Juvenile Salmonid Monitoring in Clear Creek, California, from July 2002 through September 2003

USFWS Report
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Abstract.— The U.S. Fish and Wildlife Service has been conducting a juvenile salmonid monitoring project in Clear Creek, Shasta County, California, using a rotary screw trap (RST) since December 1998. The project objectives are to determine juvenile passage indices (JPI) for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead / rainbow trout (*O. mykiss*), for inter-year comparisons and obtain juvenile salmonid life history information including size, emergence, and emigration timing, and potential factors limiting survival at various life stages. According to length-at-date late-fall, winter, spring and fall run sized Chinook salmon were collected. Passage indices with 90% and 95% confidence intervals were generated for late-fall, spring, and fall Chinook salmon runs and steelhead / rainbow trout from brood year (BY) 2002. The passage indices were: late-fall 172,708, spring 28,382 and fall Chinook salmon 3,858,446. Steelhead / rainbow trout were indexed at 12,803 for BY02 Age 0 and 884 for BY01 Age 0+. Forty-nine measured Chinook were of winter-run length and when adjusted for subsampled unmeasured fish; 266 Chinook resulted in a passage index of 3,593. Based on low catch of winter sized Chinook, non-existence of emergent fry, and lack of observations of adults and redds during our snorkel surveys, we conclude that winter Chinook salmon did not spawn in Clear Creek in 2002. It is likely that these winter sized Chinook, were late-spawned late fall Chinook salmon. The passage index of winter-run Chinook was generated based on length-at date criteria. Inaccuracy in the length at date criteria limits the ability to precisely estimate production of late-fall, winter and spring Chinook. Mis-assignment of run affects the late-fall and spring indices the most, as the cumulative effect on the much more abundant fall Chinook is small. This report presents data for the period from July 1, 2002 through September 30, 2003.

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Introduction

The U.S. Fish and Wildlife Service (USFWS), Red Bluff Fish and Wildlife Office (RBFWO) have been monitoring juvenile salmonids in Clear Creek, Shasta County, California using a rotary screw trap (RST) at river mile rm 1.7, since December 1998. This ongoing monitoring project has three primary objectives: 1) determine an annual juvenile passage index (JPI) for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead / rainbow trout (*O. mykiss*), for inter-year comparisons; 2) obtain juvenile salmonid life history information including size, emergence, emigration timing, and potential factors limiting survival at various life stages; and 3) collect otolith and tissue samples from juvenile salmonids for future analyses. Rotary screw traps have been used as the primary means to evaluate trends in juvenile salmon abundance. While RST's have limitations, they can be an effective monitoring tool, and can provide a reliable estimate of juvenile production when used consistently over a number of years (CAMP 2002, sec. 5-1).

Clear Creek is a west side tributary of the Sacramento River in Shasta County. Four runs of Chinook salmon from the Sacramento River watershed, including spring-run (SCS), fall-run (FCS), late-fall-run (LFC), and winter-run (WCS), are known to inhabit Clear Creek. Spring Chinook salmon are listed as threatened (1999) and winter Chinook salmon are listed as endangered (1994) up listed from a previous 1990 listing of threatened, under the Federal Endangered Species Act (ESA). A naturally self-sustaining population of winter Chinook does not exist in Clear Creek. The *O. mykiss* (STT) population includes both anadromous steelhead and resident rainbow trout forms.

Restoration of anadromous salmonid populations in Clear Creek is an important element of the Central Valley Project Improvement Act (CVPIA). The CVPIA has a specific goal to double populations of anadromous fishes in the Central Valley of California. The Clear Creek Restoration Program authorized by Section 3406 (b)12 of CVPIA, has funded many anadromous fish restoration actions which were outlined in the CVPIA Anadromous Fisheries Restoration Program (AFRP) Working Paper (USFWS 1995), and Draft Restoration Plan (USFWS 1997; finalized in 2001).

The current report presents data from RST sampling in Clear Creek for the period from July 1, 2002 through September 30, 2003. The previous project reporting period (Greenwald 2003) began on the date that the funding contract for the project went into effect and continued for one year. This report covers from July 1 until the end of September of 2003 to more closely correspond with breaks in brood years, and for Chinook salmon passage to be more easily compared to water years. Each subsequent report will summarize brood year data that ended during the October 1 to September 30 reporting period.

Study Area

The Clear Creek watershed below Whiskeytown Dam covers an area of approximately 48.9 miles^2, and receives supplemental water from a cross-basin transfer between Lewiston Lake in the Trinity River watershed and Whiskeytown Reservoir in the Sacramento River watershed. Separated at the Clear Creek Road Bridge, the upper and lower reaches of the creek are geomorphically distinct and support different fish communities. The upper reach flows south from Whiskeytown Reservoir almost 10 miles. The lower reach heads in an easterly direction to the Sacramento River for a distance of approximately 8.4 miles (Figure 1). In the upper reach the stream is more constrained by canyon walls and a bedrock channel, has a higher gradient, has less spawning gravel and has more deep pools. In the lower reach the stream meanders through a less constrained alluvial flood plain, has a lower gradient, has more spawning gravel and has fewer deep pools. The lower reach is managed for fall and late-fall Chinook and most supports species of the foothills fish community. The upper reach supports coldwater species and is managed for spring Chinook and steelhead which require cooler summer water temperatures than the runs managed for downstream.

Acting as a sediment trap, Whiskeytown Reservoir has starved the lower portion of Clear Creek of its sediment. Combined with years of gravel and gold mining and channel scouring by high flows, sediment starvation has limited the amount of gravel available to spawning salmonids for building redds. In some areas of the Clear Creek stream channel only clay hardpan or bedrock remains, thus the need for gravel supplementation. This sediment starvation limits the amount of gravel and cobble below the dam that is needed by spawning salmonids for building their redds, thus the need for gravel supplementation (GMA 2006).

Ambient air temperatures range from approximately 32°F (0ºC) in winter to summer highs in excess of 115°F (46ºC). Most precipitation falls into this watershed as rainfall. The average rainfall in the Clear Creek watershed ranges from approximately 20 inches in the lowest elevations to more than 60 inches in the highest elevations. Most of the watershed's rainfall occurs between November and April, with little or none occurring during the summer months (McBain and Trush et al. 2000).

The lower Clear Creek rotary screw trap is located rm 1.7 above the confluence (latitude 40º 30' 22" north, longitude 122º 23' 45" west) of the Sacramento River. The RST operates in or near the thalweg of the channel. The stream gradient at this location is approximately 1 degree. The creek bottom substrate at these locations is primarily composed of gravel and cobble. The creek's riparian zone vegetation in this area is dominated by willow (*Salix* spp.), cottonwood (*Populus sp.*), Himalayan blackberry (*Rubus discolor*). Canopy cover of the riparian vegetation over the channel in the sampling area is generally less than 5%.

Methods

Sampling protocol.— Sampling for juvenile salmonids in Clear Creek was accomplished by using standardized RST sampling techniques that generally were consistent with the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) standard protocol (CAMP 1997). The RST's deployed in Clear Creek, are manufactured by E.G. Solutions®, Corvallis, Oregon. This type of trap consists of a 5-foot diameter cone covered with 3-mm diameter perforated stainless steel screen. This cone acts as a sieve which separates fish from the sampled water. The cone is supported between two pontoons and its auger-type action passes water, fish, and debris to the rear of the trap, and directly into an aluminum live box. This live box retains fish and debris, and passes water through screens located in its back, sides, and bottom.

We selected two trees with diameter-at-breast height measurements of approximately 12-18 inches on opposite banks of the creek to use as attachment points for the traps for securing the RST in the thalweg of Clear Creek. The trees were approximately 200 feet apart and far enough above the flood plain to avoid most flood waters. Using these trees as anchors, the RST is attached to a cable high line and positioned in stream with a system of ropes, and pulleys. The RST was fished during the current reporting period from July 1, 2002 to September 30, 2003. An attempt was made to fish the RST 24-hours per day, seven days each week.

Field crews typically accessed the RST by wading from the creek banks. However, for crew access during higher flows, the RST was pulled into shallow water for boarding. After being serviced, the RST was returned back to the thalweg as soon as possible to begin fishing again. The RST was serviced 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. At each trap servicing, crews process the collected fish, clear the RST of debris, provide maintenance, and obtain environmental and RST data.

Environmental Data.— Environmental data included dates and times of RST operation, creek depth at the RST, RST cone fishing depth, number of rotations of the RST cone, amount and type of debris collected, basic weather conditions, water temperature, current velocity, and water turbidity. Water depths were measured using a graduated staff to the nearest 0.1 feet. The RST cone fishing depth was measured with a gauge that was permanently mounted to the RST frame in front of the cone. The number of rotations of the RST cone was measured with a mechanical stroke counter (Global Industrial Products, Battle Ground, WA) that was mounted to the RST railing adjacent to the cone. The amount of debris in the RST was volumetrically measured using a 10-gallon plastic tub. Water temperatures were continuously obtained with an instream Onset Optic StowAway® temperature data logger. Water velocity was measured from a grab-sample using an Oceanic® Model 2030 flowmeter (General Oceanics, Inc., Miami, Florida). This velocity was measured in the time period when the live box of the RST was being cleared of debris and the fish sorted from this debris. Water turbidity was measured from a grab-sample with a Hach® Model 2100 turbidity meter (Hach Company, Ames, Iowa).

RST Data.— To remove the contents of the RST live well for examination, we used dip nets to scoop debris and fish onto a sorting table. When the number of all fishes collected in the RST was less than approximately 250 individuals, we counted and measured all fishes while on the aft deck of the RST. When catch exceeded approximately 250 individuals, fishes were transported from the RST and placed in several 25-gallon buckets. When fish numbers collected were greater than approximately 5,000, one or two 60-gallon containers were used as needed to temporarily contain the fish. These containers were constructed with flow-through mesh sides to provide a continuous supply of fresh water when placed in the creek.

We collected juvenile Chinook salmon and steelhead trout specimens for the California Department of Fish and Game (CDFG) during the period from July 2002 through September 2003. The otoliths of these samples were to be used by CDFG as part of an ongoing Chinook salmon and STT study associated with their Stream Evaluation Program.

Counting and Measurement.— We counted and obtained length measurements (to the nearest 1.0 mm) for all fish taxa that were collected. Counts and measurements were also generated for mortalities for each fish taxa. Fish to be measured were first placed in a 1-gallon plastic tub and anesthetized with Tricaine Methanesulfonate (MS-222; Argent Chemical Laboratories, Inc. Redmond, Washington) solution at a concentration of 60 - 80 mg/l. After being measured on a wet measuring board with wet hands, the fish were placed in a 10-gallon plastic tub that was filled with fresh creek water to allow for recovery from the anesthetic effects before being released back into the creek. Water in the tubs was replaced as necessary with fresh creek water to maintain adequate temperature and oxygen levels. Due to the large numbers of juvenile salmon that were frequently encountered, and project objectives, we used different criteria to count salmon, trout, and non-salmonid species:

> *Chinook salmon.*— When less than approximately 250 salmon were collected in the RST, all were counted and measured for fork length (FL). The measured juvenile salmon were assigned a life-stage classification of fry, parr, silvery parr, or smolt. For all Chinook salmon that were counted and measured, we also assigned run designations, using length-at-date criteria from Greene (1992). These designations included fall-run, late-fall-run, winter-run, or spring-run.

When more than approximately 250 juvenile salmon were captured, subsampling was conducted. To conduct the subsampling, a cylinder-shaped 1/8" mesh "subsampling net" with a split-bottom construction was used. 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, just one side was tied shut and the other side was left open. This subsampling net was placed in a 25-gallon bucket that was partially filled with creek water. All collected juvenile salmon were poured into this bucket. The net was then lifted, resulting in a halving of the sample. Approximately one-half of the salmon were retained in the side of the net with the closed mesh bag, and approximately one-half of the salmon in the side with the open mesh bag were left in the bucket. We successively subsampled until approximately 150 - 250 individuals remained. The number of successive splits that we used varied with the number of salmon collected, from one split (= ½ split) and occasionally up to seven splits (= 1/128 split).

After subsampling the salmon to the appropriate split, all fish in the subsample of approximately 150 - 250 individuals were counted and measured for FL. These salmon were also assigned a life-stage classification and run designation, using the methods previously described above. We proceeded to successively count all salmon in each split until all salmon were counted.

Steelhead / Rainbow Trout.— Due to the smaller numbers encountered, we counted and measured the FL of all steelhead / rainbow trout that were collected in the RST. Life stages of juvenile steelhead / rainbow trout were classified similarly as salmon, as requested by the Interagency Ecological Program (IEP) Steelhead Project Work Team. Steelhead / rainbow trout were classified as one of the following yolk-sac fry, fry, parr, silvery parr, or smolt. To comply with IEP protocol, we weighed all collected juvenile STT larger than 50 mm FL to the nearest 0.01-gram using a battery-operated Ohaus Scout® digital scale (Ohaus Corporation, Florham Park, New Jersey).

Non-salmonid taxa.— All non-salmonid taxa, were counted and up to 30 randomly selected individuals were measured. We measured the total length for lamprey, cottids, and western Mosquitofish (*Gambusia affinis*), and measured the FL for all of the other non-salmonid taxa. Catch data for all fish taxa were typically consolidated to represent monthly sums. Our sampling weeks were identified by year and number. Our first sampling week of this report is Week #27 in 2002, and the last sampling week was during Week #39 in 2003 (Table 1).

Mark-recapture efficiency estimates.— One of the objectives of our monitoring project is to develop a passage index of the number of juvenile salmonids passing downstream in a given unit of time, usually in a given week or year. We call this estimate a juvenile passage index (JPI). Since the RST only captures fish from a small portion of the creek cross section, we needed to implement a method to project the RST catch numbers to parts of the creek outside of the RST capture zone. Accordingly, we needed to determine the efficiency of the RST to catch all juvenile salmonid species moving downstream during a given time period. By determining the RST efficiency, we were able to calculate a JPI from the actual catch. To determine efficiencies of the RST, mark-recapture trials were conducted.

During periods when juvenile Chinook salmon capture was sufficient and weather permitted, mark-recapture trials were attempted twice weekly. We generally attempted to mark between 500 to 1,000 juvenile Chinook salmon for each trial, with a goal to recapture at least 30 marked individuals. In an effort to meet our goal of recapturing a minimum of 30 individuals, we generally did not conduct mark-recapture studies during periods when numbers of juvenile salmon captured were less than about 200 individuals.

Only naturally-produced (unmarked, unclipped, and untagged) juvenile salmon captured by the RST were used for mark-recapture trials. We used either a single mark or a dual mark to mark salmon over the course of the study period. Single-marking was used when our releases of marked salmon occurred more than five days apart, and when USFWS, was not actively conducting salmon mark-recapture studies at nearby locations. The USFWS conducts mark and recapture trials at the Red Bluff Diversion Dam (RBDD), for monitoring Sacramento River WCS juvenile populations. The dual mark allowed RBDD to distinguish Clear Creek marked Chinook from RBDD marked Chinook. The methods used for single-marking and dual-marking are described below:

Single-marking technique.— Our single-marking technique consisted of immersion staining of salmon with Bismarck brown-Y stain (J.T. Baker Chemical Company, Phillipsburg, New Jersey). The Bismarck brown was applied at a concentration of 1.6 grams / 20gallons of water and allowed a 50-minute contact time. Due to the frequently high air temperatures in late spring and the summer months, a portable water chiller unit was used during these times to maintain ambient stream temperatures and reduce stress and mortality during the staining process.

Dual-marking techniques.— To conduct our dual-marking procedures, we first single-marked the salmon with Bismarck brown, as described above. After staining with Bismarck brown was completed, the fish were anesthetized with an MS-222 solution at a concentration of 60 - 80 mg/l. After the salmon were anaesthetized, we used either an upper or lower caudal fin clipping to attain a second mark. To perform the fin clips, we used small surgical scissors, removing an area of approximately 2 mm^2 from the corners of the caudal fin lobe. Alternate upper and lower clips were used to discern mark groups from trial to trial.

When the single-marking or dual-marking procedures were completed, the marked juvenile salmon were placed in a live car and allowed to recover overnight in the RST live well. This overnight detention allowed us to more reliably detect salmon with latent injuries and mortalities resulting from the marking procedure, so that they could be removed from use in the recapture trials. On the following evening, weak, injured, and dead fish were removed. The remaining fish were counted and transported 0.5 river miles upstream of the RST sampling site to be released. We scheduled releases in the evening no earlier than 15 minutes before sunset. The nighttime releases of marked fish were designed to 1) reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated by the transportation, and 2) imitate the tendency for natural populations of outmigrating Chinook salmon to move downstream primarily at night (Healey 1998; USFWS, RBFWO, unpublished data). The stained and marked Chinook salmon that were recaptured later by the RST were counted and measured. After being allowed to recover, they were released downstream of the RST to prevent them from being recaptured again. In most cases when flows will most certainly exceed 2,000 cfs, fish were released downstream of the trap and efficiency trials are not conducted.

Trap efficiency.— Trap efficiencies were calculated by dividing the number of recaptured juvenile Chinook salmon by the number of released (# recaptured / # released). Efficiencies calculated from the mark-recapture trials were used to generate weekly JPIs (JPI = the sum weekly catch of each salmonid species captured divided by a weekly efficiency) for Chinook salmon and steelhead trout using methods described by Thedinga et al. (1994) and Kennen et al. (1994).

Juvenile passage indices for salmonids were generated by summing the daily catch for each salmonid species and run and dividing by the trap efficiency for that week to determine a weekly passage. When instream flow fluctuations occurred or a trial did not recapture 7 recaptures to generate statistically sound estimates, the trial was excluded and a “season” efficiency value was used. Additionally, for the period of time preceding the first trial and proceeding a week after the last trial of the season we used the season efficiency. Season efficiency values were calculated by dividing the average of fish released from all valid mark and recapture trials and dividing it by the average of all trial recaptures.

1) Weekly trap efficiencies were generated using a stratified weekly estimator, which is a modification of the standard Lincoln-Peterson estimator (Bailey 1951; Steinhorst et al. 2004). The weekly 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 inaccurate of three estimators (Whitton et al., USFWS 2006).

   Weekly trap efficiencies were generated by use of the equation:

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

   Where;
   E is the calculated trap efficiency,
   r_h is the number of marked fish recaptured in week h,
   m_h is the number of marked fish released in week h.

When more than one mark and recapture trial took place and there was no significant change in environmental factors (i.e., cfs or temperature), the trials were pooled for that sample week to get a weekly efficiency.

2) Weekly JPIs for Chinook salmon and steelhead trout 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 or at times multiple strata per week because as Steinhorst et al. (2004) found, combining the data where there are likely changes in trap efficiency throughout the season leads to inaccurate estimates. Using methods described by Carlson et al. (1998) and Steinhorst et al. (2004), the weekly JPIs were estimated by

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

   Where;
   N_h is the passage during week h,
   U_h is the unmarked catch during week h,
   E_h is the calculated trap efficiency during week h.

The variance, 90% and 95% confidence intervals (CI’s) for each week (N_h) are 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 data with simulated numbers of migrants, and trap efficiencies, Steinhorst et al. (2004) determined the percentile bootstrap method for developing CI's performed the best as it had the best coverage of a 95% CI. The variance for N_h is simply the sample variance of the 1,000 iterations of N_h produced by bootstrapping U_h, E_h and m_h for each week.

As described by Steinhorst et al. (2004), and demonstrated by Whitton et al. (2006), the 90% and 95% CI's for the weekly JPIs were found by producing 1,000 iterations of N_h and locating the 25th, 50th, 950th, and 975th values of the ordered estimates. The 1000 iterations were produced by using a macro in the Systat 10 software program which used the weekly catch, the calculated efficiency and the number of marked fish for each trial. The macro produced 1000 variable numbers of recapture from which passage estimates were generated; these latter data were placed in a Microsoft Excel spreadsheet and subsequently ordered from low to high values. A separate spreadsheet was kept for both sets of data; ordered and unordered. The unordered and ordered data sets were used to determine the final CI and weekly CI, respectively.

This final CI was calculated by summing the stratum of each of the 1000 random unordered iterations horizontally on the spreadsheet. The final column was ordered and the 25th, 50th, 950th, and 975th values were used as the 90% and 95% CI. The final JPI CI uses unordered iterations in calculating values, as summing the ordered iterations produce a CI that is comprised of non-random values. To produce a weekly CI, each weekly stratum is ordered and the 25th, 50th, 950th, and 975th values were used as the 90% and 95% CI.

The standard deviations *(SD)* of the sample means of each stratum are also included with 90% and 95% CI's. Juvenile Chinook salmon and steelhead trout JPIs were summarized by brood year. For dates when sampling was not conducted, or when samples were lost or compromised, we used the mean catch of an equal number of days before, and an equal number of days after, the missing number of sample days to create a surrogate value. For example, if we were missing three days of sampling data, we would calculate the average of the three sampled days before and three sampled days after the missing period. This calculated average of six sampled days would then be used as the surrogate value for each of the three days of missing values. On days where more than half of the day was sampled, a proportionate value was given to the remainder of the day the trap did not fish based on the data that was collected.

Modifications to reduce mortality and improve efficiency.— During periods of high salmon outmigration, we often implemented a modification in the RST to reduce potential negative affects to juvenile salmon created by overly high fish densities. We implemented this "half-cone modification" to the RST by placing an aluminum plate over one of the two existing cone discharge ports and removing an exterior cone hatch cover. This created a condition where 50% of the collected fish and debris were not collected into the live well, but were discharged from the cone into the creek. This effectively reduced our catch of both fish and debris by 50%, and reduced crowding of fish in the live well.

In addition to the half-cone modification described above, we performed several other modifications to the RST equipment and operations to provide for greater protection to collected fishes and greater efficiency of collection. Other modifications to RST equipment included enlarging the size of live wells, increasing the size of flotation pontoons, and adding live well baffles. Modifications to RST operations have included the use of day and night sampling, water chilling units, and summer work hour changes. To improve JPI computation, we strived to regularly fish high flows when most juvenile salmonids are thought to outmigrate, marked large numbers of salmon, and increased the frequency of mark-recapture trials from previous years.

Results

Sampling Effort

As mentioned above, this report covers a 15 month time frame to accommodate a shift in the reporting period from the last report of July through June to October through September (Table 1). We operated the RST for 378 days of the 457-day report period. This represents 82.7% of the available sampling days. We did not sample on 79 days (17.3% of the sampling period) due to the following reasons: 10 days for high flows, 2 days for holidays, and 67 days during, the late spring and summer months due to staff shortages and reduced salmonid catch (Figure 2). Based upon our experience sampling in previous years, we expected to catch consistently low (or zero) daily salmonid numbers in the period from the beginning of July through October. Accordingly, we reduced sampling to four or five days per week from August through mid September 2002, and April through July 2003.

Due to high juvenile Chinook salmon densities that were either encountered or anticipated, we applied the half-cone modification during the period from January 26, 2003 through March 6, 2003. During this period we fished the RST for a total of 39 of 40 days.

Physical Characteristics

Stream discharge at the study site was approximated by using the U.S. Geological Survey Igo gauging station (USGS Real-Time Water Data for USGS 11372000 CLEAR C NR IGO CA), located approximately 9.2 river miles above the RST sampling site. Using these data, we determined that mean daily flows ranged from a minimum of 68 cubic feet per second (cfs) in August 2002 to a maximum of 2,170 cfs on December 20, 2002. Fifteen minute data from California Data Exchange Center (CDEC) (http://cdec.water.ca.gov/cgi-progs/queryF?s=igo) webpage for the IGO station, recorded a peak discharge of 4,640 on December 31, 2002. The minimum flows were from controlled releases out of the reservoir while maximums were results of natural storm flow accretions.

In mid winter from January 27 - 29, 2003 an experimental pulse flow from Whiskeytown Dam allowed 1200 cfs to be released for the purposes of mobilizing injection gravel at the base of Whiskeytown Dam. The increased flow was intended to determine if maximum controlled releases could move 9,500 tons of spawning gravel, stockpiled immediately downstream of Whiskeytown Dam, for the benefit of spring-run Chinook salmon and steelhead / rainbow trout spawning.

Releases were increased from 200 cfs to 1,200 cfs over a 4 hour period; held at 1,200 cfs for 20 hours; and reduced from 1,200 cfs to 200 cfs over a 35 hour period. Initial estimates showed the increased release mobilized approximately 1,425 tons of gravel (15 percent of total stockpile).

From April 29 to May 7, 2003 the “glory hole” overflow spillway in Whiskeytown Reservoir released flows into Clear Creek peaking at approximately 3,610 cfs. Flows exceeded 3,000 cfs for approximately 38.5 hours from 2045 on April 29 to 1100 on May 1, 2003. During this period, peak inflows into Whiskeytown Reservoir were approximately 6,000 cfs, raising the level of the reservoir to exceed the spillway elevation of 1,212 ft. Almost 6 inches of measured precipitation fell in the Clear Creek watershed during the 8 days preceding the spill, with 2.3 inches falling on the 29th. During normal Whiskeytown Reservoir operations a storm of this magnitude would not result in a glory hole spill because 4,000 cfs could be released through the reservoirs Spring Creek tunnel outlet to the Sacramento River. In April 2003 water could not be released to the Sacramento River because it might cause damage to the seasonal ACID Diversion Dam which was already in place on the Sacramento River. The Sacramento River was already relatively high due to flood control releases Shasta Dam into the Sacramento River.

The channel width of Clear Creek at the RST varied from approximately 30 feet at the lowest flows to more than 150 feet at the highest flows. Water depths in Clear Creek at the base of the RST cone varied from 2.5 feet to greater than 6.0 feet, with an average depth of 3.5 ft. The lowest depths were recorded during July 2002, and the deepest depths were recorded in late January 2003 and late April 2003, coinciding with the reservoir overflow.

Turbidity levels ranged from 0.04 nephelometric turbidity units (NTU) in June 2003 to 38.4 NTU in March 2003, with a mean turbidity of 2.6 NTU and a median of 1.5 NTU. Turbidity was typically the lowest during the lower flows of summer, and tended to increase during the higher winter flows (Figure 2).

Mean daily water temperatures ranged from a low of 46.1^{o}F on 11 February 2003 to 70^{o}F in July 2002 and 2003. The warmest water temperatures typically were experienced during July and August, while the coolest water temperatures were experienced during January and February. Typically, winter water temperatures were 20 - 30^{o}F cooler than summer values (Figure 3).

Fish Assemblage

A total of 234,838 individual fish, represented by 20 fish taxa was collected in our RST during the sampling period. The most abundant fish taxa collected were Chinook salmon, steelhead / rainbow trout, hardhead, lamprey fry, cottid fry, riffle sculpin, and Sacramento pike minnow. Numbers of salmonids captured may vary slightly because late-fall Chinook and steelhead production estimates include captures for each species from April – March and January – December, respectively, some of which may not have been caught during the sampling period.

Chinook salmon.— Data was summarized by the following dates for BY 2002. Late-fall April 1, 2002 to March 31, 2003, winter Chinook July 1, 2002 to June 30, 2003, spring and fall - run Chinook October 1, 2002 to September 30, 2003. The only species of salmon collected was Chinook salmon. Length-at-date tables of Greene (1992) indicated that we potentially collected individuals from all four Chinook salmon runs known from the Sacramento River basin. A total of 232,538 individuals were captured from all runs, during the study period. The value is the total number of Chinook captured during operations. We collected a total of 4 Chinook for otolith analysis by CDFG for their Stream Evaluation Program. All of these specimens were collected from catch mortalities on July 17, 2002.

Fork lengths for all runs of Chinook salmon ranged from 22 - 131 mm. We collect a greater number of Chinook salmon from smaller size classes, with the majority of individuals being 39 mm or less in FL (Figures 4, 5, and 6). Data trends for each run of Chinook salmon are discussed below:

Late-fall-run Chinook salmon.— A total of 16,783 LFC were captured. The JPI for BY 2002 LFCS was 172,708 with upper and lower 95% CI's of 192,685 and 156,297 (Figure 10, Table 5). Peak emigration occurred from April 2002 to May 2002, when 74% passed. The lowest LFC JPI values of the study period occurred in 2003 from January through March, when 0 Chinook were captured. Approximately 39% of the 6,361 LFC that were measured were in the 40 - 49 mm FL range, and 31 % were in the 30 - 39 mm FL range (Figure 4.). The most abundant life stage for LFCS was parr, 54% (Figure 7, 14).

An unknown portion of the LFC may be mis-assigned both in the beginning and end of the run migration. The FCS outmigration period for emergent fry begins in early December and extends into April. According to length-at-date tables the FCS emerge on December1st and end on March 31st. The LFC emergence period begins April 1st and ends July 1st. During the emergence of LFC this overlap in run assignment may include a portion of the FCS or LFC being assigned in either of the runs JPIs. Additionally, throughout the summer some of these LFC can have a slower growth rate and by mid September through the end of the calendar year these fish are assigned as WCS according to tables (Figure 13).

Winter-run Chinook salmon.— A total of 49 juvenile Chinook salmon classified as winter-run Chinook were measured, when adjusted for non measured fish the total number was determined to be 266. The passage index for winter-run Chinook was 3,593. Most winter-run Chinook (87%) were captured between September and December. The WCS displayed a similar size and passage timing to that of the LFCS, suggesting that most likely they are late spawned LFCS. These Chinook were just outside of the length-at date criteria limits for LFCS. No newly emergent sized Chinook (30 -39 mm FL) were captured by the rotary screw trap from July to October, suggesting there was not any production from adult WCS during the late winter and spring months. Adult Chinook snorkel surveys by the USFWS RBFWO did not recover any spawned out carcasses or make any observations of Chinook redds during the months of April, May and June of 2002.

Spring-run Chinook salmon.— A total of 707 SCS were captured. The JPI for BY 2002 SCS was 28,382 with upper and lower 95% CI's of 34,754 and 23,677 (Figure 11, Table 6). Peak emigration occurred from late November through December where 66.6% of the estimated production passed (Figure 11). A second pulse of SCS occurred during the month of February 2003. Between May 15, 2003 and September 30, 2003, no SCS were captured. Approximately 92.9% of the 521 SCS that were measured were in the 30-39mm FL range (Figure 5). The most abundant life stage for SCS was fry, 93% (Figure 8, 14).

Fall-run Chinook salmon.— A total of 227,010 FCS were captured. Fall-run Chinook salmon constituted >97% by number of all Chinook salmon captured. The JPI for BY 2002 FCS was 3,858,446 had upper and lower 95% CI's of 4,174,685 and 3,560,468 (Figure 12, Table 7). Peak emigration occurred from 1 January 2003 to March 4, 2003, when 90.5% passed. The highest passage occurred January 15-21, 2003, where an estimated 630,079 individuals passed (Figure 11, Table 6). The lowest FCS JPI values of the study period were experienced in 2002 during weeks 31 - 48 (August through November), when 11 Chinook were captured (Table 6). Approximately 85.41% of the 22,446 FCS that were measured were in the 30 - 39 mm FL range, and 4.94 % were in the 40 - 49 mm FL range (Figure 6). The most abundant life stage for FCS was fry, 89% (Figure 9, 14).

Steelhead / Rainbow Trout.— The STT passage index for BY 2002 of 12,803 had upper and lower 95% CI's of 14,193 and 11,731 (Table 8). The index for BY 2001 Age 0+ of 884 had upper and lower 95 % CI's of 939 and 838 (Table 8). Steelhead / Rainbow trout, as mentioned above were measured from January 1, 2002 to December 31, 2002. A total of 823 STT were captured. Fifty-one of the captures throughout the year were Age 0 + of BY 2001 or later. The JPI for BY 2001 Age 0+ was 884 (Figure 20, table 8). The first captures of BY 2002 young of the year (YOY) were on February 9, 2002 (Figure 17, 18). The JPI for BY 2002 STT was

12,051. The peak emigration for STT BY2002 was from early April through mid May where approximately 40% of the production passed (Table 8, Figure19). Steelhead / Rainbow trout passage estimates were generated for YOY and age 0+ fish. The fork length distribution of steelhead / rainbow trout captured in the trap was used to determine weekly catch of YOY and age 0+ (Figure 17). .The most abundant fork lengths were in the 50-70 mm range, where approximately 37% occurred (Figure15). The most abundant life stage for STT was parr, 67% (Figure16).

We collected a total of 39 steelhead trout for otolith analysis by CDFG for their Stream Evaluation Program. All of these specimens were collected from catch mortalities from April 10, through June 28, 2003. The collected STT are Age 0 BY 2003.

Non-salmonids.— We collected a total of 2,310 individual non-salmonids from 20 taxa (Appendix 1, 2). The most abundant non-salmonids included hardhead (*Mylopharodon conocephalus*), lamprey fry (*Lampetra* spp.), riffle sculpin (*Cottus gulosus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), Cyprinoidea larvae (Superfamily Cyprinoidea), and Pacific lamprey (*Lampetra tridentata*) (Appendix 1, 2). These dominant non-salmonid taxa are discussed below:

Hardhead.— A total of 301 collected, the most common non-salmonid taxa by number was hardhead. Hardhead were collected throughout the year. The greatest numbers were collected during October 2002, with 73 being captured.

Lamprey fry.— A total of 337 unidentified lamprey fry was collected. Individuals from this taxon were likely represented by Pacific lamprey (*Lampetra tridentatus*), and possibly may have also included western brook lamprey (*L. richardsoni*) and river lamprey (*L. ayresi*). Lamprey fry were primarily collected during the winter and early spring, with abundance peaks in December 2002 (85 individuals) and January 2003 (138 individuals).

Riffle sculpin.— A total of 254 riffle sculpin was collected. Individuals from this species were collected year round, with abundance peaks in July of both 2002 (36 individuals) and 2003 (94 individuals).

Sacramento sucker.— A total of 195 Sacramento sucker was collected. Individuals from this species were collected year round, with abundance peaks in July 2002 (40 individuals) and November 2002 (37 individuals). Fork lengths ranged from 24 - 373 mm, with a median of 39 mm.

Sacramento pikeminnow.— A total of 222 Sacramento pikeminnow was collected. Individuals from this species were collected year round, with the peak abundance in August 2002 (49 individuals) and September 2002 (46 individuals).

Cyprinoidea fry.— A total of 396 unidentified fry from the Superfamily Cyprinoidea was collected. Individuals from this taxon likely were represented by such species as hardhead, Sacramento sucker, Sacramento pikeminnow, and speckled dace (*Rhinichthys osculus*). We collected most Cyprinoidea fry (119 individuals) during August, September of 2002 and 2003 and October of 2003.

Mark-Recapture Efficiency Estimates

We conducted 23 different mark-recapture trials to test for RST efficiency. The release of marked fish started on January 22, 2003 and ended on May 20, 2003. A total of 16,091 Chinook salmon was marked, 328 mortalities occurred from the marking procedures, 15,763 fish were released for recapture, and 924 were recaptured (Table 2).

Two trials conducted on the January 22 and 30, used only a single Bismarck Brown marking. All other 21 trial were consisted of dual marking the Chinook with the Bismarck Brown and either an upper or lower caudal fin clip (Table 2).

The number of individual fish marked for each trial ranged from 48 – 1,041, with an average of 700. The number of individual released fish for each trial ranged from 45 – 1,032, with an average of 685. Recaptured fish numbers per trial ranged from 2 – 102 with an average of 40. Efficiencies for the RST per trial ranged from 1.14% to 13.33 %, with an average of 6.2% (Table 2). Ten trials were conducted when the trap was fishing at half-cone, and as expected our average efficiency was lowest at 4.76%. Thirteen trials were conducted when the trap was fishing at full-cone and the average efficiency was 7.6%. One trial was excluded on May 6, 2003 for not meeting the minimum number of recaptures and the full cone seasonal average was used However, to avoid seasonal flow related biases, the "seasonal," average was determined by dividing the average number of marked fish by the average number of recaptures for both half cone and full cones fishing periods. Therefore, the seasonal average for half cone was 8.0% ((44+1)/(563+1)) and the full cone average was 3.9% ((47+1)/(1227+1)).

Due to low fish collection numbers, we were unable to conduct mark-recapture studies from July 2002 until December 2002. During December 2002, we often had enough salmon available for mark-recapture studies, but due to the generally small size and delicate nature of the fish, we did not initiate marking activities until January 22, 2003. For the period from July 1, 2002 through November 25, 2002 (Weeks 27-47), we substituted the efficiency of the last successful mark-recapture trials we conducted in Clear Creek during July 2002, which was 4.85% ((7+1)/(164+1)). For the period from November 26, 2002 through January 21, 2003 (Weeks 48 - 3), the season average efficiency of 8.0% was used (Tables 1 - 4).

Mortality

Marking Mortality.— A total of 328 mortalities occurred among the 16,091 marked Chinook salmon, for a cumulative total marking mortality (= total cumulative marking mortalities / total cumulative number of fish marked = 328/16,091) of 2%. Mortalities resulting from our marking procedures for each efficiency trial ranged from 0 – 11%. The highest mortalities occurred during March 2003 (Figure 21, Table 2).

Trapping Mortality.— A total of 3,141 mortalities for all runs of BY 2002 Chinook salmon occurred as a result of RST sampling

Late-fall-run Chinook salmon — There were 12,068 BY 2002 LFCS captured in the Clear creek RST. Of these captures 787 were recorded as mortalities generating a 6.5% mortality of fish handled and .5% of the total passage index of 168,629.

Winter-run Chinook salmon — There were 259 WCS (according to length at date criteria) captured in the Clear creek RST. Of these captures 6 were recorded as mortalities generating a 2.3% mortality of fish handled and .28% of the total passage index of 2,120.

Spring-run Chinook salmon — There were 2,110 BY 2002 SCS captured in the Clear creek RST. Of these captures 137 were recorded as mortalities generating a 6.5% mortality of fish handled and .13% of the total passage index of 29,143.

Fall-run Chinook salmon — There were 227,010 BY 2002 FCS captured in the Clear creek RST. Of these captures 2,205 were recorded as mortalities generating a 2% mortality of fish handled and .01% of the total passage index of 3,874,195(Figure 21, Table 9)..

Steelhead Trout — There were 51 BY 2001 and 772 BY 2002 Steelhead trout captured in the Clear creek RST. Of these captures 20 were recorded as mortalities generating a 6.5% mortality of fish handled and .5% of the total passage index of 168,629.

Discussion and Recommendations

Sampling effort

The Clear Creek RST sampled 83% of the time during the reporting period. Staff shortages reduced the number of days sampled per week from April 2002 through September 2002. Coincidentally, the trap operated 85% of the time during the four different time periods we used to estimate the LFC, SCS, FCS and STT passage. Although, traps were operated a similar percent of the time for all four estimates, reduced sampling may have more of an impact on LFC and STT estimates. The reduced sampling occurred during the peak emigration period for LFC and STT from April to May of 2002 but not for the other runs.

Due to reduced catch in the RST and staff shortages in the months of August and September of 2003 our effort was reduced to 4 days a week. Previous years catch data show a very small percent of the annual passage estimates for LFC, SCS, and FCS occurs from July to October. STT catch is variable during June and July and may be dependent on the number of returning adults, the timing of spawning and water temperature.

Recommendation 1: We recommend operating the RST from approximately Nov 1st to the end of June or July to include 98 % of all runs with the following considerations; a) sampling should continue into July during years when catch remains high. In BY 2002, 8% of STT passed in July; b) sampling should occur 7 days a week until analysis suggests an intermittent schedule should be implemented or sampling discontinued altogether. In 2002, due to limited staff and multiple projects, we had to sample the RST on a reduced schedule of 4 days per week in April and May during LFC and STT outmigration; and c) estimating cumulative temperature units to emergence in the fall could be used to estimate the timing of and capture of salmonid fry. We could then begin RST operation shortly before fry are expected to be captured and thereby reduce the number of zero-catch days. The earliest captured YOY for SCS or FCS since monitoring with a RST began on Clear Creek was during this monitoring period on November 5, 2002.

Physical Criteria

The experimental pulse flow from Whiskeytown Dam on January 27-29 2003 allowed 1,200 cfs to be released to mobilize injection gravel at the base of Whiskeytown Dam. The pulse flow was designed to determine if 400, 600 or 1,200 cfs could move gravel from the Whiskeytown pile and re-distribute it downstream. Although higher flows may pass through the Whiskeytown “gloryhole” overflow spillway, 1,200 cfs is the maximum release possible using the controllable outlet works. It was estimated that 15% of the gravel in the pile moved downstream. Stream flows measuring 3,000 cfs or greater have been determined to initiate bedload transport of materials > 2mm while mobilizing >100 tons of material per day (GMA 2006).

Results of redd and tracer rock surveys did not detect negative impacts from the pulse flow. Redd surveys conducted before and after the experimental pulse flow found that STT and

LFC redds were still visible and experienced no significant effects from the increased flow. The tracer rock study conducted before and after the pulse flow suggested that there was little movement of the substrate and most likely little impact to redds and their surrounding areas. The average distance moved between rocks that were affected by the pulse flow was 88.8 cm. The average distance moved between all the rocks found was 21.5 cm. A total of 172 tracer rocks were placed in 5 transects distributed in Reach 1 with 19 rocks lost (Matt Brown, unpublished data). In addition, data from 2003 – 2007 suggests that greater than 93% of SCS fry have emigrated by late January past a rotary screw trap used to estimate SCS passage at rm 8.3 on Clear Creek; therefore, increased flows would have minimal impacts, because few if any alevins would be remaining in the redds.

Recommendation 2: We recommend that to mobilize more gravel at one time it may be necessary to manipulate the Whiskeytown reservoir operations to achieve flows similar to the April 2003 glory hole spill. Gravel management releases or "pulse flows," would be more effective if a greater flow is achieved. These additional flows would mobilize more than the estimated 15% of the gravel stockpile that moved at 1,200 cfs. However, redds may be disturbed during pulse flow experiments in January if the release is increased. Potential impacts to redds would be lower in June. Total observations of redds in June of 2003, 2002 and 2001 were 6, 5 and 3 respectively for STT and 0 for CHN. An additional benefit of a June pulse flow would be to attract more spring –run into Clear Creek or to attract spring-run Chinook further upstream where temperatures are cooler. Determination of the optimal season for pulse flows will likely need to consider many factors; such as water year type, concurrent storms or flood control releases, restoration or construction work, and impacts on other species.

Chinook salmon

Late-fall-run Chinook salmon — The natural spawning population of LFCS in Clear Creek has varied from about 50 to 875 since 1982 and is currently in the low hundreds (USFWS, RBFWO unpublished data). There were 157 LFC carcasses recovered between December of 2001 and March of 2002. If we assume this was the total number of LFC in the creek and that 50% were females and therefore the number of females to be 79. The 79 adult female LFC would then on average have had a minimum number of 2,200 successfully spawned fry per fish. Healey (1998) described fecundity in adult Chinook to range from less than 2,000 to more than 17,000 eggs.

Late-fall-run Chinook salmon adult surveys are often inaccurate due to high turbidity and inaccessibility of areas of the creek where carcasses fallout, during elevated flows which are typical during the adult spawning season (December–March). Inaccurate adult estimates may make juvenile productivity and juveniles per redd difficult to compare year to year. In the winter of 2001-2002, 8 of 10 (80%) LFC surveys were completed, 1 survey was cancelled on December 27, 2001 and a second survey on January 2, 2003 was cancelled due to high flows.

Recommendation 3: We recommend that the LFC carcass survey consider the following: a) conduct surveys as soon as possible following cancellations to improve annual estimates and for evaluating juvenile productivity; b) use a kayak-based survey to cover ground more quickly; and c) include surveying for STT spawners and redds.

Winter-run Chinook salmon — There is no self sustaining population of WCS in Clear Creek based on results of rotary screw trapping and snorkel surveying. The BY 2002 WCS passage estimate of 3,593 is based on length-at-date criteria and is generated from only 49 captures and an extrapolated total of 266. No confidence intervals for WCS were generated because the catch totals were so low (N= 49). The additional 217 fish that were used to calculate the total passage were apportioned from large counts of tallied Chinook and the ratio of each run in the subsample. Additionally, it is likely that the samples collected were LFCS and the apportioned fish from subsampled counts were FCS.

We expected that if WCS spawned in Clear Creek, recently emerged fry would be captured in the RST from July to September. We sampled everyday during the month of July to confirm presence or absence of WCS. Our sampling effort observed no WCS Chinook fry. None of the 49 Chinook designated as winter run by length tables were sampled for genetic analysis.

Recommendation 4: We recommend collecting genetic samples from all Chinook salmon designated as WCS by length criteria. The proper assignment of run may contribute to a more accurate estimate of LFC passage.

Spring-run Chinook salmon —The estimates of SCS using this RST are inaccurate, due to the overlapping of spawn timing of both SCS and FCS. An alternative method could be to genetically sample a significant portion of the lower RST catch and then apply the results proportionately to the catch; however the required number of genetic samples necessary would stress more fish or we may not capture adequate numbers of SCS to make an accurate passage index.

Recommendation 5: We recommend the use of an additional RST located upstream of the FCS and downstream of most SCS spawning habitat. The use of a second RST higher in the watershed will likely allow newly emergent fry to be differentiated by run based on spatial distribution of redds. The use of a weir to exclude adult fall-run Chinook may facilitate such an investigation.

Fall-run Chinook salmon — The 2002 FCS escapement was the highest on record (16,071) and the FCS JPI was the lowest on record (3,858,446). The number of females estimated from the CDFG FCS carcass survey was 8,176 (Kano 2005, CDFG 2005). The number of juvenile FCS produced per female was 472.

There are several factors that may contribute to a low juvenile production estimate including; redd scour from high flow events, missed sampling days, and results of mark and recapture trials. Although, high flow events are more difficult to conduct RST sampling, peak emergence for FCS is usually during the end of January and early February, suggesting that lower production was not related to reduced sampling effectiveness at high flows.

Four high flow events occurred on December 16, 20, 30 and 31, 2002 where peak stream discharges were measured at 2,910, 4,460, 3,860 and 4,640 respectively. The number of hours these peak flows exceeded 3,000 cfs were 0, 2.25, 4.5, and 7.75, respectively. These flows may have mobilized portions of the redds, thus reducing the productivity and subsequently resulting in a lower passage index. Stranding surveys conducted after these high flow events showed that large numbers of eggs and yolk-sac fry were deposited into the flood plain when discharge exceeded 3,000 cfs. There were only two days of missed sampling during the peak emigration period for FCS from January through March, one for higher flows (mean daily flow 1,230 cfs) and the other for an administrative meeting. The low JPI is most likely a combined result of redd scour, poor gravel quality and limited carrying capacity.

Recommendation 6: We recommend that the gravel conditions in lower Clear Creek be evaluated annually or bi-annually to determine if high proportions of fine sediment are responsible for the decline of production in years with high adult escapement. The gravel evaluation should include; a) the effect of high flows and redd scour to determine if a significant proportion of redds are being affected by gravel mobilization. b) a study of flow in hyporheic zones of redds to determine if dissolved oxygen levels are adequate for egg survival and c) a measure of the percentage of fine sediments to determine if flushing flows are required more frequently to improve the quality of spawning gravel.

Steelhead / Rainbow Trout

Further studies would be useful in determining the proportion of the anadromous and non-anadromous forms that contribute to the steelhead population. Juvenile otoliths may be analyzed to estimate the percentage of maternal anadromy. The use of redd measurement data may assist in distinguishing redds of the two forms. The proportion of anadromous STT could then be correlated with environmental factors such as water year type, temperature and food availability. These factors may effect whether STT choose to reside in Clear Creek, migrate to the Sacramento River for better opportunities or head to the ocean.

Recommendation 7: We recommend the collection and analysis of otolith samples to determine the percentage of maternal anadromy in juvenile steelhead captured from the RST.

Recommendation 8: We recommend the collection and analysis of redd measurements to identify spawn timing, channel location, longitudinal distribution or size differences between anadromous and non-anadromous redds.

Recommendation 9: We recommend evaluating the feasibility of using steelhead / rainbow trout from Coleman National Fish Hatchery for efficiency estimates. Our estimates of passage and production are based on efficiency trials conducted with juvenile Chinook salmon and which may be more accurate if we used steelhead. Although hatchery fish are known to behave and outmigrate differently than wild fish, using hatchery steelhead trout may be more representative of wild rainbow trout/steelhead behavior than wild Chinook salmon. We do not catch sufficient numbers of rainbow trout/steelhead for conducting RST efficiency trials.

Mark-Recapture Efficiency Estimates

In general mark and recapture efficiency trials were sufficient in number of trials and of recaptures. During high flows some efficiency values were lower than 3% and not as high as we would prefer. Therefore more fish should be released during high flow periods.
During high flows, accessing traps, retrieving pre-release marked fish and traveling to fish release points can be challenging. Efficiency trials are aborted when flows are projected to exceed 2,000.

Recommendation 10: We recommend improving mark-recapture trials during high flow periods by a) conducting more trials during high flow events, b) using a greater number of fish for these flow specific trials and, c) using off-site storage pens.

During high-flow efficiency trials, fish could be released as flows both increase and decrease to better understand passage rates during the ascending and descending portions of the hydrograph. Marking more fish during high flow events would likely increase the number of recaptures and increase the confidence in the estimate for those periods. Constructing an off-site holding pen could make it easier to retrieve pre-release fish. Marked fish can be temporarily placed in holding pens closer to shore than the RST, which would make for easier access and or emergency release.

Mortality

Marking Mortality.

Chinook salmon mortality associated with marking activities was reduced from 3% in 2001 to 2% in 2002. We have been diligent in our efforts to reduce mortality during our marking activities by monitoring temperatures every fifteen minutes (up from previously measuring the beginning and end of marking process only) and changing our anesthetizing solution as temperatures increased. The most challenging times for marking occur during spring when warm spells combined with the fragile physiological state of smolting Chinook can be lethal when handling fish. Higher water temperatures, elevate stress and may cause mortality.

Recommendation 11: We recommend that marking activities on Chinook salmon are reduced or ended for the season during periods of warmer weather, especially during periods when smolt-sized salmon are being collected due to their extreme sensitivity and vulnerability to stress.

Trapping Mortality

Chinook salmon mortality associated with trapping activities was reduced from 4% in 2001 to 1% in 2002 for FCS (Figure 21, Table 10). We have reduced the mortality during trapping by using the RST half cone modification and sampling the traps more than once daily during December for SCS and late January and February for FCS. However, this winter (02-03) we did not implement the half cone modification until January 29 to March 3, 2003 because mortality levels were less than 0.5%. The total mortality for LFC, SCS and FCS was 2,211, 787 and 127 respectively. Steelhead / rainbow trout mortalities were low, a total of 20 mortalities from 1,086 captures resulted from trapping

Recommendation 12: We recommend implementing the half cone modification during the peak emergence of all runs of Chinook and steelhead. The half cone modification was not implemented until late January 2003. Although, catch mortalities were less than 0.5 % prior to implementing the half cone, we could have reduced mortality further by using the modification full time.

Recommendation 13: We recommend continuing to maximize trap checks during peak spring and fall-run Chinook salmon emigration.

Recommendation 14: Condition factor – We recommend that in future field sampling we collect length and weight data for Chinook salmon and rainbow trout/steelhead to evaluate the physical condition of individual salmonids.

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Figures

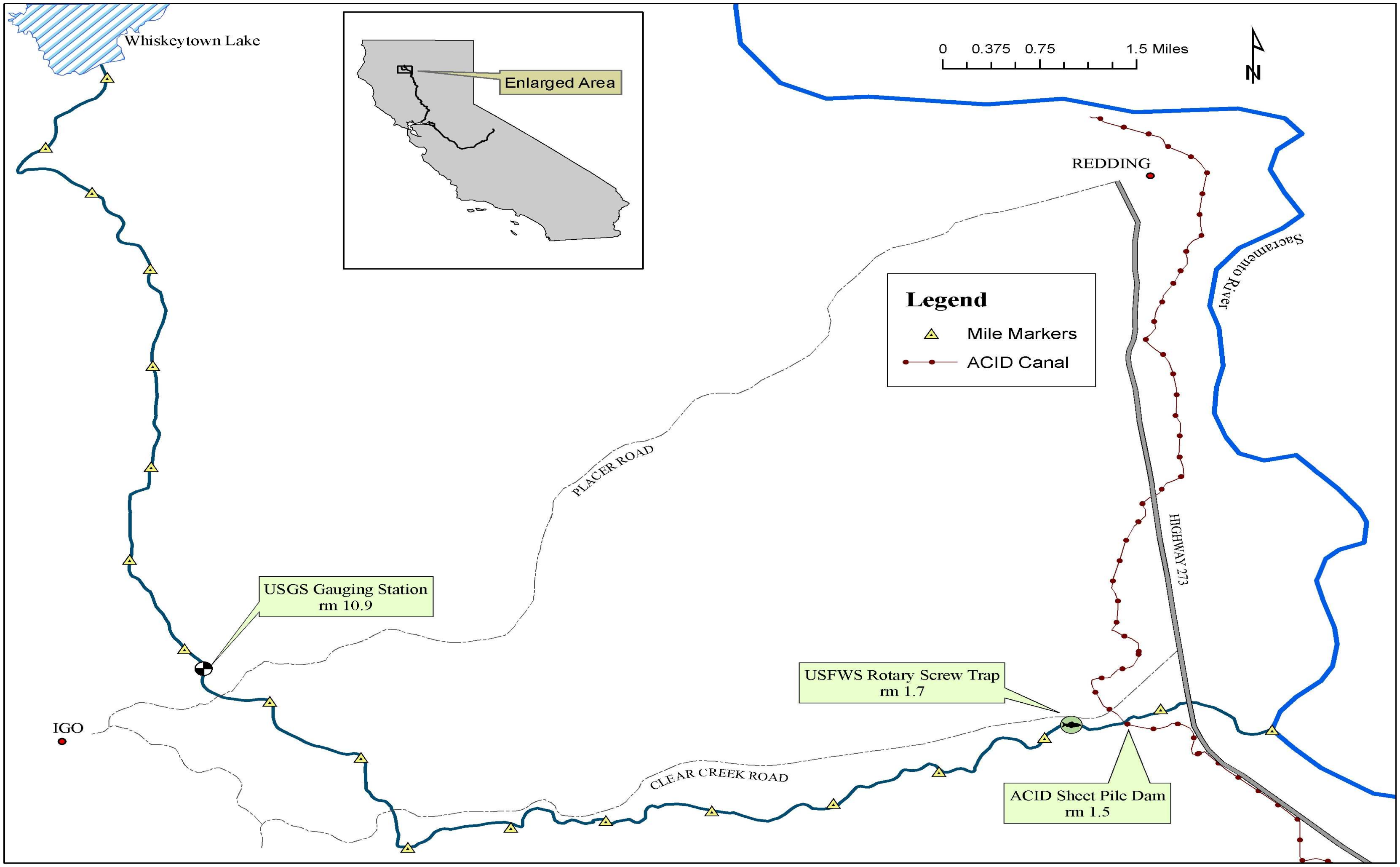

Figure 1. Location of the rotary screw trap (RST) sampling station used for salmonid monitoring by the U.S. Fish and Wildlife Service in Clear Creek, Shasta County, California from July 2002 through September 2003.

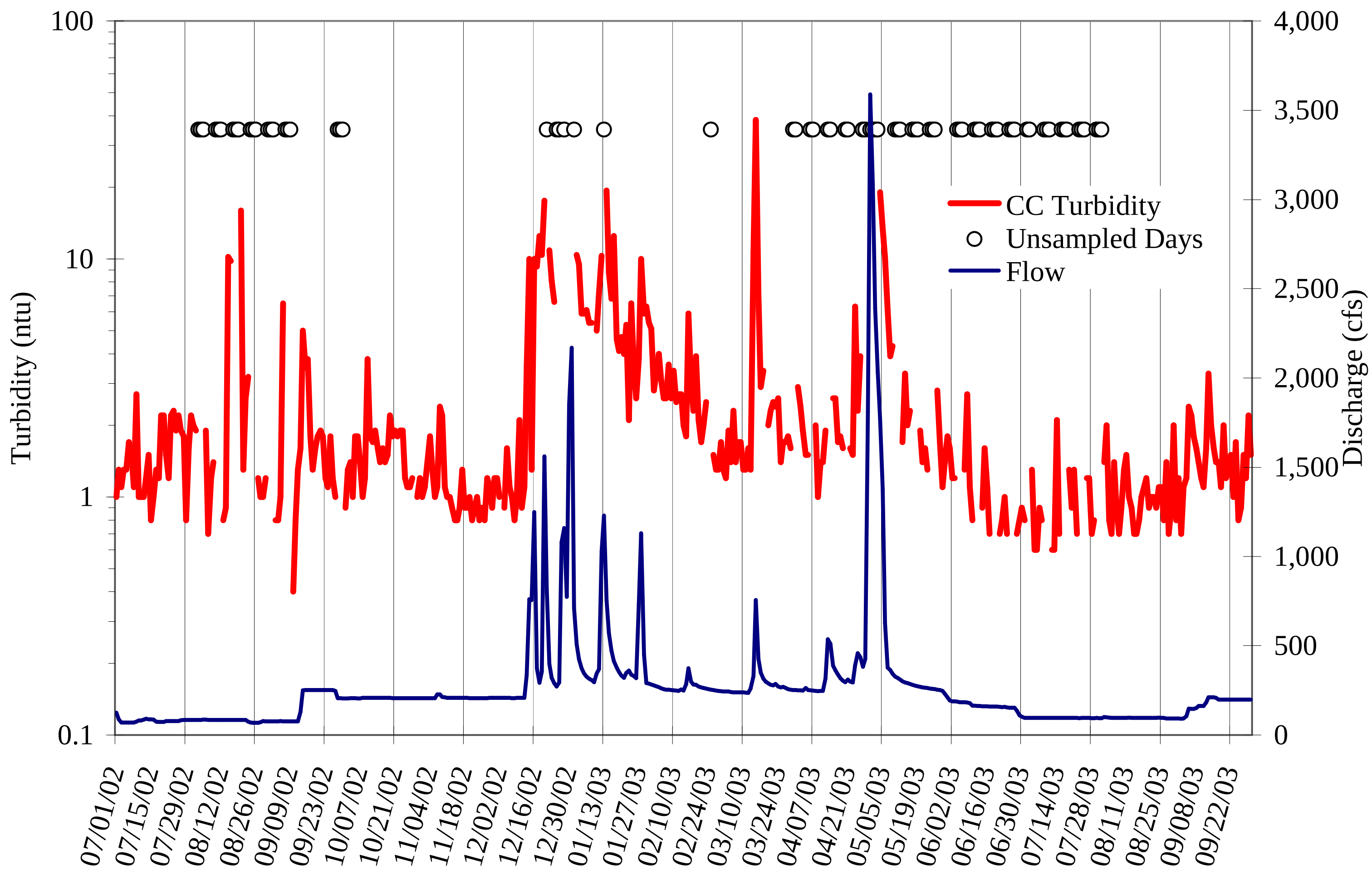

Figure 2. Mean daily flow in cubic feet per second (cfs), non sampling days and momentary turbidity in nephelometric turbidity units (NTU's), recorded at the rotary screw trap sampling station at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

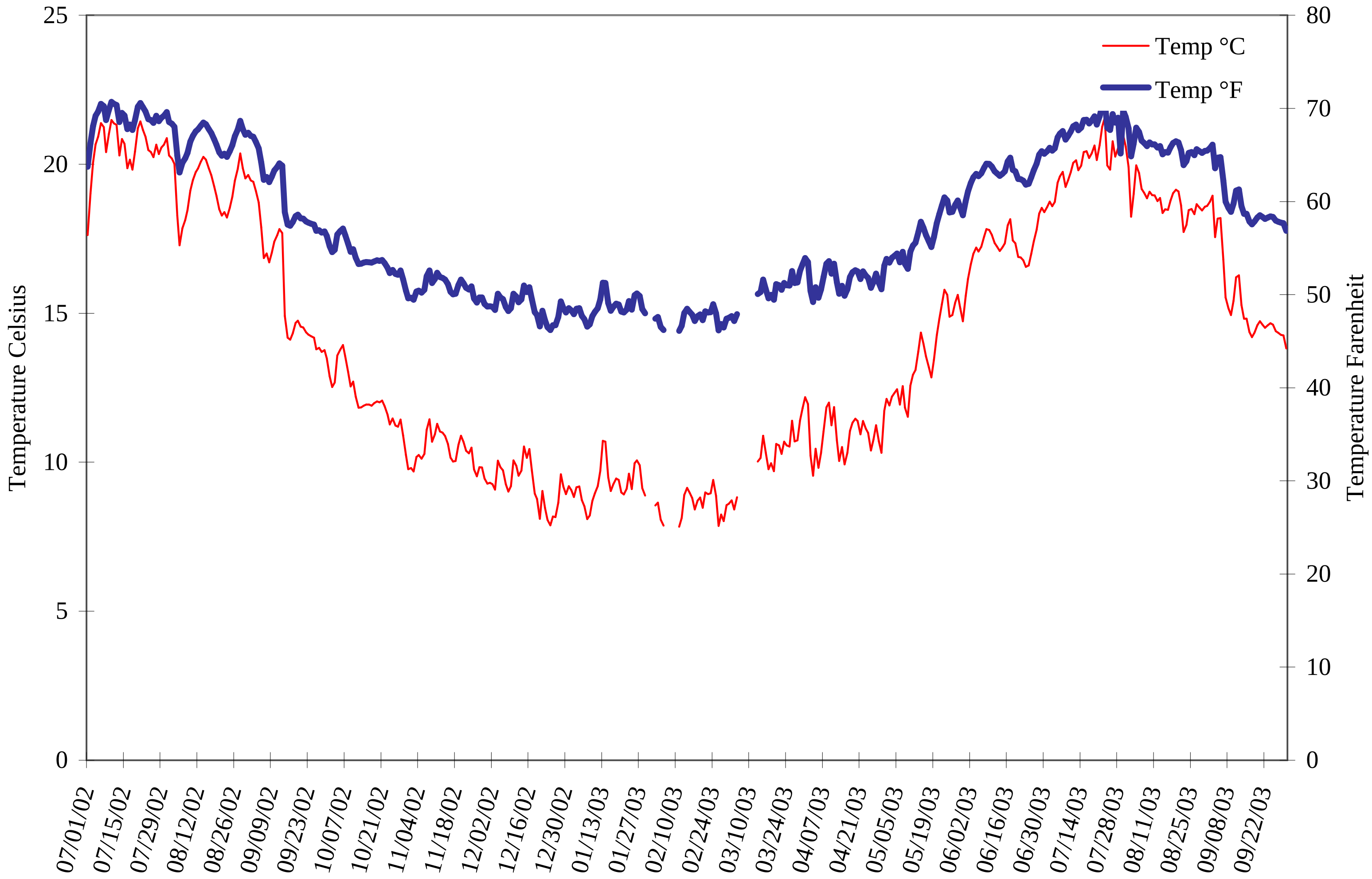

Figure 3. Mean daily water temperatures (°F and °C) recorded at the rotary screw trap sampling station at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

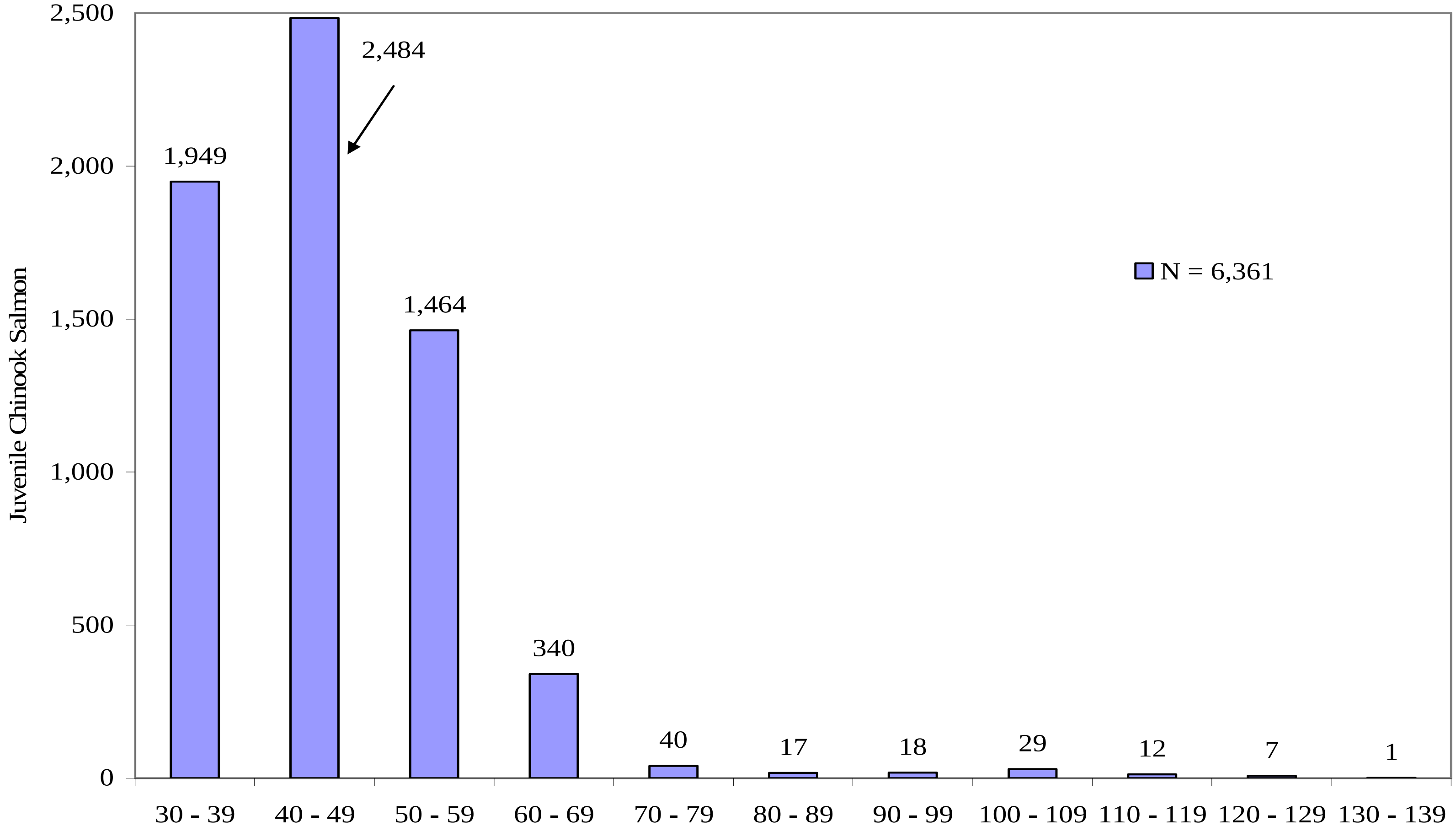

Figure 4. Fork length (mm) frequency distribution of juvenile late-fall run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 1, 2002 through March 31, 2003. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments.

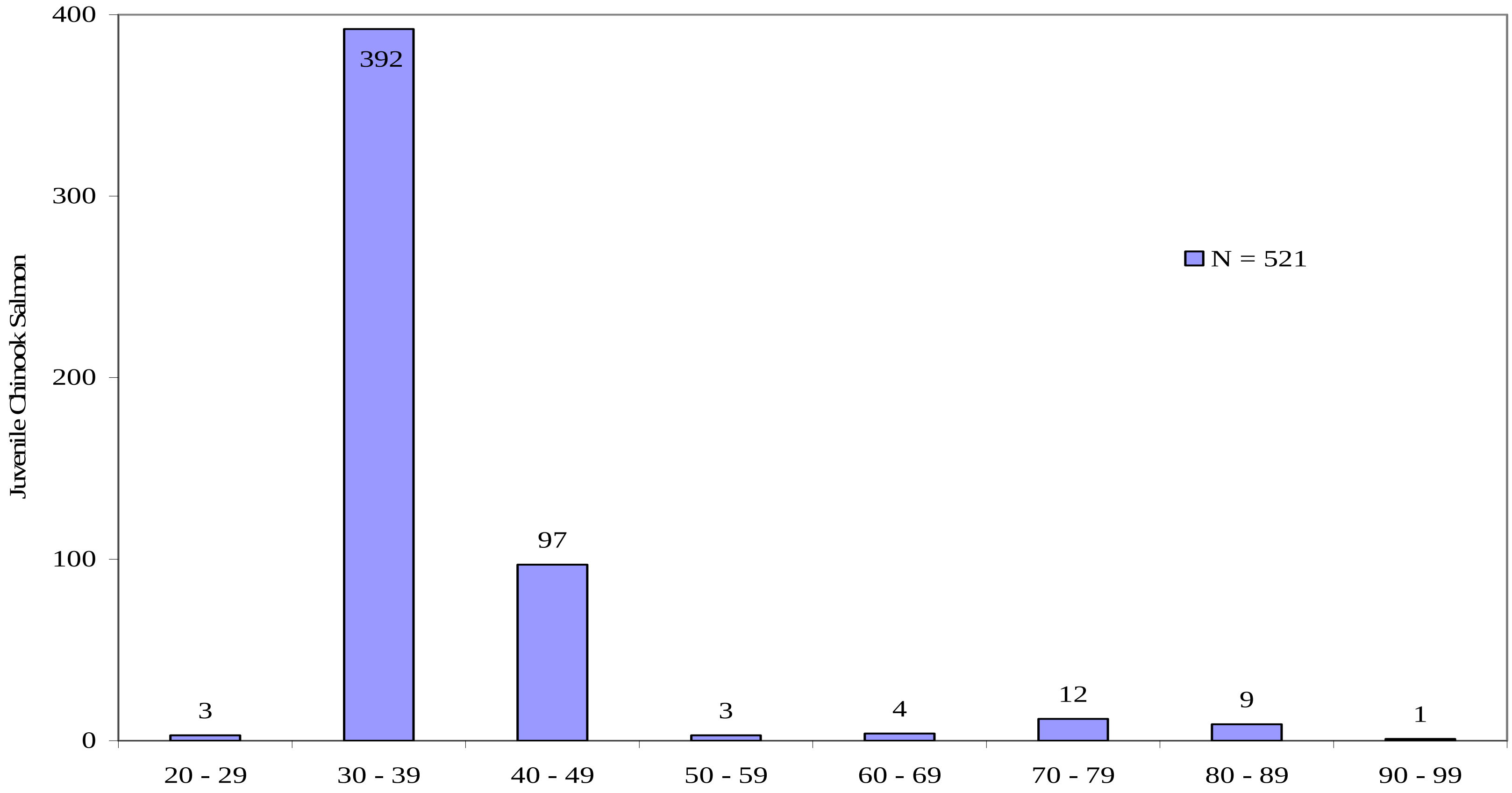

Figure 5. Fork length (mm) frequency distribution of juvenile spring-run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2003 through September 30, 2004. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments.

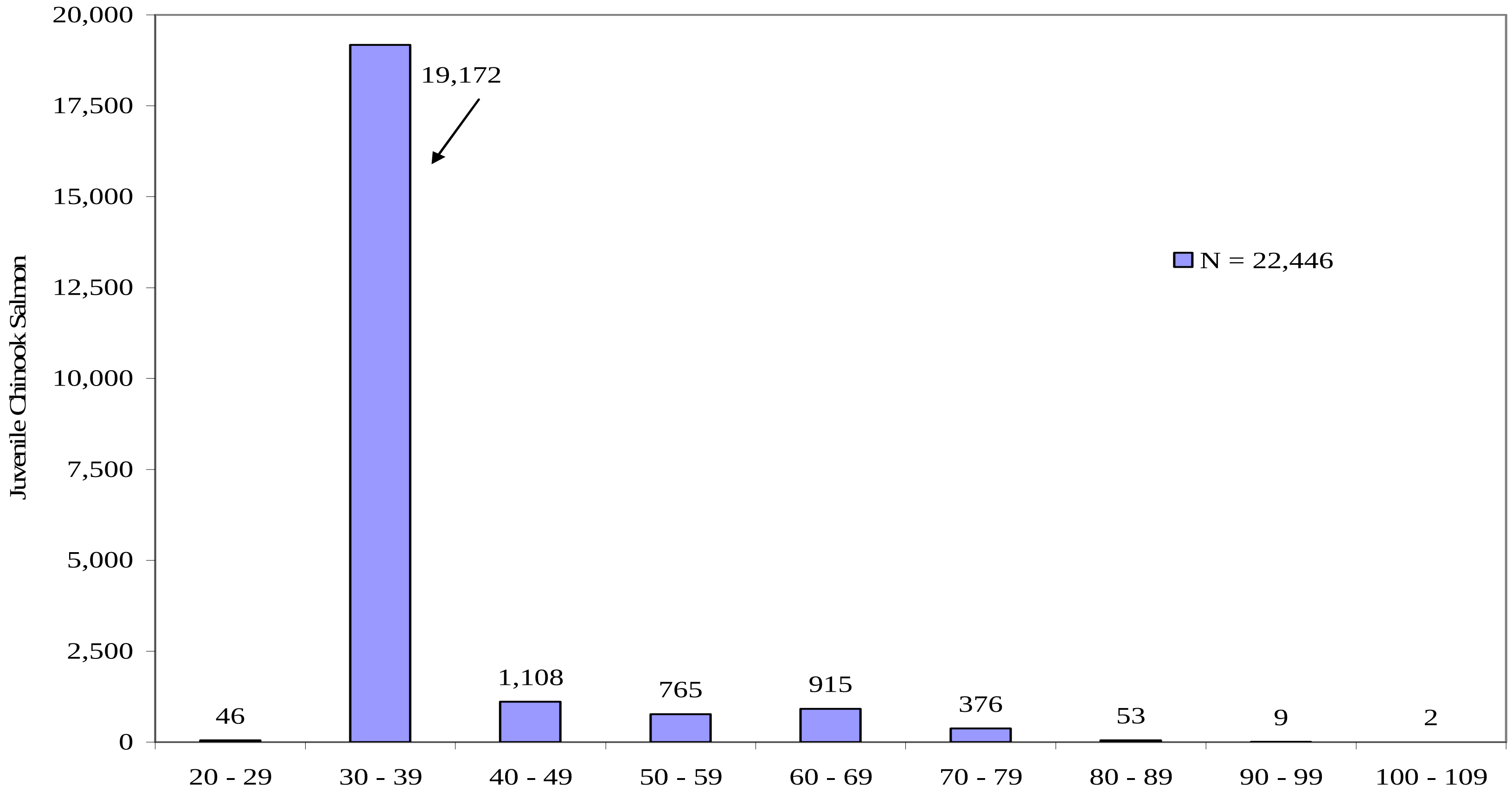

Figure 6. Fork length (mm) frequency distribution of juvenile fall-run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July1, 2003 through September 30, 2004. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments.

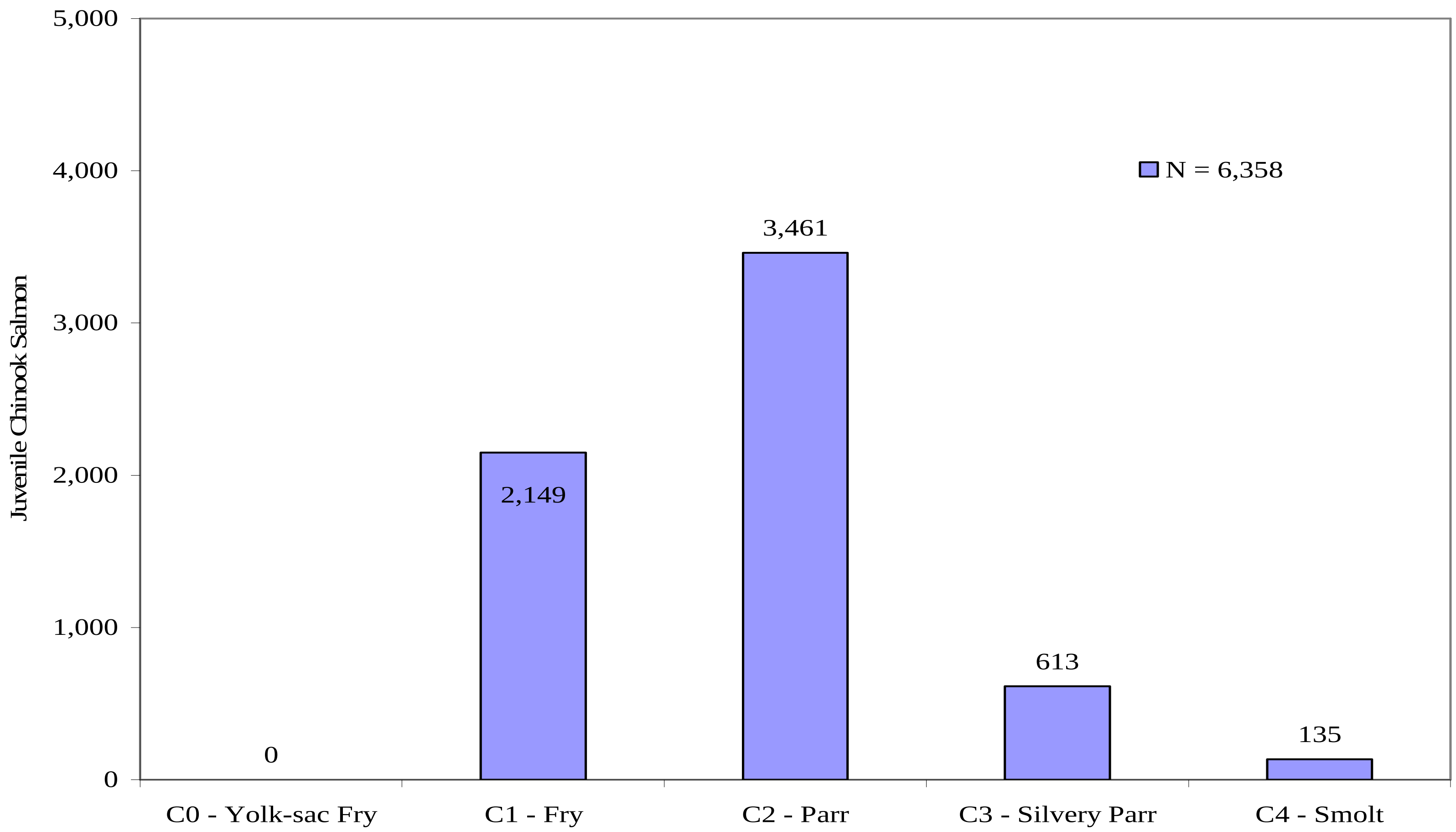

Figure 7. Life stage ratings for juvenile late-fall run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 1, 2002 through March 31, 2003.

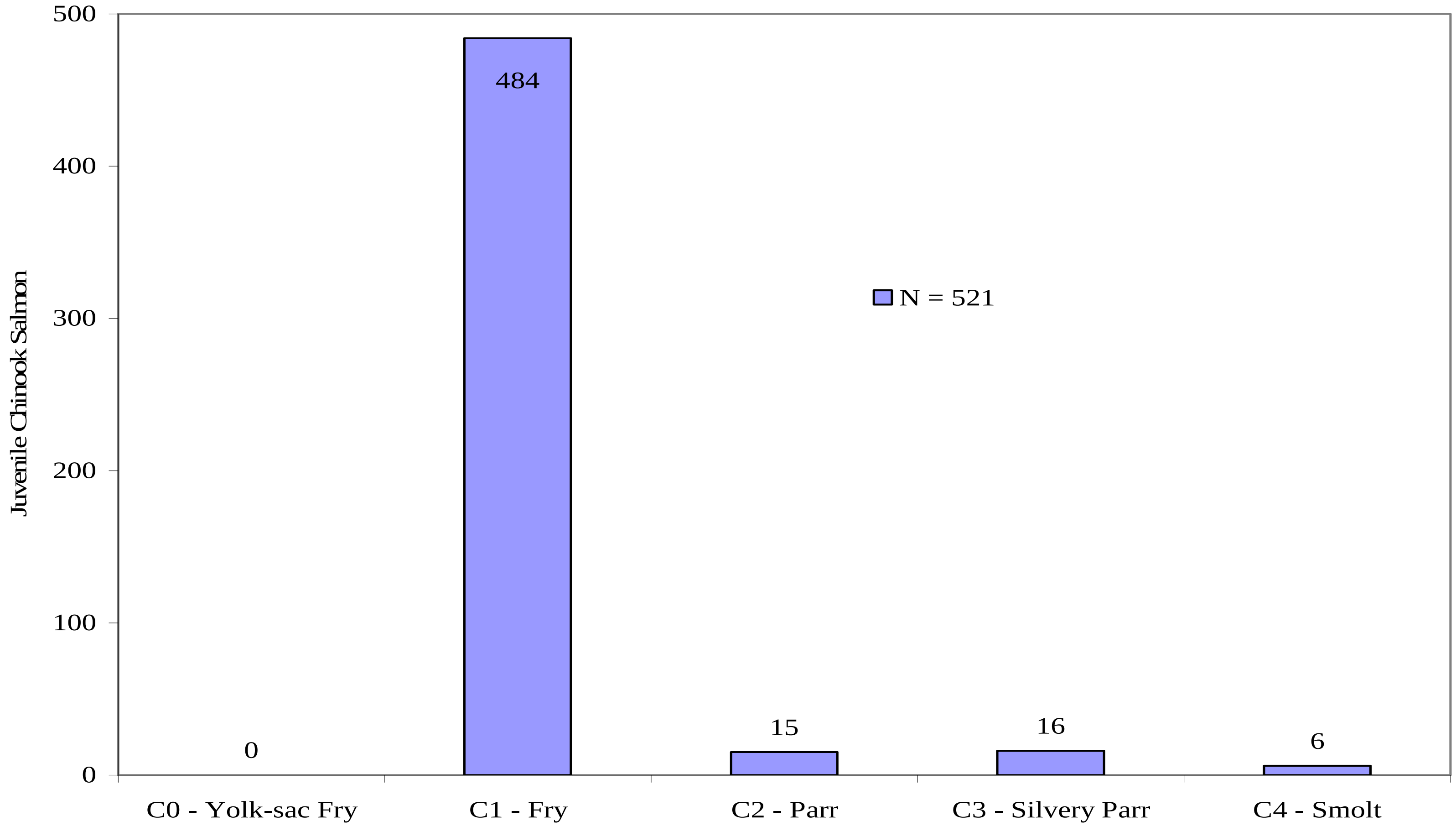

Figure 8. Life stage ratings for juvenile spring-run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

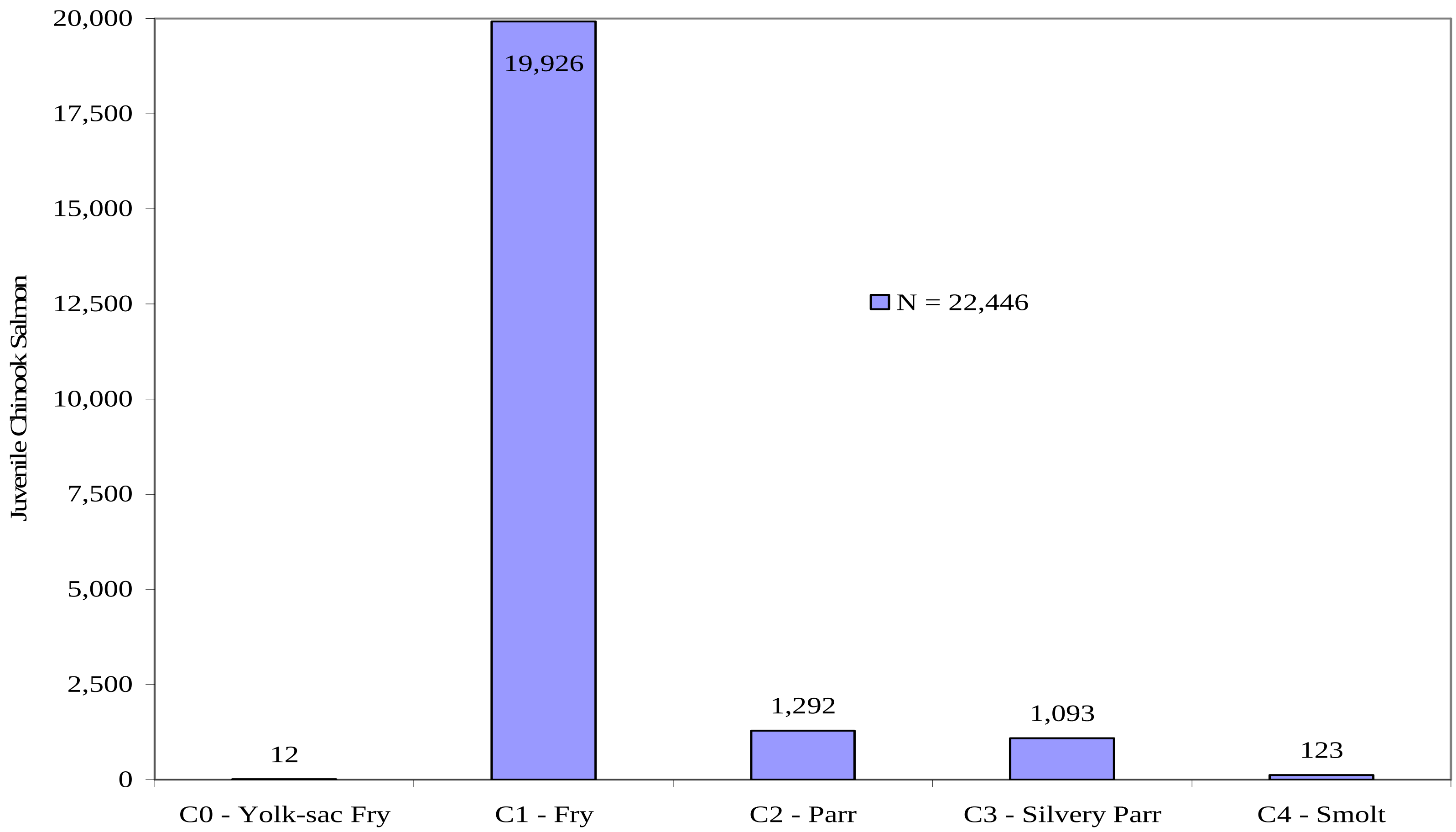

Figure 9. Life stage ratings for juvenile fall-run Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

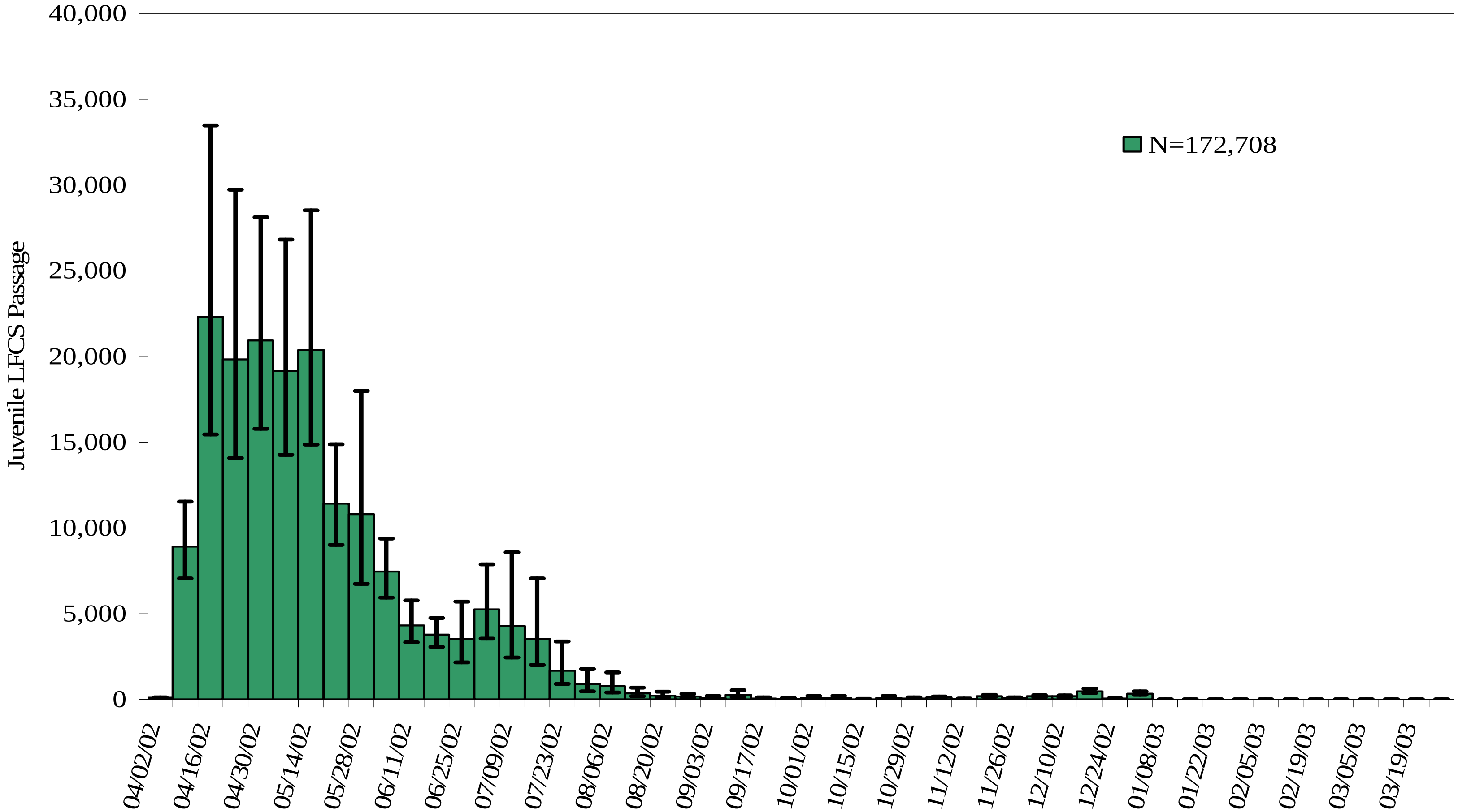

Figure 10. Passage index with 95% confidence intervals of juvenile late-fall run Chinook BY 2002 captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 2002 through March 2003.

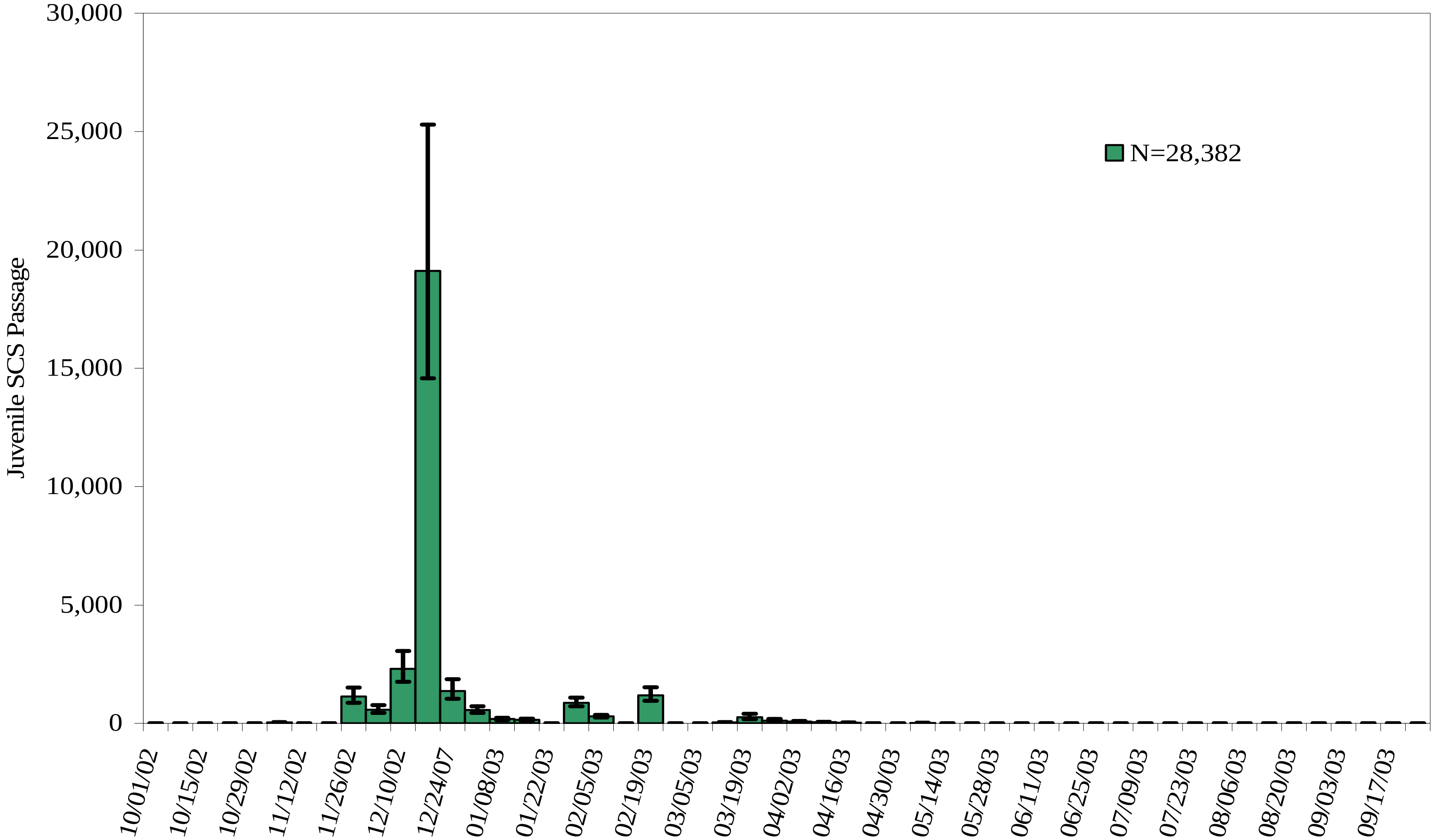

Figure 11. Passage index with 95% confidence intervals of juvenile spring-run Chinook BY 2002 captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from October 2002 through September 2003.

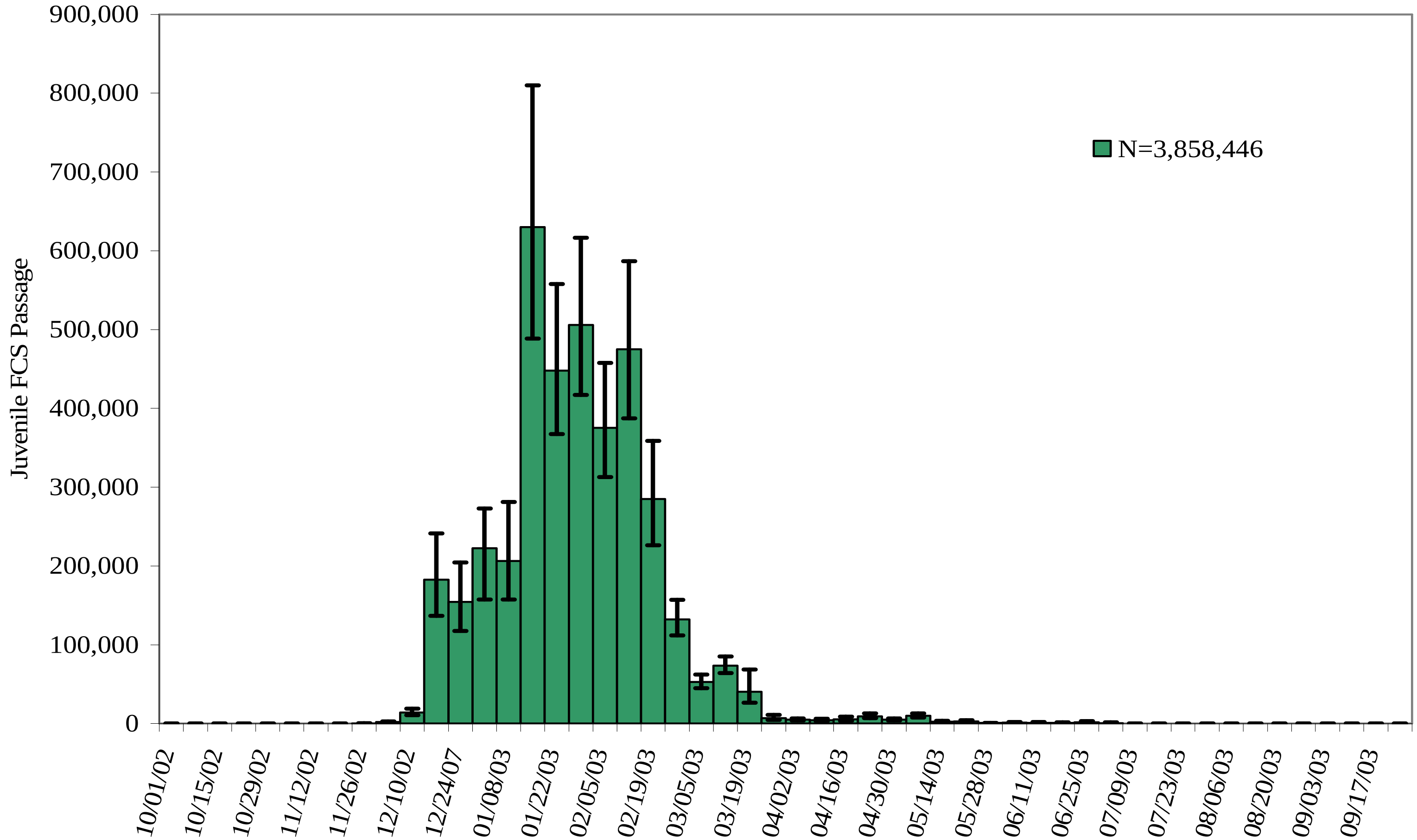

Figure 12. Passage index with 95% confidence intervals of juvenile fall-run Chinook BY 2002 captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from October 1, 2002 through September 30, 2003.

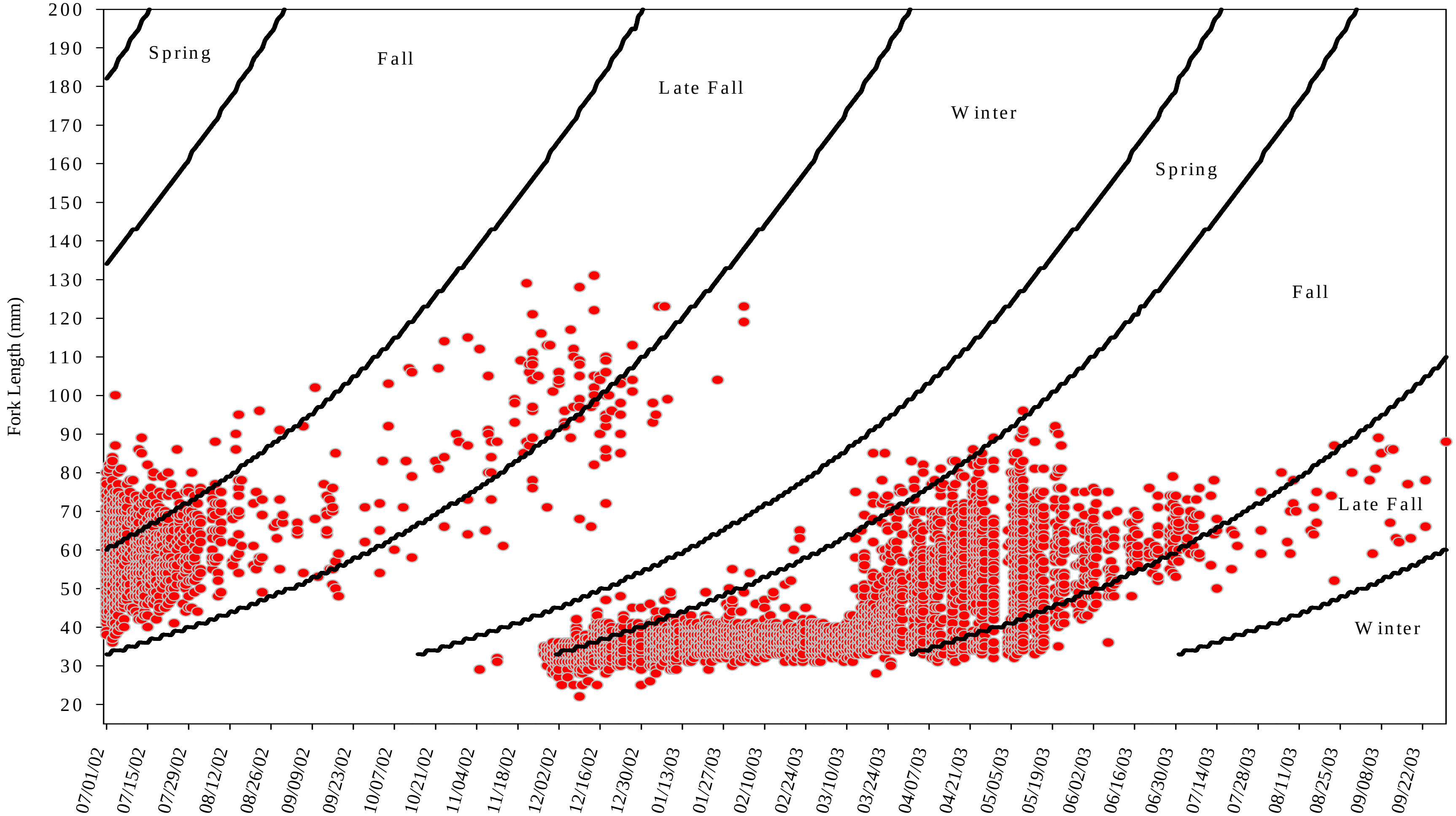

Figure 13. Fork length (mm) distribution by date and run for Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003. Spline curves represent the maximum fork lengths expected for each run by date, based upon criteria developed by the California Department of Water Resources (Greene 1992).

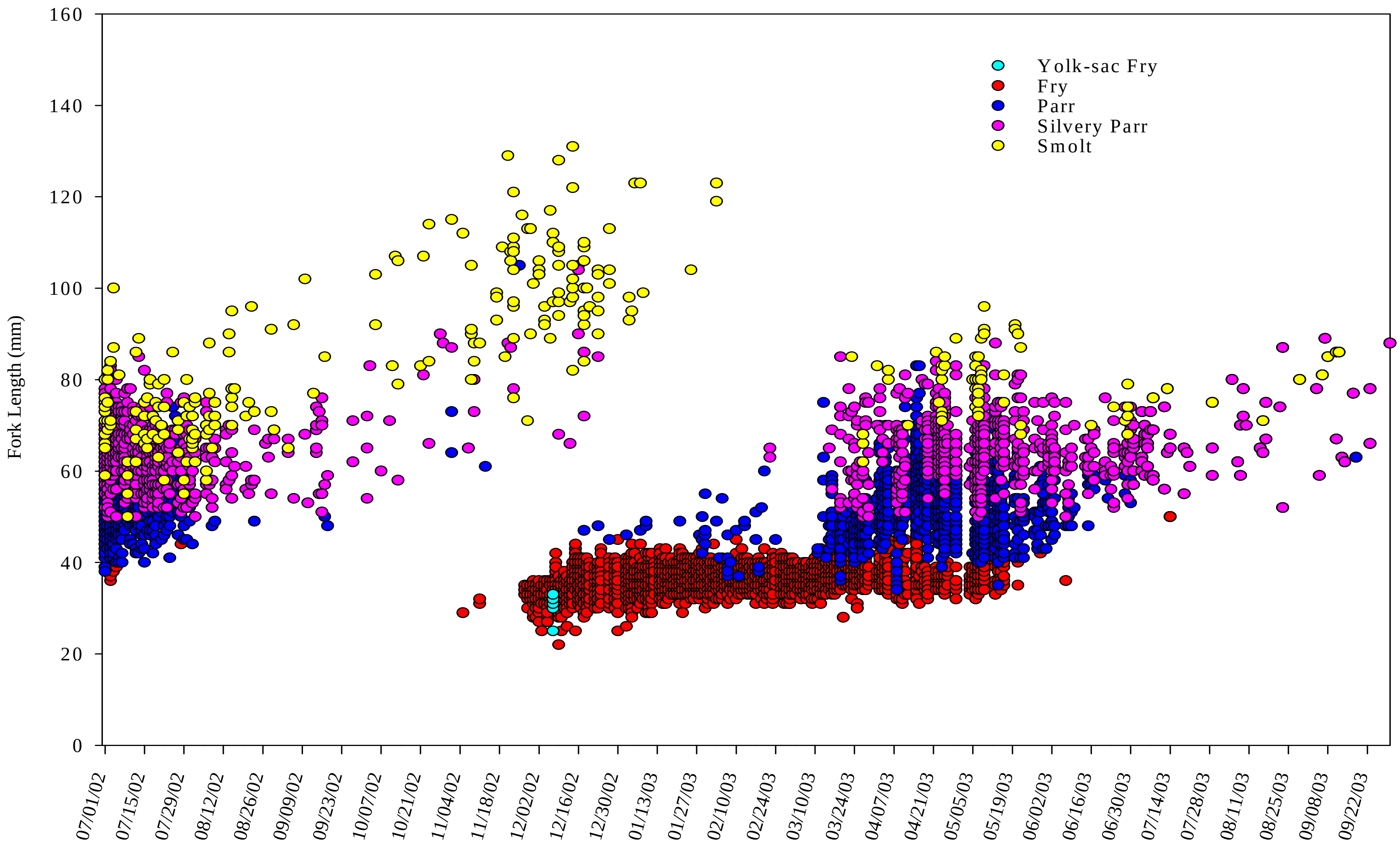

Figure 14. Life stage ratings for juvenile Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 2002 through September 2003.

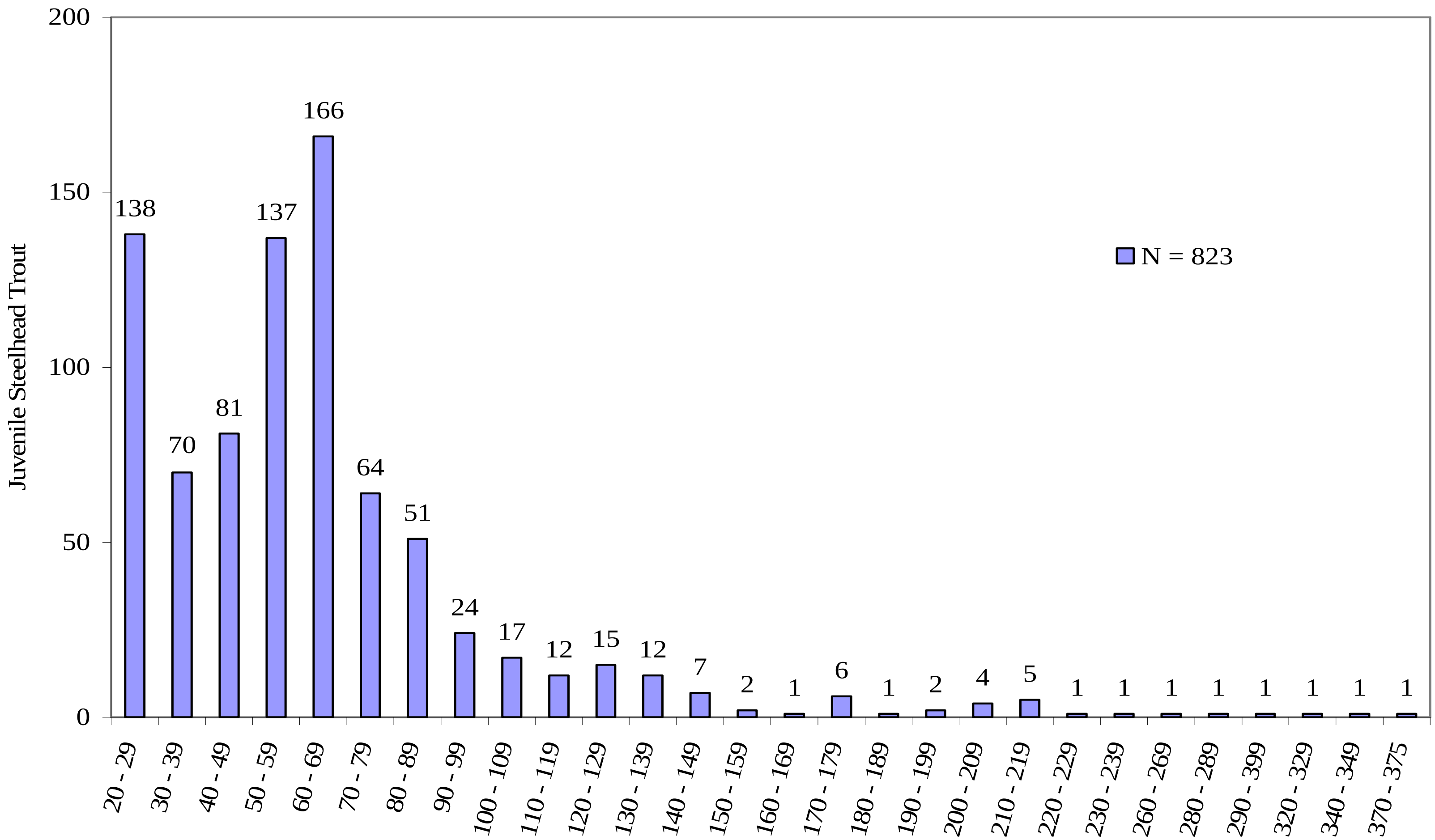

Figure 15. Fork length (mm) frequency distribution for Age 0 and Age 0+ steelhead / rainbow trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 31, 2002.

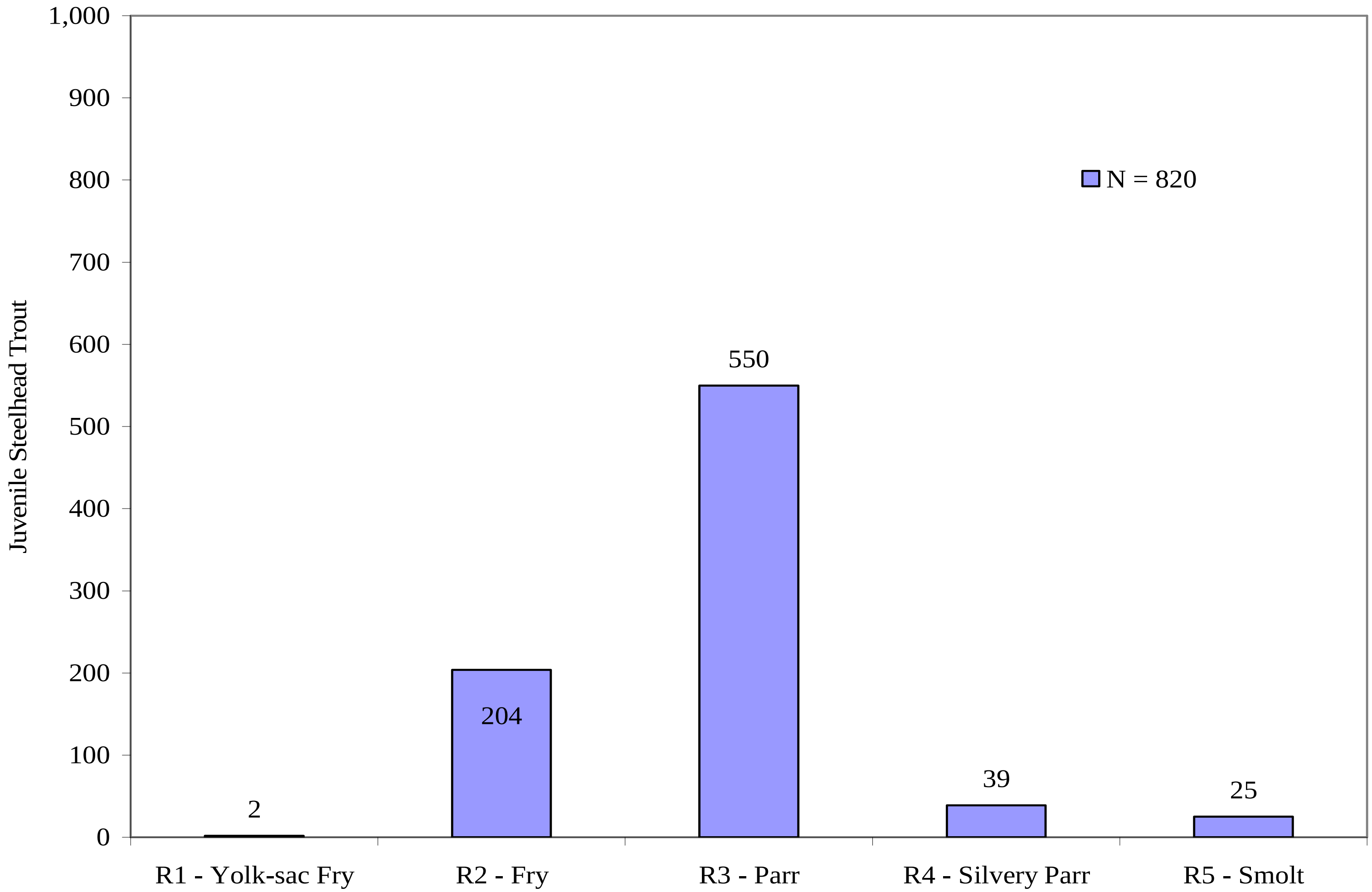

Figure 16. Life stage ratings for Age 0 and Age 0+ steelhead / rainbow trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 31, 2002.

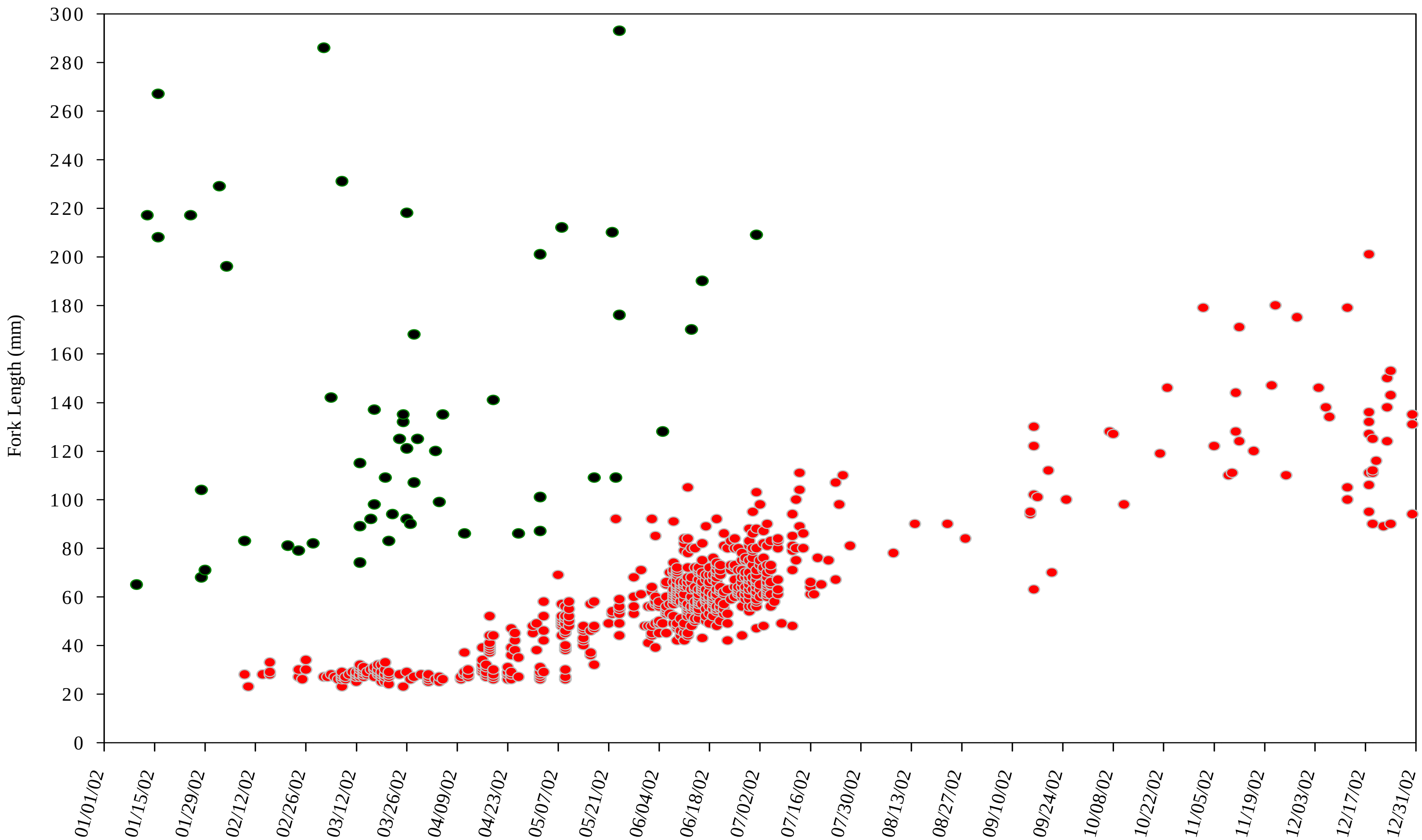

Figure 17. Fork length (mm) distribution by date for all steelhead / rainbow trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 30, 2002. Green dots represent Age 0+ steelhead / rainbow trout that most likely are of BY 2001 or earlier, while the red dots represent production from BY 2002.

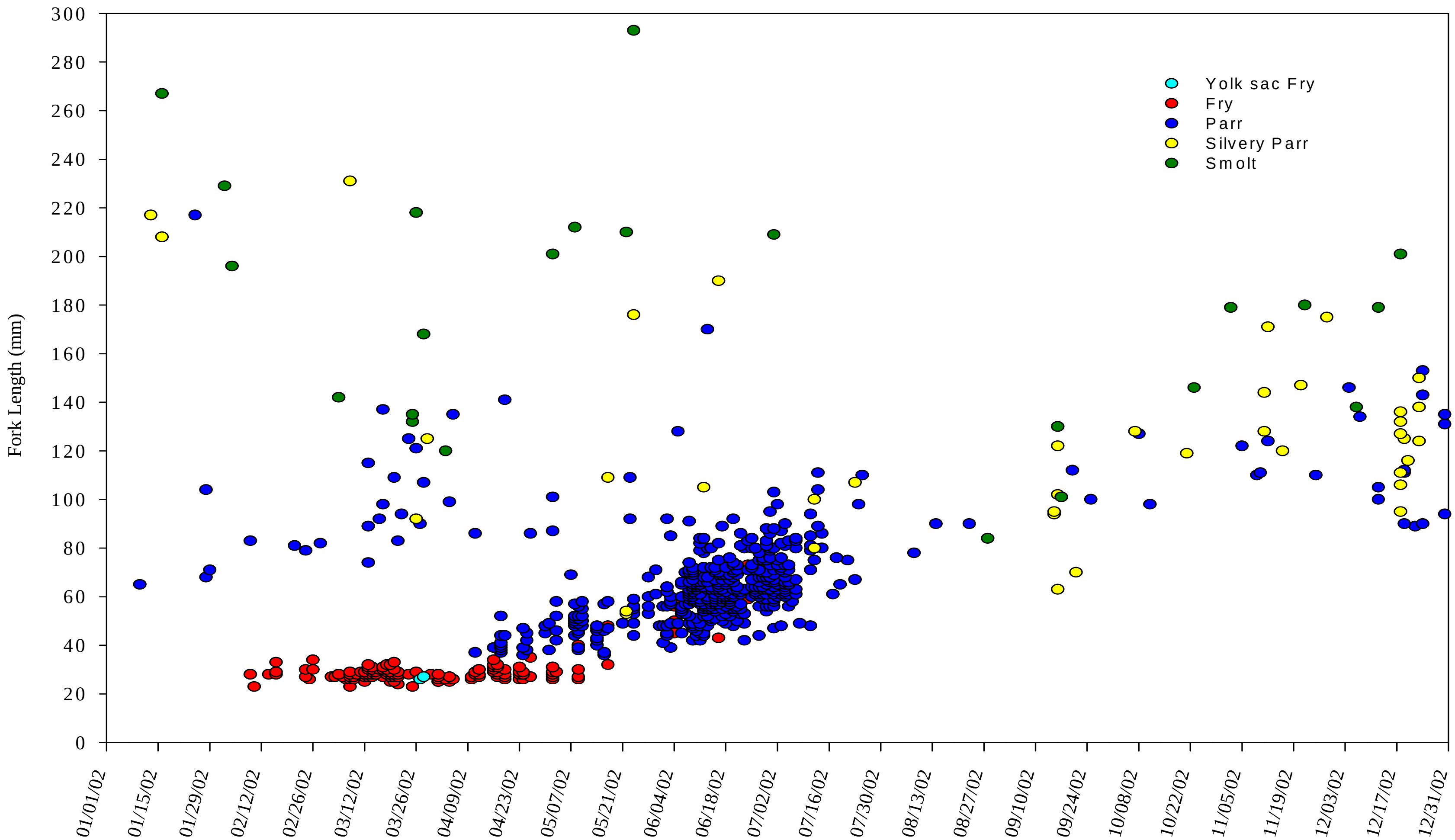

Figure 18. Life stage ratings for juvenile steelhead / rainbow trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 31, 2002.

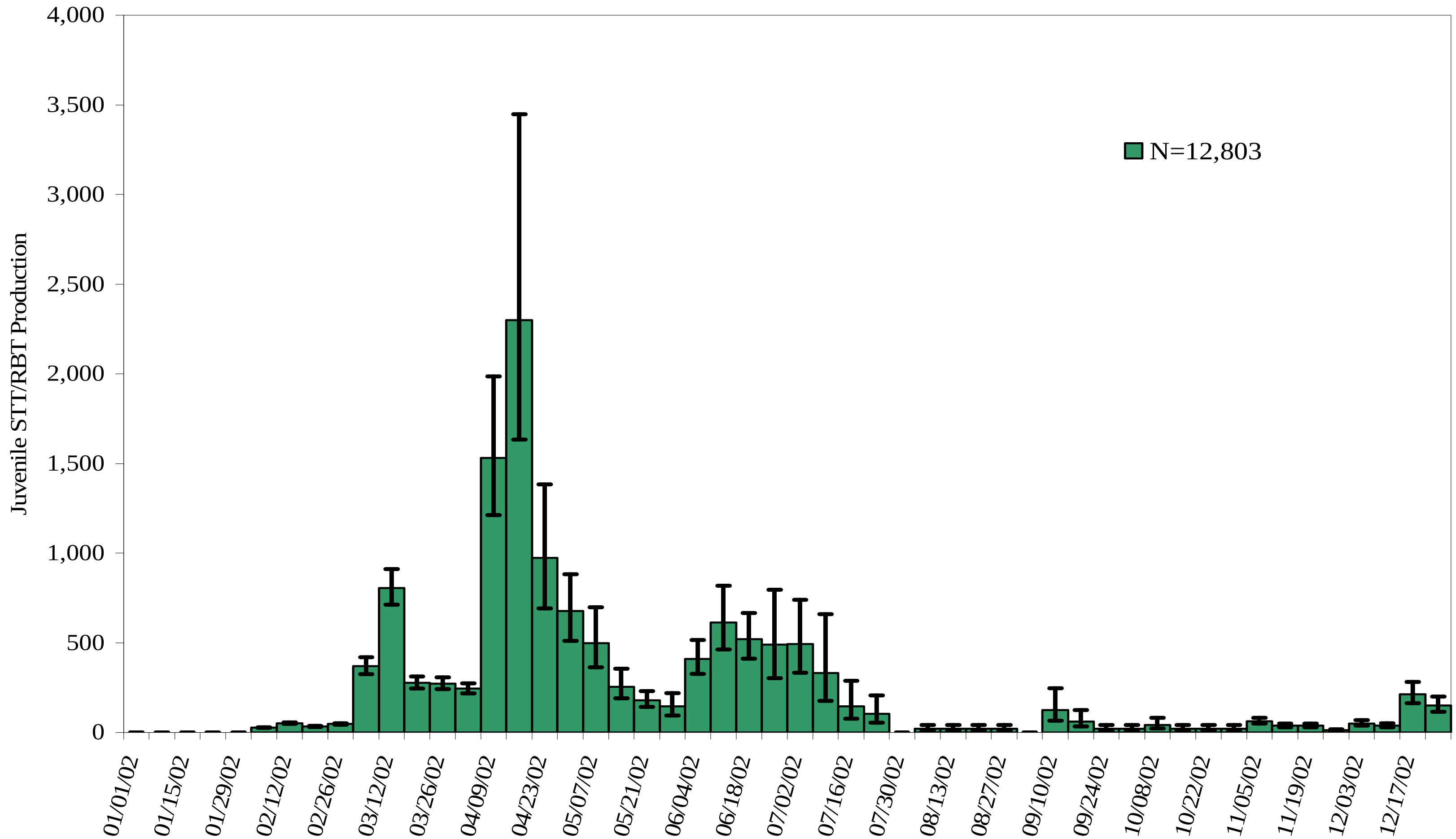

Figure 19. Passage index with 95% confidence intervals of Age 0 steelhead / rainbow trout BY 2002 captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from 1, 2002 through December 31, 2002.

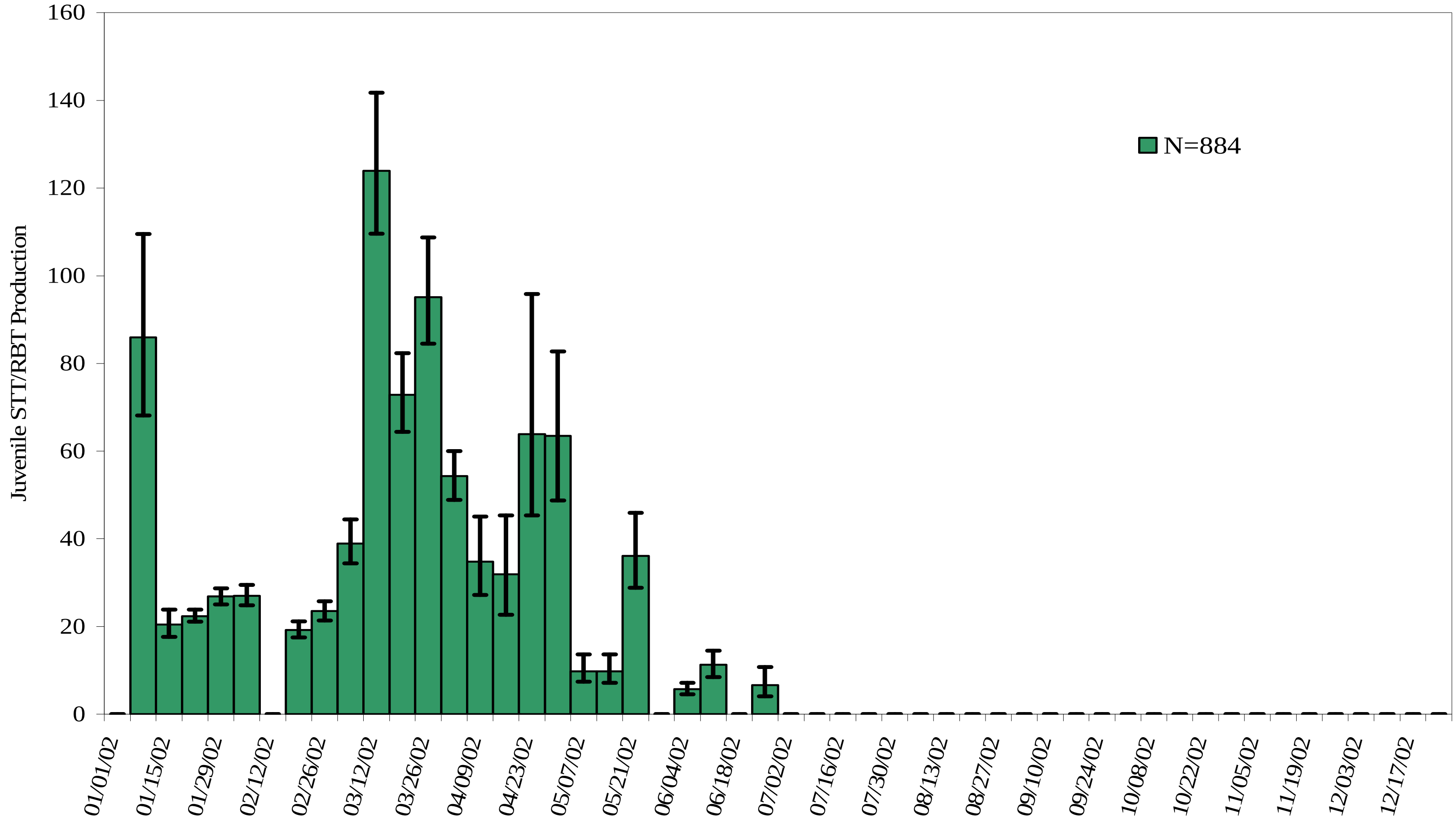

Figure 20. Passage index with 95% confidence intervals of Age 0+ steelhead / rainbow trout BY 2001 captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 31, 2002.

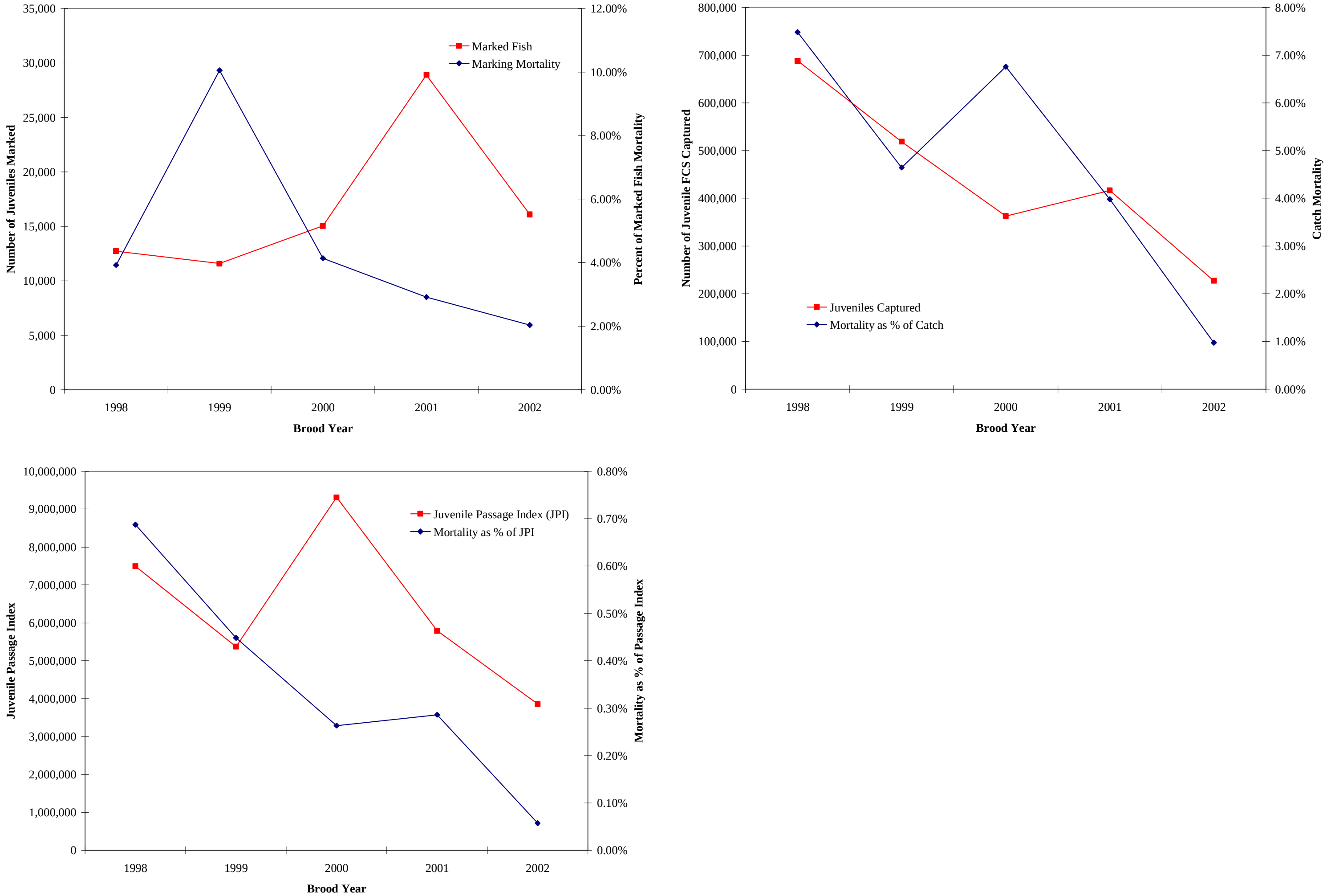

Figure 21. Mortality of fall Chinook salmon as a percentage of 1) fish marking for efficiency trials, 2) catch during trapping operations and 3) total estimated passage captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from December 1998 through September 2002.

Tables

Table 1. Dates with corresponding week numbers for rotary screw trapping operations at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

Dates	Corresponding Week	Dates	Corresponding Week
07/02/02-07/08	27	02/19-02/25	8
07/09-07/15	28	02/26-03/04	9
07/16-07/22	29	03/05-03/11	10
07/23-07/29	30	03/12-03/18	11
07/30-08/05	31	03/19-03/25	12
08/06-08/12	32	03/26-04/01	13
08/13-08/19	33	04/02-04/08	14
08/20-08/26	34	04/09-04/15	15
08/27-09/02	35	04/16-04/22	16
09/03-09/09	36	04/23-04/29	17
09/10-09/16	37	04/30-05/06	18
09/17-09/23	38	05/07-05/13	19
09/24-09/30	39	05/14-05/20	20
10/01-10/07	40	05/21-05/27	21
10/08-10/14	41	05/28-06/03	22
10/15-10/21	42	06/04-06/10	23
10/22-10/28	43	06/11-06/17	24
10/29-11/04	44	06/18-06/24	25
11/05-11/11	45	06/25-07/01	26
11/12-11/18	46	07/02-07/08	27
11/19-11/25	47	07/09-07/15	28
11/26-12/02	48	07/16-07/22	29
12/03-12/09	49	07/23-07/29	30
12/10-12/16	50	07/30-08/05	31
12/17-12/23	51	08/06-08/12	32

Dates	Corresponding Week	Dates	Corresponding Week
12/24-12/31/02*	52	08/13-08/19	33
01/01/03-01/07	1	08/20-08/26	34
01/08-01/14	2	08/27-09/02	35
01/15-01/21	3	09/03-09/09	36
01/22-01/28	4	09/10-09/16	37
01/29-02/04	5	09/17-09/23	38
02/05-02/11	6	09/24-09/30/03	39
02/12-02/18	7		

Table 2. Summary of efficiency test data gathered by using mark-recapture trials with juvenile Chinook salmon at the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 22, 2002 through May 24, 2003.

Trial	Mark Date	Release Date	Marked	Fish Released	Mortality	% Mortality	Trap Catch	Efficiency
1	1/22/2003	1/22/2003	1,000	996	4	4.76%	83	8.3%
2	1/26/2003	1/28/2003	975	975	0	1.15%	23	2.4%
3	1/30/2003	1/31/2003	1,041	1,032	9	0.00%	65	6.3%
4	2/2/2003	2/3/2003	1,010	1,005	5	0.00%	38	3.8%
5	2/5/2003	2/6/2003	1,000	992	8	0.40%	61	6.1%
6	2/9/2003	2/10/2003	1,002	993	9	0.00%	36	3.6%
7	2/12/2003	2/13/2003	994	983	11	0.00%	47	4.8%
8	2/16/2003	2/17/2003	989	977	12	0.50%	33	3.4%
9	2/19/2003	2/20/2003	943	902	41	0.81%	39	4.3%
10	2/26/2003	2/27/2003	1,000	983	17	0.73%	87	8.9%
11	3/2/2003	3/3/2003	1,000	970	30	0.25%	39	4.0%
12	3/5/2003	3/6/2003	893	887	6	0.00%	102	11.5%
13	3/9/2003	3/10/2003	614	589	25	0.67%	71	12.1%
14	3/12/2003	3/13/2003	1,041	1,026	15	1.34%	52	5.1%
15	3/16/2003	3/17/2003	387	342	45	1.54%	42	12.3%
16	3/19/2003	3/20/2003	386	373	13	1.65%	16	4.3%
17	3/25/2003	3/26/2003	286	276	10	1.23%	18	6.5%
18	4/1/2003	4/2/2003	48	45	3	10.53%	6	13.3%
19	4/8/2003	4/9/2003	182	175	7	5.65%	2	1.1%
20	4/16/2003	4/16/2003	202	201	1	4.76%	14	7.0%
21	4/22/2003	4/23/2003	588	555	33	1.15%	34	6.1%
22	5/6/2003	5/6/2003	101	98	3	0.00%	4	4.1%
23	5/19/2003	5/20/2003	409	388	21	0.00%	12	3.1%
	Totals		16,091	15,763	328	0.0204	924	

Table 3. Mark and recapture efficiency values used for weekly passage indices of Chinook captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003. Shaded rows indicate pooled values where more than one trial was used to determine efficiency.

Dates	Week	Marks	Recaptures	Efficiency
07/02/02	27	210	20	.0995
07/09/02-11/25/02	28-47	164	7	.0485
11/26/02-01/21/03	48-3*	563	44	.0798
01/22/03	4	996	83	.0843
01/29/03	5	2007	88	.0443
02/05/03	6	1997	99	.0501
02/12/03	7	1976	83	.0425
02/19/03	8	1879	72	.0388
02/26/03	9	1953	126	.0650
03/05/03	10	2840	354	.1295
03/12/03	11	1957	165	.0848
03/19/03	12	373	16	.0455
03/26/03	13	276	18	.0686
04/02/03-04/15/03	14-15**	563	44	.0798
04/16/03	16	201	14	.0743
04/23/03	17	555	34	.0629
04/30/03-05/20/03	18-20**	563	44	.0798
05/21/03	21	388	12	.0334
05/28/03	22**	563	44	.0798
06/04/03-09/30/03	23-39	388	12	.0334
	*Half Cone Average	1227	47	.0390
	**Full Cone Average	563	44	.0798

Table 4. Mark and recapture efficiency values used for weekly passage indices of steelhead trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 to December 31, 2002. Shaded rows indicate pooled values where more than one trial was used to determine efficiency.

Dates	Week	Marks	Recaptures	Efficiency
01/01/02-01/14/02	1-2	930	64	.0698
01/15/02	3	762	148	.1953
01/22/02	4	2588	694	.2684
01/29/02	5	3039	678	.2234
02/05/02	6	3058	452	.1481
02/12/02	7	2376	366	.1544
02/19/02	8	1925	400	.2082
02/26/02	9	1992	338	.1701
03/05/02	10	2030	208	.1029
03/12/02	11	2136	206	.0969
03/19/02	12	1564	214	.1374
03/26/02	13	1459	214	.1473
04/02/02	14	2450	270	.1106
04/09/02	15	991	56	.0575
04/16/02-04/29/02	16-17	430	26	.0626
04/30/02	18	454	42	.0945
05/07/02-05/20/02	19-20	341	34	.1023
05/21/02	21	504	55	.1109
05/28/02	22	83	14	.1786
06/04/02	23	307	53	.1753
06/11/02	24	224	39	.1778
06/18/02	25	437	63	.1461
06/25/02	26	85	12	.1512
07/02/02	27	210	20	.0995
07/09/02-11/25/02	28-47	164	7	.0485
11/26/02-12/31/02	48-52*	563	44	.0798
	*Full Cone Average 2003	563	44	.0798

Table 5. Weekly passage indices with 90% and 95% confidence intervals, and standard deviation (SD) of the weekly strata of Broodyear 2002 late-fall run Chinook captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 1, 2002 through March 31, 2003.

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
4 of 7	Week 14	04/02/02	105	107	113	129	131	7
4 of 7	Week 15	04/09/02	7,054	7,256	8,910	11,041	11,543	1,129
4 of 7	Week 16	04/16/02	15,450	16,285	22,315	30,127	33,474	4,649
4 of 7	Week 17	04/23/02	14,087	14,468	19,826	26,765	29,739	3,826
4 of 7	Week 18	04/30/02	15,789	16,363	20,932	26,470	28,125	3,143
4 of 7	Week 19	05/07/02	14,262	14,896	19,155	24,827	26,813	3,155
4 of 7	Week 20	05/14/02	14,863	15,509	20,388	26,423	28,536	3,457
4 of 7	Week 21	05/21/02	9,012	9,273	11,428	13,909	14,880	1,486
7 of 7	Week 22	05/28/02	6,748	7,361	10,798	16,195	17,995	2,897
7 of 7	Week 23	06/04/02	5,934	6,113	7,470	9,170	9,383	954
7 of 7	Week 24	06/11/02	3,327	3,461	4,326	5,407	5,768	617
7 of 7	Week 25	06/18/02	3,066	3,146	3,785	4,570	4,749	458
7 of 7	Week 26	06/25/02	2,175	2,283	3,513	5,074	5,708	961
7 of 7	Week 27	07/02/02	3,560	3,805	5,255	7,357	7,882	1,119
7 of 7	Week 28	07/09/02	2,451	2,451	4,290	6,864	8,580	1,759
7 of 7	Week 29	07/16/02	2,015	2,015	3,527	5,643	7,054	1,372
7 of 7	Week 30	07/23/02	902	966	1,691	2,706	3,383	684
4 of 7	Week 31	07/30/02	473	507	887	1,419	1,774	358
4 of 7	Week 32	08/06/02	418	448	784	1,254	1,568	307
4 of 7	Week 33	08/13/02	187	200	351	561	701	132
4 of 7	Week 34	08/20/02	130	130	227	363	454	93
4 of 7	Week 35	08/27/02	94	94	165	264	330	64
4 of 7	Week 36	09/03/02	55	59	103	165	206	42
7 of 7	Week 37	09/10/02	143	153	268	429	536	115
7 of 7	Week 38	09/17/02	33	38	62	99	124	24
4 of 7	Week 39	09/24/02	22	24	41	66	83	14
7 of 7	Week 40	10/01/02	59	63	103	206	206	41
7 of 7	Week 41	10/08/02	55	59	103	165	206	38

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
7 of 7	Week 42	10/15/02	11	12	21	33	41	8
7 of 7	Week 43	10/22/02	55	59	103	165	206	47
7 of 7	Week 44	10/29/02	35	38	62	99	124	23
7 of 7	Week 45	11/05/02	96	99	125	161	166	19
7 of 7	Week 46	11/12/02	29	30	38	47	50	5
7 of 7	Week 47	11/19/02	153	158	201	251	273	29
7 of 7	Week 48	11/26/02	78	79	100	125	129	14
7 of 7	Week 49	12/03/02	146	148	188	235	256	28
7 of 7	Week 50	12/10/02	132	139	179	226	239	26
6 of 7	Week 51	12/17/02	363	383	481	595	630	68
3 of 8	Week 52*	12/24/02	38	40	52	64	68	7
6 of 7	Week 1	01/01/03	268	282	346	439	464	49
6 of 7	Week 2	01/08/03	0	0	0	0	0	0
7 of 7	Week 3	01/15/03	0	0	0	0	0	0
7 of 7	Week 4	01/22/03	0	0	0	0	0	0
7 of 7	Week 5	01/29/03	0	0	0	0	0	0
7 of 7	Week 6	02/05/03	0	0	0	0	0	0
7 of 7	Week 7	02/12/03	0	0	0	0	0	0
6 of 7	Week 8	02/19/03	0	0	0	0	0	0
7 of 7	Week 9	02/26/03	0	0	0	0	0	0
7 of 7	Week 10	03/05/03	0	0	0	0	0	0
7 of 7	Week 11	03/12/03	0	0	0	0	0	0
7 of 7	Week 12	03/19/03	0	0	0	0	0	0
5 of 7	Week 13	03/26/03	0	0	0	0	0	0
309 of 365		Total	156,297	158,835	172,708	189,998	192,685	

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1.

Table 6. Weekly passage indices with 90% and 95% confidence intervals, and standard deviation (SD) of the weekly strata of Broodyear 2002 spring-run Chinook captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from October 1, 2002 through September 30, 2003.

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
7 of 7	Week 40	10/01/02	0	0	0	0	0	0
7 of 7	Week 41	10/08/02	0	0	0	0	0	0
7 of 7	Week 42	10/15/02	0	0	0	0	0	0
7 of 7	Week 43	10/22/02	0	0	0	0	0	0
7 of 7	Week 44	10/29/02	0	0	0	0	0	0
7 of 7	Week 45	11/05/02	28	30	38	47	50	6
7 of 7	Week 46	11/12/02	0	0	0	0	0	0
7 of 7	Week 47	11/19/02	0	0	0	0	0	0
7 of 7	Week 48	11/26/02	870	900	1,141	1,426	1,510	168
7 of 7	Week 49	12/03/02	432	455	577	721	763	87
7 of 7	Week 50	12/10/02	1,759	1,821	2,307	2,965	3,052	347
6 of 7	Week 51	12/17/02	14,578	15,089	19,113	23,892	25,297	2,763
3 of 8	Week 52*	12/24/07	1,042	1,079	1,367	1,708	1,863	198
6 of 7	Week 1	01/01/03	438	445	566	705	725	78
6 of 7	Week 2	01/08/03	134	139	180	226	232	26
7 of 7	Week 3	01/15/03	115	119	147	188	199	22
7 of 7	Week 4	01/22/03	0	0	0	0	0	0
7 of 7	Week 5	01/29/03	718	746	873	1,030	1,088	91
7 of 7	Week 6	02/05/03	250	256	295	348	357	28
7 of 7	Week 7	02/12/03	0	0	0	0	0	0
6 of 7	Week 8	02/19/03	961	983	1,185	1,418	1,517	138
7 of 7	Week 9	02/26/03	0	0	0	0	0	0
7 of 7	Week 10	03/05/03	0	0	0	0	0	0
7 of 7	Week 11	03/12/03	41	42	43	53	55	4
7 of 7	Week 12	03/19/03	173	180	258	374	408	66
5 of 7	Week 13	03/26/03	79	82	117	170	185	27
5 of 7	Week 14	04/02/03	56	59	76	97	100	11
5 of 7	Week 15	04/09/03	38	40	51	63	64	7

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
5 of 7	Week 16	04/16/03	17	18	27	40	45	8
5 of 7	Week 17	04/23/03	0	0	0	0	0	0
3 of 7	Week 18	04/30/03	0	0	0	0	0	0
4 of 7	Week 19	05/07/03	19	20	23	31	33	4
4 of 7	Week 20	05/14/03	0	0	0	0	0	0
4 of 7	Week 21	05/21/03	0	0	0	0	0	0
7 of 7	Week 22	05/28/03	0	0	0	0	0	0
4 of 7	Week 23	06/04/03	0	0	0	0	0	0
4 of 7	Week 24	06/11/03	0	0	0	0	0	0
4 of 7	Week 25	06/18/03	0	0	0	0	0	0
4 of 7	Week 26	06/25/03	0	0	0	0	0	0
5 of 7	Week 27	07/02/03	0	0	0	0	0	0
4 of 7	Week 28	07/09/03	0	0	0	0	0	0
4 of 7	Week 29	07/16/03	0	0	0	0	0	0
4 of 7	Week 30	07/23/03	0	0	0	0	0	0
4 of 7	Week 31	07/30/03	0	0	0	0	0	0
7 of 7	Week 32	08/06/03	0	0	0	0	0	0
7 of 7	Week 33	08/13/03	0	0	0	0	0	0
7 of 7	Week 34	08/20/03	0	0	0	0	0	0
7 of 7	Week 35	08/27/03	0	0	0	0	0	0
7 of 7	Week 36	09/03/03	0	0	0	0	0	0
7 of 7	Week 37	09/10/03	0	0	0	0	0	0
7 of 7	Week 38	09/17/03	0	0	0	0	0	0
7 of 7	Week 39	09/24/03	0	0	0	0	0	0
307 of 365		Total	23,677	24,272	28,382	33,409	34,754	

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1.

Table 7. Weekly passage indices with 90% and 95% confidence intervals, and standard deviation (SD) of the weekly strata of Broodyear 2002 fall-run Chinook captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from October 1, 2002 through September 30, 2003.

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
7 of 7	Week 40	10/01/02	0	0	0	0	0	0
7 of 7	Week 41	10/08/02	0	0	0	0	0	0
7 of 7	Week 42	10/15/02	0	0	0	0	0	0
7 of 7	Week 43	10/22/02	0	0	0	0	0	0
7 of 7	Week 44	10/29/02	0	0	0	0	0	0
7 of 7	Week 45	11/05/02	0	0	0	0	0	0
7 of 7	Week 46	11/12/02	0	0	0	0	0	0
7 of 7	Week 47	11/19/02	0	0	0	0	0	0
7 of 7	Week 48	11/26/02	291	307	389	486	514	58
7 of 7	Week 49	12/03/02	1,532	1,613	2,043	2,627	2,786	311
7 of 7	Week 50	12/10/02	10,783	11,161	14,139	17,672	18,712	2,068
6 of 7	Week 51	12/17/02	136,883	144,087	182,516	228,138	241,558	27,427
3 of 8	Week 52*	12/24/07	117,800	121,933	154,444	193,060	204,417	22,783
6 of 7	Week 1	01/01/03	157,337	162,857	222,450	257,858	273,026	30,650
6 of 7	Week 2	01/08/03	157,337	162,857	206,288	257,858	281,299	29,876
7 of 7	Week 3	01/15/03	488,852	497,428	630,079	787,595	810,097	87,515
4 of 7	Week 4	01/22/03	192,763	196,618	234,071	276,927	293,460	24,718
3 of 7	Week4 Pt. II	01/22/03	174,678	179,621	213,931	253,865	264,442	22,827
7 of 7	Week 5	01/29/03	416,902	428,813	505,895	600,338	616,786	51,796
7 of 7	Week 6	02/05/03	312,820	320,841	375,389	446,886	457,786	37,057
7 of 7	Week 7	02/12/03	387,338	398,959	474,951	561,914	586,704	51,397
6 of 7	Week 8	02/19/03	226,070	236,346	284,910	346,641	358,594	34,305
7 of 7	Week 9	02/26/03	111,912	114,196	132,180	151,233	156,886	11,534
2 of 7	Week 10	03/05/03	12,323	12,589	13,832	15,216	15,554	815
5 of 7	Week 10 Pt. II	03/05/03	32,690	33,507	39,038	45,178	46,754	3,716
7 of 7	Week 11	03/12/03	64,202	65,582	73,488	82,982	85,303	5,311
7 of 7	Week 12	03/19/03	26,410	27,467	40,398	62,424	68,666	10,516
5 of 7	Week 13	03/26/03	4,680	5,027	7,144	9,695	11,311	1,658

Days Sampled	Week	Date	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
5 of 7	Week 14	04/02/03	3,870	3,938	4,988	6,235	6,802	731
5 of 7	Week 15	04/09/03	3,309	3,483	4,407	5,672	6,016	657
5 of 7	Week 16	04/16/03	3,469	3,627	5,325	7,979	8,866	1,419
5 of 7	Week 17	04/23/03	6,873	7,179	9,230	12,424	12,921	1,575
3 of 7	Week 18	04/30/03	3,862	4,069	5,063	6,329	6,702	703
4 of 7	Week 19	05/07/03	7,614	7,886	9,815	12,617	12,989	1,434
4 of 7	Week 20	05/14/03	1,946	2,048	2,594	3,336	3,434	389
4 of 7	Week 21	05/21/03	1,704	1,789	2,753	4,474	4,474	802
7 of 7	Week 22	05/28/03	602	633	802	1,003	1,062	121
4 of 7	Week 23	06/04/03	797	836	1,287	1,859	2,390	404
4 of 7	Week 24	06/11/03	601	661	1,017	1,653	1,889	322
4 of 7	Week 25	06/18/03	574	603	928	1,340	1,507	289
4 of 7	Week 26	06/25/03	1,056	1,109	1,706	2,464	3,168	484
5 of 7	Week 27	07/02/03	482	506	778	1,264	1,445	242
4 of 7	Week 28	07/09/03	56	58	90	130	146	27
4 of 7	Week 29	07/16/03	0	0	0	0	0	0
4 of 7	Week 30	07/23/03	19	19	30	43	56	9
4 of 7	Week 31	07/30/03	19	19	30	43	56	9
7 of 7	Week 32	08/06/03	0	0	0	0	0	0
7 of 7	Week 33	08/13/03	0	0	0	0	0	0
7 of 7	Week 34	08/20/03	18	19	30	49	56	9
7 of 7	Week 35	08/27/03	0	0	0	0	0	0
7 of 7	Week 36	09/03/03	0	0	0	0	0	0
7 of 7	Week 37	09/10/03	0	0	0	0	0	0
7 of 7	Week 38	09/17/03	0	0	0	0	0	0
7 of 7	Week 39	09/24/03	0	0	0	0	0	0
307 of 365		Total	3,560,468	3,609,632	3,858,446	4,102,132	4,174,685	

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1.

Table 8. Weekly passage indices with 90% and 95% confidence intervals, standard deviation (SD) of the weekly strata for BY 2001 Age 0+ and BY 2002 Young of the Year (YOY) steelhead / rainbow trout captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2002 through December 31, 2002.

Days Sampled	Week	BY2001	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
5 of 7	Week 1	01/01/02	0	0	0	0	0	0
6 of 7	Week 2	01/08/02	68	71	86	105	110	10
7 of 7	Week 3	01/15/02	18	18	20	23	24	2
7 of 7	Week 4	01/22/02	21	21	22	24	24	1
7 of 7	Week 5	01/29/02	25	25	27	28	29	1
7 of 7	Week 6	02/05/02	25	25	27	29	29	1
7 of 7	Week 7	02/12/02	0	0	0	0	0	0
7 of 7	Week 8	02/19/02	18	18	19	21	21	1
7 of 7	Week 9	02/26/02	21	22	24	25	26	1
7 of 7	Week 10	03/05/02	34	35	39	43	44	2
7 of 7	Week 11	03/12/02	110	111	124	139	142	8
7 of 7	Week 12	03/19/02	64	65	73	80	82	5
7 of 7	Week 13	03/26/02	84	86	95	105	109	6
4 of 7	Week 14	04/02/02	49	49	54	59	60	3
4 of 7	Week 15	04/09/02	27	28	35	43	45	5
4 of 7	Week 16	04/16/02	23	24	32	43	45	6
4 of 7	Week 17	04/23/02	45	48	64	86	96	12
4 of 7	Week 18	04/30/02	49	51	63	80	83	9
4 of 7	Week 19	05/07/02	7	8	10	13	14	2
4 of 7	Week 20	05/14/02	7	7	10	13	14	2
4 of 7	Week 21	05/21/02	29	30	36	45	46	5
7 of 7	Week 22	05/28/02	0	0	0	0	0	0
7 of 7	Week 23	06/04/02	5	5	6	7	7	1
7 of 7	Week 24	06/11/02	8	9	11	14	15	2
7 of 7	Week 25	06/18/02	0	0	0	0	0	0
7 of 7	Week 26	06/25/02	4	5	7	11	11	2
7 of 7	Week 27	07/02/02	0	0	0	0	0	0

Days Sampled	Week	BY2001	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
7 of 7	Week 28	07/09/02	0	0	0	0	0	0
7 of 7	Week 29	07/16/02	0	0	0	0	0	0
7 of 7	Week 30	07/23/02	0	0	0	0	0	0
4 of 7	Week 31	07/30/02	0	0	0	0	0	0
4 of 7	Week 32	08/06/02	0	0	0	0	0	0
4 of 7	Week 33	08/13/02	0	0	0	0	0	0
4 of 7	Week 34	08/20/02	0	0	0	0	0	0
4 of 7	Week 35	08/27/02	0	0	0	0	0	0
4 of 7	Week 36	09/03/02	0	0	0	0	0	0
7 of 7	Week 37	09/10/02	0	0	0	0	0	0
7 of 7	Week 38	09/17/02	0	0	0	0	0	0
4 of 7	Week 39	09/24/02	0	0	0	0	0	0
7 of 7	Week 40	10/01/02	0	0	0	0	0	0
7 of 7	Week 41	10/08/02	0	0	0	0	0	0
7 of 7	Week 42	10/15/02	0	0	0	0	0	0
7 of 7	Week 43	10/22/02	0	0	0	0	0	0
7 of 7	Week 44	10/29/02	0	0	0	0	0	0
7 of 7	Week 45	11/05/02	0	0	0	0	0	0
7 of 7	Week 46	11/12/02	0	0	0	0	0	0
7 of 7	Week 47	11/19/02	0	0	0	0	0	0
7 of 7	Week 48	11/26/02	0	0	0	0	0	0
7 of 7	Week 49	12/03/02	0	0	0	0	0	0
7 of 7	Week 50	12/10/02	0	0	0	0	0	0
6 of 7	Week 51	12/17/02	0	0	0	0	0	0
3 of 8	Week 52*	12/24/02	0	0	0	0	0	0
311 of 365		Total	838	846	884	928	939	

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1.

Days Sampled	Week	BY2002	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
5 of 7	Week 1	01/01/02	0	0	0	0	0	0
6 of 7	Week 2	01/08/02	0	0	0	0	0	0
7 of 7	Week 3	01/15/02	0	0	0	0	0	0
7 of 7	Week 4	01/22/02	0	0	0	0	0	0
7 of 7	Week 5	01/29/02	0	0	0	0	0	0
7 of 7	Week 6	02/05/02	25	25	27	29	29	1
7 of 7	Week 7	02/12/02	47	48	52	56	56	2
7 of 7	Week 8	02/19/02	31	31	34	36	37	2
7 of 7	Week 9	02/26/02	43	43	47	51	52	2
7 of 7	Week 10	03/05/02	324	328	369	408	419	25
7 of 7	Week 11	03/12/02	712	722	805	891	911	51
7 of 7	Week 12	03/19/02	246	249	277	307	313	17
7 of 7	Week 13	03/26/02	241	245	272	301	307	17
4 of 7	Week 14	04/02/02	218	223	244	269	273	14
4 of 7	Week 15	04/09/02	1,212	1,247	1,532	1,940	1,984	207
4 of 7	Week 16	04/16/02	1,633	1,724	2,299	3,103	3,448	457
4 of 7	Week 17	04/23/02	692	730	974	1,315	1,384	188
4 of 7	Week 18	04/30/02	511	529	677	856	882	102
4 of 7	Week 19	05/07/02	363	388	498	646	698	84
4 of 7	Week 20	05/14/02	189	193	254	329	356	41
4 of 7	Week 21	05/21/02	142	146	180	220	230	23
7 of 7	Week 22	05/28/02	95	99	146	199	218	35
7 of 7	Week 23	06/04/02	326	336	411	493	516	51
7 of 7	Week 24	06/11/02	463	481	613	791	818	97
7 of 7	Week 25	06/18/02	411	427	520	640	666	65
7 of 7	Week 26	06/25/02	303	335	490	707	796	134

Days Sampled	Week	BY2002	95% CI Lower	90% CI Lower	Weekly Estimate	90% CI Upper	95% CI Upper	S.D.
7 of 7	Week 27	07/02/02	334	357	492	689	739	105
7 of 7	Week 28	07/09/02	176	189	330	528	660	120
7 of 7	Week 29	07/16/02	77	83	144	231	289	57
7 of 7	Week 30	07/23/02	55	59	103	165	206	43
4 of 7	Week 31	07/30/02	0	0	0	0	0	0
4 of 7	Week 32	08/06/02	11	12	21	33	41	8
4 of 7	Week 33	08/13/02	11	12	21	33	41	9
4 of 7	Week 34	08/20/02	11	12	21	33	41	9
4 of 7	Week 35	08/27/02	12	13	21	33	41	8
4 of 7	Week 36	09/03/02	0	0	0	0	0	0
7 of 7	Week 37	09/10/02	66	71	124	198	248	50
7 of 7	Week 38	09/17/02	33	35	62	99	124	24
4 of 7	Week 39	09/24/02	11	12	21	33	41	8
7 of 7	Week 40	10/01/02	12	12	21	33	41	8
7 of 7	Week 41	10/08/02	22	24	41	66	83	18
7 of 7	Week 42	10/15/02	11	13	21	33	41	8
7 of 7	Week 43	10/22/02	11	12	21	33	41	7
7 of 7	Week 44	10/29/02	11	12	21	33	41	8
7 of 7	Week 45	11/05/02	49	50	63	81	83	9
7 of 7	Week 46	11/12/02	29	30	38	47	50	5
7 of 7	Week 47	11/19/02	29	30	38	47	48	5
7 of 7	Week 48	11/26/02	10	10	13	16	17	2
7 of 7	Week 49	12/03/02	39	40	50	63	68	8
7 of 7	Week 50	12/10/02	28	29	38	48	51	6
6 of 7	Week 51	12/17/02	163	168	213	274	282	31
3 of 8	Week 52*	12/24/02	115	117	150	188	199	22
311 of 365		Total	11,731	11,926	12,803	13,860	14,193	

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1

Table 9. Weekly catch, passage indices and mortality of fall-run BY 2003 Chinook captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from October 1, 2002 through September 30, 2003.

Week	Date	Weekly Index	Catch	Mortality	% Passage	% Catch
Week 40	10/01/02	0	0	0	0.000%	0.00%
Week 41	10/08/02	0	0	0	0.000%	0.00%
Week 42	10/15/02	0	0	0	0.000%	0.00%
Week 43	10/22/02	0	0	0	0.000%	0.00%
Week 44	10/29/02	0	0	0	0.000%	0.00%
Week 45	11/05/02	0	0	0	0.000%	0.00%
Week 46	11/12/02	0	0	0	0.000%	0.00%
Week 47	11/19/02	0	0	0	0.000%	0.00%
Week 48	11/26/02	389	31	1	0.257%	3.23%
Week 49	12/03/02	2,043	163	15	0.734%	9.20%
Week 50	12/10/02	14,139	1,128	94	0.665%	8.33%
Week 51	12/17/02	182,516	14,562	154	0.084%	1.06%
Week 52*	12/24/02	154,444	12,323	56	0.036%	0.45%
Week 1	01/01/03	222,450	17,749	51	0.023%	0.29%
Week 2	01/08/03	206,288	16,459	41	0.020%	0.25%
Week 3	01/15/03	630,079	50,272	30	0.005%	0.06%
Week 4	01/22/03	448,002	29,203	364	0.081%	1.25%
Week 5	01/29/03	505,895	22,423	347	0.069%	1.55%
Week 6	02/05/03	375,389	18,788	195	0.052%	1.04%
Week 7	02/12/03	474,951	20,180	561	0.118%	2.78%
Week 8	02/19/03	284,910	11,063	84	0.029%	0.76%
Week 9	02/26/03	132,180	8,591	25	0.019%	0.29%
Week 10	03/05/03	52,870	6,319	13	0.025%	0.21%
Week 11	03/12/03	73,488	6,230	95	0.129%	1.52%
Week 12	03/19/03	40,398	1,836	21	0.052%	1.14%
Week 13	03/26/03	7,144	490	14	0.196%	2.86%
Week 14	04/02/03	4,988	398	7	0.140%	1.76%
Week 15	04/09/03	4,407	352	4	0.091%	1.14%
Week 16	04/16/03	5,325	395	6	0.113%	1.52%
Week 17	04/23/03	9,230	581	18	0.195%	3.10%
Week 18	04/30/03	5,063	404	1	0.020%	0.25%
Week 19	05/07/03	9,815	783	2	0.020%	0.26%
Week 20	05/14/03	2,594	207	2	0.077%	0.97%
Week 21	05/21/03	2,753	92	0	0.000%	0.00%
Week 22	05/28/03	802	64	0	0.000%	0.00%
Week 23	06/04/03	1,287	43	0	0.000%	0.00%
Week 24	06/11/03	1,017	34	0	0.000%	0.00%

Week	Date	Weekly Index	Catch	Mortality	% Passage	% Catch
Week 25	06/18/03	928	31	0	0.000%	0.00%
Week 26	06/25/03	1,706	57	2	0.117%	3.51%
Week 27	07/02/03	778	26	1	0.129%	3.85%
Week 28	07/09/03	90	3	0	0.000%	0.00%
Week 29	07/16/03	0	0	0	0.000%	0.00%
Week 30	07/23/03	30	1	0	0.000%	0.00%
Week 31	07/30/03	30	1	0	0.000%	0.00%
Week 32	08/06/03	0	0	0	0.000%	0.00%
Week 33	08/13/03	0	0	0	0.000%	0.00%
Week 34	08/20/03	30	1	1	3.342%	100.00%
Week 35	08/27/03	0	0	0	0.000%	0.00%
Week 36	09/03/03	0	0	0	0.000%	0.00%
Week 37	09/10/03	0	0	0	0.000%	0.00%
Week 38	09/17/03	0	0	0	0.000%	0.00%
Week 39	09/24/03	0	0	0	0.000%	0.00%

* Week 52 (12/24/02-12/31/02) contains 8 days for the purpose of keeping Jan. 1 as Julian calendar day 1

Table 10. Annual mortality of fall Chinook salmon captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from December 1998 through September 2003.

FCS Broodyear	1998	1999	2000	2001	2002
Juvenile Production Index	7,492,777	5,371,357	9,311,439	5,788,701	3,858,446
Juveniles Captured	688,083	518,542	362,680	416,407	227,010
Catch Mortality	51,479	24,086	24,504	16,565	2,205*
Passage Mortality (%)	0.69%	0.45%	0.26%	0.29%	0.06%
Catch Mortality (%)	7.48%	4.64%	6.76%	3.98%	0.97%
Marked Fish	12,737	11,588	15,048	28,916	16,091
Mark Mortality	500	1,165	623	844	328
Marking Mortality (%)	3.93%	10.05%	4.14%	2.92%	2.04%

* During the sampling period a total of 2,211 FCS mortalities occurred, 6 of those were in July of 2002 and considered to be part of BY 2001.

Appendix

Appendix A. Summary of non salmonid fish taxa captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Species Totals
BGS	0	0	2	2	1	2	1	0	3	1	0	0	0	0	0	12
BRB	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
CAR	0	3	1	1	0	3	1	0	0	0	1	6	14	28	12	70
CENFRY	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
COTFRY	2	0	0	0	0	0	0	0	0	0	0	2	30	0	0	34
CYPFRY	19	60	40	59	10	6	1	0	5	3	27	3	28	73	62	396
DACE	9	1	1	0	0	2	0	0	0	1	0	0	1	2	1	18
GSF	8	0	2	3	1	28	7	2	0	2	17	2	0	1	2	75
GSN	0	0	0	0	0	0	1	0	1	0	1	2	3	0	0	8
HH	14	19	36	73	22	34	11	7	13	13	11	5	4	5	6	273
LFRY	9	1	2	3	4	85	138	2	39	1	44	4	3	1	1	337
LMB	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	5
MICFRY	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
MQF	1	0	18	0	0	8	11	1	0	2	40	0	6	6	4	97
PL	0	0	0	1	1	31	0	0	0	0	0	0	0	0	0	33
PRS	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
PS	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
RFS	36	5	4	5	3	12	20	13	12	8	7	10	94	12	13	254
RL	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
SASQ	4	49	46	6	6	17	11	2	8	2	20	9	10	19	13	222
SASU	8	25	19	5	6	19	5	0	2	0	3	2	55	13	33	195
TP	0	1	0	0	1	2	1	0	1	0	1	0	0	0	0	7
TSS	69	47	23	7	2	21	22	1	9	7	20	8	17	6	1	260
															Total	2,310

Appendix B. Name key of non salmonid fish taxa captured by the rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from July 1, 2002 through September 30, 2003.

Abbreviation	Common name	Scientific Name
BGS	Blue Gill Sunfish	*Lepomis macrochirus*
BRB	Brown Bullhead	*Ameiurus nebulosis*
CAR	California Roach	*Hesperoleucus symmetricus*
CENFRY	Unknown Centrarchidae	*Centrarchidae spp.*
COTFRY	Sculpin Fry	*Cottus spp.*
CYPFRY	Minnow Fry	*Cyprinidae spp.*
DACE	Speckled Dace	*Rhinichthys osculus*
GSF	Green Sunfish	*Lepomis cyanellus*
GSN	Golden Shiner	*Notemigonus crysoleucas*
HH	Hardhead	*Mylopharodon conocephalus*
LFRY	Lamprey Fry	*Lampetra spp.*
LMB	Largemouth Bass	*Micropterus salmoides*
MICFRY	Bass Fry	*Micropterus spp.*
MQF	Western Mosquitofish	*Gambusia affinis*
PL	Pacific Lamprey	*Lampetra tridentata*
PRS	Prickly sculpin	*Cottus asper*
PS	Pumpkinseed	*Lepomis gibbosus*
RFS	Riffle sculpin	*Cottus gulosus*
RL	River Lamprey	*Lampetra ayresi*
SASQ	Sacramento Pikeminnow	*Ptychocheilus grandis*
SASU	Sacramento Sucker	*Catostomus occidentalis*
TP	Tule Perch	*Hysterocarpus traski*
TSS	Threespine Stickleback	*Gasterosteus aculeatus*