Juvenile Salmonid Monitoring in Battle Creek, California, July 2001 through September 2002

USFWS Report
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Juvenile Salmonid Monitoring in Battle Creek, California, July 2001 through September 2002

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Abstract- In July 2001, the U.S. Fish and Wildlife Service continued a juvenile salmonid monitoring project on Battle Creek, California, using rotary screw traps. Monitoring started in September 1998, but was discontinued in February 2001 due to lack of funding. Battle Creek, a tributary of the Sacramento River, is important to the conservation and recovery of federally listed anadromous salmonids in the Sacramento River watershed because of its unique hydrology, geology, and habitat suitability for several anadromous species. Information about juvenile salmonid abundance and migration in Battle Creek is necessary to guide efforts at maintaining and eventually restoring populations of threatened and endangered anadromous salmonids. From July 2001 through September 2002 four runs of Chinook salmon *Oncorhynchus tshawytscha*, rainbow trout/steelhead *Oncorhynchus mykiss*, and 17 species of non-salmonids were captured in either the Lower (LBC) or Upper Battle Creek (UBC) rotary screw traps. To determine rotary screw-trap efficiency, we conducted 32 mark-recapture trials at the LBC trap and 21trials at the UBC trap during November 2001 through June 2002. Individual and pooled trap efficiencies ranged from 1.7 to 14.1% at LBC and 2.6 to 8.2% at UBC. Chinook salmon run designations were made using length-at-date criteria developed for the Sacramento River, which likely resulted in underestimates of spring and overestimates of fall Chinook salmon production at both traps. The brood year 2001 spring and fall Chinook salmon passage estimates at the LBC trap were 8,974 and 4,038,950, respectively. The brood year 2002 late-fall Chinook salmon passage estimate at the LBC trap was 59,151. The annual passage of winter Chinook salmon was not estimated for the lower trap because of low catch rates (n=155) and because they were likely using Battle Creek for non-natal rearing. The passage estimate for age 1+ rainbow trout/steelhead at the LBC trap was 647 and 7,822 for brood year 2002 young-of-the-year. Brood year 2001 spring Chinook salmon passage at the UBC trap was 482, and fall Chinook salmon passage at the UBC trap was 20,920. The brood year 2002 late-fall Chinook salmon passage estimate at the UBC trap was 7,629. Passage estimates were not made for winter Chinook salmon at the upper trap as catch rates (n=2) were too low. The passage estimate for age 1+ rainbow trout/steelhead at the upper trap was 1,348 and 24,740 for brood year 2002 young-of-the-year.

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Introduction

In recent decades, California has experienced declines in several of its wild salmon and steelhead populations. These declines have been linked to a variety of factors, but the development of federal, state, municipal, and private water projects is likely a primary contributing factor (Jones and Stokes 2005). As a result of the declines, two populations of Chinook salmon (*Oncorhynchus tshawytscha*) and one population of steelhead (*O. mykiss*) in the Sacramento River watershed have been listed as threatened or endangered under the Endangered Species Act (ESA) or the California Endangered Species Act (CESA).

Battle Creek, a tributary of the Sacramento River, is important to the conservation and recovery of federally listed anadromous salmonids in the Sacramento River watershed because of its unique hydrology, geology, and habitat suitability for several anadromous species and historical land uses (Jones and Stokes 2005). Restoration actions and projects that are planned or have begun in Battle Creek focus on providing habitat for the endangered Sacramento River winter Chinook salmon, the threatened Central Valley spring Chinook salmon, and the threatened Central Valley steelhead. Currently the geographic range of the winter Chinook salmon Evolutionary Significant Unit is small and limited to the mainstem of the Sacramento River between Keswick Dam and the town of Red Bluff, California, where it may be susceptible to catastrophic loss. Establishing a second population in Battle Creek could reduce the likelihood of extinction. Battle Creek also has the potential to support significant, self-sustaining populations of spring Chinook salmon and steelhead.

Since the early 1900's, a hydroelectric project comprised of several dams, canals, and powerhouses has operated in the Battle Creek watershed. The hydroelectric project, which is currently owned by Pacific Gas and Electric Company (PG&E), has had severe impacts upon anadromous salmonids and their habitat (Ward and Kier 1999), including a reduction of instream flows, barriers to migration, loss of habitat, flow related temperature impacts, etc.

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 actions to restore Battle Creek, which included increasing flows past PG&E's hydroelectric power diversions to provide adequate holding, spawning, and rearing habitat for anadromous salmonids (USFWS 1997). Prior to 2001, PG&E was required under its Federal Energy Regulatory Commission (FERC) license to provide minimum instream flows of 0.08 m^3/s (3 cfs) downstream of diversions on North Fork Battle Creek and 0.14 m^3/s (5 cfs) downstream of diversions on South Fork Battle Creek. However, from 1995 to 2001, the CVPIA Water Acquisition Program contracted with PG&E to increase minimum stream flow in the lower reaches of the north and south forks of Battle Creek. This initial flow augmentation provided flows between 0.71 and 0.99 m^3/s (25 and 35 cfs) below Eagle Canyon Dam on the north fork and below Coleman Diversion Dam on the south fork.

In 1999, PG&E, California Department of Fish and Game (CDFG), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and National Marine Fisheries Service (NMFS) signed a Memorandum of Understanding (MOU) to formalize the agreement regarding the Battle Creek Chinook Salmon and Steelhead Restoration Project (Restoration Project). The planning, designing, and permitting phases of the Restoration Project have taken longer than originally anticipated; therefore, funds for increased minimum flows in North and South Fork Battle Creek from the CVPIA Water Acquisition Program ran out in 2001. However, the federal and State of California interagency program known as the CALFED Bay-Delta Program (CALFED) funded the Battle Creek Interim Flow Project beginning in 2001 and will continue to until the Restoration Project begins. The intent of the Interim Flow Project (IFP) 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. Under the IFP, PG&E would maintain minimum instream flows at 0.85 m^3/s (30 cfs) by reducing their hydroelectric power diversions from May to October. In 2001, funding for the IFP was provided for the north fork, but not the south fork. In 2002, some of the north fork IFP flows were reallocated to the south fork under an agreement which allows for changing flows on either of the forks based on environmental conditions (i.e., water temperatures, numbers and locations of live Chinook salmon and redds). Beginning in late 2002, the IFP began providing the full minimum flow of 0.85 m^3/s (30 cfs) on both forks. In 2001, increased flows were provided only on the north fork in part based on observations of higher Chinook salmon spawning on the north fork than on the south fork. Redd counts from 1995 to 1998 indicated that 39% of spawning occurred in the north fork versus 23% in the south fork (RBFWO, unpublished data).

The U.S. Fish and Wildlife Services' Red Bluff Fish and Wildlife Office began using rotary screw traps to monitor juvenile salmonids on Battle Creek, Shasta and Tehama Counties, California, in September 1998 (Whitton et al. 2006). The purpose of this report is to summarize data collected during the period July 10, 2001 through September 30, 2002. This ongoing monitoring project has three primary objectives: (1) determine an annual juvenile passage index (JPI) for Chinook salmon (salmon) and rainbow trout/steelhead (trout), for inter-year comparisons; (2) obtain juvenile salmonid life history information including size, condition, emergence, emigration timing, and potential factors limiting survival at various life stages, and (3) collect tissue samples for genetic analyses.

Study Area

Battle Creek and its tributaries drain the western volcanic slopes of Mount Lassen in the southern Cascade Range. The creek has two primary tributaries, North Fork Battle Creek which originates near Mt. Huckleberry and South Fork Battle Creek which originates in Battle Creek Meadows south of the town of Mineral, California. North Fork Battle Creek is approximately 47.5 km (29.5 miles) long from the headwaters to the confluence and has a natural barrier waterfall located 21.7 km (rm 13.5) from the confluence (Jones and Stokes 2004). South Fork Battle Creek is approximately 45 km (28 miles) long and has a natural barrier waterfall (Angel Falls) located 30.4 km (rm 18.9) from the confluence (Jones and Stokes 2004). The mainstem portion of Battle Creek flows approximately 27.3 km (17 miles) west from the confluence of the two forks to the Sacramento River east of Cottonwood, California. The entire watershed encompasses an area of approximately 93,200 ha (360 $miles^2$; Jones and Stokes 2004). The current 39 km (24.4 miles) of anadromous fishery in Battle Creek encompasses that portion of the creek from the Eagle Canyon Dam on North Fork Battle Creek and Coleman Dam on South Fork Battle Creek to its confluence with the Sacramento River (Figure 1). Historically, the anadromous fishery exceeded 85 km (53 miles).

Battle Creek has the highest base flows of any of the Sacramento River tributaries between Keswick Dam and the Feather River, and flows are influenced by both precipitation and spring flow from basalt formations (Jones and Stokes 2005). The average flow in Battle Creek is approximately 14.1 m^3/s (500 cfs; Jones and Stokes 2004). South Fork Battle Creek is more influenced by precipitation and likely experiences higher peak flows, whereas North Fork Battle Creek receives more of its water from snow melt and spring-fed tributaries. Maximum discharge usually occurs from November to April as a result of heavy precipitation. Average annual precipitation in the watershed ranges from about 64 cm (25 inches) at the Coleman Powerhouse to more than 127 cm (50 inches) at the headwaters, with most precipitation occurring between November and April (Ward and Kier 1999). Ambient air temperatures range from about 0ºC (32ºF) in the winter to summer highs in excess of 46ºC (115ºF).

Land ownership in the Battle Creek watershed is a combination of state, federal, and private including the CDFG, Bureau of Land Management (BLM), and USFWS. Most of the land within the restoration area is private and zoned for agriculture, including grazing. Currently, much of the lower Battle Creek watershed is undeveloped, with scattered private residences, ranching enterprises, and local entities.

The Red Bluff Fish and Wildlife Office installed and operated two rotary screw traps on Battle Creek, the first site was located 4.5 km (rm 2.8) upstream of the confluence with the Sacramento River, and the second site was located 9.5 km (rm 5.9) upstream of the confluence (Figure 1). The lower trap site was designated Lower Battle Creek (LBC) and the upper trap site was designated Upper Battle Creek (UBC). The stream substrate at these locations is primarily composed of gravel and cobble, and the riparian zone vegetation is dominated by California sycamore (*Plantanus racemosa*), alder (Alnus spp.), Valley Oak (*Quercus lobata*), Himalayan blackberry (*Rubus discolor)*, California wild grape (*Vitis Californica*) and other native and non-native species.

Methods

Trap Operation

In July 2001, the Red Bluff Fish and Wildlife Office reinstalled and began operating two rotary screw traps on Battle Creek. The Lower Battle Creek trap (LBC) was operated from July 10, 2001 through September 30, 2002 while the Upper Battle Creek trap (UBC) was operated from July 13, 2001 through September 30, 2002. The traps continued to fish beyond September 30, 2002, but this date was designated the end of the current reporting period as it allowed us to estimate total passage for brood year 2001 spring and fall Chinook salmon and total catch for BY 2001 winter Chinook salmon at the LBC trap. Although the designated reporting period does not include the total passage of late-fall Chinook salmon, complete passage estimates are reported as the data were available and it will prevent duplication in the 2002-2003 report.

The traps, manufactured by E.G. Solutions® in Corvallis, Oregon, consist of a 1.5-m diameter cone covered with 3-mm diameter perforated stainless steel screen. The cone, which acts as a sieve separating fish and debris from the water flowing through the trap, rotates in an auger-type action passing water, fish, and debris to the rear of the trap and directly into an aluminum live box. The live box retains fish and debris, and passes water through screens located in the back, sides, and bottom. The cone and live box are supported between two pontoons. Two 30 to 46-cm diameter trees on opposite banks of the creek were used as anchor points for securing each trap in the creek, and a system of cables, ropes and pulleys was used to position the traps in the thalweg.

We attempted to operate the traps 24 h per day; 7 d each week, but at times high flows, hatchery releases, or staff shortages limited our ability to operate the traps continuously (Appendices 1 and 2). In addition, at times when few or no salmonids were captured, we operated the traps on a reduced schedule (usually 4 or 5 d per week). Traps were not operated when stream flows exceeded certain levels in order to prevent fish mortality, damage to equipment, and to ensure crew safety. The traps were checked once per day unless high flows, heavy debris loads, or high fish densities required multiple trap checks to avoid mortality of captured fish or damage to equipment. In addition, to improve the accuracy of our juvenile passage indexes (JPI's), we attempted to fish high flows when most juvenile salmonids are thought to outmigrate and increase the number of mark-recapture trials, which were used to estimate trap efficiency. When flows allowed, the crews were able to access the traps by wading from the stream bank; however, during high flows access to the traps required that the crews use the cable and pulley system to pull the traps into shallow water. After or during sampling and maintenance, the traps were repositioned in the thalweg.

In October 2000 the LBC trap was modified by placing an aluminum plate over one of the two existing cone discharge ports and removing an exterior cone hatch cover (half-cone modification). As a result, half of the collected fish and debris were not discharged into the live box, but rather were discharged from the cone back into the creek. This effectively reduced our catch of both fish and debris by half, and also reduced crowding of fish in the live box by half. During the 2001 to 2002 reporting period, we operated the LBC trap at half-cone November 15-16, 2001 to reduce the capture of Chinook salmon released by the hatchery. In addition, we operated the trap at half-cone from January 15 to March 12, 2002 to reduce potential negative impacts to juvenile salmon created by overcrowding and excess debris, as well as to reduce the capture of Chinook salmon released by the hatchery. In previous years, additional modifications were made to the traps and daily operations to reduce the potential for impacts to captured fish and to improve our efficiency. Modifications to traps included increasing the size of the live boxes and floatation pontoons, and adding baffles to the live boxes.

Each time a trap was sampled, crews would sample fish present in the live box, remove debris from the cone and live box, collect environmental and trap data, and complete any necessary trap repairs. Data collected at each trap included, dates and times of trap operation, water depth at the trap site, cone fishing depth, number of cone rotations during the sample period, cone rotation time, amount and type of debris removed from the live box, basic weather conditions, water temperature, water velocity entering the cone, and turbidity. Water depths were measured to the nearest 0.03 m (0.1 feet) using a graduated staff. The cone fishing depth was measured with a gauge permanently mounted to the trap frame in front of the cone. The number of rotations of the RST cone was measured with a mechanical stroke counter (Reddington Counters, Inc., Windsor, CT) that was mounted to the trap railing adjacent to the cone. The amount of debris in the live box was volumetrically measured using a 44.0 liter (10-gallon) plastic tub. Water temperatures were continuously measured with an instream Onset Optic Stow Away® temperature data logger. Water velocity was measured as the average velocity from a grab-sample using an Oceanic® Model 2030 flowmeter (General Oceanics, Inc., Miami, Florida). The average velocity was measured for a minimum of 3 min while the live box was being cleared of debris. Water turbidity was measured from a grab-sample with a Hach® Model 2100 turbidity meter (Hach Company, Ames, Iowa). In addition, daily stream discharge data collected by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) was also used for trap operations and to compare discharge and downstream migration patterns. The gauge site is located below the Coleman Fish Hatchery barrier weir and approximately 0.2 km downstream of the UBC trap.

Biological Sampling

Juvenile sampling at the traps was conducted using standardized techniques that were generally consistent with the CVPIA's CAMP standard protocol (CVPIA 1997). Dip nets were used to transfer fish and debris from the live box to a sorting table for examination. Each day the trap was sampled, a minimum number of each fish taxa captured were counted and then depending on the species, either fork length (FL) or total length (TL) was measured. Mortalities were also counted and measured. Live fish to be measured were placed in a 3.8-L (1-gallon) plastic tub and anesthetized with a tricaine methanesulfonate (MS-222; Argent Chemical Laboratories, Inc. Redmond, Washington) solution at a concentration of 60 to 80 mg/L. After being measured, fish were placed in a 37.8-L (10-gallon) plastic tub filled with fresh water to allow for recovery before being released back into the creek. Water in the tubs was replaced as necessary to maintain adequate temperature and oxygen levels. Catch data for all fish taxa were typically summarized as either weekly totals for salmonids or annual totals for non-salmonids. Due to the large numbers of juvenile salmon that were frequently encountered and project objectives, different criteria were used to sample salmon, trout, and non-salmonid species.

Chinook salmon.—When less than approximately 250 salmon were captured in the trap all salmon were counted and measured for FL (to the nearest 1 mm). The measured juvenile salmon were also assigned a life-stage classification of fry (C1), parr (C2), silvery parr (C3), or smolt (C4), and a run designation of fall, late-fall, winter, or spring. Life-stage classification was based on morphological features and run designations were based on length-at-date criteria from Greene (1992). Length data for all Chinook salmon runs was combined for graphical purposes as the length-at date criteria developed for the mainstem Sacramento River may not be directly applicable to the tributary populations.

When more than approximately 250 juvenile salmon were captured, subsampling was conducted. All salmon in the subsample (150 to 250 fish) were identified, counted, and measured. These salmon were also assigned a life-stage classification and run designation, using the methods described above. All other salmon were counted and identified. A cylinder-shaped net with 3-mm mesh and a split-bottom construction was used for subsampling. The bottom of the subsampling net was constructed with a metal frame that created two equal halves. A closed mesh bag sewed onto one half of the frame and an open mesh bag sewed onto the other half of the frame. The subsampling net was placed in a 117-L (30-gallon) bucket that was partially filled with creek water. All captured juvenile salmon were poured into the bucket. Once the fish had distributed evenly throughout the bucket, the net was lifted and approximately half of the salmon were retained in the side of the net with the closed mesh bag, and approximately half of the salmon in the side with the open mesh bag were retained in the bucket. We continued to successively subsample (split) until approximately 150 to 250 individuals remained in a subsample. The number of successive splits that we used varied with the number of salmon collected. Subsampling was used to obtain a representative sample for measuring. To determine total catch, we counted all salmon in each split. Chinook salmon biological data were summarized by brood year for each run designation.

Rainbow trout/steelhead.—Due to the smaller numbers encountered, all rainbow trout/steelhead captured in the traps were counted and FL measured to the nearest 1 mm. Life stages of juvenile trout were classified similarly as salmon, with the addition of a yolk-sac fry life stage, as requested by the Interagency Ecological Program (IEP) Steelhead Project Work Team. All live rainbow trout/steelhead > 50 mm captured at both traps were weighed to the nearest 0.1 g for CDFG's Stream Evaluation Program.

Non-salmonid taxa.—All non-salmonid taxa that were captured were counted, but we only measured up to approximately 30 randomly selected individuals for each taxa. Total length was measured for lamprey *Lampetra spp.,* sculpin *Cottus spp.*, and western mosquitofish (*Gambusia affinis*); otherwise, FL was measured for all other non-salmonid taxa.

Trap Efficiency and Juvenile Salmonid Passage

One of the goals of our monitoring project was to estimate the number of juvenile salmonids passing downstream in a given unit of time, usually a week and brood year. We defined this estimate as the juvenile passage index (JPI). Since each trap only captures fish from a small portion of the creek cross section, we used trap efficiencies, which were determined using mark-recapture methods, and the actual catch to estimate the weekly and annual JPI. For days when the trap was not fishing, daily catch was estimated by averaging an equal number of days before and after the days not fished. For example, if the trap did not fish for 2 d, the daily catch for those days was estimated by averaging catch from 2 d before and 2 d after the period the trap did not fish. However, if one of the days before or after was also a missed day, it was usually not used to estimate other missed days. For example, if the trap did not fish for 3 d, but one of the 3 days before was also a missed day, then catch from the 2 d before and 3 d after the missed period were used to estimate catch. When hatchery fall Chinook salmon were captured in the traps, total daily catch was adjusted by subtracting out the number of hatchery fish captured in the trap. The total catch of hatchery fall Chinook salmon had to be estimated because only a portion of all fish released by the hatchery had adipose clips. For each release, the estimate was made using the average percent of fish marked from all raceways. A similar estimate was not necessary for hatchery late-fall Chinook salmon captured in the traps as 100% were marked; therefore, they were simply subtracted from the total catch.

Mark-recapture trials.— Mark-recapture trials were conducted to estimate trap efficiency. Ideally, separate mark-recapture trials should be conducted for each species, run, and life-stage to estimate species and age-specific trap efficiencies. However, catch rates for steelhead, spring, winter, and late-fall Chinook salmon were too low to conduct separate trials; therefore, trap efficiencies were estimated using primarily fry Chinook salmon, but larger fish were used for a few trials. We attempted to use only naturally-produced (unmarked, unclipped, and untagged) juvenile salmon for mark-recapture trials. However, when trap catches were insufficient, some hatchery fish that were captured in the LBC trap were used for mark-recapture trials. A few trials were conducted using large hatchery fish captured in the traps, however the results were not used to estimate fish passage as unmarked fish captured in the traps were much smaller and capture efficiencies may be different. Marked Chinook salmon that were recaptured in the traps were counted, measured, and subsequently released downstream of the trap to prevent them from being recaptured again.

During the 2001 to 2002 season, only a single mark was used during most trials at the LBC trap. A second mark was used during three trials conducted at the LBC trap. Photonic® tagging (New West Technologies, Santa Rosa, California) was used during one trial and a lower caudal fin-clip was used during the remaining two trials. To apply a single mark, juvenile salmon were immersed in Bismark brown-Y stain (J. T. Baker Chemical Company, Phillipsburg, New Jersey) for 50 min at a concentration of 8 g/380 L of water (211 mg/L). When air temperatures were high in late spring and summer, a portable water chiller unit was used to maintain ambient stream temperatures and reduce stress and mortality during the staining process. For trials where a dual-mark was needed, salmon were first marked with Bismark brown, and then anesthetized with an MS-222 solution at a concentration of 60 to 80 mg/L. Once the Bismark brown stained fish were anesthetized, we applied a second mark using either Photonic® tagging or a caudal fin-clip. Photonic tagging required the subcutaneous injection of fluorescent latex micro spheres into the fish using high air pressure rather than needles. For our current project, marks were placed at the base of the dorsal fin. Caudal fin-clips were applied by using scissors to remove a small portion of either the upper or lower caudal fin. Marked fish were placed in a live-car and allowed to recover. Two mark-recapture trials were conducted at the LBC trap during most weeks; however, when the numbers of salmon available for marking were low, only one trial was conducted each week at LBC. All salmon marked for LBC trials were released at the Jelly's Ferry Bridge which is located approximately 1.3 km (0.8 mi) upstream of the trap. Trials conducted at the UBC trap were done using methods similar to those used for the LBC trap (Bismark brown); however, during most trials a second mark (caudal fin-clip) was applied to allow field crews to differentiate between fish released for trials at the LBC trap. An upper caudal fin-clip was used during most trials, but a lower caudal fin-clip or Photonic tagging was used during a few trials. All fish marked for UBC trials were released at the Coleman National Fish Hatchery's Intake 3 located 1.6 km (1.0 mi) upstream of the UBC trap. Although not presented in this report, we measured the fork length of about 50 marked salmon prior to release, and then measured all of the recaptured salmon to make comparisons between marked fish released and marked fish recaptured. Marked fish were generally held overnight and released the next day. Prior to release, mortalities and injured fish were removed and the remaining fish were counted and released. During most trials, marked fish were released after dark or at dusk to reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated during transportation, and to simulate natural populations of outmigrating Chinook salmon which move downstream primarily at night (Healey 1998; USFWS, RBFWO, unpublished data).

Trap efficiency.—Trap efficiency was estimated using a stratified Bailey's estimator, which is a modification of the standard Lincoln-Peterson estimator (Bailey 1951; Steinhorst et al. 2004). The Bailey's estimator was used as it performs better with small sample sizes and is not undefined when there are zero recaptures (Carlson et al. 1998; Steinhorst et al. 2004). In addition, Steinhorst et al. (2004) found it to be the least biased of three estimators. Trap efficiency was estimated by

$$\hat{E}_h = \frac{(r_h + 1)}{(m_h + 1)}, \tag{1}$$

where m_h is the number of marked fish released in week h and r_h is the number of marked fish recaptured in week h. Although trap efficiency was calculated for all mark-recapture trials, only those trials with at least seven recaptures were used as suggested by Steinhorst et al. (2004). Occasionally if a mark-recapture trial had less than seven recaptures, but the estimated trap efficiency and the mean weekly stream flows were similar to adjacent week(s), the number of marks and recaptures were pooled prior to estimating trap efficiency. Otherwise, a season average efficiency was used to estimate the JPI during weeks where there were less than seven recaptures or during weeks when no mark-recapture trials were conducted. The season average efficiency was based on all trials with more than seven recaptures, unless there were trials that had been pooled, in which case the pooled results were used when calculating the season average efficiency. If two mark-recapture trials were conducted during the same week, the results were combined to calculate the average weekly trap efficiency.

During the 2001 to 2002 season, a half-cone modification at LBC that was used to reduce impacts from crowding and high debris loads also influenced the results of mark-recapture trials conducted during that time. Thirty-two mark-recapture trials were conducted during the season (July 10, 2001 to September 30, 2002), 17 of which occurred while the trap had the half-cone modification; therefore the trial results were not equivalent to those conducted at full-cone. To calculate production estimates for weeks when the trap was at full cone and no mark-recapture trials were conducted, the season average efficiency was estimated using the results of the trials done at full-cone, and then doubling efficiency for trials conducted at half-cone. In contrast, the season average efficiency used for weeks when the trap was at half-cone would be estimated using the results of the trials done at half-cone, and then halving the efficiency of trials done at full-cone. However, mark-recapture trials were conducted during all weeks the trap was at half-cone status; therefore, an average season efficiency was not calculated for the half-cone scenario. By either doubling the half-cone results or halving the full-cone results, the trial results are essentially equivalent allowing an estimate of season average efficiency based on trials rather than just 10 full-cone trials and 16 for half-cone trials.

Juvenile passage index(JPI).— Weekly JPI estimates for Chinook salmon and rainbow trout/steelhead were calculated using weekly catch totals and either the weekly trap efficiency, pooled trap efficiency, or average season trap efficiency. Juvenile Chinook salmon JPI's at LBC and UBC were summarized by brood year while rainbow trout/steelhead were summarized as either young-of-the-year (yoy) or age 1+, which included individuals from all other age classes. Weekly catch for all runs of Chinook salmon included all life-stages from a single brood year. The fork length distribution (fork length by date) of rainbow trout/steelhead captured in either trap was used to determine weekly catch of young-of-the-year and age 1+. With few exceptions, graphical display of fork length distribution indicated a distinct separation of the two groups. In addition, age 1+ and young-of-the-year captured during the same week could usually be distinguished by their life-stage classification.

The season was stratified by week because as Steinhorst et al. (2004) found, combining the data where there are likely changes in trap efficiency throughout the season leads to biased estimates. Using methods described by Carlson et al. (1998) and Steinhorst et al. (2004), the weekly JPI's were estimated by

$$\hat{N}_h = \frac{U_h}{\hat{E}_h}, \qquad (2)$$

where U_h is the unmarked catch during week *h*. The total JPI for the year is then estimated by

$$\hat{N} = \sum_{h=1}^{L} \hat{N}_h, \qquad (3)$$

where *L* is the total number of weeks. Variance and the 90 and 95% confidence intervals for $\hat{N}_h$ each week were determined by the percentile bootstrap method with 1,000 iterations (Efron and Tibshirani 1986; Buckland and Garthwaite 1991; Thedinga et al. 1994; Steinhorst et al. 2004). Using simulated data with known numbers of migrants, and trap efficiencies, Steinhorst et al. (2004) determined the percentile bootstrap method for developing confidence intervals performed the best, as it had the best coverage of a 95% confidence interval. Each bootstrap iteration involved first drawing 1,000 r^*_{hj} (j=1,2,…,1000; asterisk indicates bootstrap simulated values) from the binomial distribution (m_h, $\hat{E}_h$)(Carlson et al. 1998) and then calculating 1,000 $\hat{N}^*_{hj}$ using equations (1) and (2), replacing r_h with r^*_{hj}. The 1,000 bootstrap iterations of the total JPI ($\hat{N}^*_j$) were calculated as

$$\hat{N}^*_j = \sum_{h=1}^{L} \hat{N}^*_{hj}. \qquad (4)$$

As described by Steinhorst et al. (2004), the 95% confidence intervals for the weekly and total JPI's were found by ordering the1,000 $\hat{N}*_{hj}$ or $\hat{N}*_j$ and locating the 25th and 975th values. Similarly, the 90% confidence intervals for the weekly and total JPI's were found by locating the 50th and 950th values of the ordered iterations. Ordering was not performed until after the $\hat{N}*_j$ were derived. The variances for $\hat{N}_h$ and $\hat{N}$ were calculated as the standard sample variances of the 1,000 $\hat{N}*_{hj}$ and $\hat{N}*_j$, respectively (Buckland and Garthwaite 1991).

Results

Trap Operation

Lower Battle Creek (LBC).— During the current reporting period, the LBC trap was operated continuously from July 10, 2001 to September 30, 2002, except during high flows, hatchery releases, staff shortages, periods of low salmonid catch, etc (Appendix 1). Of the 448 d available, the trap was operated 341 d, of which reduced sampling due to low salmonid catch accounted for 59% of the missed sample days, staff shortages accounted for 17%, hatchery releases and other miscellaneous reasons (holidays, no rotation, trap maintenance, unknown, etc.) each accounted for 9%, and high flows accounted for the remaining 6% of missed sample days. Monthly sampling effort from July 2001 through September 2002 varied from a low of 53% in April 2003 and September 2002 to 100% for 3 months of the reporting period (Figure 2; Appendix 1).

Mean daily water temperatures at the LBC trap varied from a low of 5.5ºC on January 30, 2002 to a high of 22.8ºC on August 14, 2002 (Figure 3). At the beginning of the sample period, a peak temperature of 22.4 ºC occurred at the trap on July 26, 2001. Mean daily flow that was measured by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) varied from lows of 5.6 and 5.7 m^3/s (198 and 201 cfs) in August 2001 and 2002, to a peak flow of 67.7 m^3/s (2,391 cfs) on January 2, 2002 (Figure 3). Turbidity at the LBC trap varied from lows <1.0 NTU's on several days to a peak of 22.0 NTU's on February 6, 2002 (Figure 3). In general, turbidity increased with increasing flows, but increases in turbidity did not always appear to be related to a similar increase in flow (Figure 3).

*Upper Battle Creek (UBC).—*During the current reporting period, the UBC trap was operated continuously from July 13, 2001 to September 30, 2001, except during periods of low salmonid passage, staff shortages, high flows, etc (Appendix 2). Of the 445 d available, the trap was operated approximately 343 d, of which reduced sampling due to low salmonid catch accounted for 63% of the missed sample days, staff shortages accounted for 23%, other miscellaneous reasons (holidays, no cone rotation, and unknown reasons) accounted for 9%, and high flows accounted for the remaining 5% of missed sampled days. Monthly sampling effort varied from a low of 50% in September 2002 to 100% for 2 months of the reporting period (Figure 2; Appendix 2).

Mean daily water temperatures at the UBC trap varied from a low of 5.6 ºC on January 30, 2002 to a high of 21.0ºC on July 26, 2001 and July 14, 2002 (Figure 4). Mean daily flows for the UBC trap are the same as those reported for LBC as the same gauging station was used (Figure 4). Turbidity at the UBC trap varied from a low of 0.9 NTU's on October 28, 2001 to a high of 15.2 NTU's on December 17, 2001 (Figure 4). In general, turbidity increased with increasing flows, but increases in turbidity did not always appear to be related to similar increases in flow (Figure 4).

Biological Sampling

Spring Chinook salmon-LBC.—Brood year 2001 spring Chinook salmon were first captured at the LBC trap the week of November 19, 2001 with a peak catch of 387 the week of April 15, 2002 (Figure 5). The last BY01 spring Chinook salmon was captured the week of May 13, 2002. The BY01 spring Chinook salmon total estimated catch based on the length-at-date criteria was 762. However after adjusting the total catch for days the trap was not fished, the adjusted total catch was 789.

Fork lengths of spring Chinook salmon sampled at the LBC trap varied from 26 to 104 mm with a mean of 79 mm (Figure 6). Length frequency data for all runs were combined because it was determined by the length-at-date-criteria developed for the Sacramento River (Green 1992; Figure 7). There is overlap in fork lengths between runs, but the overlap appears to be a particular problem with spring and fall Chinook salmon. The life-stage composition of spring Chinook salmon captured at the LBC trap was 14.8% fry, 1.5% parr, 43.8% silvery parr, and 39.9% smolt (Table 1).

Fall Chinook salmon - LBC.—Fall Chinook salmon were the most abundant fish captured at the LBC trap. Initially a few brood year 2000 (BY00) fall Chinook salmon (n=9) were captured in the trap in July and August 2001, but brood year 2001 (BY01) fall Chinook salmon were not captured in the trap until early December 2001 (Figure 5). Following their initial capture, the numbers of fall Chinook salmon increased rapidly and were captured every week until early July 2002. A peak weekly catch of 42,676 occurred the week of February 4, 2002, and the last week a BY01 fall Chinook salmon was captured at the LBC trap was July 22, 2002 (Figure 5). The total number of BY01 fall Chinook salmon captured in the LBC trap on days that it was fished was 121,472. After adjusting the total catch reported above for days the trap was not operated, the adjusted total catch of BY01 fall Chinook salmon at the LBC trap was 135,512.

Fall Chinook salmon fork lengths ranged from 19 to 114 mm during the reporting period, with a mean fork length of 42 mm (Figure 6 &7). Length frequency data for all runs were combined because run-specific frequency data are influenced by the length-at-date-criteria developed for the Sacramento River (Green 1992; Figure 7). Length frequency histograms for Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 7). Fall Chinook salmon fry comprised the largest portion of these fish as they were the most abundant run captured at the LBC trap. All four life-stages of fall Chinook salmon were captured during the reporting period (Table 1). Fry were 82.7% of the fall Chinook salmon sampled at the trap, parr were 5.6%, silvery parr 9.5%, and smolt 2.2%.

Late-fall Chinook salmon - LBC.— Individuals from two brood years of late-fall Chinook salmon (BY01 and BY02) were captured at the LBC trap between July 10, 2001 and September 30, 2002; however, only a small portion of BY01 late-fall Chinook salmon were captured during the reporting period. Between July 10 and December 10, 2001, 25 BY01 late-fall Chinook salmon were captured in the trap (Figure 5). Brood year 2002 late-fall Chinook were first captured in the trap the week of April 1, 2002 with a peak weekly capture of 1,622 the week of May 6, 2002 (Figure 5). The last week of capture was December 24, 2002. Available data from the next reporting period (October 1, 2002 to December 24, 2002) was used to allow complete reporting of BY2002 late-fall Chinook salmon catch and passage estimates. Using the length-at-date criteria, the actual catch of BY02 late-fall Chinook salmon in the LBC trap was 5,473.

After adjusting the actual catch for days not operated, the adjusted total catch of BY02 late-fall Chinook salmon was 5,953.

Fork lengths of late-fall Chinook salmon captured at the LBC trap varied from 29 to 115 mm with a mean fork length of 38 mm (Figure 6). Length frequency histograms which included all runs of Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 7). Fry ≤40 mm were 87.5% of all late-fall Chinook salmon sampled at the trap. The life-stage composition of late-fall Chinook salmon sampled at the LBC trap was 87.7% fry, 10.8% parr, 1.1% silvery parr, and 0.4% smolt (Table 1).

Winter Chinook salmon - LBC.—Winter Chinook salmon were first captured at the LBC trap on September 25, 2001 with a peak weekly catch of 27 the week of November 19, 2001. The last day a winter Chinook was captured at the trap was April 16, 2002. Winter Chinook are likely migrants from the Sacramento River that are using lower Battle Creek for non-natal rearing. Using the length-at-date criteria, the actual catch of winter Chinook salmon in the LBC trap was 126. However after adjusting the actual catch for days the trap was not operated, the adjusted total catch was 155.

Fork lengths of winter Chinook salmon sampled at the LBC trap varied from 45 to 113 mm with a mean of 66 mm (Figure 6). Length frequency data for winter Chinook salmon were combined with other runs for graphical display (Figure 7). The life-stage composition of winter Chinook salmon sampled at the trap was 0% fry, 18.1% parr, 80.2% silvery parr, and 1.7% smolt (Table 1). The absence of the fry life-stage suggests that winter Chinook salmon use lower Battle Creek for non-natal rearing.

Rainbow trout/steelhead - LBC.— Rainbow trout/steelhead were first captured at the LBC trap the week of July 10, 2001 with a peak weekly capture of 107 occurring the week of March 18, 2002 (Figure 8). The actual rainbow trout/steelhead catch at the LBC trap was 552; however, after adjusting the total catch for days the trap was not operated, the adjusted total catch was 701.

Fork lengths of young-of-the-year (yoy) rainbow trout/steelhead ranged from 22 to 113 mm with a mean of 42.3 mm and a median of 28 mm (Figure 9 & 10). The range in fork lengths of yoy trout accounts for growth over time. Fork lengths of age 1+ trout ranged from 95 to 400 mm with a mean of 200 mm and a median of 198 mm (Figure 9 & 10). The length frequency histogram for trout was highly skewed towards newly emerging fry ≤30 mm (57%; Figure 10). Rainbow trout/steelhead fry (63.5%) and parr (30.7%) were the most abundant life-stages sampled at the LBC trap, whereas yolk-sac fry and smolt were the least abundant (<1.0%; Table 1). One possible adult resident rainbow trout was also captured in the trap.

Non salmonids - LBC.—From July10, 2001 through September 30, 2002, 10 native non-salmonid species were sampled at the LBC trap including, California roach *Hesperoleucus symmetricus* (n=4), speckled dace *Rhinicthys osculus* (n=68), hardhead *Mylopharodon conocephalus* (n=1,067), Pacific lamprey *Lampetra tridentata* (n=379), prickly sculpin *Cottus asper*(n=34), riffle sculpin *Cottus gulosus* (n=88), Sacramento pikeminnow *Ptychocheilus grandis* (n=362), Sacramento sucker *Catostomus occidentalis* (n=233), tule perch *Hysterocarpus traski* (n=283), and threespine stickleback *Gasterosteus* aculeatus (n=50). In addition, seven introduced non-salmonids were also captured in the LBC trap including, blue gill *Lepomis macrochirus* (n=2), green sunfish *Lepomis cyanellus* (n=10), largemouth bass *Micropterus salmoides* (n=19), western mosquitofish *Gambusia affinis* (n=33), pumpkinseed *Lepomis gibbosus* (n=1), and smallmouth bass *Micropterus dolomieu* (n=4). Next to Chinook salmon, hardheads were the next most abundant species captured in the traps. In addition, several unidentified cottid, cyprinid, centrarcid, and lamprey fry were also captured in the trap. The actual catches of non salmonids were not adjusted for days the trap was not operated.

Spring Chinook salmon - UBC.— Brood year 2001 (BY01) spring Chinook salmon were first captured at the UBC trap the week of April 1, 2002 with a peak weekly catch of 12 the week of April 8, 2002 (Figure 11). The last BY01 spring Chinook salmon was captured the week of May 7, 2002. Based on the length-at-date criteria, the actual catch of BY01 spring Chinook salmon was 17. However after adjusting the total catch for days the trap was not operated, the adjusted total catch was 29.

The fork length of spring Chinook salmon sampled at the trap varied from 37 to 102 mm with a mean fork length of 79 mm (n=17; Figure 12). Length frequency for all runs was combined because run designation was determined by the length-at-date-criteria developed for the Sacramento River, and there is overlap between runs, particularly between spring and fall Chinook salmon (Green 1992; Figure 13). Life-stage data was summarized for spring Chinook salmon, but may not be completely reliable as run designation is based on the length-at-date criteria and the sample size was small. The life-stage composition of spring Chinook salmon sampled at the UBC trap was 17.6% fry, 0% parr, 47.1% silvery parr, and 35.3% smolt (Table 1).

Fall Chinook salmon - UBC.—Fall Chinook salmon were the most abundant salmonid captured at the UBC trap. Brood year 2001 fall Chinook salmon were first captured in the trap the week of December 10, 2001 with the peak weekly catch of 156 occurring the week of December 24, 2001 (Figure 11). Following their initial capture, the numbers of fall Chinook salmon increased rapidly and were captured every week until the week of June10, 2002. The last day BY01 fall Chinook salmon were captured at the UBC trap was August 20, 2002 (Figure 11). The total number of BY01 fall Chinook salmon captured at the UBC trap on days that it was operated was 707. After adjusting the total catch reported above for days the trap was not operated, the adjusted total catch of BY01 fall Chinook salmon at the UBC trap was 1,019.

Fork lengths of fall Chinook salmon sampled at the UBC trap varied from 29 to 110 mm with a mean of 47 mm (n=710; Figure 12 and 13). The length frequency histogram which included all runs of Chinook salmon was highly skewed towards newly emerging fry ≤40 mm (Figure 13). Fall Chinook salmon fry comprised the largest portion of these fish as they were the most abundant run of Chinook salmon captured at the UBC trap. Life-stage composition of fall Chinook salmon sampled at the UBC trap was 69.6% fry, 5.8% parr, 22.3% silvery parr, and 2.3% smolt (Table 1).

Late-fall Chinook salmon - UBC.— Individuals from two brood years of late-fall Chinook salmon (BY01 and BY02) were captured at the UBC trap between July 13, 2001 and September 30, 2002; however, only a small portion of BY01 late-fall Chinook salmon were captured during the reporting period. Between July 13 and December 10, 2001, six BY01 late-fall Chinook salmon were captured in the trap (Figure 11). Brood year 2002 late-fall Chinook were first captured in the trap the week of April 1, 2002 with a peak weekly capture of 68 the week of May 6, 2002 (Figure 11). The last week of capture was November 4, 2002. Available data from the next reporting period (October 1, 2002 to December 24, 2002) was used to allow complete reporting of BY02 late-fall Chinook salmon catch and passage estimates. Only one additional late-fall Chinook salmon was captured after the end of the reporting period. Based on the length-at-date criteria, the BY02 late-fall Chinook salmon total catch was 147. After adjusting total catch for days not operated, the adjusted total catch of BY02 late-fall Chinook salmon was 248.

Fork lengths of late-fall Chinook salmon captured at the UBC trap varied from 25 to 108 mm with a mean fork length of 39 mm (Figure 12). Length frequency histograms which included all runs of Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 13). Fry ≤40 were 96.0% of all late-fall Chinook salmon sampled at the trap. The life- stage composition of late-fall Chinook salmon sampled at the UBC trap was 95.4% fry, 0.7% parr, 2.6% silvery parr, and 1.3% smolt (Table 1).

Winter Chinook salmon - UBC.—During the reporting period, only two winter Chinook salmon were captured in the UBC trap; therefore, no additional information will be reported for this race.

Rainbow trout/steelhead - UBC.— During the reporting period 80 age 1+ and 1,155 young-of-the-year (yoy) rainbow trout/steelhead were captured at the UBC trap. They were first captured the week of July 15, 2001 with a peak weekly capture of 228 occurring the week of April 1, 2002 (Figure 14). The actual rainbow trout catch at the UBC trap was 865; however, after adjusting the total catch for days the trap was not operated, the adjusted total catch was 1,235.

Fork lengths of young-of-the-year (yoy) rainbow trout/steelhead ranged from 21 to 125 mm with a mean of 43 mm and a median of 29 mm (Figure 15 & 16). The range in fork lengths of yoy trout accounts for growth over time. Fork lengths of age 1+ trout ranged from 89 to 253 mm with a mean of 152 mm and a median of 148 mm (Figure 15& 16). The length frequency histogram for trout was skewed towards newly emerging fry ≤30 mm (50%; Figure 16). Rainbow trout/steelhead fry (52.3%) and parr (42.0%) were the most abundant life-stages sampled at the LBC trap, whereas smolt and yolk-sac fry were the least abundant (1.2 and 1.7%; Table 1).

Non salmonids - UBC.— From July 13, 2001 through September 30, 2002, nine native non-salmonid species were captured in the UBC trap, including speckled dace (n=3), hardhead (n=826), Pacific lamprey (n=1,236), prickly sculpin (n=4), riffle sculpin (n=117), Sacramento pikeminnow (n=182), Sacramento sucker (n=396), tule perch (n=33), and threespine stickleback (n=35). In addition, two introduced non-salmonid species were captured including bluegill, sunfish (n=1) and green sunfish (n=1). Pacific lamprey were the most abundant species captured at the trap (n=1,236). Besides Chinook salmon and rainbow trout/steelhead, hardheads and Sacramento suckers were the next most abundant non-salmonids captured in the UBC trap. Lamprey, cyprinid, and cottid fry were also captured at the trap, but could not be identified to species. Non salmonid catch was not adjusted for days the UBC trap was not operated.

Trap Efficiency and Juvenile Salmonid Passage

Lower Battle Creek trap efficiency (LBC).—To estimate trap efficiency, 32 mark-recapture trials were conducted at the LBC trap (Table 2). We released marked Chinook salmon during 25 of the 32 weeks available between November 18, 2001 and June 16, 2002. The results of six trials were not used to calculate passage as four were conducted using large hatchery fish and two had either no recaptures (March 21, 2002) or recaptures were less than seven and the results could not be pooled with trials from an adjacent week (March 25, 2002). Of the 26 trials that were used to calculate passage, 22 had at least seven recaptures as recommended by Steinhorst et al. (2004). Three trials with less than seven recaptures were pooled with trials from adjacent weeks because weekly mean flows and trap efficiencies were similar. The remaining trial (February 25, 2002) with less than seven recaptures was one of two trials conducted during the same week: therefore, the results were pooled with the other trial conducted that week. During six of the weeks that trials were conducted, two separate mark-recapture trials were conducted and the results were pooled prior to calculating weekly passage. During one additional week, three trials were conducted and the results were pooled. During all other weeks, either one or no trial was conducted. Weekly trap efficiencies for the pooled and unpooled trials varied from 0.017 to 0.141. Using the results of these trials, the season average efficiency was estimated at 0.080. The 2001 to 2002 season average efficiency was used to estimate passage for 27 weeks during July 10, 2001 to September 30, 2002 when no trials were conducted or when trials results were not used.

Upper Battle Creek trap efficiency (UBC).—To estimate trap efficiency, 23 mark-recapture trials were conducted at the UBC trap (Table 3). We released marked Chinook salmon during 25 of the 28 weeks available between November 18, 2001 and May 29, 2002. The results of four trials were not used to calculate passage as two were conducted using large hatchery fish and two had either no recaptures (April 10, 2001) or recaptures were less than seven and the results could not be pooled with trials from an adjacent week (March 25, 2002). Of the 19 trials that were used to calculate passage, 14 had at least seven recaptures as recommended by Steinhorst et al. (2004). Four additional trials (May 2002) with less than seven recaptures were pooled with adjacent trials because weekly mean flows and trap efficiencies were similar. The remaining trial (February 15, 2002) with less than seven recaptures was one of two trials conducted during the same week; therefore the results were pooled with the other trial conducted that week. During five of the weeks that trials were conducted, two separate mark-recapture trials were conducted and the results were pooled prior to calculating weekly passage. During all other weeks, either one or no trial was conducted. Weekly trap efficiencies for the pooled and unpooled trials varied from 0.026 to 0.082. Using the results of these trials, the season average efficiency was estimated at 0.060. The 2001 to 2002 season average efficiency was used to estimate passage for 29 weeks during July 13, 2001 to September 30, 2002 when no trials were conducted or when trials results were not used.

Lower Battle Creek juvenile salmonid passage (LBC).—At the LBC trap, trap efficiency estimates were used to generate weekly and annual juvenile passage indexes (JPI) for spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead. Although juvenile passage indexes were calculated for spring Chinook salmon, they are likely unreliable because of the overlap in length with fall Chinook salmon. Juvenile passage index estimates were not calculated for winter Chinook salmon as they are likely migrants from the Sacramento River using lower Battle Creek as non-natal rearing habitat.

The annual JPI for BY01 spring Chinook salmon was 8,974, and the 90 and 95% confidence intervals were 8,109 to 9,914 and 7,984 to 10,082, respectively (Table 4). A peak weekly passage of 4,863 occurred the week of April 15, 2002 although a smaller peak of 176 occurred earlier the week of December 24, 2001. These two peaks represent the initial movement of fry out in December, and then larger fish (parr, silvery parr, and smolt) in April. The annual JPI for BY01 fall Chinook salmon was 4,038,950 (Table 5). The 90 and 95% confidence intervals for the annual JPI were 3,720,461 to 4,415,481 and 3,673,385 to 4,515,173, respectively. The weekly JPI's for fall Chinook salmon increased rapidly to a peak of 1,130,465, the week of February 11, 2002, and then began to decline until early April when passage increased for a short time. No passage estimates were made for BY01 late-fall Chinook salmon because only a portion of the run was sampled. The annual JPI for BY02 late-fall Chinook salmon was 59,151 (Table 6). The 90 and 95% confidence intervals for the annual JPI were 50,055 to 72,556 and 48,569 to 75,210, respectively. The weekly JPI's for late-fall Chinook salmon increased quickly to a peak of 15,190 the week of May 13, 2002, and then declined to < 1,000 nine weeks after the start of the outmigration; however, a few additional fish were captured sporadically until late-December. The annual JPI for yoy rainbow trout/steelhead passing the LBC trap between July 10, 2001 and September 30, 2002 was 7,822 whereas passage for age1+ fish was 647 (Table 7). The 90 and 95% confidence intervals for the yoy annual JPI estimate were 7,005 to 8,765 and 6,865 to 9,049, respectively. The 90 and 95% confidence intervals for the annual JPI for age 1+ fish were 580 to 713 and 571 to 734, respectively. Most age 1+ fish migrated during November through May, whereas yoy were not captured in the trap until mid-February with a peak weekly passage of 1,202 the week of March 18, 2002.

Upper Battle Creek juvenile salmonid passage (UBC).—At the UBC trap, trap efficiency estimates were used to generate juvenile passage indexes (JPI) for spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead. Although juvenile passage indexes were calculated for spring Chinook, they are likely unreliable because of the overlap in length with fall Chinook salmon and small sample sizes. Juvenile passage indexes were not calculated for winter Chinook salmon because catch was to low (n=2).

The annual JPI for BY01 spring Chinook salmon was 482, and the 90 and 95% confidence intervals were 389 to 615 and 377 to 644, respectively (Table 8). A peak weekly passage of 200 occurred the week of April 8, 2002.The annual JPI for BY01 fall Chinook salmon at the UBC trap was 21,273, and the 90 and 95% confidence intervals were 18,642 to 24,337 and 18,195 to 25,143, respectively (Table 9). The weekly JPI's for fall Chinook salmon increased rapidly to an early peak of 2,600 the week of December 24, 2001 and then began to decline until mid-February when passage began increasing slowly to a second peak (n=2,390) the week of May 13, 2002. The annual JPI for BY02 late-fall Chinook salmon was 7,647, and the 90 and 95% confidence intervals for the were 5,965 to 9,993 and 5,774 to 10,618, respectively (Table 10). The weekly JPI's for late-fall Chinook salmon increased quickly to a peak of 2,664 the week of May 6, 2002, and then declined to < 1,000 two weeks later. One additional late-fall Chinook salmon was captured in November 2002. No passage estimates were made for BY01 late-fall Chinook salmon captured at the UBC trap because only a small portion of the run was sampled The annual JPI for yoy rainbow trout/steelhead passing the UBC trap between July 10, 2001 and September 30, 2002 was 24,740 whereas passage for age1+ fish was 1,348 (Table 11). The 90 and 95% confidence intervals for the yoy annual JPI estimate were 21,034 to 29,565 and 20,454 to 31,426, and the 90 and 95% confidence intervals for the annual JPI for age 1+ fish were 1,201 to 1,607 and 1,170 to 1,666, respectively. Most age 1+ fish migrated during November through May, whereas yoy were not captured in the trap until mid-February with a peak weekly passage of 2,633 the week of April 8, 2002.

Discussion

Trap Operation

Staff shortages, hatchery releases, high flows, etc., limited our ability to operate either trap continuously during the sample season. However, sampling in previous years has shown that operating the trap throughout the year is not necessary (Whitton et al., 2006). Chinook salmon and rainbow trout/steelhead were the focus of our monitoring project, and catch of these salmonids was very low or zero from July through October; therefore, it was not necessary to operate the traps during this period. Staff shortages in April and May required us to operate the traps on a reduced schedule (4 d each week); therefore, we had to estimate salmonid catch on missed days. Because of staff shortages, we estimated catch for 6 d in April and 12 d in May at the LBC trap, and 12 days each month at the UBC trap (Appendices 1 and 2). At the LBC trap, hatchery releases of fall Chinook salmon in April required that we estimate catch for an additional 8 d. Estimating catch may affect our weekly and annual JPI's but the magnitude of the affect may vary with time of the year, catch, and number of consecutive days estimated. This may have been more important in April and May, because sampling in prior years has shown that a secondary peak of larger fall and spring Chinook salmon (parr, silvery parr, and smolt) occurs during this time as well as the initial peak of late-fall Chinook salmon fry. High flows had limited impacts on trap operation during the current reporting period, as they only prevented us from operating either trap for less than 6 d. Other miscellaneous reasons which required us to estimate daily catch included, holidays, no cone rotation due to low flows or debris, etc., but the number of days estimated was limited to brief periods of time throughout the sample period.

Determining whether there are better methods for estimating catch for days the traps are not operational may improve the accuracy of our passage estimates. Currently, average catch for an equal number of days before and after a period of missed sampling is used to estimate catch when the traps are not sampling. The accuracy of this method as well as others such as catch per unit volume (CPUV) or effort (CPUE) should be tested to determine whether there is a particular method that is more accurate at estimating catch during high-flow periods and other days the traps are not operated. The CPUE methodology has been used in a few other rotary screw trap studies to estimate passage during periods when traps were not operated (Griffith et al. 2001 and Volkhardt et al. 2005), but comparisons with other methods did not occur.

Biological Sampling

To effectively estimate passage and describe biological characteristics of all races of Chinook salmon on Battle Creek, the sampling methods used at the traps must be tested to ensure their applicability and accuracy. Currently, length-at-date criteria for determining run designation (Greene1992) are used on Battle Creek to differentiate runs of juvenile Chinook salmon captured in the traps. However, the criteria were developed for the mainstem Sacramento River, and do not appear to be accurate for tributary runs of Chinook salmon. There is significant size overlap between runs, particularly fall and spring Chinook salmon. This discrepancy is important when trying to accurately estimate the passage of threatened and endangered Chinook salmon. The size overlap likely resulted in underestimates of spring and overestimates of fall Chinook salmon passage at both traps. Considering the overlap between runs, genetic sampling is likely the most accurate method for assigning a run designation. However, it is expensive and will likely only be done on a portion of the total catch, which then requires the results to be extrapolated to the total catch.

Trap Efficiency and Juvenile Salmonid Passage

Trap efficiency.—Mark-recapture methods are commonly used to estimate trap efficiency, but the results are influenced by many factors, including flow, fish size and species, release time and location, predation, type of mark, etc. In 2001 to 2002, we conducted mark-recapture trials at various flows, but unlike previous years, high flows rarely limited our ability to conduct trials. In 2001 to 2002, no relationship between flow and trap efficiency was apparent. Fish size can also influence capture efficiency, and ideally we should have conducted separate trials for each species, run, and life stage at various seasons and flows. However, our ability to conduct age, run, and species specific trials was limited by the low abundance of fish available within each category; therefore we used fall Chinook salmon fry and parr as surrogates. The applicability of our estimates to these other groups is questionable, but Roper and Scarnecchia (1996) found that behavioral differences between hatchery and naturally produced Chinook salmon were minimal when traps were operated in higher velocities. They compared trap efficiencies when a 2.43 m (8 ft) trap was rotating an average of 3.05 rotations/min, 2.37 rotations/ min, and 1.40 rotations/min. During the current reporting period, our 1.5m (5 ft) traps usually rotated an average of 3 to 6 rotations/min or higher, unless there was algae build-up or during very low flows. It seems possible that at higher velocities the benefits of increased swimming ability found in larger fish may also be smaller. On January 14, 2002 we conducted two mark-recapture trials simultaneously at the LBC trap, one using naturally produced fall Chinook salmon fry (30-41mm), and the other trial using larger (90-173 mm) marked hatchery Chinook salmon. The resulting trap efficiencies for the two trials were 0.025 for the smaller fish and 0.029 for the larger hatchery fish. Although the results from the hatchery trial were not used to estimate efficiency, they suggest further study needs to be done to determine whether hatchery fish could be used as surrogates in mark-recapture trials, especially during periods of low abundance. Release location and time may have influenced trap efficiencies; however, the influences of release location and time should be similar for all trials since all marked fish were released from the same location and with a few exceptions, all fish were released at dusk or after dark.

Our passage estimates were likely inaccurate due to our inability to conduct mark-recapture trials at certain times of the year. We only conducted mark-recapture trials from January to June because insufficient numbers of naturally produced fall Chinook salmon fry and parr were available at other times of the year. The influences on our weekly JPI's were likely small at certain times of the year when catch was low, but, at other times it had a greater influence. For instance, the peak passage of spring Chinook salmon fry normally occurs in December, but to limit our impacts to a federally listed species, we did not conduct mark-recapture trials at that time. We used two methods for dealing with weeks when mark-recapture trials were not conducted or when recapture rates were low (<7). First, if the trap efficiency and mean weekly flow of an adjacent week or weeks were similar, we pooled the results of the mark-recapture trials. Otherwise, we used a season average efficiency based on all valid trials to estimate passage. The accuracy of our estimates was likely affected by the use of either method; however, the magnitude of the effect depends on the estimated catch at the time it was used and how different the efficiency used to estimate production (pooled or season average) was from the true efficiency. The influences from pooling on the annual JPI estimates was likely minimal compared to using a season average efficiency, as it was only used for weeks when recapture rates were low and when flows and efficiencies were similar for the weeks that were pooled. Using the season average efficiency likely had more influence on the annual JPI's because it was used for all weeks when trials were not conducted. The accuracy of production estimates when this method was used could be in question, particularly during weeks when large numbers of Chinook salmon were passing the trap. In future sampling, release groups for mark-recapture trials should be large enough to ensure a minimum of seven recaptures. This will eliminate the need to pool data from adjacent weeks improving the accuracy of our estimates. In addition larger groups of marked fish will reduce the width of our confidence intervals.

In future trap operations, mark-recapture trials should be conducted for all weeks when sufficient numbers are available. The use of hatchery fish is being explored for future sampling. If hatchery fish are available, trials should be done to test whether behavioral differences exist at all sizes. Hatchery fish have been used in some studies, but Roper and Scarnecchia (1996) found that trap efficiencies for hatchery and natural Chinook salmon were different because of differences in behavior. However, they also found that efficiencies for hatchery and natural Chinook were similar for a trap operated in relatively high velocities. Differences in behavior may be small when hatchery fry are used as surrogates for naturally produced fry. The use of hatchery fry would allow us to conduct trials during the peak spring Chinook salmon outmigration when flows are more variable.

Ideally, daily mark-recapture trials provide the most accurate estimates of trap efficiency (Roper and Scarnecchia 1999), however, they are also very time intensive and expensive. However, insufficient numbers of fish were available during most of the season, but when possible two trials were conducted per week. The results of these trials were combined to estimate a weekly efficiency. This method has been used successfully by others such as Thedinga et al. (1994). One advantage of this method is that variations in flow which may affect trap efficiency during the week are accounted for with a weekly estimate. This method also ensures that sufficient recaptures occur to meet the minimum of seven as was recommended by Steinhorst et al. (2004). As occurred with our study, mark-recapture release strategies can vary and the affects on the final estimates needs to be studied further to determine the most effective and efficient method for providing reasonable statistically-sound estimates of trap efficiency. Some studies have developed flow-trap efficiency models to allow the estimation of daily trap efficiencies (Martin et al. 2001). This method appears to be valid, but may not be applicable to all streams. The flow to trap efficiency relationship needs to be sufficiently strong to ensure that estimates of efficiency are accurate. Other variables besides flow should also be considered.

Juvenile salmonid passage.—Passage of juvenile fall and late-fall Chinook salmon at the Lower Battle Creek trap and fall and spring Chinook salmon at the Upper Battle Creek trap were lower than seen in previous years (Tables 12 and 13). Based on non-overlapping 95% confidence intervals, statistically significant differences include; (1) the BY01 fall Chinook JPI was lower than the BY99 JPI at the LBC trap, (2) the BY01 fall Chinook JPI was lower than BY 98, BY99, and BY00 JPIs at the UBC trap, and (3) the BY01 spring Chinook JPI was lower than BY 98 and BY99 spring Chinook JPIs at the UBC trap (Tables 12 and 13). A variety of factors may be responsible for the reduced juvenile passage indices, including reduced adult passage, poor adult survival and spawning success, reduced survival to emergence, and inaccurate estimates of actual juvenile passage.

The decrease in fall and spring Chinook juvenile passage estimates at the UBC trap in 2001 may be directly related to adult passage. The UBC trap monitors juvenile production from adult Chinook salmon escaping above the Coleman National Fish Hatchery (CNFH) barrier weir. In 2001, escapement estimates of adult Chinook salmon upstream of the weir were 100 spring and 9 to 14 fall Chinook salmon (Brown and Newton 2002). In addition, hatchery staff passed 98 unclipped Chinook salmon above the barrier weir prior to March 3, 2001. These salmon were likely late-fall Chinook salmon, but could have included other runs. Brown and Newton (2002) stated that because of low flows in 2001 it is unlikely that additional adult salmon were able to jump over the weir undetected (Figure 17). In contrast, escapement was thought to be much higher in 1998 and 1999 because unusually high flows made it easier for spring and CHFH fall Chinook salmon to jump over the weir undetected (Figure 17, USFWS 2001). Correspondingly, in 1998 redd counts above the barrier weir were the highest on record (J. M. Newton, USFWS, unpublished data) and there was substantial over-escapement of CNFH fall Chinook salmon returning to Battle Creek in 1998 and 1999 (USFWS 2001).

Low flows and high water temperatures in 2001 could have reduced the survival of adult salmon during holding periods and also reduced spawning success in the fall. In 2001, minimum instream flows in South Fork Battle Creek were greatly reduced, resulting in higher water temperatures during the Chinook salmon holding and spawning periods. In comparison, minimum instream flows of at least 0.85 m^3/s (30 cfs) were provided in both the North Fork Battle Creek and the South Fork Battle Creek in 1998 to 2000 (Figure 17). Coincidentally, in 2001, an above average proportion of Chinook salmon held and spawned in the south fork (63% of adults and 38% of redds; Alston et al. 2007). In contrast, during 2001 to 2006 the average percent of adult spawners and redds observed in the south fork was 36% and 16%, respectively. In 2001, 32 redds were observed above the barrier weir, but 247 redds were observed above the barrier weir in 1998. Mean daily water temperatures at the UBC trap were generally lower in 1998 and 1999 than in 2000 and 2001, possibly resulting in better juvenile rearing conditions and survival in the earlier years (Figure 18). Brown and Newton (2002) observed delayed spawning in fall 2001 until water temperatures were more suitable. They also noted that although water temperatures in 2001 were adequate for successful production of juveniles, it was likely reduced due to the exposure to temperatures that could increase adult mortality and reduce fertility.

Survival to emergence data is not available for any year; therefore it is not possible to determine whether the low flows and temperatures observed in 2001 influenced juvenile survival and the resulting passage estimates. However, Brown and Newton (2001) stated some incubating Chinook salmon eggs in the south fork, north fork, and upper mainstem potentially experienced high water temperatures, but in general their temperature, redd distribution, and spawn timing data indicated that most Chinook salmon eggs were exposed to good temperatures for most of the incubation period. Limited exposure to high temperatures may account for some of the reduction in juvenile passage, but the available information suggests it was unlikely the primary cause. Estimates of survival to emergence would provide further information allowing us to better determine which factors may be affecting annual juvenile passage.

The accuracy of our juvenile passage estimates is also uncertain, but the methods we use are standard methods used by others trying to gather similar information. Without complete catch of outmigrating juveniles, which is not possible, we can only estimate juvenile Chinook salmon passage. We are exploring alternative methods (CPUV or CPUE) for estimating passage as well as ways to improve the accuracy of our current methods.

In 2001, the numbers of late-fall Chinook salmon captured at the Upper Battle Creek trap were high enough that a passage estimate could be made (Table 13). During 1998 to 2000, no estimates were made because of low numbers captured in the trap. However, the hatchery staff began passing unclipped late-fall upstream of the barrier weir in 2001 and did not pass them in 1998 to 2000 (Robert Null, USFWS, unpublished data). This may account for the increased numbers captured at the upper Battle Creek trap from July 13, 2001 to September 30, 2002. Rainbow trout/steelhead passage estimates at both traps are similar to the 2000 estimates although the time periods reported were slightly different. Young-of-the-year accounted for the largest portion of the trout captured, which is similar to previous years. A production estimate of rainbow trout/steelhead was not calculated in 2001 because the trap was not operational during the peak outmigration of fry.

Recommendations

1. Investigate the use of CPUV, CPUE, or other methods to estimate catch for days the trap is not fished.

2. Develop or utilize methods such as genetics for determining the run designation of Chinook salmon captured in the traps.

3. Investigate methods for conducting mark-recapture trials that will improve the accuracy of trap efficiencies such as: (a) conducting robust day and nighttime trials and applying the results to day and nighttime catch, (b) increasing the size of release groups during periods when trap efficiencies are likely to be low (i.e., high flows), (c) marking Chinook salmon so that fish from a particular trial are distinguishable from other trials, and (d) testing the effect of trial frequency on weekly passage estimates.

4. Investigate the differences in capture efficiency of hatchery and naturally produced Chinook salmon at various life-stages. The ability to use hatchery fish at times when insufficient

naturally produced fish are available would reduce the need to use the average season efficiency.

5. Investigate the feasibility of estimating survival to emergence for Chinook and/or rainbow trout/steelhead to assist in evaluating the effectiveness of the Battle Creek Restoration Project.

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Tables

Table 1. Life stage summary of fall, late-fall, spring and winter Chinook salmon and rainbow trout/steelhead captured at the Lower and Upper Battle Creek rotary screw traps from July 2001 through September 2002.

	Fall Chinook		Late-Fall Chinook		Spring Chinook		Winter Chinook		Rainbow	
Life Stage	#	%	#	%			#	%	#	%
Lower Battle Creek (LBC)										
Yolk Sac Fry	---	---	---	---	--	---	---	---	3	0.6
Fry	18,507	82.7	1,478	87.7	30	14.8	0	0.0	343	63.5
Parr	1,252	5.6	183	10.8	3	1.5	21	18.1	166	30.7
Silvery Parr	2,122	9.5	19	1.1	89	43.8	93	80.2	13	2.4
Smolt	490	2.2	6	0.4	81	39.9	2	1.7	14	2.6
Adult (?)									1	0.2
Totals	22,371	100	1,686	100	203	100	116	100	540	100
Upper Battle Creek (UBC)										
Yolk Sac Fry	---	---	---	---	---	---	---	---	14	1.7
Fry	494	69.6	144	95.4	3	17.6	0	0	437	52.3
Parr	41	5.8	1	0.7	0	0	0	0	351	42.0
Silvery Parr	158	22.3	4	2.6	8	47.1	2	100	23	2.8
Smolt	16	2.3	2	1.3	6	35.3	0	0	10	1.2
Totals	709	100	151	100	17	100	2	100	835	100

Table 2. Summary of the mark-recapture trials conducted at the Lower Battle Creek rotary screw trap (LBC) during July 10, 2001 through September 30, 2002. Marked fish for all LBC trials were released at the Jelly's Ferry Bridge. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. Trials conducted during the same week were pooled to calculate the average weekly trap efficiency. During weeks when recaptures were <7 mark-recapture data were pooled with data from adjacent weeks if flows and trap efficiencies were similar, otherwise the season average trap efficiency (E=0.080) was used to calculate weekly passage. The season average trap efficiency was also used to calculate passage during weeks when no mark-recapture trials were conducted. Hatchery fish were used for the trials listed in bold text; however, because of potential behavioral differences, these trials were not use to estimate passage.

Release Date	Time of Release	Number Released	Recaptures	Efficiency[a]	Pooled /Season Avg. Efficiency	Weekly Mean Flow, m^3/s (cfs)
11/18/01	**1720**	**119**	**11**	**0.100** [b]	**0.080**	**13.5 (477)**
12/13/01	**1730**	**408**	**16**	**0.042** [b]	**0.080**	**11.7 (413)**
12/16/01	**1500**	**201**	**19**	**0.099** [b]	**0.080**	**21.5 (759)**
01/05/02	1630	434	48	0.113 [b]	---	20.1 (710)
01/14/02	**1700**	**207**	**5**	**0.029** [b]	**0.080**	**12.7 (448)**
01/14/02	1700	396	9	0.025[c]	---	12.7 (448)
01/22/02	1715	1,643	27	0.017 [c]	0.017	12.4 (438)
01/25/02	1628	615	10	0.018 [c]	0.017	12.4 (438)
01/28/02	1743	2,047	34	0.017 [c]	0.021	11.4 (403)
01/31/02	1630	1,292	34	0.027 [c]	0.021	11.4 (403)
02/04/02	1725	1,331	57	0.044 [c]	0.045	11.2 (396)
02/07/02	1739	973	46	0.048 [c]	0.045	11.2 (396)
02/10/02	1800	1,915	35	0.019 [c]	0.028	10.8 (381)
02/14/02	1743	1,884	72	0.039 [c]	0.028	10.8 (381)
02/18/02	1700	1,014	22	0.023 [c]	0.017	21.9 (773)
02/21/02	2000	941	10	0.012 [c]	0.017	21.9 (773)
02/25/02	1750	441	5	0.014 [c]	0.026	13.8 (487)
02/28/02	1720	335	14	0.045 [c]	0.026	13.8 (487)
03/04/02	1823	778	44	0.058 [c]	0.044	14.2 (501)
03/07/02	2106	727	30	0.043 [c]	0.044	14.2 (501)
03/11/02	1845	399	8	0.023 [c]	0.044	14.2 (501)
03/14/02	1755	450	28	0.064 [b]	---	12.9 (456)
03/18/02	1818	145	12	0.089 [b]	---	12.1 (427)
03/21/02	1830	66	0	---	---	12.1 (427)
03/25/02	1915	97	5	0.061 [b]	0.080	12.5 (441)
04/01/02	1840	117	17	0.153 [b]	0.141	13.7 (484)
04/10/02	2103	45	5	0.130 [b]	0.141	13.7 (484)
05/01/02	2045	195	15	0.082 [b]	---	12.7 (448)
05/07/02	1330	166	25	0.156 [b]	---	12.2 (431)
05/15/02	2220	85	7	0.093 [b]	---	12.1 (427)
05/22/02	1930	51	4	0.096 [b]	0.091	11.9 (420)
06/12/02	9:15 ?	58	5	0.102 [b]	0.091	9.7 (343)

[a] Bailey's Efficiency was calculated by: $\hat{E} = \frac{r+1}{m+1}$, where r = recaptures and m = number of marked fish released.

[b] Bailey's efficiency was halved for this trial when calculating the season average efficiency for periods when the trap was at half-cone.

[c] Bailey's efficiency was doubled for this trial when calculating the season average efficiency for periods when the trap was at full cone.

Table 3. Summary of the mark-recapture trials conducted at the Upper Battle Creek rotary screw trap (UBC) during July 13, 2001 through September 30, 2002. Marked fish for all UBC trials were released at Intake 3. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. Trials conducted during the same week were pooled to calculate the average weekly trap efficiency. During weeks when recaptures were <7 mark-recapture data were pooled with data from adjacent weeks if flows and trap efficiencies were similar, otherwise the season average trap efficiency (E=0.060) was used to calculate weekly passage. The season average trap efficiency was also used to calculate passage during weeks when no mark-recapture trials were conducted. Large hatchery fish were released during the first two trials (**bold text**); however, because of potential behavioral differences, these trials were not used to estimate passage.

Release Date	Release Time	Number Released	Recaptures	Efficiency[a]	Pooled /Season Avg. Efficiency	Weekly Mean Flow, m^3/s (cfs)
11/18/01	**1630**	**115**	**4**	**0.043**	**0.060** [b]	**13.5 (477)**
01/15/02	**1710**	**291**	**5**	**0.021**	**0.060** [b]	**12.9 (456)**
01/15/02	1715	285	23	0.084	0.060	12.9 (456)
01/22/02	1723	200	12	0.065	0.070	12.4 (438)
01/25/02	1638	200	15	0.080	0.070	12.4 (438)
01/28/02	1810	200	19	0.099	0.082	11.4 (403)
01/31/02	1655	200	13	0.070	0.082	11.4 (403)
02/04/02	1705	200	7	0.040	0.050	11.2 (396)
02/07/02	1800	199	12	0.065	0.050	11.2 (396)
02/10/02	1735	201	8	0.040	0.038	10.8 (381)
02/15/02	1730	192	6	0.036	0.038	10.8 (381)
02/18/02	1715	191	8	0.047	0.061	21.9 (773)
02/21/02	1350	200	15	0.080	0.061	21.9 (773)
02/25/02	1738	150	10	0.073	---	13.8 (487)
03/25/02	1923	87	1	0.023	0.060[b]	12.5 (441)
04/01/02	1850	117	12	0.110	---	13.7 (484)
04/10/02	2120	30	0	---	0.060[b]	14.2 (501)
04/17/02	2107	132	8	0.068	---	13.9 (491)
05/01/02	2100	196	7	0.041	---	12.7 (448)
05/08/02	1345	174	3	0.023	0.026[b]	12.2 (431)
05/15/02	2155	123	3	0.032	0.026[b]	12.1 (427)
05/22/02	1935	74	3	0.053	0.026[b]	11.9 (420)
05/29/02	2020	59	1	0.034	0.026[b]	11.8 (417)

[a] Bailey's Efficiency is calculated by: $\hat{E} = \frac{r+1}{m+1}$, where r = recaptures and m = marks.

[b] During weeks when recaptures were less than seven, mark-recapture data was pooled with data from adjacent weeks if flows and trap efficiencies were similar. Otherwise the season average trap efficiency was used to calculate weekly passage.

Table 4. Weekly summary of brood year 2001 juvenile spring Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which spring Chinook salmon were captured are included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
11/19/01	0.080[a]	2	25	3	21	30	20	31
11/26/01	0.080[a]	7	88	9	75	106	73	110
12/03/01	0.080[a]	1	13	1	11	15	10	15
12/10/01	0.080[a]	5	63	6	54	75	52	78
12/17/01	0.080[a]	12	151	16	128	179	125	184
12/24/01	0.080[a]	14	176	18	150	208	145	220
12/31/01[d]	0.080[a]	1	13	1	11	15	10	15
01/06/02[e]	0.113	1	9	1	7	11	7	12
02/25/02	0.026	2	78	18	56	111	52	120
03/04/02[f]	0.044	1	23	2	19	17	19	28
04/01/02	0.141	15	106	22	79	144	74	153
04/08/02	0.141	131	928	182	689	1,256	647	1,334
04/15/02	0.080[a]	387	4,863	487	4,139	5,731	4,027	5,960
04/22/02	0.080[a]	149	1,872	189	1,593	2,206	1,550	2,295
04/29/02	0.082	34	417	103	278	606	267	666
05/06/02	0.156	13	84	17	62	114	59	121
05/13/02	0.093	16	65	25	37	103	37	129
Totals		***789***	***8,974***	***546***	***8,109***	***9,914***	***7,984***	***10,082***

[a] Season average efficiency for weeks when the trap was at full-cone. Efficiencies were doubled for half-cone trials to make all mark-recapture trials equivalent.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.
[d] This week is 1 d short as the last day was included in the following week as mark-recapture fish were released on 1/5/02 instead of 1/6/02.
[e] This week includes two extra days as marked fish were released early on 1/5/02, and because the trap was modified to half-cone on 1/15/02.
[f] This week includes two extra days because on 3/11 and 3/12/02 the trap was still at half-cone while the rest of the week was at full-cone.

Table 5. Weekly summary of brood year 2001 juvenile fall Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
11/26/01	0.080[a]	1	13	1	11	15	10	16
12/03/01	0.080[a]	34	427	44	361	505	352	518
12/10/01	0.080[a]	70	880	86	744	1,026	724	1,067
12/17/01	0.080[a]	531	6,673	672	5,627	7,863	5,476	8,177
12/24/01	0.080[a]	1,489	18,711	1,872	15,924	21,770	15,494	22,931
12/31/01[d]	0.080[a]	4,344	54,587	5,451	46,457	63,510	45,201	66,017
01/06/02[e]	0.113	6,436	57,136	8,079	45,896	71,786	43,745	73,675
01/15/02[f]	0.025	1,988	78,924	29,347	46,426	131,539	43,846	157,847
01/21/02	0.017	6,805	404,539	68,228	313,724	530,086	301,421	549,018
01/28/02	0.021	5,714	275,763	31,915	226,519	333,818	221,251	345,957
02/04/02	0.045	42,676	945,848	88,942	806,297	1,105,260	793,292	1,143,816
02/11/02	0.028	32,129	1,130,465	108,450	968,970	1,312,798	946,436	1,371,800
02/18/02	0.017	13,102	776,591	140,351	595,989	1,025,100	557,120	1,114,240
02/25/02	0.026	1,292	50,194	12,244	35,853	71,706	33,463	77,222
03/04/02[g]	0.044	2,211	50,746	5,608	42,545	60,171	41,294	62,865
03/13/02[h]	0.064	580	9,020	1,655	6,707	11,890	6,380	13,079
03/18/02	0.089	411	4,616	1,282	3,000	6,667	2,857	7,501
03/25/02	0.080[a]	243	3,054	327	2,491	4,215	2,382	4,566
04/01/02	0.141	285	2,020	405	1,499	2,733	1,408	2,903
04/08/02	0.141	769	5,450	1,155	3,917	7,373	3,798	8,356
04/15/02	0.080[a]	2,316	29,103	2,970	24,768	34,295	23,884	35,666
04/22/02	0.080[a]	2,592	32,571	3,232	27,466	37,896	26,730	39,392
04/29/02	0.082	4,453	54,549	14,264	36,366	79,344	34,912	87,279
05/06/02	0.156	1,780	11,433	2,214	8,743	15,645	8,257	16,514
05/13/02	0.093	1,240	13,330	5,103	7,617	21,328	7,109	26,660
05/20/02	0.091	808	8,888	3,033	5,555	14,813	5,228	17,776
05/27/02	0.091	798	8,778	3,097	5,486	14,630	5,164	17,556
06/03/02	0.091	274	3,014	989	1,884	5,023	1,773	5,023
06/10/02	0.091	93	1,023	334	639	1,705	602	2,046
06/17/02	0.080[a]	34	427	44	364	510	351	524
06/24/02	0.080[a]	8	101	11	85	118	83	125

Table 5. (Cont.)

07/01/02	0.080[a]	5	63	7	53	75	52	78
07/08-09/30/02	0.080[a]	1	13	1	11	15	10	15
Totals	---	***135,512***	***4,038,950***	***213,837***	***3,720,461***	***4,415,481***	***3,673,385***	***4,515,173***

[a] Season average efficiency based on valid trials conducted January 5, 2002 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.
[d] This week is 1 d short as the last day was included in the following week as mark-recapture fish were released on 1/5/02 instead of 1/6/02.
[e] This week includes 2 extra days as marked fish were released early on 1/5/02, and because the trap was modified to half-cone on 1/15/02.
[f] This week only includes 6 d because 1/14/02 was included in the previous week as the trap was at full cone on that day and at half-cone the rest of the week.
[g] This week includes 2 extra days because on 3/11 and 3/12/02 the trap was still at half-cone while the rest of the week was at full-cone.
[h] This week is 2 d short as the first 2 d of the week were included in the previous week. The trap was at half-cone on those days, but at full-cone the rest of the week.

Table 6. Weekly summary of brood year 2002 juvenile late-fall Chinook salmon passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which late-fall Chinook salmon were captured are included. However, several weeks outside of the reporting dates (October 1 to December 24, 2002) are included to allow estimation of the total annual JPI for brood year 2002 (below dashed line).

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
04/01/02	0.141	41	291	58	216	393	203	418
04/08/02	0.141	119	843	179	626	1,212	588	1,293
04/15/02	0.080 [a]	199	2,501	246	2,128	2,909	2,071	3,124
04/22/02	0.080 [a]	432	5,428	539	4,620	6,316	4,495	6,653
04/29/02	0.082	886	10,854	2,705	7,550	15,787	7,236	17,366
05/06/02	0.156	1,622	10,418	2,120	7,739	14,257	7,524	15,049
05/13/02	0.093	1,413	15,190	5,269	8,680	24,304	8,680	30,380
05/20/02	0.091	503	5,533	1,928	3,458	9,222	3,255	11,066
05/27/02	0.091	463	5,093	1,865	3,183	8,488	2,996	10,186
06/03/02	0.091	186	2,046	664	1,278	3,410	1,204	3,410
06/10/02	0.091	57	627	200	392	1,045	369	1,045
06/17/02	0.080[a]	7	88	9	76	104	74	108
06/24/02	0.080 [a]	2	25	3	21	29	20	30
07/01/02	0.080 [a]	5	63	6	53	73	52	77
09/16/02	0.080 [a]	1	13	1	11	15	10	16
10/1 to 12/24/02	0.123 [d]	26	138	16	115	166	111	172
Totals		***5,962***	***59,151***	***7,125***	***50,055***	***72,556***	***48,569***	***75,210***

[a] The 2001 to 2002 season average efficiency, which was based on valid trials conducted January 5, 2002 through June 10, 2002, was used to estimate passage during weeks when mark-recapture trials were not conducted.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.
[d] The 2002 to 2003 season average was used to estimate passage for weeks outside of the reporting period. No mark-recaptured trials were conducted during this period.

Table 7. Weekly summary of rainbow trout/steelhead passage estimates for the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Weekly estimates listed above the dotted line are for trout from previous brood years (age 1+). Weekly estimates below the line are for brood year 2002 trout captured during the reporting period. Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Weeks with no catch are not included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
Previous Brood Years (Age 1+)								
7/10 to 01/05/02[d]	0.080[a]	19	239	24	200	279	195	290
01/28/02	0.021	1	48	6	40	60	39	62
02/18/02	0.017	3	178	31	137	235	130	245
03/04/02[e]	0.044	3	69	8	58	83	56	87
03/13/02	0.064	1	16	3	12	22	11	23
03/25/02	0.074	1	13	1	11	15	10	15
04/01/02	0.141	1	7	1	5	10	5	10
04/15/02	0.080[a]	3	38	4	32	44	31	46
04/22/02	0.080[a]	1	13	1	11	15	10	15
05/27/02	0.091	1	11	4	7	18	6	22
07/08/02	0.076	1	13	1	11	15	10	16
Totals	---	***35***	***647***	***41***	***580***	***713***	***571***	***734***
Brood Year 2002 (YOY)								
02/11/02	0.028	2	70	7	61	84	59	85
02/18/02	0.017	10	593	108	445	782	425	850
02/25/02	0.026	8	311	70	214	444	207	478
03/04/02[e]	0.044	4	92	10	77	107	75	110
03/13/02	0.064	15	233	47	174	308	169	338
03/18/02	0.089	107	1,202	344	781	1,736	744	1,953
03/25/02	0.080[a]	89	1,118	109	952	1,301	935	1,353
04/01/02	0.141	98	695	141	515	940	484	998
04/08/02	0.014	24	170	34	122	230	119	261
04/15/02	0.080[a]	21	264	27	224	312	218	326
04/22/02	0.080[a]	22	276	29	233	332	226	341
04/29/02	0.082	39	478	120	332	695	306	764
05/06/02	0.156	40	257	49	191	352	181	371
05/13/02	0.093	32	344	123	197	550	183	688

Table 7. (Contin.)

05/20/02	0.091	63	693	232	433	1,155	408	1,386
05/27/02	0.091	47	517	184	323	862	304	1,034
06/03/02	0.091	27	297	97	186	424	175	594
06/10/02	0.091	9	99	30	62	165	58	165
06/17/02	0.079[a]	2	25	3	21	30	21	31
06/24/02	0.079[a]	6	75	8	64	90	62	93
07/01/02	0.079[a]	1	13	1	11	15	10	16
Totals		***666***	***7,822***	***551***	***7,005***	***8,765***	***6,865***	***9,049***

[a] Season average efficiency based on valid trials conducted January 5, 2002 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.
[d] The week of 12/31/2001 was 1d short because the last day was included in the next week since mark-recapture fish were released on 1/5/02 instead of 1/6/02.
[e] This week includes 2 extra days because on 3/11 and 3/12/02 the trap was still at half-cone while the rest of the week was at full-cone.

Table 8. Weekly summary of brood year 2001 juvenile spring Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which spring Chinook salmon were captured are included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
12/10/01	0.060[a]	3	50	13	35	75	32	82
04/01/02	0.110	2	18	6	12	26	11	34
04/08/02	0.060[a]	12	200	48	138	277	133	327
04/15/02	0.068	9	133	47	80	200	75	239
04/22/02	0.060[a]	1	17	4	12	23	11	25
04/29/02	0.041	1	25	12	14	39	13	49
05/06/02	0.026	1	39	12	24	62	23	72
Totals	---	***29***	***482***	***73***	***389***	***615***	***377***	***644***

[a] Season average efficiency based on valid trials conducted January 5, 2002 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.

Table 9. Weekly summary of brood year 2001 juvenile fall Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
12/10/01	0.060[a]	19	317	88	219	475	304	518
12/17/01	0.060[a]	90	1,500	372	1,038	2,077	1,000	2,250
12/24/01	0.060[a]	156	2,600	609	1,800	3,600	1,733	4,255
12/31/01	0.060[a]	82	1,367	341	946	2,050	911	2,236
01/07/02	0.060[a]	19	317	76	219	438	211	518
01/14/02	0.084	11	131	26	95	175	90	197
01/21/02	0.070	24	344	62	253	458	247	481
01/28/02	0.082	9	109	19	82	138	80	157
02/04/02	0.050	10	200	47	138	286	133	308
02/11/02	0.038	1	26	7	18	39	16	44
02/18/02	0.061	5	82	17	59	115	56	123
02/25/02	0.073	8	110	32	71	173	67	201
03/04/02	0.060[a]	10	167	40	120	250	111	273
03/11/02	0.060[a]	57	950	234	658	1,425	611	1,555
03/18/02	0.060[a]	59	983	232	681	1,475	656	1,609
03/25/02	0.060[a]	18	300	70	208	415	193	450
04/01/02	0.110	60	545	158	373	885	377	1,011
04/08/02	0.060[a]	28	467	161	311	646	300	700
04/15/02	0.067	42	621	303	372	931	349	1,117
04/22/02	0.060[a]	38	633	156	422	877	407	950
04/29/02	0.041	68	1,675	645	957	2,679	893	3,349
05/06/02	0.026	52	2,037	662	1,245	3,202	1,180	3,735
05/13/02	0.026	61	2,390	794	1,461	3,756	1,384	4,382
05/20/02	0.026	56	2,194	692	1,341	3,448	1,270	4,023
05/27/02	0.026	27	1,058	364	685	1,662	647	1,940
06/03/02	0.060[a]	6	100	23	69	138	67	150
07/15to 8/20/02	0.060[a]	3	50	12	35	75	32	82
Totals	***---***	***1,019***	***21,273***	***1,759***	***18,642***	***24,337***	***18,195***	***25,143***

[a] Season average efficiency based on valid trials conducted January 5, 2002 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.

Table 10. Weekly summary of brood year 2002 juvenile late-fall Chinook salmon passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Only weeks in which late-fall Chinook salmon were captured are included. However, one week outside of the reporting dates (October 1 to December 24, 2002) is included to allow estimation of the total annual JPI for brood year 2002 (below dashed line).

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c]		95% Confidence Interval[c]	
					Lower CI	Upper CI	Lower CI	Upper CI
04/01/02	0.110	3	27	8	18	44	17	51
04/08/02	0.060[a]	18	300	68	208	415	200	450
04/15/02	0.067	32	473	182	284	709	266	851
04/22/02	0.060[a]	17	283	70	196	425	182	464
04/29/02	0.041	28	690	255	394	1,103	368	1,379
05/06/02	0.026	68	2,664	904	1,628	4,187	1,543	4,885
05/13/02	0.026	60	2,351	810	1,437	3,694	1,361	4,310
05/20/02	0.026	10	392	130	239	615	227	718
05/27/02	0.026	11	431	144	263	677	250	790
07/22/02	0.060[a]	1	17	4	12	25	11	27
11/4/02	0.053[d]	1	19	4	14	26	13	28
Totals	---	***249***	***7,647***	***1,306***	***5,965***	***9,993***	***5,774***	***10,618***

[a] Season average efficiency based on valid trials conducted January 5 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.
[d] Season average efficiency based on valid trials conducted January 22 through April 23, 2003.

Table 11. Weekly summary of rainbow trout/steelhead passage estimates for the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 90 and 95% confidence intervals (CI). Weekly estimates listed above the dotted line are for trout from previous brood years (age 1+). Weekly estimates below the line are for brood year 2002 trout captured during the reporting period. Shaded rows indicate adjacent weeks where the results of mark-recapture trials were pooled to calculate passage. Weeks with no catch are not included.

Week	Efficiency (E)	Catch[b]	Estimated Passage (N)	SE[c]	90% Confidence Interval[c] Lower CI	90% Confidence Interval[c] Upper CI	95% Confidence Interval[c] Lower CI	95% Confidence Interval[c] Upper CI
Previous Brood Years (Age 1+)								
7/13 to 10/7/02	0.060[a]	3	50	12	35	70	33	82
10/22/01	0.060[a]	1	17	4	12	25	11	27
10/29/01	0.060[a]	1	17	4	12	25	11	27
11/05/01	0.060[a]	1	17	4	12	25	11	27
11/12/01	0.060[a]	1	17	4	12	25	11	27
11/19/01	0.060[a]	22	367	91	254	508	244	550
11/26/01	0.060[a]	12	200	47	138	277	133	327
12/03/01	0.060[a]	14	233	58	162	350	156	382
02/10/01	0.060[a]	2	33	8	23	46	22	55
12/17/01	0.060[a]	2	33	8	23	46	22	55
12/31/01	0.060[a]	10	167	39	115	231	111	273
01/07/02	0.060[a]	3	50	12	35	69	33	75
02/18/02	0.061	2	33	7	24	46	22	49
02/25/02	0.073	1	14	5	9	22	8	25
03/04/02	0.060[a]	1	17	4	12	23	11	25
04/15/02	0.068	3	44	21	27	80	25	80
05/20/02	0.026	1	39	13	25	62	23	72
Totals	---	***80***	***1,348***	***126***	***1,201***	***1,607***	***1,170***	***1,666***
Brood Year 2002 (YOY)								
02/11/02	0.038	1	26	7	17	39	17	44
02/25/02	0.073	1	14	5	9	22	8	25
03/04/02	0.060[a]	12	200	48	144	300	133	327
03/11/02	0.060[a]	25	417	103	288	625	268	682
03/18/02	0.060[a]	75	1,250	295	865	1,875	833	2,045
03/25/02	0.060[a]	88	1,467	342	1,015	2,031	943	2,200
04/01/02	0.110	228	2,070	578	1,345	2,989	1,281	3,363
04/08/02	0.060[a]	158	2,633	670	1,823	3,950	1,756	4,309
04/15/02	0.068	125	1,847	755	1,108	3,325	1,039	3,325
04/22/02	0.060[a]	45	750	181	519	1,125	500	1,227

Table 11. (Contin.)

04/29/02	0.041	73	1,798	701	1,027	2,876	959	3,595
05/06/02	0.026	33	1,293	386	790	2,032	790	2,370
05/13/02	0.026	75	2,939	970	1,796	4,618	1,701	5,388
05/20/02	0.026	158	6,191	2,074	3,782	9,728	3,584	11,350
05/27/02	0.026	39	1,528	548	989	2,401	885	2,801
06/03/02	0.060[a]	15	250	63	180	375	167	409
06/10/02	0.060[a]	2	33	8	23	46	21	50
06/24/02	0.060[a]	1	17	4	11	23	11	25
07/08/02	0.060[a]	1	17	4	11	23	11	25
Totals	---	***1,155***	***24,740***	***2,810***	***21,034***	***29,565***	***20,454***	***31,426***

[a] Season average efficiency based on valid trials conducted January 5, 2002 through June 10, 2002.
[b] Daily catch was estimated for days the trap was not fishing.
[c] Confidence intervals were calculated using the percentile bootstrap method and SEs were calculated using bootstrapped values.

Table 12. Summary of spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead juvenile passage estimates at the Lower Battle Creek rotary screw traps including run designation, brood year, original CAMP estimate, current estimate (N), and the 90 and/or 95% confidence intervals for the current estimates. Shaded rows indicated estimates for the current reporting period.

Run	Brood Year	Original CAMP Estimate[c]	Current Estimate	90% Confidence Interval		95% Confidence Interval	
				Lower CI	Upper CI	Lower CI	Upper CI
Spring	1998	---	---	---	---	---	---
	1999	---	---	---	---	---	---
	2000	---	---	---	---	---	---
	2001		8,978	8,113	10,002	8,003	10,160
Fall	1998	4,909,700	4,897,569	---	---	4,238,511	5,732,692
	1999	16,697,610	18,708,768	---	---	14,103,348	26,372,818
	2000-partial[a]	---	5,451,599	---	---	4,270,908	7,182,598
	2001	---	4,040,686	3,721,942	4,413,372	3,676,854	4,522,353
Late-Fall	1999	113,684	86,305	---	---	72,258	98,591
	2000	99,803	86,940	---	---	73,793	106,967
	2001	---	---	---	---	---	---
	2002	---	59,183	50,087	72,672	48,738	75,194
RBT/Steelhead	1999[b]	---	7,057	---	---	6,196	8,368
	2000[b]	---	8,417	---	---	7,699	9,608
	2001	---	---	---	---	---	---
	2002 (1+)[d]	---	647	580	713	571	734
	2002 (YOY)	---	7,822	7,005	8,765	6,865	9,049

[a] This passage estimate is not a complete brood year as the trap was not fished past February 9, 2001.

[b] These estimates are not brood years, rather two periods are summarized: October 9, 1998 to December 26, 1999 and December 27, 1999 to February 9, 2001. In addition, age 1+ and yoy were combined in these estimates.

[c] The original CAMP estimates cover the period January 1 through December 31; therefore, they may not include the entire brood year, and late-fall estimates may include fish from two brood years.

[d] Passage estimates for age 1+ trout are not for the current brood year, but rather a mixture of previous year-classes captured during the reporting period

Table 13. Summary of spring, fall, and late-fall Chinook salmon and rainbow trout/steelhead juvenile passage estimates at the Upper Battle Creek rotary screw traps including run designation, brood year, original CAMP estimate, current estimate (N), and the 90 and/or 95% confidence intervals for the current estimates. Shaded rows indicated estimates for the current reporting period.

Run	Brood Year	Original CAMP Estimate[c]	Current Estimate	90% Confidence Interval		95% Confidence Interval	
				Lower CI	Upper CI	Lower CI	Upper CI
Spring	1998	4,589	4,791	---	---	3,949	6,204
	1999	10,061	6,233	---	---	5,225	7,678
	2000	---	---	---	---	---	---
	2001	---	482	389	615	377	644
Fall	1998	1,466,274	1,193,916	---	---	996,588	1,546,430
	1999	211,662	239,152	---	---	202,274	291,194
	2000-partial[a]	---	43,850	---	---	37,476	54,567
	2001	---	20,920	18,642	24,337	18,195	25,143
Late-Fall	1999	---	212	177	261	170	273
	2000	---	50	36	70	35	78
	2001	---	---	---	---	---	---
	2002	---	7,628	5,950	9,969	5,753	10,604
RBT/Steelhead	1999[b]	---	10,388	---	---	8,810	12,976
	2000[b]	---	25,710	---	---	21,865	30,713
	2001	---	---	---	---	---	---
	2002 (1+)[d]	---	1,348	1,201	1,607	1,170	1,666
	2002 (YOY)	---	24,740	21,034	29,565	20,454	31,426

[a] This passage estimate is not a complete brood year as the trap was not fished past February 9, 2001.

[b] These estimates are not brood years, rather two periods are summarized: October 9, 1998 to December 26, 1999 and December 27, 1999 to February 9, 2001. In addition, age 1+ and yoy are combined in these estimates.

[c] The original CAMP estimates cover the period January 1 through December 31; therefore, they may not include the entire brood year, and late-fall estimates may include fish from two brood years.

[d] Passage estimates for age 1+ trout are not for the current brood year, but rather a mixture of previous year-classes captured during the reporting period

Figures

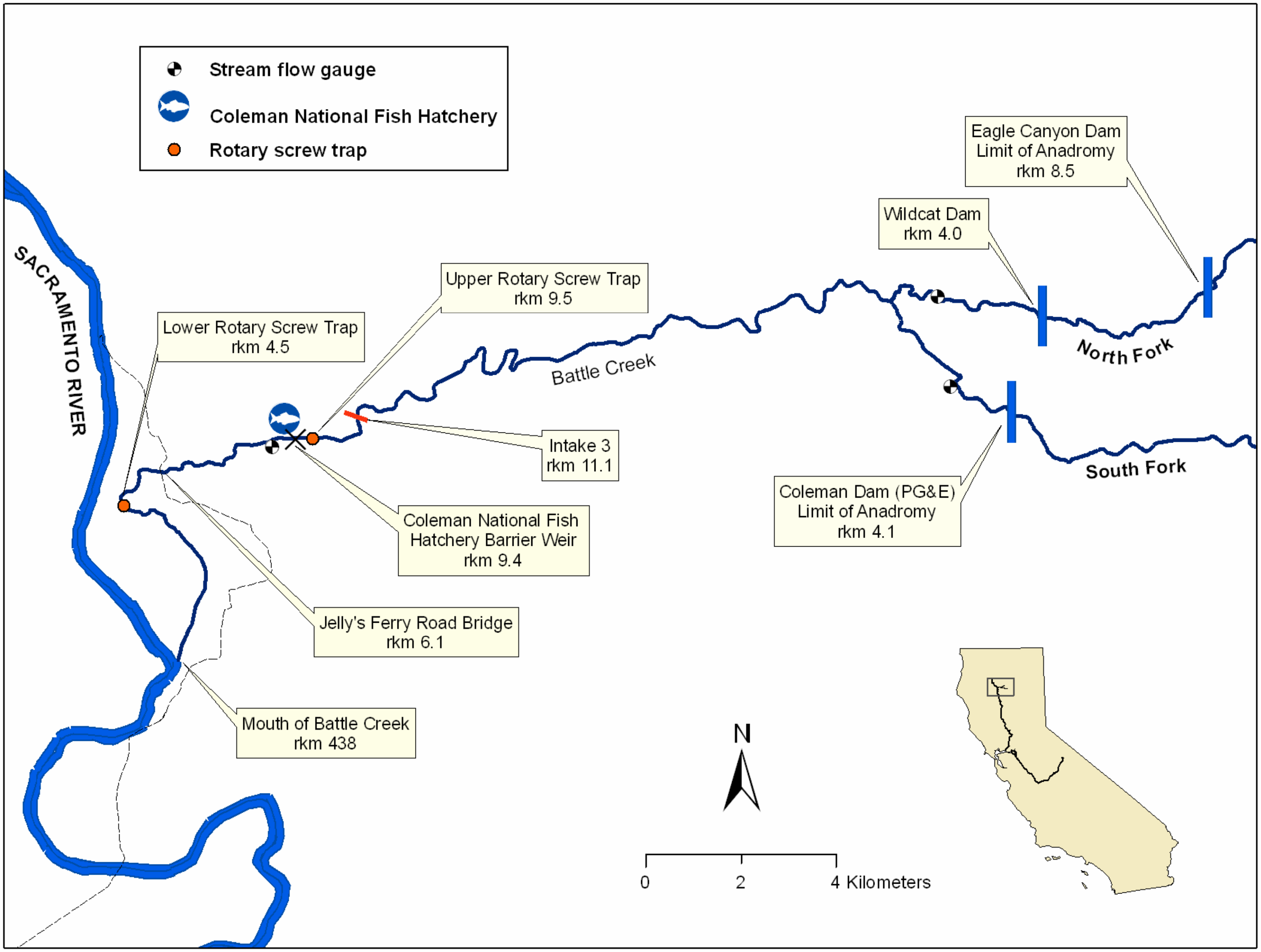

Figure 1. Map of Battle Creek depicting the location of USFWS' rotary screw traps and other important features.

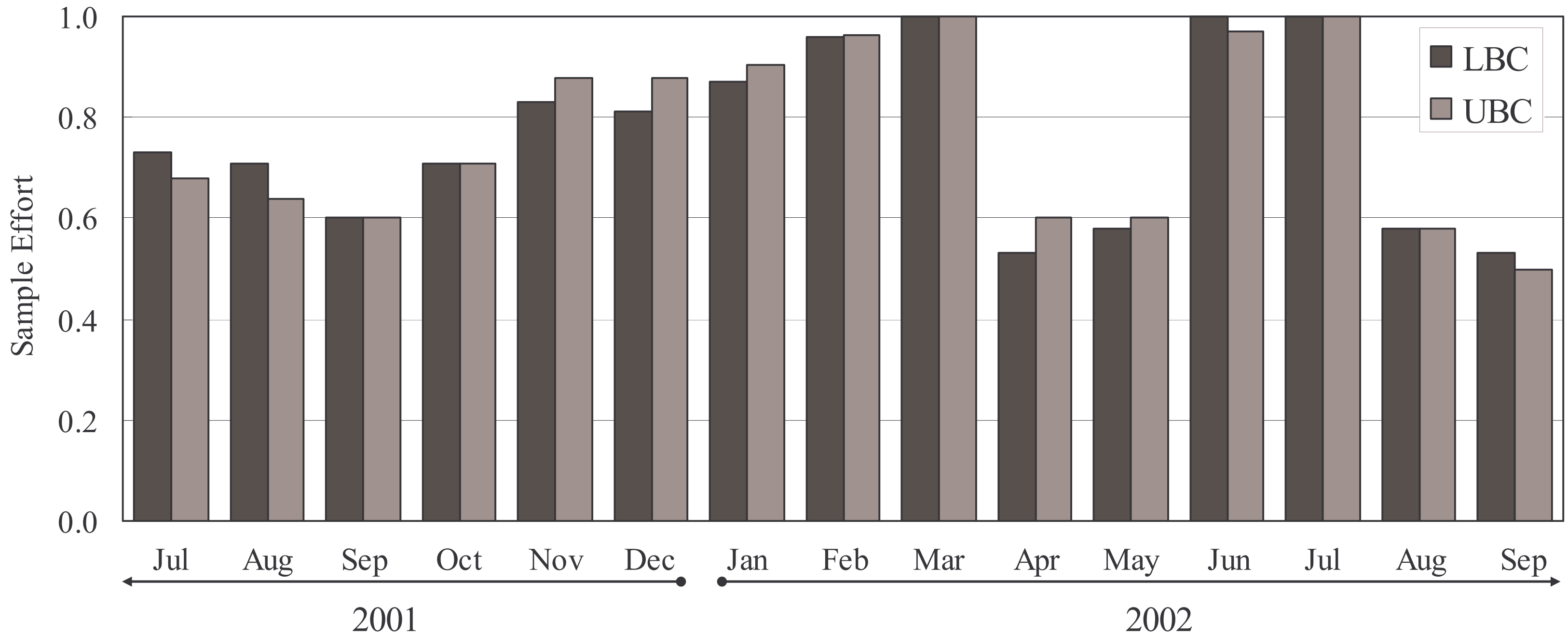

Figure 2. Sampling effort summarized as the proportion (range: 0 to 1) of days fished each month at the Lower and Upper Battle Creek rotary screw traps from July 2001 to September 30, 2002.

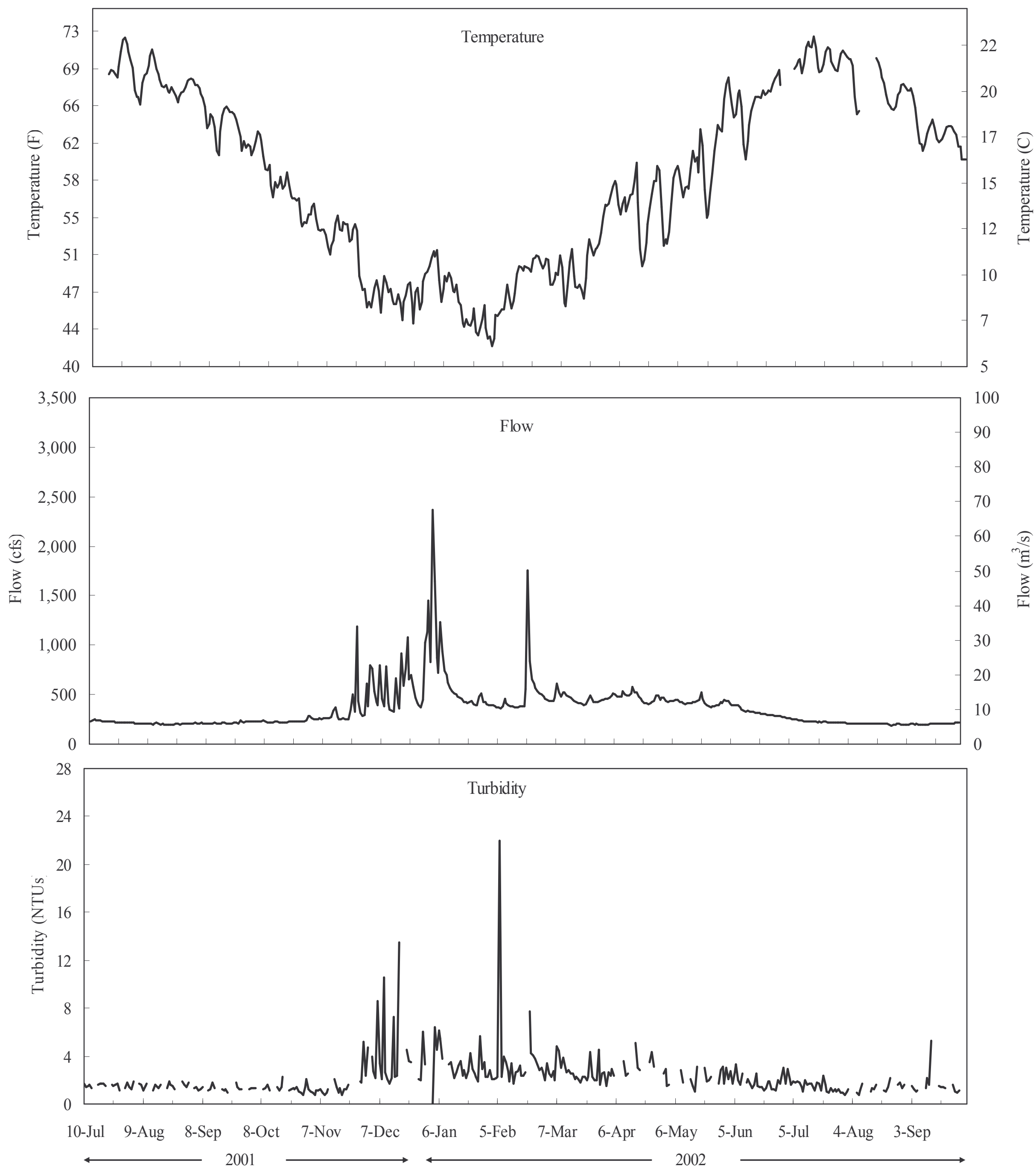

Figure 3. Mean daily temperature (ºC), turbidity (NTU's), and mean daily flows (m^3/s), at the Lower Battle Creek rotary screw trap from July 10, 2001 through September 30, 2002.

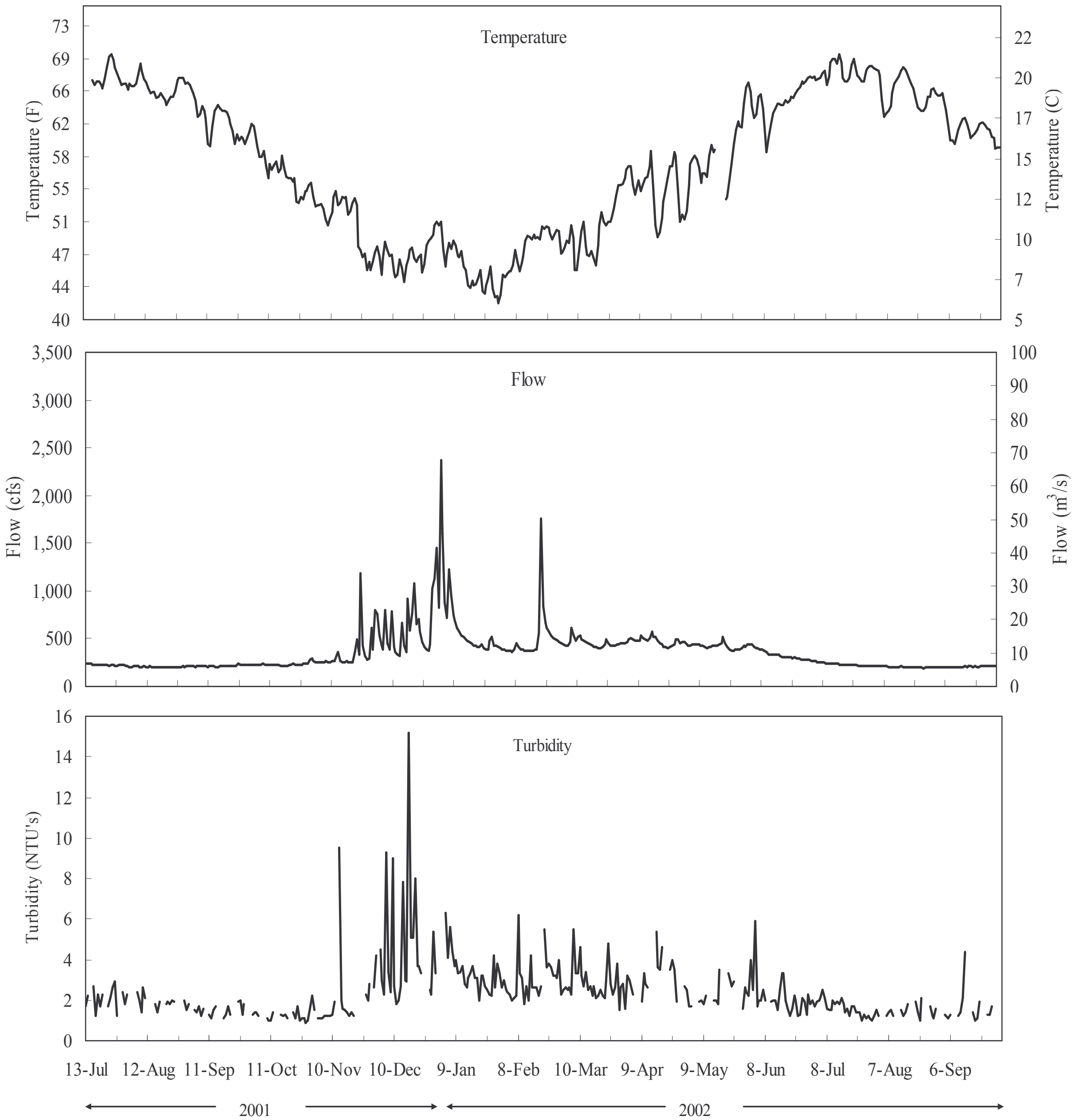

Figure 4. Mean daily temperature (ºC), turbidity (NTU's), and mean daily flows (m^3/s), at the Upper Battle Creek rotary screw trap from July 13, 2001 through September 30, 2002.

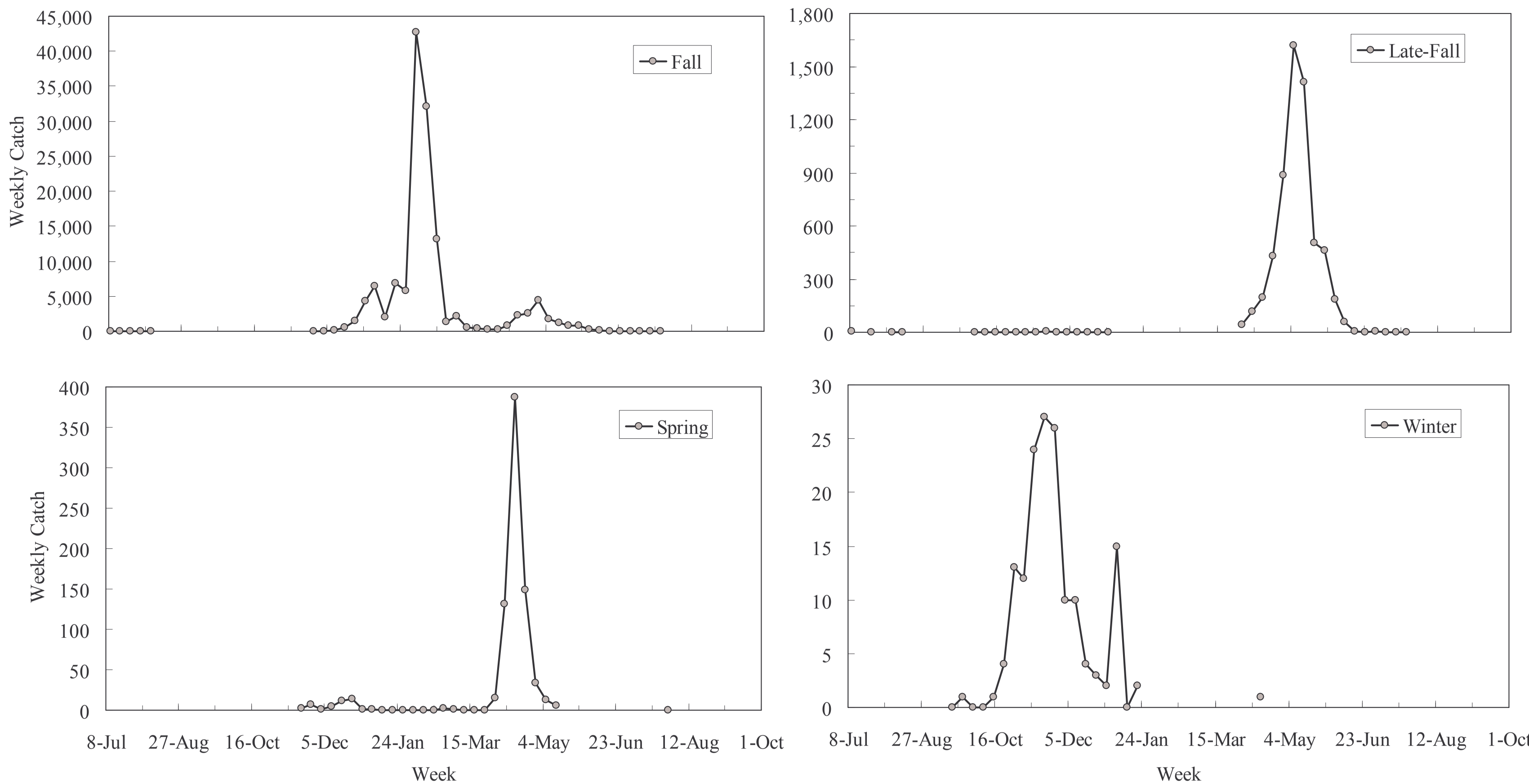

Figure 5. Weekly catch of fall, late-fall, spring, and winter Chinook salmon captured at the Lower Battle Creek rotary screw trap from July 10, 2001 to September 30, 2002. Run designation was assigned using the length-at-date criteria developed for the Sacramento River (Green 1992).

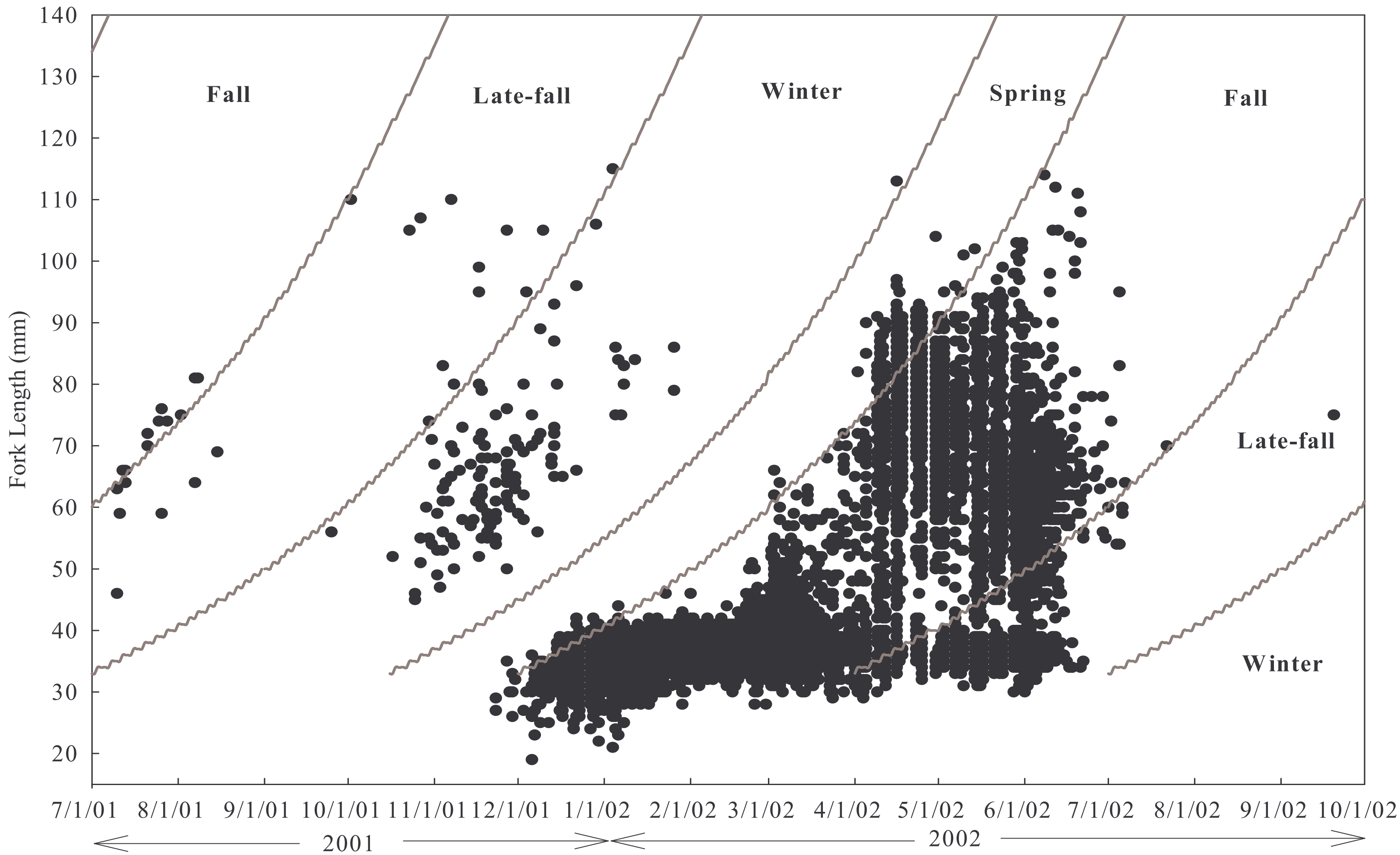

Figure 6. Fork length (mm) distribution by date and run for Chinook salmon captured at the Lower Battle Creek rotary screw trap from July 10, 2001 to September 30, 2002. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992).

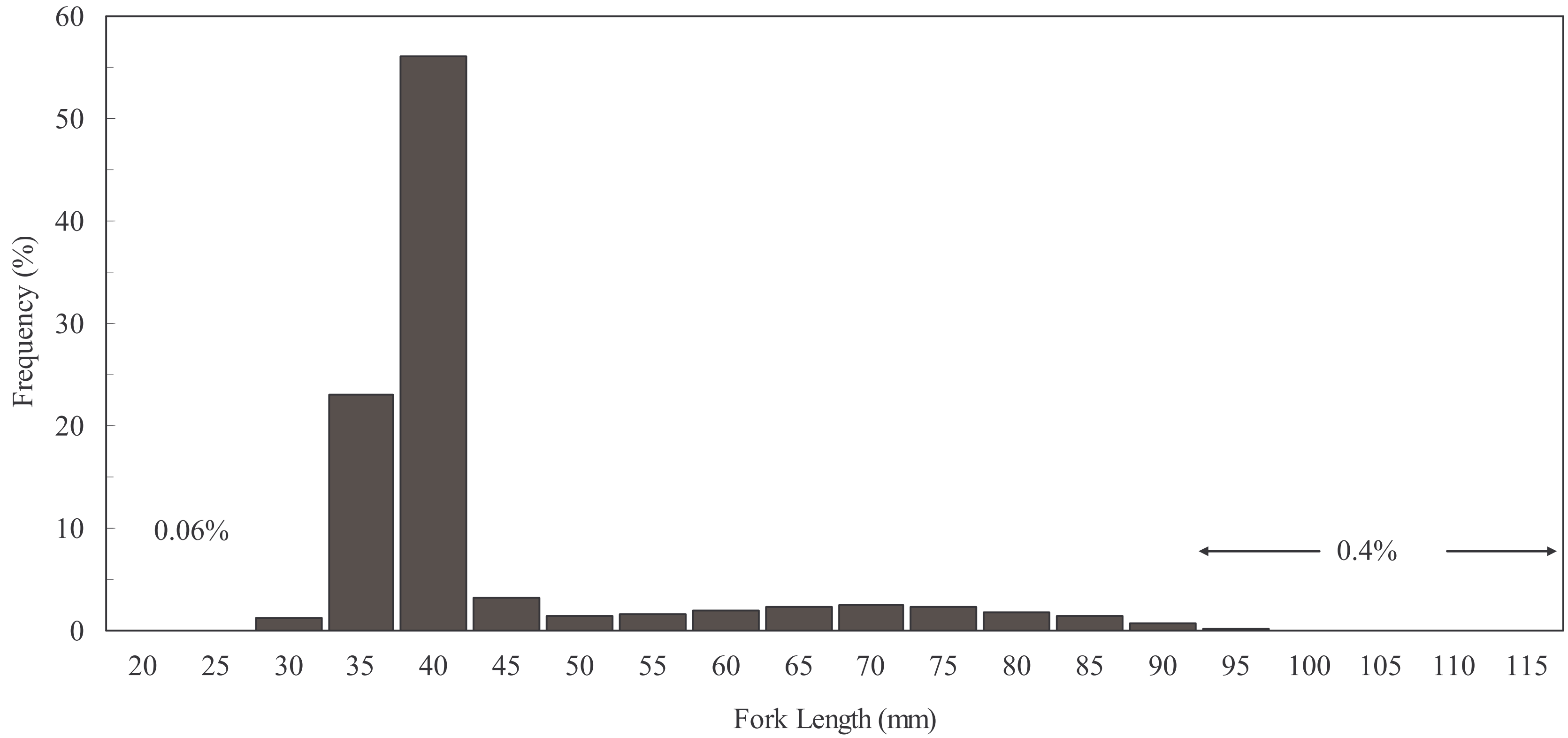

Figure 7. Length frequency (%) for all runs of Chinook salmon measured at the Lower Battle Creek rotary screw trap (LBC) during July 10, 2001 through September 30, 2002. Fork length axis labels indicate the upper limit of a 5-mm length range.

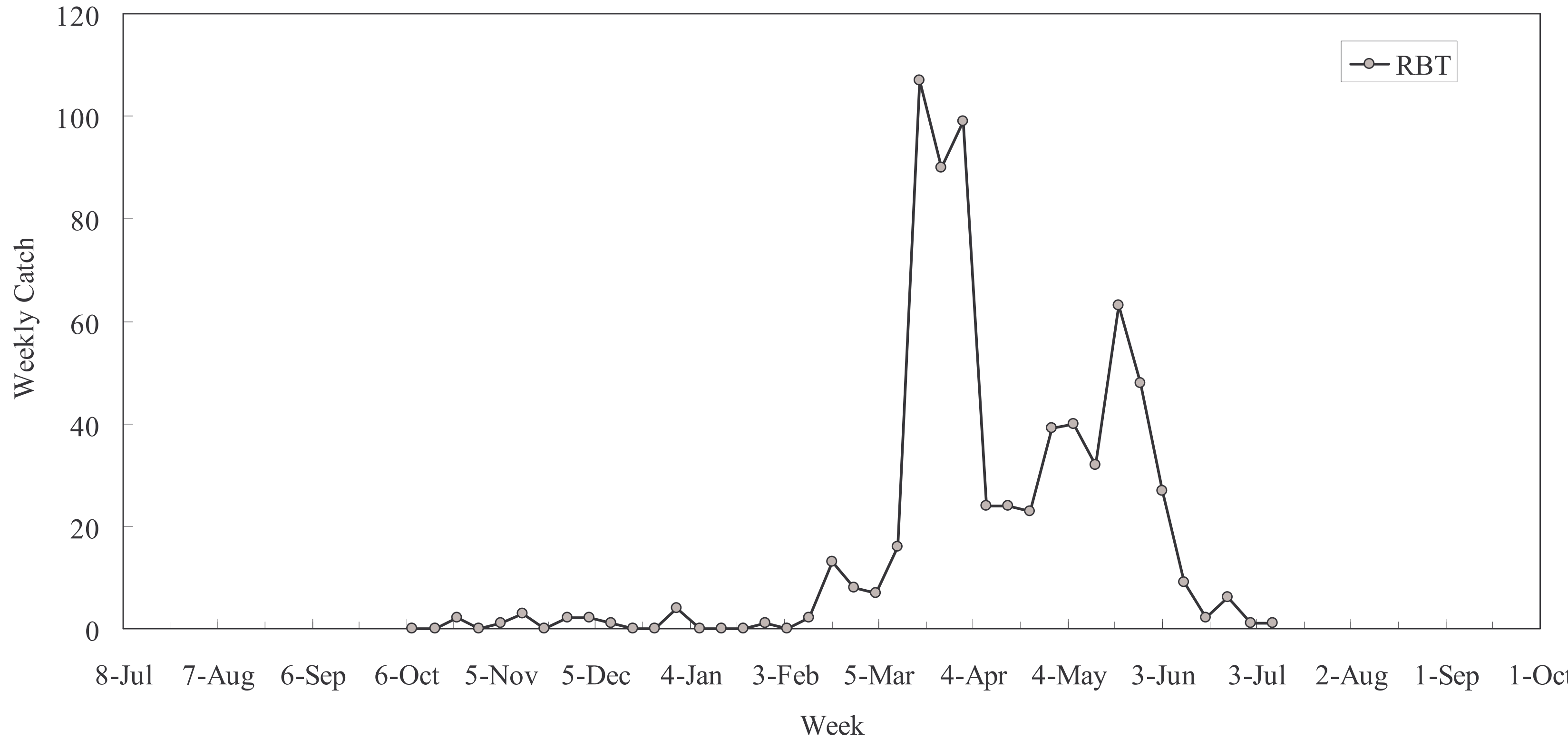

Figure 8. Weekly catch of rainbow trout/steelhead weekly catch at the Lower Battle Creek rotary screw trap from July 10, 2001 to September 30, 2002.

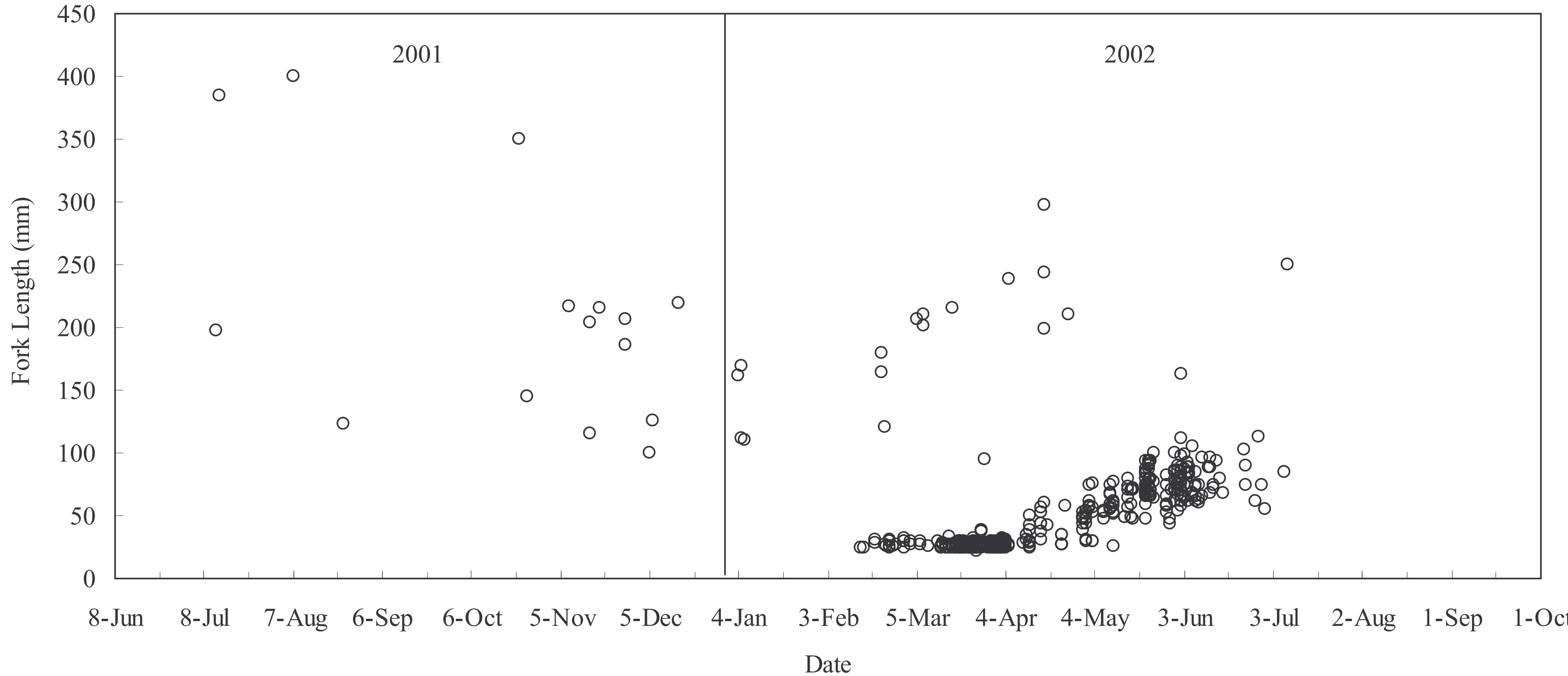

Figure 9. Fork length (mm) distribution for rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during July 10, 2001 through September 30, 2002.

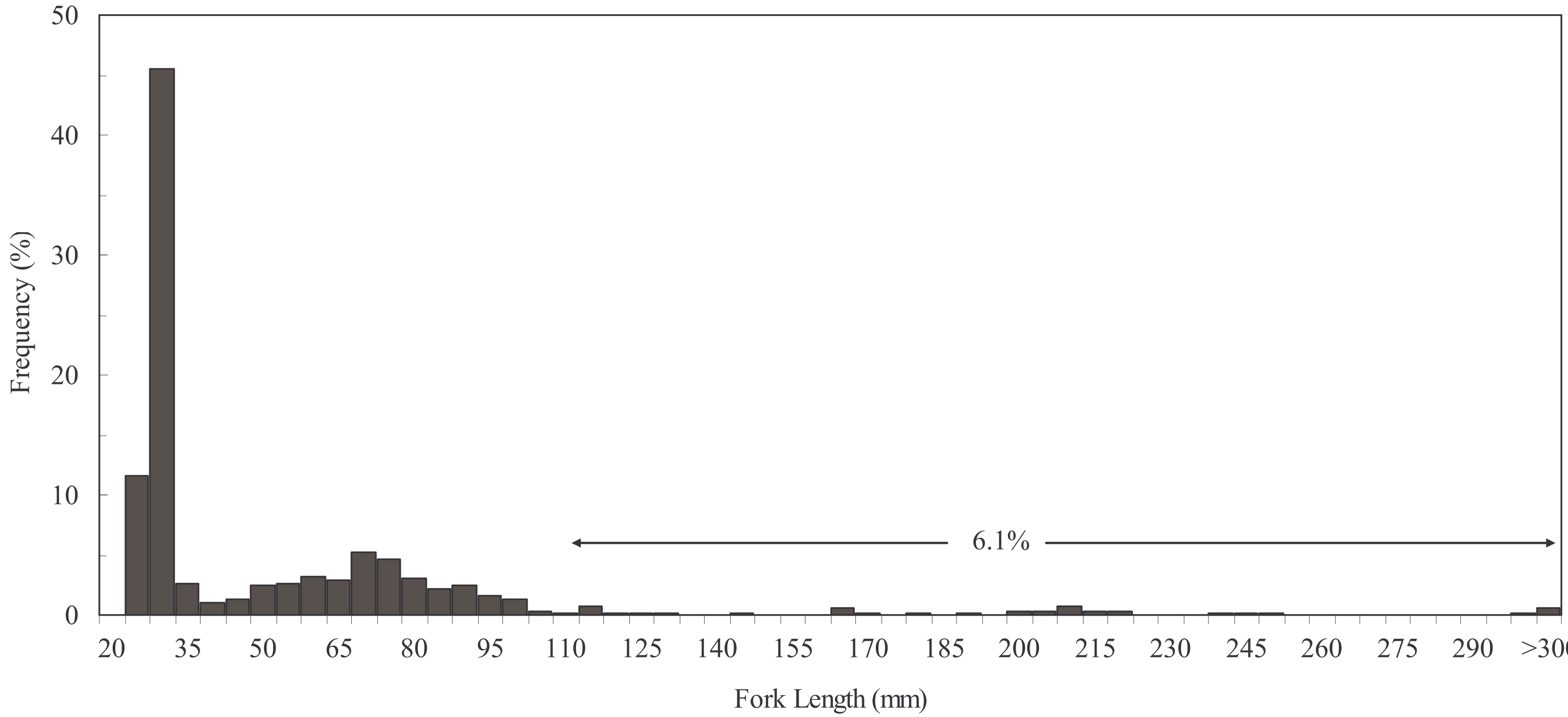

Figure 10. Fork length frequency (%) for rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during July 10, 2001 through September 30, 2002. Fork axis labels indicate the upper limit of a 5-mm length range.

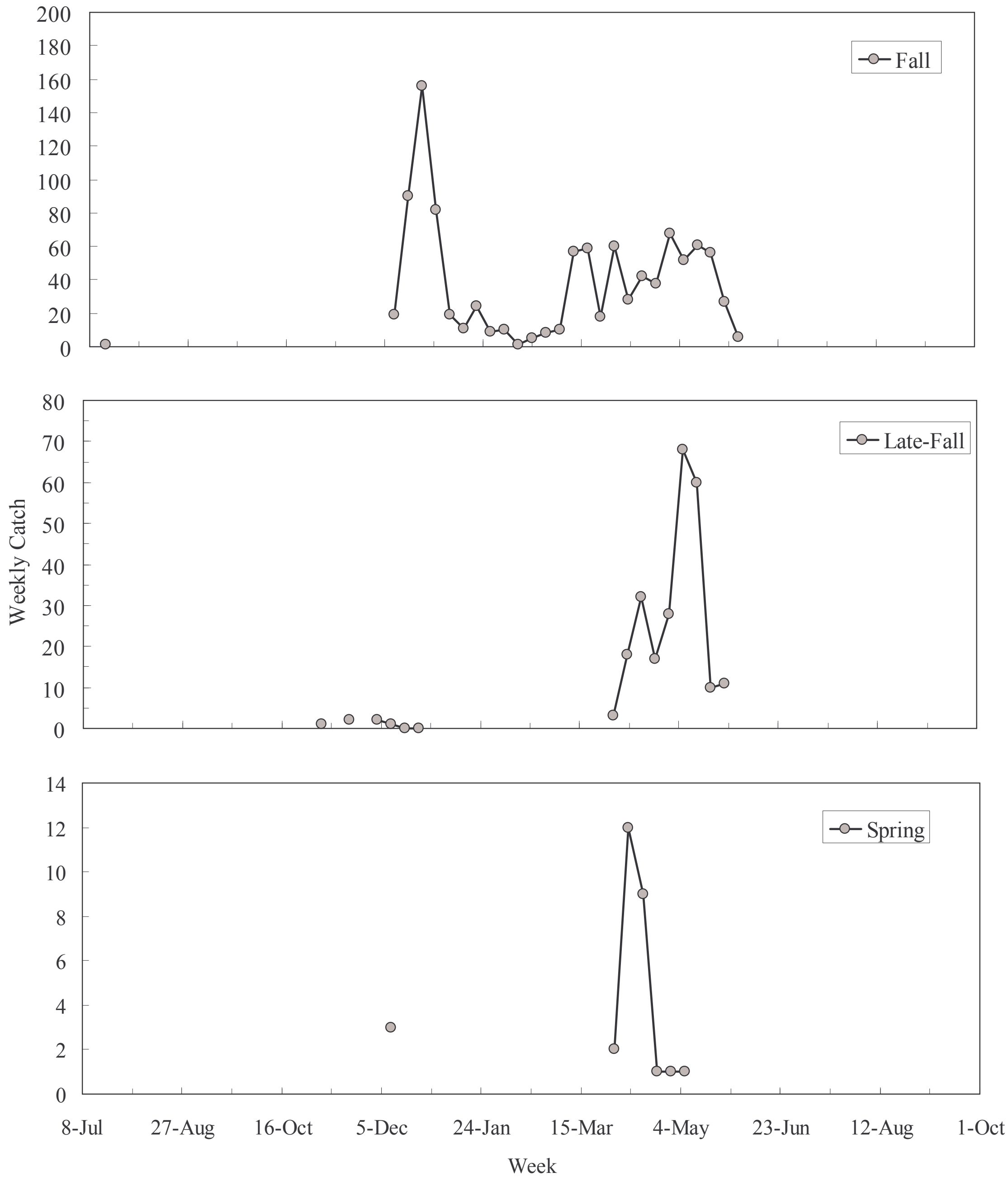

Figure 11. Weekly catch of fall, late-fall, and spring Chinook salmon captured at the Upper Battle Creek rotary screw trap from July 13, 2001 to September 30, 2002. Only two winter Chinook salmon were captured and therefore, are not displayed graphically. Run designation was assigned using the length-at-date criteria developed for the Sacramento River (Green 1992).

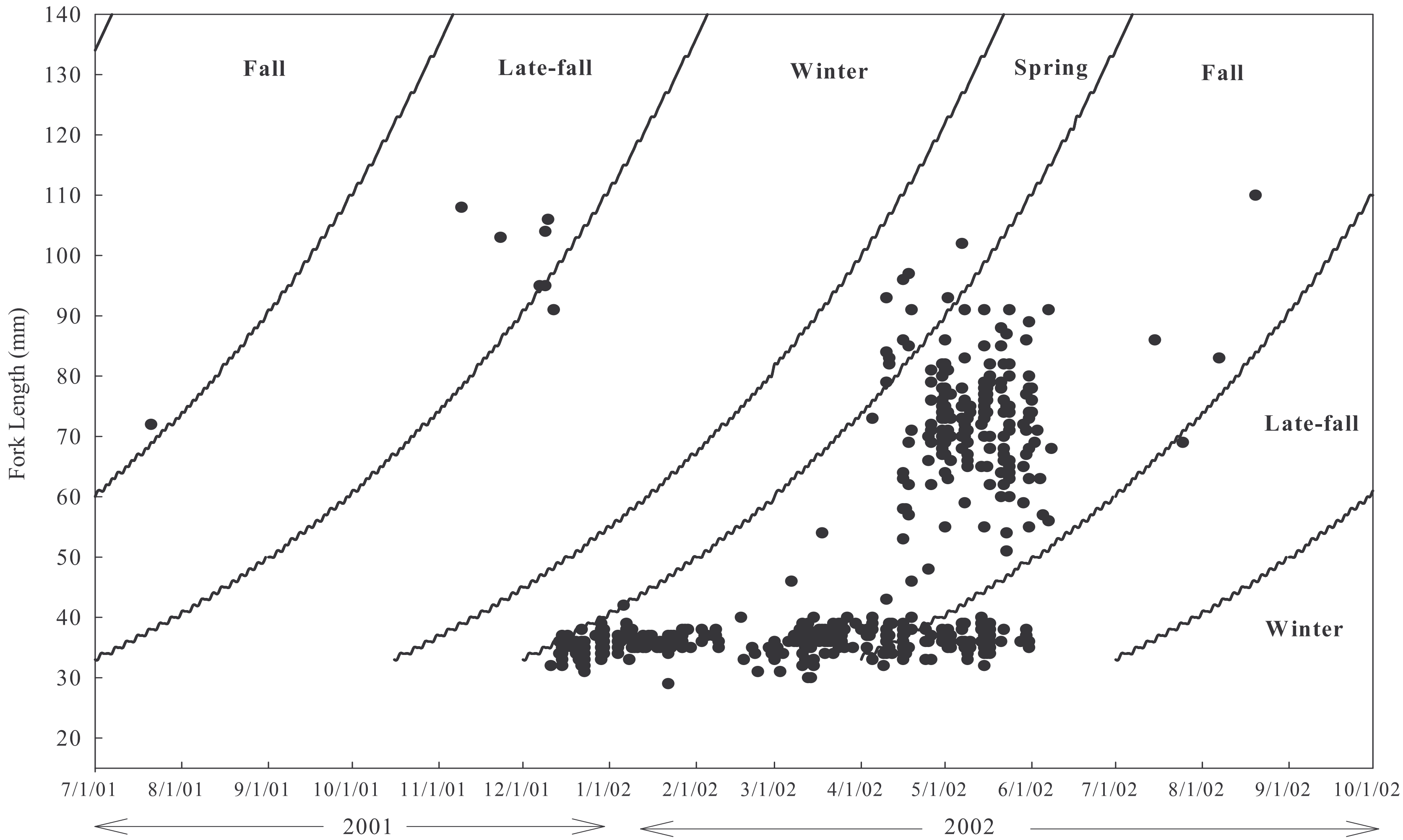

Figure 12. Fork length (mm) distribution by date and run for Chinook salmon captured at the Upper Battle Creek rotary screw trap from July 13, 2001 to September 30, 2002. Spline curves represent the maximum fork lengths expected for each run by date, based on criteria developed by the California Department of Water Resources (Greene 1992).

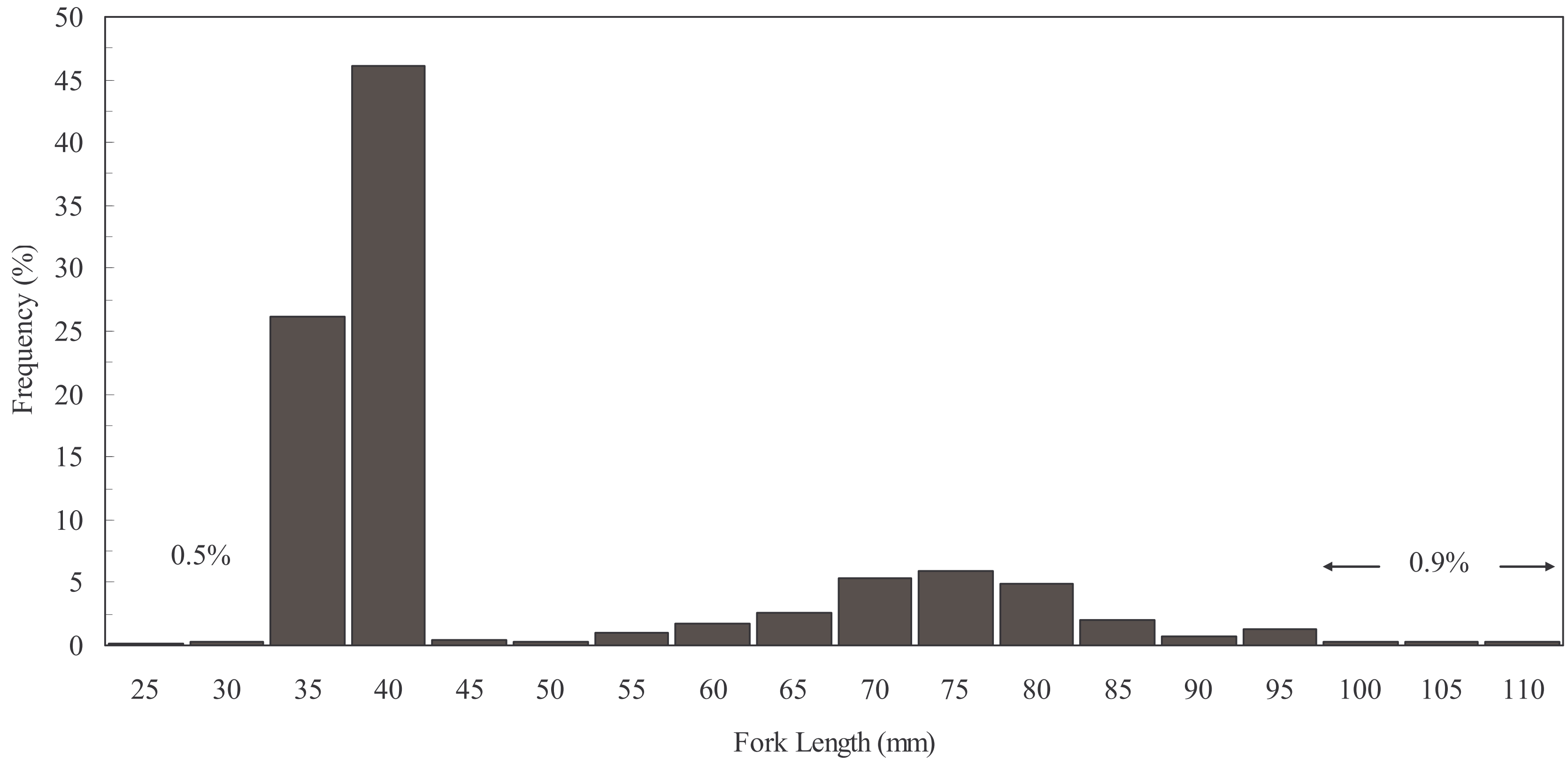

Figure 13. Length frequency (%) for all runs of Chinook salmon measured at the Upper Battle Creek rotary screw trap (UBC) during July 13, 2001 through September 30, 2002. Fork length axis labels indicate the upper limit of a 5-mm length range.

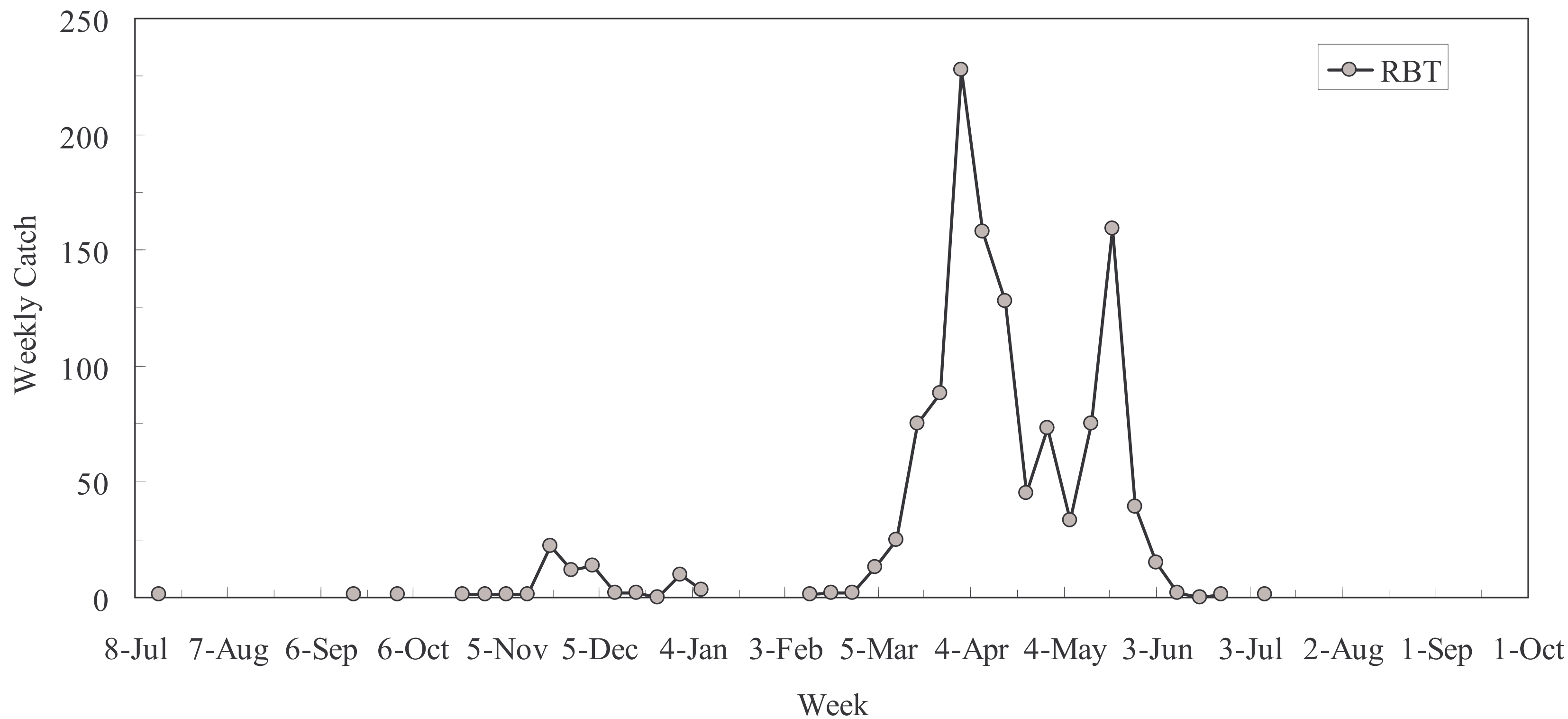

Figure 14. Weekly catch of rainbow trout/steelhead weekly catch at the Upper Battle Creek rotary screw trap from July 13, 2001 to September 30, 2002.

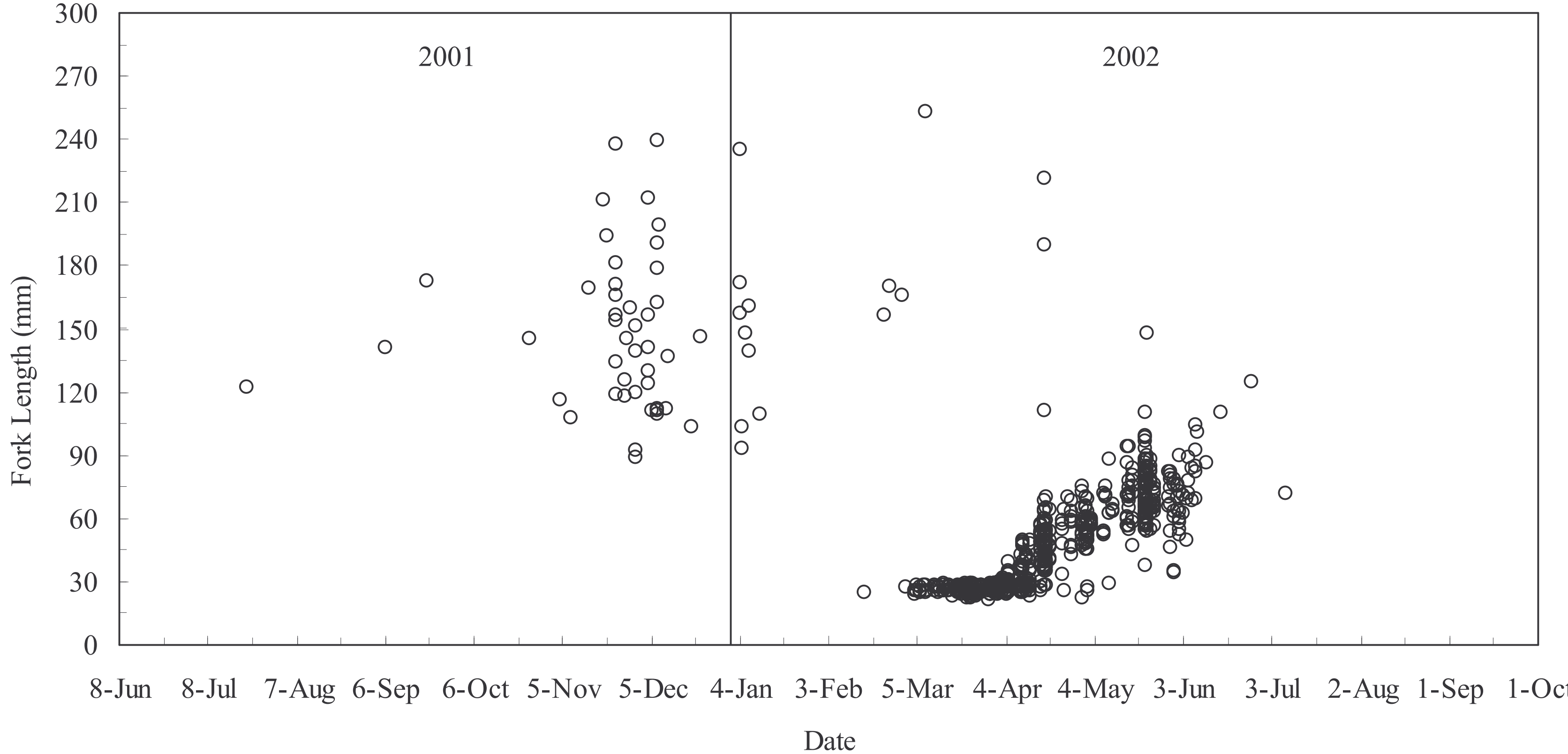

Figure 15. Fork length (mm) distribution by date for rainbow trout/steelhead measured at the Upper Battle Creek rotary screw trap during July 13, 2001 through September 30, 2002.

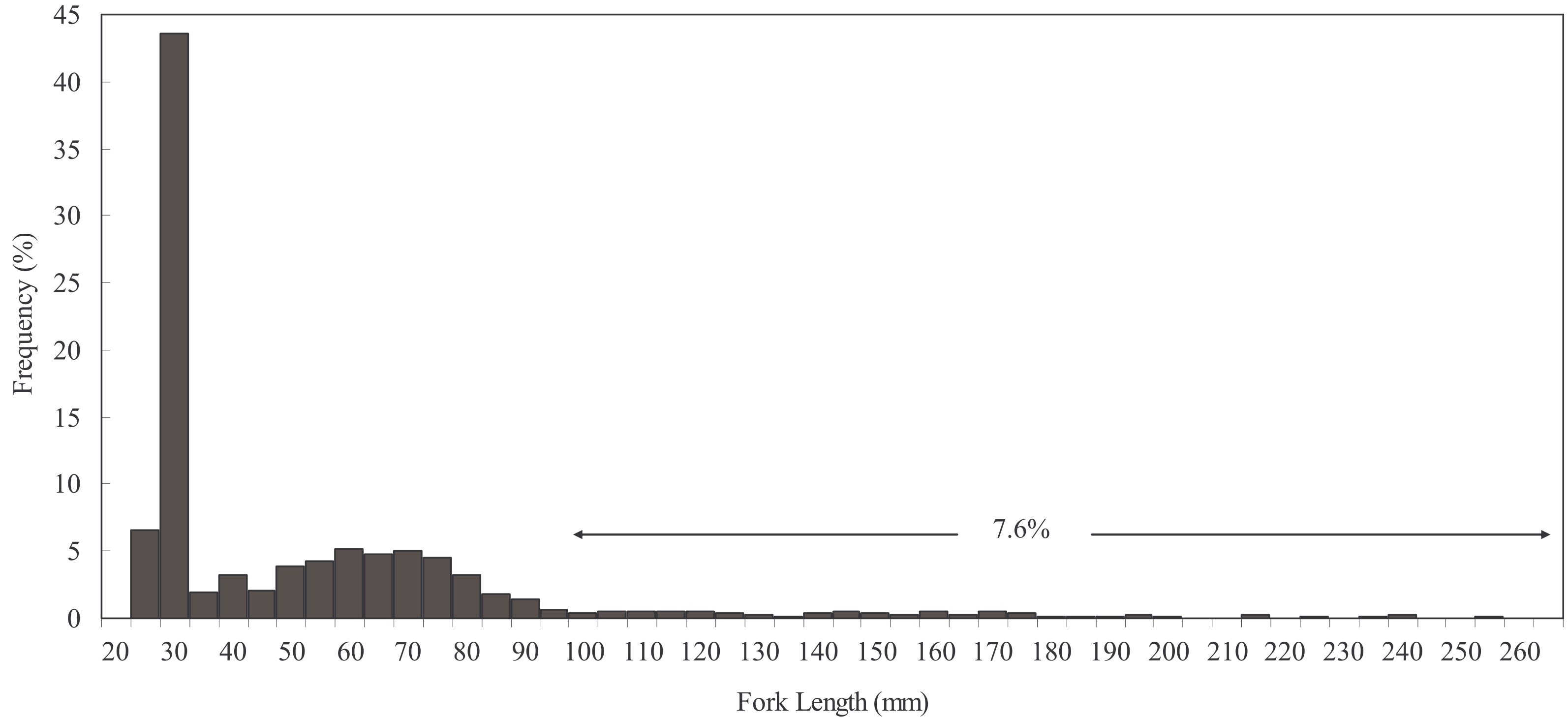

Figure 16. Fork length frequency (%) for rainbow trout/steelhead sampled at the Upper Battle Creek rotary screw trap during July 13, 2001 through September 30, 2002. Fork axis labels indicate the upper limit of a 5-mm length range.

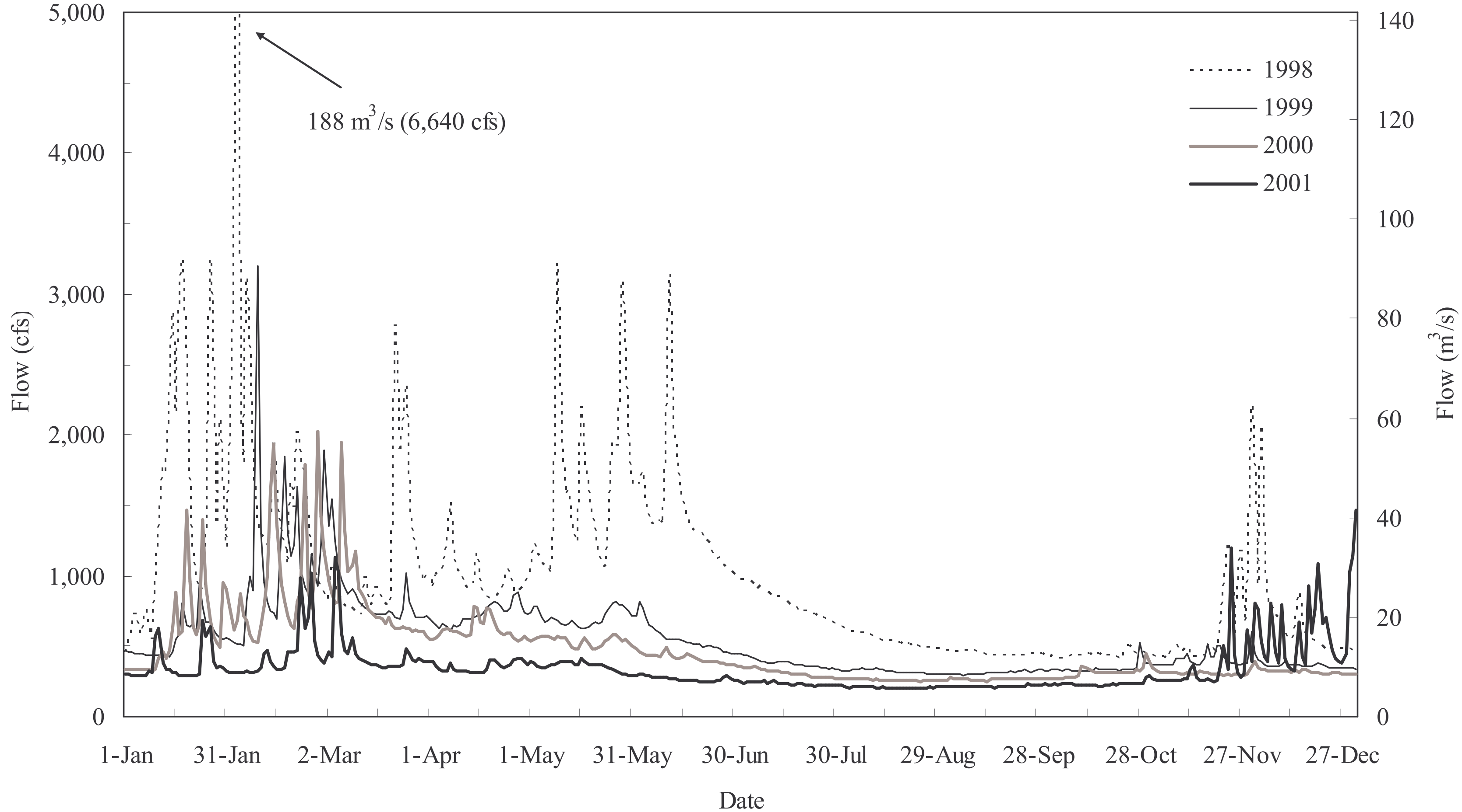

Figure 17. Mean daily flows recorded at the U. S. Geological Survey gauging station (BAT-#11376550) located below the Coleman National Fish Hatchery barrier weir, 1998-2001.

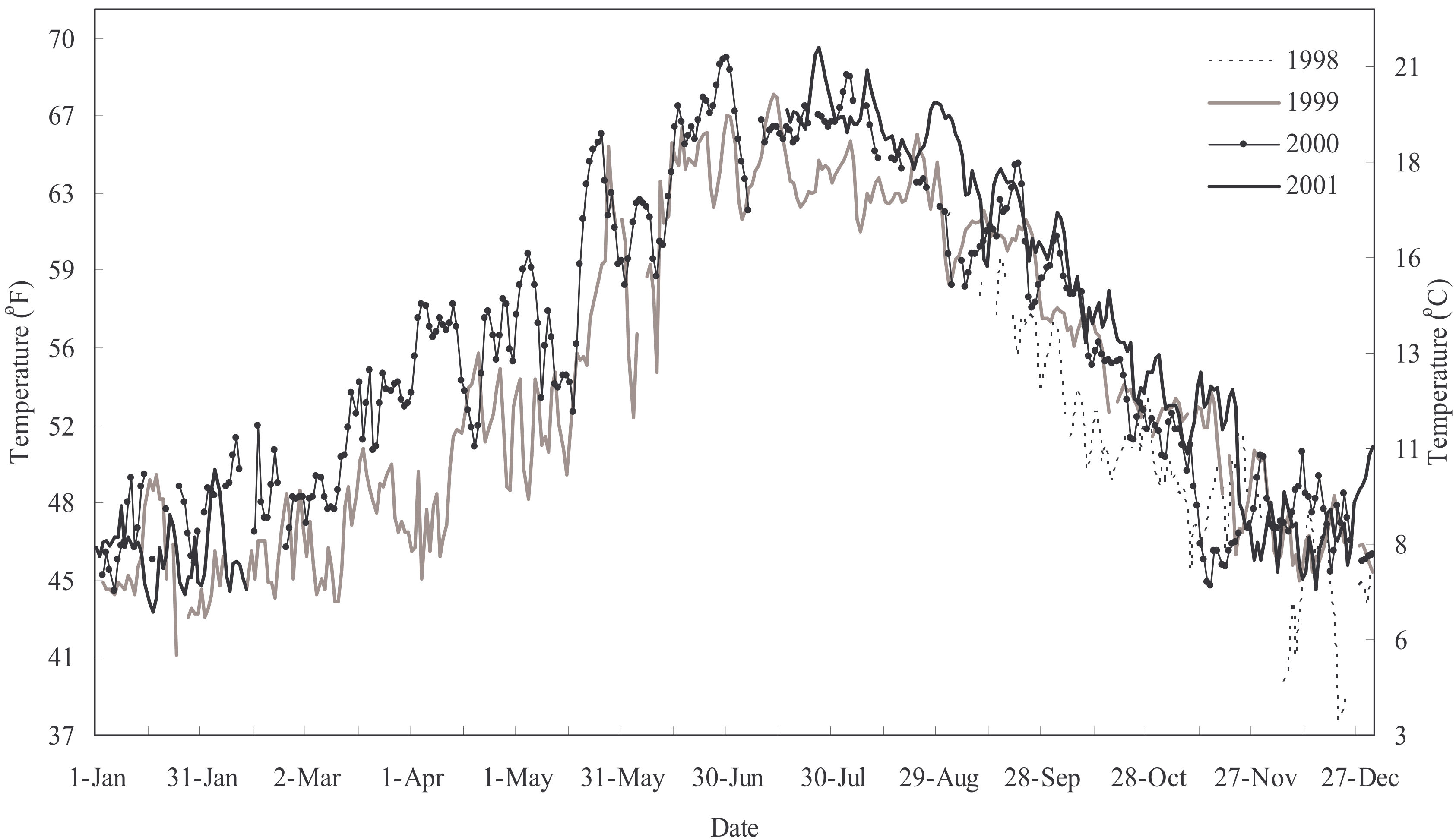

Figure 18. Mean daily water temperatures at the Upper Battle Creek rotary screw trap from 1998 to 2001. Data is incomplete for 1998 and 2001 when the trap was not operated.

Appendix

Appendix 1. Summary of days the Lower Battle Creek rotary screw trap was not fished, including dates, hours fished, and reason during July 10, 2001 to September 30, 2002.

Dates	Hours Fished	Reason
	2001	
July 15-16, 22-23, 29-30	0	Low Salmonid Catch
August 5-6, 12-13	0	Low Salmonid Catch
August 19-20, 26-28	0	Low Salmonid Catch
September 2-3, 9-10 15-17, 22-24	0	Low Salmonid Catch
September 29 to October 1	0	Low Salmonid Catch
October 6-8, 13-15, 20-21	0	Low Salmonid Catch
November 13	0	Trap Stopped
November 22	0	Unknown
November 24-25	0	High Flow & Holiday
November 26	0	Trap Maintenance
December 2	0	Unknown
December 18	6	Trap Jammed
December 20	23	High Flows
December 24-26	0	Christmas Holidays
December 31	10	High Flows - Log
	2002	
January 2-3	0	High Flows
January 9-10	0	Hatchery Release
February 20	0	Too Much Debris-High Flows
April 6-8 & 13-15	0	Staff Shortages
April 19-22 & 26-29	0	Hatchery Release
May 4-6	0	Staff Shortages
May 8	5	Tree in the Cone
May 11-13, 18-20, 25-27	0	Staff Shortages
August 3-5, 10-12, 17-19, 24-26, 31	0	Low Salmonid Catch
September 1-2, 7-9, 14-16, 21-23,	0	Low Salmonid Catch
September 28-30	0	Low Salmonid Catch

Appendix 2. Summary of days the Upper Battle Creek rotary screw trap was not operated, including dates, hours fished, and reason during July 13, 2001 to September 30, 2002.

Dates	Hours Fished	Reason
	2001	
July 14-15, 22-23, & 29-30	0	Low Salmonid Catch
August 3	7	Log in Cone
August 5-6 & 12-13	0	Low Salmonid Catch
August 15	5	Low water, cone not rotating
August 19-20 & 26-28	0	Low Salmonid Catch
August 29	5	Low water, cone not rotating
September 2-3, 9-10, & 15-17	0	Low Salmonid Catch
September 22-24 & 29-30	0	Low Salmonid Catch
October 1, 6-8, 13-15, & 20-21	0	Low Salmonid Catch
November 22	0	? Unknown
November 24-25	0	High Flows
November 29	7	Cone not rotating
December 24-26	0	Holiday
December 31	9	Trap not rotating
	2002	
January 1	0	Holiday
January 2-3	0	High Flows
February 20	0	High Flows
April 6-8, 13-15, 20-22, & 27-29	0	Staff Shortages
May 4-6 & 11-13	0	Staff Shortages
May 16	18	Log in Cone
May 18-20 and 25-27	0	Staff Shortages
June 23	5	Log in Cone
August 3-5, 10-12, 17-19	0	Low Salmonid Catch
August 24-26 & 31	0	Low Salmonid Catch
September 1-2, 7-9, 14-16, & 21-23	0	Low Salmonid Catch
September 27-30	0	Low Salmonid Catch