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Monitoring Adult Chinook Salmon, Rainbow Trout, and Steelhead in Battle Creek, California, from November 2002 through November 2003

USFWS Report

Prepared by:
Matthew R. Brown
Naseem O. Alston

U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
Red Bluff, California 96080

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U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
10950 Tyler Road
Red Bluff, CA 96080

Abstract.—We estimate that 13 clipped and 221 unclipped Chinook (*Oncorhynchus tshawytscha*) passed through the Coleman National Fish Hatchery (CNFH) barrier weir fish ladder into upper Battle Creek between March 3 and August 29, 2003. 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: Zero were winter Chinook, approximately 100 were spring Chinook, 130 were fall Chinook, and 4 were late-fall Chinook. Thirteen clipped Chinook passing during video monitoring were apportioned 6 as spring Chinook, 3 as fall Chinook, and 4 as late-fall Chinook and were included in run estimates. Only 8 of these clipped Chinook were detected on videotape, the other 5 were calculated to have passed during periods of equipment outage or poor video quality. 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 57 unclipped Chinook were passed above the barrier weir prior to March 2 by CNFH personnel during their late-fall Chinook propagation program. While these 57 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 (176 total redds), we estimate a spawning population of 352 spring and fall Chinook.

Overall, water temperatures in 2003 were adequate for spring Chinook to successfully produce juveniles but 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. Our temperature, redd distribution, and spawn timing data taken in combination suggest that most Chinook eggs were in good temperatures for the majority of their incubation period.

We estimate that 772 clipped and 534 unclipped rainbow trout (*Oncorhynchus mykiss*) passed above the CNFH barrier weir in 2003 for a total of 1,306 rainbow trout. Of these, 769 clipped and 416 unclipped rainbow trout were passed by the hatchery prior to March 3 during their steelhead propagation program.

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Introduction

Battle Creek is important to the conservation and recovery of federally listed anadromous salmonids in the Central Valley of California. Restoration actions and projects planned or underway in Battle Creek focus on providing habitat for three federally listed species in the Central Valley Evolutionary Significant Unit (ESU); the endangered winter Chinook salmon (*Oncorhynchus tshawytscha*), threatened spring Chinook salmon, 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 2008). 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 and 2003 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 December 2002, kayak surveys were initiated to determine the number and distribution of steelhead / rainbow trout redds during the winter. In March 2003, we began to study the impact of daily barrier weir closure on salmonids and to reduce these potential impacts by increasing hours of trap operation.

In 2003, the Interim Flow Project increased flows on the South Fork and North Fork to 30 cfs. 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. In 2001, flows were increased on the North Fork only, from 3 cfs to 30 cfs, and the South Fork was maintained at 5 cfs.

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 Coleman National Fish Hatchery (CNFH) barrier weir fish trap and video counts along with stream surveys to monitor adult salmonids in Battle Creek between November 19, 2002 and November 14, 2003. 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-origin or hatchery-origin (not all hatchery Chinook are clipped). We considered all unclipped rainbow trout to be natural-origin as CNFH has clipped 100% of their steelhead production since 1998. It is likely that unclipped Chinook returning to Battle Creek during our monitoring period are mostly spring Chinook. However, it is also possible that some unclipped Chinook are 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, because of the difficulties in differentiating the anadromous and non-anadromous forms in the field.

Coleman National Fish Hatchery Barrier Weir

Operation of the CNFH barrier weir (the barrier weir) blocked upstream passage of fish through the fish ladder (rm 5.8) from August 30, 2002 through March 2, 2003. During this period, fish were periodically directed into holding ponds at CNFH, where fall and late-fall Chinook and steelhead were used in propagation programs. Passage of fishes upstream of the barrier weir in Battle Creek was afforded from March 3 through 29 August 2003 by opening the fish ladder. Fish passage was monitored during this time period using live trapping until May 30 followed by underwater videography until August 29.

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 8-10 hours a day, 7 days a week from March 3 through May 30, 2003 (0730-1530 hours - March 3-7; 0930-1730 hours - March 8-April 24; 0530-1530 hours - April 26-May 22; 0430-1430 hours - May 23-30). During hours when the trap was not operated (e.g.: 1530 - 0530 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, weather conditions were noted, and water temperature and stage gauge was documented. Every two hours temperatures and stage gauge levels were recorded. When water temperature exceeded 60°F, trapping for that day was terminated to minimize the effects of handling. Trapping was terminated for the season and videography began when water temperatures exceeded 60°F (as determined by stowaway temp loggers) for a majority of the trap operation period in a day.

The trap was checked every 30 minutes. Captured non-target fish were identified to species, counted, and released upstream. Captured 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 to 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 slime coat. While in the fish tank, Chinook and rainbow trout were anesthetized with CO_2.

Anesthetized salmonids were measured (fork length) to the nearest 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 designation, hatchery of origin, and age. Since only a fraction of clipped rainbow trout are tagged with a CWT, they were first scanned using a "V" detector (Northwest Marine Technology, Field Sampling Detector FSD-I). Clipped trout possessing a CWT were sacrificed for tag recovery and all others were released upstream of the barrier weir. Unclipped Chinook (after genetic sampling) 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 first 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 30 through August 29. 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 160 minute-VHS tapes were used. A time-date stamp was recorded. Tapes were later 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. This rating was completed by more experienced personnel. A good rating signified complete confidence in determining species and presence or absence of an adipose fin; fair suggested confidence in determining species and presence or absence of an adipose fin but additional review was needed 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 review 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 2003. 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 2003 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 3. The equations used for estimating passage during barrier weir trapping were:

$$P_{tu} = \sum_{i=1}^{13} \left(\left[\left(\frac{u_i}{(c_i + u_i)} \right) * unk_i \right] + u_i \right)$$

$$P_{tc} = \sum_{i=1}^{13} \left(\left[\left(\frac{c_i}{(c_i + u_i)} \right) * unk_i \right] + c_i \right)$$

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 week *i*;

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

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

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

$$P_{vu} = \sum_{i=1}^{13} \left(\left[\left(\frac{u_i}{(c_i + u_i)} \right) * unk_i \right] + u_i \right) * \left(\frac{T_i}{V_i} \right)$$

$$P_{vc} = \sum_{i=1}^{13} \left(\left[\left(\frac{c_i}{(c_i + u_i)} \right) * unk_i \right] + c_i \right) * \left(\frac{T_i}{V_i} \right)$$

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 week i;

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

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

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

V = number of hours of actual good and fair video recorded fish passage at the barrier weir during week i.

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

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

Stream Surveys

We conducted stream surveys of Battle Creek bi-monthly from November 19, 2002 - April 10, 2003 for steelhead spawning surveys, and from June 11 - November 14, 2003 for salmonid snorkel surveys. The 21.6 mile survey was divided into 7 reaches (Table 1; Figure 1) during snorkel surveys, and usually required 4 days to complete, depending on personnel availability and flow conditions. Kayak surveys usually combined two reaches within each days survey. 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.

Steelhead in the upper Sacramento Valley typically spawn from the latter part of December through April. Inflatable kayaks (Hyside brand) were utilized to conduct the steelhead redd survey. Kayak surveys replaced snorkel surveys in the winter due to high stream flows, elevated turbidity (2-5 NTU), and low water temperatures (44-52˚F). For optimal viewing conditions, observers wore polarized sunglasses, kneeled on pontoons, or stood up in the kayak. Moving downstream with the current, three kayakers spanning the width of the creek, documented the location and number of redds. Observations of adult steelhead and carcasses were also recorded. At each redd, a GPS point was taken, and each redd was flagged, and labeled with a unique number. Each encountered carcass received a GPS point, and had a genetic sample collected. To determine the number of days or weeks a redd would be visible in Battle Creek, steelhead redds were revisited each survey and "aged." The following key was used to classify the "age" of a redd: 1= a redd in progress, 2= clearly visible and clean, 3= older, tail spill flat or pit with fines, 4= old and hard to discern, and 5= no redd visible, only flag in place to indicate presence.

Snorkel type surveys were used on all reaches. 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 greater than young of the year to 16 inches as small, rainbow trout from 16 inches to 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.

When survey personnel encountered carcasses, they would collect genetic tissue samples 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 later extracted from heads in the laboratory.

Stream flow, water turbidity, and water temperature can all influence the effectiveness of snorkel surveys (Thurow, 1994). We collected data on these three parameters for each snorkel survey. Stream flow was measured at three 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 in Battle Creek for spring Chinook holding (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 3 locations on the South Fork (reach 3), 3 locations on the North Fork (reaches 1 and 2), and 4 locations on the mainstem (reaches 4-6). Temperature data was obtained from Onset Stowaway™ temperature loggers installed and maintained by the RBFWO and from two DWR gaging stations located at the Manton Road Bridge on the South Fork and the Wildcat Road Bridge on the North Fork. Evaluating temperatures at these sites 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, 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. 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 15 September through 31 October. Evaluating temperatures at these sites provide a range of conditions Chinook eggs may have been exposed to in each of these three creek segments.

Velocity at barrier measurements.— Physical measurements were taken of Coleman Diversion Dam at the radial gate opening to determine if it was passable to Chinook salmon at various flows using a Marsh-McBirney water velocity meter. Barrier measurements included the following:

1) vertical height: height from the water surface of the plunge pool to the water surface flowing over the barrier.
2) width at base of passage route.
3) breadth (horizontal distance parallel to flow from the top to bottom of the structure).
4) depth of plunge pool.
5) water velocity: at the top of barrier.
6) water velocity: at the tail out of the barrier

Based on these measurements, a determination was made if barrier conditions were within the swimming and leaping capabilities of adult Chinook. For swimming up chutes, we assumed the swimming capabilities of Chinook in poor to good physical condition ranged from 11.2 - 16.8 ft/s which is 50 - 75% of the maximum burst speed of 22.4 ft/s for Chinook (Powers and Orsborn 1985, Bell 1990). For successful jumping of cascades and small waterfalls, the capability of a salmon to both clear the height and the breadth of the structure was evaluated using the following equation described by Powers and Orsborn (1985) for the parabolic trajectory of a leaping salmon:

$$H = (\tan\theta)X - 32.2(X)2/2(V\cos\theta)2$$

where:

H = height of leap;
θ = angle of trajectory upon leaving the water
X = horizontal distance of leap;
V = 75% of the maximum burst speed of a Chinook = 0.75 * 22.4 ft/s.

In addition to the leaping capabilities of Chinook, we also assumed that, for a successful jump, the depth of the jump pool needed to be either 1.25 times the vertical height or greater than about 8 feet (Reiser and Peacock 1985, cited in Bain and Stevenson 1999).

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 vial 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 using the Puregene method and individuals were genotyped at 7 loci (Hedgecock et al. 2001). Two separate 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 determine if an individual fish is a winter Chinook or non-winter Chinook.

Results

Coleman National Fish Hatchery Barrier Weir

Trapping.—A total of 203 Chinook were captured in the barrier weir trap between March 3 and May 30, 2003. Of these, 136 were clipped and 67 were unclipped (Table 3).

We retrieved coded-wire tags (CWT) from 133 clipped Chinook captured in the trap. Tag codes revealed all readable tags (130) to be from late-fall Chinook from CNFH (Appendix A). We did not recover any coded-wire tagged winter Chinook. Three ad-clipped Chinook had no tag detectable, and zero tags were lost during removal.

Diel timing of Chinook entering the barrier weir trap showed some variation throughout the trapping season (Figures 2, 3). To decrease potential impacts of barrier weir trap closure, trap opening and closing times were altered throughout the trapping season. Trapping began with a 0730-1530 hours starting and ending time and continued until March 7, 0930-1730 from March 8-April 24, 0530-1530 from April 25-May 22, and 0430-1430 from May 23-May 30. Early in the season clipped Chinook were trapped most frequently in the afternoon, between 1230-1730 hours, 76% of all clipped Chinook (n=102) were trapped in the second time shift trapping period, whereas unclipped Chinook were infrequent (only 21 fish for the second time shift trapping period). During the third time shift trapping period, clipped Chinook were less frequent (only 5 clipped Chinook for the rest of the trapping period). Unclipped Chinook were trapped more in the morning hours, 0530-0830 hours, trapped 21 out of 30 Chinook.

A total of 65 rainbow trout were captured in the barrier weir trap. Of these, 2 were clipped, 61 were unclipped, and 2 escaped prior to being examined for an adipose fin (Table 4). The escaped rainbow trout were approximately 10 inches in length. They escaped through the bars of the trap. In addition, one small unclipped rainbow trout, while attempting to escape, got stuck between the bars and fatally injured itself. We designated the two unknown clip status rainbow trout as unclipped, based on the proportion of clipped and unclipped observed for that particular week or surrounding weeks. The one CWT rainbow trout was lost during retrieval. We released the other clipped rainbow trout upstream of the weir as it did not have a coded-wire tag.

Diel timing of rainbow trout entering the barrier weir trap also showed some variation throughout the trapping season (Fig. 4, 5). During the 0730 hours start time trapping period (3 days of trapping), rainbow trout were trapped most frequently at 1530 hours (50% -5 out of 10). During the 0930 hours start time trapping period (51 days of trapping), rainbow trout were trapped most frequently at the trap open time (0930- 24% - 10 out of 41) with a secondary peak at 1630 (7 rainbow trout). Eighty Percent of rainbow trout passed during these two trapping periods, as only 13 rainbow trout passed during the 0530 and 0430 hours trapping time.

Genetic Analyses.—Sixty eight samples from 67 Chinook from barrier weir trapping were analyzed by BML (Vanessa Rashbrook, personal communication). Using the WHICHRUN individual run assignment methodology (Hedgecock et al. 2001), zero were winter run. MSA results indicated that zero % were winter Chinook, 68 % were spring Chinook, 32 % were fall Chinook and zero were late-fall Chinook. We collected 77 samples from carcasses encountered during stream surveys. These samples have not been analyzed.

Video counts.—A total of 135 Chinook were observed passing through the barrier weir fish ladder between May 30 and August 29, 2003. Of these, 8 were clipped and 127 were unclipped (Table 5). During a break of 21 days from July 12 through August 1, no Chinook were observed. Similar periods of no fish passage from mid-July through early-August occurred in 2000, 2001 and 2002. During the video monitoring period, 79% (1726 hours) of the afforded passage was video recorded with a good or fair picture quality. However, the first 421 hours (18 days) of passage was of poor quality due to high turbidity and equipment malfunction. Therefore, 98% of the remaining 1760 hours (73 days) of passage was recorded with a good or fair picture quality (Table 5).

Extrapolation for poor picture quality, due to turbidity or video equipment malfunction added 32 Chinook to the passage estimate. More specifically, extrapolation from May 30 - June 17 added 23 unclipped Chinook and 5 clipped Chinook to the passage estimate. Extrapolation between August 3-23, added 4 unclipped Chinook.

A total of 43 rainbow trout were observed on video tape passing through the barrier weir fish ladder. Of these, 2 were clipped and 41 were unclipped (Table 6). Extrapolation for poor viewing quality or equipment malfunction, resulted in a total passage estimate of 58 rainbow trout. Extrapolation from May 30-June 17, added 13 unclipped rainbow trout to the passage estimate.

Diel timing of Chinook passage during video monitoring peaked between 0500 and 0700 hours. Sixty-three percent of Chinook passed between 0200 hours and 0700 hours. Also, 57% of Chinook passed during dark hours (Figure 6, 7). Diel timing of rainbow trout passage during video monitoring had no apparent pattern, with only 9% passing during dark hours, and with only a slight peak from 1500-2000 hours where 20 out of 43 rainbow trout passed (Figure 8, 9).

Passage estimation.—Passage estimates for unclipped salmonids are higher than actual numbers observed due to our estimates made during periods of poor video quality. We estimate 13 clipped and 221 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 3 and August 29, 2003. An additional 57 unclipped Chinook were released above the barrier weir by CNFH personnel prior to opening the barrier weir fish ladder on March 3 (Table 7). These 57 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 57 Chinook were considered natural-origin and were released into Battle Creek, upstream of the barrier weir, to spawn naturally.

We estimate that 3 clipped and 118 unclipped rainbow trout passed through the barrier weir fish ladder between March 3 and August 29, 2003. An additional 769 clipped and 416 unclipped rainbow trout were released above the barrier weir by CNFH prior to March 3 (Table 7). 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 3 (the first day the fish ladder was open) and peaked the week of May 11-17. Following a continuous 21 day period (July 12 through August 1) in which Chinook did not appear to migrate above the weir, there was a secondary peak the week of August 17-23. The middle 50% of the run before the no passage period passed between May 4 and June 14. Following this period, migration of unclipped Chinook was 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 10). The migration of clipped Chinook also began March 3, 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 11). Passage of rainbow trout was greatest during the first two weeks of trap operation (March 3-15), after which, weekly counts of rainbow trout gradually declined until May 31 when counts began rising again. A secondary peak of rainbow trout passage occurred the week of June 15-21. 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 79 cm and ranged in length from 54 cm to 108 cm (n=206). The length-frequency distribution was continuous and was approximately normal with a mode of 81-85 cm (Figure 12).

Rainbow trout captured in the barrier weir trap had a mean fork length of 43 cm and ranged from 30 to 63 cm (n=65). The length-frequency distribution for rainbow trout was continuous and was approximately normal with a mode of 41-45 cm (Figure 13).

The ratio of male to female clipped Chinook captured in the barrier weir (which were all late-fall run) was 1:2.2 (n=133). The sex ratio for unclipped Chinook was not determined due to the difficulty in determining sex before the appearance of secondary sex characteristics. For the majority of rainbow trout, the sex ratio was undetermined.

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=53), 4-year-olds (n=75), and 5-year-olds (n=5). 68% of males were 3-year-olds, while 68% of females were 4-

year-olds. There was overlap in fork length between Chinook of different ages (Figure 14). Age was not determined for unclipped Chinook.

Stream Surveys

Winter Redd Surveys (December through April) - A feasibility study using kayaks for a steelhead redd survey was conducted from November 19, 2002 through April 10, 2003. Only the mainstem (reaches 4-7) of Battle Creek was surveyed (through March 18) due to minimal flows and elevated turbidities in the forks. We were able to survey each reach five times, except for reach 7 which was only surveyed four times. We observed a total of 10 steelhead redds above the CNFH barrier weir. Towards the end of steelhead spawning season on April 10, 2003, we were able to perform one survey on the South Fork where we observed 13 steelhead redds. We also encountered three steelhead carcasses during these surveys. Information gathered from aging steelhead redds includes length of time redds remained visible. Variables affecting redd visibility may include relative likelihood of substrate smoothing at higher flows, amount of sediment available for deposition, substrate size as it effects substrate mobility, and water temperature as it effects algal growth. Redd visibility ages ranged from two to six weeks, however most redds were visible for four to six weeks unless a high flow rain event occurred between observations.

Snorkel type stream surveys (May through November) - During regularly scheduled bi-monthly stream surveys, we observed 38 adult Chinook in June, 77 in July, 94 in August, 58 in September, 3 in October, and 1 in November (Table 8, 9). During regular monthly surveys and supplemental surveys, we observed a total of 176 redds above the barrier weir: 1 in June, 28 in September, and 147 in October. We recovered a total of 83 carcasses: 1 in June, 6 in July, 1 in August, 11 in September, 61 in October, and 3 in November. The first snorkel survey of the season was during the week of June 24 because of the unsafe and impractical conditions of high flows and high turbidity. Flows on the South Fork remained high (over 100 cfs) in 2003 through mid June.

Small rainbow trout were the dominant size group in all the reaches. Medium rainbow trout were the highest on reach 4. Large rainbow trout counts were low on all reaches (3 or less), although reach 7 counted 8 large on one survey (Tables 10, 11). Monthly mean rainbow trout numbers by reach show that Reach 1 had the greatest abundance (897) followed by Reach 4 (536). The fewest rainbow trout were observed in Reach 6 and 7.

Conditions for snorkel type surveys were good to excellent: stream flows were stable (Figure 15), temperatures ranged from 49˚ to 77˚F, and average daily turbidity was low (0.8 to 2.8 NTU). The presence or absence of an adipose fin usually could not be determined for Chinook seen during our surveys.

Compared to 2001 and 2002, flows in 2003 were increased in the South Fork. (Figure. 16). We compared water temperatures between years at two sites on the South fork during the holding period (June 1-September 30). At Coleman Dam on the South Fork, water temperatures averaged 60.6˚F in 2001, with 7 cfs, and in 2003, averaged 60.6˚F with 78 cfs (but had 41 days -34%- of missing data). During the holding period at Manton Bridge temperatures averaged 65.6˚F in 2001 with 7 cfs, and averaged 60.6˚F in 2003 with and 78 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 52.9˚F (but had 30 days -65%- of missing data) in 2003 with 34 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 2003 with 34 cfs.

We also 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 61.6˚F in 2003 with 73 cfs. During the egg incubation period temperatures averaged 57.0˚F in 2001 with 43 cfs, and averaged 56.7˚F in 2003 with 41 cfs.

Holding location.—Monitoring results indicate Chinook held in Battle Creek for about three months (from start of surveying, late June through mid September) prior to spawning. Barrier weir monitoring showed that an estimated 106 unclipped Chinook migrated into Battle Creek during the second peak of August 17-23. Including those August fish, 75% of unclipped Chinook had not passed the weir until the second to the last week of video monitoring. Stream surveys indicated that most Chinook spawned the end of September through mid October (see below). Therefore, we considered survey observations made during June, July, August, and early September to be during the holding period for spring Chinook in 2003.

From June through early September, Chinook numbers and proportions steadily changed throughout the holding period, starting with 39% in the North Fork, 29% in the South Fork and 32% in the mainstem, and ending with 3% in the North Fork, 28% in the South Fork and 69% in the mainstem.

Monthly maximum counts of Chinook in the North Fork were 15 in June, 19 in July, 7 in August, and the lowest count of 3 in early September, then up again to 17 in late September, 19 in mid October, and one in the end of October. Flows in the North Fork increased in March up to 500 cfs and maintained flows of around 300 cfs through May. In June, flows gradually decreased until mid July, where flows remained more consistent and normal, in the low 40 cfs range.

Monthly maximum counts of Chinook in the South Fork were 11 in June, 25 in July, 31 in August, 25 in early September, 12 in late September, 7 in mid October and zero in late October.

Monthly maximum counts of Chinook in the mainstem were 12 in June, 33 in July, 56 in August, 61 in early September, 29 in late September, 20 in mid October, and 2 the end of October. 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.(Tables 8, 9).

Using the Ward and Kier (1999) thermal criteria for holding (Table 2), we evaluated South Fork water temperatures at three sites, classifying into days of either good, fair, poor, or very poor (Table 12). Coleman Diversion Dam (rm 2.5), with 42 days of no data available, had 44 days fair (36%), and 36 days good (29.5%), at Manton Road Bridge (rm 1.7), 0 days poor, 51 days fair (42%) and 71 days good (58%), and the confluence, 10 days poor (8%), 68 days fair (58%) and 44 days good (36%) (Figure 17).

We used the same criteria to classify temperatures in the North Fork where we evaluated holding temperatures at Wildcat Dam, 89 days had no data available, 3 days fair (2.5%), 30 days good (24.6%), at Wildcat Road, 11 days poor (9%), 59 days fair (48.4%), and 52 days good (42.6%), and the confluence (rm 0.1), 14 days of no data available, 14 days poor (11.5%), 57 days fair (47%) and 37 days good (30%) (Figure 18). 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), below confluence had 55 days of no data available, 7 days poor (5.7%), 33 days fair (27%), and 27 days of good (22%). River Mile 16.3, had 76 days of no data available, 12 days of fair (10%), and 34 days of good (28%). River Mile 12.9, had 96 days of no data available, 14 days of fair (11.5%), and 12 days of good (10%). River Mile 12.0, had 27 days of no data available, 25 days of poor (20.5%), 56 days of fair (46%), and 14 days of good (11.5%). River Mile 9.3, had 96 days of no data available, 15 days of poor (12%), 11 days of fair (9%) and zero days of good.

Spawning location and timing.—We observed 26 redds in the South Fork, 79 in the North Fork, and 70 in the mainstem. In the South Fork, Chinook began spawning by September 16 (8 redds), constructed about half of their redds by the beginning of October, and finished spawning by October 29 (Table 8). Our last survey on the South Fork was on November 12. In the North Fork, Chinook began spawning September 16 and continued until October 29. Our last survey on the North Fork was November 14. In the mainstem, Chinook also began spawning on the week of September 16, but only on reach 4 until October 2, when the other reaches on the mainstem had some redds observed. Our last survey on the mainstem was ended November 14, and zero redds were observed during this final survey, therefore the end of spawning is approximately October 31. Consequently, there was one redd observed on reach 5 of the mainstem Battle Creek, on our first survey June 26. This redd was observed in conjunction with an ad-clipped late-fall Chinook carcass from CNFH, found 1 mile downstream that same day.

Sixty percent of Chinook redds were located in the North Fork and South Fork of Battle Creek. All of the redds in the South Fork were above Manton Road Bridge, 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. In the past two years, redds were only observed 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. However, this year, redds were observed as far up as rm 4.2, because of high flows March through June. From the 83 carcasses encountered, 76 samples were taken. The remaining 7 were not taken due to decomposition. We were unable to determine the spawning status of 57 of the 83 carcasses (69%) because of many potential factors: advanced state of consumption /of being eaten by scavengers, skinning and fileting by poachers, and decomposition. Also, carcasses may have remained hidden under rocks, in large woody debris or in turbid pools, and then flushed out later. There were only 26 carcasses for which spawning status could be determined. In the North Fork, zero were unspawned, 14 were spawned, and 25 were of unknown spawning status. In the South Fork 1 was unspawned, 2 were spawned, and 9 were of unknown spawning status. In the mainstem, 2 were unspawned, 7 were spawned, and 16 were of unknown spawning status. One of the carcasses was a coded wire tagged late-fall from CNFH.

Using the Ward and Kier (1999) thermal criteria for egg incubation (Table 2), we evaluated South Fork temperatures, at Coleman Diversion Dam, 31 days had no data available, and 16 days good (34%), Manton Bridge, 5 days fair (10.6%), and 42 days good (89.4%), and at the confluence, 15 days fair (32%) and 32 days good (68%).

North Fork temperatures were evaluated at Wildcat Dam, 17 days had no data available, and 30 days good (64%), Wildcat Road, 18 days fair (38%), and 29 days good (61.7%), and at the confluence, 15 days had no data available, 9 days fair (19%), and 23 days good (49%).

Mainstem Battle Creek water temperatures were also evaluated below the confluence, RM 16.8 had 5 days poor (10.6%), 17 days fair (36%), and 25 days good (53%), RM 16.3 had 2 days poor (4%), 18 days fair (38%), and 27 days good (57.4%), RM 12.9 had 13 days poor (27.7%), 11 days fair (23.4%), and 23 days good (49%), RM 12.0 had 18 days of no data available, 6 days fair (13%) and 23 days good (49%), and RM 9.3, had 15 days of no data available, 3 days of very poor (6.4%), 6 days poor (13%), 1 day fair (2%), and 22 days good (47%) (Table 13).

Powerhouse Outage - Physical measurements were made on August 12, 2003 at the opening of the Coleman Diversion Dam (CDD) radial gate to determine the likelihood of Chinook passage. Four water velocity measurements were made on river left (closest to the dam) ranging from 2.53 to 10.73 ft/s, and three measurements ranging from 11.8 to 14.8 ft/s, were made on river right. Passage criteria for Chinook were met at all measurements for salmonids in "good" physical condition (16.8 ft/s). In the passage routes where criteria were not met (on river right), water velocities only exceeded the swimming capabilities of salmon in "poor" physical condition (11.2 ft/s). After completing these measurements, a snorkel survey took place from Inskip Tailrace to CDD (0.2 of a mile upstream), and a total of six adult Chinook were observed. This reach above the CDD was included in subsequent snorkel surveys of reach 3 until the end of the survey period. On August 20, 3 Chinook were seen. On September 3rd , 17th and October 1st, one Chinook was seen above the CDD. One redd and one test redd were first observed on October 1 above the CDD.

Discussion and Recommendations

Chinook Salmon Population and Passage Estimates

We estimated that 221 unclipped Chinook passed through the barrier weir fish ladder into upper Battle Creek between March 2 and August 29, 2003. 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: Zero were winter Chinook, approximately 100 were spring Chinook, 130 were fall Chinook, and 4 were late-fall Chinook.

Thirteen clipped Chinook passing during the video monitoring period may have been from any run but were apportioned 6 as spring Chinook, 3 as fall Chinook, and 4 as late-fall Chinook and were included in run estimates. Only 8 of these clipped Chinook were detected on videotape, the other 5 were calculated to have passed during periods of equipment outage or poor video quality. We added 6 of the 13 clipped fish to the spring Chinook total estimate because they passed during the peak of spring Chinook migration during June. We assigned 3 of the unclipped fish to the fall Chinook total estimate because they passed in August after a break in passage that we interpret as the break between spring-run and fall-run migration (Figure 10). We assigned 4 of the clipped fish as late-fall Chinook because, although this is much later than the typical late-fall migration period, we have captured CWT late-fall-run in this period during other years and late-fall Chinook are by far the most numerous clipped Chinook we encounter.

No winter Chinook were detected using either the WHICHRUN or MSA. According to Chinook run timing, one redd was observed during the winter run period on June 26. However, the four runs of Chinook overlap during various times of the year. The observed redd was likely created by a late-fall Chinook because an ad-clipped CNFH female late-fall Chinook carcass was observed a mile downstream on the same day.

We estimated that 94 of the unclipped Chinook were spring run based on the following assumptions and reasoning we have been using for the last few years: MSA indicated that 68% of the samples were spring Chinook, so we assigned 46 of the 67 Chinook passing during barrier weir trapping as spring Chinook. We assumed that all 48 of the unclipped Chinook passing during the first portion of video monitoring were spring Chinook. We estimated that 127 of the unclipped Chinook were fall run. MSA indicated that 32% of the samples were fall Chinook, so we assigned 21 of the 67 unclipped Chinook passing during barrier weir trapping as fall Chinook. We assigned all 106 of the unclipped Chinook passing during the latter portion of video monitoring (i.e., August) as fall Chinook.

Based on run timing, we question the accuracy of the MSA fall-run assignments and our fall Chinook passage estimates. The genetic results suggest that 32% of the Chinook during March to May were fall run, which are not thought to immigrate during this period (Vogel and Marine 1991). Similarly, none of the unclipped Chinook were designated as late-fall Chinook during this period, when late-fall are migrating as evidenced by the 130 CWTs obtained in 2003 by barrier weir trapping. It is possible that the 21unclipped Chinook designated as fall-run are actually late-fall Chinook, spring Chinook, fall / spring hybrid Chinook or "Battle Creek" spring Chinook which differ genetically from the Deer / Mill or Butte Creek spring Chinook to which they were compared.

Our passage estimates are preliminary because the MSA is not intended to give individual run assignments, but is a more general population level analysis. We will re-analyze tissue with an improved set of genetic markers, which will replace the population level tool with an individual level tool. We plan to have Dr Michael Banks of Oregon State University, re-run 2003 and all past year's non-winter run genetic samples. These future results will provide run individual run determination which will produce more accurate population estimates. WHICHRUN is considered an accurate method for individual run assignment for winter run. Therefore we have more confidence in the winter Chinook population estimate.

Recommendation One: Analyze tissue samples from unclipped Chinook collected in 2003 using newly developing genetic techniques capable of determining the run of individual Chinook.

In the majority of years barrier weir passage has been monitored by underwater video, we have observed a decrease in passage followed by a gap of zero passage during July. In 2000 through 2003 video monitoring continued through August, and during these years we observed passage continuing after the gap in July, in August.

In 2003, during video monitoring, from August 1-29, an estimated 106 Chinook passed the barrier weir. It is likely that these fish returning in August are fall run Chinook returning to CNFH. Fall run Chinook may be ready to spawn during the end of spring Chinook spawn timing, which could potentially lead to superimposition or hybridization. In attempt to avoid passing these potential fall run Chinook into Battle Creek upstream of CNFH, we recommend ceasing passage at the weir at the beginning of August. We also recommend obtaining tissue samples from those fish entering the ladder in August in order to determine run.

Recommendation Two: 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 superimposing redds on or interbreeding with spring Chinook.

> **Recommendation Three:** 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 if an individual Chinook is a spring run become available, selectively passing only spring Chinook could also be considered.

In 2003 we changed the hours of the barrier weir operation in attempt to decrease impacts of trap closure on salmonid passage. We observed 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.

There are some uncertainties in accurately determining Chinook population estimates as the CNFH barrier weir is not considered fish tight. During September through March when the ladder to upstream Battle Creek is closed to passage, there is the potential for salmonids to escape upstream by jumping or swimming over the barrier weir. The ability of salmonids successfully jumping or swimming over the weir during a particular year may be affected by flow, or concentration of salmonids below the weir, or other factors. A feasibility study using video cameras to capture these "jumpers" was attempted in 2003 from September through November. The distance and angle of the camera did not prove to be effective, and results were inconclusive. In future trials, we recommend attaching cameras to an arm over the creek ladder aimed directly across the barrier weir for better views of jumpers. These video cameras could also potentially record salmonids falling back downstream. We also documented Chinook passage at the weir during storm flow periods in 2003.

> **Recommendation Four:** 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.

> **Recommendation Five:** Continue feasibility investigation for monitoring steelhead spawning populations. We primarily used kayaks to count redds and collect carcasses in reaches 4 to 7 in 2003.

Evaluation and Adaptive Management of Battle Creek Stream Flow

North Fork flows remained high during March to July (over 100cfs up to nearly 600cfs), because of late season storms. The natural barrier at rm 3.04, identified as impassible at 30 cfs in 2001 and 2002 was successfully passed sometime between March and July in 2003. In 2001 and 2002, no Chinook redds were observed above this barrier (Brown and Newton 2002; Brown et al 2005), while in 2003, 14 redds were observed upstream as far as rm 4.2. Higher flows may have attracted relatively more Chinook into the North Fork in 2003. In 2001 and 2002 relatively more spring Chinook may have been attracted into the South Fork during PG&E power outages.

Future monitoring is still needed to determine if Restoration Project flows (35 cfs during the corresponding migration period; NMFS et al. 1999) are sufficient for passage at this temporary barrier. Increasing stream flow above 30 cfs 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.

> **Recommendation Six:** If Chinook are blocked by the natural barrier at RM 3.05 on the North Fork, increase flows from 30 to 35 cfs on the North Fork for a week in September, to determine if Restoration Project minimum flows will be sufficient to allow Chinook passage at the barrier. Subsequent North Fork flows could be reduced by 1.25 cfs for 4 weeks in October to offset the cost of the increased flows.

> **Recommendation Seven:** Develop methods to quickly increase flows once a decision for a flow increase has been made. Both flow increases in the South Fork in 2002 were delayed from the point that recommendations were made by the Interim Flow Project Science Team to actual implementation. Administrative roles and methods could be better defined and streamlined to ensure quicker changes in flow.

Overall, water temperatures in 2003 were adequate for spring Chinook to successfully produce juveniles but 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. Our temperature, redd distribution, and spawn timing data taken in combination suggest that most Chinook eggs were in good temperatures for the majority of their incubation period.

> **Recommendation Eight:** Analyze the impact of annual variation in air temperature on water temperatures achieved under various flows. Improve PG&E's water temperature model 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 more difficult.

Planned powerhouse outage and associated flow increase on the South Fork

In previous years PG&E performed annual maintenance outage of the hydropower system in May. In 2003 the maintenance was postponed until August to not coincide with potential Spring run upstream migration. The scheduled outage from August 4 through August 16 resulted in a flow increase from 36 cfs to 250 cfs, when PG&E opened the radial gate at the dam, and blocked water from continuing down the Coleman Canal. Opening the radial gate potentially allowed fish to continue upstream of the CDD which is usually the upper limit to fish migration on the South Fork due to closure of the fish ladder. The radial gate was used instead of the more typical method of spilling water through the first canal gates, to insure the safety of workers operating in the upper end of the Coleman Canal.

Direct observation indicated that at least 6 Chinook passed, and redds were made upstream of the CDD. Velocity measurements at the radial gate confirmed that passage was possible. Water velocities through the radial gate ranged from 2.53 to 14.8 ft/s . Passage criteria for Chinook in good physical condition is 16.8 ft/s. After the radial gate was closed on August 16th, it would have been difficult for the adult Chinook to return below the dam. Fry emerging from redds above the dam probably perished when attempting to out-migrate through the canal and powerhouse. The canal diverts the large majority of flow from the reach. Therefore production from Chinook that passed upstream of the CDD was lost.

Recommendation Nine. Investigate the feasibility of not using the radial gate on CDD during outages. Use of the radial gate should be avoided if possible. Investigate methods to block adult fish passage upstream, if the radial gate is to be used. Continue to plan outages on the South Fork to occur in early August.

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Tables

Table 1. Reach numbers and locations with associated river miles (RM) for Battle Creek spawning ground surveys in 2003.

	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	≤58	<8% Mortality	Good
Eyed-egg Stage	>58 to ≤60	15 to 25% Mortality	Fair
	>60 to ≤62	50 to 80% Mortality	Poor
	>62	100% Mortality	Very Poor

Table 3. Chinook captured at CNFH barrier weir trap and associated passage estimates for 2003

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
3-8 March	29	1	0	0	1
9-15 March	42	0	0	0	0
16-22 March	24	5	0	0	5
23-29 March	13	4	0	0	4
30 March-5 April	7	0	0	0	0
6-12 April	7	5	0	0	5
13-19 April	5	4	0	0	4
20-26 April	4	2	0	0	2
27 April-3 May	1	5	0	0	5
4-10 May	1	5	0	0	5
11-17 May	1	16	0	0	16
18-24 May	0	11	0	0	11
25-30 May	2	9	0	0	9
Totals	136	67	0	0	67

Table 4. Rainbow trout / Steelhead captured at CNFH barrier weir trap and associated passage estimates for 2003. During the first week of trapping, a rainbow trout died while attempting to escape through the trap bars, and was therefore not added to the passage estimate. The week of April 27- May 3 the ad-clipped rainbow trout has a coded-wire tag detected and was sacrificed for retrieval.

Dates	Actual number clipped	Actual number unclipped	Actual number unknown	Passage estimate: clipped	Passage estimate: unclipped
3-8 March	0	14	0	0	13
9-15 March	0	16	0	0	16
16-22 March	1	5	0	1	5
23-29 March	0	7	0	0	7
30 March-5 April	0	1	1	0	2
6-12 April	0	4	0	0	4
13-19 April	0	2	0	0	2
20-26 April	0	0	0	0	0
27 April-3 May	1	3	0	0	3
4-10 May	0	1	0	0	1
11-17 May	0	3	0	0	3
18-24 May	0	4	0	0	4
25-30 May	0	1	1	0	2
Totals	2	61	2	1	62

Table 5. Chinook salmon video recorded passing the CNFH barrier weir fish ladder and associated passage estimates for 2003. Passage estimates calculations include estimated passage 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
30 May-7 June	205	0	0	0	0	2	8
8-14 June	168	0	0	0	0	2	8
15-21 June	168	120	0	0	0	1	7
22-28 June	168	168	2	9	0	2	9
29 June-5 July	168	168	1	7	0	1	7
6-12 July	168	168	2	9	0	2	9
13-19 July	168	168	0	0	0	0	0
20-26 July	168	168	0	0	0	0	0
27 July-2 August	168	168	0	1	0	0	1
3-9 August	168	144	0	9	0	0	11
10-16 August	168	160.5	1	11	0	1	12
17-23 August	168	165.5	1	49	0	1	50
24-29 August	128	128	1	32	0	1	32
Totals	2181	1726	8	127	0	13	154

Table 6. Rainbow trout / steelhead video recorded passing the CNFH barrier weir fish ladder and associated passage estimates for 2003. Passage estimates include estimated passage 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
30 May-7 June	205	0	0	0	0	0	5.5
8-14 June	168	0	0	0	0	0	5.5
15-21 June	168	120	0	10	0	0	14
22-28 June	168	168	0	9	0	0	9
29 June-5 July	168	168	1	3	0	1	3
6-12 July	168	168	0	1	0	0	1
13-19 July	168	168	0	9	0	0	9
20-26 July	168	168	1	5	0	1	5
27 July-2 August	168	168	0	1	0	0	1
3-9 August	168	144	0	2	0	0	2
10-16 August	168	160.5	0	0	0	0	0
17-23 August	168	165.5	0	0	0	0	0
24-29 August	128	128	0	1	0	0	1
Totals	2181	1726	2	41	0	2	56

Table 7. Total passage estimates for Chinook and rainbow trout / steelhead above CNFH barrier weir in 2003.

Passage Route	Chinook Passage: Clipped	Chinook Passage: Unclipped	Steelhead Passage: Clipped	Steelhead Passage: Unclipped
CNFH	0	57	769	416
Barrier Weir: Trap	0	67	1	62
Barrier Weir: Video	13	154	2	56
Total Passage	13	278	772	534

Table 8. Chinook salmon live adults, carcasses, and redds observed during the 2003 Battle Creek stream 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 [a]	Carcasses	Redds
1	06/24/03	11	0	0
1	07/08/03	18	3	0
1	07/29/03	18	0	0
1	08/19/03	7	1	0
1	09/02/03	3	3	0
1	09/16/03	4	0	6
1	09/30/03	1	0	4
1	10/14/03	4	4	4
1	10/28/03	0	2	0
1	11/14/03	0	0	0
2	06/25/03	4	0	0
2	07/09/03	1	0	0
2	07/30/03	1	1	0
2	08/20/03	0	0	0
2	09/03/03	0	1	0
2	09/17/03	3	1	5

2	10/01/03	16	6	27
2	10/15/03	15	15	21
2	10/29/03	1	7	12
2	11/12/03	0	2	0
3	06/17/03	1	0	0
3	06/25/03	11	0	0
3	07/09/03	6	0	0
3	07/30/03	25	0	0
3	08/20/03	31	0	0
3	09/03/03	25	1	0
3	09/17/03	13	0	8
3	10/01/03	12	0	8
3	10/15/03	7	5	4
3	10/29/03	0	3	6
3	11/14/03	0	1	0
4	06/26/03	12	0	0
4	07/10/03	37	0	0
4	07/31/03	33	1	0
4	08/21/03	52	0	0
4	09/04/03	61	1	0
4	09/18/03	35	1	5
4	10/02/03	26	2	16
4	10/16/03	9	3	12
4	10/30/03	1	9	12
4	11/13/03	0	0	0
5	06/26/03	0	1	1
5	07/10/03	0	0	0
5	07/31/03	0	1	0

5	08/21/03	0	0	0
5	09/04/03	0	1	0
5	09/18/03	1	0	0
5	10/02/03	2	0	1
5	10/16/03	3	1	6
5	10/30/03	0	1	2
5	11/13/03	0	0	0
6	06/27/03	0	0	0
6	07/11/03	1	0	0
6	08/01/03	0	0	0
6	08/22/03	2	0	0
6	09/05/03	0	1	0
6	09/19/03	1	0	0
6	10/03/03	1	0	1
6	10/17/03	8	0	7
6	10/31/03	1	3	8
6	11/14/03	1	0	0
7	06/27/03	0	0	0
7	07/11/03	0	0	0
7	08/01/03	0	0	0
7	08/22/03	2	0	0
7	09/05/03	19	0	0
7	09/19/03	2496	1	0
		Totals	83	176

Table 9. Total Monthly Counts of Live Chinook Observed on Battle Creek stream surveys 2003. Returning Coleman Hatchery Fall-Run Chinook in September, not counted in total.

Date	June	July	July/Aug	August	September	September	Sept/Oct	October	October	November
Reach 1-7	24-27	8-11	29-01	19-22	2-5	16-19	30-03	14-17	28-31	10-14
1	11	18	18	7	3	4	1	4	0	0
2	4	1	1	0	0	3	16	15	1	0
3	11	6	25	31	25	13	12	7	0	0
4	12	37	33	52	61	35	26	9	1	0
5	0	0	0	0	0	1	2	3	0	0
6	0	1	0	2	0	1	1	8	1	1
7	0	0	0	2	19	2496	X	X	X	X
Totals	38	63	77	94	108	57	58	46	3	1

Table 10. Rainbow trout / steelhead observed during the 2003 Battle Creek stream surveys. 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	06/24/03	1005	0	0	1005
1	07/08/03	1273	2	0	1275
1	07/29/03	1149	4	0	1153
1	08/19/03	800	2	0	802
1	09/02/03	1202	13	0	1215
1	09/16/03	976	2	0	978
1	09/30/03	792	1	0	793
1	10/14/03	446	1	0	447
1	10/28/03	389	1	0	390
1	11/14/03	337	2	0	339
2	06/25/03	204	0	0	204
2	07/09/03	292	2	0	294
2	07/30/03	536	3	0	539
2	08/20/03	539	15	0	554
2	09/03/03	578	2	1	581
2	09/17/03	626	10	0	636
2	10/01/03	400	1	0	401

2	10/15/03	278	1	0	279
2	10/29/03	392	0	0	392
2	11/12/03	242	0	0	242
3	06/17/03	163	2	0	165
3	06/25/03	400	8	0	408
3	07/09/03	336	11	0	347
3	07/30/03	196	8	0	104
3	08/20/03	322	24	1	347
3	09/03/03	357	55	3	415
3	09/17/03	236	32	0	268
3	10/02/03	241	14	0	255
3	10/15/03	280	30	1	311
3	10/29/03	348	22	2	372
3	11/14/03	145	21	1	167
4	06/26/03	272	11	3	286
4	07/10/03	579	16	2	597
4	07/31/03	423	35	1	459
4	08/21/03	544	122	3	669
4	09/04/03	570	167	3	740
4	09/18/03	683	66	1	750

4	10/02/03	414	45	3	462
4	10/16/03	435	16	0	451
4	10/30/03	353	55	0	408
4	11/13/03	174	7	3	184
5	06/26/03	77	6	0	83
5	07/10/03	236	33	0	269
5	07/31/03	202	22	1	225
5	08/21/03	330	54	2	386
5	09/04/03	191	22	2	215
5	09/18/03	220	26	2	248
5	10/03/03	173	21	0	194
5	10/16/03	87	34	1	122
5	10/30/03	126	17	0	143
5	11/13/03	124	5	0	129
6	06/27/03	23	2	0	25
6	07/11/03	47	4	1	52
6	08/01/03	56	2	0	58
6	08/22/03	38	8	1	47
6	09/05/03	39	0	0	39
6	09/19/03	69	6	0	75

6	10/04/03	32	2	0	34
6	10/17/03	33	11	0	44
6	10/31/03	34	2	1	37
6	11/14/03	24	1	0	25
7	06/27/03	24	4	2	30
7	07/11/03	36	2	0	38
7	08/01/03	43	5	2	50
7	08/22/03	31	16	8	55
7	09/05/03	36	6	1	43
7	09/19/03	22	11	1	34

Table 11. Rainbow trout/Steelhead totals from Monthly stream surveys on Battle Creek 2003.

Date Reach 1-7	June 24-27	July 8-11	July/Aug 29-01	August 19-22	September 2-5	Sept 16-19	Sept/Oct 30-3	October 14-17	Oct 28-31	November 10-14	Mean Totals
1	1005	1275	1153	802	1215	978	793	447	390	339	895
2	204	294	539	554	581	636	401	279	392	242	431
3	408	347	204	347	415	268	255	311	372	167	325
4	286	597	459	669	740	750	462	451	408	184	536
5	83	269	225	386	215	248	194	122	143	129	209
6	25	52	58	47	39	75	34	44	37	25	46
7	30	38	51	55	43	34	X	X	X	X	42
Totals	2041	2872	2689	2860	3248	2989	2139	1654	1742	1086	2443

Table 12. 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	55	0	7	33	27
MS R4 Upper	16.3	76	0	0	12	34
MS R4 Lower (Barn)	12.9	96	0	0	14	12
MS R5 Upper	12	27	0	25	56	14
MS R5 Lower (Spring Branch)	9.3	96	0	15	11	0
NF Battle (Wild Cat Dam)	2.5	89	0	0	3	30
NF Wildcat Road (CDEC)	0.9	0	0	11	59	52
NF Battle (Confluence)	0.02	14	0	14	57	37
SF Battle (Coleman Diversion Dam)	2.6	42	0	0	44	36
SF Manton Bridge (CDEC)	1.7	0	0	0	51	71
SF Battle (Confluence)	0.02	0	0	10	68	44
Totals		495	0	82	408	357

Table 13. 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	0	0	5	17	25
MS R4 Upper	16.3	0	0	2	18	27
MS R4 Lower (Barn)	12.9	0	0	13	11	23
MS R5 Upper	12	18	0	0	6	23
MS R5 Lower (Spring Branch)	9.3	15	3	6	1	22
NF Battle (Wild Cat Dam)	2.5	17	0	0	0	30
NF Wildcat Road (CDEC)	0.9	0	0	0	18	29
NF Battle (Confluence)	0.02	15	0	0	9	23
SF Battle (Coleman Diversion Dam)	2.6	31	0	0	0	16
SF Manton Bridge (CDEC)	1.7	0	0	0	5	42
SF Battle (Confluence)	0.02	0	0	0	15	32
Totals		96	3	26	100	292

Figures

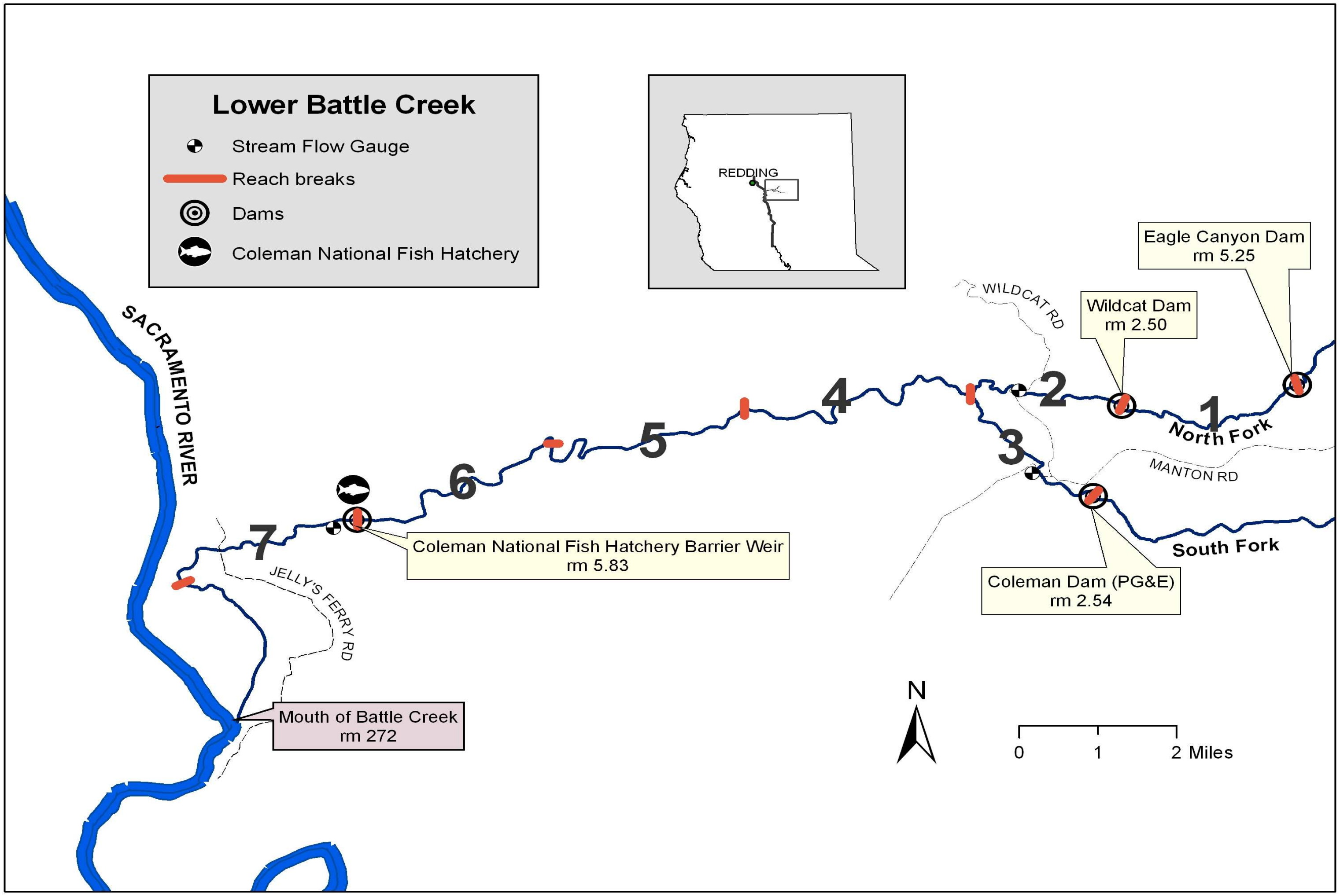

Figure 1. Map of Battle Creek depicting location of the Coleman National Fish Hatchery barrier weir and stream survey reaches.

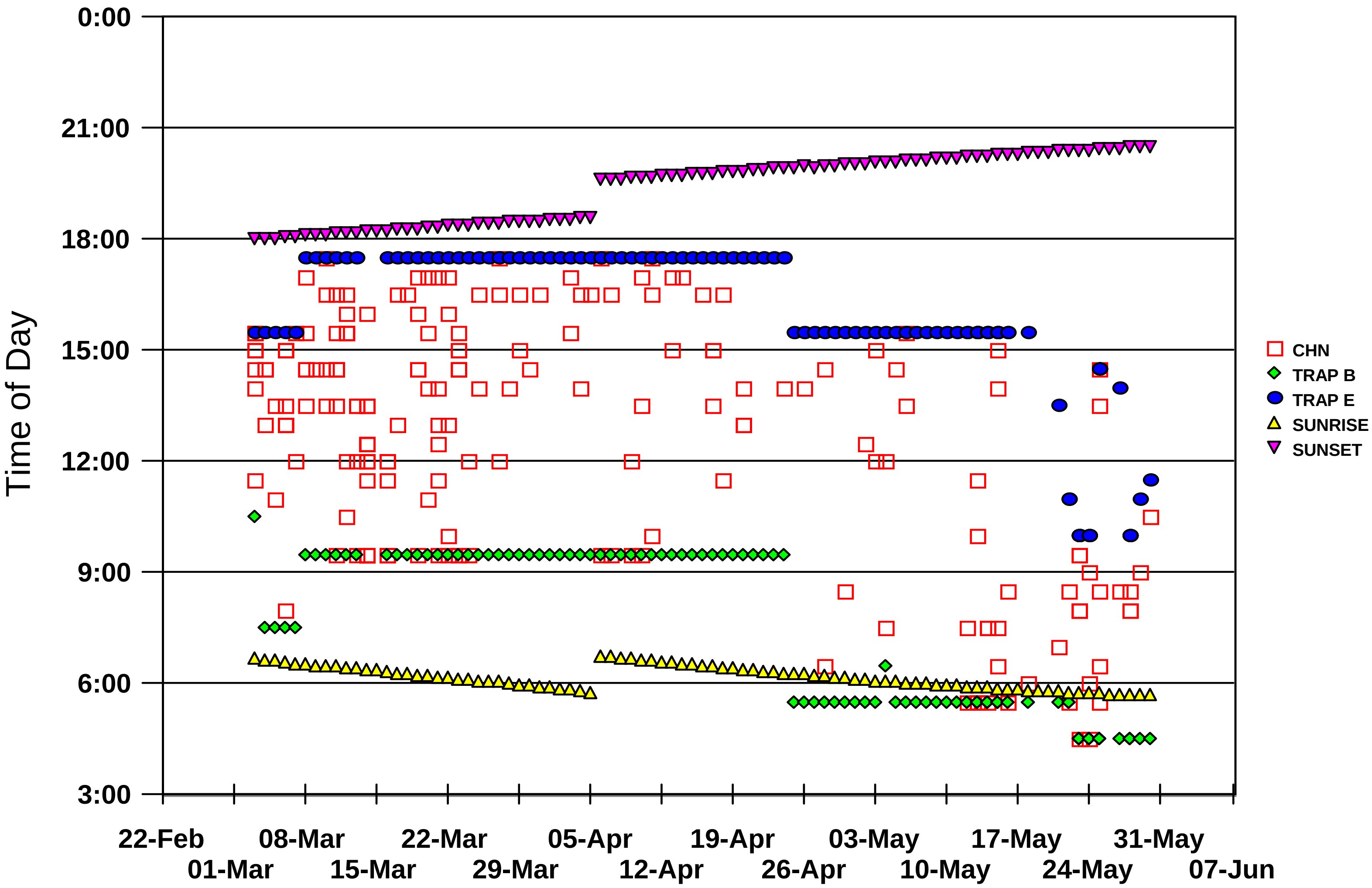

Figure 2. Diel timing of Chinook passing the Battle Creek barrier weir during trapping in 2003.

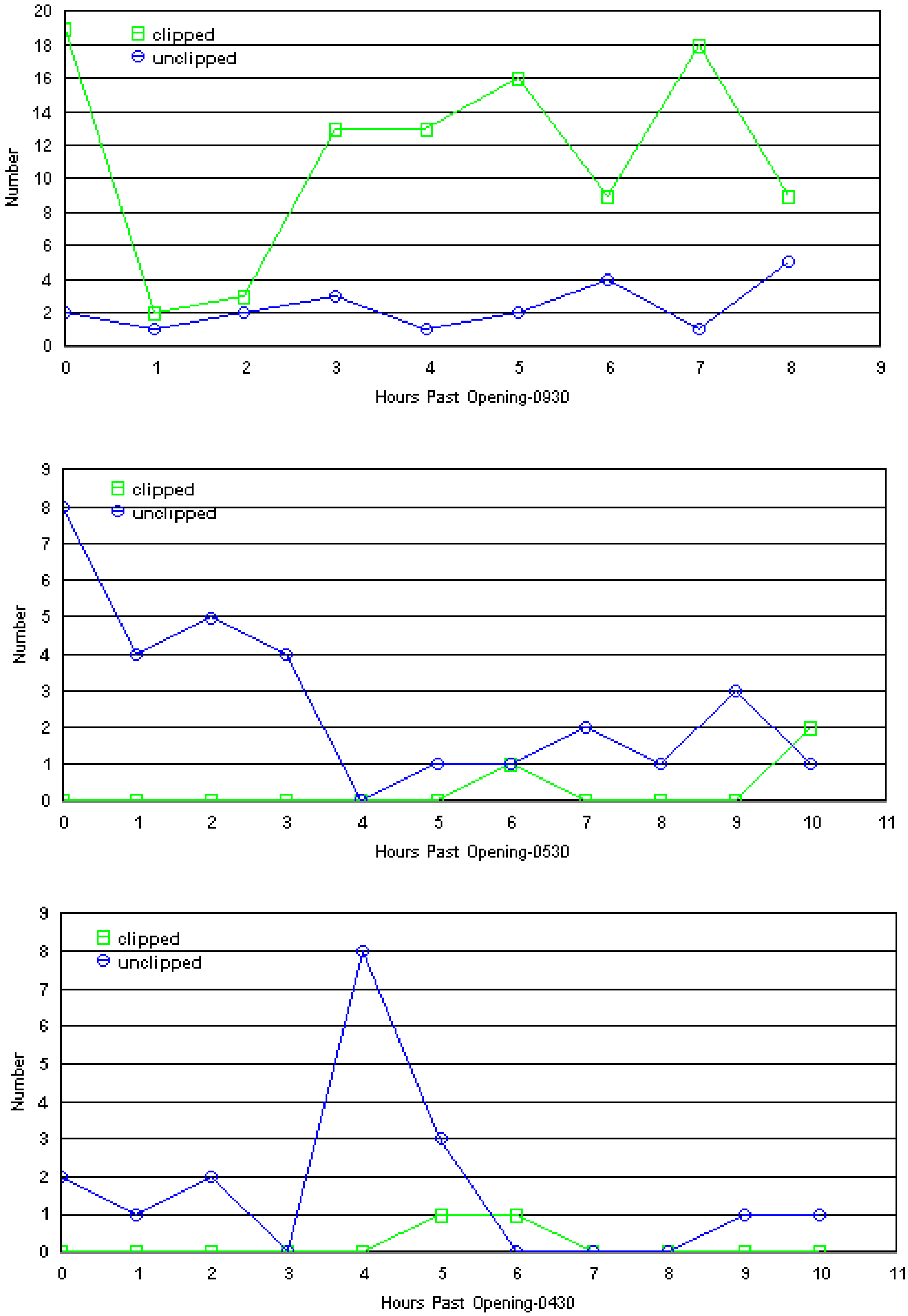

Figure 3. Time Frequency of Chinook captured at weir trap. Three graphs represent three different start times. Start times were shifted to capture earlier passing Chinook. In addition these earlier times coincided with lower water temperatures.

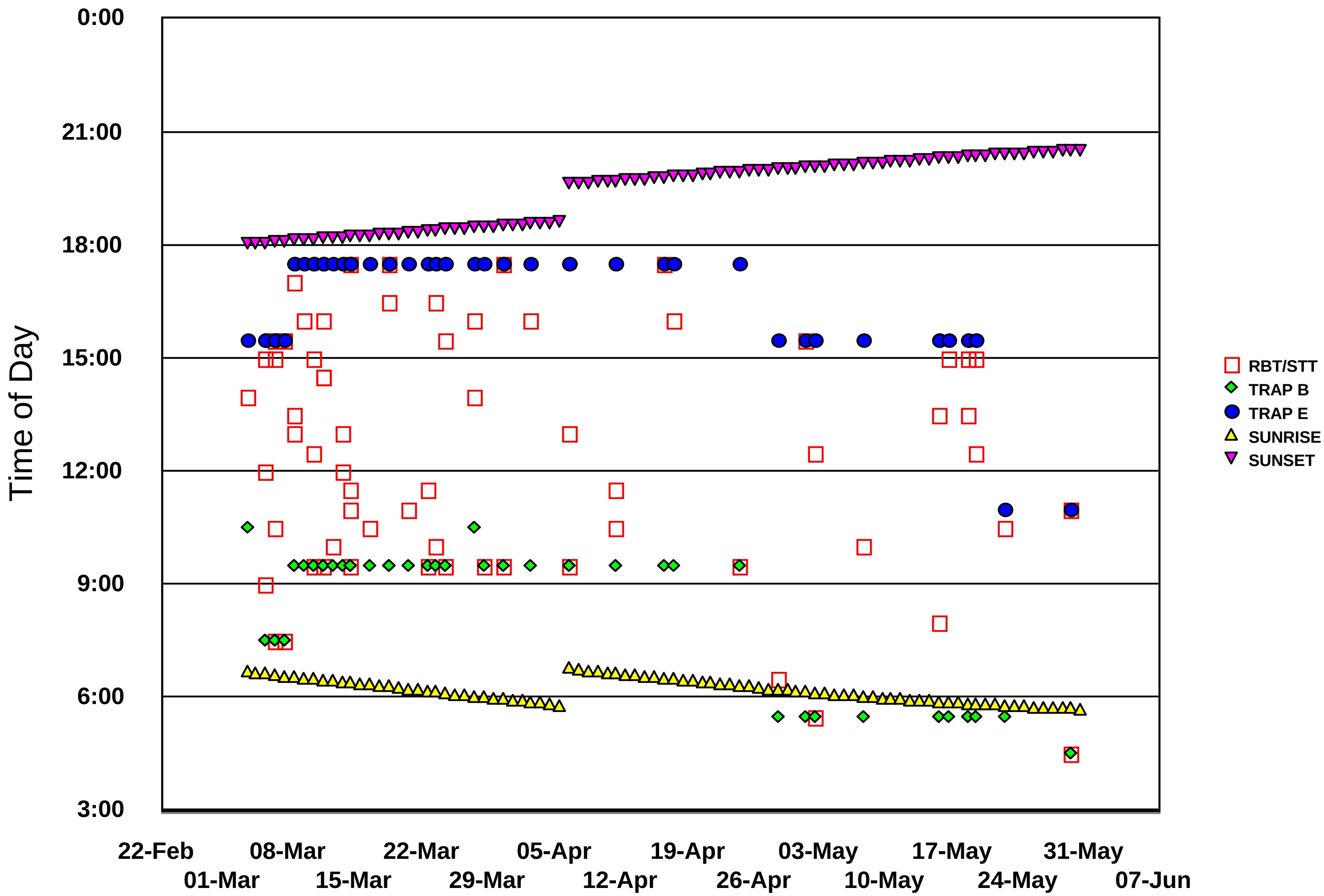

Figure 4. Diel timing of rainbow trout / steelhead passing the Battle Creek barrier weir during trapping in 2003.

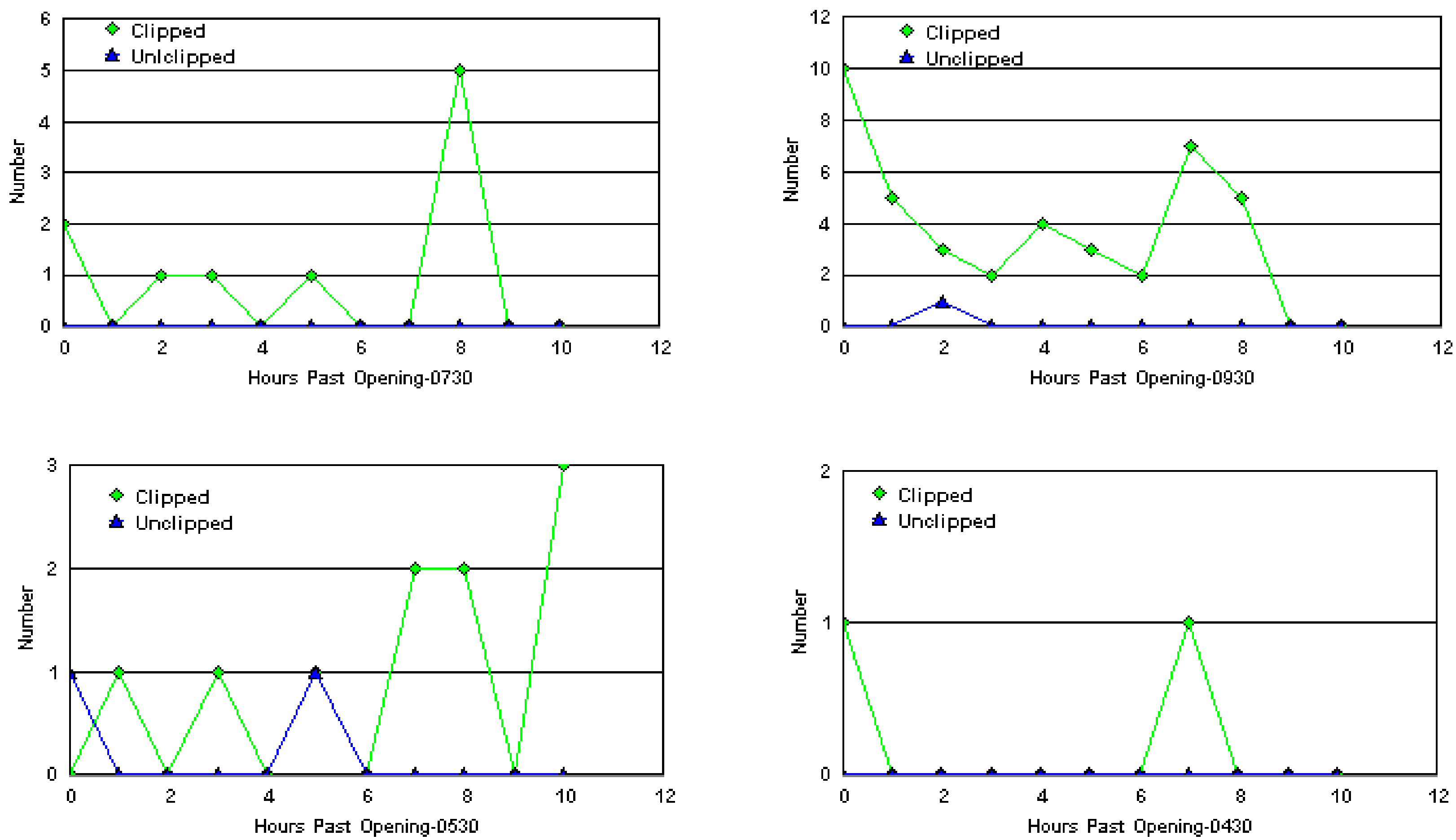

Figure 5. Time frequency of rainbow trout / steelhead captured at weir trap. Four graphs represent four different start times. Start times were shifted to capture earlier passing Chinook, and a wider range of rainbow trout. In addition these earlier times coincided with lower water temps.

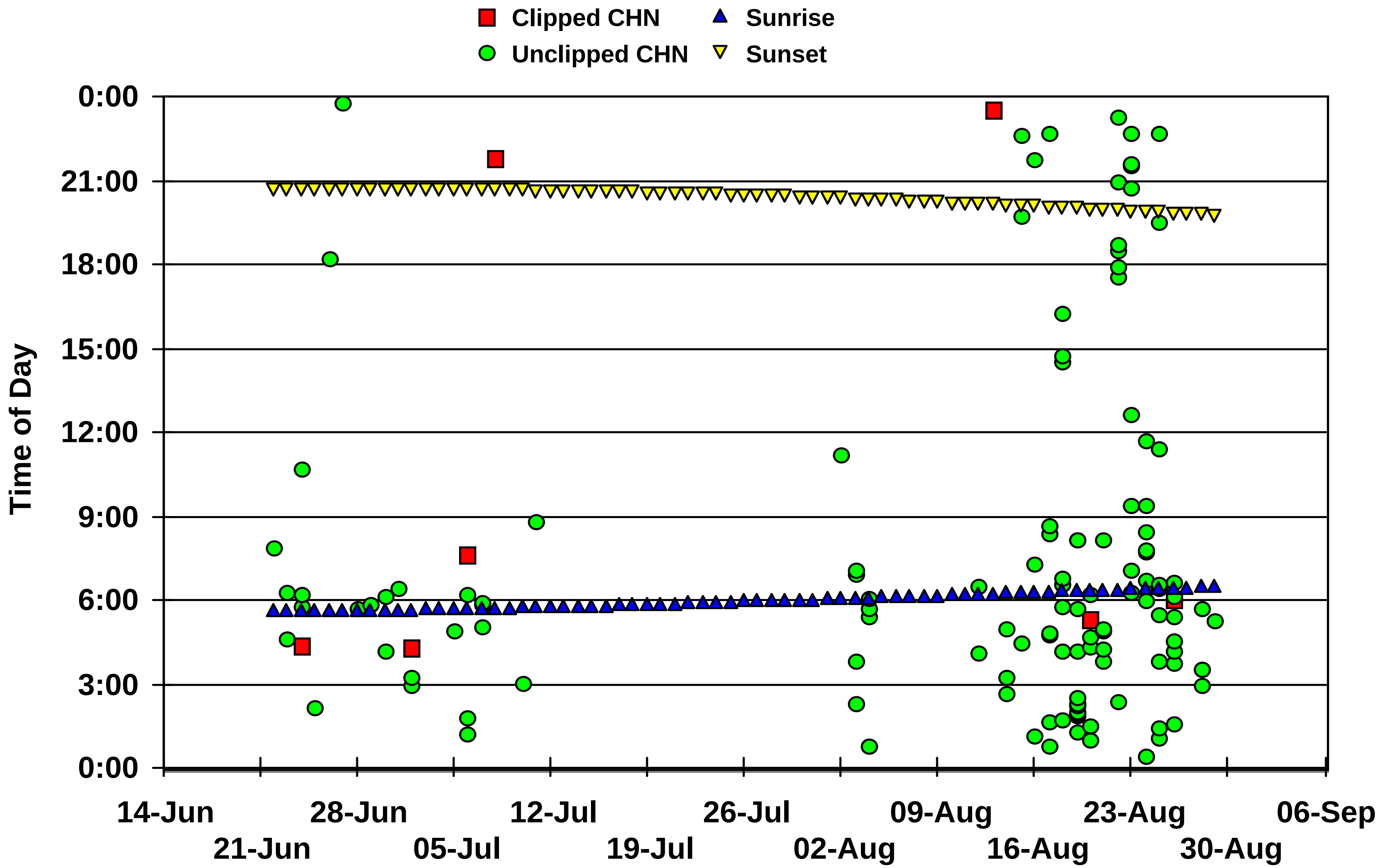

Figure 6. Diel migration timing of Chinook video taped passing Battle Creek barrier weir in 2003.

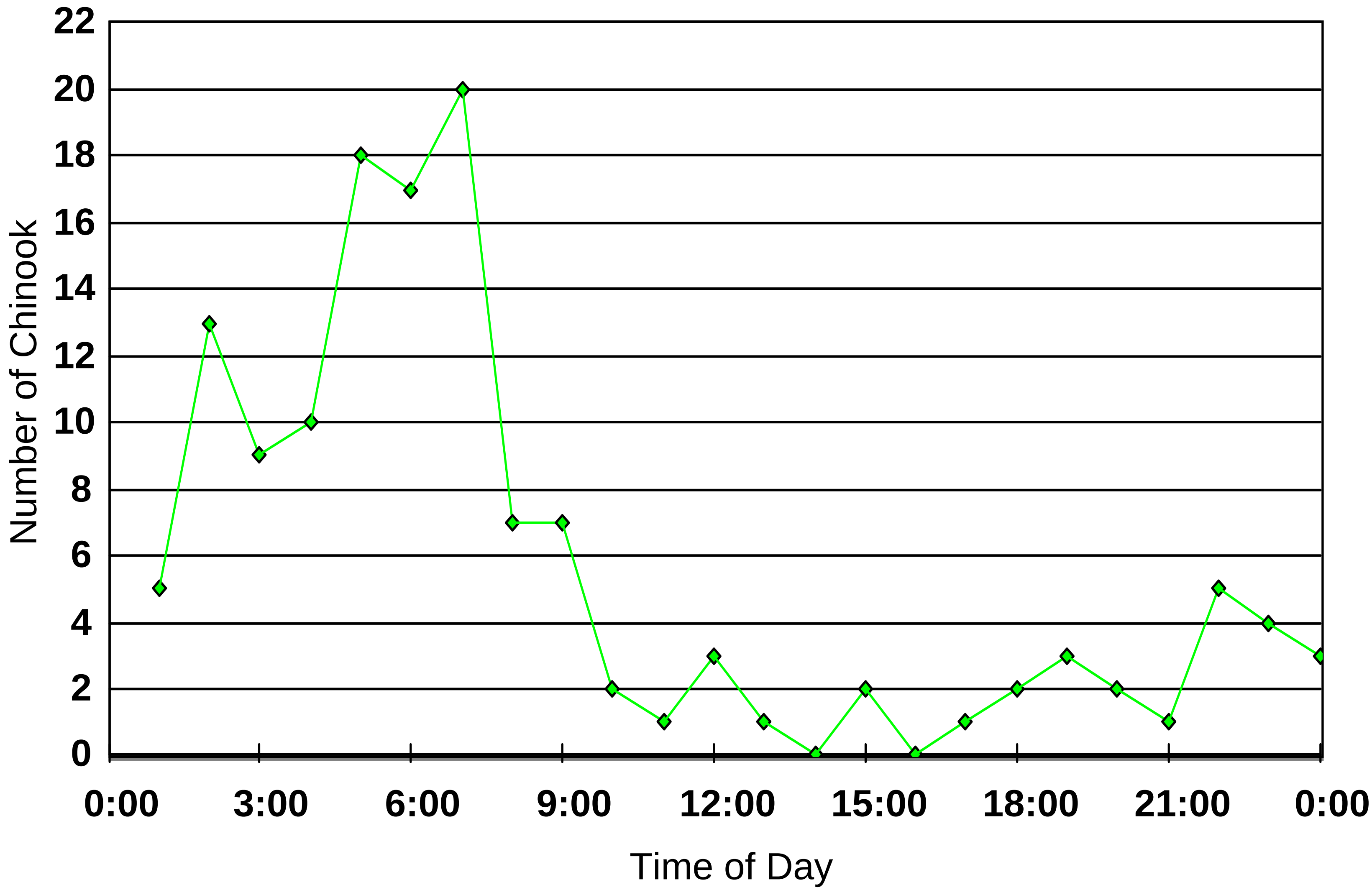

Figure 7. Time of day Chinook passed during underwater video monitoring in 2003.

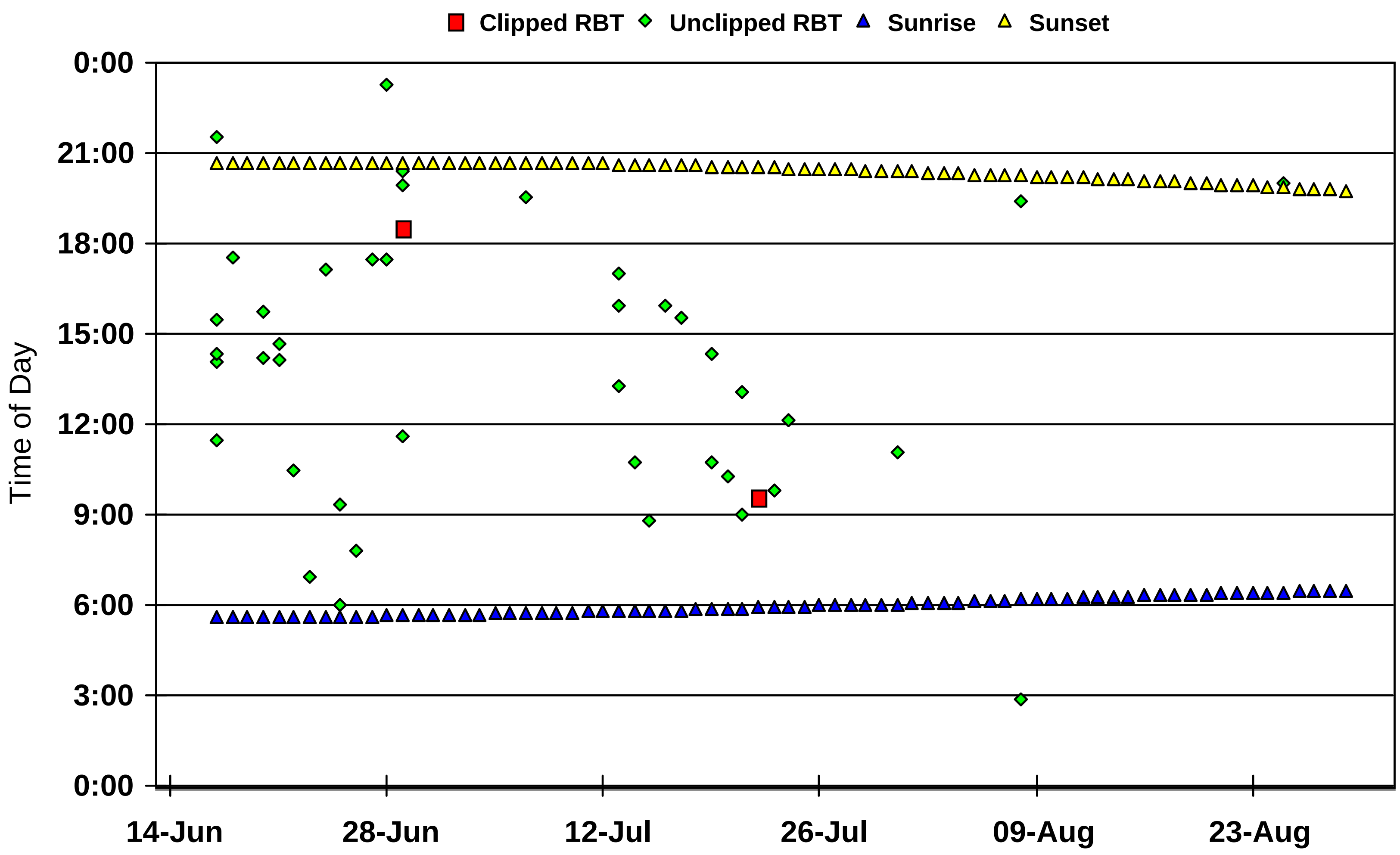

Figure 8. Diel migration timing of rainbow trout video taped passing Battle Creek barrier weir in 2003.

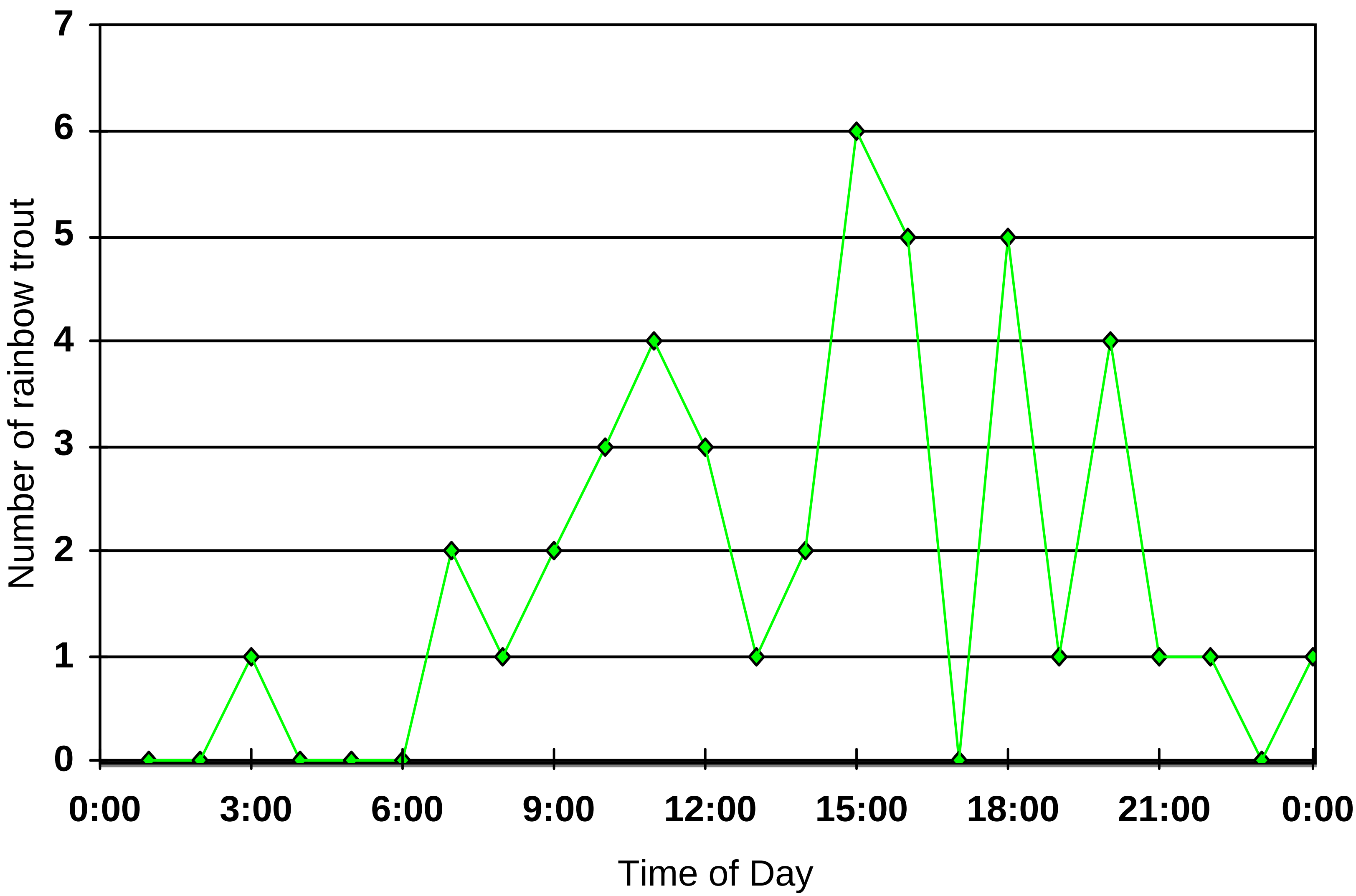

Figure 9. Time of day rainbow trout passed during underwater video monitoring in 2003.

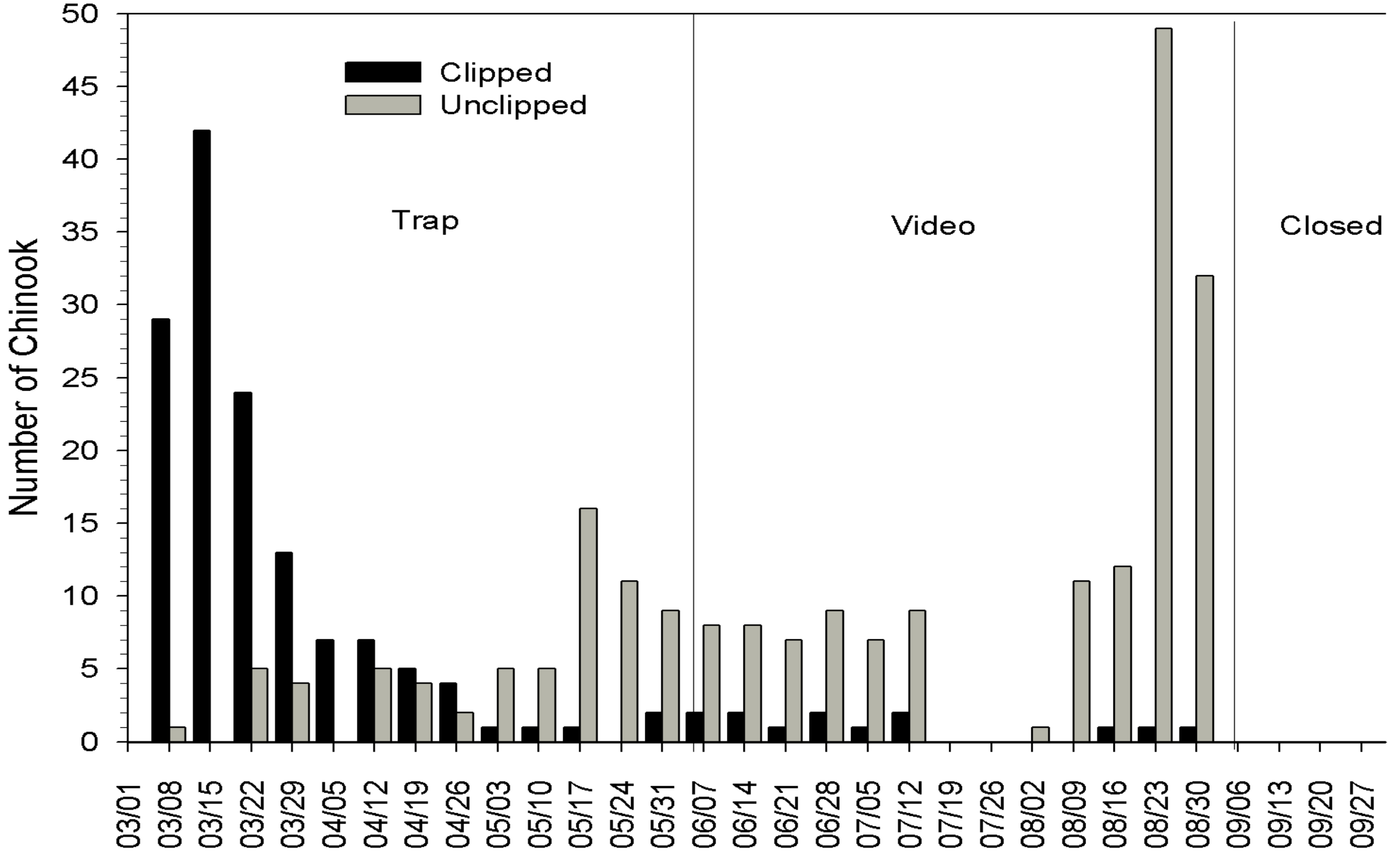

Figure 10. Clipped and unclipped Chinook observed passing through Battle Creek weir fish ladder in 2003.

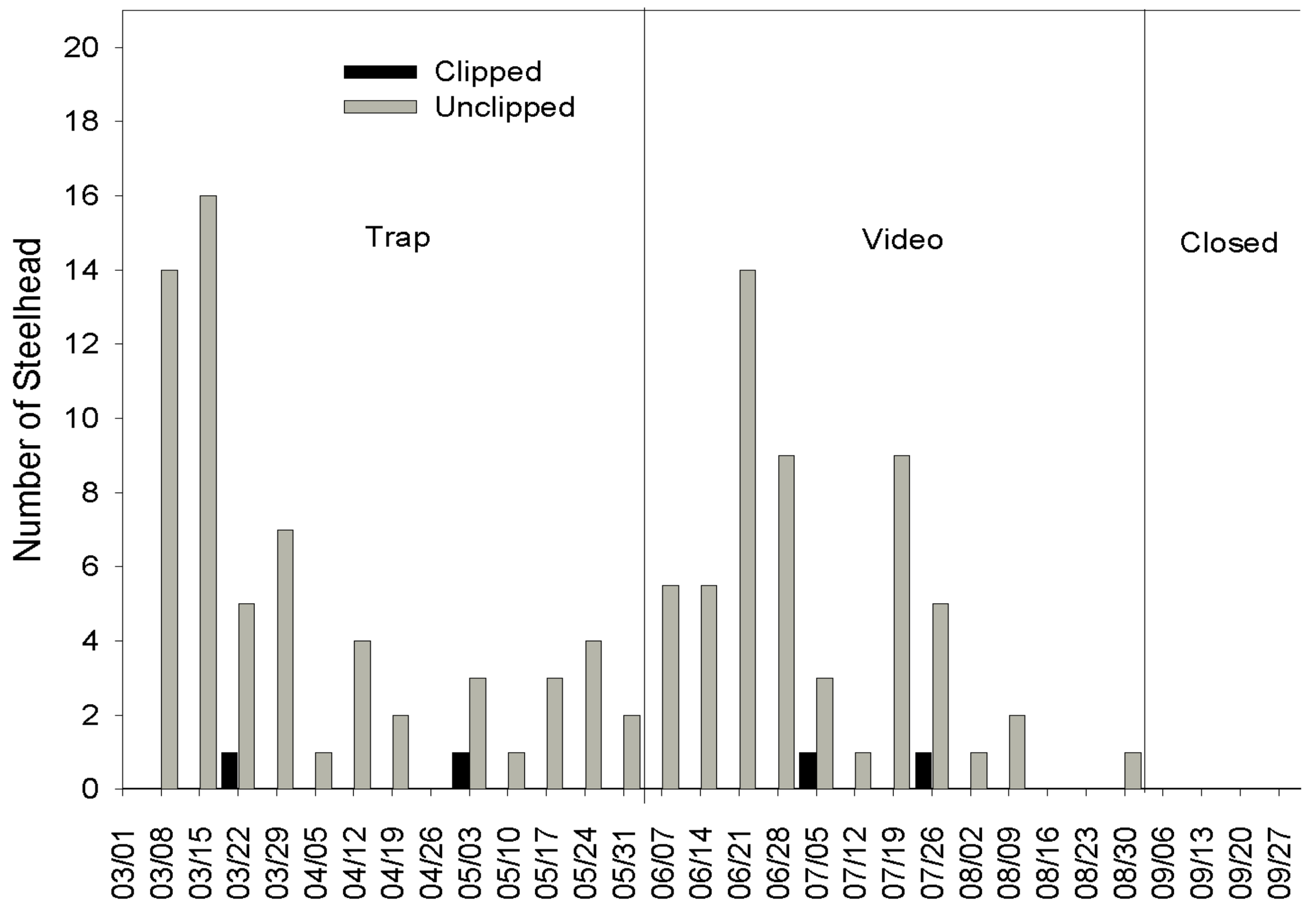

Figure 11. Clipped and unclipped rainbow trout / steelhead observed passing through Battle Creek weir fish ladder in 2003.

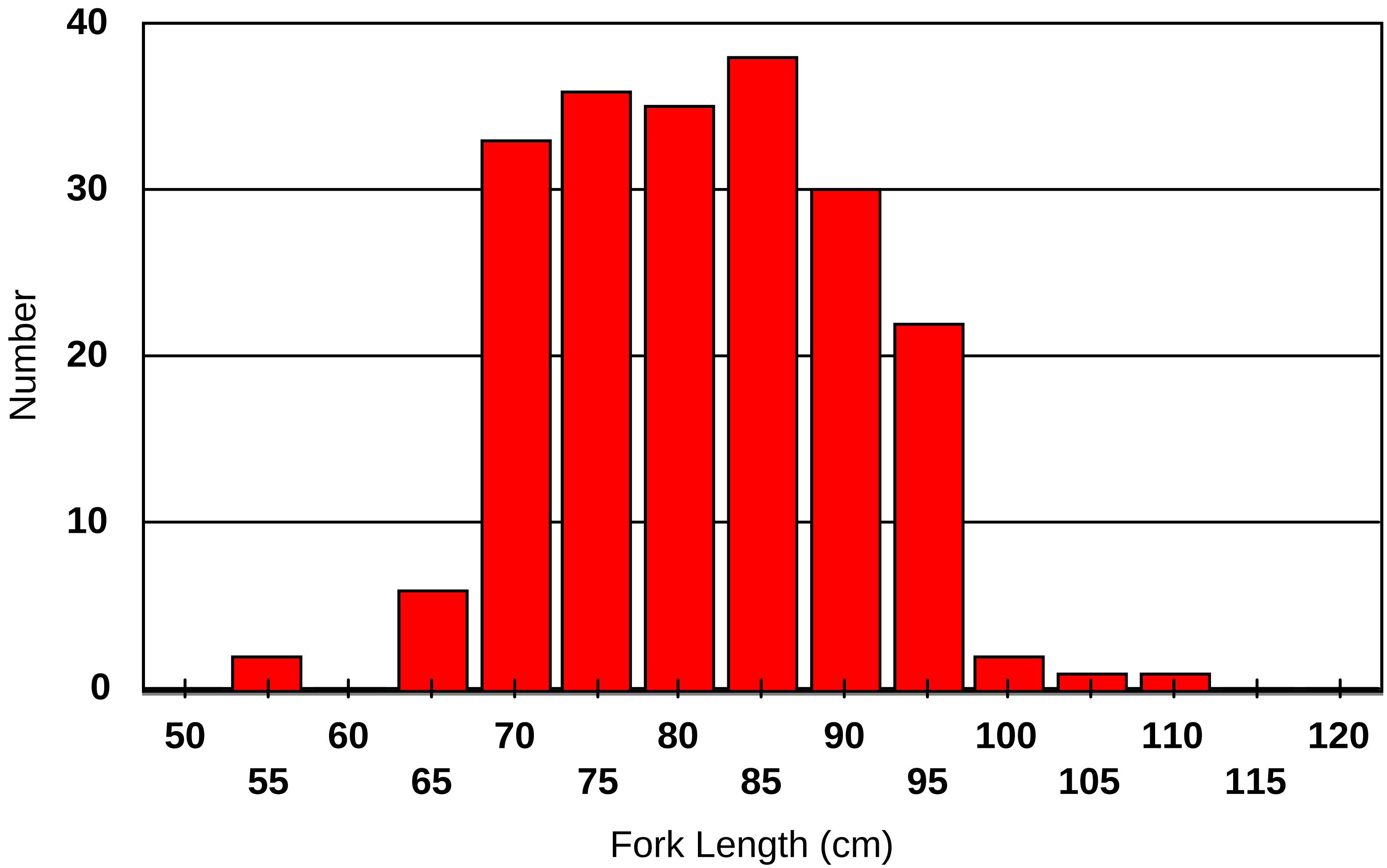

Figure 12. Length frequency distribution of Chinook captured in the Battle Creek barrier weir trap in 2003.

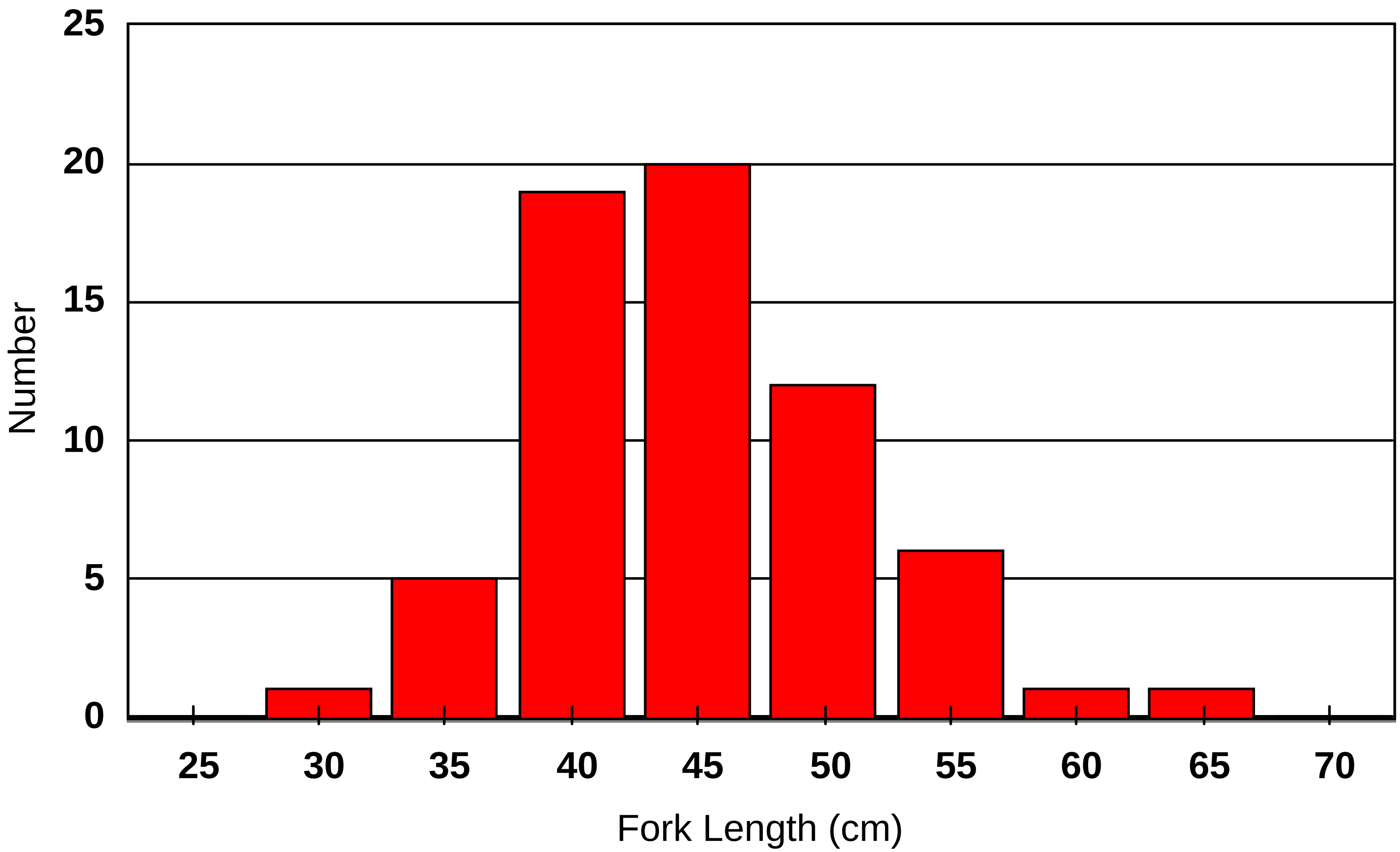

Figure 13. Length frequency distribution of rainbow trout / steelhead in the Battle Creek barrier weir trap in 2003.

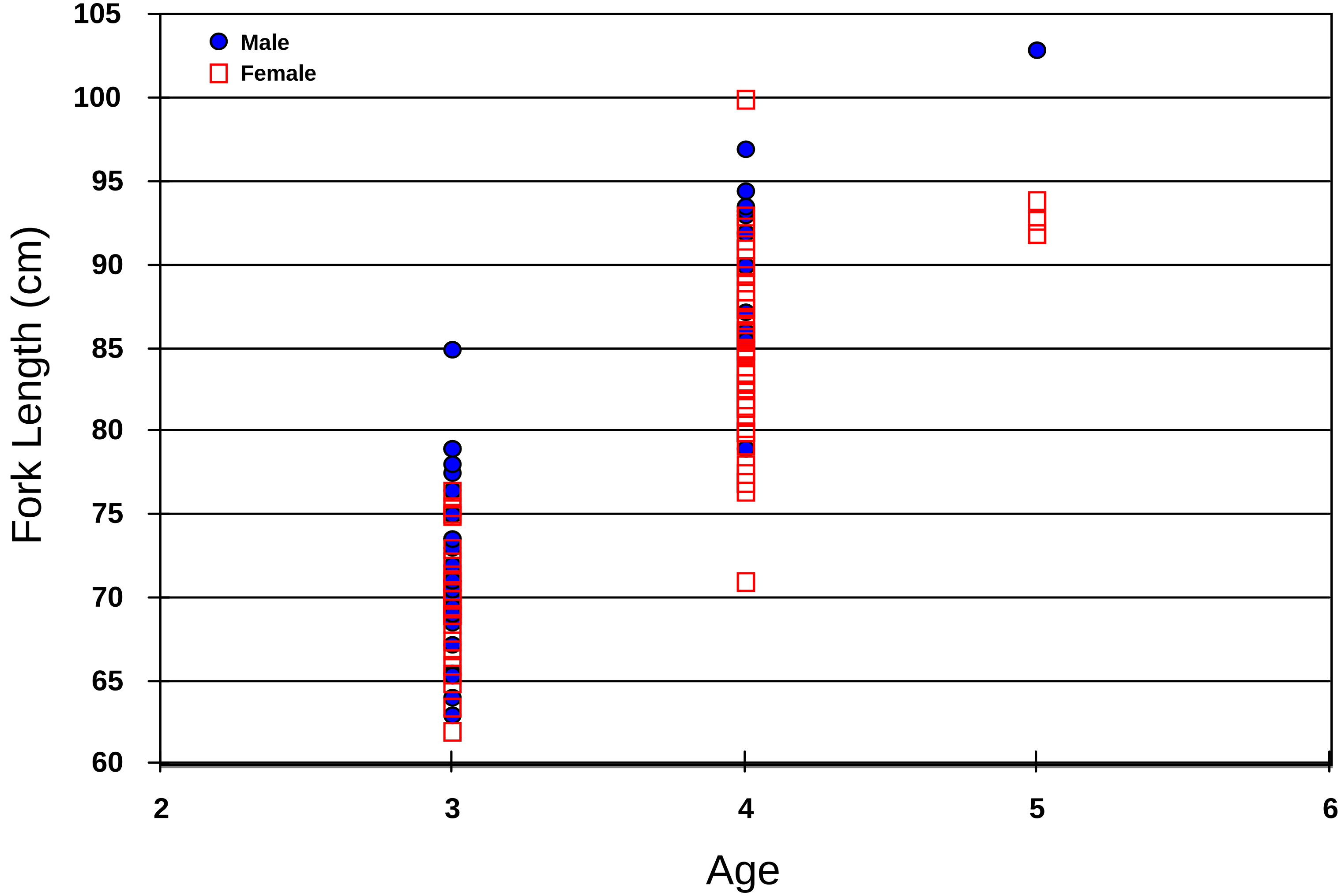

Figure 14. Relationship between fork length and age for coded-wire tagged Chinook captured in the Battle Creek barrier weir trap in 2003.

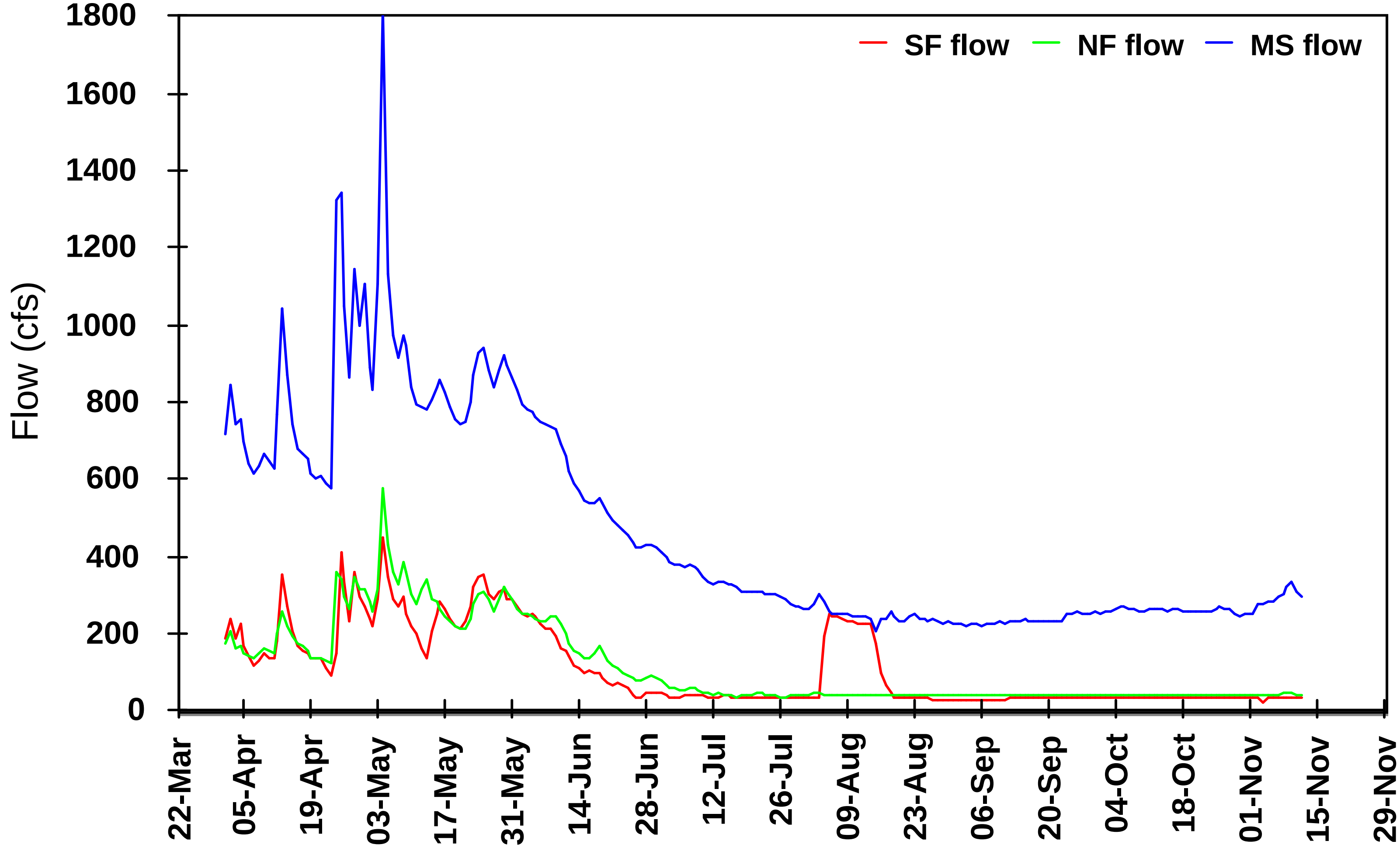

Figure 15. Mean daily flows at the Battle Creek barrier weir (mainstem rm 5.8), Wildcat Road Bridge (North Form rm 0.9), and Manton Road Bridge (South Form rm 1.7) for water year 2003.

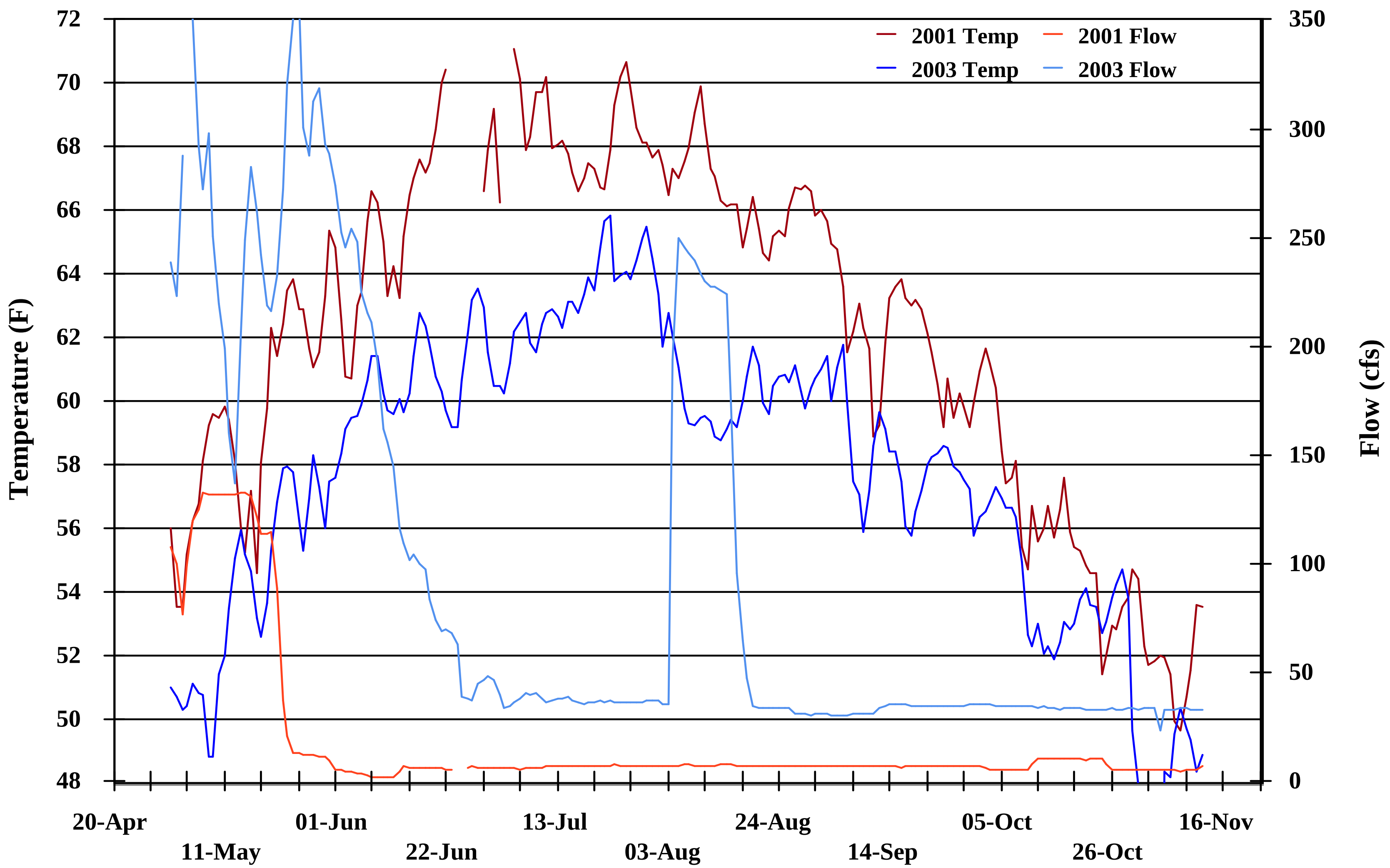

Figure 16. South Fork Battle Creek mean daily flows and mean daily water temperatures at Manton Road Bridge (rm 1.7), during 2001 and 2003.

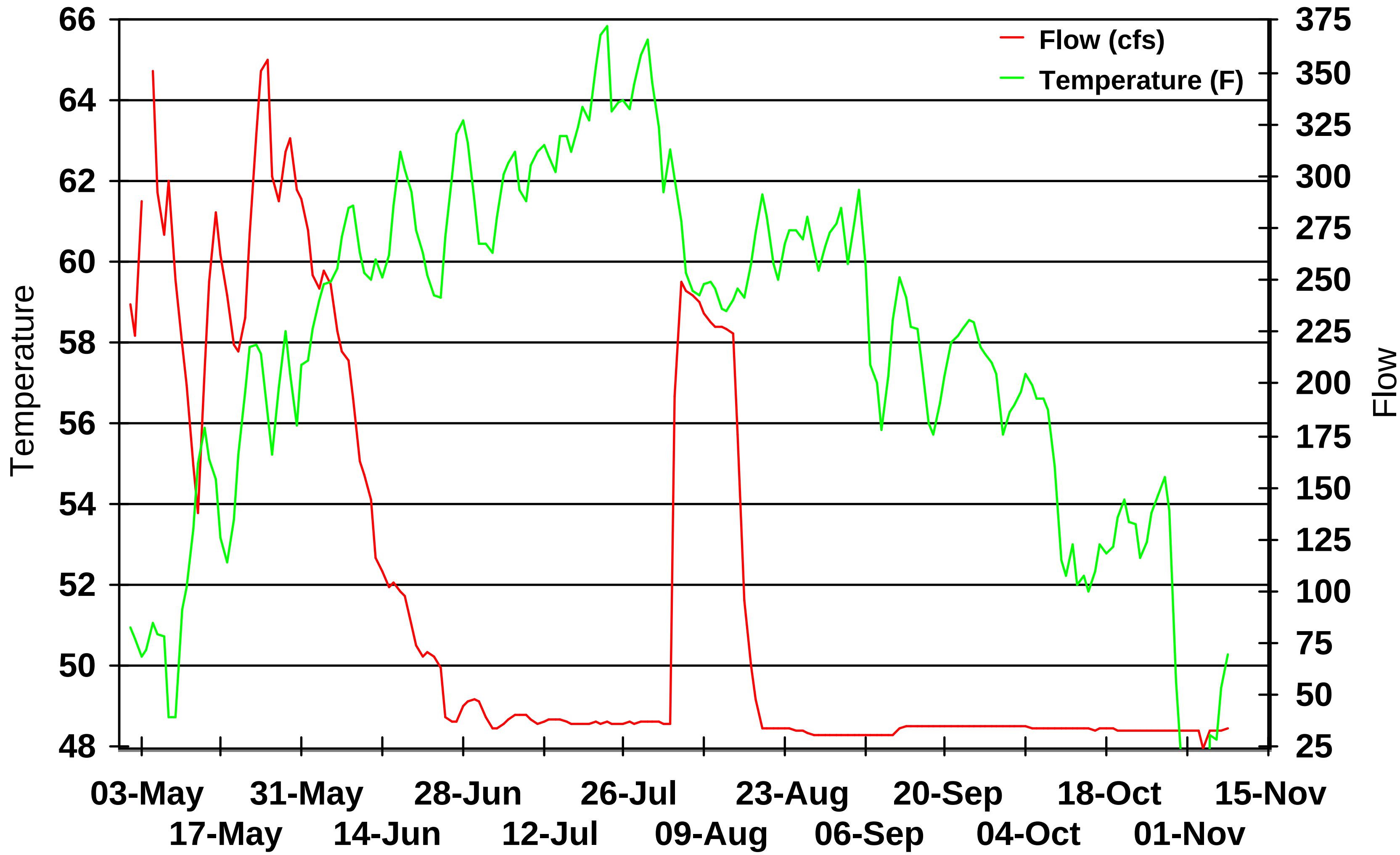

Figure 17. South Fork Battle Creek mean daily flows at Manton Road Bridge (rm 1.7) and mean daily water temperatures at Manton Road Bridge during 2003.

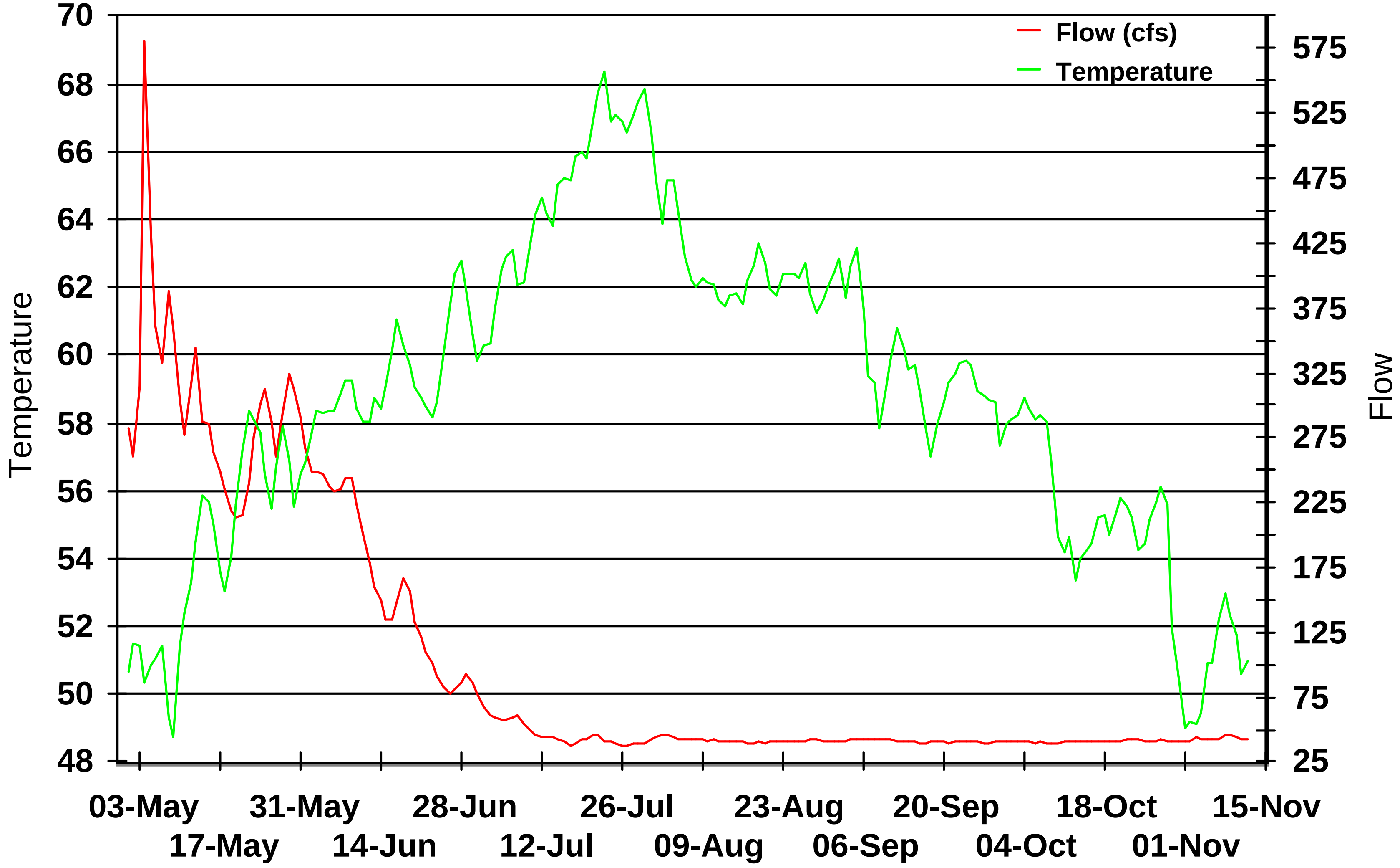

Figure 18. North Fork Battle Creek mean daily flows and mean daily water temperatures at Wildcat Road Bridge (North Fork rm 0.9).

Appendix A. Coded-wire tags recovered during Battle Creek adult salmonid monitoring activities in 2003.

Collection Date	Collection Location and Method	Species	Sex	Fork Length (cm)	Tag Code	Hatchery of Origin	Run	Brood Year
3/3/2003	Barrier Weir Trap	Chinook	female	77	055209	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	male	93	055208	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	female	91.5	055141	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	male	92	055213	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	male	79	050470	CNFH	Late Fall	2000
3/3/2003	Barrier Weir Trap	Chinook	female	89	055210	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	female	62	050468	CNFH	Late Fall	2000
3/3/2003	Barrier Weir Trap	Chinook	male	93.3	055208	CNFH	Late Fall	1999
3/3/2003	Barrier Weir Trap	Chinook	male	67.2	050467	CNFH	Late Fall	2000
3/4/2003	Barrier Weir Trap	Chinook	female	82	055213	CNFH	Late Fall	1999
3/4/2003	Barrier Weir Trap	Chinook	male	103	052309	CNFH	Late Fall	1998
3/4/2003	Barrier Weir Trap	Chinook	female	66	050469	CNFH	Late Fall	2000
3/5/2003	Barrier Weir Trap	Chinook	female	86.8	055212	CNFH	Late Fall	1999
3/5/2003	Barrier Weir Trap	Chinook	female	86	055134	CNFH	Late Fall	1999
3/6/2003	Barrier Weir Trap	Chinook	female	67	050467	CNFH	Late Fall	2000
3/6/2003	Barrier Weir Trap	Chinook	male	71	050470	CNFH	Late Fall	2000
3/6/2003	Barrier Weir Trap	Chinook	male	68.5	050470	CNFH	Late Fall	2000
3/6/2003	Barrier Weir Trap	Chinook	female	73.5	NTD			
3/6/2003	Barrier Weir Trap	Chinook	female	76.5	050397	CNFH	Late Fall	2000
3/6/2003	Barrier Weir Trap	Chinook	female	68.5	050469	CNFH	Late Fall	2000
3/6/2003	Barrier Weir Trap	Chinook	female	91	055209	CNFH	Late Fall	1999
3/6/2003	Barrier Weir Trap	Chinook	male	79	050467	CNFH	Late Fall	2000
3/7/2003	Barrier Weir Trap	Chinook	female	75.2	050469	CNFH	Late Fall	2000
3/7/2003	Barrier Weir Trap	Chinook	female	77	055210	CNFH	Late Fall	1999
3/8/2003	Barrier Weir Trap	Chinook	female	87.5	055213	CNFH	Late Fall	1999
3/8/2003	Barrier Weir Trap	Chinook	male	86	055211	CNFH	Late Fall	1999
3/8/2003	Barrier Weir Trap	Chinook	female	80	055210	CNFH	Late Fall	1999

3/8/2003	Barrier Weir Trap	Chinook	female	80	055211	CNFH	Late Fall	1999
3/8/2003	Barrier Weir Trap	Chinook	female	81.5	055210	CNFH	Late Fall	1999
3/9/2003	Barrier Weir Trap	Chinook	female	70	050469	CNFH	Late Fall	2000
3/10/2003	Barrier Weir Trap	Chinook	female	71	050469	CNFH	Late Fall	2000
3/10/2003	Barrier Weir Trap	Chinook	female	91	055207	CNFH	Late Fall	1999
3/10/2003	Barrier Weir Trap	Chinook	female	89.5	055209	CNFH	Late Fall	1999
3/10/2003	Barrier Weir Trap	Chinook	female	81.5	055213	CNFH	Late Fall	1999
3/11/2003	Barrier Weir Trap	Chinook	male	77.5	050470	CNFH	Late Fall	2000
3/11/2003	Barrier Weir Trap	Chinook	female	86	055211	CNFH	Late Fall	1999
3/11/2003	Barrier Weir Trap	Chinook	male	78	050470	CNFH	Late Fall	2000
3/11/2003	Barrier Weir Trap	Chinook	female	80	055212	CNFH	Late Fall	1999
3/11/2003	Barrier Weir Trap	Chinook	male	85	050481	CNFH	Late Fall	2000
3/11/2003	Barrier Weir Trap	Chinook	female	85	055140	CNFH	Late Fall	1999
3/11/2003	Barrier Weir Trap	Chinook	female	63.5	050397	CNFH	Late Fall	2000
3/12/2003	Barrier Weir Trap	Chinook	female	78	055212	CNFH	Late Fall	1999
3/12/2003	Barrier Weir Trap	Chinook	female	86.5	055212	CNFH	Late Fall	1999
3/12/2003	Barrier Weir Trap	Chinook	female	71	055212	CNFH	Late Fall	1999
3/12/2003	Barrier Weir Trap	Chinook	male	69	050470	CNFH	Late Fall	2000
3/12/2003	Barrier Weir Trap	Chinook	male	79	050469	CNFH	Late Fall	2000
3/12/2003	Barrier Weir Trap	Chinook	female	84	055211	CNFH	Late Fall	1999
3/12/2003	Barrier Weir Trap	Chinook	female	87.5	055209	CNFH	Late Fall	1999
3/13/2003	Barrier Weir Trap	Chinook	male	79	055209	CNFH	Late Fall	1999
3/13/2003	Barrier Weir Trap	Chinook	female	81	055213	CNFH	Late Fall	1999
3/13/2003	Barrier Weir Trap	Chinook	male	71	050465	CNFH	Late Fall	2000
3/13/2003	Barrier Weir Trap	Chinook	female	92	052314	CNFH	Late Fall	1998
3/14/2003	Barrier Weir Trap	Chinook	female	86	055140	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	90	055141	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	69	050470	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	male	70.5	050470	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	male	73.5	050467	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	male	97	055210	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	82	055211	CNFH	Late Fall	1999

3/14/2003	Barrier Weir Trap	Chinook	male	73.5	050469	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	female	83	055209	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	82.5	055210	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	male	100	055209	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	75	050468	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	female	83	055208	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	92	054129	CNFH	Late Fall	1998
3/14/2003	Barrier Weir Trap	Chinook	female	83	055213	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	female	69	050466	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	female	88	055212	CNFH	Late Fall	1999
3/14/2003	Barrier Weir Trap	Chinook	male	70	050470	CNFH	Late Fall	2000
3/14/2003	Barrier Weir Trap	Chinook	female	85	055209	CNFH	Late Fall	1999
3/16/2003	Barrier Weir Trap	Chinook	male	70.5	050469	CNFH	Late Fall	2000
3/16/2003	Barrier Weir Trap	Chinook	female	88	055141	CNFH	Late Fall	1999
3/16/2003	Barrier Weir Trap	Chinook	female	80	055212	CNFH	Late Fall	1999
3/16/2003	Barrier Weir Trap	Chinook	female	87.5	055210	CNFH	Late Fall	1999
3/16/2003	Barrier Weir Trap	Chinook	female	83	055141	CNFH	Late Fall	1999
3/17/2003	Barrier Weir Trap	Chinook	female	84.8	055211	CNFH	Late Fall	1999
3/17/2003	Barrier Weir Trap	Chinook	female	94	052313	CNFH	Late Fall	1998
3/18/2003	Barrier Weir Trap	Chinook	female	93	NTD			
3/19/2003	Barrier Weir Trap	Chinook	female	70	050468	CNFH	Late Fall	2000
3/19/2003	Barrier Weir Trap	Chinook	male	69.5	050465	CNFH	Late Fall	2000
3/19/2003	Barrier Weir Trap	Chinook	female	77.5	055209	CNFH	Late Fall	1999
3/19/2003	Barrier Weir Trap	Chinook	female	69	050467	CNFH	Late Fall	2000
3/19/2003	Barrier Weir Trap	Chinook	female	85	055208	CNFH	Late Fall	1999
3/20/2003	Barrier Weir Trap	Chinook	male	65.5	050469	CNFH	Late Fall	2000
3/20/2003	Barrier Weir Trap	Chinook	female	70.5	050466	CNFH	Late Fall	2000
3/20/2003	Barrier Weir Trap	Chinook	female	85.5	055213	CNFH	Late Fall	1999
3/20/2003	Barrier Weir Trap	Chinook	female	85	055212	CNFH	Late Fall	1999
3/21/2003	Barrier Weir Trap	Chinook	male	65.3	050470	CNFH	Late Fall	2000
3/21/2003	Barrier Weir Trap	Chinook	female	85.7	055212	CNFH	Late Fall	1999
3/21/2003	Barrier Weir Trap	Chinook	male	73	050467	CNFH	Late Fall	2000

3/21/2003	Barrier Weir Trap	Chinook	female	67.5	050469	CNFH	Late Fall	2000
3/22/2003	Barrier Weir Trap	Chinook	female	81	055209	CNFH	Late Fall	1999
3/22/2003	Barrier Weir Trap	Chinook	female	90	055209	CNFH	Late Fall	1999
3/22/2003	Barrier Weir Trap	Chinook	female	87.5	055209	CNFH	Late Fall	1999
3/23/2003	Barrier Weir Trap	Chinook	male	75	050466	CNFH	Late Fall	2000
3/23/2003	Barrier Weir Trap	Chinook	female	73	050465	CNFH	Late Fall	2000
3/23/2003	Barrier Weir Trap	Chinook	female	85	055210	CNFH	Late Fall	1999
3/23/2003	Barrier Weir Trap	Chinook	female	83	055207	CNFH	Late Fall	1999
3/23/2003	Barrier Weir Trap	Chinook	male	87.2	055209	CNFH	Late Fall	1999
3/23/2003	Barrier Weir Trap	Chinook	female	82	055211	CNFH	Late Fall	1999
3/24/2003	Barrier Weir Trap	Chinook	female	80	055211	CNFH	Late Fall	1999
3/25/2003	Barrier Weir Trap	Chinook	male	90	055212	CNFH	Late Fall	1999
3/25/2003	Barrier Weir Trap	Chinook	female	71.5	050467	CNFH	Late Fall	2000
3/27/2003	Barrier Weir Trap	Chinook	female	93	055213	CNFH	Late Fall	1999
3/28/2003	Barrier Weir Trap	Chinook	female	83.5	055213	CNFH	Late Fall	1999
3/29/2003	Barrier Weir Trap	Chinook	female	69.5	050465	CNFH	Late Fall	2000
3/29/2003	Barrier Weir Trap	Chinook	male	63	050470	CNFH	Late Fall	2000
3/30/2003	Barrier Weir Trap	Chinook	male	69	050470	CNFH	Late Fall	2000
3/31/2003	Barrier Weir Trap	Chinook	female	82	055210	CNFH	Late Fall	1999
4/3/2003	Barrier Weir Trap	Chinook	female	84.5	055212	CNFH	Late Fall	1999
4/3/2003	Barrier Weir Trap	Chinook	female	92.8	052317	CNFH	Late Fall	1998
4/4/2003	Barrier Weir Trap	Chinook	female	81.7	055208	CNFH	Late Fall	1999
4/4/2003	Barrier Weir Trap	Chinook	female	83.6	055211	CNFH	Late Fall	1999
4/5/2003	Barrier Weir Trap	Chinook	female	65	050469	CNFH	Late Fall	2000
4/6/2003	Barrier Weir Trap	Chinook	female	72.3	050470	CNFH	Late Fall	2000
4/9/2003	Barrier Weir Trap	Chinook	female	92.3	055213	CNFH	Late Fall	1999
4/9/2003	Barrier Weir Trap	Chinook	male	85.5	055133	CNFH	Late Fall	1999
4/10/2003	Barrier Weir Trap	Chinook	female	76.5	055211	CNFH	Late Fall	1999
4/10/2003	Barrier Weir Trap	Chinook	female	75.5	050466	CNFH	Late Fall	2000
4/10/2003	Barrier Weir Trap	Chinook	female	65.5	050470	CNFH	Late Fall	2000
4/11/2003	Barrier Weir Trap	Chinook	female	88.5	055210	CNFH	Late Fall	1999
4/14/2003	Barrier Weir Trap	Chinook	female	82.5	055211	CNFH	Late Fall	1999

4/16/2003	Barrier Weir Trap	Chinook	female	86.2	055212	CNFH	Late Fall	1999
4/17/2003	Barrier Weir Trap	Chinook	female	79.2	055207	CNFH	Late Fall	1999
4/18/2003	Barrier Weir Trap	Chinook	female	71	050465	CNFH	Late Fall	2000
4/18/2003	Barrier Weir Trap	Chinook	male	76.5	050469	CNFH	Late Fall	2000
4/20/2003	Barrier Weir Trap	Chinook	male	94.5	055211	CNFH	Late Fall	1999
4/20/2003	Barrier Weir Trap	Chinook	male	64	050468	CNFH	Late Fall	2000
4/24/2003	Barrier Weir Trap	Chinook	male	65.5	NTD			
4/26/2003	Barrier Weir Trap	Chinook	male	73.5	050470	CNFH	Late Fall	2000
5/2/2003	Barrier Weir Trap	RBT/STT	unk	54.1	Lost			
5/3/2003	Barrier Weir Trap	Chinook	female	81.5	055210	CNFH	Late Fall	1999
5/4/2003	Barrier Weir Trap	Chinook	male	72	050470	CNFH	Late Fall	2000
5/15/2003	Barrier Weir Trap	Chinook	female	69.5	050469	CNFH	Late Fall	2000
5/29/2003	Barrier Weir Trap	Chinook	male	71.1	050469	CNFH	Late Fall	2000
5/30/2003	Barrier Weir Trap	Chinook	male	93.5	055211	CNFH	Late Fall	1999
06/26/03	Snorkel Survey	Chinook	female	79.0	055212	CNFH	Late Fall	1999