Juvenile Salmonid Monitoring in Battle Creek, California from September 1998 to February 2001

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Juvenile Salmonid Monitoring in Battle Creek, California from September 1998 to February 2001

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Abstract- In September 1998, the U.S. Fish and Wildlife Service began a juvenile salmonid monitoring project on Battle Creek, California, using rotary screw traps. 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 September 1998 to February 2001 four runs of Chinook salmon *Oncorhynchus tshawytscha*, rainbow trout/steelhead *Oncorhynchus mykiss*, and 20 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 54 and 49 mark-recapture trials at the LBC and UBC traps, respectively during 1998 through 2001. The results of several trials from adjacent weeks were pooled because of low recaptures rates. Individual and pooled trap efficiencies ranged from 1.7 to 13.8%. Chinook salmon run designations were made using length-at-date criteria developed for the Sacramento River, which resulted in underestimates of spring and overestimates of fall Chinook salmon production at both traps. Brood year 1998 and 1999 fall Chinook salmon passage estimates at the Lower Battle Creek trap were 4,897,569 and 18,708,768, respectively. Brood year 1999 and 2000 late-fall Chinook salmon passage estimates at the lower trap were 86,305 and 86,934. The annual passage of spring and winter Chinook salmon were not estimated for the lower trap because of low catch rates. Passage estimates of rainbow trout/steelhead at the lower trap were 7,057 in September 1998 through December 1999 and 8,417 in January 2000 through February 9, 2001. Brood year 1998 and 1999 fall Chinook salmon passage at the Upper Battle Creek trap was 1,193,916 and 239,152, respectively. Brood year spring Chinook salmon passage estimates at the upper trap were 4,791 and 6,233. Passage estimates were not made for late-fall and winter Chinook salmon at the upper trap as catch rates were too low. Passage estimates of rainbow trout/steelhead at the upper trap were 10,388 in September 1998 through December 1999 and 25,710 in January 2000 through February 9, 2001. Condition factor and weight-length relationships were evaluated for Chinook salmon and comparisons were made using similar information collected in Clear Creek, a west-side tributary of the Sacramento River. Comparison of the weight-length relationship among all three traps (UBC, LBC, and CC) could only be done for April 1999 because this was the only month weight-length data was collected at UBC. Results indicated that mean weight at a given length was generally greatest for UBC.

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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. The geographic range of the current 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 (3cfs) 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 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). Then, beginning in late 2002, the IFP began providing the full minimum flow of 0.85 m^3/s 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. However, an agreement was reached 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). 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 has been using rotary screw traps to monitor juvenile salmonids on Battle Creek, Shasta and Tehama Counties, California, since September 1998. Funding for the rotary screw trap monitoring project was initially provided by the Comprehensive Assessment and Monitoring Program (CAMP) for the period September 1998 to February 2001. The purpose of this report is to summarize data collected during that period. Written reports were not required in the original agreement for this work. The updated juvenile salmonid production estimates generated by this effort will be used in CAMPs Goal 2 assessment of CVPIA. This ongoing monitoring project has three primary objectives: (1) determine an annual juvenile passage index (JPI) for Chinook salmon and rainbow trout/steelhead, 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 and otolith samples from adult and juvenile salmonids for genetic and age 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. 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. 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 $miles^2$). 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). 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) whereas 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 September and October 1998, the Red Bluff Fish and Wildlife Office installed and began operating two rotary screw traps on Battle Creek. The Lower Battle Creek trap (LBC) was operated from October 9, 1998 through February 9, 2001while the Upper Battle Creek trap (UBC) was operated from September 1, 1998 through February 9, 2001. 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 hours per day; seven days each week, but at times high flows, hatchery releases, or staff shortages may have limited our ability to operate the traps continuously (Appendix 1). 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. To investigate potential differences in daytime and nighttime catch, the LBC trap was checked twice daily from January 24, 2000 through June 23, 2000 and the UBC trap was checked twice daily from February 19, 2000 through June 23, 2000. 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 October 2000 through February 2001, we periodically operated the trap at half-cone to reduce potential negative impacts to juvenile salmon created by overcrowding and excess debris, as well as reduce the capture of Chinook salmon or steelhead released by the hatchery. In addition to the LBC half-cone modification described above, we made additional modifications to the traps and daily operations to reduce the potential for impacts to captured fish and to improve our efficiency. Modifications to the traps included increasing the size of the live boxes and floatation pontoons, and adding baffles to the live boxes.

Each time the 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 while the live box was being cleared of debris and while fish were sorted from the debris (minimum of 3 min). Daily stream discharge data collected by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) was 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. Water turbidity was measured from a grab-sample with a Hach® Model 2100 turbidity meter (Hach Company, Ames, Iowa).

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 measured (to the nearest 1 mm). Mortalities were also counted and measured. 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 monthly totals for non-salmonids. Sampling weeks were identified by year and number. 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 fork length (FL, 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). The life-stage classification system was not implemented at either trap until March 14, 1999. 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. Beginning in March 1999, subsamples of approximately 50 Chinook salmon were periodically measured and weighed at both traps to evaluate fish condition. When more than approximately 250 juvenile salmon were captured, sub-sampling was conducted. All salmon in the sub-sample (150 to 250 fish) were identified, enumerated, and measured. All other salmon were enumerated unless total capture exceeded approximately 1,000 fish, at which time the total daily catch was estimated based on the weight (g) and counts of individuals from two random subsamples and the weight (g) of the total catch.

In January 2001, subsampling techniques were revised. Instead of using weights and counts to estimate total catch, 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. Each half of the subsampling net bottom was built with a mesh bag that was capable of being tied shut; however, one side was tied shut and the other side was left open. 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. When the net was lifted, 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 successively subsampled until approximately 150-250 individuals remained in a subsample (split). The number of successive splits that we used varied with the number of salmon collected. Once the desired number of salmon (150 to 250 fish) was obtained, the sub-sample was counted and the fork length of individual fish measured. These salmon were also assigned a life-stage classification and run designation, using the methods described above. To estimate the total catch when sub-sampling, we proceeded to successively count all salmon in each split (smallest to largest) until at least 3,000 salmon were counted. If more salmon remained after counting approximately 3,000 salmon, we estimated the remainder of the catch by calculating the number of fish counted in each successive split, and multiplying by the appropriate split factor. Using this method, we mathematically estimated the total number of salmon captured in the trap, estimated the number of mortalities, and assigned run designation for uncounted and unmeasured salmon. 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 fork lengths (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. Starting in late July 2000, all live rainbow trout/steelhead > 50mm 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 30 randomly selected individuals for each taxa. Total length (1 mm) was measured for lamprey *Lampetra spp.,* sculpin *Cottus spp.*, and western mosquitofish (*Gambusia affinis*); otherwise, FL (1 mm) 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 or 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 and the actual catch to estimate the weekly or 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 two days, the daily catch for those days was estimated by averaging catch from two days before and two days after the period the trap did not fish. 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 estimated for juvenile fall Chinook salmon fry were used as surrogates to calculate all JPIs. 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. 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.

1998-1999 Mark-Recapture Trials.—During the 1998 to 1999 season, mark-recapture trials were initiated in December 1998 when sufficient numbers of juvenile Chinook salmon were captured in the traps. The first two trials conducted in December 1998 were used to determine the effort necessary to conduct mark-recapture trials. During these two trials, a single group of approximately 100 marked Chinook salmon was released at Intake 3. In subsequent trials (January through June 1999), two to five groups of marked Chinook salmon were released during most weeks. All marked fish were released at the Coleman National Fish Hatchery's

Intake 3, which is located 1.6 km (1.02 mi) upstream of UBC and 6.6 km (4.10 mi) upstream of LBC.

During the 1998-1999 trials, only a single mark was used. Juvenile salmon were immersed in Bismarck brown-Y stain (J.T. Baker Chemical Company, Phillipsburg, New Jersey) for 50 min. Bismarck brown was applied at a concentration of 8 g/380 L of water (211 mg/L). During periods of high air temperatures 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. The fork length of all marked fish was also measured. 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.

1999-2000 Mark-Recapture Trials.—During the 1999 to 2000 season, mark-recapture methods used in the previous season were modified to allow us to distinguish between marked fish released for both traps, and when our releases occurred less than 5 days apart. Initially a single mark of Bismark brown was used for trials conducted during the first 3 weeks. The methods used for Bismark brown application were the same as described above. However, starting in early February 2000, a dual-marking system was implemented. Fish marked for one trap were dual-marked whereas fish for the other trap were single marked. This method was also used if two releases less than 5 days apart were made for the same trap. During some trials, both groups of fish were dual-marked. For trials where a dual-mark was needed, salmon were first marked with Bismarck brown, and then fish were anesthetized with an MS-222 solution at a concentration of 60 to 80 mg/L. Once they were anaesthetized, we used Photonic® tagging (New West Technologies, Santa Rosa, California) to apply a second mark on the Bismarck brown stained salmon. Photonic tagging requires the subcutaneous injection of fluorescent latex micro spheres into the fish using high air pressure rather than needles. This tagging method allows for multiple marks using a variety of tag colors and locations (e.g., dorsal, caudal, or anal fin). For our current project, we used different color tags (red, pink, orange, and green) placed at the base of either the dorsal or caudal fin to designate specific release groups by date and trap. Marked juvenile salmon were placed in a live car and allowed to recover in the trap box. In addition to changing marking methods, the release location for LBC mark-recapture trials was changed to the Jelly's Ferry Bridge which is located approximately 1.3 km (0.8 mi) upstream of the trap.

Beginning in mid-April 2000, a series of paired mark-recapture trials were conducted to investigate differences in trap efficiency for marked fish released in the morning and marked fish released after dark. Between mid-April and mid-June, seven paired trials were conducted at UBC and eight at LBC. During this time, the traps were also checked twice per day to determine daytime and nighttime catch.

2000-2001 Mark-Recapture Trials.—During the 2000 to 2001 season, mark-recapture trial methods were again revised from previous seasons. Rather than multiple release groups or paired trials, a single large group of marked Chinook salmon was released for each trial. Fish were only marked with Bismark brown, and the UBC and LBC trials were staggered to reduce the likelihood of fish released for a UBC trial being confused with fish released for a LBC trial. The methods used for Bismark brown application were the same as described above. With the exception of one trial, the release time for all trials occurred after 1700 hours. Nighttime releases were conducted to reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated by the transportation, and to simulate the tendency for natural populations of outmigrating Chinook salmon to move downstream primarily at night (Healy 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. In 2000, the results of the paired daytime and nighttime mark-recaptures trials were pooled as several trials conducted at UBC had less than seven recaptures. Therefore, to maintain consistency with data analyses, the results of the LBC paired trials were also pooled.

In the 2000 to 2001 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. Five mark-recapture trials were conducted during the season (September 1, 2000 to February 6, 2001), three 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 was estimated using the results of the trials done at half-cone, and then halving the efficiency of trials done at full-cone. 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 5 trials rather than just 2 for full-cone periods and 3 for half-cone periods.

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. 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

$$\hat{N}_h = \frac{U_h}{\hat{E}_h}, \tag{2}$$

where U_h is the unmarked catch during week *h*. Variance and the 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. The variance for $\hat{N}_h$ is simply the sample variance of the 1,000 iterations of $\hat{N}_h$ produced by bootstrapping $U_h, \hat{E}_h$ and m_h for each week. The total JPI for the year is then estimated by the

$$\hat{N} = \sum_{h=1}^{L} \hat{N}_h \ . \tag{3}$$

The bootstrap variance of $\hat{N}$ is the sample variance of the $\hat{N}_h$ (Buckland and Garthwaite 1991)

$$\hat{V}\left(\hat{N}\right) = \frac{\left[\sum \hat{N}_h^2 - \left(\sum \hat{N}_j\right)^2 / b\right]}{b-1} \tag{4}$$

where *b* is the number of iterations (i.e., 1,000). As described by Steinhorst et al. (2004), the 95% confidence intervals for the weekly and total JPI's were found by producing 1,000 estimates of $\hat{N}_h$ or $\hat{N}$ and locating the 25th and 975th values of the ordered estimates. Juvenile Chinook salmon JPI's were summarized by brood year while rainbow trout/steelhead JPI's at UBC were summarized for the periods September 1, 1998 through December 31, 1999 and January 1, 2000 through February 9, 2006. Rainbow trout/steelhead sampled at LBC were summarized for the periods October 9, 1998 through December 31, 1999 and January 1, 2000 through February 9, 2001.

Chinook Salmon Condition and Weight-Length Relationship

Precise measurement of the physiological condition of fish usually includes the measurement of fat content which is often expressed as a percent of body weight. Physiological condition of fish is often estimated morphometrically by measuring the weight and length of fish and comparing the weight-length relationship between study groups. The assumption of morphometric indexes of fish condition is that heavier fish of a given length are in better condition. Unlike fat content data, weight-length data can be collected quickly and economically from a large number of individuals in a non-lethal manner.

We collected weight-length data from juvenile Chinook captured in the LBC trap in 1999 and 2000, in the UBC trap in 1999 and on the nearby tributary of Clear Creek in 1999 and 2000. Clear Creek is a west-side tributary of the Sacramento River whose confluence is 27 km upstream of Battle Creek. Weight data was collected to the nearest 0.01 gram using and Ohaus Scout® digital scale. Length data was collected to the nearest millimeter. Only fish ≥50mm were analyzed due to the relatively large variability in weight measurements from very small juveniles.

The weight-length relationship is often very strong and is usually modeled by the power function

$$W = aL^b, \qquad (5)$$

where W=weight, L=length, and "a" and "b" are parameters for intercept and slope, respectively. Parameters "a" and "b" can most easily be estimated by taking the logarithm of both sides of the above equation and re-writing it in the form of a straight line (Cone 1989):

$$\log_e(W) = \log_e(a) + b\log_e(L). \qquad (6)$$

Standard linear regression techniques are used to estimate $log_e(a)$ and b. If b=3.0, growth may be isometric meaning the three-dimensional shape does not change as fish grow. Conversely, growth is allometric when shape changes as fish grow. For example, if b>3.0, then fish become more rotund as length increases.

We chose not to use common morphometric indexes of fish condition such as Fulton's condition factor (*K;* Ricker 1975), relative condition factor (*Kn*; Le Cren 1951) or relative weight (*Wr*; Wege and Anderson 1978). These condition indices were undesirable because they are: (1) based on assumptions which are often violated (e.g. isometric growth), or (2) are only meaningful within a sample, not among samples, and are not useful as a general summary metric for the weight-length relationship (Cone 1989).

Instead of condition indices, we directly compared linear regression lines among samples (i.e., compared the slope and intercept parameters) using standard multiple regression and General Linear Model (GLM) techniques. The GLM was used first to determine if there was a statistically significant difference among the slopes of sample groups. If there was no difference among slopes, we tested for differences among intercepts. However, it is possible to detect a statistically significant difference among populations which is so small as to be biologically insignificant. This is especially common for large samples sizes such as our weight-length data set. Therefore, prior to statistical analysis, we set the level of biological significance at 5.0%. That is, to be categorized as biologically different, the predicted weights from two competing linear regression lines had to be >5.0% different at any length between 50 and 99 mm (within two standard deviations for the mean length).

Results

Trap Operation

Lower Battle Creek (LBC).— Operation of the LBC trap began on October 9, 1998 and continued until February 9, 2001 when funding ran out. During this time, sampling effort at the LBC trap was fairly high (80.5%). We defined sampling effort as the percent of days during which the trap was operated. The trap was fished 688 days out of a possible 855 days, and the monthly sampling effort varied from a low of 45% in January 2000 to 100% for 6 months of the reporting period (Figure 2; Appendix 1). Days that were not fished were generally the result of high flows, hatchery releases, staff shortages, trap maintenance, and staff holidays (Appendix 1).

During 1998 to 2001, mean daily water temperatures at the LBC trap varied from a low of 3.4ºC in 1998 to a high of 21.9ºC in 2000 (Figure 3). In 1999 and 2000, peak temperatures at the trap occurred on July 1, 1999 and June 30, 2000, respectively. The lowest mean daily water temperatures at the trap occurred on December, 22, 1998 (3.4ºC), January 6, 2000 (6.9 ºC), and January 15, 2001 (6.0 ºC). Mean daily flow that was collected by the U.S. Geological Survey at the Coleman Hatchery gauging station (#11376550) varied from a low of 7.2 m^3/s on September 11, 2000 to a high of 90.6 m^3/s on February 9, 1999 (Figure 3). During the first high flow period (1998-1999), flows first exceeded 20 m^3/s on November 22, 1998, whereas during the second high flow period (1999-2000) flows did not exceed 20 m^3/s until January 16, 2000. During the third high flow period (2000-2001), flows never exceeded 20 m^3/s before trap operation ceased on February 9, 2001. Turbidity at the LBC trap varied from a low of 0.6 NTU's on April 20, 2000 to a high of 15.6 NTU's on October 29, 2000 (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).—Operation of the UBC trap began September 1, 1998 and continued until February 9, 2001 when funding ran out. During this time, sampling effort at the UBC trap was high (91.0%). The trap sampled 813 days out of a possible 893 days, and the monthly sampling effort varied from a low of 61% in August 2000 to 100% for 13 months of the reporting period (Figure 2; Appendix 2). Days that were not fished were generally the result of high flows, staff shortages, trap maintenance, and staff holidays.

During 1998 to 2001, mean daily water temperatures at the UBC trap varied from a low of 3.7ºC in 1998, to a high of 20.4ºC in 2000 (Figure 4). In 1999 and 2000, peak temperatures at the trap occurred on July 14, 1999 and June 30, 2000, respectively. The lowest mean daily water temperatures at the trap occurred on December, 22, 1998 (3.5ºC), January 6, 2000 (6.8 ºC), and January 17, 2001 (6.2 ºC). 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 0.8 NTU's on December 17, 2000 to a high of 24.0 NTU's on January 24, 2000 (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

Fall Chinook Salmon - LBC.—Fall Chinook salmon were the most abundant fish captured at the LBC trap. Initially a few brood year 1997 (BY97) fall Chinook salmon were captured in the trap in late October 1998, but brood year 1998 (BY98) fall Chinook salmon were captured in the trap a short time later in early December 1998 (Figure 5). Following their initial capture, the numbers of fall Chinook salmon increased rapidly and were captured every week until mid-August 1999. A peak catch of 32,010 occurred the week of February 1, 1999, and the last week a BY98 fall Chinook salmon was captured at the LBC trap was October 18, 1999 (Figure 5). The total number of BY98 fall Chinook salmon captured in the LBC trap on days that it was fished was approximately 156,146. The actual catch of fall Chinook salmon is unknown because run designation was assigned to the unmeasured Chinook salmon based on the proportion of measured salmon that were fall run according to the length-at-date criteria (Green 1992). In addition, after adjusting the total catch reported above for days the trap was not fished, the estimated total catch of BY98 fall Chinook salmon at the LBC trap was 229,840.

Brood year 1999 (BY99) fall Chinook salmon demonstrated a migration pattern similar to that observed with BY98 salmon, but with some distinct differences (Figure 5). The time of first capture was essentially the same for both brood years, but the last week BY99 fall Chinook salmon were captured at the LBC trap was the week of September 18, 2000 which was about a month earlier than that of BY98. Peak migration for both brood years occurred in late January through February; however, BY99 peak migration occurred during a shorter period of time whereas peak migration for BY98 was more protracted (Figure 5). The BY99 peak catch of 150,327 occurred the week of February 7, 2000 which was a week later than BY98 and significantly larger. From September 1, 1999 through August 31, 2000 approximately 331,001 BY99 fall Chinook salmon were captured at the LBC trap on the days that the trap was fished. After adjusting the total catch reported above for days the trap was not fished, the estimated total catch of BY99 fall Chinook salmon was 449,850.

Brood year 2000 (BY00) fall Chinook salmon data is limited to the period September 1, 2000 through February 9, 2001; therefore, it is possible that peak migration may not have occurred prior to trap removal, and the last day of migration is unknown. December 3, 2000, the first date of capture, was similar to that seen for both BY98 and BY99 (Figure 5). Prior to trap removal, a peak weekly catch of 91,908 occurred the week of January 22, 2001, which is earlier than the peaks for BY 98 and BY99. From September 1, 2000 through February 9, 2001 approximately 105,299 BY00 fall Chinook salmon were captured at the LBC trap. After adjusting total catch for days not fished, the estimated total catch of BY00 fall Chinook salmon was 196,681.

Fall run Chinook salmon fork lengths (mm) ranged from 20 to 142 mm during the 98-99 sample period (October 9, 1998 to August 31, 1999), 22 to 156 mm during sample period 99-00 (September 1, 1999 to August 31, 2000), and 23 to 112 mm during sample period 00-01 (September 1, 2000 to February 9, 2001) (Figure 6). Length frequency histograms which included all runs of 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 of Chinook salmon captured at the LBC trap. As mentioned previously, the sample period 00-01 data does not extend past February 9, 2001 which likely explains the low numbers of Chinook salmon >50mm (Figure 7).

Life stage composition of fall Chinook salmon sampled at the LBC trap varied between sample periods, but much of this difference is likely explained by sample methods or effort (Figure 8). During the 98-99 sample period (October1, 1998 to August 31, 1999), the life stage classification system was not implemented until March 14, 1999; therefore, fry were only 30% of the fall Chinook salmon sampled at the LBC trap. The life-stage composition for the 99-00 sample period (September 1, 1999 to August 31, 2000) is likely the most representative, as it includes a complete year of sampling. During this period, fry were 70.3% of the fish sampled, parr were 4.2%, silvery parr were 19.3% and smolt were 6.1% (Figure 8). During the 00-01 sample period (September 1, 2000 to February 9, 2001) fry accounted for 99.7% of the fall Chinook sampled at the trap, but as mentioned previously the trap was not fished past February 9, 2001, which likely accounts for the small percentage of parr, silvery parr, and smolt which tend to be more abundant later in the sample period.

Late-Fall Chinook Salmon - LBC.— Three brood years of late-fall Chinook salmon were captured at the LBC trap between October 9, 1998 and February 9, 2001, but only BY99 and BY00 were complete years. Between October 9, 1998 and December 26, 1998, 205 BY98 late-fall Chinook salmon were captured in the trap (Figure 9). Brood year 1999 late-fall Chinook were first captured in the trap the week of March 29, 1999 and a peak capture of 548 occurred the week of June 7, 1999 (Figure 9). The last week of capture was December 13, 1999. The BY99 late-fall Chinook salmon total catch was approximately 3,114 based on the length-at-date criteria. After adjusting total catch for days not fished, the estimated total catch of BY99 late-fall Chinook salmon was 3,690. Brood year 2000 (BY00) late-fall Chinook salmon demonstrated a migration pattern very different than that observed for BY99 (Figure 9). Although week of first capture (March 27, 2000) was similar to BY99 late-fall Chinook salmon, the week of peak catch (n=599) occurred much earlier on April 24, 2000. As seen with BY98 fall Chinook salmon, the period of peak migration was more protracted for the BY99 late-fall Chinook salmon than BY00. The last week BY00 late-fall Chinook salmon were captured at the trap was December 11, 2000. The BY00 late-fall total was approximately 4,868 based on the length-at-date criteria. After adjusting the total catch reported above for days the trap was not fished, the estimated total catch of BY00 late-fall Chinook salmon was 5,918.

The fork length (mm) of late-fall Chinook salmon captured at the LBC trap varied from 24 to 137mm during the 98-99 sample period, 24 to 232 mm during the 99-00 sample period, and 77 to 130 mm during the 00-01 sample period (Figure 6 and 7). Sample period 99-00 is likely the most representative as the trap was fished throughout the year. In sample period 99-00 one large fish with fork length 232 mm was captured, otherwise the next largest fish was 115mm.

Life stage composition of late-fall Chinook salmon sampled at the LBC trap was similar between the 98-99 and 99-00 sample periods with fry comprising ≥90 % of the fish sampled. However, the sample period 00-01 was quite different with no fry or parr sampled (Figure 8). The difference is likely due to the fact that the LBC trap was not fished after February 9, 2001, and late-fall Chinook salmon fry and parr are usually not captured at the trap until April.

Spring Chinook Salmon-LBC.—Brood year 1998 (BY98) spring Chinook salmon were first captured at the LBC trap the week of November 16, 1998 with a peak catch of 79 the week of May 3, 1999 (Figure 10). The BY98 spring Chinook salmon total estimated catch based on the length-at-date criteria was 219. However after adjusting the total catch for days the trap was not fished, the estimated total catch was 336. The last BY98 spring Chinook salmon was captured the week of May 31, 1999. Brood year 1999 (BY99) had a slightly different migration pattern than BY98. Brood year 1999 (BY99) spring Chinook salmon were first captured a week later whereas the peak catch was earlier. The first BY99 spring Chinook salmon were captured at the trap the week of November 29, 1999 with a peak catch of 368 captured the week of April 17, 1999 (Figure 10). The BY99 total estimated catch based on the length-at-date criteria was 1,147. The adjusted total which includes estimated catch on days the trap was not fished was 1,601. The last BY99 spring run Chinook salmon was captured the week of June 5, 2000. Only 11 BY00 spring Chinook salmon were captured before the trapping ceased on February 9, 2001. The fork length of spring Chinook salmon captured was not summarized because there is likely overlap with fall chinook salmon at the LBC trap. Length data for all runs were combined (Figure 6 and 7). Life-stage data was not summarized for spring Chinooks salmon as too few were captured, and because run designation is based on the length-at-date criteria which may not be valid for tributary runs. The overlap in fork lengths appears to be a particular problem with spring and fall Chinook salmon.

Winter Chinook Salmon - LBC.—Winter Chinook salmon were captured at the LBC trap during all three sample periods, but migration patterns were not described as they likely are migrants from the Sacramento River that are using lower Battle Creek for non-natal rearing. The total catch for the 98-99 season was 336, 67 were caught in the 99-00 season, and 80 in the 00-01 season. Fork length data for all Chinook salmon runs was combined for graphical display (Figure 6 and 7). Life-stage data for winter Chinook salmon was not summarized due to small sample sizes.

Rainbow trout/Steelhead - LBC.—During the period October 9, 1998 through December 1999, 362 rainbow trout/steelhead were captured at the LBC trap. They were first captured the week of October 19, 1998 with a peak capture of (n=70) occurring the week of June 14, 1999 (Figure 11). During the period January 1, 2000 through February 9, 2001, 584 rainbow trout/steelhead were captured at the LBC trap. They were first captured the week of on January 17, 2000 with peak capture (n=60) occurring the week of May 22, 2000 (Figure 11).

During the period October 9, 1998 to December 31, 1999 the fork length (mm) of rainbow trout/steelhead ranged from 25 to 593 mm with a mean fork length of 99 mm and a median fork length of 78 mm (Figure 12). During the period January 1, 2000 through February 9, 2001 fork length ranged from 22 to 490 mm with a mean fork length of 81 mm and a median fork length of 64 mm (Figure 13). The fork length distributions and length frequencies for the two periods are very different. Length frequencies for the 2000 to 2001 period show that fish in the 26-30 mm length range were >18% of the entire catch, whereas in the previous period fish in this length range were not sampled at the trap (Figure 12 and 13). We are unsure as to the reason for this spike, but it is possible that a change in screen size on the rotary screw trap prevented newly emerged fry from escaping during the second period. The only information available to support this theory is anecdotal at best. A similar spike occurred at UBC trap and the rotary screw trap operated on Clear Creek.

Rainbow trout/steelhead parr and silvery parr were the most abundant life-stages sampled at the LBC trap during both sample periods whereas yolk sac fry were the least abundant (<1.0%; Figure 14). During the 2000 to 2001 sample period, fry were more abundant (25.7%) than seen in the 1998 to 1999 sample period (1.2%). This could be the result of changes to the screens on the trap, but no definitive information is available to verify this.

Non Salmonids - LBC.—From October 9, 1998 through February 9, 2001, 20 non-salmonid species were also captured in the LBC trap, including 11 native species (California roach *Hesperoleucus symmetricus*, speckled dace *Rhinicthys osculus*, hitch *Lavinia exilicauda*, hardhead *Mylopharodon conocephalus*, Pacific lamprey *Lampetra tridentata*, prickly sculpin *Cottus asper*, riffle sculpin *Cottus gulosus*, Sacramento pikeminnow *Ptychocheilus grandis*, Sacramento sucker *Catostomus occidentalis*, tule perch *Hysterocarpus traski*, and threespine stickleback *Gasterosteus aculeatus*), and 9 introduced species (blue gill *Lepomis macrochirus*, black bullhead A*meiurus melas,* green sunfish *Lepomis cyanellus*, golden shiner *Notemigonus crysoleucas*, largemouth bass *Micropterus salmoides*, western mosquitofish *Gambusia affinis*, pumpkinseed *Lepomis gibbosus*, spotted bass *Micropterus punctulatus*, and white catfish *Ameriurus catus*) (Appendix 3). Next to Chinook salmon, Sacramento suckers were the second most abundant fish captured in the traps in 1999 (n=3,207) and 2000 (n=1,073). Hardheads, lamprey and cyprinid fry, riffle sculpin, and Sacramento pikeminnow were also abundant in the LBC trap, but the order of abundance varied between years (Appendix 3).

Fall Chinook Salmon - UBC.—Fall Chinook salmon were the most abundant fish captured at the UBC trap. Brood year 1998 (BY98) fall Chinook salmon were first captured in the trap the week of November 30, 1998, with the peak catch of 16,885 occurring the week of January 18, 1999 (Figure 15). Following their initial capture, the numbers of fall Chinook salmon increased rapidly and were captured every week until the week of May 31, 1999. The last day BY98 fall Chinook salmon were captured at the UBC trap was August 28, 1999 (Figure 15). The total number of BY98 fall Chinook salmon captured in the UBC trap on days that it was fished was 37,2137. The actual catch of fall Chinook salmon is unknown because run designation was assigned to the unmeasured Chinook salmon based on the proportion of measured salmon that were fall run according to the length-at-date criteria (Green 1992). In addition, after adjusting the total catch reported above for days the trap was not fished, the estimated total catch of BY98 fall Chinook salmon at the UBC trap was 43,929.

Brood year 1999 (BY99) fall Chinook salmon demonstrated a migration pattern similar to that observed with BY98 salmon, but with some small differences (Figure 15). Brood year 1999 were captured a week later during the week of December 6, 1999, with the peak catch of 7,187 occurring the week of January 10, 2000 which is a week earlier than seen with BY98. The last BY99 fall Chinook was capture at the UBC trap the week of September 20, 2000. From September 1, 1999 through August 31, 2000 approximately 331,001 BY99 fall Chinook salmon were captured at the UBC trap on the days that the trap was fished. After adjusting the total catch reported above for days the trap was not fished, the estimated total catch of BY99 fall Chinook salmon was 449,850.

Brood year 2000 (BY00) fall Chinook salmon data is limited to the period September 1, 2000 through February 9, 2001; therefore, it is possible that peak migration may not have occurred prior to trap removal, and the last day of migration is unknown. December 3, 2000, the first date of capture, was similar to that seen for both BY98 and BY99 (Figure 15). Prior to trap removal, a peak daily catch of 35,618 occurred on January 25, 2001, which is earlier than the peaks for BY 98 and BY99. From September 1, 2000 through February 9, 2001 approximately 105,299 BY00 fall Chinook salmon were captured at the UBC trap. After adjusting total catch for days not fished, the estimated total catch of BY00 fall Chinook salmon was 196,681.

Fall run Chinook salmon fork lengths (mm) ranged from 20 to 142 mm during the 98-99 sample period (October 9, 1998 to August 31, 1999), 22 to 156 mm during sample period 99-00 (September 1, 1999 to August 31, 2000), and 23 to 112 mm during sample period 00-01 (September 1, 2000 to February 9, 2001) (Figure 16). Length frequency histograms which included all runs of Chinook salmon were highly skewed towards newly emerging fry ≤40 mm (Figure 17). 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. As mentioned previously, the sample period 00-01 data does not extend past February 9, 2001 which likely explains the low numbers of Chinook salmon>50mm (Figure 16 and17).

Life stage composition of fall Chinook salmon sampled at the UBC trap varied between sample periods, but much of this difference is likely explained by sample methods or effort (Figure 18). During the 98-99 sample period (October1, 1998 to August 31, 1999), the life stage classification system was not implemented until March 14, 1999; therefore, fry were only 30% of the fall Chinook salmon sampled at the UBC trap. The life-stage composition for the 99-00 sample period (September 1, 1999 to August 31, 2000) is likely the most representative, as it includes a complete year of sampling. During this period, fry were 70.3% of the fish sampled, parr were 4.2%, silvery parr were 19.3%, and smolt were 6.1%. During the 00-01 sample period (September 1, 2000 to February 9, 2001) fry accounted for 99.7% of the fall Chinook sampled at the trap, but as mentioned previously the trap was not fished past February 9, 2001, which likely accounts for the small percentage of parr, silvery parr, and smolt which tend to be more abundant later in the sample period.

Late-Fall Chinook Salmon - UBC.—During the reporting period, only 37 late-fall Chinook salmon were captured in the UBC trap; therefore, no additional information will be reported for this race.

Spring Chinook Salmon - UBC.— Brood year 1998 (BY98) spring Chinook salmon were first captured at the UBC trap the week of November 16, 1998 with a peak catch of 78 the week of April 26, 1999 (Figure 19). The BY98 spring Chinook salmon total estimated catch based on the length-at-date criteria was 218. However after adjusting the total catch for days the trap was not fished, the estimated total catch was 227. The last BY98 spring Chinook salmon was captured the week of July 12, 1999. Brood year 1999 (BY99) had a slightly different migration pattern than BY98. Brood year 1999 (BY99) spring Chinook salmon were captured at about the same time (November 15, 1999) as BY 98, but the peak catch of 96 the week of April 17, 2000 was about 1 week earlier (Figure 19). However, both brood years also exhibited two peaks with a smaller one in November and then a larger one in April 2000. The first peak was newly emerged fry whereas the later peak included older life-stages. The BY99 total estimated catch based on the length-at-date criteria was 287. The adjusted total which includes estimated catch on days the trap was not fished was 291. The last BY99 spring run Chinook salmon was captured the week of May 15th. Only three BY00 spring Chinook salmon were captured at the UBC trap before the trapping ceased on February 9, 2001.

The fork length of spring Chinook salmon sampled at the UBC trap was combined with other runs because there is likely overlap, particularly with fall run Chinook salmon (Figure 16 and 17). Life-stage data was summarized for spring Chinooks salmon, but may not be completely reliable as run designation is based on length-at-date criteria. Spring Chinook salmon life-stage varied between year, but as sample sizes were small the actual differences may not be as big (Figure 18). No silvery parr or smolt were captured during the 200 to 2001 sample period, but these life-stage categories are usually capture in April, and the trap only fished until February 9, 2001.

Winter Chinook Salmon - UBC.—During the reporting period, only five 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 period September 1, 1998 through December 1999, 282 rainbow trout/steelhead were captured at the UBC trap. They were first captured on the week of September 14, 1998 with peak capture (n=37) occurring the week of May 31, 1999 (Figure 20). During the period January 1, 2000 through February 9, 2001, 1,222 rainbow trout/steelhead were captured at the UBC trap. They were first captured the week of January 3, 2000 with peak capture (n=381) occurring the week of March 13, 2000 (Figure 20).

During the period September 1, 1998 to December 31, 1999 the fork length (mm) of rainbow trout/steelhead at the UBC trap ranged from 22 to 299mm with a mean fork length of 95 mm and median fork length of 74 mm (Figure 21). During the period January 1, 2000 through February 9, 2001 fork lengths ranged from 18 to 635 mm with a mean fork length of 49 mm and a median fork length of 27 mm (Figure 22). The fork length distributions and length frequencies for the two periods are very different. Length frequencies for the 2000 to 2001 period show that fish in the 26 to 30 mm length range were >45% of the entire catch, whereas in the previous period fish in this length range were approximately 1% of fish sampled at the UBC trap. We are unsure as to the reason for this spike, but it is possible that a change in screen size on the rotary screw trap prevented newly emerged fry from escaping during the second period. The only information available to support this theory is anecdotal at best. A similar spike occurred at UBC trap.

Life-stage composition for rainbow trout/steelhead captured at the UBC trap varied between the 1998-1999 and 2000-2001 summary periods (Figure 23). During 2000-2001, fry were greater than 60% of the rainbow trout/steelhead sampled at the trap, whereas in the first period, fry were less than 60%. The percent of parr, silvery parr, and smolt were all higher during the 1998 to1999. The increase in fry in 2000 to 2001 may be the result of a change in screen size as mentioned previously.

Non Salmonids - UBC.— From September 1 through February 9, 2001, 1998, 12 non-salmonid species were captured in the UBC trap, including 11 native species (California roach, speckled dace, hitch, hardhead, Pacific lamprey, prickly sculpin, riffle sculpin, Sacramento pikeminnow, Sacramento sucker, tule perch, and threespine stickleback), and one introduced species (golden shiner) (Appendix 4). Next to Chinook salmon, Sacramento suckers were the second most abundant fish captured in the traps in 1998 to 2000. Hardheads, lamprey fry, Pacific lamprey, cyprinid fry, riffle sculpin, and Sacramento pikeminnow were also abundant in the UBC trap, but the order of abundance varied between years (Appendix 4).

Trap Efficiency and Juvenile Salmonid Passage

Lower Battle Creek Trap Efficiency (LBC).—To estimate trap efficiency, mark-recapture trials were conducted at the LBC trap during all three sample periods (98-99, 99-00, and 00-01). During the 98-99 sample season, we attempted to conduct mark-recapture trials each week. We released marked Chinook salmon during 24 of the 28 weeks available between December 14, 1998 and June 21, 1999, but during eight of the trials the trap had to be pulled due to high flows or hatchery releases (Table 1). Of the remaining 16 trials, only 10 had at least seven recaptures as recommended by Steinhorst et al. (2004). One additional trial with 6 recaptures was pooled with an adjacent trial with 9 recaptures because weekly mean flows and trap efficiencies (0.020 and 0.029) were similar. Weekly trap efficiencies for the nine unpooled and one pooled trial varied from 0.023 to 0.079. Using the results of these trials, the season average efficiency was estimated at 0.047. The 98-99 season average efficiency was used to estimate passage for 36 weeks during October 9, 1998 to September 2, 1999 when no trials were conducted or when trials results were not used.

During the 99-00 sample season (September 1, 1999 to August 31, 2000), we released marked Chinook salmon 16 weeks between January 27 and June 21, 2000 (Table 2). Seven paired daytime and nighttime mark-recapture trials were conducted from April 17 to June 7, 2000. To maintain consistency with methods applied to UBC trials, the results of the paired trials were pooled; however, further analyses may be conducted in a future report. Four additional trials were pooled as with adjacent trials because there were <7 recaptures. Trap efficiencies for trials with more than seven recaptures (n=3) and the nine pooled trap efficiencies varied from 0.018 to 0.138. A season average efficiency of 0.057 estimated from these trials was used to estimate passage for 41 weeks during the sample season.

During the 00-01 sample season (September 1, 2000 to February 9, 2001) we released marked Chinook salmon 5 weeks between December 25, 2000 and February 9, 2001 (Table 3). Two trials occurred while the trap was at full-cone status, while the remaining three trials occurred while the trap was at half-cone status. All five trials were considered valid as recaptures varied from 9 to 46. Trap efficiencies for the trials conducted at full-cone status varied form 0.060 to 0.092, whereas trials conducted at half-cone status varied from 0.032 to 0.042. For those weeks when mark-recapture trials were not conducted, a season average efficiency of 0.072 was used to estimate passage during 15 weeks when the trap was at full-cone status, and a season average efficiency of 0.037 was used for 3 weeks when the trap was at half-cone status. The 00-01 season average efficiency was similar to the 99-00 season average efficiency, but different than the 98-99 season average efficiency.

Upper Battle Creek Trap Efficiency (UBC).—To estimate trap efficiency, mark-recapture trials were also conducted at the UBC trap during all three sample periods (98-99, 99-00, & 00-01). During the 98-99 sample season, we attempted to conduct mark-recapture trials each week that there were sufficient fish available for marking. We released marked Chinook salmon during 24 of the 28 weeks available between December 14, 1998 and June 21, 1999 (Table 4). Of the 24 trials, 12 had at least seven recaptures as recommended by Steinhorst et al. (2004). The results of two of these trials were pooled with the results of adjacent trials which had less than seven recaptures. Five additional trials which had 2 to 6 recaptures were also pooled. Trap efficiencies for the 9 unpooled and 5 pooled trials varied from 0.012 to 0.109. The season average efficiency estimated from these 14 trap efficiencies was 0.042, which was then applied to 14 weeks when no trials were conducted or when trial results were not used.

During the 99-00 sample season (September 1, 1999 to August 31, 2000), we released marked Chinook salmon 13 weeks between January 10 and May 28, 2000 (Table 5). Five paired daytime and nighttime mark-recapture trials were conducted from April 17 to May 28, 2000. Recaptures for most of the paired trials were less than seven; therefore the trials were pooled if the pooled recaptures were ≥7, otherwise the trials were not used. Trap efficiencies for trials with more than seven recaptures (n=3) and the pooled trap efficiencies (n=3) varied from 0.033 to 0.098. A season average efficiency of 0.049 was estimated from these trials was used to estimate passage for 20 weeks during the sample season.

During the 00-01 sample season (September 1, 2000 to February 9, 2001) we released marked Chinook salmon 3 weeks between January 1, 2001 and February 9, 2001 (Table 6). All three trials had more than seven recaptures, and trap efficiencies varied from 0.017 to 0.128. A season average efficiency of 0.066 was estimated and applied to 9 weeks of the sample period. The 00-01 season average efficiency was different than the 98-99 and 99-00 season average efficiencies which were similar (0.042 and 0.049, respectively). The difference may be the result of a shorter season, fewer mark-recapture trials, and different environmental conditions.

Lower Battle Creek Juvenile Passage (LBC).—At the LBC trap, trap efficiency estimates were used to generate juvenile passage indexes (JPI) for fall and late-fall Chinook salmon and rainbow trout/steelhead. Juvenile passage indexes were not calculated for spring Chinook salmon as the overlap in length with fall Chinook made the estimates unreliable and catch was <2,000 for any brood year. Estimates of JPI were also not calculated for winter Chinook salmon as they are likely migrants from the Sacramento River and were using lower Battle Creek as non-natal rearing habitat. The JPI for BY98 and BY99 fall Chinook salmon was 4,897,569 and 18,708,768, respectively (Table 7 and 8). The JPI for BY00 was 5,551,428, but data for this brood year was limited to the period September 1, 2000 through February 9, 2001 (Table 9). However, considering that 56.7% of BY98 and 41.2% of BY99 passage occurred after February 9, we used the average percent passage (49%) after February 9 for these two brood years to calculate an extrapolated JPI of 10,885,153 for BY00 fall Chinook salmon. The 95% confidence intervals for the JPI's were 4,238,511 to 5,732,692 for BY98 and 14,103,348 to 26,372,818 for BY 99. A 95% confidence interval of 4,369,908 to 7,246,076 was generated for the partial-season JPI for BY00, but not for the extrapolated annual JPI. For BY98, the week of January 18, 1999 had the highest estimated JPI of 637,582 whereas the week of February 7, 2000 had the highest estimated weekly JPI for BY99 (8,386,099). The highest weekly JPI for BY00 was 2,914,024 during the week of January 22, 2001, which is similar to that of BY98. The weekly JPI's for BY98 and BY99 both increased quickly to the week of peak passage and then began to decline until mid- to late-April when weekly JPI's increased for a short period of time.

The JPI for BY99 and BY00 late-fall Chinook salmon were 86,305 and 86,934 respectively (Table 10 and 11). Although BY98 late-fall Chinook were captured in the LBC trap, no weekly or total JPI's were estimated as the total catch was only 70. The 95% confidence intervals for the JPI's were 72,258 to 98,591 for BY99 and 73,775 to 106,959 for BY00. The highest weekly JPI for BY99 was 14,067 during the week of April 12, 1999, whereas the highest weekly JPI for BY00 was 24,461 during the week of April 24, 2000. The weekly JPI's for both brood years increased shortly after the first late-fall Chinook were captured in the trap in late March. Weekly estimates for BY99 declined to <1,000 15 weeks after the start of the season, whereas BY00 estimates declined to <1,000 11 weeks after the start of the season.

The total JPI for rainbow trout/steelhead passing the LBC trap during the period October 9, 1998 through December 31, 1999 was 7,057 and 8,577 for the period January 1, 1999 through February 9, 2001 (Table 12 and 13). The JPI's for rainbow trout/steelhead were not calculated by brood year as the presence of both resident rainbow trout and steelhead make it difficult to differentiate the brood year of larger fish without additional information. The 95% confidence intervals for these estimates were 6,196 to 8,368 for the first period and 7,694 to 9,592 for the second period. During the first period, a peak weekly JPI of 1,265 occurred the week of June 14, 1999 whereas during the second period, a peak weekly JPI of 895 occurred the week of April 3, 2000. Peak passage appeared to be more protracted during the first period, whereas during the second period the time of peak passage was much narrower. The reason for the difference in peak passage time is unknown, but it is possible that a change in screen size on the rotary screw trap prevented newly emerged fry from escaping during the second period. The only information available to support this theory is anecdotal at best. A similar spike occurred at UBC trap and the rotary screw trap operated on Clear Creek.

Upper Battle Creek Juvenile Passage (UBC).—At the UBC trap, trap efficiency estimates were used to generate juvenile passage indexes (JPI) for fall and spring Chinook salmon and rainbow trout/steelhead. Juvenile passage indexes were not calculated for late-fall and winter Chinook salmon as the catch was to low for any brood year. The JPI for BY98 and BY99 fall Chinook salmon was 1,193,916 and 239,152 respectively (Table 14 and 15). The JPI for BY00 was 43,850 but data for this brood year was limited to the period September 1, 2000 through February 9, 2001 (Table 16). As done with the LBC BY00 estimate for fall Chinook salmon passage, we considered using the average of the BY98 and BY99 passage after February 9, but considering that the potential passage of adult fall Chinook salmon above the barrier weir was very different between 1998 and 1999 we used the BY99 estimate of passage after February 9 to estimate the total JPI for BY00 as the likelihood for fall Chinook passage at the barrier weir was similar. The extrapolated annual JPI for BY00 fall Chinook salmon at the UBC trap was 45,820. The 95% confidence intervals for the fall Chinook salmon 996,588 to 1,546,430 for BY98 and 202,274 to 291,194 for BY 99. A 95% confidence interval of 37,476 to 54,567 was generated for the partial estimate of total JPI for BY00, but not for the extrapolated annual JPI. However, the confidence interval encompasses the extrapolated JPI calculated with the BY99 percent passage after February 9. The peak weekly passage of 398,276 for BY98 and 73,992 for BY99 both occurred in mid-January. The peak weekly passage of 10,720 for BY00 occurred 2 weeks later than the two previous brood years although it is important to remember that the sample period ended on February 9, 2001.

The JPI for BY98 and BY99 spring Chinook salmon were 4,791 and 6,233, respectively (Table 17 and 18). The 95% confidence intervals for the JPI's were 3,949 to 6,204 for BY99 and 5,225 to 7,678 for BY99. The highest weekly JPI for BY98 was 1,876 during the week of

April 26, 1999, whereas the highest weekly JPI for BY99 was 1,879 during the week of April 17, 2000. No estimate was made for BY2000 as the total catch at the UBC trap was three.

The total JPI for rainbow trout/steelhead passing the UBC trap during the period September 1, 1998 through December 31, 1999 was 10,388, and 25,710 for the period January 1, 1999 through February 9, 2001 (Table 19 and 20). The JPI's for rainbow trout/steelhead were not calculated by brood year as the presence of both resident rainbow trout and steelhead make it difficult to differentiate the brood year of larger fish without additional information. The 95% confidence intervals for these estimates were 8,610 to 12,976 for the first period and 21,865 to 30,713 for the second period. During the first period, a peak weekly JPI of 2,134 occurred the week of May 31, 1999 whereas during the second period, a peak weekly JPI of 7,800 occurred the week of March 13, 2000. The reason for the difference in peak passage time is unknown, but it is possible that a change in screen size on the rotary screw trap prevented newly emerged fry from escaping during the second period. The information available to support this theory is largely anecdotal. A similar spike occurred at UBC trap and the rotary screw trap operated on Clear Creek.

Chinook Salmon Condition and Weight-Length Relationship

Comparison of the weight-length relationship among all three traps (UBC, LBC, and CC) could only be done for April 1999 because this was the only month weight-length data was collected at UBC. Results indicated that mean weight at a given length was generally greatest for UBC (Figure 24). GLM results showed that the slopes (parameter b) of the three regression lines were not all the same ($p=0.025$). Follow-up pairwise comparisons showed that the slope for UBC was significantly larger than both LBC and CC ($p<0.05$). Differences in slope were categorized as biologically significant with predicted weights at UBC being up to 7% greater than LBC and up to 11% greater than CC. There was no difference between LBC and CC in April, May or June of 1999 and 2000.

We analyzed weight-length data from the LBC trap to determine if there were inter-annual differences between 1999 and 2000 in April, May or June. Results showed that there were no inter-annual differences in slope or intercept parameters that were both statistically and biologically significant. The intercept parameters between June 1999 and 2000 were statistically different but the difference was biologically insignificant resulting in only a 3.6% difference between predicted weights of each year. A 3.6% difference in predicted weights was a difference of 0.14 g at the median fork length of 71 mm.

Weight-length data collected at the LBC trap was analyzed to see if there were differences associated with time-of-year. Due to the limited period during which data were collected, we compare three time periods: early-April (first 14 days), mid-May (middle 14 days) and late-June (last 14 days). In 2000, the late-June category was replaced by mid-June (June 4-17) due to data availability. Results indicated that in 1999, mean weight at a given length was generally greatest in late June (Figure 25). In 1999, the slope parameter "b" for late June was significantly greater than early April ($p<0.05$). Predicted weights in late June were at least 5% greater than early April at lengths ≥72 mm. Conversely, in 2000, mean weight at a given length was generally least in mid-June and nearly equal in April and May (Figure 26). In 2000, the intercept parameter "a" for mid-June was significantly less than both early-April and mid-May. Predicted weights in mid-June were 6% less than early-April and 7% less than mid-May at all lengths (Figure 26).

Discussion

Trap Operation

Sample effort at both traps was fairly high during the reporting period, but it does not appear that either trap can be operated continuously. Hatchery releases and high flows were the two primary factors responsible for reduced trap operation. However, high flow periods were often limited to short periods of time whereas during hatchery releases, the LBC trap was occasionally inoperable for several days. Sample effort at the UBC trap was much higher because hatchery releases did not occur upstream of the trap. Reduced funding and staff shortages were also a problem during portions of the reporting period. Developing methods to increase our ability to operate the traps continuously or estimate passage when the traps are not operational would help improve the accuracy of juvenile 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 passage during high-flow periods. The CPUV and CPUE have been used in a few other rotary screw trap studies to estimate passage during periods when traps were not operated, but whether other methods were evaluated and compared is unknown.

The authors of this report were not part of the original crew or staff present during sampling; therefore, our analyses were limited to the available data. Important anecdotal information and first-hand knowledge of sampling methods were not available to provide additional context.

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. It is likely the size overlap 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 expanded to the total catch and then the total estimated passage of a particular run.

Trap Efficiency and Juvenile Salmonid Passage

Mark-recapture methods are commonly used to estimate trap efficiency, but often the underlying assumptions are never tested which can reduce the accuracy and validity of estimates. Unfortunately the conditions necessary to conduct ideal mark-recapture studies are not always present or practical. We used mark-recapture methods to estimate rotary screw trap efficiency at various flows, but ideally separate trials should have been conducted for each species, run, and life stage at various seasons to estimate species and age-specific trap efficiencies. However, our ability to conduct age, run, and species specific trials was limited by low abundance within each category; therefore we used fall Chinook salmon fry and parr as surrogates. The applicability of our estimates to these other groups is unknown. Fish abundance limited our trials to the period December to June because insufficient numbers of Chinook salmon were available to conduct good trials during other times of the year. In addition, high flows often limited our ability to conduct trials during periods of high immigration.

We used two methods for dealing with weeks when mark-recapture trials were not conducted or recapture rates were low (less than seven). 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. Ideally efficiency trials should be conducted each week that fish are migrating past the trap; however, that was not possible because sufficient fish were not available to conduct trials throughout the migration period. Hatchery fish have been used in some studies, but Roper and Scarnecchia (1996) found that trap efficiencies for hatchery and wild Chinook salmon were different because of differences in behavior. 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 (pooled or season average) to estimate production was from the true efficiency. The impact from pooling 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 affect on production estimates 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 trap operations, mark-recapture trials should be conducted for all weeks when sufficient numbers are available. If hatchery fish are available, trials should be done to test whether behavioral differences exist at all sizes. In addition, release groups for mark-recapture trials should be large enough to ensure a minimum of seven recaptures. This will reduce or eliminate the need to pool mark-recaptured data from adjacent weeks.

The methods we used to conduct our mark-recapture trials changed each year as we attempted to determine which method might provide the most accurate estimates of trap efficiency and juvenile salmonid passage. 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. During the 1998 to 1999 season, we released several groups during the week. As all groups had identical marks, we combined the results 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 are accounted for with a weekly estimate. Using this method we also had the highest number of trials with at least seven recaptures as was recommended by Steinhorst et al. (2004).

During portions of the 1999 to 2000 season we modified our methods further by attempting to determine the differences in trap efficiency for Chinook salmon captured during the day versus those captured at night. Ideally the trap efficiencies for the day and nighttime trials would be applied to the day and nighttime catch. This method is also time intensive as it requires marking and releasing two groups of fish, and also requires checking the trap twice a day to determine day and nighttime catch. Unfortunately, the numbers of recaptures were very low for several trials at the UBC trap; therefore, we pooled the data for each trap to maintain consistency in analyses. The effects of pooling the data depend on the differences in the day and nighttime trap efficiencies. If they were similar, the effects from pooling were minimal, but if they were very different the effect could be much higher. The use of day and nighttime trap efficiencies should be investigated further as catch does appear to be much higher at night.

During the 2000 to 2001 season we released a single large group of marked Chinook salmon during the weeks that trials were conducted. This method was the least time intensive of those used during the reporting period, as it required marking and releasing a single group during the week the trial was conducted. However, it also accounted for the least amount of variation in flows or catch that occurred during the week. 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.

The accuracy of weekly and total season juvenile passage estimates are dependent upon the results of mark-recapture trials as well as the ability to accurately assign a run designation to all Chinook salmon captured in the traps. Improving the accuracy of estimates will require developing or improving methods to estimate trap efficiency and accurately assign run designation.

The new JPI provided in this report (Table 21) are different than the original CAMP estimates (USFWS and BOR 2002). The passage estimates differ due to improvements and standardization in the use of efficiency estimates based on more recent statistical literature. We standardized statistical techniques to better allow comparison of estimates between years. The original CAMP estimates covered the periods January 1 through December 31, 1999 and 2000; therefore, the estimates did not include passage for the entire brood year.

Chinook Salmon Condition and Weight-Length Relationship

On average, juvenile Chinook were heavier, at a given length, at the UBC trap than both the LBC and CC traps in April 1999. This may indicate that the juveniles captured in the UBC trap were in better physical condition than those from the other traps (Anderson and Gutreuter 1983; Sutton et al. 2000). Assuming the heavier UBC fish were in better condition, a potential explanation is the relatively low density of rearing juveniles and reduced competition for food and habitat resources in upper Battle Creek. There is about 29.8 km of rearing habitat upstream of the UBC trap and the estimated adult escapement in 1998-99 (parent generation) was 2,498 Chinook salmon (USFWS 2001; M. Brown, USFWS, unpublished data). In comparison, Clear Creek had an estimated adult escapement of 4,259 adults (C. Harvey-Arrison, CDFG, unpublished data) in 7.1 km of anadromous habitat and lower Battle Creek had an estimated in-river adult escapement of 53,957 adults (C. Harvey-Arrison, CDFG, unpublished data) in the 5.0 km of habitat between the LBC and UBC traps. Additionally, in lower Battle Creek, CNFH released over 12 million juvenile fall Chinook between March 31 and April 28 1999. Water temperatures in April 1999 do not appear to be associated with the differences among the traps as mean monthly temperatures were about 10.5°C at the LBC trap, 10.5-11.7°C in the upper mainstem Battle Creek and 12.2°C at the CC trap. More study in other months and years is needed to confirm the difference between the UBC trap and the LBC and CC traps.

Weight-length data from the LBC trap indicated there were differences associated with time-of-year. Specifically, in 1999 mean weight-at-a-given-length was statistically greater in late-June than early-April. Conversely, in 2000 mean weight-at-a-given-length was statistically less in mid-June than both early-April and mid-May. These seemingly contradictory results may be due to annual differences in water temperature (and associated flow). According to Moyle (2002) optimal temperatures for rearing and growth of Central Valley fall-run Chinook fry are 12.8-17.8°C with positive growth being observed throughout the range of Chinook at temperatures of 5.0-18.9°C. In 1999, the average Mean Daily Temperature (MDT) in mid-June was 16.7°C, within the optimal temperature range. But, the average MDT in early-April 1999 was 9.4°C, outside the optimal range. Conversely, in 2000 the average MDT in late-June was 20.6°F, well outside the optimal and positive growth ranges. But, the average MDT in early-April and mid-May 2000 were 13.3°C and 13.9°C, both within the optimal range. In each year, regardless of statistical differences, the rank (i.e. order) of the three weight-length regression lines exactly matched the rank of how closely their associated MDT were to the mid-point of the optimal range for water temperatures.

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. Continue to investigate apparent differences in the weight-length relationship of juvenile Chinook salmon among a) locations in Battle Creek, Clear Creek and other Sacramento River tributaries and b) among seasons or months within Battle Creek.

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Tables

Table 1. Summary of the mark-recapture trials conducted at the Lower Battle Creek rotary screw trap during September 1, 1998 through August 31, 1999. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. Trials which are bolded were not considered valid as the trap was not fishing for several days during the week. The season average efficiency (E=0.047) was used to calculate production for weeks when recaptures were <7, or weeks when no mark-recapture trials were conducted.

Week	Number Released	Recaptures	Bailey's Efficiency[a]	Pooled Efficiency	Weekly Mean Flow (cfs)	Pooled Mean Flow (cfs)
12/14/1998	100	7	0.079	---	610	---
12/28/1998	**97**	**5**	**0.061**	**---**	**469**	**---**
01/11/1999	**210**	**6**	**0.033**	**---**	**474**	---
01/18/1999	**100**	**0**	**---**	**---**	**723**	**---**
02/01/1999	216	10	0.051	---	634	---
02/15/1999	**112**	**2**	**0.027**	**---**	**1,308**	**---**
02/22/1999	275	3	0.015	**---**	1,020	---
03/01/1999	**258**	**2**	**0.012**		**1,282**	**---**
03/08/1999	203	7	0.039	---	823	---
03/15/1999	502	23	0.048	---	733	---
03/22/1999	523	2	0.006	---	783	---
03/29/1999	**115**	**0**	**---**	**---**	**680**	**---**
04/05/1999	346	9	0.029	0.023	647	683
04/12/1999 [b]	352	6	0.020	0.023	719	683
04/19/1999	**134**	**0**	**---**	**---**	**781**	**---**
04/26/1999	**131**	**0**	**---**	**---**	**790**	**---**
05/03/1999	508	26	0.053	---	701	---
05/10/1999	517	25	0.050	---	654	---
05/17/1999	509	25	0.051	---	665	---
05/24/1999	396	6	0.018	---	783	---
05/31/1999	293	22	0.078	---	716	---
06/07/1999	138	6	0.050	---	565	---
06/14/1999	252	13	0.055	---	526	---
06/21/1999	115	3	0.034	---	490	---

[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.

Table 2. Summary of the mark-recapture trials conducted at the Lower Battle Creek rotary screw trap during September 1, 1999 through August 31, 2000. The results of paired am and pm trials were pooled (shaded rows) to maintain with Upper Battle Creek. The season average efficiency (E = 0.057) was used for weeks where recaptures were <7, or when no mark-recapture trials were conducted. The first five shaded rows are trials that were pooled with adjacent weeks.

Release Date	Time of Release	Number Released	Recaptures	Bailey's Efficiency[a]	Pooled Efficiency	Weekly Mean Flow (cfs)
01/25/2000	n/a	167	3	0.024	0.025	792
01/28/2000	n/a	186	5	0.032	0.025	792
02/01/2000	n/a	182	1	0.011	0.018	750
02/04/2000	n/a	231	5	0.026	0.018	750
02/10/2000	n/a	367	7	0.022	0.018	808
03/03/2000	12:41 pm	341	18	0.056	---	1,145
03/16/2000	12:10 pm	131	2	0.023	---	711
04/10/2000	am	234	16	0.072	---	661
04/17/2000	8:40 am	210	14	0.071	0.053	656
04/17/2000	21:02 pm	224	8	0.040	0.053	656
04/25/2000	8:07 am	142	11	0.084	0.078	555
04/25/2000	22:15 pm	240	18	0.079	0.078	555
05/03/2000	10:45 am	485	6	0.014	---	564
05/10/2000	12:48 pm	72	2	0.041	0.086	524
05/10/2000	20:20 pm	113	13	0.123	0.086	524
05/18/2000	08:30 am	115	15	0.138	0.138	506
05/18/2000	20:04 pm	123	17	0.145	0.145	506
05/24/2000	13:55 am	125	9	0.079	0.102	557
05/24/2000	21:30 pm	100	13	0.139	0.102	557
05/31/2000	12:12 am	74	8	0.120	0.108	468
05/31/2000	21:20 pm	64	6	0.108	0.108	468
06/07/2000	11:30 am	56	8	0.157	0.115	446
06/07/2000	20:35 pm	47	3	0.083	0.115	446
06/15/2000	21:20 pm	51	6	0.135	---	426
06/21/2000	20:28 pm	18	0	---	---	391

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

Table 3. Summary of the mark-recapture trials conducted at the Lower Battle Creek rotary screw trap during September 1, 2000 through February 9, 2001. To calculate the season efficiency, efficiencies were either halved or doubled to make all trials equivalent during period of half- and full-cone operation. The appropriate season average efficiency was used for weeks when no mark-recapture trials were conducted.

Week	Number Released	Recaptures	Bailey's Efficiency[a]	Weekly Mean Flow (cfs)
12/25/2000 [b]	108	9	0.092	303
01/05/2001 [b]	416	24	0.060	293
01/15/2001[c]	517	21	0.042	299
01/22/2001[c]	538	16	0.032	461
02/05/2001[c]	1,279	46	0.037	315

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

[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 4. Summary of the mark-recapture trials conducted at the Upper Battle Creek rotary screw traps during September 1, 1998 through August 31, 1999. Marked fish for all trials were released at Intake 3. Shaded rows indicate weeks where mark-recapture data were pooled for analysis. The season average efficiency (E=0.042) was used to calculate production for weeks when recaptures were <7, or weeks when no mark-recapture trials were conducted.

Week	Number Released	Recaptures	Bailey's Efficiency[a]	Pooled Efficiency	Weekly Mean Flow (cfs)	Pooled Mean Flow (cfs)
12/14/1998	100	10	0.109	---	610	---
12/28/1998	97	6	0.071	0.09[b]	469	461
01/11/1999	360	35	0.100	0.09[b]	474	461
01/18/1999	100	2	0.030	---	723	---
02/01/1999	216	17	0.083	---	634	---
02/15/1999	276	2	0.011	0.012[b]	1,308	1,211
02/22/1999	275	2	0.011	0.012[b]	1,020	1,211
03/01/1999	259	5	0.023	0.012[b]	1,282	1,211
03/08/1999	204	15	0.078	---	823	---
03/15/1999	502	37	0.076	---	733	---
03/22/1999	523	20	0.040	---	783	---
03/29/1999	172	11	0.069	---	680	---
04/05/1999	346	19	0.058	---	647	---
04/12/1999	353	15	0.045	---	719	---
04/19/1999	134	8	0.067	---	781	---
04/26/1999	133	4	0.037	---	790	---
05/03/1999	508	12	0.026	---	701	---
05/10/1999	518	5	0.012	0.015[b]	654	659
05/17/1999	512	9	0.019	0.015[b]	665	659
05/24/1999	396	5	0.015	0.017[b]	783	750
05/31/1999	295	6	0.024	0.017[b]	716	750
06/07/1999	138	1	0.014	---	565	---
06/14/1999	252	3	0.016	---	526	---
06/21/1999	115	4	0.043	---	490	---

[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.

Table 5. Summary of the mark-recapture trials conducted at the Upper Battle Creek rotary screw trap during September 1, 1999 through August 31, 2000. Due to low recapture rates, the results of paired am and pm trials were pooled (shaded rows) as long as the number of recaptures for each trial was >0 and the combined number of recaptures was >7. The season average efficiency (E=0.049) was used for weeks where recaptures were <7, or no mark-recapture trials were conducted.

Week	Time of Release	Number Released	Recaptures	Bailey's Efficiency[a]	Pooled Efficiency	Weekly Mean Flow (cfs)
01/10/2000	n/a	508	49	0.098	---	516
01/24/2000	n/a	381	6	0.018	---	792
02/07/2000	n/a	513	19	0.039	---	808
02/14/2000	09:29 am	407	7	0.020	---	1,008
02/14/2000	12:00 am	209	0	---	---	1,008
02/21/2000	n/a	513	3	0.006	---	1,168
02/21/2000	09:27 am	101	0	---	---	1,168
02/21/2000	08:40 am	269	0	---	---	1,168
04/03/2000	n/a	79	4	0.051	---	605
04/10/2000	10:30 am	243	0	---	---	678
04/10/2000	08:40 am	170	5	0.029	---	978
04/17/2000	08:25 am	146	6	0.048	0.051	569
04/17/2000	21:35 pm	127	7	0.063	0.051	569
04/24/2000	08:25 am	138	2	0.022	0.037	560
04/24/2000	22:15 pm	189	9	0.053	0.037	560
05/01/2000	10:40 am	299	6	0.023	---	546
05/08/2000	10:05 am	153	5	0.039	0.033	501
05/08/2000	20:28 pm	145	4	0.034	0.033	501
05/15/2000	11:05 am	78	0	0.013	---	543
05/15/2000	20:50 pm	77	1	0.026	---	543
05/22/2000	09:22 am	45	0	0.022	---	501
05/22/2000	? pm	31	1	0.063	---	501

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

Table 6. Summary of the mark-recapture trials conducted at the Upper Battle Creek rotary screw trap during September 1, 2000 through February 9, 2001. The season average efficiency (E=0.066) was used to calculate production for weeks where recaptures were <7, or for weeks when no mark-recapture trials were conducted.

Week	Number Released	Recaptures	Bailey's Efficiency[a]	Weekly Mean Flow (cfs)
01/01/2001	516	65	0.128	293
01/08/2001	859	53	0.063	414
01/29/2001	633	10	0.017	326

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

Table 7. Weekly summary of brood year 1998 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 95% confidence intervals (CI). Shaded rows indicate weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
11/30/1998	0.047[a]	8	169	42	113	277
12/07/1998	0.047[a]	26	550	141	354	901
12/14/1998	0.047[a]	367	4,633	1,914	2,648	9,267
12/21/1998	0.079	336	7,112	1,772	4,572	10,668
12/28/1998	0.047[a]	784	16,595	3,915	11,063	27,155
01/04/1999	0.047[a]	6,215	131,551	33,094	87,700	215,265
01/11/1999	0.047[a]	16,894	357,590	86,796	238,393	585,147
01/18/1999	0.047[a]	30,122	637,582	152,169	409,874	1,043,317
01/25/1999	0.047[a]	11,355	240,348	56,838	160,232	360,521
02/01/1999	0.051	32,010	631,470	208,218	365,588	1,157,695
02/08/1999	0.047[a]	27,461	581,258	140,466	387,505	951,149
02/15/1999	0.047[a]	19,209	406,591	101,450	261,380	665,330
02/22/1999	0.047[a]	22,176	469,392	112,745	312,928	704,088
03/01/1999	0.047[a]	19,575	414,338	102,184	276,225	678,007
03/08/1999	0.039	12,624	321,912	156,721	171,686	343,824
03/15/1999	0.048	13,376	280,339	59,952	192,232	420,508
03/22/1999	0.047[a]	2,353	49,805	11,237	33,203	74,708
03/29/1999	0.047[a]	896	18,965	4,637	12,644	31,034
04/05/1999	0.023	1,637	71,516	18,064	45,771	114,426
04/12/1999	0.023	466	20,358	5,263	13,029	32,573
04/19/1999	0.047[a]	1,342	28,406	7,071	18,261	46,482
04/26/1999	0.047[a]	1,694	35,856	8,522	23,904	58,674
05/03/1999	0.053	3,690	69,563	13,325	49,427	98,853
05/10/1999	0.050	1,424	28,370	5,527	19,936	40,980
05/17/1999	0.051	1,215	23,833	5,245	16,307	34,425
05/24/1999	0.047[a]	1,020	21,590	5,133	13,879	32,385
05/31/1999	0.078	576	7,363	1,540	5,132	11,290
06/07/1999	0.047[a]	268	5,673	1,392	3,647	8,509
06/14/1999	0.055	358	6,470	1,764	3,938	10,064
06/21/1999	0.047[a]	193	4,085	1,049	2,626	6,685
06/28/1999	0.047[a]	61	1,959	363	861	2,113
07/05/1999	0.047[a]	77	1,630	430	1,048	2,667
07/12/1999	0.047[a]	14	296	72	191	485
07/19/1999	0.047[a]	9	191	46	122	312
07/26/1999	0.047[a]	1	41	5	14	35
08/02/1999	0.047[a]	1	41	5	14	35
08/09/1999	0.047[a]	1	41	5	14	35
08/16/1999	0.047[a]	1	41	5	14	35
08/23/1999	0.047[a]	1	41	5	14	35
Totals [d]	---	***229,840*** [d]	***4,897,569*** [d]	***386,960*** [d]	***4,238,511***[d]	***5,732,692***[d]

[a] Season average efficiency based on valid trials conducted December 14 1998 through June 21, 1999.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.
[d] Five additional fall Chinook salmon that were captured after 8/30/1999 are not shown, but the results are included in the total passage estimate.

Table 8. Weekly summary of brood year 1999 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 95% confidence intervals (CI). Shaded rows indicate weeks where mark-recapture data were pooled to calculate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
11/29/1999	0.057[a]	20	351	84	226	575
12/06/1999	0.057[a]	157	2,756	683	1,772	4,510
12/13/1999	0.057[a]	320	5,618	1,383	3,745	9,193
12/20/1991	0.057[a]	2,129	37,376	9,487	24,027	61,160
12/27/1999	0.057[a]	5,757	101,067	25,088	64,972	151,601
01/03/2000	0.057[a]	9,080	159,404	37,342	106,270	260,844
01/10/2000	0.057[a]	21,566	378,603	94,507	252,402	619,532
01/17/2000	0.057[a]	29,971	526,158	126,330	350,772	860,985
01/24/2000	0.025	41,049	1,614,594	664,276	908,209	2,906,269
01/31/2000	0.018	110,090	6,141,449	1,751,400	3,908,195	10,747,500
02/07/2000	0.018	150,327	8,386,099	2,471,527	5,104,582	14,675,700
02/14/2000	0.057[a]	46,820	821,951	196,038	547,967	1,232,927
02/21/2000	0.057[a]	13,367	234,665	57,225	156,443	383,997
02/28/2000	0.056	4,431	79,758	19,103	52,255	126,284
03/06/2000	0.057[a]	960	16,853	3,787	11,236	25,280
03/13/2000	0.057[a]	446	7,830	1,927	5,033	12,812
03/20/2000	0.057[a]	106	1,861	439	1,241	2,791
03/27/2000	0.057[a]	390	6,847	1,598	4,401	10,220
04/03/2000	0.057[a]	458	8,040	1,949	5,169	12,061
04/10/2000	0.072	1,398	19,325	5,164	12,636	32,853
04/17/2000	0.053	4,141	78,319	16,444	52,980	120,089
04/24/2000	0.078	2,194	28,010	5,083	20,007	40,014
05/01/2000	0.057[a]	814	14,290	3,640	9,187	23,384
05/08/2000	0.086	844	9,812	2,467	6,541	15,698
05/15/2000	0.138	916	6,634	1,274	4,733	9,465
05/22/2000	0.102	886	8,706	1,828	6,068	13,349
05/29/2000	0.108	747	6,922	1,894	4,514	11,537
06/05/2000	0.115	305	2,643	834	1,669	4,531
06/12/2000	0.057[a]	82	1,440	401	960	2,356
06/19/2000	0.057[a]	41	720	189	463	1,178
06/26/2000	0.057[a]	15	263	64	169	431
07/03/2000	0.057[a]	13	228	55	147	342
07/10/2000	0.057[a]	3	53	12	35	79
07/17/2000	0.057[a]	3	53	13	35	86
07/24/2000	0.057[a]	4	70	17	47	115
Totals	---	***449,850***	***18,708,768***	***3,103,928***	***14,103,348***	***26,372,818***

[a] Season average efficiency based on valid trials conducted January 25, 1999 through June 21, 2000.
[b] Daily catch was estimated for days when the trap was not fishing
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 9. Partial weekly summary of brood year 2000 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 95% confidence intervals (CI). Only weeks in which fall Chinook were captured are included. Total passage is only a partial estimate as the trap was not fished after February 9, 2001.

Week	E	Catch[c]	N	SE[d]	Lower[d] 95 % CI	Upper[d] 95% CI
11/27/2000	0.075[a]	4	53	8	40	72
12/04/2000	0.075[a]	11	147	21	113	197
12/11/2000	0.075[a]	194	2,587	391	1,950	3,474
12/18/2000	0.075[a]	727	9,693	1,382	7,439	12,623
12/25/2000	0.092	1,402	15,282	4,638	8,989	25,470
01/01/2001	0.060	1,786	29,790	6,047	21,279	43,810
01/08/2001	0.075[a]	13,462	179,493	26,975	137,745	241,054
01/15/2001	0.043	23,055	542,840	115,669	373,203	796,166
01/22/2001	0.032	91,908	2,914,024	705,075	1,905,324	4,503,492
01/29/2001	0.033[b]	36,150	1,095,455	266,487	714,274	1,726,163
02/05/2001	0.037	27,982	762,063	110,059	577,693	1,023,342
Totals	**---**	***196,681***	***5,551,427***	***768,560***	***4,369,304***	***7,246,076***

[a] Season average efficiency is based on a full cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies were doubled for half cone trials to make all five trials equivalent.
[b] Season average efficiency is based on a half-cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies were halved for full-cone trials to make all five trials equivalent.
[c] Daily catch was estimated for days when the trap was not fishing.
[d] The stand errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 10. Weekly summary of brood year 1999 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 95% confidence intervals (CI). Shaded rows indicate weeks where the results of mark-recapture trials were pooled to calculate passage.

Week	E	Catch[c]	N	SE[d]	Lower[d] 95 % CI	Upper[d] 95% CI
03/29/1999	0.047[a]	28	3,248	153	381	970
04/05/1999	0.023	150	6,553	1,832	4,194	10,485
04/12/1999	0.023	322	14,067	3,531	8,657	22,508
04/19/1999	0.047[a]	228	4,826	1,217	3,102	7,897
04/26/1999	0.047[a]	217	4,593	1,176	2,953	7,516
05/03/1999	0.053	133	2,507	490	1,782	3,761
05/10/1999	0.050	164	3,267	629	2,360	4,720
05/17/1999	0.051	396	7,768	1,538	5,458	11,220
05/24/1999	0.047[a]	392	8,297	2,124	5,334	13,577
05/31/1999	0.078	253	3,234	663	2,254	4,649
06/07/1999	0.047[a]	548	11,599	3,000	7,457	18,981
06/14/1999	0.055	495	8,945	2,200	5,693	13,915
06/21/1999	0.047[a]	163	3,450	1,787	2,300	5,175
06/28/1999	0.047[a]	52	1,048	274	734	1,801
07/05/1999	0.047[a]	37	783	185	503	1,282
07/12/1999	0.047[a]	18	381	103	254	623
07/19/1999	0.047[a]	5	106	28	68	173
07/26/1999	0.047[a]	7	148	36	95	242
08/02/1999	0.047[a]	3	64	16	41	104
08/09/1999	0.047[a]	6	127	31	85	208
08/16/1999	0.047[a]	3	64	16	41	104
09/06/1999	0.057[b]	3	53	12	35	79
09/20/1999	0.057[b]	1	18	4	11	29
09/27/1999	0.057[b]	3	53	12	34	79
10/11/1999	0.057[b]	2	35	9	23	57
10/18/1999	0.057[b]	5	88	22	56	144
10/25/1999	0.057[b]	13	228	59	152	373
11/01/1999	0.057[b]	11	193	45	129	290
11/08/1999	0.057[b]	9	158	38	105	259
11/15/1999	0.057[b]	8	140	35	94	230
11/22/1999	0.057[b]	6	105	26	68	172
11/29/1999	0.057[b]	3	53	12	35	79
12/06/1999	0.057[b]	1	18	5	12	29
12/13/1999	0.057[b]	5	88	22	56	144
Totals	---	***3,690***	***86,305***	***6,921***	***72,258***	***98,591***

[a] Season average efficiency based on valid trials conducted December 14, 1998 through June 21, 1999.
[b] Season average efficiency based on valid trials conducted January 25, 2000 through June 21, 2000.
[c] Daily catch was estimated for days the trap was not fishing.
[d] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 11. Weekly summary of brood year 2000 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 95% confidence intervals (CI). Only weeks where late fall Chinook salmon were captured are included. Shaded rows indicate weeks where the mark-recapture data were pooled to calculate passage.

Week	E	Catch[d]	N	SE[e]	Lower[e] 95 % CI	Upper[e] 95% CI
03/27/2000	0.057[a]	49	860	213	553	1,408
04/03/2000	0.057[a]	488	8,567	2,165	5,711	14,019
04/10/2000	0.072	567	7,838	2,067	5,396	14,030
04/17/2000	0.053	869	16,435	3,553	11,118	25,201
04/24/2000	0.078	1916	24,461	4,348	17,898	34,944
05/01/2000	0.057[a]	1,092	19,171	4,854	12,780	31,370
05/08/2000	0.086	192	2,232	569	1,428	3,247
05/15/2000	0.138	104	753	130	552	1,081
05/22/2000	0.102	321	3,154	719	2,198	4,836
05/29/2000	0.108	170	1,575	455	985	2,626
06/05/2000	0.115	78	676	196	406	1,159
06/12/2000	0.057[a]	8	140	34	90	211
06/19/2000	0.057[a]	11	193	48	124	290
06/26/2000	0.057[a]	8	140	35	90	230
07/03/2000	0.057[a]	7	123	29	79	184
07/24/2000	0.057[a]	3	53	13	34	86
07/31/2000	0.057[a]	1	18	4	12	29
08/07/2000	0.057[a]	4	70	17	47	105
08/14/2000	0.057[a]	6	105	29	68	172
08/21/2000	0.057[a]	4	70	17	45	115
09/04/2000	0.075[b]	2	27	4	20	36
09/11/2000	0.075[b]	2	27	4	20	36
09/25/2000	0.075[b]	2	27	4	20	36
10/16/2000	0.033[c]	1	30	8	19	52
10/23/2000	0.033[c]	1	30	8	20	48
10/30/2000	0.075[b]	3	40	6	31	54
11/06/2000	0.075[b]	1	13	2	10	18
11/13/2000	0.075[b]	2	27	4	20	36
11/20/2000	0.075[b]	4	53	8	40	72
12/04/2000	0.075[b]	1	13	2	10	17
12/11/2000	0.075[b]	1	13	2	10	18
Totals	---	***5,918***	***86,934***	***8,245***	***73,775***	***106,959***

[a] Season average efficiency based on valid trials conducted January 25, 1999 through June 21, 2000.
[b] Season average efficiency is based on a full cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies were doubled for half cone trials to make all five trials equivalent.
[c] Season average efficiency is based on a half-cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies were halved for full-cone trials to make all five trials equivalent.
[d] Daily catch was estimated for days when the trap was not fishing.
[e] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 12. Weekly summary of juvenile rainbow trout/steelhead passage estimates for October 9, 1998 through January 2, 2000 at the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 95% confidence intervals (CI). Shaded rows indicate adjacent strata where mark-recapture data were pooled.

Week[a]	E	Catch[c]	N	SE[e]	Lower[e] 95 % CI	Upper[e] 95% CI
10/19/1998	0.047[b]	3	64	15	41	104
10/26/1998	0.047[b]	3	64	16	42	104
11/02/1998	0.047[b]	1	21	5	14	35
11/16/1998	0.047[b]	1	21	5	14	35
12/21/1998	0.047[b]	2	42	10	28	64
01/18/1999	0.047[b]	1	21	5	14	35
01/25/1999	0.047[b]	2	42	10	27	69
02/08/1999	0.047[b]	2	42	10	28	64
03/01/1999	0.047[b]	1	21	5	14	35
03/22/1999	0.047[b]	2	42	10	28	64
04/12/1999	0.023	5	218	54	140	350
05/03/1999	0.053	8	151	29	107	214
05/10/1999	0.050	11	219	44	154	317
05/17/1999	0.051	18	353	71	248	510
05/24/1999	0.047[b]	15	318	78	212	520
05/31/1999	0.078	36	460	100	321	706
06/07/1999	0.047[b]	53	1,122	279	721	1,836
06/14/1999	0.055	70	1,265	379	805	2,214
06/21/1999	0.047[b]	41	868	206	579	1,420
06/28/1999	0.047[b]	12	254	60	163	381
07/05/1999	0.047[b]	19	402	99	259	603
07/12/1999	0.047[b]	11	233	60	15	381
07/19/1999	0.047[b]	1	21	6	14	35
07/26/1999	0.047[b]	1	21	6	14	35
08/02/1999	0.047[b]	3	64	15	41	95
08/23/1999	0.047[b]	1	21	5	14	35
09/06/1999	0.057[d]	2	35	9	23	57
09/13/1999	0.057[d]	2	35	9	23	57
09/20/1999	0.057[d]	1	18	4	11	26
09/27/1999	0.057[d]	1	18	4	11	26
10/11/1999	0.057[d]	1	18	4	11	29
10/18/1999	0.057[d]	15	263	67	176	431
10/25/1999	0.057[d]	11	193	49	124	316
11/01/1999	0.057[d]	1	18	4	12	26
11/15/1999	0.057[d]	3	53	14	35	86
11/22/1999	0.057[d]	1	18	4	12	29
11/29/1999	0.057[d]	1	18	4	11	29
Totals	---	***362***	***7,057***	***577***	***6,196***	***8,368***

[a] Weeks where no rainbow trout/steelhead were captured, are not listed.
[b] Season average efficiency based on valid trials conducted September 1, 1998 through August 31, 1999.
[c] Daily catch was estimated for days the trap was not fishing.
[d] Season average efficiency based on valid trials conducted September 1,1999 through August 31, 2000.
[e] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 13. Weekly summary of juvenile rainbow trout/steelhead passage estimates for January 3, 2000 through February 9, 2001 at the Lower Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 95% confidence intervals (CI). Shaded rows indicate strata where am and pm mark-recapture trials were pooled.

Week[a]	E	Catch[c]	N	SE[e]	Lower[e] 95 % CI	Upper[e] 95% CI
01/07/2000	0.057[b]	5	88	23	56	132
01/24/2000	0.025	3	118	42	66	212
01/31/2000	0.018	6	335	97	204	586
02/07/2000	0.018	3	167	46	107	260
02/14/2000	0.057[b]	16	281	67	187	421
02/21/2000	0.057[b]	3	53	13	35	79
02/28/2000	0.056	6	108	27	68	171
03/06/2000	0.057[b]	14	246	53	164	369
03/13/2000	0.057[b]	25	439	112	282	718
03/20/2000	0.057[b]	34	597	142	398	977
03/27/2000	0.057[b]	34	597	143	398	895
04/03/2000	0.057[b]	51	895	232	576	1,465
04/10/2000	0.072	36	498	128	325	769
04/17/2000	0.053	37	700	147	473	1,073
04/24/2000	0.078	18	230	41	164	328
05/01/2000	0.057[b]	25	439	100	293	718
05/08/2000	0.086	43	500	133	320	800
05/15/2000	0.138	56	406	69	304	558
05/22/2000	0.102	60	590	122	411	848
05/29/2000	0.108	44	408	110	255	680
06/05/2000	0.115	27	234	70	140	401
06/12/2000	0.057[b]	7	123	31	82	201
06/19/2000	0.057[b]	6	105	26	70	172
06/26/2000	0.057[b]	5	88	22	56	144
07/03/2000	0.057[b]	5	88	21	56	144
07/17/2000	0.057[b]	1	18	4	11	29
07/24/2000	0.057[b]	1	18	4	11	29
10/23/2000	0.033[d]	2	61	12	37	88
10/30/2000	0.075[f]	5	67	10	53	92
11/06/2000	0.075[f]	2	27	4	21	38
11/13/2000	0.075[f]	1	13	2	10	19
11/27/2000	0.075[f]	3	40	6	32	55
Totals	---	***584***	***8,577***	***489***	***7,694***	***9,592***

[a] Weeks where no rainbow trout/steelhead were captured, are not listed.
[b] Season average efficiency based on valid trials conducted September 1, 1999 through August 31, 2000.
[c] Daily catch was estimated for days the trap was not fishing.
[d] Season average efficiency is based on a half-cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies were halved for full-cone trials to make all five trials equivalent.
[e] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.
[f] Season average efficiency is based on a full-cone modification of both full and ½ cone trials conducted December 25, 2000 through February 6, 2001. Efficiencies7 were doubled for half-cone trials to make all five trials equivalent.

Table 14. Weekly summary of brood year 1998 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 95% confidence intervals (CI). Only weeks in which fall Chinook salmon were capture are included. Shaded rows indicate weeks where mark-recapture data were pooled to estimate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
10/25/1998	0.042 [a]	1	24	6	16	39
11/30/1998	0.042 [a]	4	94	21	64	144
12/07/1998	0.042 [a]	104	2,453	655	1,608	4,094
12/14/1998	0.109	688	6,317	1,872	3,860	11,581
12/21/1998	0.042 [a]	301	7,100	1,719	4,827	10,861,
12/28/1998	0.092	835	9,105	1,342	6,829	11,589
01/04/1999	0.092	1,488	16,226	2,492	12,170	21,984
01/11/1999	0.092	6,635	72,353	11,534	55,251	98,027
01/18/1999	0.042 [a]	16,886	398,276	99,692	261,114	664,655
01/25/1999	0.042 [a]	4,819	113,668	27,061	77,282	173,886
02/01/1999	0.083	5,025	60,579	15,710	38,944	99,130
02/08/1999	0.012	2,973	241,110	88,143	141,830	482,221
02/15/1999	0.012	1,341	108,455	38,817	63,974	217,510
02/22/1999	0.012	655	53,121	17,442	31,247	106,241
03/01/1999	0.012	739	59,933	23,074	35,255	119,866
03/08/1999	0.078	294	3,767	977	2,511	6,027
03/15/1999	0.076	113	1,496	242	1,093	2,030
03/22/1999	0.040	27	674	159	456	1,088
03/29/1999	0.069	106	1,528	500	965	2,620
04/05/1999	0.058	48	833	188	555	1,281
04/12/1999	0.045	22	487	131	312	779
04/19/1999	0.067	55	825	359	464	1,485
04/26/1999	0.042 [a]	186	4,474	1,046	2,876	7,322
05/03/1999	0.026	271	10,611	3,016	6,270	17,242
05/10/1999	0.015	119	8,179	2,093	5,112	13,632
05/17/1999	0.015	98	6,736	1,733	4,042	10,104
05/24/1999	0.017	84	4,844	2,359	2,906	9,688
05/31/1999	0.017	10	577	196	346	1,153
07/05/1999	0.042 [a]	1	24	6	15	39
07/26/1999	0.042 [a]	2	47	11	32	72
Totals	---	***43,930***	***1,193,916***	***145,138***	***996,588***	***1,546,430***

[a] Season average efficiency based on valid trials conducted December 14, 1998 through June 21, 1999.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 15. Weekly summary of brood year 1999 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 95% confidence intervals (CI). Only weeks in which fall Chinook salmon were capture are included. Shaded rows indicate weeks where mark-recapture data from am and pm releases were pooled to calculate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
12/06/1999	0.049[a]	19	389	90	255	616
12/13/1999	0.049[a]	91	1,863	437	1,264	2,950
12/20/1999	0.049[a]	42	860	217	563	1,362
12/27/1999	0.049[a]	307	6,285	1,406	4,118	9,952
01/03/2000	0.049[a]	582	11,916	2,931	7,807	18,867
01/10/2000	0.089	7,187	73,164	10,049	56,280	96,268
01/17/2000	0.049[a]	3,614	73,992	17,660	48,477	117,154
01/24/2000	0.049[a]	1,088	22,275	5,344	14,594	35,269
01/31/2000	0.049[a]	1,433	29,339	7,256	19,222	46,453
02/07/2000	0.039	426	10,948	2,595	7,299	16,843
02/14/2000	0.020	84	4,284	1,737	2,285	8,568
02/21/2000	0.049[a]	65	1,331	312	872	2,107
02/28/2000	0.049[a]	19	553	131	362	875
03/06/2000	0.049[a]	8	164	37	107	259
03/13/2000	0.049[a]	3	61	15	40	97
03/20/2000	0.049[a]	3	61	15	40	97
03/27/2000	0.049[a]	15	307	69	208	486
04/03/2000	0.049[a]	9	184	42	121	269
04/10/2000	0.049[a]	8	164	40	107	259
04/17/2000	0.051	19	372	102	237	651
04/24/2000	0.037	16	437	138	262	750
05/01/2000	0.049[a]	5	102	24	67	150
05/08/2000	0.033	2	60	20	35	100
05/15/2000	0.049[a]	2	41	10	27	65
Totals	---	***15,047***	***239,152***	***22,847***	***202,274***	***291,194***

[a] Season average efficiency based on valid trials conducted January 1, 2000 through May 22, 2000.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 16. Partial weekly summary of brood year 2000 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 95% confidence intervals (CI). Only weeks in which fall Chinook salmon were capture are included. Total passage is only a partial estimate as the traps were not fished after February 9, 2001.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
9/20/2000	0.066[a]	1	15	2	11	20
11/27/2000	0.066[a]	1	15	2	11	20
12/04/2000	0.066[a]	2	30	5	23	42
12/11/2000	0.066[a]	42	639	97	477	853
12/18/2000	0.066[a]	156	2,374	343	1,834	3,167
12/25/2000	0.066[a]	177	2,694	412	2,045	3,594
01/01/2001	0.128	268	2,099	250	1,669	2,665
01/08/2001	0.063	569	9,062	1,185	7,092	11,651
01/15/2001	0.066[a]	328	4,995	735	3,789	6,659
01/22/2001	0.066[a]	692	10,537	1,550	7,994	14,489
01/29/2001	0.017	186	10,720	3,559	6,207	19,654
02/05/2001	0.066[a]	44	670	97	517	867
Totals	***---***	***2,466***	***43,850***	***4,125***	***37,476***	***54,567***

[a] Season average efficiency based on valid trials conducted December 14, 1998 through June 21, 1999.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 17. Weekly summary of brood year 1998 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 95% confidence intervals (CI). Only weeks in which spring Chinook salmon were captured are included. Shaded rows indicate where weeks where mark-recapture data were pooled to calculate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
11/16/1998	0.042[a]	6	71	37	93	236
11/23/1998	0.042[a]	28	660	153	433	1,010
11/30/1998	0.042[a]	3	71	17	45	108
12/07/1998	0.042[a]	16	377	95	247	630
12/14/1998	0.109	47	432	128	250	791
01/18/1999	0.042[a]	1	24	6	15	39
02/22/1999	0.012	1	81	38	48	162
03/15/1999	0.076	1	13	2	10	18
03/29/1999	0.069	12	173	51	104	297
04/05/1999	0.058	5	87	120	58	133
04/12/1999	0.045	1	22	6	15	35
04/19/1999	0.067	11	165	58	93	297
04/26/1999	0.042[a]	78	1,876	473	1,202	3,070
05/03/1999	0.026	13	509	150	315	827
05/10/1999	0.015	3	206	47	129	309
07/12/1999	0.042[a]	1	24	5	16	36
Totals	---	***227***	***4,791***	***565***	***3,949***	***6,204***

[a] Season average efficiency based on valid trials conducted December 14, 1998 through June 21, 1999.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 18. Weekly summary of brood year 1999 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 95% confidence intervals (CI). Only weeks in which spring Chinook salmon were capture are included. Shaded rows indicate weeks where mark-recapture data from am and pm releases were pooled to calculate passage.

Week	E	Catch[b]	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
10/19/1999	0.049[a]	1	20	5	13	32
11/30/1999	0.049[a]	4	82	18	54	130
12/06/1999	0.049[a]	11	225	54	148	357
12/13/1999	0.049[a]	4	82	20	54	130
01/24/2000	0.049[a]	3	61	14	42	97
01/31/2000	0.049[a]	1	20	5	13	32
02/14/2000	0.020	6	306	115	163	612
02/21/2000	0.049[a]	18	369	87	241	584
02/28/2000	0.049[a]	19	389	95	255	616
03/06/2000	0.049[a]	8	164	39	107	259
03/13/2000	0.049[a]	3	61	15	40	97
03/20/2000	0.049[a]	6	123	31	80	195
03/27/2000	0.049[a]	22	450	112	306	713
04/03/2000	0.049[a]	22	450	110	295	713
04/10/1999	0.049[a]	32	655	163	455	1,037
04/17/2000	0.051	96	1,879	521	1,096	3,288
04/24/2000	0.037	25	683	227	390	1,367
05/01/2000	0.049[a]	8	164	37	111	259
05/08/2000	0.033	1	30	5	17	60
05/15/2000	0.049[a]	1	20	5	13	32
Totals	**---**	***291***	***6,233***	***622***	***5,225***	***7,678***

[a] Season average efficiency based on valid trials conducted January 10, 2000 through May 22, 2000.
[b] Daily catch was estimated for days the trap was not fishing.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 19. Weekly summary of juvenile rainbow trout/steelhead passage estimates for September 1, 1998 through January 2, 1999 at the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 95% confidence intervals (CI). Shaded rows indicate adjacent strata where mark-recapture data were pooled to calculate passage.

Week[a]	E	Catch[c]	N	SE[e]	Lower[e] 95 % CI	Upper[e] 95% CI
09/14/1998	0.042 [b]	1	24	6	15	39
11/09/1998	0.042 [b]	1	24	6	15	36
12/21/1998	0.042 [b]	4	96	24	62	157
01/18/1999	0.042 [b]	2	48	12	30	79
01/25/1999	0.042 [b]	1	24	6	15	36
02/01/1999	0.083	1	12	3	8	20
02/22/1999	0.012	2	162	57	95	324
03/01/1999	0.012	4	324	114	191	649
03/15/1999	0.076	1	13	2	7	17
03/22/1999	0.040	6	150	35	101	242
04/05/1999	0.058	4	69	18	46	107
04/12/1999	0.045	4	89	25	57	142
04/19/1999	0.067	4	60	21	34	108
04/26/1999	0.042 [b]	1	24	6	16	39
05/03/1999	0.026	8	313	90	185	509
05/10/1999	0.015	9	619	152	387	928
05/17/1999	0.015	17	1,168	306	730	1,947
05/24/1999	0.017	29	1,672	543	1,003	2,867
05/31/1999	0.017	37	2,134	713	1,280	3,658
06/07/1999	0.042[b]	21	505	125	337	827
06/14/1999	0.042[b]	35	842	201	541	1,377
06/21/1999	0.042[b]	20	481	112	309	787
06/28/1999	0.042[b]	10	241	56	160	361
07/05/1999	0.042[b]	12	289	69	192	472
07/12/1999	0.042[b]	3	72	18	46	118
07/26/1999	0.042[b]	1	24	6	16	36
08/09/1999	0.042[b]	1	24	6	15	39
08/16/1999	0.042[b]	1	24	5	16	36
08/23/1999	0.042[b]	1	24	6	16	39
09/06/1999	0.049[d]	1	20	5	13	32
09/13/1999	0.049[d]	2	41	10	28	65
09/27/1999	0.049[d]	1	20	5	13	32
10/04/1999	0.049[d]	1	20	5	13	32
10/11/1999	0.049[d]	2	41	10	27	65
10/25/1999	0.049[d]	23	471	106	320	688
11/01/1999	0.049[d]	2	41	9	27	65
11/08/1999	0.049[d]	1	20	5	13	32
11/15/1999	0.049[d]	6	123	29	83	195
11/22/1999	0.049[d]	1	20	5	13	32
11/29/1999	0.049[d]	1	20	5	14	32
Totals	*---*	***282***	***10,388***	***1,021***	***8,810***	***12,976***

[a] Weeks in which no rainbow trout/steelhead were captured, are not listed.
[b] Season average efficiency based on valid trials conducted September 1, 1998 through August 31, 1999.
[c] Daily catch was estimated for days the trap was not fishing.
[d] Season average efficiency based on valid trials conducted September 18, 1999 through August 31, 2000.
[e] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.

Table 20. Weekly summary of juvenile rainbow trout/steelhead passage estimates for January 3, 2000 through February 9, 2001 at the Upper Battle Creek rotary screw trap, including week, efficiency (E), catch, estimated passage (N), standard error (SE), and the 95% confidence intervals (CI). Shaded rows indicate strata where am and pm mark-recapture trials were pooled.

Week [a]	E	Catch	N	SE[c]	Lower[c] 95 % CI	Upper[c] 95% CI
01/03/2000	0.049[b]	1	20	5	13	32
01/10/2000	0.098	21	214	30	164	281
01/17/2000	0.049[b]	34	696	159	472	1,102
01/24/2000	0.049[b]	2	41	10	27	65
01/31/2000	0.049[b]	4	82	18	56	130
02/07/2000	0.039	4	103	25	69	158
02/14/2000	0.020	18	918	374	490	1,836
02/21/2000	0.049[b]	13	266	63	181	421
02/28/2000	0.049[b]	14	287	69	188	454
03/06/2000	0.049[b]	76	1,556	361	1,056	2,464
03/13/2006	0.049[b]	381	7,800	1769	5,111	11,401
03/20/2000	0.049[b]	231	4,729	1098	3,099	6,912
03/27/2006	0.049[b]	98	2,006	498	1,315	3,177
04/03/2006	0.049[b]	16	328	87	222	519
04/10/2006	0.049[b]	20	409	103	268	648
04/17/2000	0.051	32	626	191	381	1,096
04/24/2006	0.037	23	629	214	377	1,078
05/01/2000	0.049[b]	22	450	105	295	713
05/08/2000	0.033	32	957	323	532	1,914
05/15/2000	0.049[b]	36	737	171	483	1,167
05/22/2000	0.049[b]	71	1,454	321	986	2,125
05/29/2000	0.049[b]	26	532	112	361	843
06/05/2000	0.049[b]	14	287	68	195	454
06/12/2000	0.049[b]	3	61	15	40	97
06/19/2000	0.049[b]	3	61	15	40	97
06/26/2000	0.049[b]	2	41	10	28	65
07/03/2000	0.049[b]	2	41	10	27	65
07/10/2000	0.049[b]	1	20	5	13	32
07/17/2000	0.049[b]	2	41	10	27	65
07/24/2000	0.049[b]	2	41	9	27	65
08/21/2000	0.049[b]	1	20	5	13	32
09/11/2000	0.066[d]	2	30	4	23	41
09/18/2000	0.066[d]	1	15	2	11	20
09/25/2000	0.066[d]	1	15	2	12	20
10/09/2000	0.066[d]	2	30	4	23	41
10/16/2000	0.066[d]	1	15	2	12	20
10/23/2000	0.066[d]	1	15	2	12	20
10/30/2000	0.066[d]	5	76	11	58	102
11/06/2000	0.066[d]	1	15	2	12	21
11/13/2000	0.066[d]	1	15	2	12	21
12/18/2000	0.066[d]	1	15	2	12	21
01/08/2001	0.063	1	16	2	12	21
Totals	*---*	***1,222***	***25,710***	***2,326***	***21,865***	***30,713***

[a] Weeks in which no rainbow trout/steelhead were captured, are not listed.
[b] Season average efficiency based on valid trials conducted September 1, 1999 through August 31, 2000.
[c] The standard errors and 95% confidence intervals were calculated using the percentile bootstrap method.
[d] Season average efficiency based on valid trials conducted September 1, 2000 through February 9, 2001.

Table 21. Summary of fall, late-fall, and spring Chinook salmon and rainbow trout/steelhead juvenile passage estimates at the Lower and Upper Battle Creek rotary screw traps including run designation, brood year, original CAMP estimate, 2006 estimate (N), and the 95% confidence intervals for the 2006 estimates.

Run	Brood Year	Original CAMP Estimates[c]	2006 Estimates	2006 Lower 95% CI	2006 Upper 95% CI
LBC					
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
Late-fall	1999	113,684	86,305	72,258	98,591
	2000	99,803	86,940	73,793	106,967
RBT/Steelhead	1999[b]	---	7,057	6,196	8,368
	2000[b]	---	8,417	7,699	9,608
UBC					
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
Spring	1998	4,589	4,791	3,949	6,204
	1999	10,061	6,233	5,225	7,678
RBT/Steelhead	1999[b]	---	10,388	8,810	12,976
	2000[b]	---	25,710	21,865	30,713

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

[b] Rainbow trout 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.

[c] The original CAMP estimates cover the period January 1 through December 31; therefore, they may not include the entire brood year.

Figures

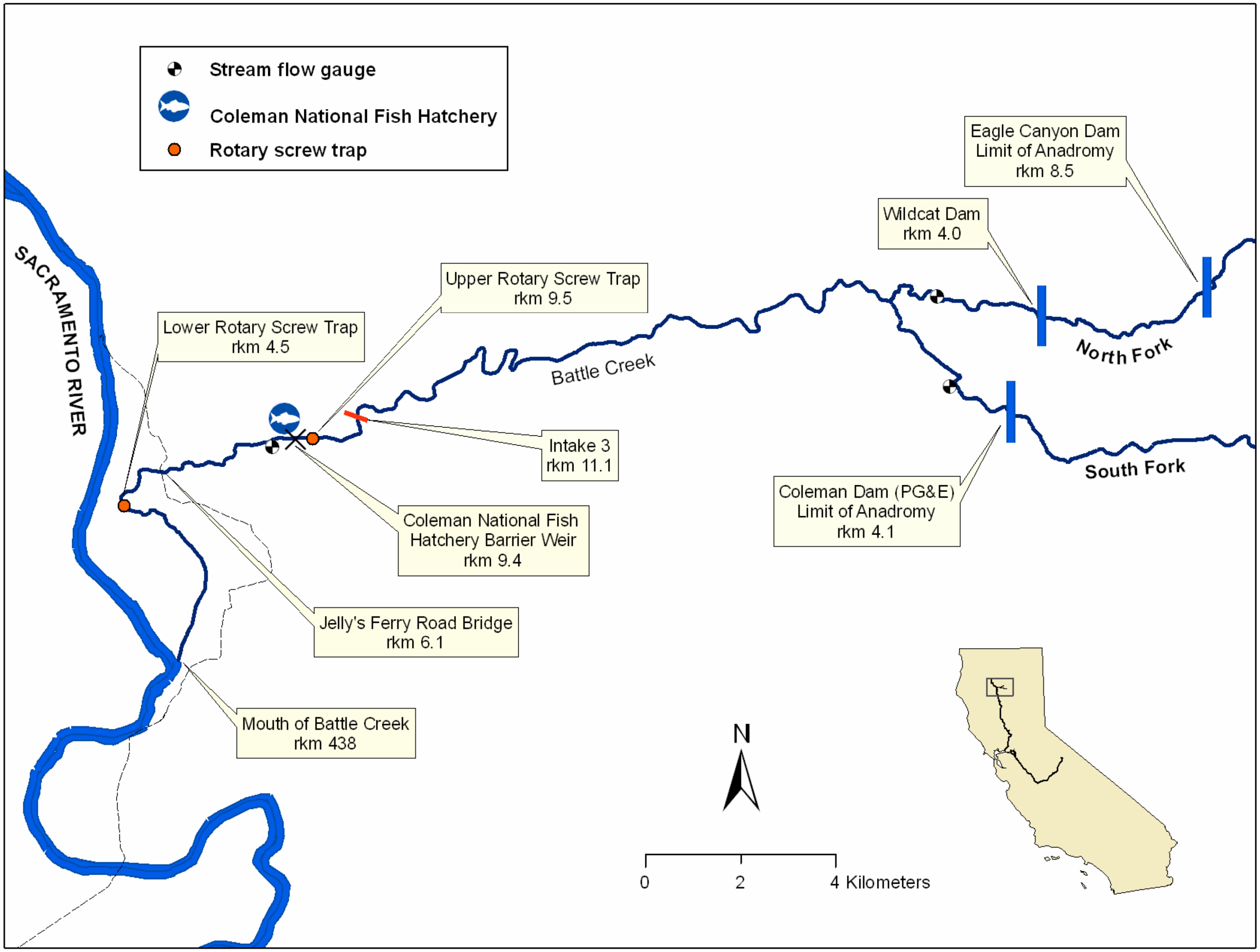


Figure 1. Map of Battle Creek depicting the location of USFWS' rotary screw traps and other important features.

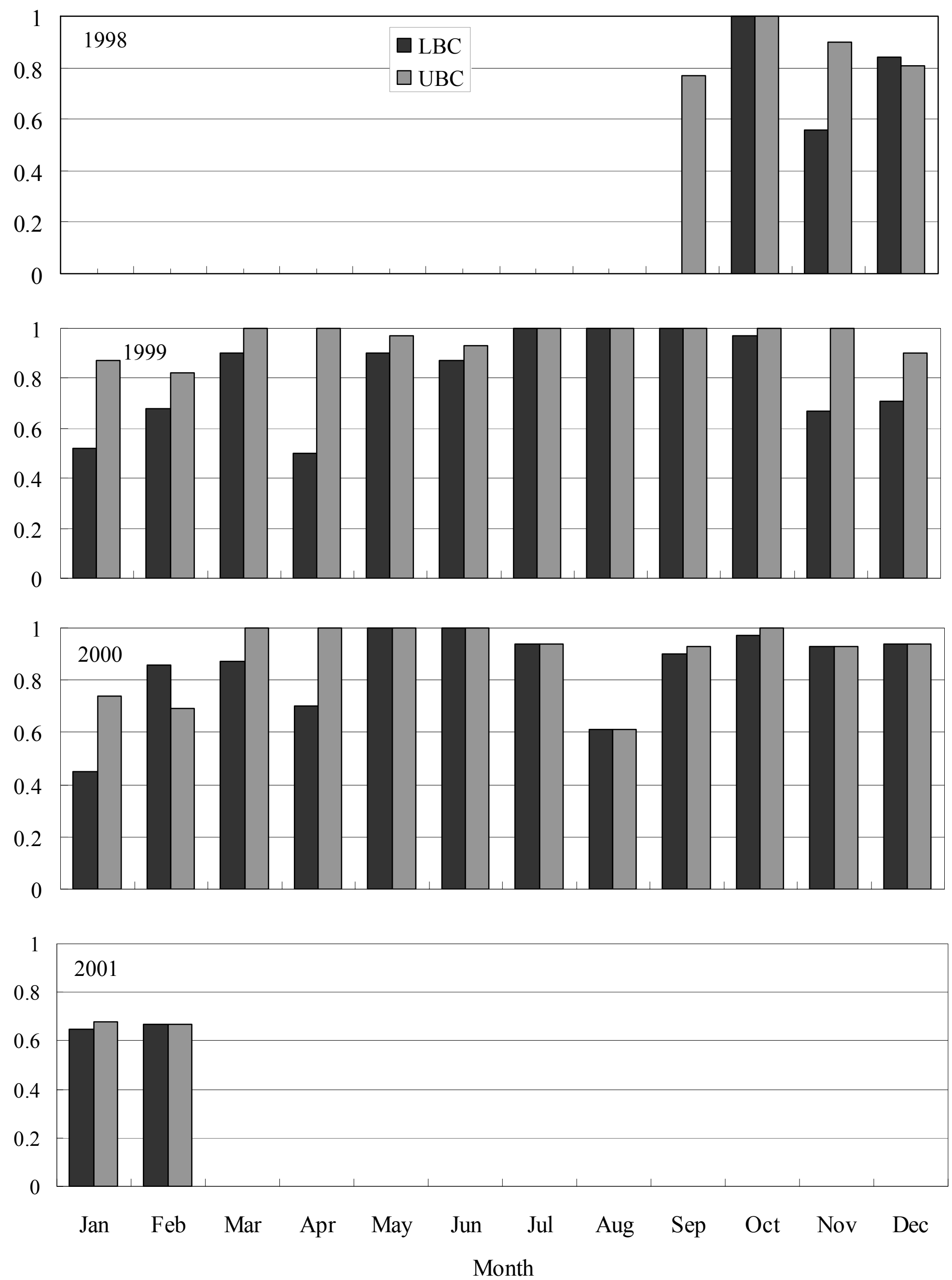


Figure 2. Sampling effort summarized as the proportion (range: 0 to 1) of days fished each month at the Upper and Lower Battle Creek rotary screw traps from September 1, 1998 to February 9, 2001.

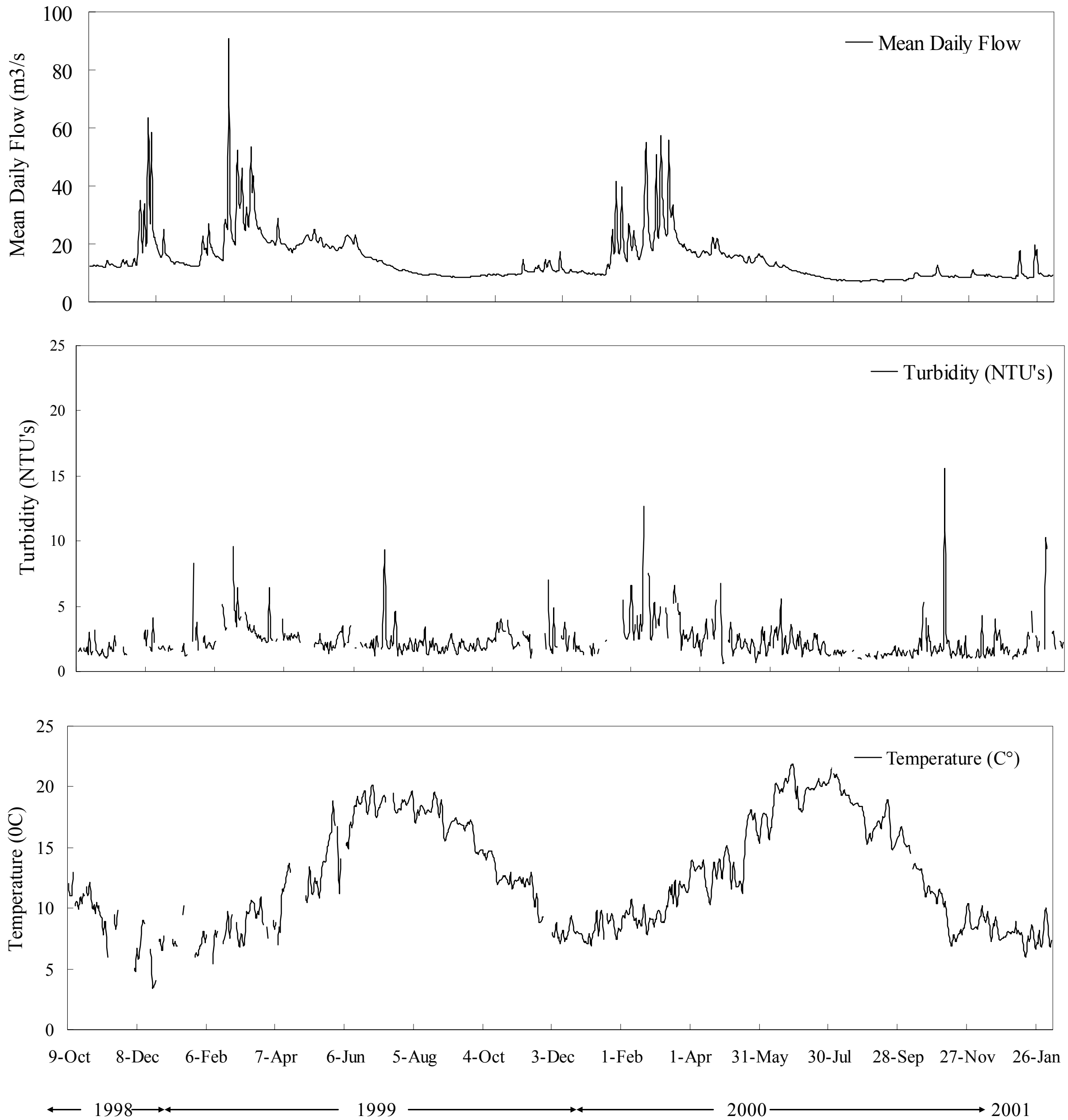


Figure 3. Mean daily flows (m^3/s), turbidity (NTU's), and mean daily temperature (ºC) at the Lower Battle Creek rotary screw trap from October 9, 1998 through February 9, 2001.

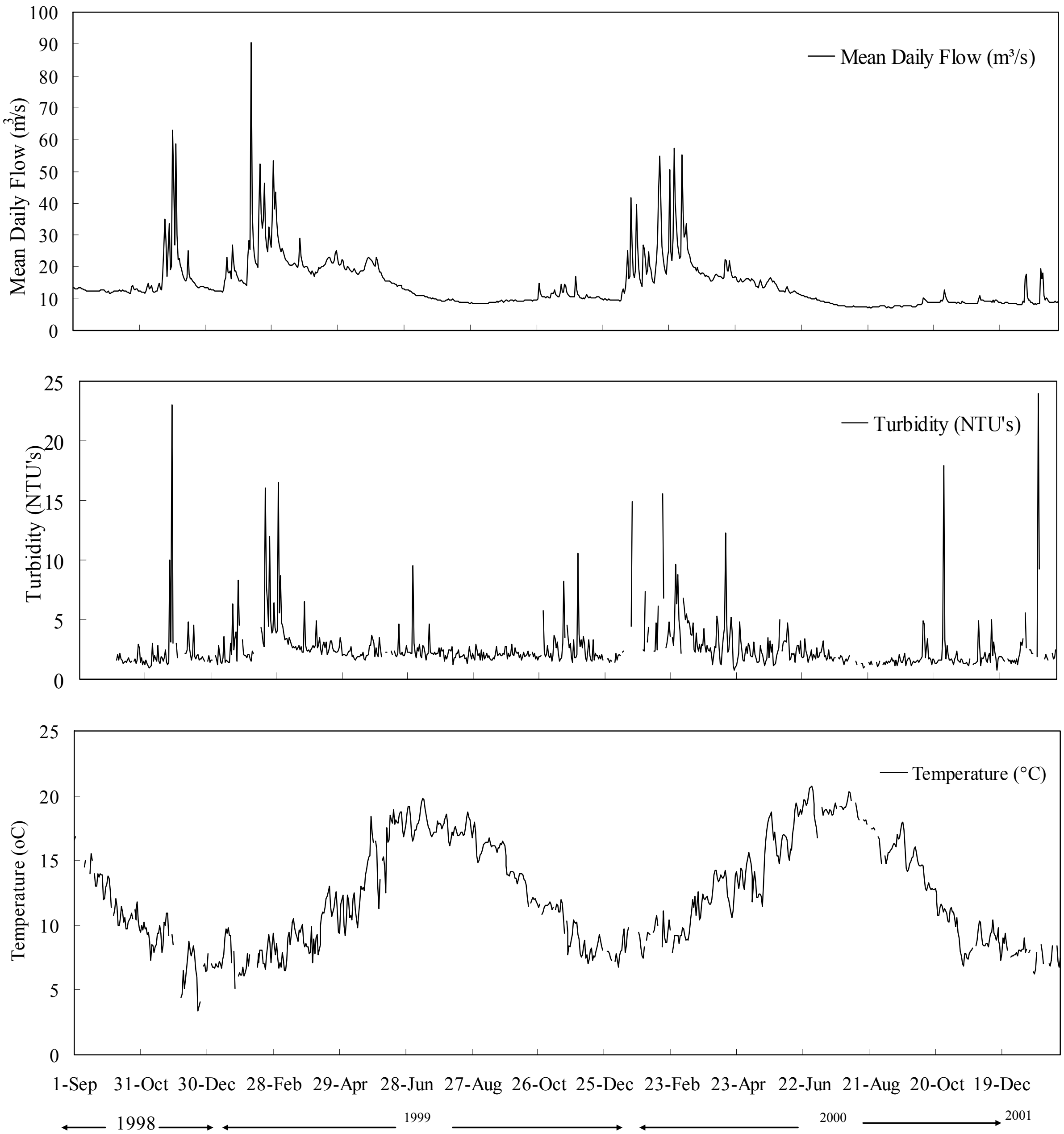


Figure 4. Mean daily fows (m^3/s), turbidity (NTU's), and mean daily temperature at the Upper Battle Creek rotary screw trap from September 1, 1998 through February 9, 2001.

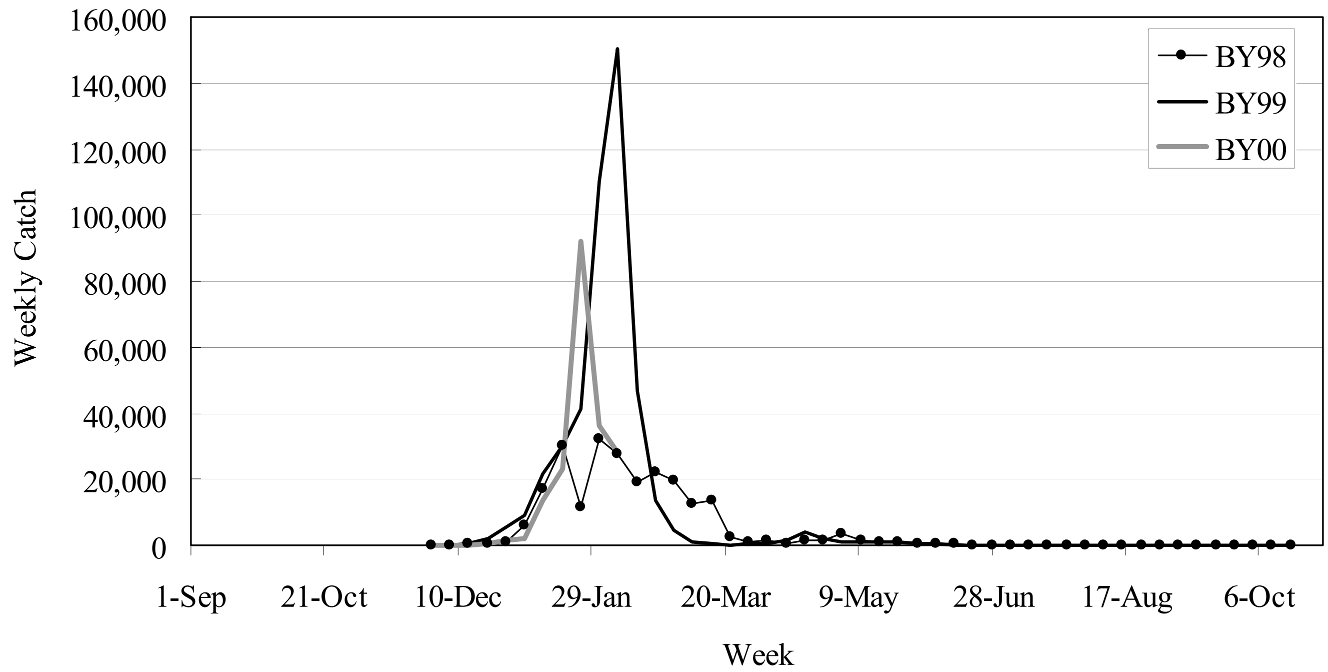


Figure 5. Weekly catch of fall Chinook salmon at the Lower Battle Creek rotary screw trap for brood years 1998, 1999, and 2000.

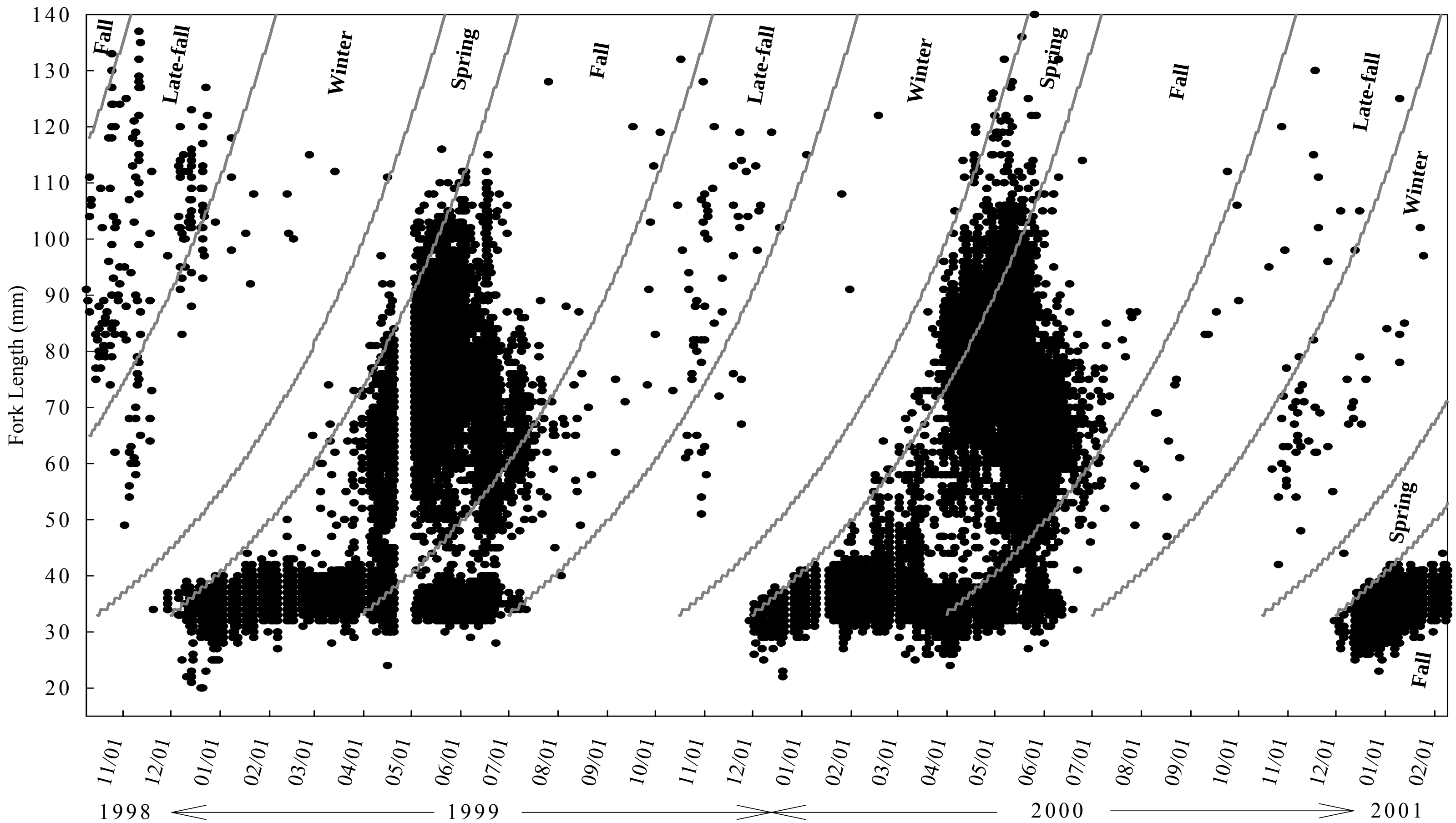


Figure 6. Fork length (mm) distribution by date and run for Chinook salmon captured at the Lower Battle Creek rotary screw trap from October 9, 1998 to February 9, 2001. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992).

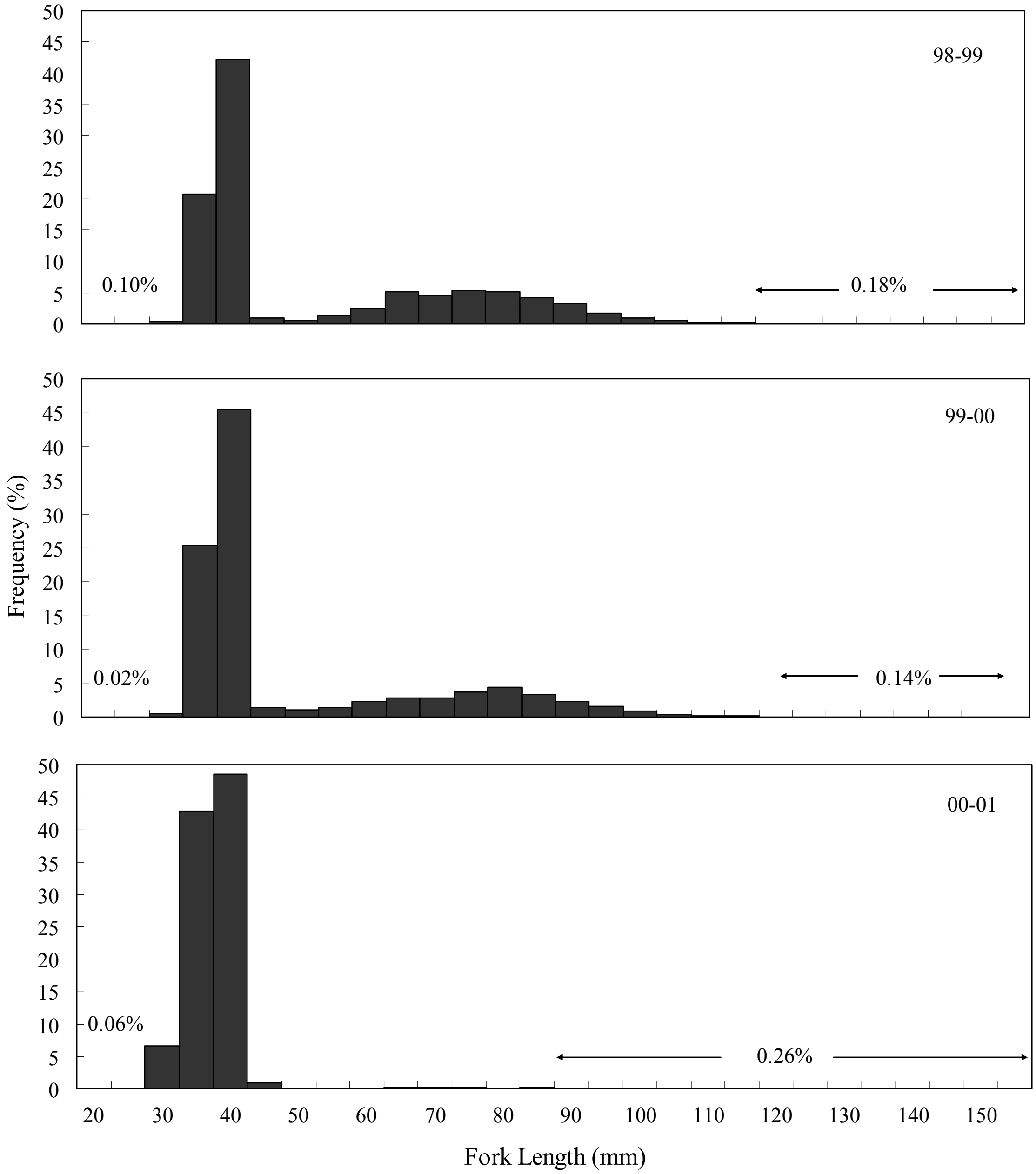


Figure 7. Chinook salmon length frequency (%) at the Lower Battle Creek rotary screw trap for the periods October 9, 1998 to August 31, 1999 (98-99), September 1, 1999 to August 31, 2000 (99-00), and September 1, 2000 to February 9, 2001. Fork length axis labels on the lower graph indicate the upper limit of a 5-mm length range.

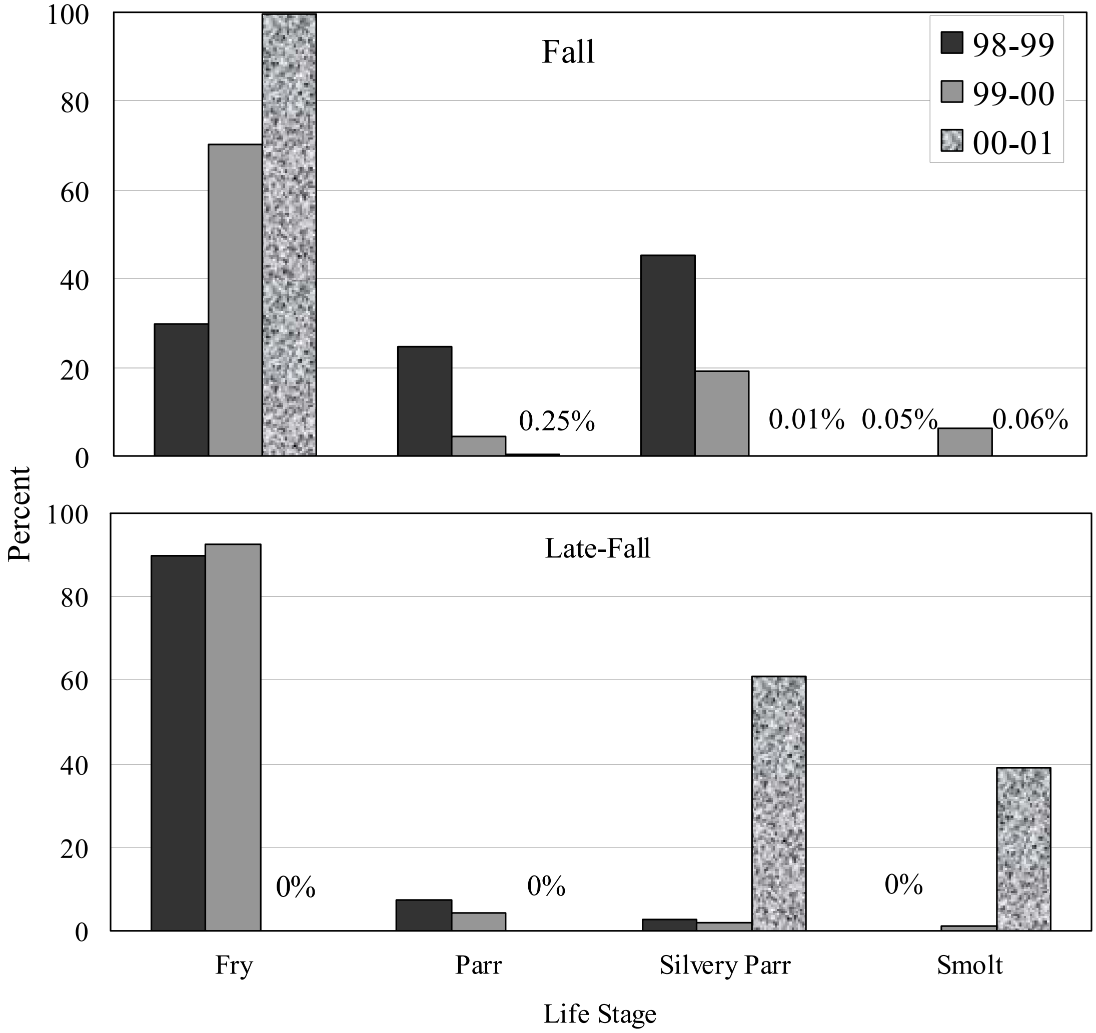


Figure 8. Life-stage composition of fall and late-fall Chinook salmon sampled at the Lower Battle Creek rotary screw trap during October 9, 1998 to February 9, 2001. The length-at-date criteria developed by Greene (1992) were used to assign run designation and overlap between runs may have reduced the accuracy of life-stage composition.

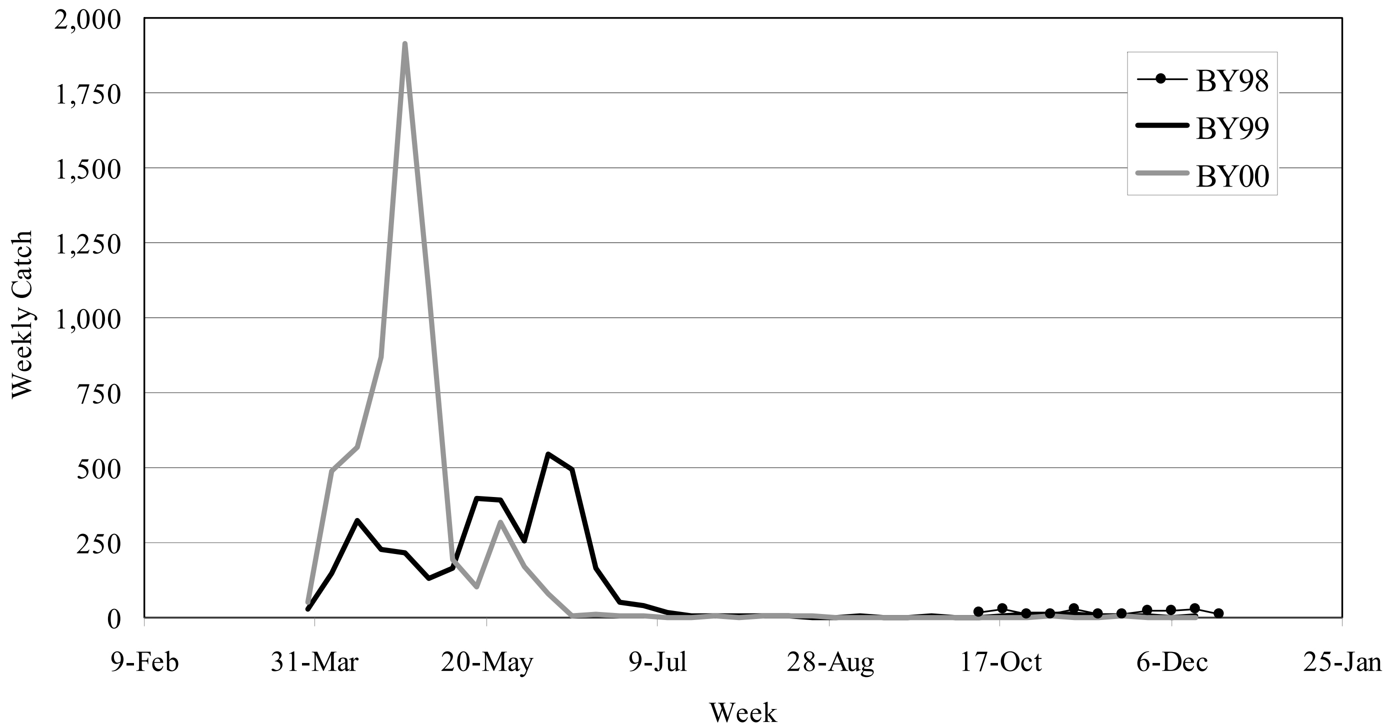


Figure 9. Weekly catch of late-fall Chinook salmon at the Lower Battle Creek rotary screw trap for brood years 1998, 1999, and 2000.

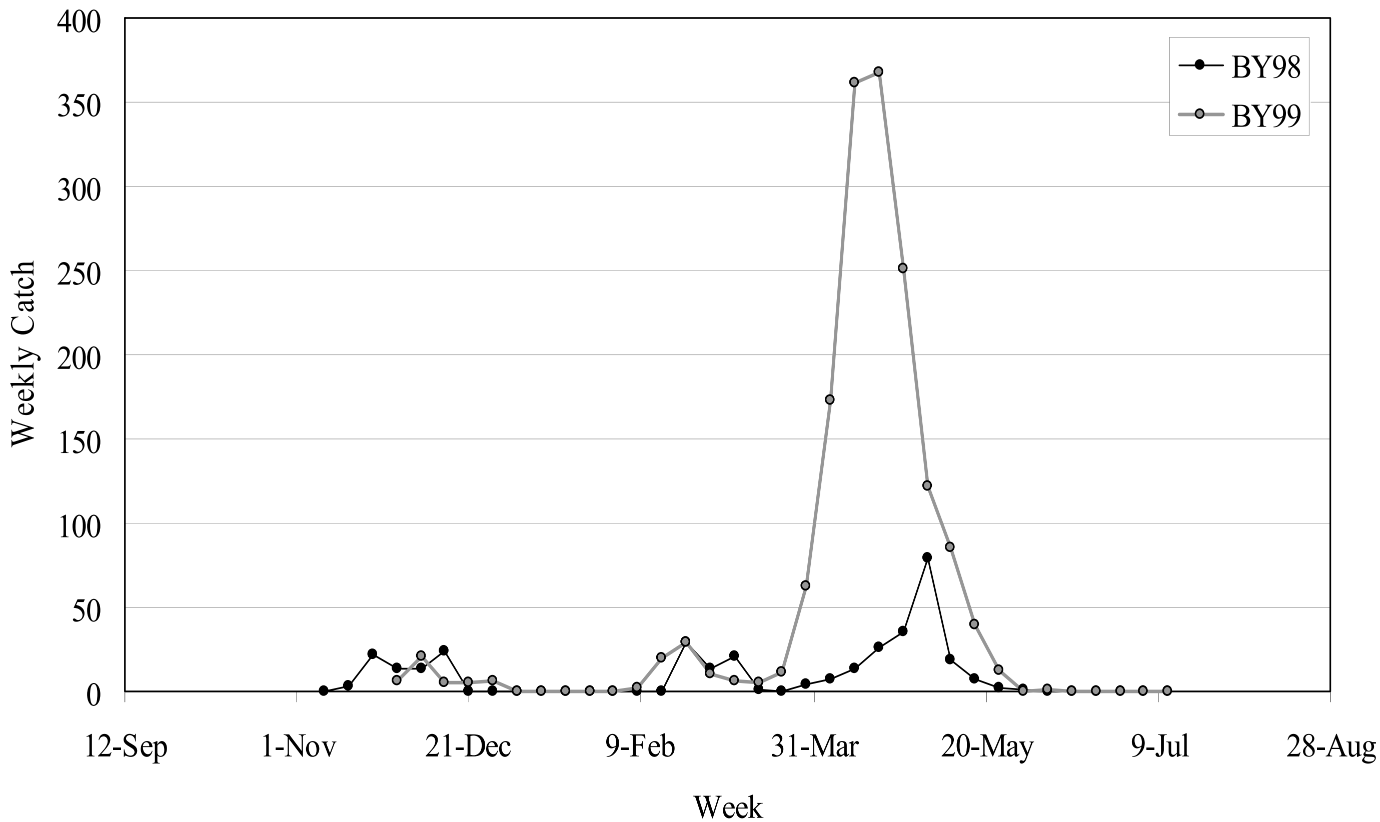


Figure 10. Weekly catch of spring Chinook salmon at the Lower Battle Creek rotary screw trap from October 9, 1998 through February 9, 2001. Brood year 2001 is not included because only eleven fish were caught during the period September 1, 2000 through February 9, 2001 with only eleven fish being caught.

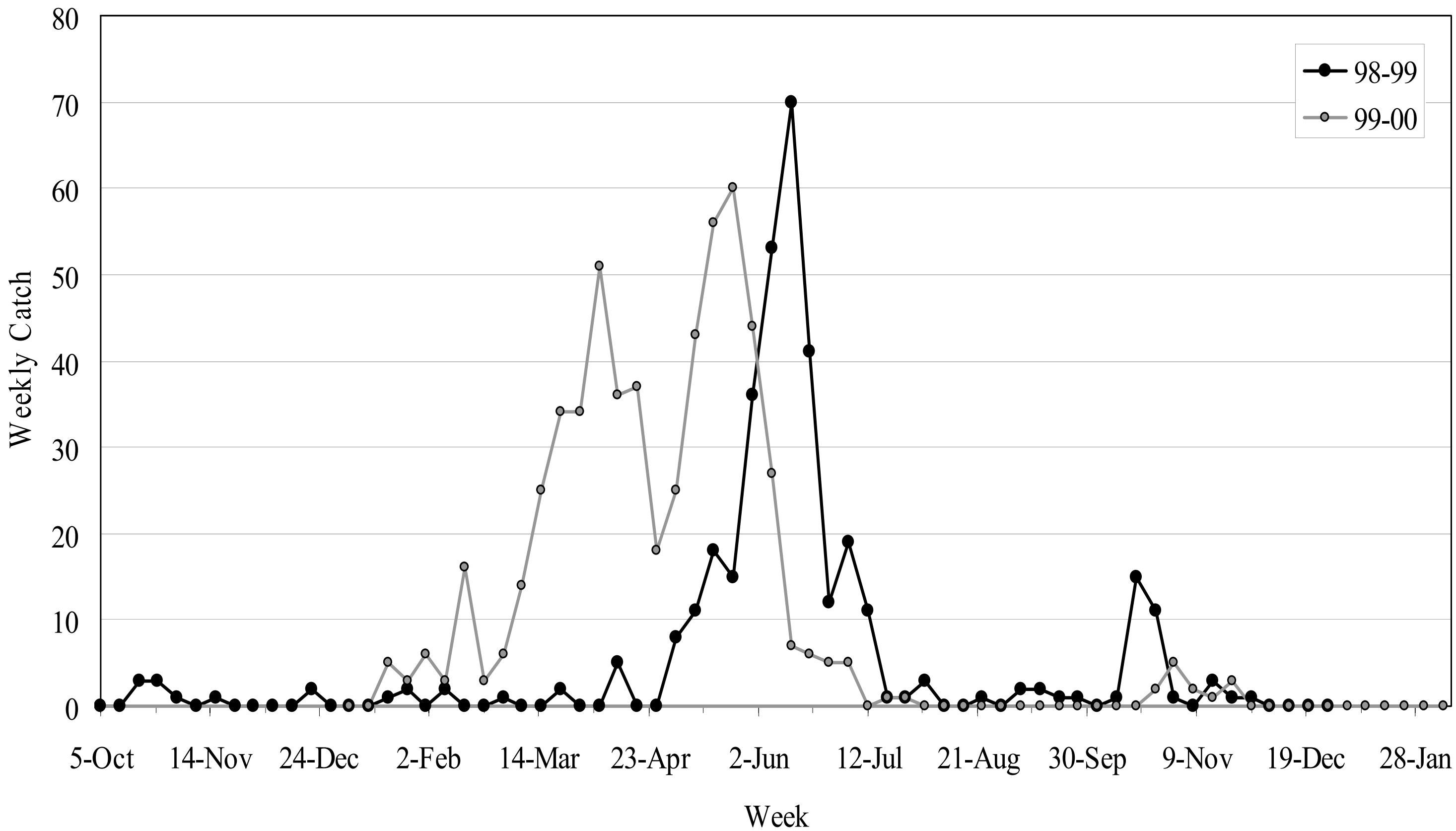


Figure 11. Estimated juvenile rainbow trout/steelhead weekly passage at the Lower Battle Creek rotary screw trap for the periods October 9, 1998 to December 31, 1999 (98-99), and January 1, 2000 through February 9, 2001 (00-01).

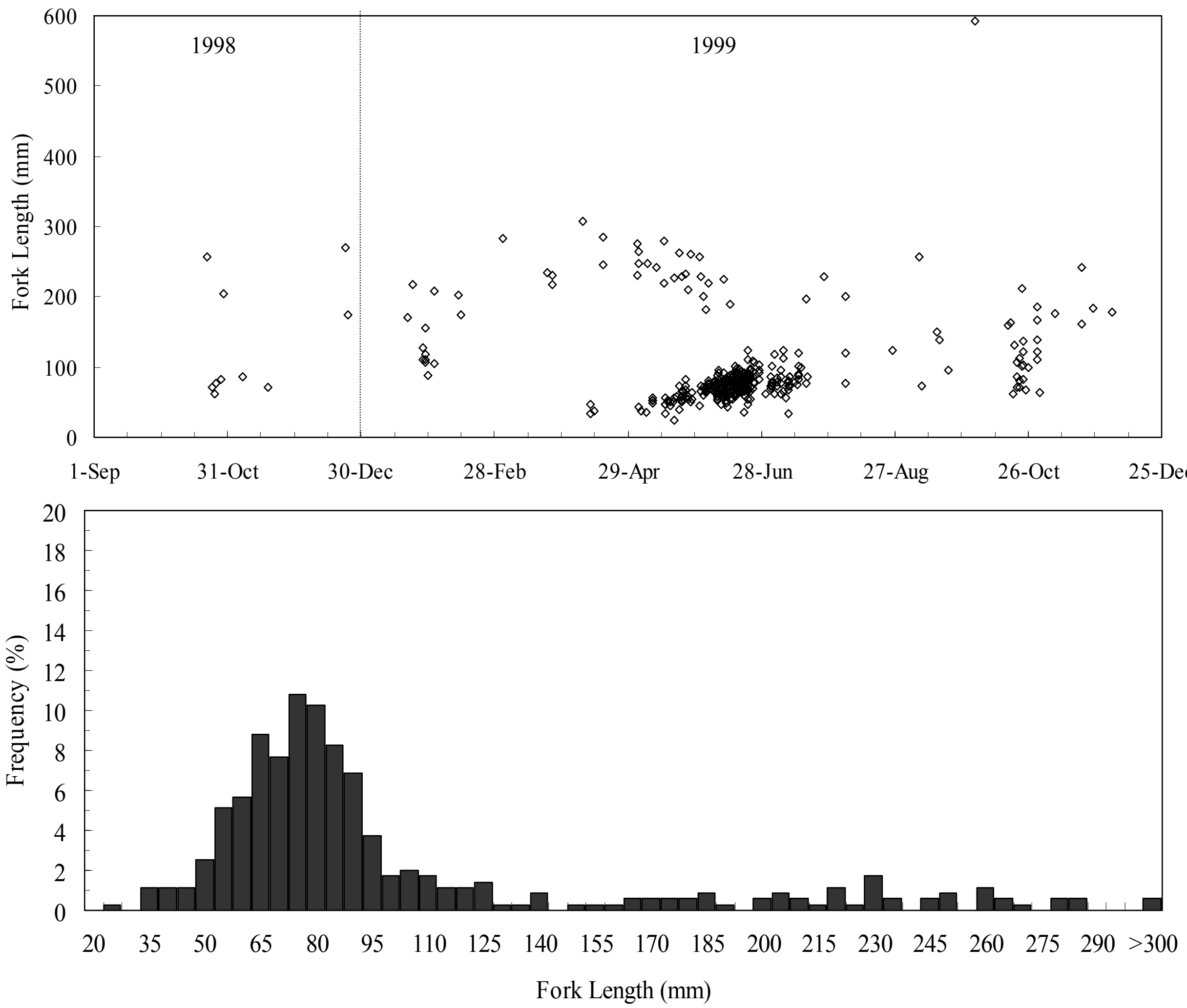


Figure 12. Fork length (mm) distribution and length frequency (%) for rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during October 9, 1998 through December 31, 1999. Fork length axis labels on the lower graph indicate the upper limit of a 5-mm length range.

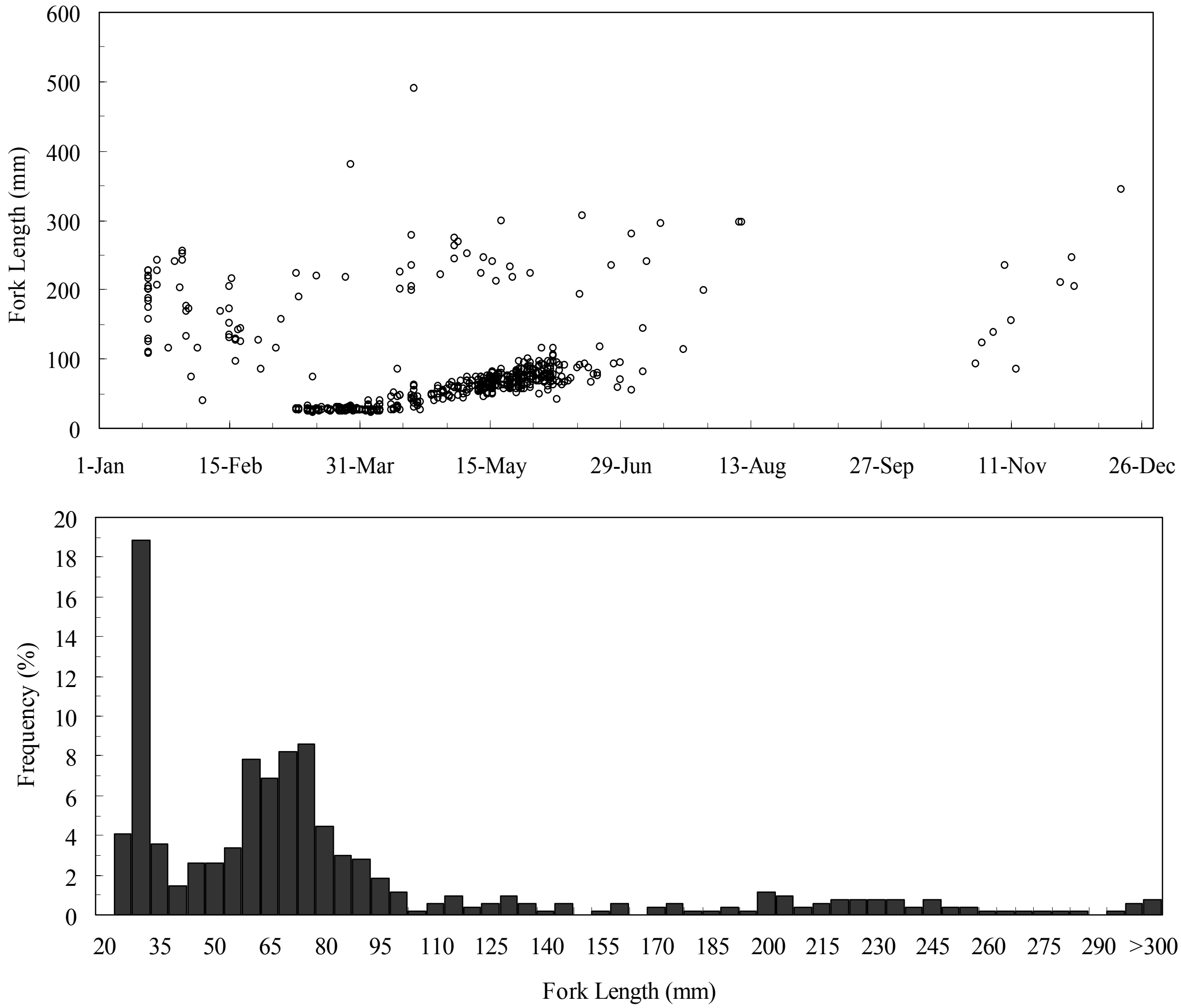


Figure 13. Fork length (mm) distribution (upper) and length frequency (%; lower) for rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap during January 1 through December 31, 2000. Fork length axis labels on the lower graph indicate the upper limit of a 5-mm length range.

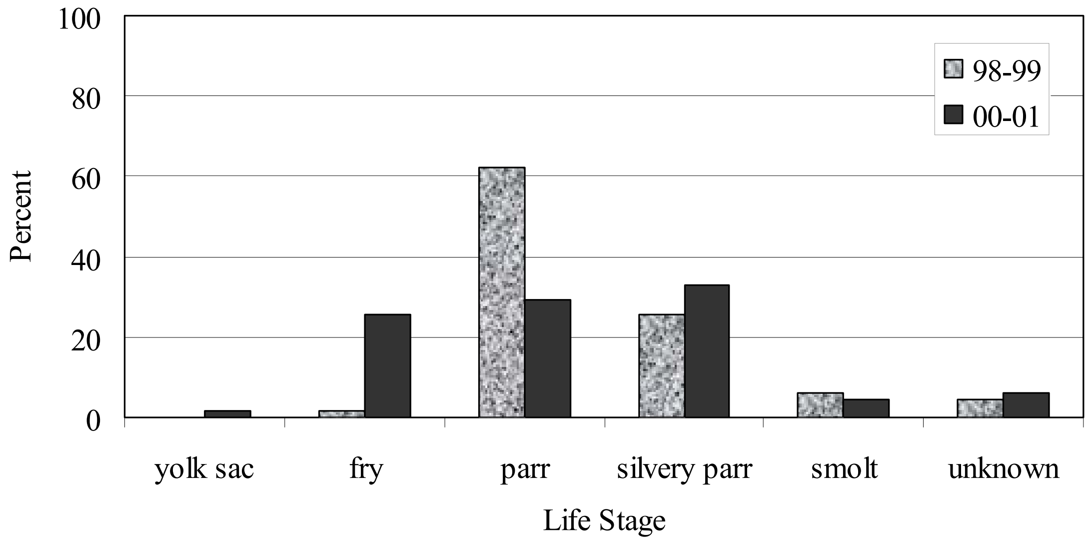


Figure 14. Life-stage composition of rainbow trout/steelhead sampled at the Lower Battle Creek rotary screw trap from for the periods October 9, 1998 to December 31, 1999 and January 1, 2000 to February 9, 2001.

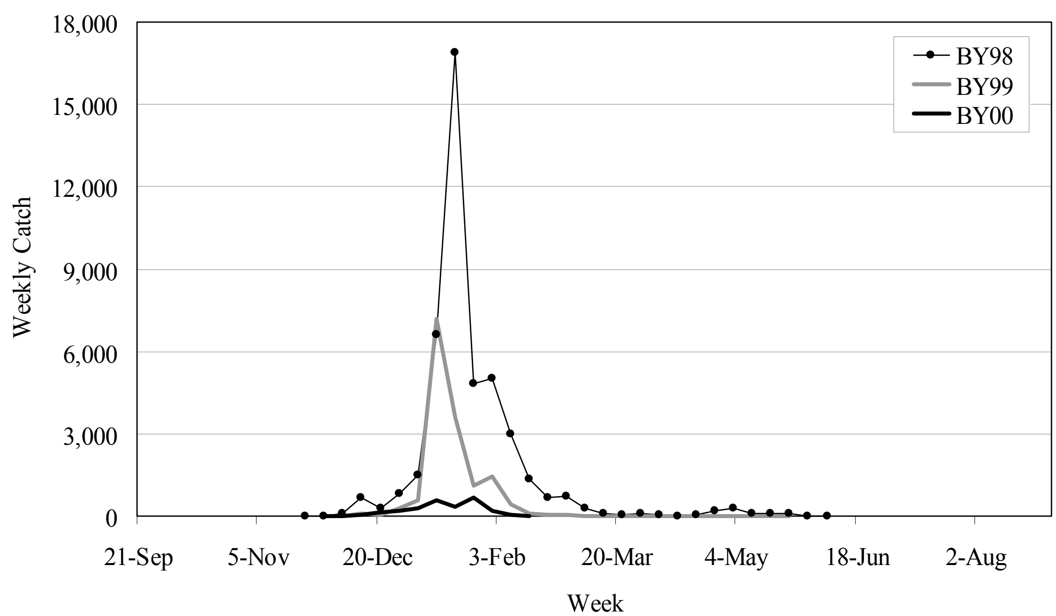


Figure 15. Weekly catch of fall Chinook salmon at the Upper Battle Creek rotary screw trap for brood years 1998, 1999, and 2000.

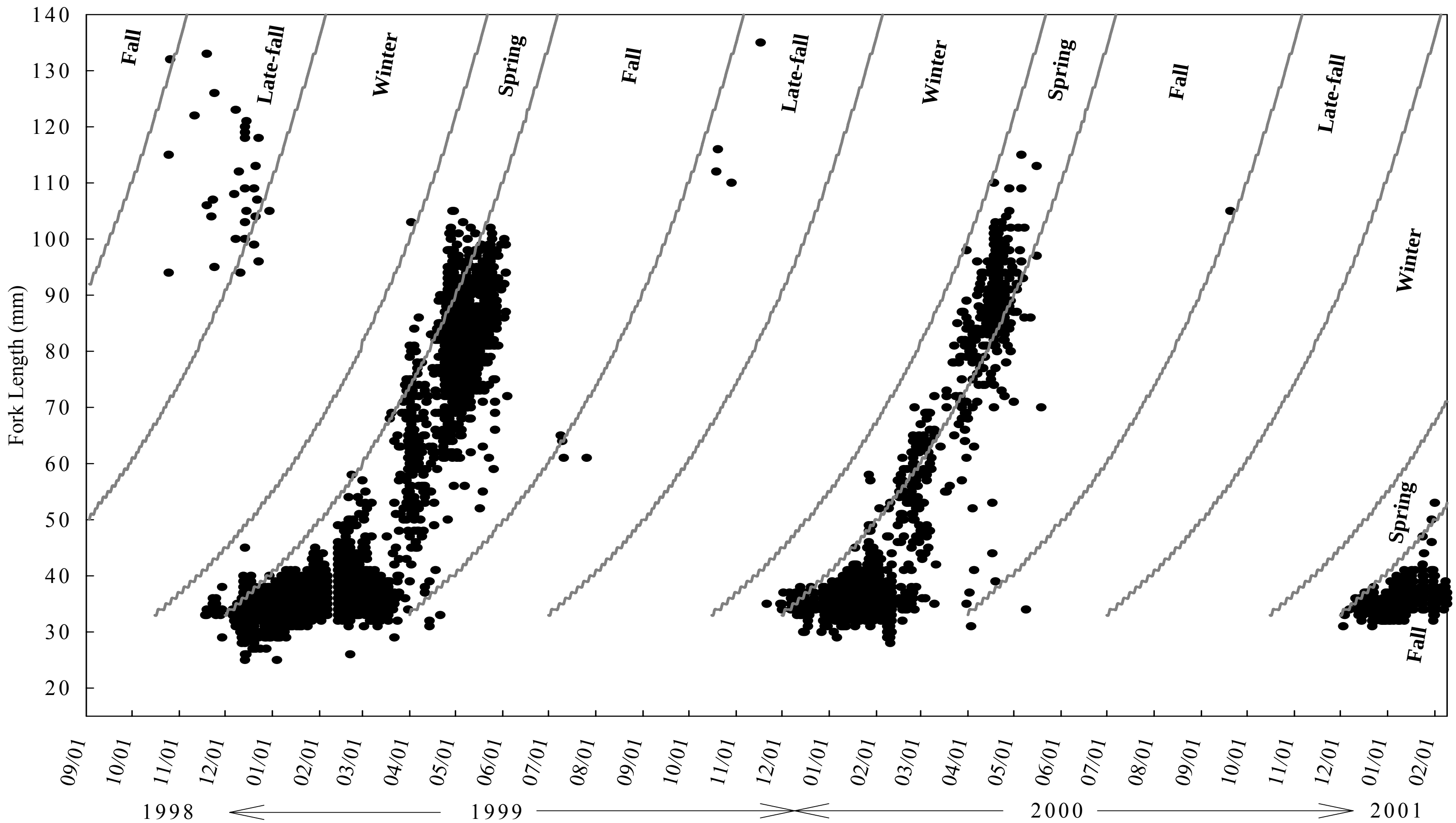


Figure 16. Fork length (mm) distribution by date and run for Chinook salmon captured at the Upper Battle Creek rotary screw trap from September 1, 1998 to February 9, 2001. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992).

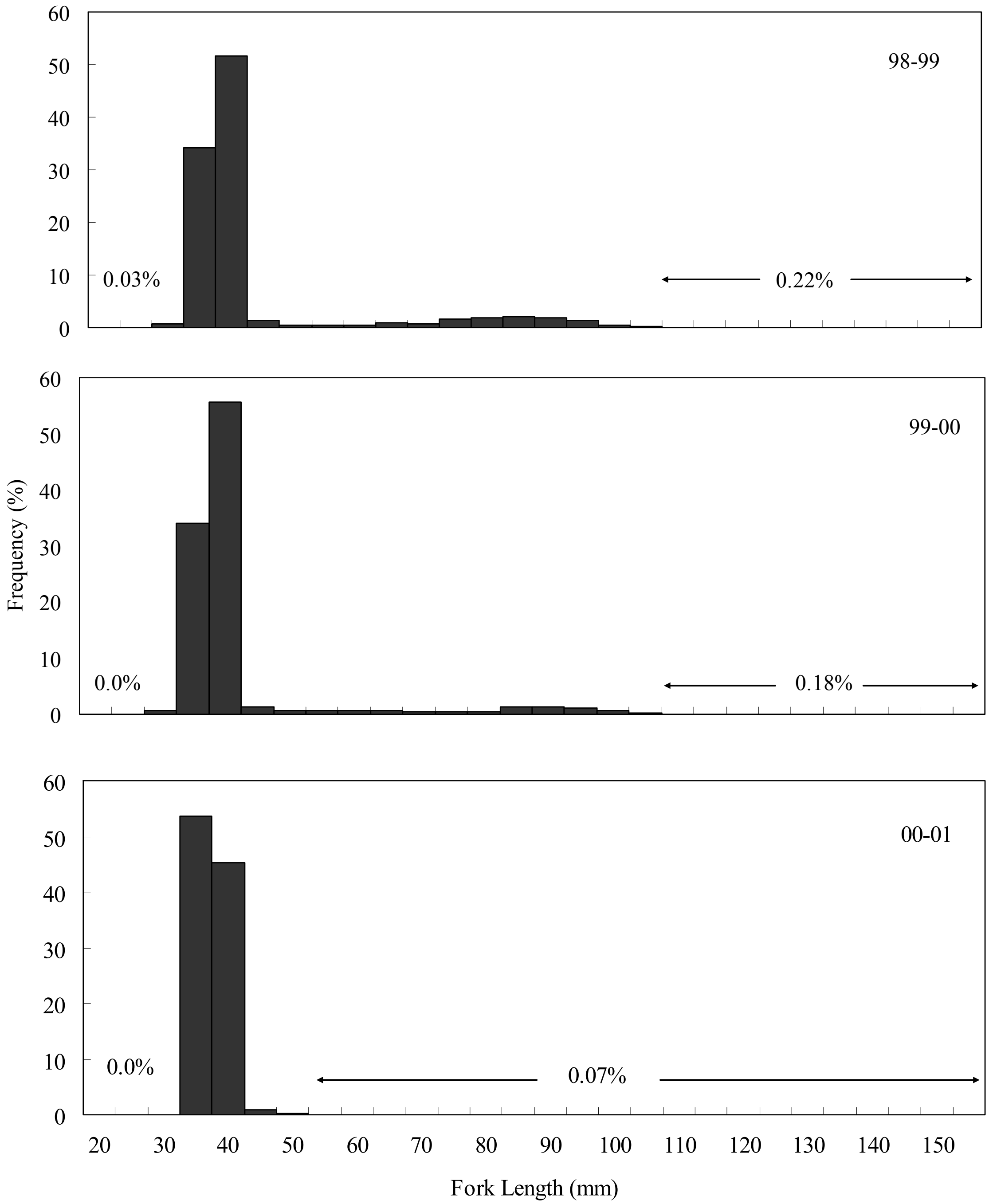


Figure 17. Chinook salmon length frequency (%) at the Upper Battle Creek rotary screw trap for the periods September 1, 1998 to August 31, 1999 (98-99), September 1, 1999 to August 31, 2000 (99-00), and September 1, 2000 to February 9, 2001 (00-01).

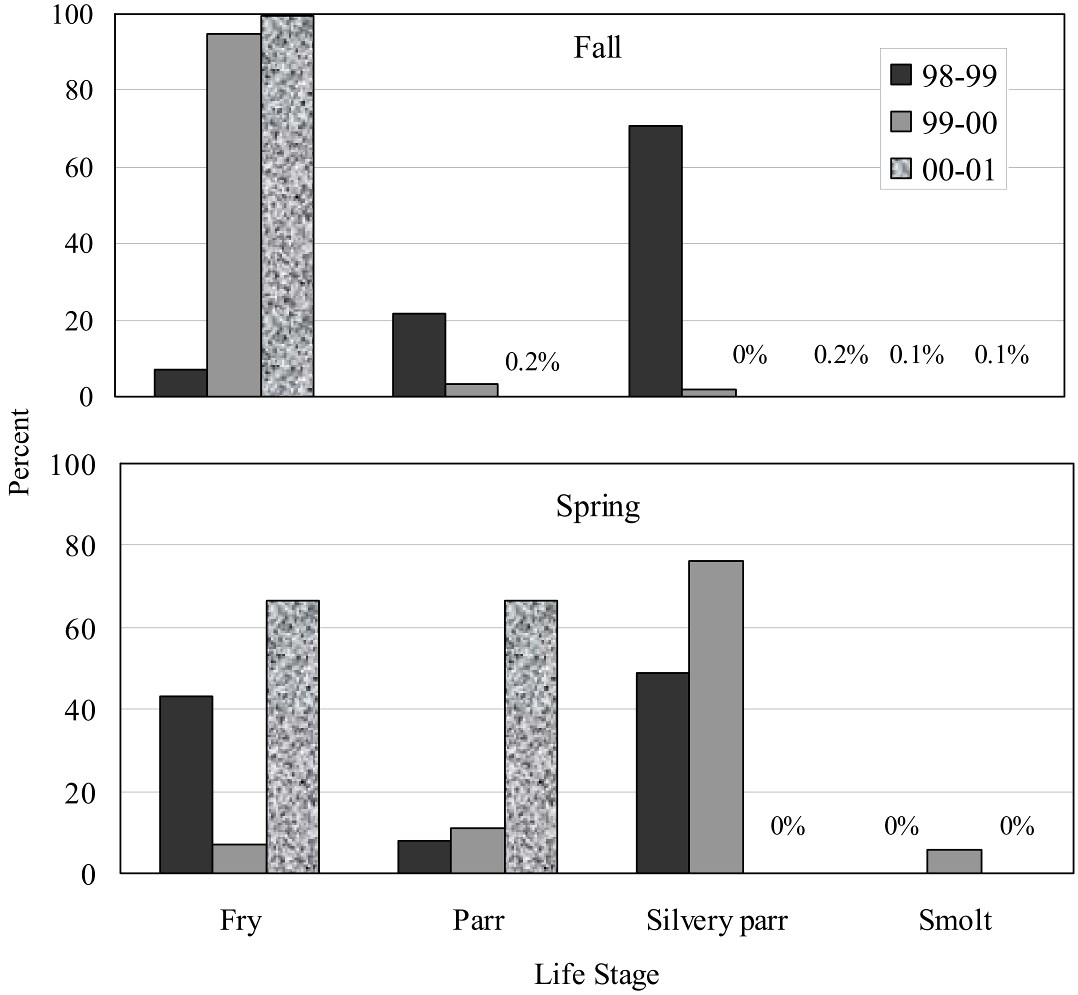


Figure 18. Life-stage composition for fall and spring Chinook salmon captured at the Upper Battle Creek rotary screw trap during the periods September 1, 1998 to August 31, 1999, September 1, 1999 to August 31, 2000, and September 1, 2000 to February 9, 2001. Late-fall and winter Chinook life-stage composition is not included as very few were captured at the trap.

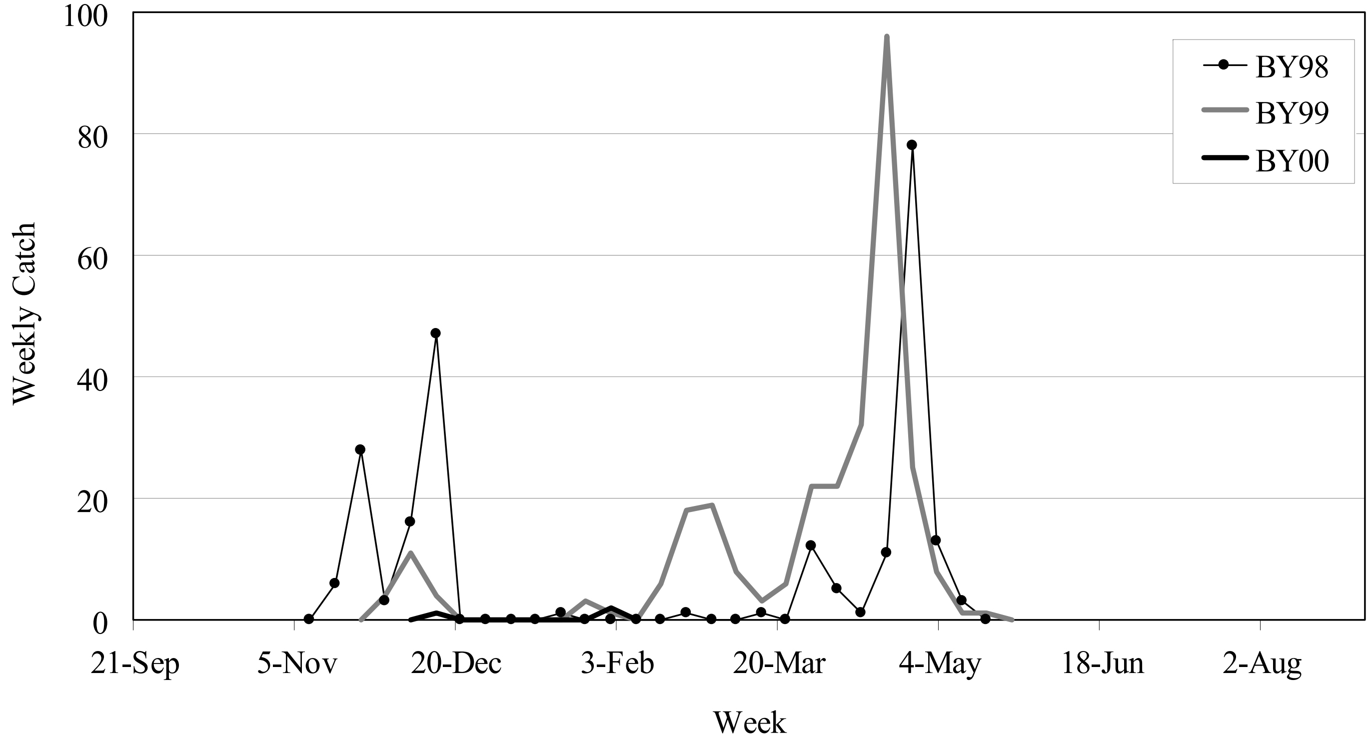


Figure 19. Weekly catch of spring Chinook salmon at the Upper Battle Creek rotary screw trap for brood years 1998-2000.

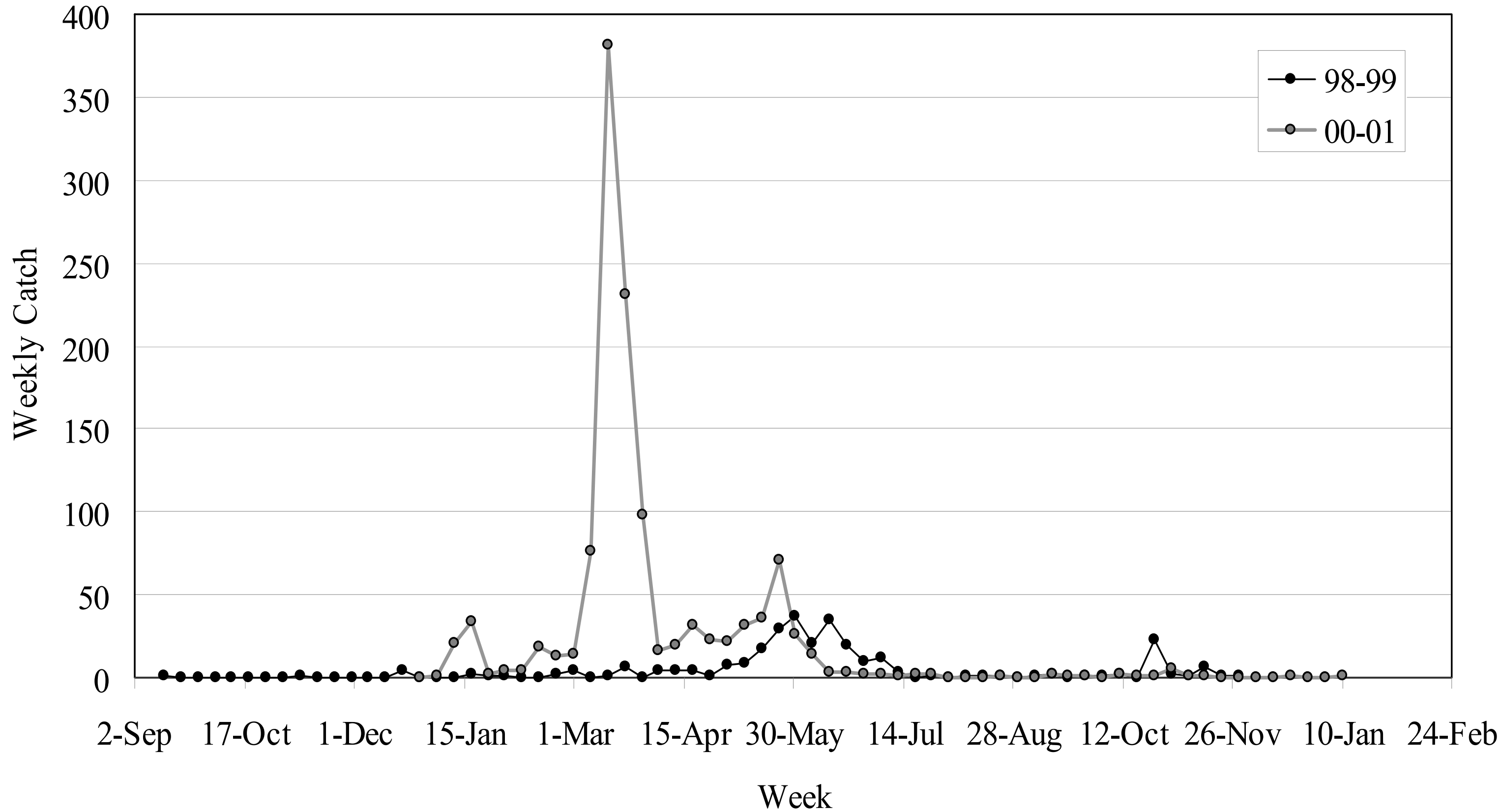
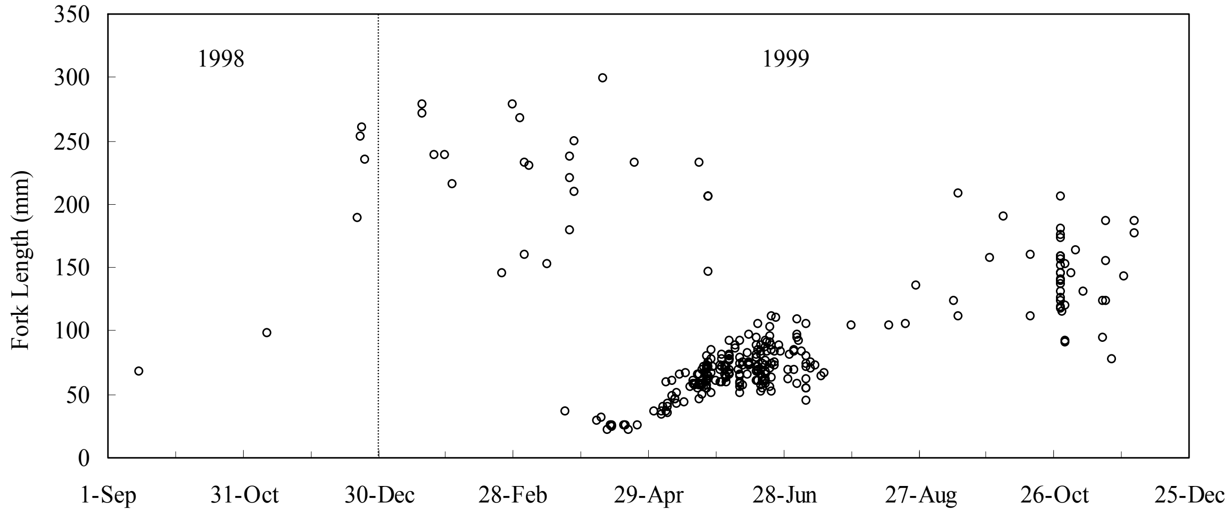


Figure 20. Weekly catch of rainbow trout/steelhead at the Upper Battle Creek rotary screw trap from September 1, 1998 through February 9, 2001.



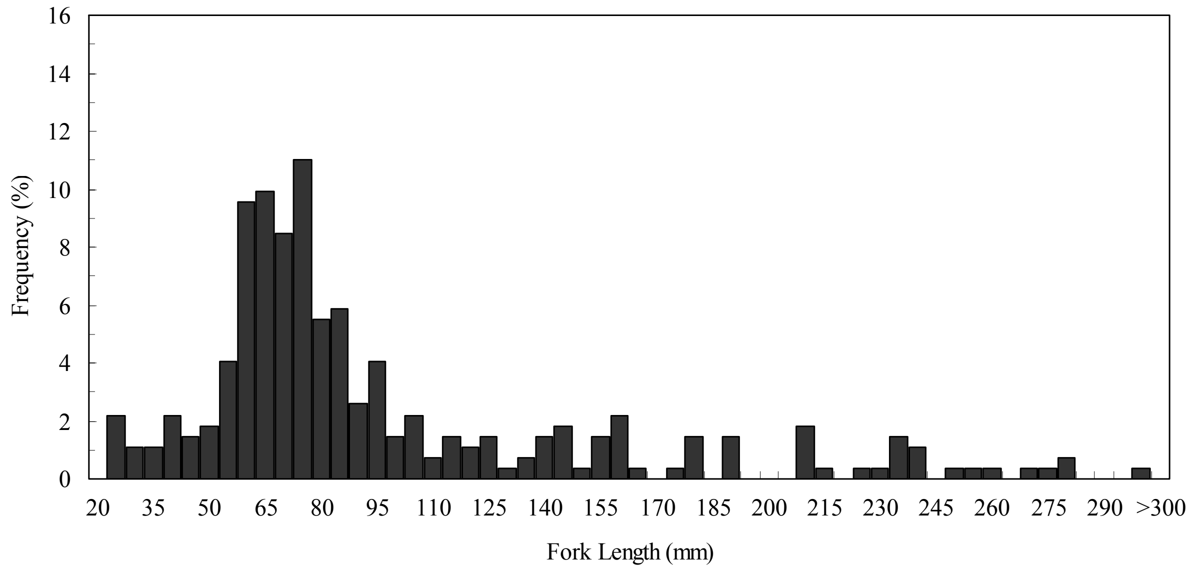


Figure 21. Fork length (mm) distribution and length frequency (%) for rainbow trout/steelhead sampled at the Upper Battle Creek rotary screw trap during September 1, 1998 through December 31, 1999. Fork length axis labels on the lower graph indicate the upper limit of a 5-mm length range.

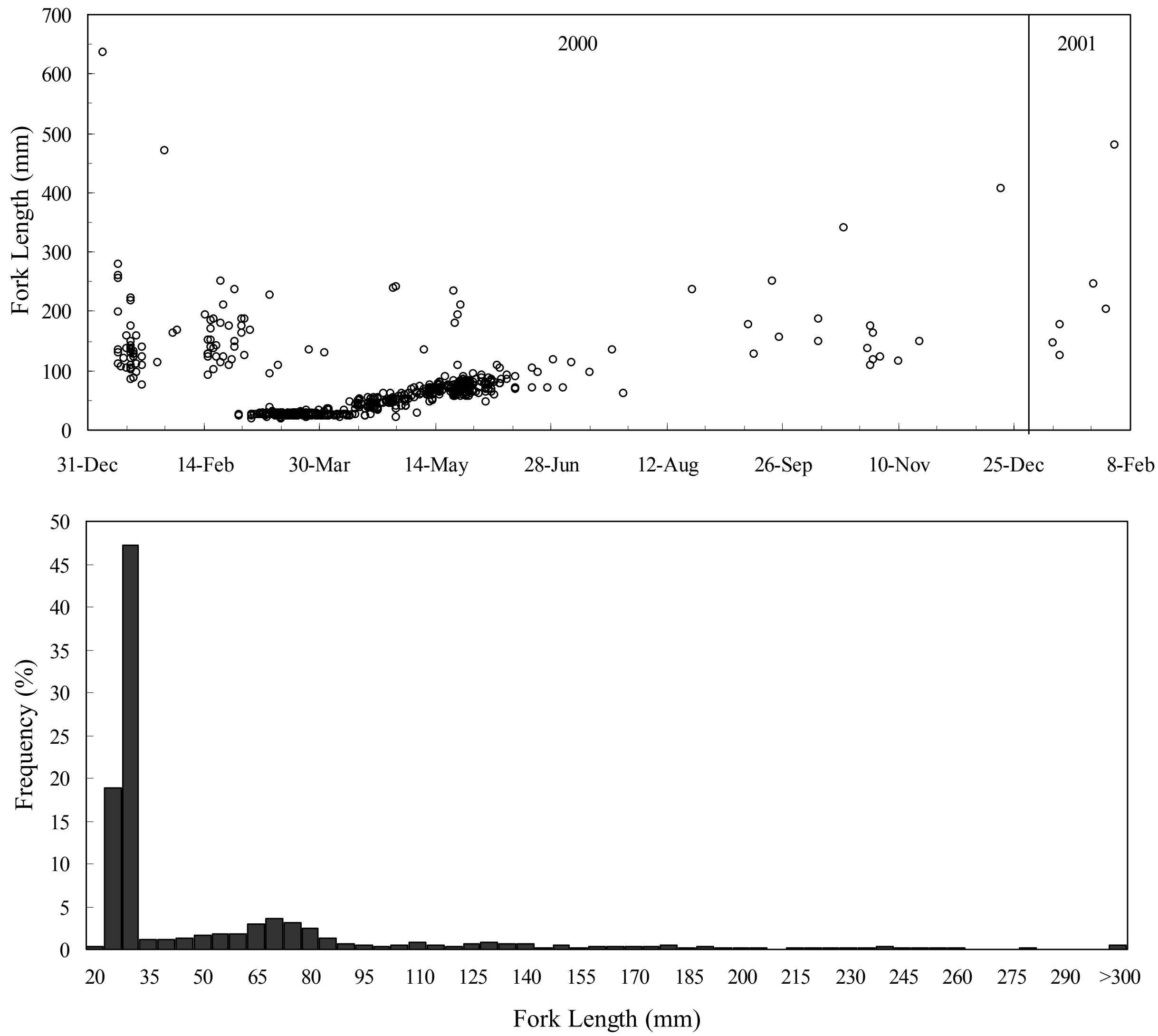


Figure 22. Fork length (mm) distribution and length frequency (%) for rainbow trout/ steelhead sampled at the Upper Battle Creek rotary screw trap during January 1 through December 31, 2000. Fork length axis labels on the lower graph indicate the upper limit of a 5-mm length range.

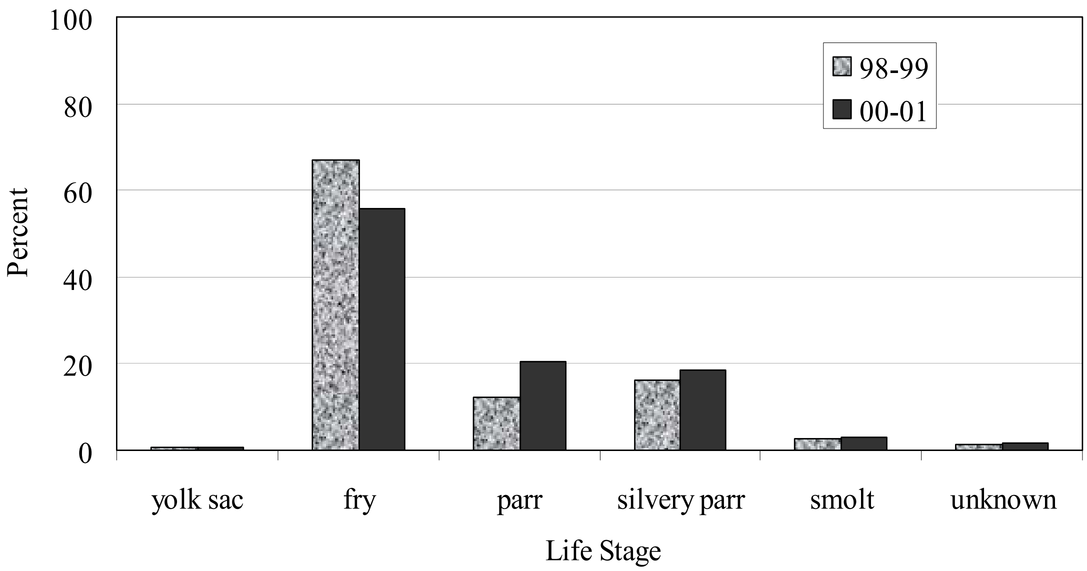


Figure 23. Life-stage composition of rainbow trout/steelhead sampled at the Upper Battle Creek rotary screw trap from for the periods September 1, 1998 to December 31, 1999 and January 1, 2000 to February 9, 2001.

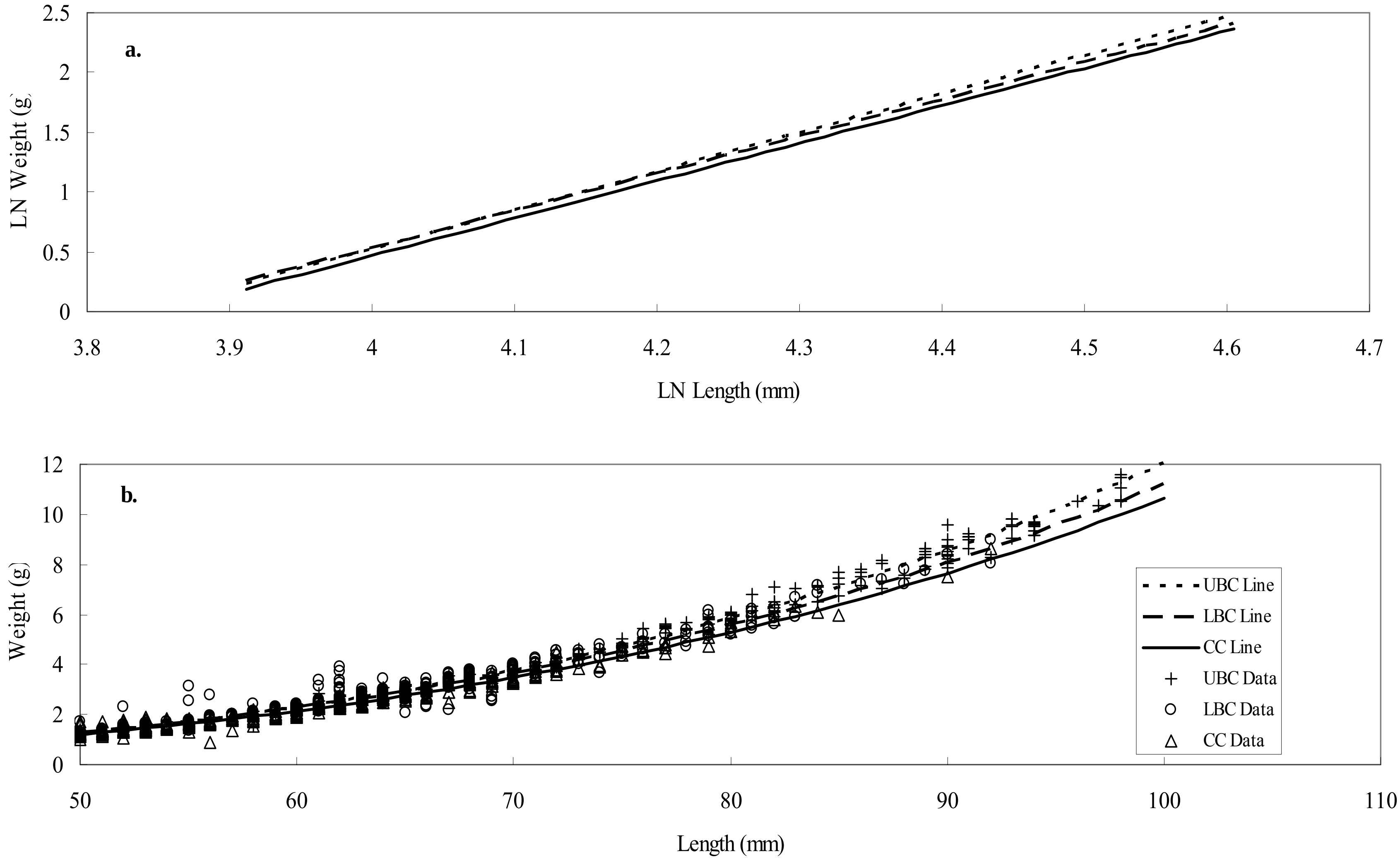


Figure 24. The linear relationship between weight and length of juvenile Chinook captured in the upper Battle Creek rotary screw trap (UBC), the lower Battle Creek trap (LBC) and the Clear Creek trap (CC) in April 1999. Comparison includes (a) the Simple Linear Regression lines based on the natural log (LN) of weight and length and (b) the line equation rewritten in units of grams and millimeters and plotted with the data.

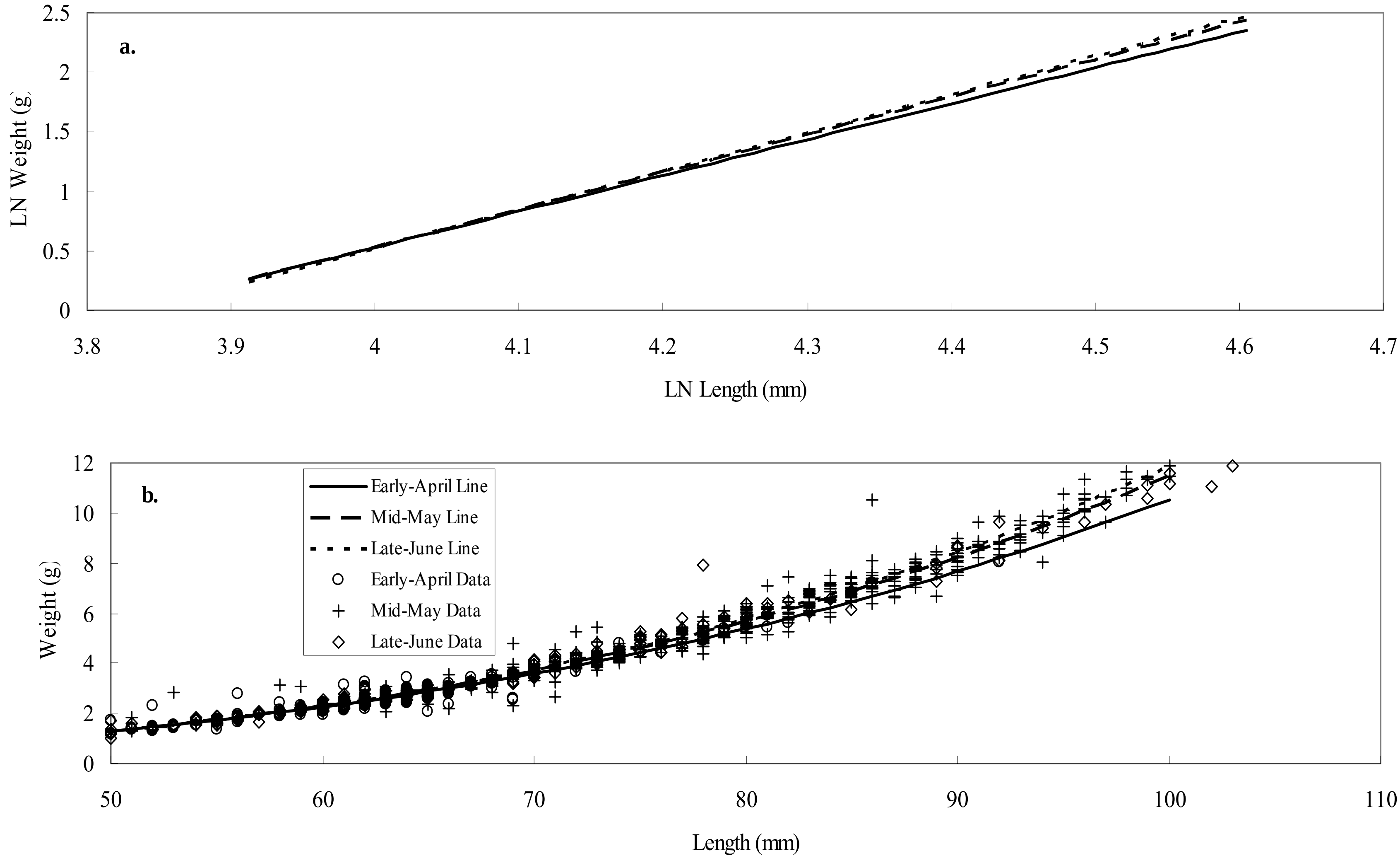
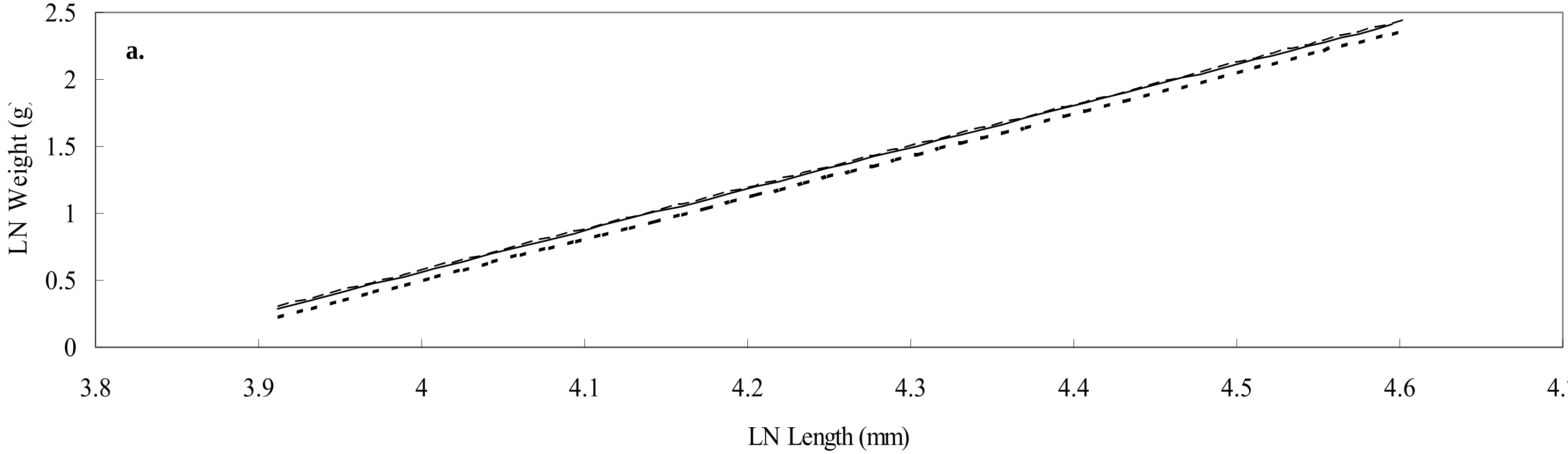


Figure 25. The linear relationship between weight and length of juvenile Chinook captured in the upper Battle Creek rotary screw trap (UBC) in early-April, mid-May and late-June 1999. Comparison includes (a) the Simple Linear Regression lines based on the natural log (LN) of weight and length and (b) the line equation rewritten in units of grams and millimeters and plotted with the data.



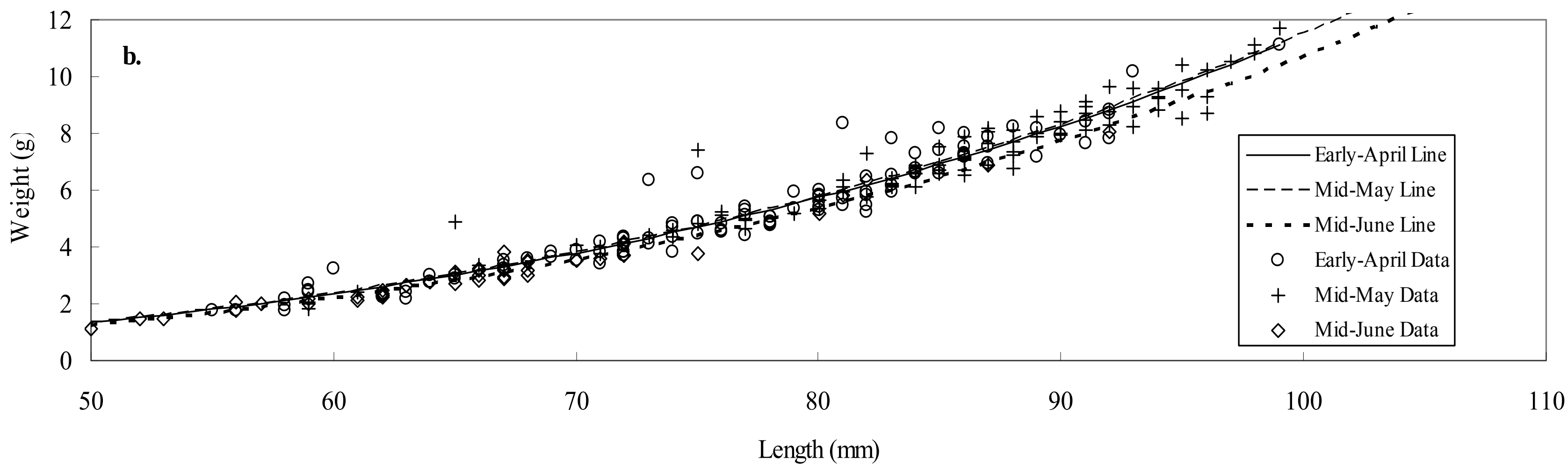


Figure 26. The linear relationship between weight and length of juvenile Chinook captured in the upper Battle Creek rotary screw trap (UBC) in early-April, mid-May and mid-June 2000. Comparison includes (a) the Simple Linear Regression lines based on the natural log (LN) of weight and length and (b) the line equation rewritten in units of grams and millimeters and plotted with the data.

Appendix

Appendix 1. Summary of days the Lower Battle Creek rotary screw trap was not fished, including sample dates, hours fished, and reason during October 9, 1998 to February 9, 2001.

Sample Dates	Hours Fished	Reason
	1998	
November 13 - 17, 1998	0	Hatchery Release
November 22 - 28, 1998	0	High Flows and Holiday
November 30 to December 5, 1998	0	High Flows
December 16 - 18, 1998	0	Hatchery Release
December 25 - 26, 1998	0	Holiday
	1999	
January 1 - 2, 1999	0	Holiday
January 4 - 7, 1999	0	Unknown
January 13 – 16 & 19, 1999	0	Unknown
January 23 – 26, 1999	0	Hatchery Release (?)
February 7 – 11, 1999	Unknown	High Flows
February 17 – 20, 1999	0	High Flows (?)
March 1 & 3, 1999	0	High Flows
March 29, 1999	0	Back Screen Repair
April 1 – 4 and 8, 1999	0	Hatchery Release
April 21 to May 2, 1999	0	Hatchery Release
May 30, 1999	0	Holiday (?)
June 5 – 6, 1999	0	Maintenance
June 28 – 29, 1999	0	Controlled Burn
October 29, 1999	0	Back Screen Replaced –Dam.
November 8-9, & 11, 1999	0	No Cone Rotation
November 13 – 15, 1999	0	Hatchery Release
November 16 – 17, 20, & 30, 1999	0	No Cone Rotation
December 1, 1999	0	High Flows
December 10 – 12, 1999	0	Hatchery Release
December 22 – 26, 1999	0	Hatchery Release & Holiday
	2000	
January 1 - 2, 2000	0	Holidays
January 5 – 8, 11 – 17, 2000	0	Hatchery Release
January 19 – 20, 2000	0	High Flows
January 22 – 24, 2000	5.5	High Flows
February 13 – 15 & 23, 2000	0	High Flows
February 27 to March 1, 2000	7.75	Unknown
March 5, 7, & 8, 2000	0	High Flows
March 11, 2000	8+	Log in Cone
April 8 – 10, 15 – 17, 22 – 24, 2000	0	Hatchery Release
July 23 – 24, 2000	0	Weekend
August 5 - 7, 12 – 14, 19 – 21, 2000	0	Weekend
August 26 – 28, 2000	0	Weekend
September 2 – 3, 2000	0	Weekend
September 28, 2000	0	Trap Service

Appendix 1. Continued

Sample Dates	Hours Fished	Reason
October 12, 2000	0	Convert Trap to ½ Cone
November 23 – 24, 2000	0	Holiday
December 25 - 26, 2000	0	Holiday
	2001	
January 3, 2001	0	Hatchery Release/Cone Modif.
January 11, 2001	0	High Flows
January 14 - 15, 2001	0	Staff Shortage
January 20 - 22, 2001	0	Staff Shortage
January 26, 2001	0	High Flows
January 27 - 29, 2001	0	Staff Shortage
February 3 – 5, 2001	0	Staff Shortage

Appendix 2. Summary of days the Upper Battle Creek rotary screw trap was not fished, including sample dates, hours fished, and reason during September1, 1998 to February 9, 2001.

Sample Dates	Hours Fished	Reason
	1998	
September 5 – 8 & 12-14, 1998	0	Unknown
November 24, 1998	4.75	High Flows
November 26 - 27, 1998	0	Holiday
November 30 to December 2, 1998	Unknown	High Flows
December 4 - 5, 1998	Unknown	High Flows
December 25 - 26, 1998	0	Holidays
	1999	
January 1 - 2, 1999	0	Holidays
January 25 - 26, 1999	0	Unknown
February 7 -12, 1999	Unknown	High Flows
May 30, 1999	0	Holiday
June 5 - 6, 1999	0	Unknown
December 24 - 26, 1999	0	Holidays
	2000	
January 1 - 2, 2000	0	Holidays
January 16, 2000	0	Log in Cone
January 20, 2000	?	Unknown
January 22 - 23, 2000	?	Weekend (?)
January 25, 2000	4	High Flows
January 31 to February 1, 2000	8.25	Weekend
February 5 - 7, 2000	8.0	High Flows
February 12 -15, 2000	7.5	High Flows
February 23, 2000	0	Unknown
July 23 - 24, 2000	0	Weekend
August 5 – 7 & 12 – 14, 2000	0	Weekend
August 19 – 21 & 26 – 28, 2000	0	Weekend
September 2 - 3, 2000	0	Weekend
November 23 - 24, 2000	0	Holiday
December 25 - 26, 2000	0	Holiday
	2001	
January 11, 2001	0	High Flows
January 14 - 15, 2001	0	Staff Shortage
January 20 - 22, 2001	0	Staff Shortage
January 26, 2001	0	High Flows
January 27 - 29, 2001	0	Staff Shortage
February 3 – 5, 2001	0	Staff Shortage

Appendix 3. Summary of non-salmonid species captured at the Lower Battle Creek rotary screw trap from October 9, 1998 through February 8, 2001.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
								1998					
AMS	---	---	---	---	---	---	---	---	---	0	0	0	0
BGS	---	---	---	---	---	---	---	---	---	8	0	0	8
BLB	---	---	---	---	---	---	---	---	---	0	0	0	0
CAR	---	---	---	---	---	---	---	---	---	2	0	0	2
CENFRY	---	---	---	---	---	---	---	---	---	0	0	1	1
COTFRY	---	---	---	---	---	---	---	---	---	0	0	0	0
CYPFRY	---	---	---	---	---	---	---	---	---	14	1	0	15
DACE	---	---	---	---	---	---	---	---	---	0	0	1	1
HCH	---	---	---	---	---	---	---	---	---	0	0	0	0
GSF	---	---	---	---	---	---	---	---	---	1	1	0	2
GSN	---	---	---	---	---	---	---	---	---	0	0	0	0
HH	---	---	---	---	---	---	---	---	---	32	16	13	61
LFRY	---	---	---	---	---	---	---	---	---	311	170	178	659
LMB	---	---	---	---	---	---	---	---	---	0	0	0	0
MQF	---	---	---	---	---	---	---	---	---	0	0	0	0
PL	---	---	---	---	---	---	---	---	---	17	15	21	53
PRS	---	---	---	---	---	---	---	---	---	1	0	1	2
PS	---	---	---	---	---	---	---	---	---	4	0	0	4
RFS	---	---	---	---	---	---	---	---	---	5	9	7	21
SASQ	---	---	---	---	---	---	---	---	---	486	8	13	507
SASU	---	---	---	---	---	---	---	---	---	0	89	54	143
SMB	---	---	---	---	---	---	---	---	---	1	0	1	2
SPB	---	---	---	---	---	---	---	---	---	0	0	0	0
TP	---	---	---	---	---	---	---	---	---	8	3	1	12
TSS	---	---	---	---	---	---	---	---	---	0	2	0	2
WHC	---	---	---	---	---	---	---	---	---	1	0	0	1

Appendix 3. Continued

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							1999						
AMS	0	0	0	0	0	0	0	0	0	0	0	0	0
BGS	0	0	0	0	13	0	5	2	0	0	0	0	20
BLB	0	0	0	0	0	0	0	0	0	2	0	0	2
CAR	0	1	0	0	0	2	1	0	0	0	0	0	4
CENFRY	0	2	1	0	5	192	6	0	0	0	0	0	206
COTFRY	0	0	0	0	0	6	30	0	0	0	0	0	36
CYPFRY	0	0	1	1	3	11	3	15	12	156	28	22	252
DACE	0	0	1	1	1	1	3	8	5	3	1	1	25
GSF	0	0	0	0	0	17	38	51	3	4	1	0	114
GSN	0	0	0	0	0	0	0	0	0	0	0	0	0
HCH	0	0	0	0	0	0	1	0	0	0	0	0	1
HH	1	3	0	11	54	23	7	19	3	23	10	5	159
LFRY	34	172	87	159	141	64	37	10	18	148	70	23	963
LMB	0	0	0	0	0	2	4	1	0	1	1	3	12
MQF	0	0	0	0	0	0	1	0	0	0	0	0	1
PL	6	4	0	0	1	1	0	0	0	9	16	46	83
PRS	0	0	1	0	2	0	4	0	0	0	0	0	7
PS	0	0	0	0	0	0	0	0	0	0	0	0	0
RFS	2	8	7	5	48	45	111	75	22	5	19	49	386
SASQ	0	11	9	18	48	24	16	6	4	7	5	3	151
SASU	7	14	4	6	35	187	1,536	744	344	195	73	62	3,207
SPB	0	0	0	0	0	37	3	0	0	0	0	0	40
TP	0	0	2	0	1	3	19	5	10	9	6	6	61
TSS	0	0	0	0	0	0	2	1	1	2	5	2	13
WHC	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3. Continued

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct [a]	Nov [b]	Dec [c]	Total
							2000						
AMS	0	0	0	0	0	0	0	0	0	0	0	0	0
BGS	0	0	0	0	2	2	0	0	1	1	1	0	7
BLB	0	0	0	0	0	0	0	0	0	0	0	0	0
CAR	3	0	1	0	0	3	0	0	0	0	0	1	8
CENFRY	0	0	0	0	0	0	0	0	1	0	0	0	1
COTFRY	0	0	0	0	0	0	0	0	0	0	0	0	0
CYPFRY	24	6	9	18	10	1	79	54	6	12	1	0	220
DACE	1	1	0	2	2	2	7	1	1	2	2	1	22
GSF	0	1	0	1	0	0	0	0	1	2	2	0	7
GSN	0	0	0	0	0	0	0	0	0	0	0	0	0
HCH	0	0	2	0	0	0	0	0	0	0	0	0	2
HH	6	12	20	66	150	56	10	77	30	208	35	14	684
LFRY	87	133	74	39	23	10	6	7	18	52	41	41	531
LMB	1	0	0	0	17	18	0	0	0	4	1	0	41
MQF	0	1	0	0	0	3	5	0	1	0	0	0	10
PL	87	50	0	2	1	0	0	0	1	4	7	35	187
PRS	0	2	1	0	3	3	1	0	0	0	1	7	18
PS	0	2	0	0	0	0	0	0	0	0	0	0	2
RFS	15	17	10	23	68	113	39	9	7	1	11	19	332
SASQ	6	5	2	11	14	32	29	36	5	17	5	0	162
SASU	33	33	10	14	37	131	540	144	62	46	7	16	1,073
SPB	0	0	0	0	0	0	1	0	0	0	0	0	1
TP	2	1	2	3	4	47	7	2	6	8	3	1	86
TSS	3	11	5	1	3	6	0	0	0	3	4	3	39
WHC	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3. Continued

Species	Jan [d]	Feb [e]	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							2001						
CENFRY	0	0	---	---	---	---	---	---	---	---	---	---	0
COTFRY	0	0	---	---	---	---	---	---	---	---	---	---	0
CYPFRY	0	0	---	---	---	---	---	---	---	---	---	---	0
DACE	0	0	---	---	---	---	---	---	---	---	---	---	0
GSF	1	0	---	---	---	---	---	---	---	---	---	---	1
GSN	0	0	---	---	---	---	---	---	---	---	---	---	0
HCH	0	0	---	---	---	---	---	---	---	---	---	---	0
HH	6	0	---	---	---	---	---	---	---	---	---	---	6
LFRY	36	0	---	---	---	---	---	---	---	---	---	---	36
LMB	0	0	---	---	---	---	---	---	---	---	---	---	0
MQF	0	0	---	---	---	---	---	---	---	---	---	---	0
PL	37	2	---	---	---	---	---	---	---	---	---	---	39
PRS	7	0	---	---	---	---	---	---	---	---	---	---	7
PS	0	0	---	---	---	---	---	---	---	---	---	---	0
RFS	16	5	---	---	---	---	---	---	---	---	---	---	21
SASQ	4	0	---	---	---	---	---	---	---	---	---	---	4
SASU	4	0	---	---	---	---	---	---	---	---	---	---	4
SPB	1	0	---	---	---	---	---	---	---	---	---	---	1
TP	1	0	---	---	---	---	---	---	---	---	---	---	1
TSS	0	0	---	---	---	---	---	---	---	---	---	---	0
WHC	0	0	---	---	---	---	---	---	---	---	---	---	0

[a] Fished at half cone from October 13 -30, 2000. Totals reflect actual fish caught.
[b] Fished at half cone from November 4-6, 2000. Totals reflect actual fish caught.
[c] Fished at half cone from December 9-11, 2000. Totals reflect actual fish caught.
[d] Fished at half cone from January 3-4 & 12-31, 2001. Totals reflect actual fish caught.
[e] Fished at half cone from February 1-9, 2001. Totals reflect actual fish caught. Trap pulled on February 9, 2001.

Appendix 4. Summary of non-salmonid species captured by the upper Battle Creek rotary screw trap from September 1, 1998 through February 9, 2001.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
								1998					
AMS	---	---	---	---	---	---	---	---	0	0	0	0	0
BGS	---	---	---	---	---	---	---	---	0	0	0	0	0
BLB	---	---	---	---	---	---	---	---	0	0	0	0	0
CAR	---	---	---	---	---	---	---	---	0	1	0	0	1
CENFRY	---	---	---	---	---	---	---	---	0	0	0	0	0
COTFRY	---	---	---	---	---	---	---	---	0	0	0	0	0
CYPFRY	---	---	---	---	---	---	---	---	0	6	0	2	8
DACE	---	---	---	---	---	---	---	---	0	0	0	0	0
GSF	---	---	---	---	---	---	---	---	0	0	0	0	0
GSN	---	---	---	---	---	---	---	---	18	2	0	0	20
HCH	---	---	---	---	---	---	---	---	0	0	0	0	0
HH	---	---	---	---	---	---	---	---	0	91	0	10	101
LFRY	---	---	---	---	---	---	---	---	3	19	0	39	61
LMB	---	---	---	---	---	---	---	---	0	0	0	0	0
MQF	---	---	---	---	---	---	---	---	0	0	0	0	0
PL	---	---	---	---	---	---	---	---	3	2	6	2	13
PRS	---	---	---	---	---	---	---	---	0	0	0	0	0
PS	---	---	---	---	---	---	---	---	0	0	0	0	0
RFS	---	---	---	---	---	---	---	---	0	1	2	0	3
SASQ	---	---	---	---	---	---	---	---	1	7	18	10	36
SASU	---	---	---	---	---	---	---	---	1,437	206	122	9	1,774
SPB	---	---	---	---	---	---	---	---	0	0	0	0	0
TP	---	---	---	---	---	---	---	---	0	0	0	0	0
TSS	---	---	---	---	---	---	---	---	0	0	0	0	0
WHC	---	---	---	---	---	---	---	---	0	0	0	0	0

Appendix 4. Continued

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							1999						
AMS	0	0	0	0	0	0	0	0	0	0	0	0	0
BGS	0	0	0	0	0	0	0	0	0	0	0	0	0
BLB	0	0	0	0	0	0	0	0	0	0	0	0	0
CAR	0	0	0	0	0	0	0	0	0	0	0	0	0
CENFRY	0	0	0	0	0	0	0	0	0	0	0	0	0
COTFRY	0	0	0	0	0	5	1	0	0	0	0	0	6
CYPFRY	1	1	2	1	0	3	13	142	44	76	39	64	386
DACE	0	0	0	0	0	1	0	0	0	0	0	0	1
GSF	0	0	0	0	0	0	0	0	0	0	0	0	0
GSN	0	1	0	0	0	0	0	0	0	0	0	0	1
HCH	0	0	0	0	0	0	0	0	0	0	0	0	0
HH	0	2	1	1	1	1	48	80	1	2	6	93	236
LFRY	9	43	13	27	45	44	19	15	9	10	23	10	267
LMB	0	0	0	0	0	0	0	0	0	0	0	0	0
MQF	0	0	0	0	0	0	0	0	0	0	0	0	0
PL	15	2	0	0	1	0	0	0	1	1	1	4	25
PRS	0	1	2	0	0	0	1	0	0	0	0	0	4
PS	0	0	0	0	0	0	0	0	0	0	0	0	0
RFS	0	2	1	6	3	9	12	7	5	0	0	1	46
SASQ	0	9	6	3	3	4	0	17	1	2	2	5	52
SASU	2	12	11	10	7	68	1,183	663	398	174	50	40	2,618
SPB	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	0	2	0	0	0	0	0	2
TSS	0	1	0	0	0	1	0	1	0	0	0	0	3
WHC	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 4. Continued

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							2000						
AMS	0	0	0	0	0	0	0	0	0	0	0	0	0
BGS	0	0	0	0	0	0	0	0	0	0	0	0	0
BLB	0	0	0	0	0	0	0	0	0	0	0	0	0
CAR	1	0	7	1	0	1	0	0	0	0	0	1	11
CENFRY	0	0	0	0	0	0	0	0	0	0	0	0	0
COTFRY	0	0	0	0	0	0	0	0	0	0	0	0	0
CYPFRY	44	17	13	4	12	2	175	117	3	0	0	0	387
DACE	0	0	0	1	0	0	0	0	0	0	0	0	1
GSF	0	0	0	0	0	0	0	0	0	0	0	0	0
GSN	0	0	0	0	0	0	0	0	0	0	0	0	0
HCH	0	0	0	0	0	0	0	0	0	0	0	0	0
HH	82	15	12	28	113	30	7	62	14	47	52	37	499
LFRY	17	44	42	45	40	34	11	6	4	6	1	2	252
LMB	0	0	0	0	0	0	0	0	0	0	0	0	0
MQF	0	0	0	0	0	0	0	0	0	0	0	0	0
PL	357	7	1	1	0	0	0	0	0	0	1	2	369
PRS	0	0	0	1	1	0	0	0	0	0	0	0	2
PS	0	0	0	0	0	0	0	0	0	0	0	0	0
RFS	1	2	4	9	12	20	35	12	1	6	6	4	112
SASQ	14	2	3	2	1	16	4	21	3	3	2	6	77
SASU	43	26	13	6	34	119	829	389	89	42	19	5	1,614
SPB	0	0	0	0	0	0	0	0	0	0	0	0	0
TP	0	0	0	0	0	0	0	0	0	0	0	0	0
TSS	0	0	0	0	1	1	2	1	3	2	0	1	11
WHC	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 4. Continued

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							2001						
AMS	0	0	---	---	---	---	---	---	---	---	---	---	0
BGS	0	0	---	---	---	---	---	---	---	---	---	---	0
BLB	0	0	---	---	---	---	---	---	---	---	---	---	0
CAR	0	0	---	---	---	---	---	---	---	---	---	---	0
CENFRY	0	0	---	---	---	---	---	---	---	---	---	---	0
COTFRY	0	0	---	---	---	---	---	---	---	---	---	---	0
CYPFRY	1	0	---	---	---	---	---	---	---	---	---	---	1
DACE	0	0	---	---	---	---	---	---	---	---	---	---	0
GSF	0	0	---	---	---	---	---	---	---	---	---	---	0
GSN	0	0	---	---	---	---	---	---	---	---	---	---	0
HCH	0	0	---	---	---	---	---	---	---	---	---	---	0
HH	42	4	---	---	---	---	---	---	---	---	---	---	46
LFRY	14	0	---	---	---	---	---	---	---	---	---	---	14
LMB	0	0	---	---	---	---	---	---	---	---	---	---	0
MQF	0	0	---	---	---	---	---	---	---	---	---	---	0
PL	49	4	---	---	---	---	---	---	---	---	---	---	53
PRS	0	0	---	---	---	---	---	---	---	---	---	---	0
PS	0	0	---	---	---	---	---	---	---	---	---	---	0
RFS	1	1	---	---	---	---	---	---	---	---	---	---	2
SASQ	6	1	---	---	---	---	---	---	---	---	---	---	7
SASU	15	1	---	---	---	---	---	---	---	---	---	---	16
SPB	0	0	---	---	---	---	---	---	---	---	---	---	0
TP	0	0	---	---	---	---	---	---	---	---	---	---	0
TSS	1	0	---	---	---	---	---	---	---	---	---	---	1
WHC	0	0	---	---	---	---	---	---	---	---	---	---	0