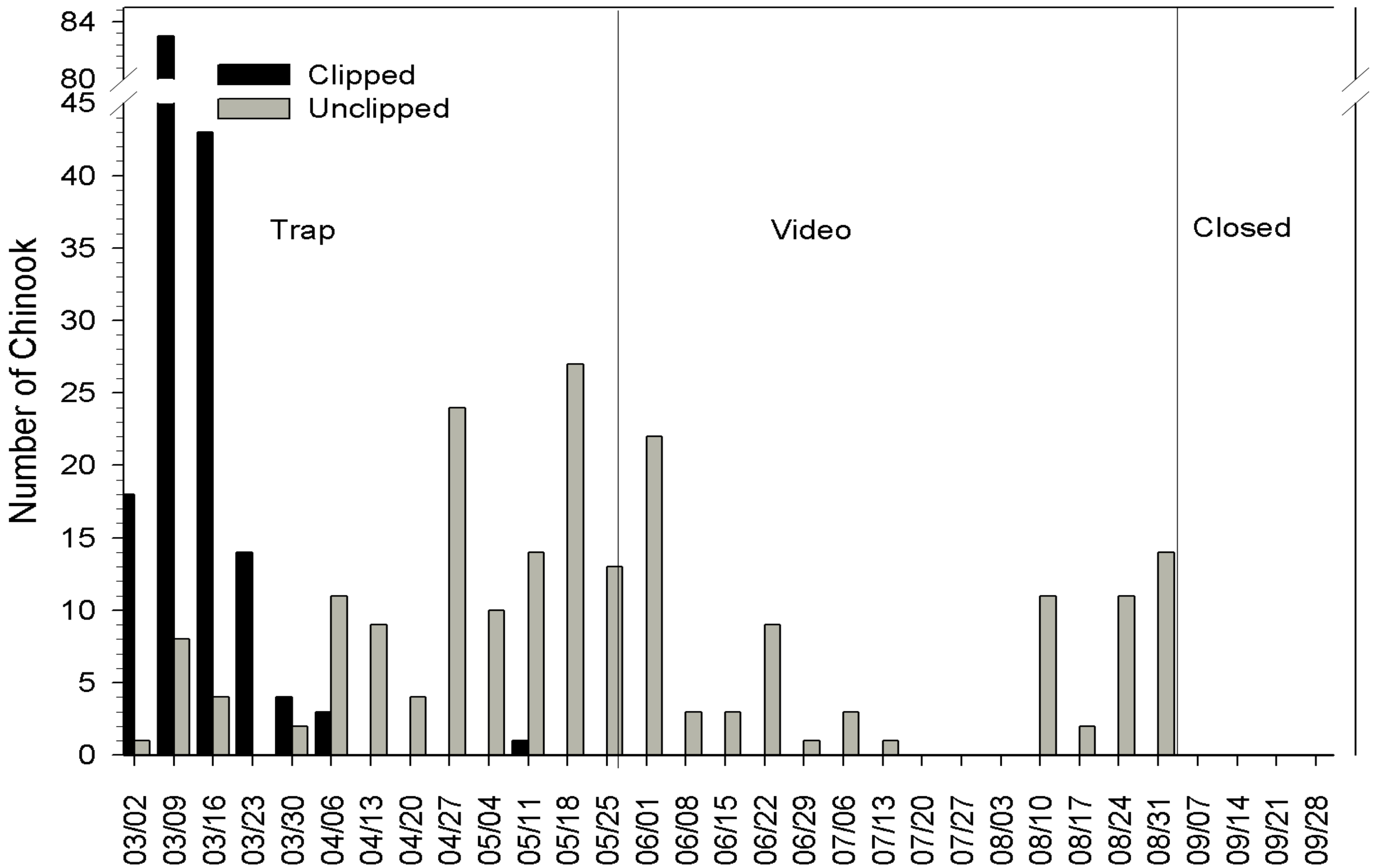

FIGURE 12. Clipped and unclipped Chinook observed passing through Battle Creek weir fish ladder in 2002.

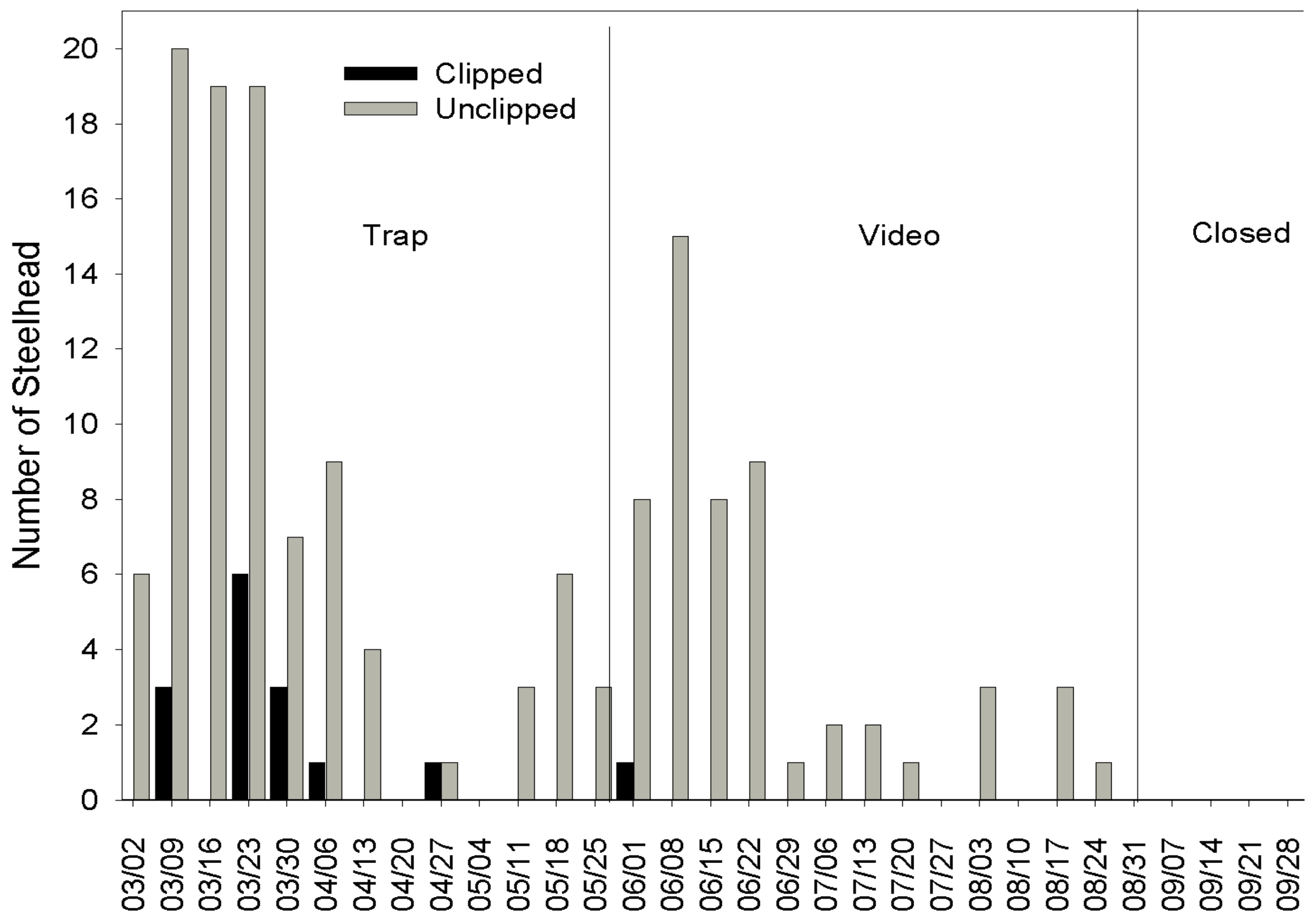

FIGURE 13. Clipped and unclipped rainbow trout observed passing through Battle Creek weir fish ladder in 2002.

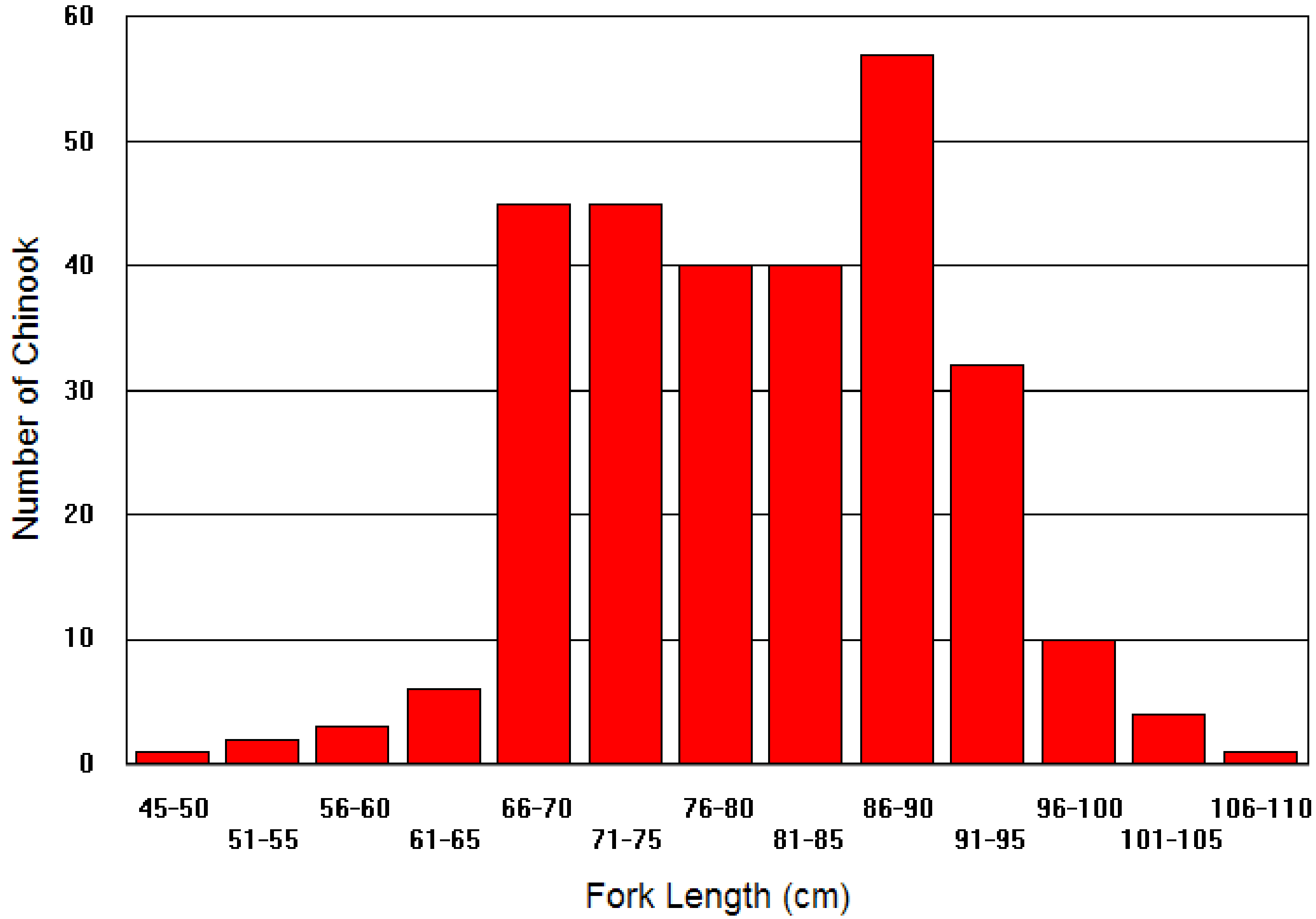

FIGURE 14. Length frequency distribution of Chinook captured in the Battle Creek barrier weir trap in 2002.

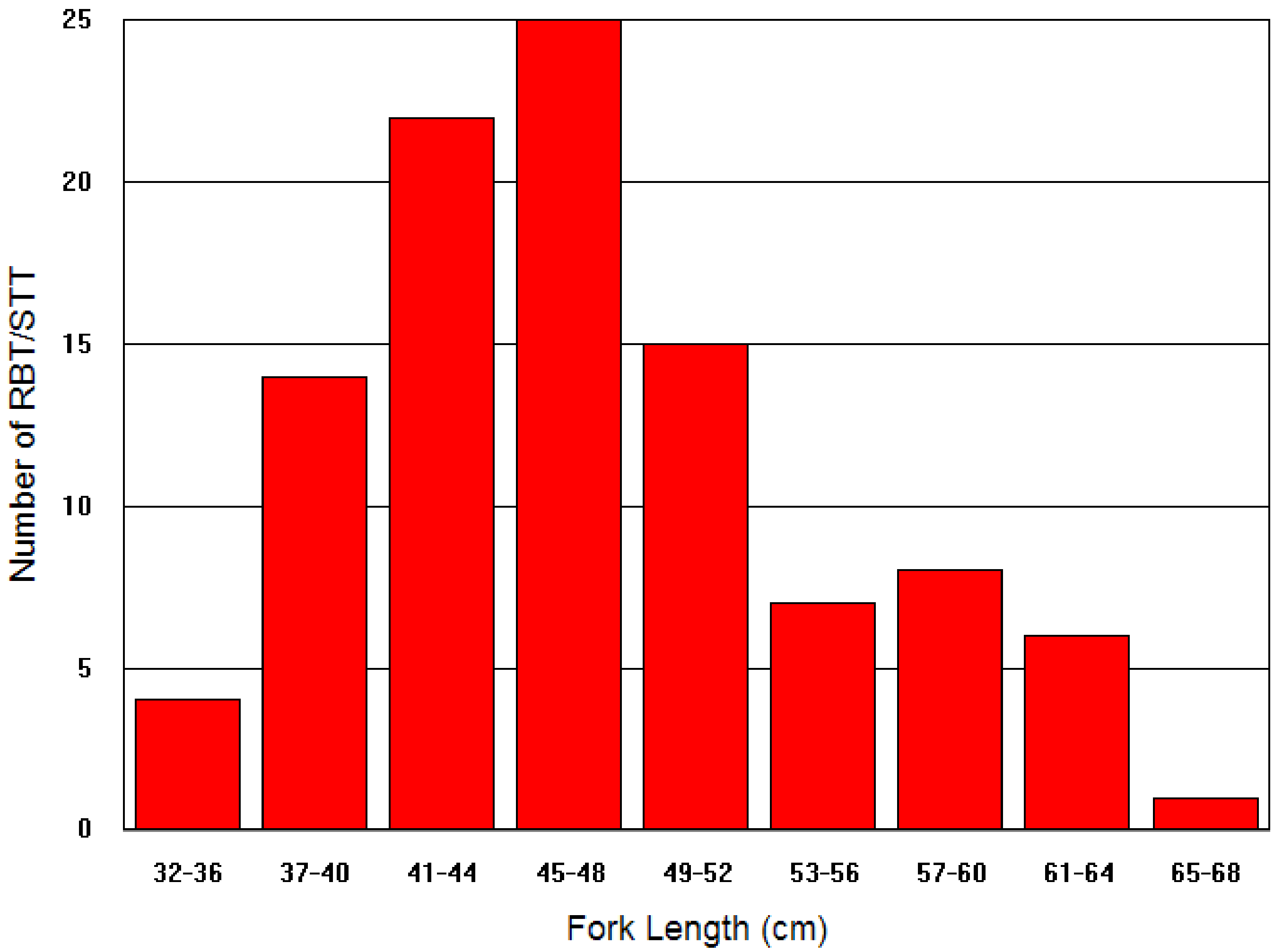

FIGURE 15. Length frequency distribution of rainbow trout captured in the Battle Creek barrier weir trap in 2002.

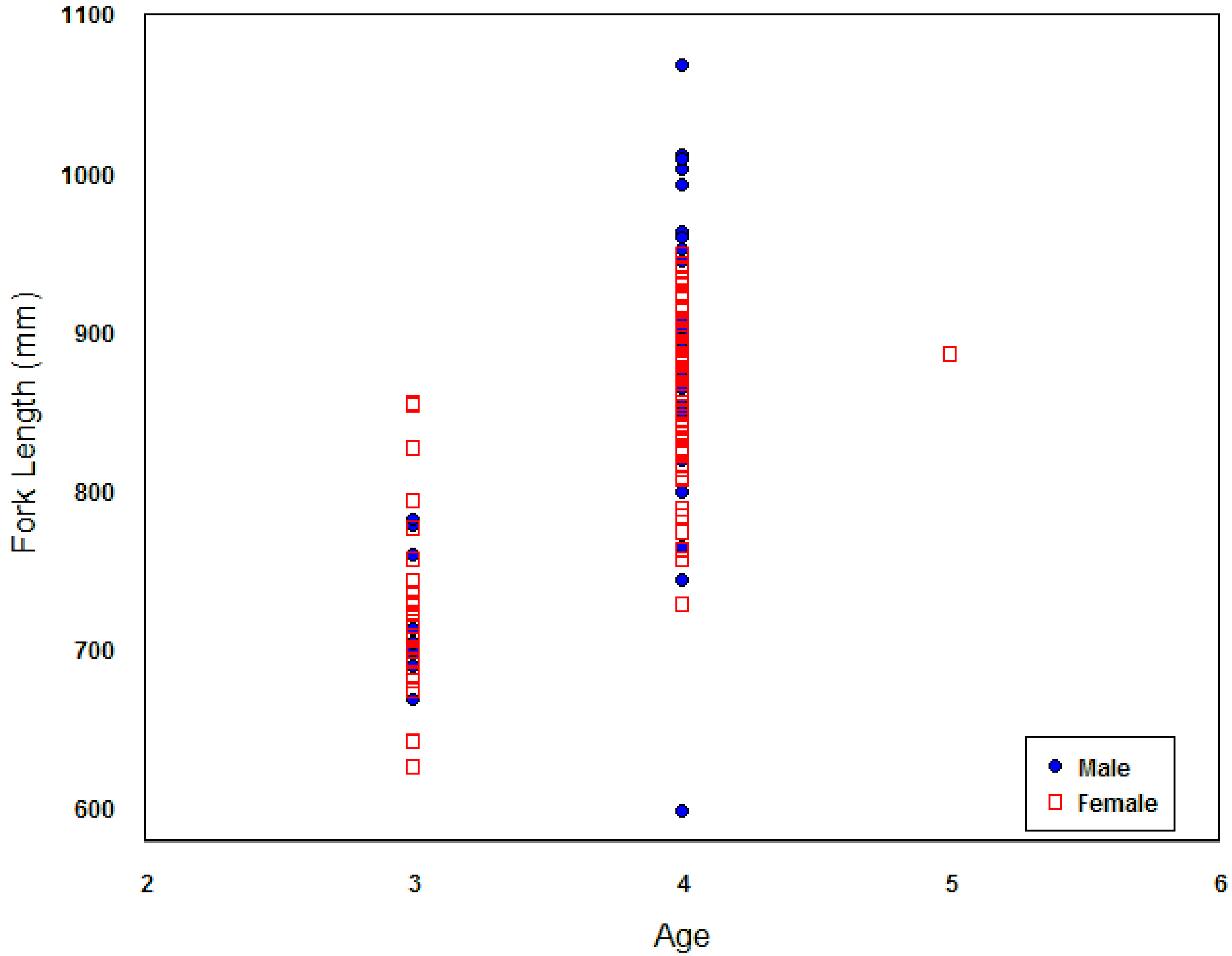

FIGURE 16. Relationship between fork length and age for coded-wire tagged Chinook captured in the Battle Creek barrier weir fish trap in 2002.

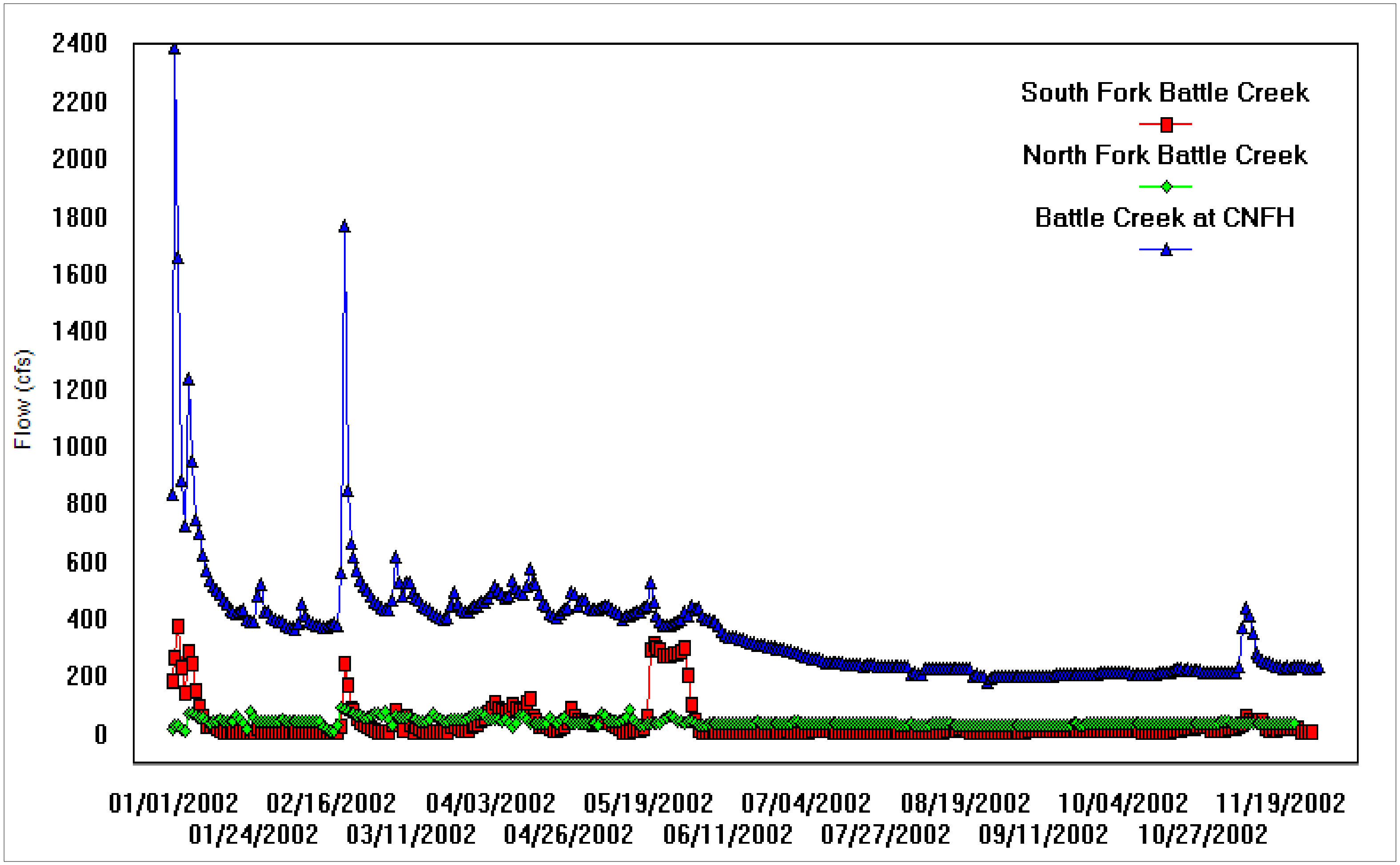

FIGURE 17. Mean daily flows at Battle Creek barrier weir (mainstem rm 5.8), Wildcat Road Bridge (North Fork rm 0.9), and Manton Road Bridge (South Fork rm 1.7) for water year 2002.

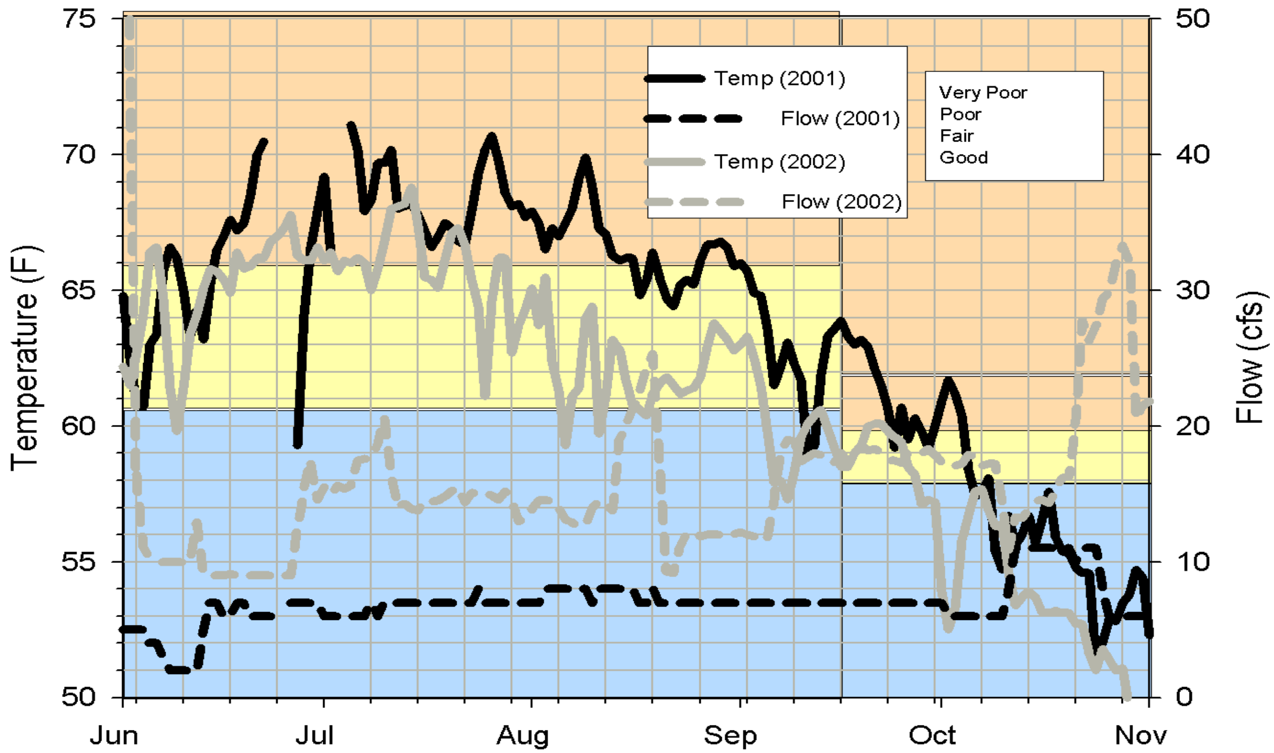

FIGURE 18. Benefits of increased flows in the South Fork Battle Creek.

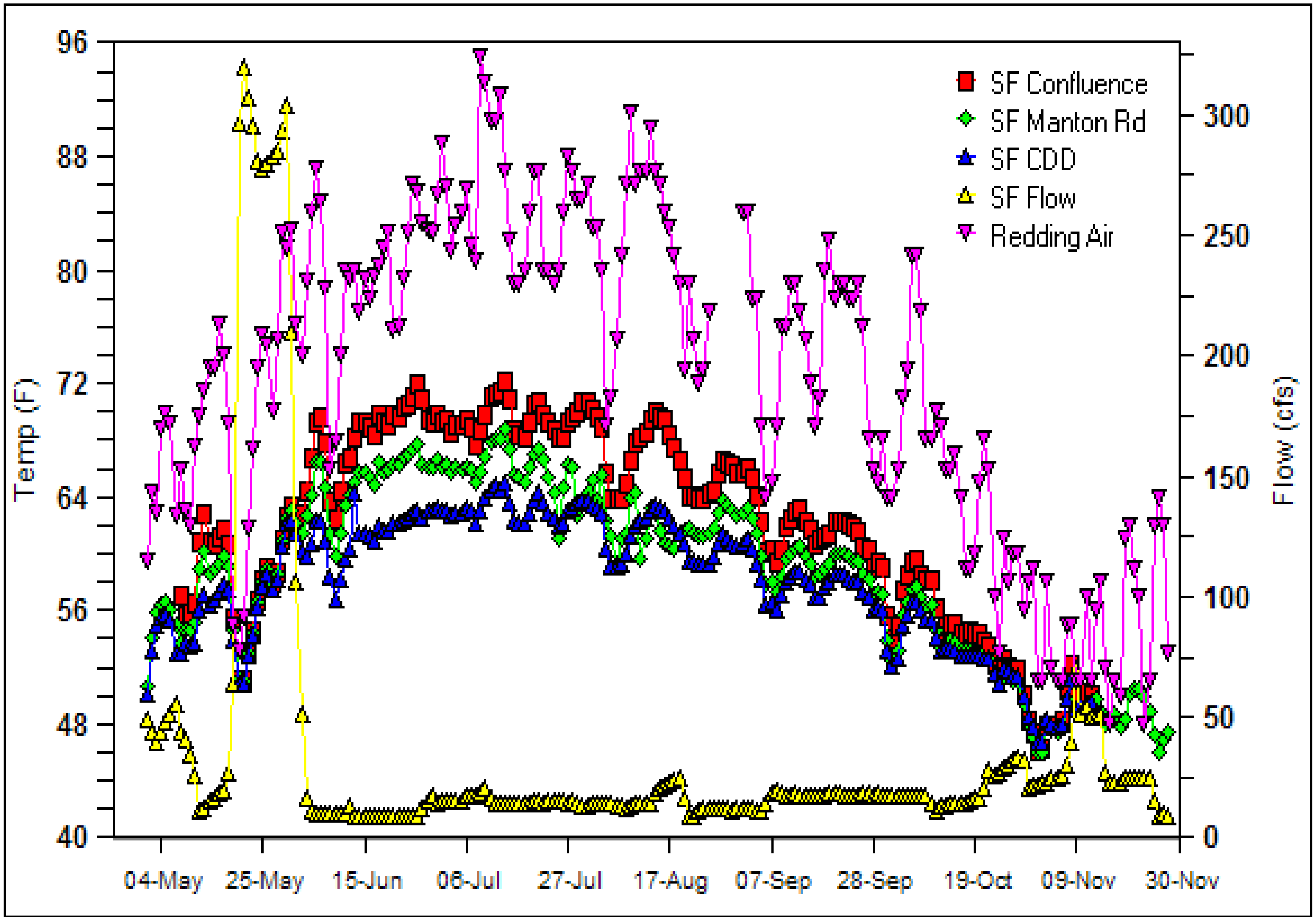

FIGURE 19. South Fork Battle Creek mean daily flows at Manton Road Bridge (rm 1.7) and mean daily water temperatures at South Fork Confluence, Manton Road Bridge, and South Fork Coleman Diversion Dam during 2002.

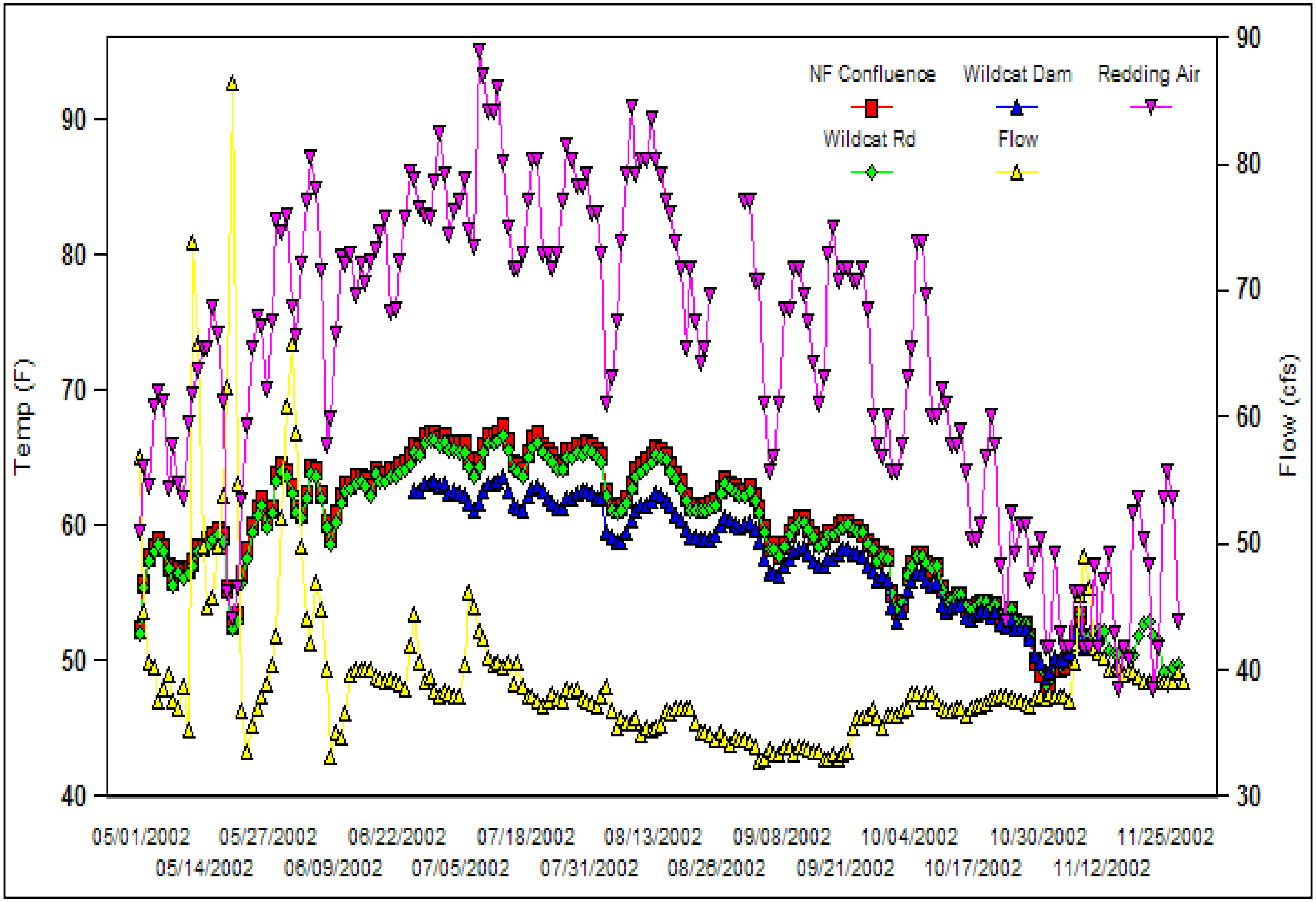

FIGURE 20. North Fork Battle Creek mean daily flows at Wildcat Road Bridge (rm 0.9) and mean daily water temperatures at Wildcat Dam and North Fork Confluence during 2002.

Appendices

APPENDIX A. Coded-wire tags recovered during Battle Creek adult Chinook monitoring activities in 2002.

Collection date	Collection location	Species	Sex	Fork length (mm)	Tag code	Hatchery of origin	Run	Brood year
03/01/02	Barrier Weir	Chinook	F	833	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	863	054128	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	865	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	695	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	850	052313	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	783	055210	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	900	052319	CNFH	Late-Fall	1998
03/02/02	Barrier Weir	Chinook	M	865	052311	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	886	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	755	*052310/ 055212	CNFH	Late-Fall	*1998/ 1999
	Barrier Weir	Chinook	F	904	*052310/ 052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	883	*052316/ 052315	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	915	*052310/ 055213	CNFH	Late-Fall	*1998/ 1999
03/03/02	Barrier Weir	Chinook	F	825	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	854	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	705	055211	CNFH	Late-Fall	1999

	Barrier Weir	Chinook	F	910	052311	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	1012	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	825	052314	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	599	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	758	055210	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	852	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	841	052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	860	052315	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	828	052310	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	860	*052316/ 052310	CNFH	Late-Fall	*1998/ 1999
	Barrier Weir	Chinook	F	837	*052310/ 052313	CNFH	Late-Fall	1998
03/04/02	Barrier Weir	Chinook	F	685	055209	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	779	055140	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	766	052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	785	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	857	055141	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	800	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	731	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	669	055210	CNFH	Late-Fall	1999

	Barrier Weir	Chinook	M	994	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	852	052313	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	708	055209	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	964	052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	883	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	890	052315	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	700	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	840	052313	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	825	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	851	052309	CNFH	Late-Fall	1998
03/05/02	Barrier Weir	Chinook	F	930	054128	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	795	055207	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	809	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	690	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	714	055141	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	950	054128	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	670	*052316/ 052310	CNFH	Late-Fall	*1998/ 1999
	Barrier Weir	Chinook	F	827	*052310/ 052313	CNFH	Late-Fall	1998
03/06/02	Barrier Weir	Chinook	M	903	052317	CNFH	Late-Fall	1998

	Barrier Weir	Chinook	F	860	052313	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	737	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	910	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	945	052310	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	828	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	845	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	826	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	887	055059	CNFH	Late-Fall	1997
	Barrier Weir	Chinook	F	857	052314	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	628	055141	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	890	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	865	052309	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	925	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	936	052317	CNFH	Late-Fall	1998
03/07/02	Barrier Weir	Chinook	F	744	055209	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	675	055210	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	910	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	724	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	723	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	860	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	865	052310	CNFH	Late-Fall	1998

	Barrier Weir	Chinook	M	960	052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	923	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	849	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	1010	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	778	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	790	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	940	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	916	052314	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	934	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	700	055211	CNFH	Late-Fall	1999
03/08/02	Barrier Weir	Chinook	M	820	054129	CNFH	Late-Fall	1998
03/10/02	Barrier Weir	Chinook	M	895	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	878	052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	682	055207	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	725	055141	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	835	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	874	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	730	055141	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	934	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	850	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	885	052317	CNFH	Late-Fall	1998

	Barrier Weir	Chinook	F	730	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	885	052317	CNFH	Late-Fall	1998
03/11/02	Barrier Weir	Chinook	F	885	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	900	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	895	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	890	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	902	054128	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	906	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	890	052319	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	833	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	760	055209	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	1003	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	935	052317	CNFH	Late-Fall	1998
03/12/02	Barrier Weir	Chinook	F	764	052315	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	846	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	698	055211	CNFH	Late-Fall	1999
03/13/02	Barrier Weir	Chinook	F	876	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	892	052317	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	944	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	M	953	052319	CNFH	Late-Fall	1998
03/14/02	Barrier Weir	Chinook	F	707	055207	CNFH	Late-Fall	1999

03/15/02	Barrier Weir	Chinook	F	855	055140	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	M	745	054129	CNFH	Late-Fall	1998
03/16/02	Barrier Weir	Chinook	F	917	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	872	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	719	055212	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	876	052316	CNFH	Late-Fall	1998
03/17/02	Barrier Weir	Chinook	F	644	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	838	052318	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	888	052313	CNFH	Late-Fall	1998
03/20/02	Barrier Weir	Chinook	F	710	055207	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	702	055211	CNFH	Late-Fall	1999
	Barrier Weir	Chinook	F	873	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	850	054129	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	810	052314	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	775	052319	CNFH	Late-Fall	1998
03/21/02	Barrier Weir	Chinook	F	758	052313	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	865	052317	CNFH	Late-Fall	1998
	Barrier Weir	Rainbow Trout	M	419	055128	CNFH	Winter	1999
03/22/02	Barrier Weir	Chinook	F	815	052318	CNFH	Late-Fall	1998

03/23/02	Barrier Weir	Chinook	F	871	*052310/ 055212	CNFH	Late-Fall	*1998/ 1999
03/24/02	Barrier Weir	Chinook	M	1069	*052310/ 052316	CNFH	Late-Fall	1998
	Barrier Weir	Chinook	F	925	052317	CNFH	Late-Fall	1998
03/27/02	Barrier Weir	Chinook	M	871	*052316/ 052315	CNFH	Late-Fall	1998
04/01/02	Barrier Weir	Chinook	M	755	*052310/ 055213	CNFH	Late-Fall	*1998/ 1999
	Barrier Weir	Chinook	F	875	052318	CNFH	Late-Fall	1998
04/06/02	Barrier Weir	Chinook	F	914	052311	CNFH	Late-Fall	1998
05/05/02	Barrier Weir	Chinook	M	850	052319	CNFH	Late-Fall	1998
05/28/02	Snorkel Reach 7	Chinook	Unk	750	054129	CNFH	Late-Fall	1998

* Uncertainty due to potentially mislabeled samples.

APPENDIX B. Genetic samples taken from Chinook during Battle Creek barrier weir trap monitoring activities in 2002 by using WHICHRUN .

Collection Date	Gender	Fork-Length (cm)	Sample ID	Run
03/02/02	Female	83.5	02-1401	non-winter
03/03/02	Female	93.9	02-1402	non-winter
03/03/02	Male	96.0	02-1403	non-winter
03/04/02	Female	80.3	02-1404	non-winter
03/06/02	Female	88.5	02-1405	non-winter
03/06/02	Female	87.9	02-1406	non-winter
03/06/02	Female	98.5	02-1407	non-winter
03/07/02	Male	83.0	02-1408	non-winter
03/09/02	Female	79.0	02-1409	non-winter
03/10/02	Female	88.0	02-1410	non-winter
03/10/02	Female	87.2	02-1411	non-winter
03/10/02	Male	97.0	02-1412	non-winter
03/11/02	Female	86.0	02-1413	non-winter
03/24/02	Unknown	85.1	02-1414	non-winter
03/28/02	Female	67.0	02-1415	non-winter
03/31/02	Female	--	02-1417	non-winter
03/31/02	Female	71.4	02-1416	non-winter
04/03/02	Unknown	68.5	02-1418	non-winter
04/03/02	Unknown	71.0	02-1419	non-winter
04/03/02	Unknown	66.5	02-1420	non-winter
04/03/02	Unknown	75.5	02-1421	non-winter
04/04/02	Unknown	61.6	02-1422	non-winter
04/04/02	Unkown	70.2	02-1423	non-winter
04/04/02	Unknown	65.5	02-1424	non-winter
04/05/02	Female	72.5	02-1425	**winter**

04/06/02	Female	89.0	02-1426	non-winter
04/10/02	Unknown	71.5	02-1427	non-winter
04/10/02	Unknown	66.5	02-1428	non-winter
04/10/02	Unknown	68.2	02-1429	non-winter
04/11/02	Unknown	68.7	02-1430	non-winter
04/11/02	Unknown	82.7	02-1431	non-winter
04/11/02	Unknown	68.5	02-1432	non-winter
04/11/02	Unknown	53.5	02-1433	non-winter
04/12/02	Unknown	72.4	02-1434	non-winter
04/12/02	Female	86.5	02-1435	non-winter
04/14/02	Unknown	76.4	02-1436	non-winter
04/14/02	Female	71.0	02-1437	non-winter
04/15/02	Female	69.0	02-1438	non-winter
04/17/02	Unknown	68.3	02-1439	non-winter
04/22/02	Female	65.0	02-1440	non-winter
04/23/02	Unknown	84.0	02-1441	non-winter
04/23/02	Unknown	73.3	02-1442	non-winter
04/23/02	Unknown	72.4	02-1443	non-winter
04/23/02	Unknown	62.7	02-1444	non-winter
04/23/02	Unknown	73.2	02-1445	non-winter
04/23/02	Unknown	78.5	02-1446	non-winter
04/23/02	Unknown	66.5	02-1447	non-winter
04/23/02	Unknown	71.5	02-1448	non-winter
04/24/02	Unknown	72.6	02-1474	non-winter
04/24/02	Unknown	78.4	02-1475	non-winter
04/24/02	Unknown	67.5	02-1449	non-winter
04/24/02	Unknown	72.4	02-1450	non-winter
04/24/02	Unknown	72.3	02-1451	non-winter

04/24/02	Unknown	65.4	02-1452	non-winter
04/24/02	Unknown	70.5	02-1453	non-winter
04/25/02	Unknown	74.0	02-1454	non-winter
04/25/02	Unknown	75.4	02-1455	non-winter
04/26/02	Female	81.0	02-1456	non-winter
04/26/02	Female	70.0	02-1457	non-winter
04/26/02	Female	77.4	02-1458	non-winter
04/27/02	Unknown	69.9	02-1459	non-winter
04/27/02	Unknown	76.0	02-1460	non-winter
04/27/02	Unknown	75.4	02-1461	non-winter
04/29/02	Unknown	66.0	02-1462	non-winter
04/30/02	Unknown	76.5	02-1463	non-winter
04/30/02	Unknown	77.1	02-1464	non-winter
05/01/02	Female	71.0	02-1465	non-winter
05/03/02	Female	68.3	02-1466	non-winter
05/03/02	Female	66.8	02-1467	non-winter
05/03/02	Male	58.5	02-1468	non-winter
05/03/02	Male	63.0	02-1469	non-winter
05/03/02	Female	67.1	02-1470	non-winter
05/04/02	Unknown	80.5	02-1471	non-winter
05/05/02	Unknown	69.0	02-1472	non-winter
05/05/02	Unknown	98.0	02-1473	non-winter
05/05/02	Unknown	75.5	02-1476	non-winter
05/06/02	Unknown	77.1	02-1477	non-winter
05/06/02	Unknown	66.5	02-1478	non-winter
05/07/02	Unknown	75.0	02-1479	non-winter
05/07/02	Unknown	65.5	02-1480	non-winter
05/07/02	Unknown	70.4	02-1481	non-winter
05/08/02	Unknown	74.0	02-1482	non-winter

05/08/02	Unknown	70.5	02-1483	non-winter
05/08/02	Unknown	78.5	02-1484	non-winter
05/10/02	Unknown	69.5	02-1485	non-winter
05/10/02	Unknown	45.5	02-1486	non-winter
05/10/02	Unknown	67.5	02-1487	non-winter
05/12/02	Unknown	80.0	02-1488	non-winter
05/12/02	Unknown	69.0	02-1489	non-winter
05/12/02	Unknown	55.0	02-1490	non-winter
05/12/02	Unknown	74.0	02-1491	non-winter
05/13/02	Unknown	69.5	02-1492	non-winter
05/13/02	Unknown	73.5	02-1493	non-winter
05/13/02	Unknown	79.7	02-1494	non-winter
05/13/02	Unknown	82.9	02-1495	non-winter
05/14/02	Unknown	77.0	02-1496	non-winter
05/14/02	Unknown	67.0	02-1497	non-winter
05/14/02	Unknown	67.0	02-1498	non-winter
05/15/02	Unknown	68.5	02-1499	non-winter
05/15/02	Unknown	58.5	02-1500	non-winter
05/16/02	Unknown	70.0	02-1501	non-winter
05/16/02	Unknown	71.0	02-1502	non-winter
05/17/02	Male	80.5	02-1503	non-winter
05/17/02	Unknown	72.0	02-1504	non-winter
05/18/02	Unknown	75.5	02-1505	non-winter
05/18/02	Unknown	85.5	02-1506	non-winter
05/18/02	Unknown	79.9	02-1507	non-winter
05/18/02	Unknown	65.8	02-1508	non-winter
05/18/02	Unknown	82.8	02-1509	non-winter
05/18/02	Unknown	76.5	02-1510	non-winter
05/18/02	Unknown	80.5	02-1511	non-winter

05/18/02	Unknown	72.4	02-1512	non-winter
05/18/02	Unknown	88.3	02-1513	non-winter
05/18/02	Male	79.2	02-1514	non-winter
05/20/02	Unknown	91.0	02-1517	**winter**
05/20/02	Female	66.5	02-1515	non-winter
05/20/02	Female	76.0	02-1516	non-winter
05/20/02	Female	81.5	02-1525	non-winter
05/21/02	Female	73.2	02-1518	non-winter
05/22/02	Unknown	70.0	02-1520	non-winter
05/22/02	Unknown	78.0	02-1519	non-winter
05/23/02	Unknown	74.0	02-1521	non-winter
05/23/02	Unknown	67.0	02-1522	non-winter
05/24/02	Unknown	68.0	02-1523	non-winter
05/24/02	Unknown	71.5	02-1524	non-winter
05/25/02	Unknown	74.5	02-1526	non-winter
05/25/02	Unknown	68.0	02-1527	non-winter
05/26/02	Unknown	75.0	02-1528	non-winter
05/26/02	Unknown	77.0	02-1529	non-winter