Brood Year 2011 Juvenile Salmonid Monitoring in Clear Creek, California

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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 at river mile (RM) 1.7 since December 1998. This monitoring project has three primary objectives: 1) calculate an annual juvenile passage index for Chinook Salmon *Oncorhynchus tshawytscha* and Rainbow Trout / steelhead *O. mykiss* for inter-year comparisons and analyses of the effectiveness of stream restoration activities; 2) obtain juvenile salmonid life history information including size, emergence timing, emigration timing, and potential factors limiting survival at various life stages; and 3) collect otolith and genetic samples from juvenile salmonids for analyses and to develop baseline markers for the Clear Creek salmonid populations. Chinook run classifications show that late-fall, winter, spring and fall-run Chinook Salmon were captured in our RST. However, due to overlapping spawn timing of spring-run and fall-run Chinook Salmon, and presence of both, it was problematic to index the juvenile passage using only the rotary screw trap at RM 1.7. Since 2003 a weir has been used to isolate adult spring-run Chinook Salmon from adult fall-run Chinook Salmon. Also in 2003, a second rotary screw trap was installed at RM 8.4 to better estimate the passage of juvenile spring-run Chinook Salmon. We attempted to fish the traps continuously from November 1, 2011 until June 30, 2012. Passage indices with 90% and 95% CIs were generated for late-fall, spring and fall-run Chinook Salmon from brood year 2011 and Rainbow Trout / steelhead from brood years 2010 age-0+ and 2011 age-0. The spring-run Chinook Salmon index for brood year 2011 from the upper Clear Creek rotary screw trap was 55,737 for the Creek upstream of the trap, and was 59,453 after adjusting for the redd below the trap and above the separation weir. The indices of passage for brood year 2011 from the lower Clear Creek trap site were as follows: 8,703 late-fall-run, 7,780 spring-run and 10,408,622 fall-run Chinook Salmon. The fall-run Chinook Salmon passage is the second highest measured over the fourteen years of trapping at the lower location. The Rainbow Trout / steelhead indices from lower trap were as follows: 259 for brood year 2010 age-0+, and 19,647 for brood year 2011. Mark-recapture trials were conducted from January 2012 through mid-April 2012 to determine trapping efficiencies at both locations. The efficiency ranged from 3.0% to 10.5%. Sixteen times between the months of December 2011 and June 2012, we conducted 24-hour interval-sampling at our lower rotary screw trap location to better identify daily passage timing and environmental variables that may contribute to it (e.g. turbidity, barometric pressure, flow, etc.). Results suggest that 81.5% percent of fall-run Chinook move downstream between the hours 1900 and 0000.

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Introduction

The U.S. Fish and Wildlife Service (USFWS) Red Bluff Fish and Wildlife Office (RBFWO) has seasonally monitored juvenile salmonids in Clear Creek, Shasta County, California since December 1998, using a rotary screw trap (RST) placed 1.7 river miles (RM) above the confluence with the Sacramento River (lower Clear Creek, LCC). Since 2003, a second trap has been seasonally operated at RM 8.4 (upper Clear Creek, UCC).

Our monitoring efforts focus on three federally listed species: the endangered winter-run Chinook Salmon (winter Chinook) *Oncorhynchus tshawytscha*; threatened spring-run Chinook Salmon (spring Chinook); and, threatened Central Valley steelhead trout *O. mykiss*. We use the terms *O. mykiss* to refer to both the stream resident (Rainbow Trout) and anadromous (steelhead) life histories, because of the difficulties in differentiating the anadromous and resident forms in the field. Additionally, our monitoring provides us the capability to generate estimates for the other salmonids; Late-fall run Chinook Salmon (late-fall Chinook) and fall-run Chinook Salmon (fall Chinook), found in the system.

Clear Creek is a west side tributary of the Sacramento River in Shasta County. The runs of Chinook from the Sacramento River watershed that inhabit Clear Creek are: late-fall, spring and fall. Spring Chinook were listed as threatened in 1999 under the Federal Endangered Species Act (ESA) (64 FR 50394). Winter Chinook are occasional visitors to Clear Creek; however a naturally self-sustaining population does not exist in Clear Creek. Sacramento winter Chinook were listed as endangered in 1994 (59 FR 440). The brood year passage for Clear Creek *O. mykiss* is calculated from fish caught from January 1 through December 31 of the calendar year. The age-0+ age class represents those fish from all prior brood years. The California Central Valley steelhead population has been listed as threatened under the ESA since March 1998 (63 FR 13347).

Late-fall Chinook migrate into Clear Creek November through April, with peak migration in December and peak spawning occurring in January. These fish primarily utilize the lower reaches of Clear Creek (Reaches 6 and 7; Table 1, Figure 1) for all instream life history phases. Spring Chinook generally migrate into Clear Creek before late August, and spawn in the upper reaches of Clear Creek (Reaches 1-5b; RM 7.4 - 18.1; Table 1) in September and October. Fall Chinook spawning occurs soon after and often overlaps in time with that of spring Chinook, with 98-99% taking place in Reaches 6 and 7, below the Gorge Cascade. A picket weir is utilized each August to November to prevent fall Chinook from spawning in the upper reaches (Giovannetti and Brown 2013).

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. The Clear Creek Restoration Program, authorized by Section 3406 (b)12 of the CVPIA has funded many anadromous fish restoration actions which were outlined in the CVPIA Anadromous Fisheries Restoration Program Working Paper (USFWS 1995), and Final Restoration Plan (USFWS 2001).

Since 2010 increased water releases from Whiskeytown Reservoir have occurred during the months of April and June to provide spring attraction flows, also referred to as "pulse flows." The pulse flows were designed to fulfill "Action I.1.1. Spring Attraction Flows" of the 2009 National Marine Fisheries Service's (NMFS) Biological Opinion for the Bureau of Reclamation's Operations Criteria and Plan for the Central Valley Project (NMFS 2009). The objective of the flows is to encourage adult spring Chinook to move to upstream Clear Creek habitats for holding and spawning. In these habitats spring Chinook can access a) colder water temperatures, b) large and remote holding pools, and c) newly-provided and clean spawning gravel; and can avoid hybridization and competition with fall Chinook. Ideally, the spring Chinook adult population would migrate upstream of the UCC RST at RM 8.4, not only for spring Chinook habitat and population integrity purposes, but also for clean fish production estimation (juveniles produced per adult or redd).

The RBFWO has used rotary screw traps as the primary means to evaluate trends in juvenile salmon abundance in Clear Creek. While RSTs have limitations (e.g. can be challenging to effectively fish through rapid changes in flow), they can be an effective monitoring tool for providing reasonable estimates of juvenile production, and facilitate annual comparisons when used consistently over a number of years (USFWS 2002).

Since 2003, the RBFWO has been using the UCC RST to index passage of spring Chinook. Passage indices of spring Chinook using the LCC RST, at RM 1.7, were found to be significantly underestimated (Gaines, Null and Brown 2003; Greenwald, Earley and Brown 2003; Brown and Earley 2007). It is difficult to delineate between spring Chinook and fall Chinook at the lower trap because early spawning fall Chinook and late spawning spring Chinook can occur at the same time and thus the fork lengths of juveniles captured at LCC can overlap. In August 2011 the Clear Creek picket weir was installed instream at RM 8.1 (Giovannetti and Brown 2013) to protect the spring Chinook population spawning upstream of that point from potential superimposition and genetic introgression with fall Chinook. The juvenile passage index is adjusted for redds identified above the weir at RM 8.1 but below UCC. The use of the picket weir has greatly minimized the presence of fall Chinook in the upper watershed. This report presents sampling data from the upper and lower Clear Creek RSTs. This monitoring project has three primary objectives: 1) calculate annual juvenile passage indexes (JPI) for Chinook Salmon (Chinook) and *O. mykiss*, for inter-year comparisons and analyses of the effectiveness of stream restoration activities; 2) obtain juvenile salmonid life history information including size, emergence timing, emigration timing, and potential factors limiting survival at various life stages; and 3) collect otolith and genetic samples from juvenile salmonids for analyses and development of baseline markers for the Clear Creek salmonid populations. In this report we discuss the passage indices and life history information. The genetic results, condition factor and survival factors will be covered individually in future reports. All passage data are from brood year (BY) 2011.

Study Area

The Clear Creek watershed below Whiskeytown Dam covers an area of approximately 48.9 miles and receives supplemental water from a cross-basin transfer between Lewiston Lake in the Trinity River watershed and Whiskeytown Lake 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 Dam almost 10.1 mi. The lower reach heads in an easterly direction to the Sacramento River for a distance of approximately 8.2 mi (Figure 1). In the upper reach, the stream is more constrained by canyon walls and a bedrock channel, has a higher gradient, less spawning gravel, and more deep pools. In the lower reach, the stream meanders through a less constrained alluvial floodplain, has a lower gradient, more spawning gravel and fewer deep pools. The lower reach is managed for fall Chinook and late-fall Chinook and supports species of the foothills fish community. The dominant fishes found in foothills community are: Pacific

Lamprey *Entosphenus tridentatus*, Sacramento Pikeminnow *Ptychocheilus grandis*, Sacramento Sucker *Catostomus occidentalis*, Hardhead *Mylopharodon conocephalus*, and Riffle Sculpin *Cottus gulosus*. It is comparable to Moyle's (2002) pikeminnow-hardhead-sucker assemblage, except that large numbers of *O. mykiss* utilize the lower reach as well. The upper reach is managed for spring Chinook, which require cooler summer water temperatures than do the runs downstream. Although it was once anticipated that *O. mykiss* would predominately be in the uppermost reaches, recent data show greater spawning distributions in Reach 6 of the lower river (Figure 1).

Whiskeytown Dam acts as a sediment trap. This along with an altered flow regime and historic gold and gravel mining operations has impacted the lower portion of Clear Creek by reducing the gravel and other sediments needed for spawning, habitat forming geomorphological process, and floodplain quality. The resultant reduction in habitat quality in Clear Creek below Whiskeytown Dam has been well documented by various investigators (Coots 1971; Graham Matthews & Associates 2003). Effects of reduced coarse sediment include: riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition and riparian regeneration, and a reduction in the amount and quality of spawning gravel available for anadromous salmonids (Graham Matthews & Associates and Pittman 2007). In some areas of the Clear Creek stream channel only clay hardpan or bedrock remained. The Clear Creek restoration program has been addressing some of these habitat impacts with floodway restoration projects and gravel injection. These are ongoing efforts.

Ambient air temperatures range from approximately 16 °F in winter to summer highs in excess of 112 °F. Most precipitation falls into this watershed as rainfall, and averages 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 Thrush 2001). The LCC RST is located at RM 1.7 above the confluence (latitude 40.506159 north, longitude 122.396079 west). The UCC RST is located at RM 8.4 above the confluence with the Sacramento River (latitude 40.491850 north, longitude 122.496572 west). The RSTs operate in or near the thalweg of the channel at both locations. The stream gradients at these locations range from approximately 1.0 degree to 1.5 degrees.

Methods

Rotary screw trap operations

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 (USFWS 1997). The RSTs deployed in Clear Creek are manufactured by E.G. Solutions, Corvallis, Oregon. This type of trap consists of a 5 ft diameter cone covered with 1/8-in diameter perforated stainless steel screen. This cone acts as a sieve, which separates fish from the sampled water. The cone and live-box are supported between two pontoons and the cone's auger-type action passes water, fish, and debris to the rear of the trap, and directly into the live-box. This live-box retains fish and debris, and passes water through screens located in its back, sides, and bottom.

Because of the high numbers of salmon out-migrating from Clear Creek, modifications have been made to the RSTs to reduce potential negative effects to juvenile salmonids created by high fish densities in the live-box. A "half-cone modification" has been made to the RSTs by placing an aluminum plate over one of the two cone discharge ports and removing an exterior cone hatch cover. This created a condition in which 50% of the collected fish and debris were not passed into the live-box, but were discharged from the cone into the creek. This effectively reduced the catch of both fish and debris by 50%, and reduced overcrowding of fish in the live-box. Both traps were fished in the half cone configuration for the entire season.

Other modifications to RST equipment that provided greater protection to collected fish included enlarging the size of the live-box and increasing the size of flotation pontoons (to accommodate the larger live-box). Inside the live-box a midway fish exclusionary device made of expanded aluminum was added. This device prevents large predatory fish from harassing and preying on smaller salmonids. A panel of clear polycarbonate was attached to the rear screen of the live-box to reduce water velocities within the live-box. Modifications to RST operations have included day and night sampling during the peak out-migration periods for spring Chinook and fall Chinook. To improve JPI computation, an attempt was made to fish high flow events when juvenile salmonids are thought to out-migrate, and to increase the frequency of mark–recapture trials during those events except when flows in excess of 2,000 cfs (LCC) or 800 cfs (UCC) were encountered.

Each RST is attached to a cable high line and positioned instream with a system of ropes and pulleys. The both traps were installed October 11, were operational on October 31, 2011 and they fished through June 30, 2012. An attempt was made to fish the RSTs 24 hours per day, seven days each week. Methods for access and data collection were identical for both traps.

Fisheries crews typically accessed the RST by wading from the creek bank. However, 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 daily unless conditions (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 processed the collected fish, cleared the RST of debris, and provided maintenance. Once per day (at the end of the approximately 24-h sampling period), the crew obtained environmental and RST data. Collected data included: dates and times of RST operation, creek depth at the RST, RST cone fishing depth, number of rotations of the RST cone during the sampling period, the amount and type of debris collected, basic weather conditions, water temperature, current velocity, and turbidity. Water depths were measured using a graduated staff to the nearest 0.1 ft. The RST cone fishing depth (in) was measured with a gauge that was permanently mounted to the RST pontoon adjacent to the cone. The rate of rotation (revolutions per min) of the RST cone were measured with a mechanical stroke counter that was mounted to the RST railing adjacent to the cone. The amount of debris in the RST was volumetrically measured using a 10-gal plastic tub.

Water temperatures were continuously obtained at 30-min. intervals with an instream data logger (HOBO® Water Temperature Pro v2 Logger; Onset Computer Corp, Bourne, MA). The crews uploaded temperatures weekly. Water velocity was measured from on the RST in front of the cone using a mechanical flow meter (Oceanic ® Model 2030 flowmeter; General Oceanics, Miami, FL). Water turbidity was measured from a grab-sample with Hach Model 2100D turbidimeter (Hach Company, Ames, IA). Mean daily discharge data were collected at the U.S. Geological Survey's Igo gauge site (Station #11372000), located at Clear Creek near Igo CA, and approximately 2.6 RM upstream of the UCC trap (Figure 1). All environmental and biological data were entered into a Microsoft Access database at the trap site using a Panasonic Toughbook® (Model CF-19).

Dip nets were used to remove the contents of the RST live-box and place them on the sorting table for examination. In general, when the number of all fish collected in the RST was less than approximately 5,000 individuals, they were brought to shore in lidded 5-gal buckets where they were transferred to 10- or 25-gal buckets with aerators. They were then counted and measured. When catch exceeded approximately 5,000 individuals, a large portion of fish were removed from the live-box and transported to shore. The remaining fish were sorted and counted on the aft deck of the RST.

Counting and measurement

The monitoring team 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. Fish to be measured were anesthetized in a 1-qt plastic tub with solution of Tricaine Methanesulfonate (MS-222) at a concentration of 60–80 mg/l. Fish were measured on a wet measuring board, placed in a 10-gal plastic tub filled with creek water and fish protectant, and allowed to recover 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. Based on project objectives and large numbers of juvenile salmon that were frequently encountered, different criteria were used to count salmon, trout, and non-salmonid species. In general, during trap clears that were not at the end of the 24-h sampling period, fish were identified, classified to age class and counted, but no length measurements were taken.

Chinook — 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 to a life stage classification: yolk-sac fry (C0), fry (C1), parr (C2), silvery parr (C3), or smolt (C4). All Chinook that were measured were assigned run designations, using length-at-date tables from Greene (1992). These designations included fall Chinook, late-fall Chinook, winter Chinook, and spring Chinook. At the UCC RST, all Chinook captured that were assigned fall Chinook by Greene were considered instead to be spring Chinook because we installed a picket weir to block fall Chinook from passing upstream of UCC. There is undoubtedly overlap in the fork lengths of adjoining runs of juvenile salmon that are not captured by the dichotomous length-at-date criteria.

When more than approximately 250 juvenile salmon were captured, subsampling was conducted. To do this, a cylinder-shaped 1/8-in mesh “subsampling net” 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. One side of the net was tied shut and the other side was left open. This subsampling net was placed in a 25-gal bucket that was partially filled with creek water. All collected juvenile salmon were poured into this bucket (except when the remainder of the fish was left in the live-box to reduce handling for fish health considerations when catch was exceptionally high, see below). 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. The trap catch (or a portion, on large catch days) was successively subsampled until approximately 150–250 individuals remained. The number of successive splits that were used varied with the number of salmon collected, from one split (to create a one-half subsample) up to seven splits (to create a 1/128th subsample). When approximately more than 20,000 fish were captured, the live-box was subsampled and approximately 10,000 fish were brought to shore for further subsampling.

The fish remaining in the live-box were considered the first split and were sorted and counted from the aft deck of the RST. The *O. mykiss* and non-salmonid species encountered during the sorting of live-box fish were brought ashore for measurement.

O. mykiss — All *O. mykiss* that were collected in the RSTs were counted, and FL was measured for most. The juvenile trout were classified to life stage in much the same manner as salmon (i.e., yolk-sac fry (R1), fry (R2), parr (R3), silvery parr (R4), and smolt (R5)). All live juvenile *O. mykiss* greater than 50 mm that were captured during the daytime sample were weighed to the nearest 0.1 g with an electronic scale for condition factor analysis.

Non-salmonid taxa — All non-salmonid taxa were counted, and up to 20 randomly selected individuals were measured. Total length was measured for species that do not have a forked caudal fin; otherwise, FL was measured for all other non-salmonid taxa. In contrast to previous seasons, lamprey were recorded by life stage (ammocoetes, macropthalmia or transformer, and adult). Catch data for all fish taxa were typically consolidated to represent monthly sums. Sampling weeks were identified by year and number. The weeks mentioned in this report are calendar year weeks, with Week 1 being January 1–7 and Week 52 of 2011, December 24–31, is eight days long. The first sampling week of the current study was during Week 44 in 2011 and the last sampling week was Week 26 in 2012 (Table 2).

Genetic and otolith sampling

Genetic samples were taken on selected Chinook for the purpose of run identification. Samples were taken by removing a 1 mm^2 tissue sample from the top or bottom lobe of the caudal fin. The samples were divided into three equal parts and placed in 2 ml triplicate vials of the same record number with 0.5 ml of 100% ethanol as a preservative. The triplicate samples were taken for: 1) USFWS archive, 2) California Department of Fish and Wildlife (CDFW) archive, and 3) for future analysis.

Samples at UCC and LCC were taken when the FL designated the Chinook as winter Chinook, late-fall Chinook, or when the FL was > 100 mm. In addition, at UCC samples were taken proportionately to the anticipated out-migration distribution of spring Chinook. An attempt was made to collect samples from a range of fork lengths to minimize sampling siblings which might potentially bias the genetic analysis.

Mark–recapture trials

Since the RST only captures fish from a small portion of the creek cross section, it is necessary to implement a method to project the RST catch numbers to parts of the creek outside of the RST capture zone. Mark–recapture trials were conducted to determine the efficiency of the RST to catch juvenile salmonids moving downstream during a given time period.

Ideally separate mark–recapture trials should be conducted for each species, run, and life-stage to estimate species and age-specific trap efficiencies. However, catch rates for *O. mykiss*, spring Chinook, and late-fall Chinook were too low to conduct separate trials; therefore, all species and life-stage passage estimates were calculated using mark–recapture trials from fall Chinook fry collected at the LCC RST. Trials were attempted once weekly, weather permitting. An attempt was made to mark a minimum of 400 juvenile Chinook for each trial, with a goal to recapture at least seven marked individuals in order to generate reliable estimates (Steinhorst et al. 2004). In an effort to meet that goal, no mark–recapture studies were conducted with less than 100 individuals. Two of the releases consisted of fish marked with a single mark (see below). The other four consisted of two mark groups, one group with an upper and the other with a lower caudal fin clip. The RBFWO also conducts mark–recapture trials at the Red Bluff Diversion Dam (RBDD) for estimating trap efficiency while monitoring Sacramento River juvenile salmonid populations. The dual mark allowed RBDD to distinguish Clear Creek marked Chinook from those marked at the RBDD. The methods used for marking are described below.

Marking strategies — Single marked fish consisted of immersing the salmon in a solution of 1.6 g of Bismarck brown-Y stain in 20 gal of water for a duration of 50-min. Dual marked fish were first anesthetized with a 60–80 mg/l solution of MS-222, and then surgical scalpels were used to remove an area of approximately 1 mm^2, or less, from the corner of either the upper or lower caudal fin lobe. After the clipping process was completed, the salmon were marked with Bismarck brown.

Release and recovery — When the marking procedures were completed, the marked juvenile salmon were placed in a live-car and allowed to recover overnight in the RST live-box. This overnight retention allowed for the detection of salmon with latent injuries and mortalities resulting from the marking procedure. On the following evening, weak, injured, and dead fish were removed. The remaining fish were counted and transported for release 0.2 (UCC) or 0.4 (LCC) RM upstream of the RST sampling site. Each group was released in batches of less than 50 fish. The next group was released in the same manner no less than 5 min after the last of the prior group, until all groups were released. Fish were released in the evening no earlier than 15 min before sunset. The nighttime releases of marked fish were designed: 1) to reduce the potential for unnaturally high predation on the marked fish possibly experiencing temporary disorientation by the transportation, and 2) to imitate the tendency for natural populations of out-migrating Chinook to move downstream primarily at night (Groot and Margolis 1998). The stained and marked Chinook that were recaptured later by the RST were counted and measured. To explore the relationship of trap efficiency to biological and environmental variables we collected the following information at the time of release: flow, water temperature, turbidity, moon fraction, light from the moon, cloud cover, rain, wind speed and barometric pressure. Marked Chinook that were recaptured in the trap were counted, measured, and subsequently released downstream of the trap to prevent them from being recaptured again. In most cases when stream flows were predicted to exceed 2,000 cfs, fish being held for a subsequent mark–recapture test were released downstream of the trap and efficiency trials were not conducted, reducing the chance of mortalities and for crew-related safety concerns.

Trap efficiency

The number of fish released and recaptured from each group from a trial was pooled to get the weekly trial totals. Weekly trap efficiencies were then generated using a stratified Bailey's 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. Weekly trap efficiencies were generated by use of the equation:

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

where

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

Although trap efficiency was calculated for all mark–recapture trials, only trials with at least seven recaptures were used to estimate passage as suggested by Steinhorst et al. (2004). When instream flow fluctuations occurred or a trial did not recapture seven fish to generate statistically sound estimates, the trial was excluded and the "season" efficiency value was used. Additionally, for the periods preceding the first trial and proceeding a week after the last trial of the season, the season efficiency was used for those strata. Season efficiency values were calculated by dividing the mean number of fish recaptured plus one from all valid mark–recapture trials by the mean of all valid trial releases plus one.

Interpolated data

Average method — When the trap could not be safely fished or the cone stopped rotating during the sampling period, the daily catch was interpolated. We used an average method to interpolate (generate) a daily catch. Interpolated catch data were generated by use of the equation:

$$I = (C_b + C_a) / (D * 2)$$

where

I = the interpolated catch for each day the trap did not fish in succession
D = the number of days the trap did not fish
C_b = the mean catch of D before the RTS did not fish
C_a = the mean catch of D after the RTS did not fish

Hourly percent of daily catch method — We used the hourly distribution of daily catch to estimate missing data for times when the trap sampled an incomplete portion of the 24-h sample period. This was only applied when at least some catch occurred prior to stoppage and the trap stoppage time could be determined.

This season we conducted sixteen 24-h sampling events during which the trap was sampled hourly on the hour (see Interval Sampling in Methods section). The hourly proportion of the daily catch was calculated for each hour of each sampling event. The mean hourly proportion of the daily catch was then calculated for each hour of the day from all sampling events (Table 3). This distribution of daily catch was used to estimate what the total daily catch would have been had the trap fished a complete 24 hours (actual catch plus the estimated missing catch):

$$I_d = C / P$$

where

I_d = the total daily catch (actual catch plus the estimated missing catch) rounded to the nearest fish
C = the actual catch for the time period the trap sampled
P = the average proportion of the daily catch (in the 24-h sampling events) for the time the trap sampled

The missing catch was estimated by subtracting actual catch from the estimated total daily catch:

$$I_m = I_d - C$$

where

I_m = the estimated missing catch for the time period that the trap did not sample

Juvenile passage indices

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. Weekly juvenile passage indices for Chinook and *O. mykiss* were calculated using weekly catch totals and either the weekly trap efficiency, pooled trap efficiency, or season average trap efficiency. The *O. mykiss* JPI was calculated for both young-of-the-year and age-0+, which included individuals from all other age classes (not including adult fish). The FL distribution (FL by date) of *O. mykiss* captured in the trap was used to determine weekly catch of young-of-the-year and age-0+. With few exceptions, graphical display of FL distribution indicated a distinct separation of the two groups. In addition, age-0+ and young-of-the-year captured during the same week could usually be distinguished by their life-stage classification.

Because the release dates for mark–recapture trials occurred on the 5th day of the week and efficiency results were used for a 7-d period, most weeks were divided into two strata. Other weeks were further divided because changes in flow and or turbidity can affect trap efficiencies. Combining the data in which there are likely changes in trap efficiency throughout the season leads to inaccurate estimates (Steinhorst et al. 2004). Using methods described by Carlson et al. (1998) and Steinhorst et al. (2004), the weekly juvenile passage indices were estimated by:

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

where

N_h = the passage during week h,
U_h = the unmarked catch during week h,
E_h = the calculated trap efficiency during week h.

The variance and 95% confidence intervals 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). Using data with simulated numbers of migrants and trap efficiencies, Steinhorst et al. (2004) determined the percentile bootstrap method 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 95% confidence intervals for the weekly juvenile passage indices were found by producing 1,000 iterations of N_h and locating the 25th and 975th values of the ordered estimates. The 1,000 iterations were produced by using R (version 3.1.0, www.r-project.org), which used the weekly catch, the calculated efficiency, and the number of marked fish for each trial.

The SE of the sample means of each stratum are also included with the 95% confidence interval. Juvenile Chinook and *O. mykiss* juvenile passage indices were summarized by brood year (BY).

Pulse flow sampling

In late April and late June of 2012, the releases from Whiskeytown Reservoir were increased to provide Spring Attraction flows, also referred to as “pulse flows.” The pulse flows were designed to fulfill “Action I.1.1. Spring Attraction Flows” of the 2009 National Marine Fisheries Service’s Biological Opinion for the Bureau of Reclamation’s Operations Criteria and Plan for the Central Valley Project (NMFS 2009). The objective of the flows was to encourage adult spring-run Chinook to move to upstream Clear Creek habitats for holding and spawning. We monitored the effects of these flows on juvenile salmonids to identify outmigration patterns, and to see if fish are responding differently to artificial flows than to the natural flow events. The LCC RST was operated and sampled hourly for 24 hours during each of the two events. Fish catch was measured and other environmental parameters (e.g. flow, turbidity, velocity) were collected on an hourly basis.

Interval Sampling

Based on recommendations from the 2011 RST report (Earley, Colby and Brown 2013), we conducted sixteen, 24-h interval samples at our LCC trap. The objective was to obtain temporal (diurnal) out-migration data and the environmental cues that spur outmigration. The hourly proportion of the daily catch can then be used to interpolate the missing catch data for partially sampled 24-h sampling periods. The live-box was sampled every hour on the hour, turbidity, sky cover, and weather conditions were recorded as well. Nine of the events were for a full 24-hour period. The other six where conducted from 1900 until 0700 the next morning. During those events the trap was sampled in the morning so that the catch between 0800 and 1900 time period was known. The sampling events were conducted sporadically (when staff were available) during both peak and non-peak fall Chinook outmigration periods from December 15, 2011, through June 7, 2012.

Results

Sampling effort

Upper Clear Creek — The UCC RST operated from October 31, 2011, through June 30, 2012 for 243 d. We expected catch of emergent salmonids would have been low or zero in the period from the beginning of August through October.

O. mykiss brood year — The trap did not fish from March 13 through May 6, 2011 because we were waiting for parts to repair some mechanical damage to the cone. This was during peak out-migration of BY11 *O. mykiss*.

Spring Chinook brood year — To determine when to begin our trapping season, we estimated emergence timing utilizing an accumulated thermal units method (Murray and Beacham 1986, Murray and McPhail 1988, Brown and Earley 2007). We used redd timing data from fall 2011, 2011 water temperature data from redd construction forward, and temperature data from water years 2009 and 2010 (to estimate accumulated thermal units (ATU) for the days not yet realized at the time of calculation), we predicted that spring Chinook emergence would not occur until mid-November. The traps were set two weeks before the estimated emergence to accommodate variation in actual vs model input temperature, and variation in emergence timing not captured by the ATU model (most ATU methods predict the number of days to 50% emergence from a redd).

The UCC RST did not sample for 125 of the 243 d during the trap season. Ninety-seven of the days were because the trap was inoperable due to mechanical damage, six were the result of pulse flows that were too high to safely trap, and the remainder were due to staff shortage. There was only one partially sampled trap day in which the cone had been stopped by debris partway through a set (Table 4). The half-cone modification was used during the entire sampling season.

Lower Clear Creek — The LCC RST was operated for 243 d. The LCC RST did not sample for 3 of the 243 d during the sample season.

O. mykiss brood year — Conditions were fair during the *O. mykiss* outmigration and the catch for 11 days had to be interpolated for times the trap could not fish.

Late-fall Chinook brood year — Trapping conditions during late-fall Chinook outmigration were great and only on day had to be interpolated.

Spring and fall Chinook brood year — Of the three days the trap did not fish, one of the days was the result of high flows. A lack of staff prevented the RBFWO from fishing the trap the other two days. Five days were only partially sampled because the cone had been stopped by debris or the cone was raised partway through a set because of high flows (Table 4). The half-cone modification was applied during the entire sampling season.

Physical characteristics

During the trap season, mean daily flows ranged at the USGS Igo gauge from a minimum of 83 cfs in early September, 2012 to a maximum of 1,420 cfs on March 30, 2012. The maximum measured flow was 2,110 cfs on March 28, 2012. The minimum flows were comprised almost entirely from controlled releases out of Whiskeytown Lake, while maximums resulted largely from natural storm flow accretions.

Upper Clear Creek — The channel width of Clear Creek at the UCC RST spanned from approximately 30 ft at the lowest flows to more than 130 ft at the highest flows. Measured water depths in Clear Creek at the base of the RST cone ranged from 3.9 ft to 6.3 ft, with an average depth of 5.0 ft. The shallowest depths were recorded in December 2011 and February 2012 (mean of 4.9 ft), and the deepest depths were recorded in May 2012 (mean of 5.4 ft).

Measured turbidity levels ranged from 0.69 nephelometric turbidity units (NTU) on June 4, 2012, to 13.6 NTU on January 22, 2012, with a mean turbidity of 1.6 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 temperature during the sampling season at UCC ranged from a low of 41.7 °F on February 4, 2012, to a high of 60.8 °F on June 17, 2012 (Figure 3).

Lower Clear Creek — The channel width of Clear Creek at the LCC RST spanned from approximately 40 ft at the lowest flows to more than 150 ft at the highest flows. Measured water depths in Clear Creek at the base of the RST cone varied from 2.5 ft to 5.5 ft, with an average depth of 2.9 ft. The shallowest depths were recorded in May 2012 (mean of 2.8 ft), and the deepest depths were recorded in March 2012 (mean of 3.2 ft).

Measured turbidity levels ranged from 0.54 NTU on June 12, 2012, to 38.2 NTU on March 16, 2012, with a mean turbidity of 2.16 NTU (Figure 2). Mean daily water temperature ranged from a low of 40.0 °F on January 17, 2012, to 66.6 °F on June 28, 2012 (Figure 3). Temperatures are measured year round; however, the values above represent temperatures for the days that the traps were sampled.

Mark –recapture efficiency estimates

Upper Clear Creek — Six mark–recapture trials were conducted to estimate UCC RST efficiency. The first release of marked fish occurred on January 4, 2012, and the last on February 9, 2012. During the six trials 3,626 marked Chinook salmon (from LCC) were released upstream of UCC, and 291 were recaptured. The number of individual fish released for each trial ranged from 595 to 616, with an average of 604. Recaptured fish numbers per trial ranged from 32 to 65 with an average of 49. Efficiencies ranged from 5.54% to 10.86% per trial (Table 6). The season average was 8.26%. No mark–recapture studies were conducted from November 1 through December 31, 2011, and from February 12 through June 30, 2012, because of low fish collection numbers.

O. mykiss — Annual juvenile passage indices for *O. mykiss* are for the dates from January 1 to December 31, 2011, requiring trap efficiencies from the same time period. Trap efficiencies from the 2010-2011 (Earley, Colby and Brown 2013) and the 2011-2012 trap seasons were used to calculate the weekly and annual JPI (Table 7).

Spring Chinook — The trap season covers the spring Chinook brood year. As such, the individual trials and season average were used to calculate the spring Chinook weekly and annual juvenile passage indices (Table 7).

Lower Clear Creek — Of the 15 mark–recapture trials conducted to test for the LCC RST efficiency, 14 were valid trials (during trial 10, only one fish was recaptured). The first release of marked fish occurred on January 10 and the last on April 12, 2012. During the 15 trials 8,924 marked Chinook were released and 542 were recaptured. The number of individual fish released for each trial ranged from 469 to 630, with an average of 594. Recaptured fish numbers per trial ranged from 1 to 57 with an average of 36 (21-57, mean = 39 for valid trials). Efficiencies for valid trials ranged from 3.80% to 9.34% per trial (Table 8) with a season average of 6.72%.

No mark–recapture studies were conducted from November 1, 2011 to January 9, 2012, and from April 15 through June 30, 2012, because of low fish collection numbers.

O. mykiss — Four trials were conducted with a total of 355 fish released and 21 recaptured. Trials one and two were invalid because of low numbers of recaptures. The number of *O. mykiss* released ranged from 77 to 103 with an average of 89, recaptures ranged from 1 to 7 with an average of 5 and, efficiencies ranged from 7.69% to 9.30% for valid trials (Table 9). These efficiency values were not used to calculate the *O. mykiss* passage indices, and the trials conducted with Chinook Salmon were used instead.

Weekly trial data and season average from the 2010-2011 (Earley, Colby and Brown 2013) and 2011-2012 seasons were used to calculate the *O. mykiss* weekly and annual passage at the LCC trap (Table 10).

Late-fall Chinook — The JPI for late-fall Chinook encompassed the dates from April 1, 2011 to March 31, 2012. Weekly trial data and season average from the 2010-2011 (Earley, Colby and Brown 2013) and 2011-2012 seasons were used to calculate the late-fall Chinook weekly and annual passage indices (Table 10).

Fall and spring Chinook — The trap season covers the spring and fall Chinook brood year. As such, the individual trials and season average were used to calculate the spring Chinook weekly and annual juvenile passage indices (Table 10).

Salmonid catch and passage indices

Upper Clear Creek — A total of 4,887 fish representing nine taxa were collected in the UCC RST during the sampling period. The most abundant fish taxa collected were Chinook, *O. mykiss*, California Roach *Lavinia symmetricus*, Pacific Lamprey *Entosphenus tridentatus*, and Riffle Sculpin *Cottus gulosus*.

O. mykiss — A total of 371 young-of-the-year BY11 *O. mykiss* were captured in the UCC trap. The first fish was caught on February 7 and the last on December 29, 2011 (Figure 4). Fork lengths ranged from 23 to 373 mm and the mean and median was 83 and 65 mm, respectively. The life stage frequencies were as follows: 0.2% yolk-sac fry, 26.0% fry, 67.7% parr 4.8% silvery parr and 1.4% smolt (Table 11). The official weekly and annual passage indices are calculated using LCC RST data because much of the *O. mykiss* spawning occurs below the UCC RST. The passage data presented below are for comparison purposes.

Passage peaked at 460 on Week 22 (Figure 5). The annual JPI was 3,859 with upper and lower 95% confidence intervals of 4,123 and 3,594, respectively (Table 12).

A total of 133 age-0+ *O. mykiss* from pervious brood years were captured at UCC. Three life stages were represented; 81.2% parr, 13.5% silvery parr and 5.3% smolt (Table 11). Fork lengths ranged from 50 to 144 mm and the mean and median was 144 and 130 mm, respectively.

Chinook — Length-at-date tables of Greene (1992) indicated that we collected fall and spring Chinook. The UCC RST captured 4,614 Chinook during the study period. Chinook of all life stages were collected (Figure 6). The data trends for each size-classified run of Chinook, along with our assumptions and adjustments, are summarized below.

Late-fall Chinook — No late-fall Chinook were captured.

Winter Chinook — No winter Chinook were captured.

Spring Chinook — For spring and fall Chinook estimates at UCC, we did not strictly rely on length-at-date tables. Installation of the picket weir confined most adult fall Chinook below the picket weir, preventing them from spawning upstream. However, two marked and coded wire tagged adults were able to either migrate upstream of the weir before installation or were able to find a way around or through the weir. The carcasses of the two fish were recovered in reach 5a. Based upon coded wire tags both were BY09 fall Chinook, one from the Feather River Hatchery (California) and the other from Coleman National Fish Hatchery (Giovannetti and Brown 2013). We assigned all length-at-date fall Chinook as spring Chinook for the UCC indices. Fork lengths for all BY 2012 spring Chinook captured ranged from 31 mm to 98 mm, with mean and median fork lengths of 35 and 34 mm, respectively. The life stage composition was as follows: < 0.1% yolk-sac fry, 99.2% fry, 0.7% parr, < 0.1% silvery parr and < 0.1% smolt (Table 11). The majority of measured individuals (99.4%) were 39 mm or less in FL.

Peak out-migration occurred over a four-week period from December 3 through December 31, 2011 (Figure 7). The annual JPI was 55,737 with upper and lower 95% confidence intervals of 61,085 and 50,351, respectively (Table 13). USFWS RBFWO adult snorkel surveys observed 15 redds above the UCC RST (Giovannetti and Brown 2013) and from this we calculated a juvenile per redd production of 3,747.

Lower Clear Creek — A total of 651,813 individual fish representing 17 taxa were collected in the LCC RST during the sampling period. The most abundant fish taxa collected were Chinook, followed by *O. mykiss*, Pacific Lamprey, Micropterus fry, and Riffle Sculpin. The LCC RST capture data are reported below.

O. mykiss — A total of 1,117 young-of-the-year BY11 *O. mykiss* were captured in the LCC trap. The first fish was caught on January 19 and the last on December 14, 2011 (Figure 8). Fork lengths ranged from 21 to 165 mm and the mean and median was 35 and 27 mm, respectively. The life stage frequencies were as follows: 2.1% yolk-sac fry, 71.5% fry and 26.5% parr (Table 14). The official weekly and annual passage indices are calculated using LCC RST.

Passage peaked at 1,973 on Week 13, Weeks 8–10 and 14–15 also had passages above 1,000 (Figure 9). The annual JPI was 19,647 with upper and lower 95% confidence intervals of 21,364 and 17,875, respectively (Table 15). A total of 218 *O. mykiss* redds were observed in Clear Creek from December 2010 through March 2011 (Giovannetti, Bottaro and Brown 2013), yielding 90 juveniles per redd.

There were only 18 age-0+ fish captured and all were parr.

Chinook — Length-at-date tables of Greene (1992) indicated that we collected individuals from all four Chinook runs known from the Sacramento River basin. During the study period 649,318 individuals were captured. Fork lengths of measured Chinook (n = 26,935) ranged from 24 mm to 122 mm, with a mean and median of 38 and 36 mm, respectively. All life stages were collected (Figure 10), 98.4% of those we classified were fry stage fish (n = 649,332). The majority (91.8%) of individuals were 39 mm or less in FL. The data trends for each run of Chinook are discussed below.

Late-fall Chinook — The actual catch of BY11 late-fall Chinook this trap season was 554, with a peak catch of 98 on May 18, 2011 and peak passage during Week 16 (Figure 11). Fork lengths of late-fall Chinook varied from 28 to 122 mm with a mean and median of 39 and 35 mm, respectively. The life-stage composition was 86.3% fry, 8.3% parr, 1.4% silvery parr and 4.0% smolt (Table 14).

The annual JPI for BY11 late-fall Chinook was 8,703, with an upper and lower 95% CI of 9,754 and 7,798, respectively (Table 16). There were 21 total late-fall Chinook redds observed, all in Reach 6 and above LCC (Giovannetti, Bottaro and Brown 2013); from those redds a juveniles per redd production of 414 was calculated.

Winter Chinook — Eight winter Chinook sized fish were captured this season, however genetic analysis indicates that seven of these fish were either fall Chinook or late-fall Chinook, one had no call. Of these, one was a silvery parr and the others were smolts.

Spring Chinook — According to length at date tables, 515 spring Chinook were captured at the LCC RST. The passage index for spring Chinook is determined by using the UCC RST. The data presented here for the LCC RST is provided for comparison purposes. Peak out-migration occurred during Week 47-48 (Figure 12). Fork lengths of spring Chinook ranged from 27 to 75 mm with a mean and median of 35 and 34 mm, respectively. The life stage composition was 1.4% yolk-sac fry, 96.8% fry, 1.2% parr and 0.6% silvery parr (Table 14). The annual passage index was 7,780, with upper and lower 95% confidence intervals of 9,282 and 6,681, respectively (Table 17).

Fall Chinook — A total of 647,145 fall Chinook were captured. Fall Chinook made up 80.8% of all salmon captured. The minimum FL was 24 mm, the maximum was 91 with the mean and median 38 and 36 mm, respectively; 89.9% of the fall Chinook that were measured were in the 30-39 mm FL range. The life stage composition was: 0.1% yolk-sac fry, 99.5% fry, 0.2% parr, 0.2% silvery parr and < 0.1% smolt (Table 14). Peak out-migration occurred from early January through mid-March. The highest weekly passage occurred during the Week 9 when 2,769,582 individuals estimated to have passed the LCC RST (Figure 13). The annual JPI was 10,408,622 with upper and lower 95% confidence intervals of 11,041,760 and 9,767,159, respectively (Table 18).

Non salmonid catch

Upper Clear Creek — A total of 55 non-salmonids were caught. These included 15 California Roach, 13 Riffle Sculpin, 10 Pacific Lamprey (9 ammocoetes and 1 macropthalmia), 11 Sacramento Sucker *Catostomus occidentalis*, 3 unclassified *Lampetra spp*. ammocoetes, and one each of Brown Bullhead *Ameiurus nebulosus*, Hardhead *Mylopharodon conocephalus* and, an unidentified lamprey ammocoete (Table 19, Table 20)

Lower Clear Creek — A total of 1,046 individual non-salmonids from 15 taxa were captured by LCC RST. The most abundant non-salmonids were Pacific Lamprey, and Micropterus fry (Table 21).

Pacific Lamprey — A total of 115 ammocoetes and 432 macropthalmia were collected. Ammocoetes were collected manly from March through June (*n* = 96) and 382 macropthalmia were captured in January.

Micropterus fry — Bass fry were captured in May and June.

Riffle Sculpin — A total of 83 Riffle Sculpin were collected. This species was collected throughout the sampling season.

Genetic and otolith sampling

Genetic samples were taken from 233 Chinook during this sampling season. Thirty-two were collected at LCC and 201 were collected from UCC. This season *O. mykiss* were sacrificed for otolith sample collection; 44 at UCC and 49 at LCC. All *O. mykiss* sacrificed for otolith samples were > 50 mm in FL.

Mortality

The RBFWO is authorized by NMFS to take threatened and endangered species under an Endangered Species Act section 10(a)(1)(A) collection permit (permit) for scientific research and enhancement purposes. This permit limits the number of mortalities (indirect and incidental) that can occur because of trap operations. Indirect mortality is a given number of fish per season, while incidental mortality is a percent of the total take (catch). The incidental mortality limit for each trap on Clear Creek is 4% for *O. mykiss* and spring and winter Chinook.

The mortality numbers in this report are for the trap year, not brood years, unless otherwise noted. Note that it is impossible to differentiate dead or dying fish that our trap captured as part of the creek's drift and debris sieved by our trap from those that expired in our trap directly due to our operations. Every fish encountered dead in our live-box is treated here as a mortality.

Marking mortality — A total of 63 mortalities occurred among the 12,550 marked Chinook at both traps, or 0.5% of fish marked. Mortalities resulting from the marking of fall Chinook for each efficiency trial ranged from zero to 22 (Table 6, Table 8). Of the 355 *O. mykiss* marked 6 died during the process, or 1.7%. Mortalities for each *O. mykiss* trial ranged from 0% to 3.8% (Table 9)

Trapping mortality — A total of 1,402 mortalities for all runs of Chinook and 7 for *O. mykiss* occurred as a result of RST operations during the 2011-2012 trap season.

Upper Clear Creek — A total of 4,614 Chinook of all runs were captured at UCC resulting in 26 mortalities. A total of 218 *O. mykiss* were captured resulting in zero mortality.

O. mykiss — There were a total of 218 *O. mykiss* captured at UCC this season with zero mortalities. The indirect mortality limit set by the permit for *O. mykiss* is 315. Neither of the permit limits was exceeded.

Spring Chinook — There were 4,588 BY 2011 spring Chinook captured in the UCC RST. Of these, 26 were recorded as mortalities, or 0.6% of the fish handled. The indirect mortality limit for spring Chinook is 4,275. Neither of the limits were exceeded for spring Chinook at either trap.

Lower Clear Creek — A total of 649,318 Chinook of all runs were captured at LCC resulting in 1,388 mortalities. A total of 1,445 *O. mykiss* were captured resulting in seven mortalities.

O. mykiss — There were 1,455 *O. mykiss* captured in the LCC RST this trap season, seven were mortalities, or 0.5% of the catch. Neither of the permit limits were exceeded.

Late-fall Chinook — There were 1,649 late-fall Chinook captured in the LCC RST during the trap season. Of these captures 21 were recorded as mortality, or 1.2% mortality rate of the fish handled. No mortality limits have been placed on late-fall Chinook.

Winter Chinook — Eight winter run sized Chinook were captured and one was a mortality. However, genetics results indicate that seven of the eight fish were not winter Chinook (including the one mortality), and race designation of the other fish was inconclusive. Therefore there were no winter Chinook mortalities. The indirect mortality limit for winter Chinook is 300.

Spring Chinook — There were 515 BY11 spring Chinook captured in the lower Clear Creek RST. Two spring Chinook mortalities were recorded or 0.4% of the catch. Neither of the limits were exceeded for spring Chinook at either trap.

Fall Chinook — There were 647,145 BY11 fall Chinook captured in the LCC RST. Of these captures 1,364 were recorded as mortalities, or 0.2% mortality of the fish handled. No mortality limits have been placed on late-fall Chinook.

Interval sampling

Thirteen successful interval sampling events were conducted this season at the LCC RST. Nine full 24-h period events were conducted early in the trap season during most of the peak fall Chinook out-migration (December 15, 2011, through March 2, 2012, Figure 14). The other four events where conducted from 1900 until 0700 the next morning. During those events the trap was sampled in the morning so that the catch between 0800 and 1900 time period was known. These sampling events were conducted during non-peak outmigration (April 12, through June 7, 2012, Figure 15). The combined results for the early season 24-h sampling events show that 80.1% of Chinook pass the LCC RST between 1800 and 0000 hours, while during the same time period for the late season 1900–0700 events 49.2% passed the trap from 1800–0000 hours. However, 73.9% of Chinook passed the trap during the hours of 2100–0300 (Figure 16).

The hourly catch of *O. mykiss* was bimodal with a peak at 2300–0000 hours and another at 0400 hours with 78.7% of the fish passing the trap between the hours of 2100–0400. Another 9.6% passed from 0400 to 0500 hours (Figure 17).

Pulse Flow Sampling

Two pulse flows were conducted on Clear Creek during this trap season. The first and lower occurred May 2127, 2012, and had a peak flow of 400 cfs. We sampled LCC hourly from 0700 hours on May 22 through 0700 hours on May 24, 2012. The catch for May 2224 was 248, 103, and 49, respectively. During the time period of 21000400 hours 89.3% of the fish were caught in the trap on May 22–23 and 89.8% on May 23–24. The second pulse flow was from June 4 to 10 and peaked at 1,000 cfs. We conducted interval sampling on June 5 to 7, 2012, and the catch was as follows: 62, 17, and 17. The percentage of catch occurring between the hours of 2100–0400 was 70.6% on June 5–6 and 100% on June 6–7; however the sample size was small.

Discussion

Sampling effort

The trapping conditions during the BY11 season were generally good for capture of all races of Chinook and BY11 *O. mykiss*. High flow events that impeded trapping came at a time when fall Chinook out-migration was coming to an end (March 28 through April 1, 2012).

Upper Clear Creek — The upper trap fished for nearly 100% of the peak of spring Chinook out-migration and none of catch data had to be interpolated for times that the trap was not fishing (Figure 18). The trap did not fish on November 5–6, 2011, because of staffing difficulties. The trap had a catastrophic mechanical failure and did not fish from February 15 through May 21, 2012. The cone was raised and it was removed from the thalweg because of high flows and was not fished for the rest of the season (Table 4). Though the trap only fished approximately 48% of the entire trap season, historic catch records at UCC indicate that 97.7% of the passage of spring Chinook occurs during the time period (weeks 44–52, 1–6 and 22) that UCC was operational during this season.

Lower Clear Creek — The LCC trap missed 3 days because of high flows or lack of staff to tend to the trap during peak fall Chinook out-migration. A flow event occurred in late March and the trap fished for a partial day on March 28 and did not sample on March 31, 2012 (Table 5). The catches had to be estimated via interpolation on those days and were 4,438 and 1,033, respectively. Interpolated catch data comprised 0% of the spring Chinook and 0.8% of the fall Chinook total catch (Figure 19).

Sampling conditions were great for late-fall Chinook as well, and there was only one day that the trap could not operate during the peak out-migration period. Three days were interpolated (nine fish) and this accounted for 1.6% of the total catch.

Mark –recapture efficiency estimates

Upper Clear Creek — This season's average efficiency (8.26%) for the UCC RST was near the trap's 2003–2010 average (Figure 20). This year, six mark-recapture studies were conducted using naturally spawned fall Chinook captured at LCC.

Spring Chinook — Six mark–recapture studies using fall Chinook from LCC were used to calculate 15.2% of the UCC spring Chinook passage index, while 84.8% of the passage index was calculated using the season average (Table 7). If trials could have been conducted for the weeks 48 through 52 utilizing wild spring Chinook when adequate numbers were available for mark–recapture trials, then 92.4% of the JPI could have been calculated using actual trial data, instead of the season average efficiency.

Lower Clear Creek

Chinook trials — Fourteen valid trials were conducted for expanding the fall Chinook catch data. The season average (6.72%) was the highest in the trap's history. The range of efficiency throughout the season was from 4.03% to 9.34% (Figure 21). The trial held on March 15, 2012 was not valid because only one fish was recaptured; therefor the trial held on March 6 was used to expand five days in Week 10 and six in Week 11. The trials were used to expand 98.1% of the fall Chinook catch.

O. mykiss trials — Four trials were conducted with a total of 355 fish released and 21 recaptured. Two trials were invalid because of insufficient recaptures. The results from the two valid trials are higher than the two valid trials from the 2008-2009 trap season, 6.61% and 6.15%. More study is needed to determine if efficiency trials conducted with *O. mykiss* fry should be used to expand the *O. mykiss* catch. These trials were not used to calculate the passage indices. This year, as in previous years, the trials held with fall Chinook were used to calculate the juvenile passage indices for *O. mykiss*.

Salmonid passage indices

Upper Clear Creek

Spring Chinook — The JPI was 55,737 with the upper and lower CIs of 61,085 and 50,351, respectively (Table 13). The 15 spring Chinook redds observed above the UCC RST (USFWS in progress) was well below the mean from 2003 to 2010 (n = 49). The juvenile per redd (n = 3,747) production was the highest in the trap's history (Figure 22), the historic mean is 1,974. The total catch (actual and interpolated for days not fished, n = 4,614) was the third lowest in the trap's history; the mean for 2003–2010 is 7,240. The adjusted passage index of 59,453 (for redds downstream of UCC but upstream of the segregation weir) was also well below the mean of 102,139 (Table 22). The high juveniles per redd could be the result of nearly perfect trapping conditions during the peak of spring Chinook out-migration. All life stages except fry are rarely captured by UCC. This year we had the lowest catch of silvery parr and smolt life stages (Table 23). The trap only fished for 15 days (May 22 through June 5, 2015) during the larger life stage out-migration period. The only season when smolts accounted for greater than 1% of the catch was BY04 (silvery parr 2.79% and smolt 1.04%) when the trap fished for a full water year. Based upon otolith $^{87}Sr/^{86}Sr$ isotope ratio analysis of Chinook in the Stanislaus River, a tributary of the San Joaquin River in the Central Valley of California, fish that out-migrated from the Stanislaus to the San Joaquin as smolts comprised 13–44% of the returning adults to the system. The low end represents a wet year outmigration, and the high a dry year (Sturrock et al. 2015). Smolt sized fish are seen during juvenile habitat use and adult snorkel surveys in Reach 6 of Clear Creek (personal observation). As mentioned above, these fish are not readily captured by the UCC RST. This could be because the sample season regularly ends on June 30 in most seasons. Do the fish move down stream to rear in the lower reaches? Perhaps the smolts' enhanced swimming ability (over that of fry or parr) allows them to evade capture? More study is needed in Reaches 1–5 to determine if fish are rearing to smolt life stage there as well.

Lower Clear Creek

O. mykiss — The *O. mykiss* present in Clear Creek exhibit characteristics of a winter-run steelhead, with adults migrating upstream in the late fall and winter and fry out-migration typically beginning in late January or early February and peaking during the months of April and May. This year's emergence started in mid-January and peaked during weeks 9–15 (Table 15, Figure 9). The annual JPI of 19,647 was very close to the BY99–10 mean of 18,438 (Table 24). There has been a dramatic decline in juvenile per redd production since BY08; however BY11 has shown an increase from the low of 50 (BY10). The juveniles per redd of 90 for BY11 was still below the mean (BY01–10) of 167. Eleven days during peak BY11 *O. mykiss* fry out-migration had to be interpolated for days the trap did not fish (6.5%). Perhaps a greater percentage of fish held back to rear in the lower reaches of Clear Creek instead of migrating to the Sacramento River.

This season's catch for BY10+ age-0+ STT was 31. Peak out-migration was during Weeks 12–13. The JPI for the brood year season was 259 with upper and lower 95% confidence intervals of 299 and 224, respectively. The JPI was about half the nine-year mean of 422.

Late-fall Chinook — A total of 554 BY11 late-fall Chinook were captured. Passage peaked during Week 20 (Table 16, Figure 11). The JPI (n = 8,703) was lowest in the trap's history (Table 25) as was the juveniles per redd for redds above the LCC trap (414). The annual passage mean (BY99–10) is 95,478 and mean juvenile per redd (BY03–10) is 2,623. Conditions for screw trap operations during the late-fall Chinook out-migration were good. Only one day during peak fry out-migration and 2 days during the smolt migration had to be interpolated (1.6% of the total catch). The JPI for late-fall Chinook juveniles generated by length-at-date tables could be inaccurate because of the large number of fall Chinook juveniles present and the lack of differentiation between the two runs in late-March and early-April. As noted previously, many smolt size fish rear in Reach 6 and are present after LCC stops sampling, these could be late-fall Chinook. Late fall Chinook also spawn in Reach 7 below the LCC RST, because of these reasons it is very difficult to get an accurate JPI for late-fall Chinook and it could be much underestimated.

Fall Chinook — The total catch of 648,095, JPI of 10,310,540 and, juveniles per female of 2,661 were all nearly double that of the BY98–10 averages of 391,728, 5,970,261 and 1,579, respectively (Table 26). The number of females was estimated by carcass surveys conducted by the USFWS and CDFW (CDFW 2016). Passage peaked during Weeks 9–11 (Table 18, Figure 13). Only two days catch (0.8%) had to be interpolated and neither was during peak out-migration. It is possible that the total catch and JPI are slightly inflated because of the inclusion of early brood year 2012 late-fall Chinook that fall into Greene's (1992) fall Chinook growth curves for Sacramento River Chinook Salmon. Another metric used to determine spawning and /or trapping success is the number of juveniles to spawning area used by adult fall Chinook. The analysis is currently in progress (USFWS RBFWO, Provins and Chamberlain).

Winter Chinook — Eight juvenile salmon were designated as winter Chinook by the Greene (1992) fork length charts. Genetic analysis indicates that seven of these fish were either fall Chinook or late-fall Chinook, one had no call. These fish were not included in either the fall Chinook or the late-fall Chinook JPI because current genetic methods cannot differentiate between the two.

Interval sampling

In the spring of 2011 during our pulse flow sampling we observed that juvenile fall Chinook fry were moving out primarily around 2100 hours. Our sampling at the time was in two hour intervals. Based upon these observations a recommendation was made in the 2011 report that interval sampling be conducted to gather information about daily temporal passage and to identify environmental variables that may contribute to fish altering this pattern of downstream movement. Collecting hourly information will assist in developing an average daily distribution curve of fish passage. The sampling objectives were to sample traps at 1-h intervals during a 24-h period every two weeks where possible, during peak out-migration of fall Chinook at our LCC RST location.

Twelve successful interval sampling events were conducted from December 15, 2011, through June 7, 2012, at LCC. Seven were conducted early in the season, December 15 through March 2, the other five late in the season, April 12 through June 7, 2012 (Figure 16). When the data is summed for the two data sets, it is apparent that the out-migration shifts two hours later for the late season data set (Figure 16). The sun sets later as the trap season progresses and this could explain the shift in the peak of the nightly out-migration. The season average is very similar to the early season average because the early season has greater catch numbers and as such skews the season average to earlier in the night. We hope to use this data to interpolate partial catch on days that the trap stops fishing because of debris, vandalism or high flows.

Pulse flow sampling

Interval sampling was conducted during the April and June pulse flows for the second year, in order to determine how salmonids behave during artificial higher flow events. Conducting these sampling events enabled us to discover that the diel out-migration pattern shifts later over time. The daily catch results were similar to last year's results (Earley, Colby and Brown 2013; Figure 23 and Figure 24).

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Tables

Table 1. The 2011 Clear Creek snorkel survey reach numbers, locations and river miles for reference. In August 2011, the Clear Creek picket weir was placed instream at the Reading Bar site located at river mile 8.1 RM (Giovannetti and Brown 2013) to protect the spring-run Chinook Salmon population from potential spawning superimposition from fall-run Chinook Salmon. The juvenile passage index is adjusted for redds identified above the weir at RM 8.1 and below the upper rotary screw trap at RM 8.4, Clear Creek, Shasta County.

Reach	River mile	Location
1	18.3–16.1	Whiskeytown Dam to Need Camp bridge
2	16.1–13.2	Need Camp bridge to Kanaka Creek
3	13.2–11.0	Kanaka Creek to Igo gauge
4	11.0–8.6	Igo gauge to Clear Creek Road bridge
5a	8.6–8.2	Clear Creek Road bridge to Reading Bar picket weir site
5b	8.2–7.5	Reading Bar picket weir site to Shooting Gallery picket weir site
5c	7.5–6.5	Shooting Gallery picket weir site to old McCormick-Saeltzer Dam site
6	6.5–1.7	Old McCormick-Saeltzer Dam site to USFWS lower rotary screw trap
7	1.7–0.2	Lower rotary screw trap to USFWS video counting weir

Table 2. Dates with corresponding week numbers for rotary screw trap operations at river mile 1.7 and 8.4 in Clear Creek, Shasta County.

Dates	Corresponding week	Dates	Corresponding week
01/01–01/07	1	07/02–07/08	27
01/08–01/14	2	07/09–07/15	28
01/15–01/21	3	07/16–07/22	29
01/22–01/28	4	07/23–07/29	30
01/29–02/04	5	07/30–08/05	31
02/05–02/11	6	08/06–08/12	32
02/12–02/18	7	08/13–08/19	33
02/19–02/25	8	08/20–08/26	34
02/26–03/04	9	08/27–09/02	35
03/05–03/11	10	09/03–09/09	36
03/12–03/18	11	09/10–09/16	37
03/19–03/25	12	09/17–09/23	38
03/26–04/01	13	09/24–09/30	39
04/02–04/08	14	09/30–10/06	40
04/09–04/15	15	10/07–10/13	41
04/16–04/22	16	10/14–10/20	42
04/23–04/29	17	10/21–10/27	43
04/30–05/06	18	10/28–11/03	44
05/07–05/13	19	11/04–11/10	45
05/14–05/20	20	11/11–11/17	46
05/21–05/27	21	11/18–11/24	47
05/28–06/03	22	11/25–12/01	48
06/04–06/10	23	12/02–12/08	49
06/11–06/17	24	12/09–12/15	50
06/18–06/24	25	12/16–12/22	51
06/25–07/01	26	12/23–12/31	52[a]

[a] Week 52 (December 23 to 31, 2012) contains 9 days for keeping January 1 as Julian calendar day 1.

Table 3. Hourly catch and percent of daily catch of juvenile Chinook Salmon for the interval sampling events conducted at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County. Sampling events were conducted from December 15, 2011, through June 7, 2012. Early season covered the December 15, 2011, through March 2, 2012, time period, late season was April 12, through June 7, 2012.

	Catch			Percent of catch		
Time	Early season	Late season	Mean hourly catch	Early season	Late season	Mean percent of daily catch
0800	238	3	241	0.4%	1.0%	0.4%
0900	198	2	200	0.3%	0.7%	0.3%
1000	70	0	70	0.1%	0.0%	0.1%
1100	154	0	154	0.2%	0.0%	0.2%
1200	4	2	6	0.0%	0.7%	0.0%
1300	8	0	8	0.0%	0.0%	0.0%
1400	14	0	14	0.0%	0.0%	0.0%
1500	44	0	44	0.1%	0.0%	0.1%
1600	219	3	222	0.3%	1.0%	0.4%
1700	854	0	854	1.4%	0.0%	1.4%
1800	682	0	682	1.1%	0.0%	1.1%
1900	4,369	1	4,370	6.9%	0.3%	6.9%
2000	13,456	0	13,456	21.4%	0.0%	21.3%
2100	14,576	10	14,586	23.2%	3.3%	23.1%
2200	8,947	36	8,983	14.2%	12.0%	14.2%
2300	4,543	59	4,602	7.2%	19.7%	7.3%
0000	4,515	41	4,556	7.2%	13.7%	7.2%
0100	3,092	23	3,115	4.9%	7.7%	4.9%
0200	1,692	33	1,725	2.7%	11.0%	2.7%
0300	1,244	29	1,273	2.0%	9.7%	2.0%
0400	1,315	19	1,334	2.1%	6.4%	2.1%
0500	1,412	16	1,428	2.2%	5.4%	2.3%
0600	958	16	974	1.5%	5.4%	1.5%
0700	314	6	320	0.5%	2.0%	0.5%
Total	62,918	299	63,217			

Table 4. Summary of days the upper rotary screw trap did not fish for extended number of hours or days during the report period (November 1, 2011, to June 30, 2012), including sample dates, approximate hours fished, and reason for not fishing. The trap is located at river mile 8.4, in Clear Creek, Shasta County.

Sample dates	Hours fished (approx.)	Reason
Nov 4–6, 2011	26.00	Trap not fishing because of lack of staff
Jan 20, 2012	22.00	Log stopped cone
Feb 14–May 21, 2012	22.75	Trap damage, inoperable
Jun 4–10, 2012	10.50	High flows, pulse flow
Jun 11–30, 2012	0.00	Trap not fishing because of lack of staff

Table 5. Summary of days the upper rotary screw trap did not fish for an extended number of hours or days during the report period (November 1, 2011, to June 30, 2012), including sample dates, approximate hours fished, and reason for not fishing. The trap is located at river mile 1.7, in Clear Creek, Shasta County.

Sample dates	Hours fished (approx.)	Reason
November 4-6, 2011	24.50	Trap not fishing because of lack of staff
November 7, 2011	12.00	Log stopped cone
November 15, 2011	19.50	Log stopped cone
January 21, 2012	18.00	Log stopped cone
March 27–28, 2018	30.75	High flows
March 30–31, 2012	14.75	High flows

Table 6. Summary of efficiency test data gathered by using mark–recapture trials with naturally reared juvenile Chinook Salmon at the upper rotary screw trap at river mile (RM) 8.4 in Clear Creek, Shasta County, from January 5, 2012, through February 10, 2012. The fish for the studies were captured at the lower rotary screw trap at RM 1.7.

Trial	Mark date	Release date	Released	Mortality	Percent mortality	Recaptured	Bailey's efficiency
1	4-Jan-12	5-Jan-12	600	1	0.17%	59	9.98%
2	12-Jan-12	13-Jan-12	610	0	0.00%	38	6.38%
3	20-Jan-12	21-Jan-12	616	2	0.32%	51	8.43%
4	26-Jan-12	27-Jan-12	598	1	0.17%	46	7.85%
5	2-Feb-12	3-Feb-12	607	1	0.17%	65	10.86%
6	9-Feb-12	10-Feb-12	595	2	0.33%	32	5.54%
		Totals	3,626	7	0.19%	291	

Table 7. Mark–recapture efficiency values used for weekly passage indices of brood year 2011 juvenile Rainbow Trout / steelhead (RBT) and spring-run Chinook Salmon (SCS) captured in the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from January 1, 2011, to June 30, 2012. The juvenile passage index column represents to which species or salmon race the efficiency value was applied to calculate the weekly passage index. Light grey shaded rows indicate weeks in which the 2010-2011 season average efficiency was used (Earley, Colby and Brown 2013). Dark grey shaded rows indicate weeks in which the 2011-2012 season average efficiency was used.

Dates	Week	Released	Recaptured	Bailey's efficiency	Juvenile passage index
1-Jan-11 to 30-Jun-11	1	440	46	10.66%	RBT
1-Nov-11 to 31-Dec-11	44 - 52	604	49	8.26%	RBT, SCS
1-Jan-12 to 7-Jan-12	1	600	59	9.98%	SCS
8-Jan-12 to 14-Jan-12	2	610	39	6.55%	SCS
15-Jan-12 to 21-Jan-12	3	616	51	8.43%	SCS
22-Jan-12 to 28-Jan-12	4	598	46	7.85%	SCS
29-Jan-12 to 4-Feb-12	5	607	65	10.86%	SCS
5-Feb-12 to 11-Feb-12	6	595	44	7.55%	SCS
12-Feb-12 to 30-Jun-12	7 - 26	604	49	8.26%	SCS

Table 8. Summary of efficiency test data gathered by using mark–recapture trials with naturally reared juvenile fall-run Chinook Salmon at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, from January 10, 2012, through April 12, 2012. Trial 10 is an invalid trial because only one fish was recaptured; seven are needed to make for a valid trial. The equation for estimating efficiency is E = (number recaptured + 1) / (number released + 1).

Trial	Mark date	Release date	Fish released	Mortality	Percent mortality	Recapture	Bailey's efficiency
1	9-Jan-12	10-Jan-12	615	0	0.00%	49	8.12%
2	16-Jan-12	17-Jan-12	630	4	0.63%	23	3.80%
3	23-Jan-12	24-Jan-12	620	3	0.48%	57	9.34%
4	30-Jan-12	31-Jan-12	600	1	0.16%	38	6.49%
5	6-Feb-12	7-Feb-12	609	0	0.00%	29	4.92%
6	13-Feb-12	14-Feb-12	594	0	0.00%	54	9.24%
7	20-Feb-12	21-Feb-12	619	1	0.16%	24	4.03%
8	27-Feb-12	28-Feb-12	617	1	0.16%	40	6.63%
9	5-Mar-12	6-Mar-12	608	6	0.97%	51	8.54%
10	14-Mar-12	15-Mar-12	603	1	0.16%	1	0.33%
11	17-Mar-12	17-Mar-12	601	2	0.33%	25	4.32%
12	20-Mar-12	21-Mar-12	612	3	0.48%	46	7.67%
13	28-Mar-12	29-Mar-12	540	4	0.73%	36	6.84%
14	3-Apr-12	4-Apr-12	587	22	3.64%	48	8.33%
15	11-Apr-12	12-Apr-12	469	8	1.66%	21	4.68%
		Totals	8,924	56	0.63%	542	

Table 9. Summary of efficiency test data gathered by using mark–recapture trials with naturally reared juvenile Rainbow Trout / steelhead at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, from March 17, 2012, through April 24, 2012. Trials 1 and 2 are invalid because too few fish were recaptured; seven are needed to make for a valid trial. The equation for estimating efficiency is E = (number recaptured + 1) / (number released + 1).

Trial	Mark date	Release date	Released	Mortality	Percent mortality	Recaptured	Bailey's efficiency
1	17-Mar-12	17-Mar-12	77	1	1.30%	1	2.56%
2	25-Mar-12	26-Mar-12	90	0	0.00%	6	7.69%
3	11-Apr-12	12-Apr-12	85	2	2.27%	7	9.30%
4	23-Apr-12	24-Apr-12	103	3	3.75%	7	7.69%
		Totals	355	6	1.69%	21	

Table 10. Mark–recapture efficiency values used for weekly passage indices of brood year 2011 juvenile Rainbow Trout / steelhead (RBT), late-fall run Chinook Salmon (LFCS), spring-run Chinook Salmon (SCS) and fall-run Chinook Salmon (FCS) captured in the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from January 1, 2011, through June 30, 2012. The juvenile passage index column represents to which species or salmon race the efficiency value was applied to calculate the weekly passage index. Light grey shaded rows indicate weeks in which the 2010-2011 season average efficiency was used (Earley, Colby and Brown 2013). Dark grey shaded rows indicate weeks in which the 2011-2012 season average efficiency was used.

Dates	Week	Released	Recaptured	Bailey's efficiency	Juvenile passage index
1-Jan-11	1a	549	34	3.63%	RBT
2-Jan-11 to 4-Jan-11	1b	445	26	6.05%	RBT
5-Jan-11 to 7-Jan-11	1c	595	32	5.54%	RBT
8-Jan-11 to 11-Jan-11	2a	460	25	5.64%	RBT
12-Jan-11 to 14-Jan-11	2b	595	38	6.54%	RBT
15-Jan-11 to 18-Jan-11	3a	599	36	6.17%	RBT
19-Jan-11 to 21-Jan-11	3b	619	60	9.84%	RBT
22-Jan-11 to 25-Jan-11	4a	644	44	6.98%	RBT
26-Jan-11 to 28-Jan-11	4b	586	32	5.62%	RBT
29-Jan-11 to 1-Feb-11	5a	605	32	5.45%	RBT
2-Feb-11 to 4-Feb-11	5b	580	42	7.40%	RBT
5-Feb-11 to 8-Feb-11	6a	594	31	5.38%	RBT
9-Feb-11 to 11-Feb-11	6b	605	52	8.75%	RBT
12-Feb-11 to 15-Feb-11	7a	601	62	10.47%	RBT
16-Feb-11 to 18-Feb-11	7b	594	40	6.89%	RBT
19-Feb-11 to 22-Feb-11	8a	598	29	5.01%	RBT
23-Feb-11 to 25-Feb-11	8b	588	32	5.60%	RBT
26-Feb-11 to 1-Mar-11	9a	752	35	4.78%	RBT
2-Mar-11 to 4-Mar-11	9b	606	17	2.97%	RBT
5-Mar-11 to 8-Mar-11	10a	818	43	5.37%	RBT
9-Mar-11 to 11-Mar-11	10b	518	42	8.29%	RBT
12-Mar-11 to 18-Mar-11	11	302	11	3.96%	RBT
19-Mar-11 to 29-Mar-11	12–13a	549	34	6.36%	RBT
30-Mar-11 to 1-Apr-11	13b	227	24	10.96%	RBT, LFCS
2-Apr-11 to 22-Apr-11	14–16	549	34	6.36%	RBT, LFCS

Dates	Week	Released	Recaptured	Bailey's efficiency	Juvenile passage index
23-Apr-11 to 29-Apr-11	17	93	7	8.51%	RBT, LFCS
30-Apr-11 to 30-Jun-11	18–26	549	34	6.36%	RBT, LFCS
1-Nov-11 to 9-Jan-12	44–2a	594	39	6.72%	RBT, LFCS, SCS, FCS
10-Jan-12 to 14-Jan-12	2b–3a	615	49	8.12%	LFCS, SCS, FCS
17-Jan-12 to 21-Jan-12	3b–4a	630	23	3.80%	LFCS, SCS, FCS
24-Jan-12 to 28-Jan-12	4b–5a	620	57	9.34%	LFCS, SCS, FCS
31-Jan-12 to 4-Feb-12	5b–6a	600	38	6.49%	LFCS, SCS, FCS
7-Feb-12 to 11-Feb-12	6b–7a	609	29	4.92%	LFCS, SCS, FCS
14-Feb-12 to 18-Feb-12	7b–8a	594	54	9.24%	LFCS, SCS, FCS
21-Feb-12 to 25-Feb-12	8b–9a	619	24	4.03%	LFCS, SCS, FCS
28-Feb-12 to 3-Mar-12	9b–10a	617	40	6.63%	LFCS, SCS, FCS
6-Mar-12 to 16-Mar-12	10b–11a	608	51	8.54%	LFCS, SCS, FCS
17-Mar-12 to 20-Mar-12	11b–12a	601	25	4.32%	LFCS, SCS, FCS
21-Mar-12 to 28-Mar-12	12b–13a	612	46	7.67%	LFCS, SCS, FCS
29-Mar-12 to 3-Apr-12	13b–14a	540	36	6.84%	LFCS, SCS, FCS
4-Apr-12 to 11-Apr-12	14b–15a	587	48	8.33%	SCS, FCS
12-Apr-12 to 14-Apr-12	15b	469	21	4.68%	SCS, FCS
15-Apr-12 to 30-Jun-12	16–26	594	39	6.72%	SCS, FCS

Table 11. Brood year 2011 life-stage summary for Rainbow Trout / steelhead, late-fall, winter and spring-run Chinook Salmon captured at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County.

	Brood year 2011 Rainbow Trout / steelhead		Brood year 2010 age-0+ Rainbow Trout / steelhead		Late-fall run Chinook Salmon		Winter-run Chinook Salmon		Spring-run Chinook Salmon	
Life Stage	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Yolk-sac fry	1	0.3%	0	0.0%	0	0.0%	0	0.0%	2	<0.1%
Fry	131	35.3%	0	0.0%	0	0.0%	0	0.0%	4,579	99.2%
Parr	233	62.8%	108	81.2%	0	0.0%	0	0.0%	31	0.7%
Silvery parr	6	1.6%	18	13.5%	0	0.0%	0	0.0%	1	<0.1%
Smolt	0	0.0%	7	5.3%	0	0.0%	0	0.0%	1	<0.1%
Totals	371		133		0		0		4,614	

Table 12. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile Rainbow Trout / steelhead captured at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from January 1 through December 31, 2011. Weeks in which no passage occurred are omitted.

Days Sampled	Week	Date	Weekly catch	Weekly mortality	95% CI Lower	Weekly passage	95% CI Upper	SE
7 of 7	6	5-Feb-11	10	0	74	94	126	0.43
7 of 7	7	12-Feb-11	8	0	58	75	101	0.34
7 of 7	8	19-Feb-11	21	0	149	197	265	0.90
7 of 7	9	26-Feb-11	37	1	263	347	466	1.60
7 of 7	10	5-Mar-11	17	1	123	159	214	0.72
1 of 7	11	12-Mar-11	7	0	51	66	88	0.30
0 of 55	11–18	No sampling from 13-Mar-11 to 6-May-11						
7 of 7	19	7-May-11	12	0	85	113	147	0.49
7 of 7	20	14-May-11	25	0	181	235	306	1.00
5 of 7	21	21-May-11	13	0	169	216	282	0.92
7 of 7	22	28-May-11	49	0	354	460	584	1.98
7 of 7	23	4-Jun-11	15	0	108	141	189	0.64
7 of 7	24	11-Jun-11	15	0	108	141	184	0.64
7 of 7	25	18-Jun-11	27	0	192	253	331	1.15
6 of 7	26	25-Jun-11	29	0	210	272	355	1.24
0 of 123	26–44	No sampling from 1-Jul-11 to 31-Oct-11						
4 of 7	44	1-Nov-11	4	0	38	48	64	0.21
5 of 7	45	5-Nov-11	8	0	110	145	186	0.65
7 of 7	46	12-Nov-11	12	0	110	145	191	0.64
7 of 7	47	19-Nov-11	29	0	266	351	462	1.52
4 of 7	48	26-Nov-11	8	0	74	97	127	0.44
7 of 7	49	3-Dec-11	6	0	57	73	96	0.32
7 of 7	50	10-Dec-11	5	0	47	61	80	0.26
7 of 7	51	17-Dec-11	6	0	56	73	93	0.31
8 of 8	52[a]	24-Dec-11	8	0	73	97	127	0.43
173 of 365		Season	371	2	3,594	3,859	4,123	4.32

[a] Week 52 (December 23 to 31, 2012) contains nine days for keeping January 1 as Julian calendar day 1.

Table 13. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile spring-run Chinook Salmon captured at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Weeks in which no passage occurred are omitted.

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
0 of 30	40–43	No sampling from 1-Oct-11 to 31-Oct-11						
5 of 7	45	5-Nov-11	1	0	9	12	16	0.05
7 of 7	46	12-Nov-11	40	12	378	484	637	2.09
7 of 7	47	19-Nov-11	310	3	2,930	3,753	4,936	16.56
7 of 7	48	26-Nov-11	331	0	3,129	4,007	5,270	17.48
7 of 7	49	3-Dec-11	691	0	6,532	8,366	10,719	35.62
7 of 7	50	10-Dec-11	702	3	6,636	8,499	11,177	37.11
7 of 7	51	17-Dec-11	1,053	1	9,954	12,748	16,335	52.95
8 of 8	52[a]	24-Dec-11	783	3	7,288	9,479	12,466	41.15
7 of 7	1	1-Jan-12	335	0	2,649	3,357	4,284	12.81
7 of 7	2	8-Jan-12	189	0	2,179	2,885	3,982	14.13
5 of 7	3	15-Jan-12	151	4	1,391	1,791	2,329	7.52
5 of 7	4	22-Jan-12	25	0	245	318	428	1.45
7 of 7	6	5-Feb-12	2	0	20	26	35	0.12
0 of 96	8–20	No sampling from 15-Feb-12 to 21-May-12						
7 of 7	22	27-May-12	1	0	10	12	16	0.05
0 of 117	24–43	No sampling from 6-Jun-12 to 30-Sep-12						
119 of 366		Season	4,614	26	50,351	55,737	61,085	86.05

[a] Week 52 (December 23 to 31, 2012) contains nine days for keeping January 1 as Julian calendar day 1.

Table 14. Brood year 2011 life-stage summary for Rainbow Trout / steelhead, late-fall, winter, spring and fall-run Chinook Salmon captured at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County.

	Brood year 2011 Rainbow Trout / steelhead		Brood year 2010 age-0+ Rainbow Trout / steelhead		Late-fall run Chinook Salmon		Winter-run Chinook Salmon		Spring-run Chinook Salmon		Fall-run Chinook Salmon	
Life Stage	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Yolk-sac fry	23	2.1%	0	0.0%	0	0.0%	0	0.0%	7	1.4%	632	0.1%
Fry	811	72.6%	0	0.0%	478	86.3%	0	0.0%	487	94.6%	644,142	99.5%
Parr	283	25.3%	18	100.0%	46	8.3%	0	0.0%	13	2.5%	994	0.2%
Silvery parr	0	0.0%	0	0.0%	8	1.4%	1	12.5%	8	1.6%	1,104	0.2%
Smolt	0	0.0%	0	0.0%	22	4.0%	7	87.5%	0	0.0%	273	<0.1%
Totals	1,117		18		554		8		515		647,145	

Table 15. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile Rainbow Trout / steelhead captured at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from January 1 through December 31, 2011. Weeks in which no passage occurred are omitted.

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
7 of 7	3	15-Jan-11	2	0	16	20	26	0.08
4 of 4	4a	22-Jan-12	6	0	65	86	117	0.40
3 of 3	4b	26-Jan-11	6	0	77	107	149	0.59
7 of 7	5	29-Jan-11	6	0	77	110	149	0.59
4 of 4	6a	5-Feb-11	5	0	66	93	129	0.51
3 of 3	6b	9-Feb-11	4	0	35	46	59	0.19
4 of 4	7a	12-Feb-11	6	1	46	57	74	0.22
3 of 3	7b	16-Feb-11	7	0	77	102	134	0.47
4 of 4	8a	19-Feb-11	22	0	314	439	628	2.56
3 of 3	8b	23-Feb-11	28	0	366	500	687	2.61
4 of 4	9a	26-Feb-11	46	0	707	962	1,332	5.11
3 of 3	9b	2-Mar-11	43	0	932	1,450	2,175	10.36
4 of 4	10a	5-Mar-11	61	0	876	1,135	1,561	5.29
3 of 3	10b	9-Mar-11	32	0	297	386	519	1.84
5 of 7	11	12-Mar-11	18	1	379	631	1,082	5.76
2 of 7	12	19-Mar-11	2	0	328	440	616	2.21
1 of 4	13a	19-Mar-11	6	0	316	424	594	2.30
3 of 3	13b	26-Mar-11	48	1	313	438	644	2.66
7 of 7	14	2-Apr-11	165	0	1,891	2,593	3,630	14.03
6 of 7	15	9-Apr-11	49	0	854	1,147	1,606	6.25
7 of 7	16	16-Apr-11	31	0	355	487	682	2.61
7 of 7	17	23-Apr-11	56	0	351	658	1,316	7.46
7 of 7	18	30-Apr-11	63	0	737	990	1,386	5.31
7 of 7	19	7-May-11	33	0	378	519	726	2.86
7 of 7	20	14-May-11	68	0	763	1,069	1,438	5.79
7 of 7	21	21-May-11	51	0	584	801	1,122	4.18
7 of 7	22	28-May-11	125	1	1,432	1,964	2,750	10.46
7 of 7	23	4-Jun-11	56	0	642	880	1,185	4.54

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
7 of 7	24	11-Jun-11	7	0	79	110	154	0.60
7 of 7	25	18-Jun-11	12	0	138	189	264	1.00
6 of 7	26	25-Jun-11	28	0	321	440	616	2.36
0 of 123	27–43	No sampling from 1-Jul-11 to 31-Oct-11						
4 of 7	44	1-Nov-11	4	0	45	60	82	0.30
7 of 7	45	5-Nov-11	1	0	11	15	21	0.07
7 of 7	46	12-Nov-11	4	0	45	60	79	0.28
7 of 7	47	19-Nov-11	9	0	99	134	179	0.67
7 of 7	48	26-Nov-11	2	0	22	30	40	0.14
7 of 7	49	3-Dec-11	2	0	22	30	41	0.15
7 of 7	50	10-Dec-11	3	0	33	45	62	0.23
231 of 365		Season	1,117	4	17,875	19,647	21,364	28.30

Table 16. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile late-fall run Chinook Salmon captured at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from April 1, 2011, through March 31, 2012. Weeks in which no passage occurred are omitted.

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
1 of 1	13	1-Apr-11	1	0	6	9	13	0.06
7 of 7	14	2-Apr-11	43	0	493	676	910	3.43
6 of 7	15	9-Apr-11	19	0	298	409	572	2.28
7 of 7	16	16-Apr-11	110	0	1,260	1,729	2,521	9.31
7 of 7	17	23-Apr-11	30	0	188	353	705	4.67
7 of 7	18	30-Apr-11	77	1	901	1,210	1,694	6.51
7 of 7	19	7-May-11	19	2	222	299	402	1.54
7 of 7	20	14-May-11	105	0	1,229	1,650	2,221	8.46
7 of 7	21	21-May-11	63	0	722	990	1,386	5.34
7 of 7	22	28-May-11	36	1	413	566	792	3.03
7 of 7	23	4-Jun-11	21	1	246	330	481	1.76
7 of 7	25	18-Jun-11	4	0	47	63	88	0.33
6 of 7	26	25-Jun-11	2	0	23	31	42	0.17
0 of 124	27–43			No sampling from 1-Jul-11 to 31-Oct-11				
4 of 4	44	1-Nov-11	2	0	22	30	41	0.15
5 of 7	45	5-Nov-11	5	1	79	104	139	0.51
7 of 7	46	12-Nov-11	3	0	34	45	62	0.22
7 of 7	47	19-Nov-11	10	0	110	149	198	0.73
7 of 7	48	26-Nov-11	4	0	45	60	85	0.31
239 of 366		Season	554	6	7,798	8,703	9,754	15.72

Table 17. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile spring-run Chinook Salmon captured at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Weeks in which no passage occurred are omitted.

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
0 of 31	40–43	No sampling from 1-Oct-11 to 31-Oct-11						
4 of 7	44	1-Nov-11	6	0	67	89	123	0.46
7 of 7	46	12-Nov-11	37	0	408	551	759	2.81
7 of 7	47	19-Nov-11	174	2	1,917	2,589	3,570	12.96
7 of 7	48	26-Nov-11	198	0	2,234	2,961	3,947	15.11
7 of 7	49	3-Dec-11	55	0	606	818	1,128	4.11
7 of 7	50	10-Dec-11	15	0	168	223	298	1.08
7 of 7	51	17-Dec-11	9	0	101	134	185	0.68
7 of 7	1	1-Jan-12	2	0	22	30	40	0.15
2 of 2	2a	8-Jan-12	1	0	11	15	21	0.08
5 of 5	2b	10-Jan-12	1	0	9	12	16	0.05
7 of 7	3	15-Jan-12	10	0	175	263	394	1.71
7 of 7	9	26-Feb-12	1	0	17	25	36	0.16
7 of 7	11	11-Mar-12	6	0	54	70	91	0.31
0 of 92	27–39	No sampling from 1-Jul-12 to 30-Sep-12						
240 of 366		Season	517	2	6,681	7,780	9,282	20.43

[a] Week 52 (December 23 to 31, 2012) contains nine days for keeping January 1 as Julian calendar day 1.

Table 18. Weekly catch, mortality and passage indices with the upper (UCI) and lower (LCI) 95% confidence interval and SE of the weekly strata for brood year 2011 juvenile fall-run Chinook Salmon captured at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Weeks in which no passage occurred are omitted.

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
0 of 31	40–43	No sampling from 1-Oct-11 to 31-Oct-11						
7 of 7	48	26-Nov-11	24	0	264	357	476	2
7 of 7	49	3-Dec-11	261	0	2,876	3,884	5,177	19
7 of 7	50	10-Dec-11	319	0	3,515	4,747	6,545	25
7 of 7	51	17-Dec-11	1,025	2	11,507	15,253	21,030	75
8 of 8	52[a]	24-Dec-11	2,760	6	30,985	41,071	54,740	195
7 of 7	1	1-Jan-12	16	5,071	56,929	75,461	104,043	380
2 of 2	2a	8-Jan-12	1	1,573	17,332	23,408	31,198	114
5 of 5	2b	10-Jan-12	5	10,444	98,977	128,621	169,303	588
2 of 2	3a	15-Jan-12	15	5,692	53,943	70,099	89,904	301
5 of 5	3b	17-Jan-12	94	41,384	768,038	1,089,053	1,632,082	7,669
2 of 2	4a	22-Jan-12	53	23,070	415,919	607,105	909,823	3,953
5 of 5	4b	24-Jan-12	47	28,524	239,370	305,396	402,577	1,279
2 of 2	5a	29-Jan-12	13	4,247	36,129	45,471	58,609	177
5 of 5	5b	31-Jan-12	60	31,369	362,553	483,344	650,095	2,419
2 of 2	6a	5-Feb-12	7	9,087	107,084	140,015	188,320	702
5 of 5	6b	7-Feb-12	61	28,631	415,831	581,931	831,662	3,336
2 of 2	7a	12-Feb-12	15	22,702	329,720	461,423	659,439	2,735
5 of 5	7b	14-Feb-12	105	55,180	469,030	597,186	781,717	2,559
2 of 2	8a	19-Feb-12	15	8,351	69,984	90,379	118,306	376
5 of 5	8b	21-Feb-12	28	37,574	647,108	932,357	1,370,346	6,207
2 of 2	9a	26-Feb-12	27	24,120	415,400	598,511	879,671	3,764
5 of 5	9b	28-Feb-12	156	100,404	1,149,068	1,514,389	2,068,322	7,233
2 of 2	10a	4-Mar-12	11	22,140	248,773	333,937	456,084	1,600
5 of 5	10b	6-Mar-12	20	37,645	347,361	440,808	573,145	1,896
6 of 6	11a	11-Mar-12	571	128,037	1,163,799	1,499,262	1,949,363	6,428
1 of 1	11b	17-Mar-12	2	3,664	59,614	84,815	122,540	509
3 of 3	12a	18-Mar-12	10	3,716	60,460	86,019	124,280	532

Days sampled	Week	Date	Weekly catch	Weekly mortality	95% LCI	Weekly passage	95% UCI	SE
4 of 4	12b	21-Mar-12	5	1,786	17,658	23,286	31,281	107
4 of 4	13a	25-Mar-12	4	2,417	24,289	31,512	42,332	148
2 of 3	13b	29-Mar-12	3	1,535	26,888	36,330	48,014	178
3 of 3	14a	1-Apr-12	3	1,848	19,614	27,032	38,473	142
4 of 4	14b	4-Apr-12	3	652	5,981	7,815	10,346	34
4 of 4	15a	8-Apr-12	0	268	2,501	3,217	4,041	13
3 of 3	15b	12-Apr-12	2	146	2,079	3,120	4,901	21
7 of 7	16	15-Apr-12	1	80	898	1,190	1,641	6
7 of 7	17	22-Apr-12	1	173	1,906	2,574	3,431	12
7 of 7	18	29-Apr-12	0	180	2,021	2,679	3,693	14
7 of 7	19	6-May-12	1	251	2,818	3,735	4,978	18
7 of 7	20	13-May-12	0	312	3,438	4,643	6,401	24
7 of 7	21	20-May-12	1	303	3,402	4,509	6,010	22
7 of 7	22	27-May-12	0	52	573	774	1,067	4
7 of 7	23	3-Jun-12	0	75	811	1,116	1,539	6
7 of 7	24	10-Jun-12	0	32	359	476	657	2
7 of 7	25	17-Jun-12	0	13	146	193	267	1
6 of 7	26	24-Jun-12	0	8	88	119	159	1
0 of 92	27–39			No sampling from 1-Jul-13 to 30-Sep-12				
240 of 366		Season	5,745	642,764	9,767,159	10,408,622	11,041,760	16,423

[a] Week 52 (December 23 to 31, 2012) contains nine days for keeping January 1 as Julian calendar day 1.

Table 19. Name key of non-salmonid fish taxa captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, from November 1, 2011, through June 30, 2012.

Abbreviation	Common name	Scientific name
BGS	Bluegill	*Lepomis macrochirus*
BKT	Brook Trout	*Salvelinus fontinalis*
BRB	Brown Bullhead	*Ameiurus nebulosus*
CAR	California Roach	*Hesperoleucus symmetricus*
CENFRY	Unidentified centrarchid fry	
COTFRY	Unidentified *Cottus* fry	*Cottus spp.*
CYPFRY	Unidentified cyprinid fry	
DACE	Speckled Dace	*Rhinichthys osculus*
EAMMO	Pacific Lamprey ammocoete	*Entosphenus tridentatus*
GSF	Green Sunfish	*Lepomis cyanellus*
HH	Hardhead	*Mylopharodon conocephalus*
LAMMO	Unclassified Brook Lamprey ammocoete	*Lampetra spp.*
MICFRY	Unidentified *Micropterus* fry	*Micropterus spp.*
MQF	Western Mosquitofish	*Gambusia affinis*
PL	Pacific Lamprey adult	*Entosphenus tridentatus*
PLT	Pacific Lamprey transformer	*Entosphenus tridentatus*
RFS	Riffle Sculpin	*Cottus gulosus*
SASU	Sacramento Sucker	*Catostomus occidentalis*
SPB	Spotted Bass	*Micropterus punctulatus*
SPM	Sacramento Pikeminnow	*Ptychocheilus grandis*
TSS	Threespine Stickleback	*Gasterosteus aculeatus*
UAMMO	Unidentified ammocoete	
WBLT	Unclassified Brook Lamprey transformer	*Lampetra spp.*

Table 20. Summary of non-salmonid fish taxa captured by the upper Clear Creek rotary screw trap at river mile 8.4, Shasta County, from November 1, 2011, to June 30, 2012.

Species	November	December	January	February	March	April	May	June	Totals
BRB		1							1
CAR	1	3	5				3	3	15
EAMMO	1	1	6					1	9
HH			1						1
LAMMO							3		3
PLT		1							1
RFS	1						7	5	13
SASU	2	5	2	1			1		11
UAMMO	1								1

Table 21. Summary of non-salmonid fish taxa captured by the lower Clear Creek rotary screw trap at river mile 1.7, Shasta County from November 1, 2011, to June 30, 2012.

Species	November	December	January	February	March	April	May	June	Totals
BGS			1		1				2
BKT								1	1
BRB								1	1
CAR					1	1		3	5
CENFRY		1							1
COTFRY							2		2
CYPFRY	4	4	3	2	8	3	4	1	29
DACE	3				1				4
EAMMO	3		16		34	34	5	23	115
GSF					2		1	1	4
HH	1				2	3	8	3	17
MICFRY							148	161	309
MQF					3	1	2	1	7
PL		1							1
PLT	3	4	382	3	40				432
RFS	2	4	9	3	42	8	11	4	83
SASU		1	7		4	1	1	2	16
SPB								3	3
SPM			2		2	3	2		9
TSS				1			1	1	3
UAMMO						1			1
WBLT		1							1

Table 22. Brood year passage indices of juvenile spring-run Chinook Salmon with the upper (UCI) and lower (LCI) 95% confidence interval and SE for brood years 2003–2011 captured by upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County. The adjusted passage index (proportionate to juveniles per redd) includes redds below the trap (RST), yet above the separation weir.

Brood year	95% LCI	Passage index	95% UCI	Standard error	Adjusted passage index	Juveniles per redd above RST	Redds above RST	Total redds
2003	88,817	108,338	137,672	483.03	110,422	2,083	52	53
2004	87,093	107,027	136,366	396.72	110,000	2,973	36	37
2005	87,516	104,197	128,418	372.88	106,241	2,043	51	52
2006	111,749	127,197	148,539	302.51	151,162	1,843	69	82
2007	92,728	110,224	135,069	352.37	124,295	2,345	47	53
2008	88,834	96,166	104,402	129.11	121,622	1,414	68	86
2009	62,213	68,296	75,384	108.83	74,084	1,158	59	64
2010	15,228	17,359	19,910	38.45	19,288	1,929	9	10
2011	50,351	55,737	61,085	86.05	59,453	3,716	15	16

Table 23. Life stage composition of classified catch for brood years 2003–2011 of spring-run Chinook Salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek in Clear Creek, Shasta County. Unless otherwise noted the latest the trap fished during the sample year was June, 30.

Brood year	C0 - Yolk-sac fry	C1 - Fry	C2 - Parr	C3 - Silvery parr	C4 - Smolt
2003	0.90%	96.11%	0.80%	1.60%	0.59%
2004[a]	0.52%	94.35%	1.31%	2.79%	1.04%
2005	1.33%	97.99%	0.19%	0.40%	0.09%
2006[b]	0.04%	96.43%	1.42%	1.90%	0.20%
2007	0.01%	99.02%	0.48%	0.38%	0.11%
2008	0.12%	99.34%	0.14%	0.36%	0.04%
2009	0.33%	98.30%	0.37%	0.56%	0.44%
2010	0.29%	98.01%	0.49%	1.17%	0.05%
2011	0.04%	99.54%	0.37%	0.02%	0.02%
Totals	0.40%	97.68%	0.62%	1.02%	0.29%

[a] The trap fished until September 30, 2005.
[b] The trap fished until July 13, 2007.

Table 24. Brood year (January 1 through December 31) passage indices of juvenile Rainbow Trout / steelhead with upper (UCI) and lower (LCI) 90% and 95% confidence intervals and SE for brood years 1999–2011 captured by lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County.

Brood year	95% LCI	Passage index	95% UCI	Standard error	Adjusted index	Reaches 1-6 redds	Juveniles per redd Reaches 1- 6
1999	3,986	4,229	4,506	N/A			
2000	7,951	8,507	9,162	N/A			
2001	8,120	8,742	9,424	N/A		38	230
2002	11,731	12,803	14,193	19.53		101	127
2003	8,758	9,772	10,954	18.77		78	125
2004	24,137	28,989	36,746	106.59		151	192
2005	22,247	24,791	29,454	56.69		144	172
2006	9,362	10,762	12,632	26.92		43	250
2007	27,515	33,910	43,292	127.46		165	206
2008	33,284	36,499	40,983	60.10		148	247
2009	28,103	30,487	33,599	44.95		409	75
2010	8,172	11,760	17,262	18.78		233	50
2011	17,965	19,508	21,612	28.30		218	90

Table 25. Brood year (April 1, 2011 through March 31, 2012) passage indices of juvenile late-fall run Chinook Salmon with upper (UCI) and lower (LCI) 90% and 95% confidence intervals and SE for brood years 1999–2011 captured by lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County.

Brood year	95% LCI	90% LCI	Passage index	90% UCI	95% UCI	Standard error	Reach 6 redds
1999	272,930	275,736	292,323	310,697	314,778	N/A	
2000	90,576	92,331	101,347	113,299	116,274	N/A	
2001	68,446	70,733	86,836	107,359	112,386	N/A	
2002	156,297	158,835	172,708	189,998	192,685	298.48	
2003	29,432	30,130	33,902	38,705	39,638	87.01	24
2004	9,570	9,915	11,906	14,701	15,644	48.12	20
2005	17,808	18,163	20,401	22,733	23,384	44.63	28
2006	70,716	72,560	86,918	105,130	113,960	381.30	14
2007	149,395	155,897	202,011	279,553	319,016	1,816.12	25
2008	39,129	39,999	45,903	53,145	54,452	126.95	17
2009	61,181	61,979	68,624	76,913	79,425	154.77	122
2010	19,929	20,231	22,853	26,166	27,111	58.77	33
2011	7,798	7,942	8,703	9,546	9,754	15.72	21

Table 26. Brood year passage indices of juvenile fall-run Chinook Salmon with upper (UCI) and lower (LCI) 90% and 95% confidence intervals and SE for brood years 1999–2011 captured by lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County.

Brood year	95% LCI	90% LCI	Passage index	90% UCI	95% UCI	Standard error	Female spawners	Juveniles per female
1998	5,656,571	5,760,186	6,395,638	7,150,348	7,303,438	N/A	2,485	2,574
1999	5,951,440	6,009,301	6,405,765	6,956,968	7,121,563	N/A	4,089	1,567
2000	13,535,844	13,681,994	14,955,182	16,222,612	16,483,244	N/A	3,344	4,473
2001	5,577,387	5,602,563	5,788,701	6,007,409	6,042,987	3,923	5,615	1,031
2002	3,560,468	3,609,632	3,858,446	4,102,132	4,174,685	4,783	8,176	472
2003	5,311,235	5,406,501	6,056,834	6,797,575	7,003,322	14,005	5,435	1,114
2004	5,361,896	5,465,198	6,190,757	6,987,786	7,216,897	15,604	3,722	1,663
2005	2,570,162	2,609,782	2,969,321	3,444,467	3,566,470	8,341	9,607	309
2006	4,275,282	4,359,617	4,929,544	5,667,355	5,832,272	12,915	5,208	947
2007	4,816,781	4,906,462	5,545,303	6,359,077	6,614,700	14,327	2,634	2,105
2008	7,129,073	7,241,051	8,451,186	10,081,615	10,397,719	29,879	4,453	1,898
2009	2,226,170	2,264,739	2,499,990	2,790,382	2,834,759	5,055	1,776	1,408
2010	3,305,917	3,347,938	3,566,723	3,827,295	3,871,986	4,522	3,697	965
2011	9,767,159	10,310,540	10,408,622	10,426,732	11,041,760	16,423	3,911	2,661

Figures

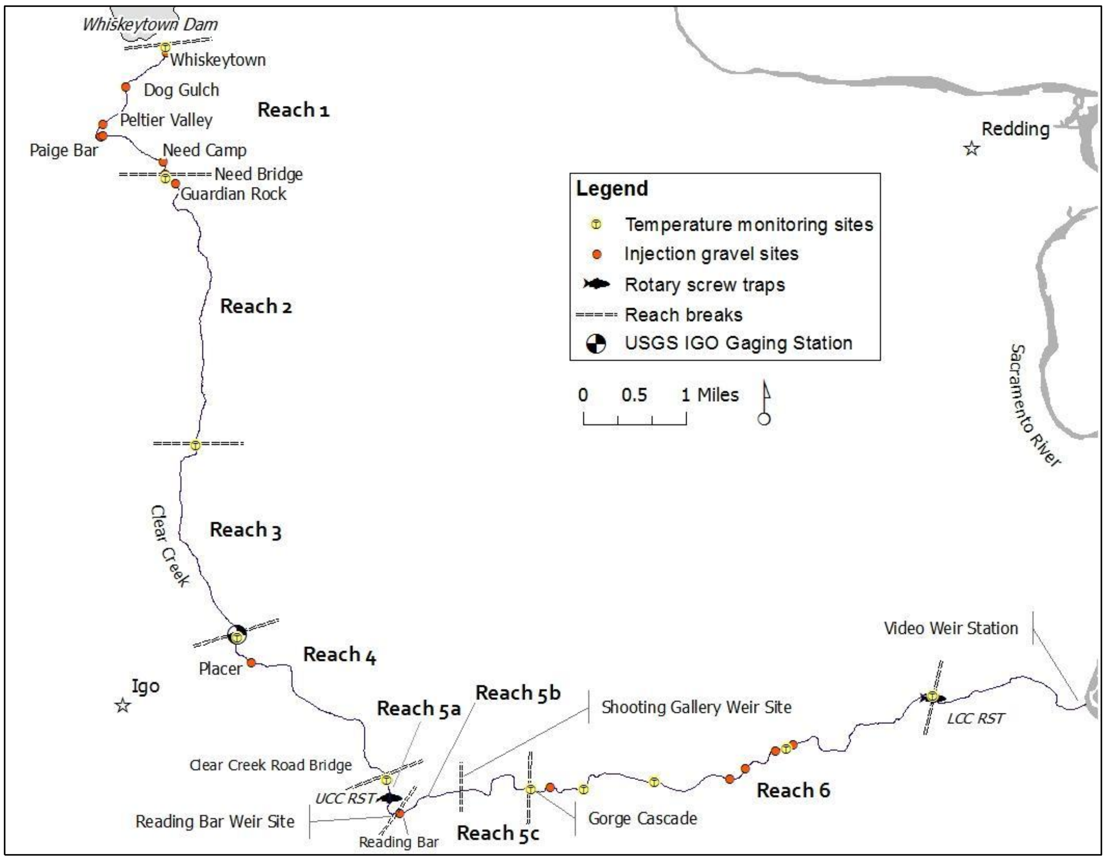

Figure 1. Locations of the upper (UCC)and lower (LCC) rotary screw trap sampling stations used for juvenile salmonid monitoring at river mile 8.4 (UCC) and 1.7 (LCC) in Clear Creek, Shasta County by the U.S. Fish and Wildlife Service.

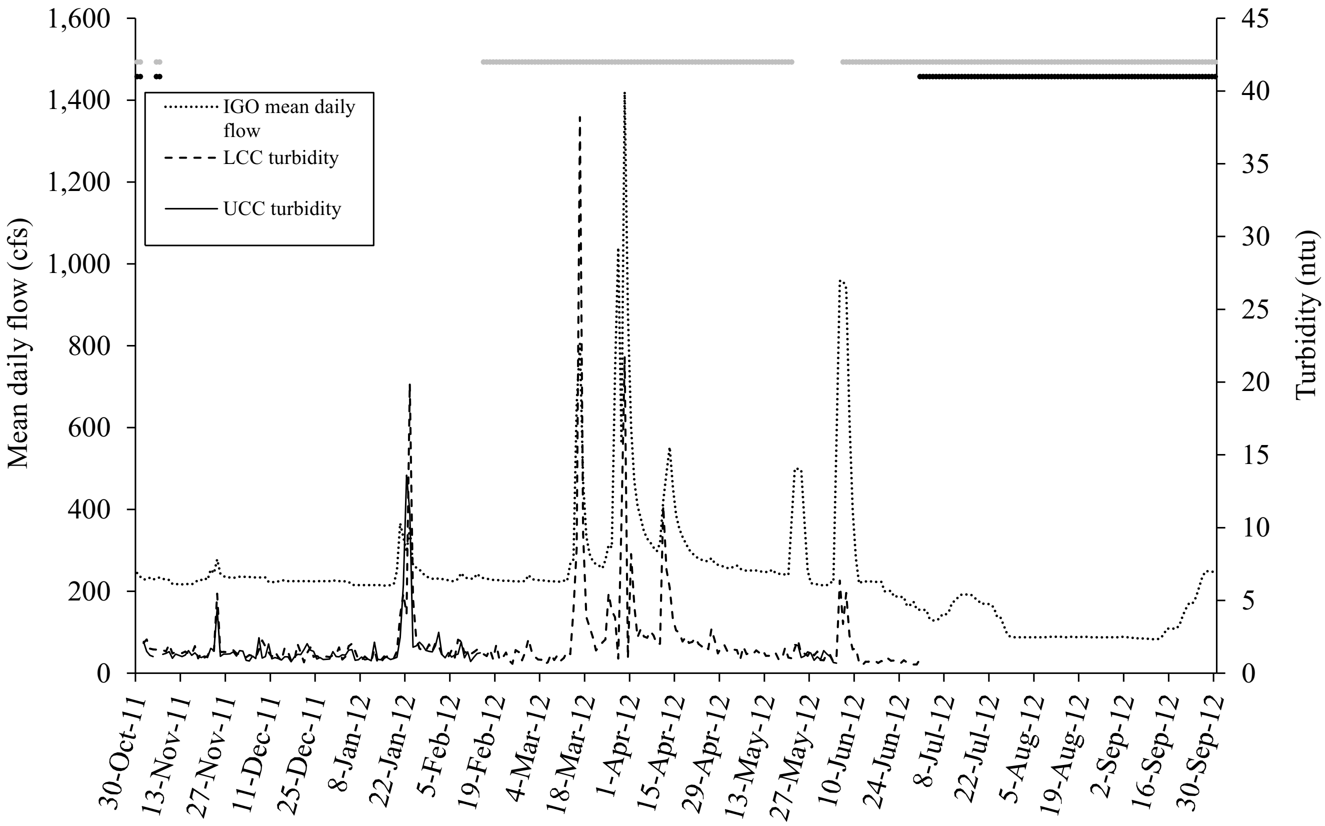

Figure 2. Mean daily flow measured at the USGS IGO station and momentary turbidity recorded at the upper (UCC) and lower (LCC) Clear Creek rotary screw trap sampling stations at river mile 8.4 and 1.7 in Clear Creek, Shasta County from October 1, 2011, through September 30, 2012. Upper and Lower Clear Creek non-sampling dates (UCC NS and LCC NS) are shown at the top of the figure in gray and black, respectively.

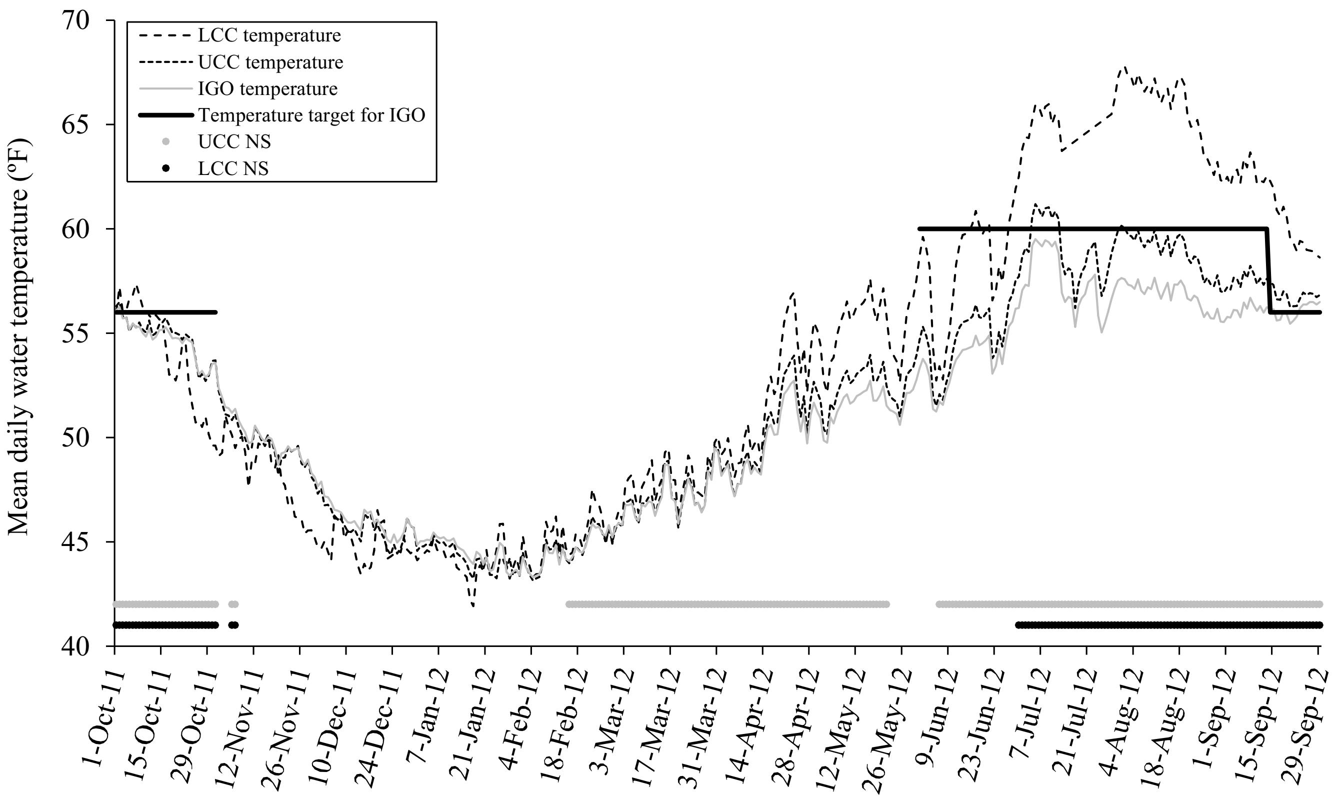

Figure 3. Mean daily water temperatures recorded at the upper (UCC) and lower (LCC) Clear Creek rotary screw trap sampling stations (river mile 8.4 and 1.7) in Clear Creek, Shasta County from October 1, 2014, through September 30, 2012. Clear Creek Fish Restoration Program temperature targets for fish protection and the temperatures recorded at the Clear Creek IGO gauge (river mile 11.0) are provided for comparison. Upper and Lower Clear Creek non-sampling dates (UCC NS and LCC NS) are shown in at the bottom of the figure in gray and black, respectively.

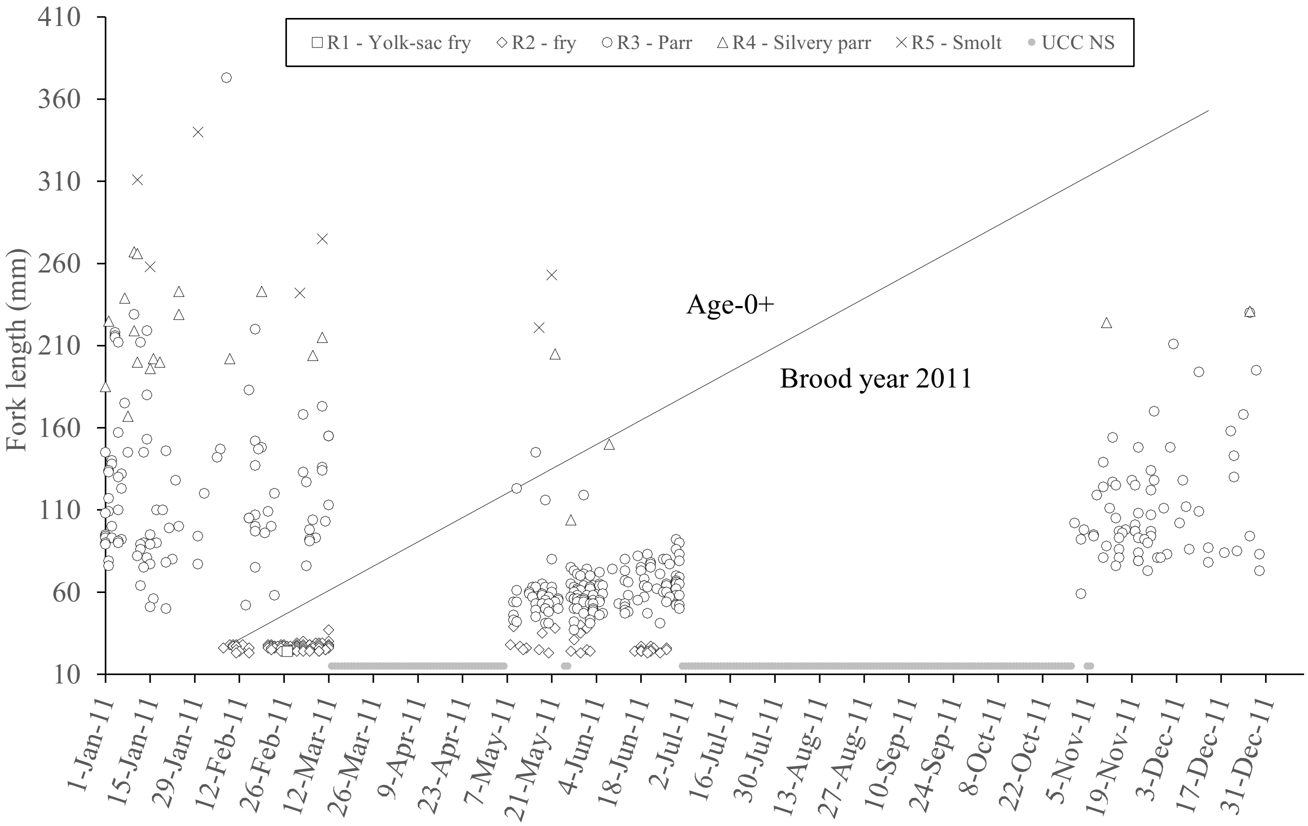

Figure 4. Fork length and life stage distribution by date and life stage for brood year 2011 and brood year 2010 age-0+ juvenile Rainbow Trout / Steelhead captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from January 1 to December 31, 2011. The black line separates age-0+ fish from brood year 2011 fish. Upper Clear Creek non-sampling days (UCC NS) are indicated at the bottom of the figure in grey.

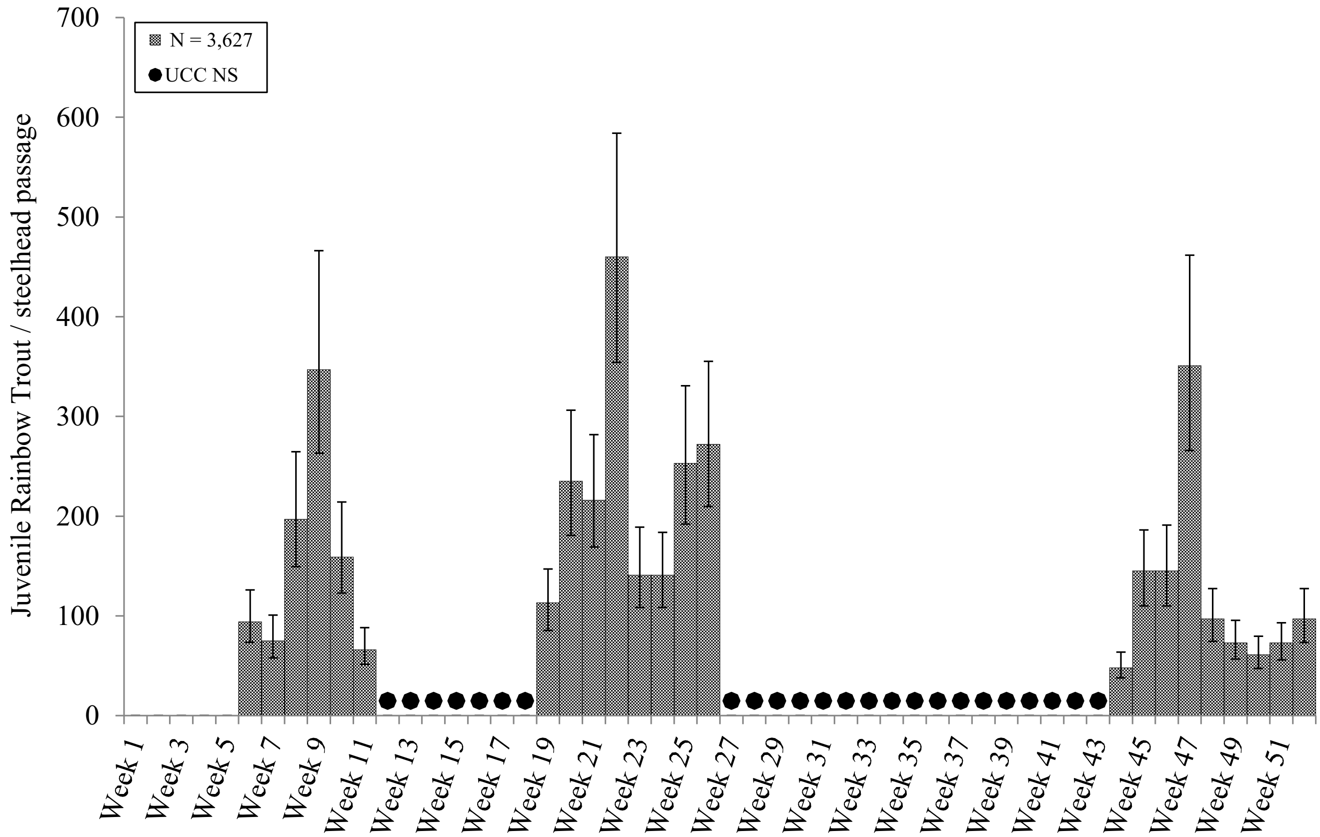

Figure 5. Weekly passage indices with 95% confidence intervals for brood year 2011 juvenile Rainbow Trout / steelhead captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from January 1 through December 31, 2011. Non-sampled weeks (UCC NS) are indicated at the bottom of the figure as circles.

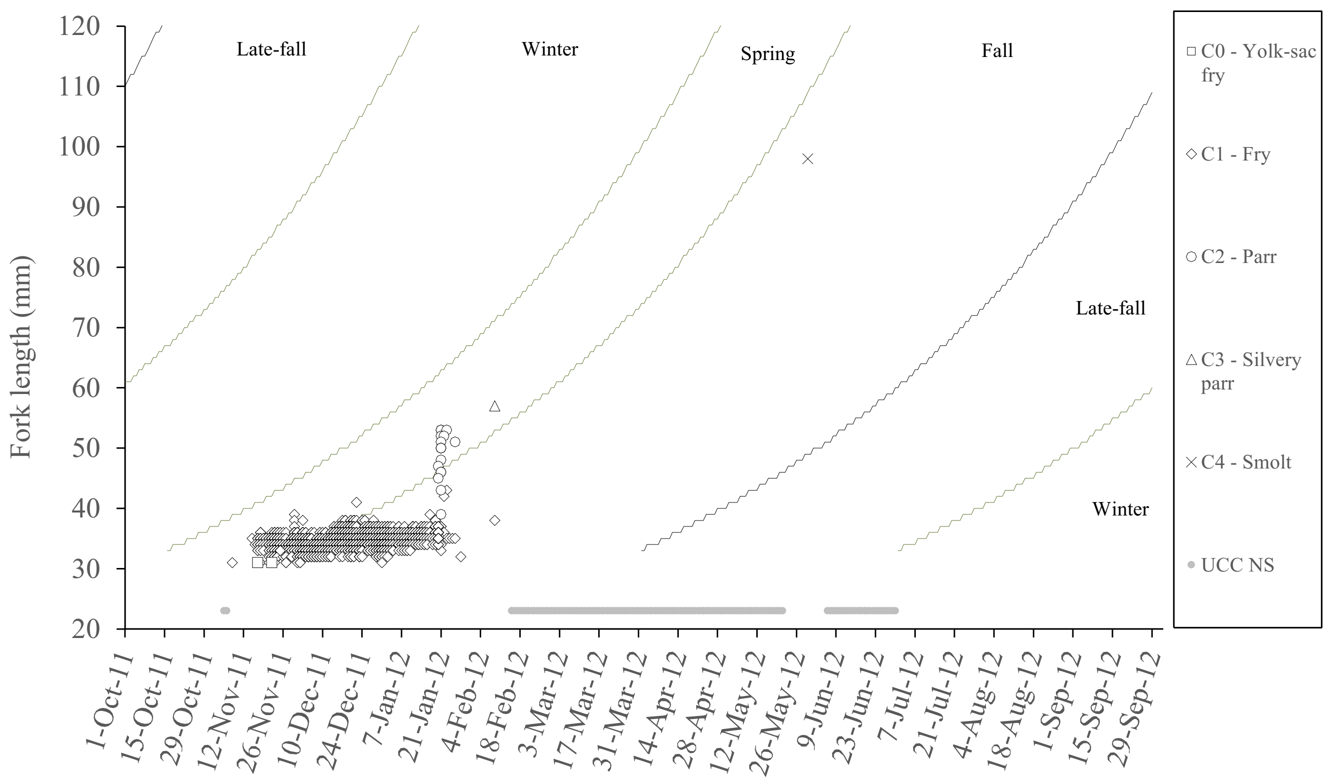

Figure 6. Fork length and life stage distribution by date, life stage, and run for all juvenile Chinook Salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Upper Clear Creek non-sampling days (UCC NS) are indicated at the bottom of the figure in grey. Spline curves represent the maximum fork lengths expected for each run by date, and are based upon tables of projected annual growth developed by the California Department of Water Resources (Greene 1992).

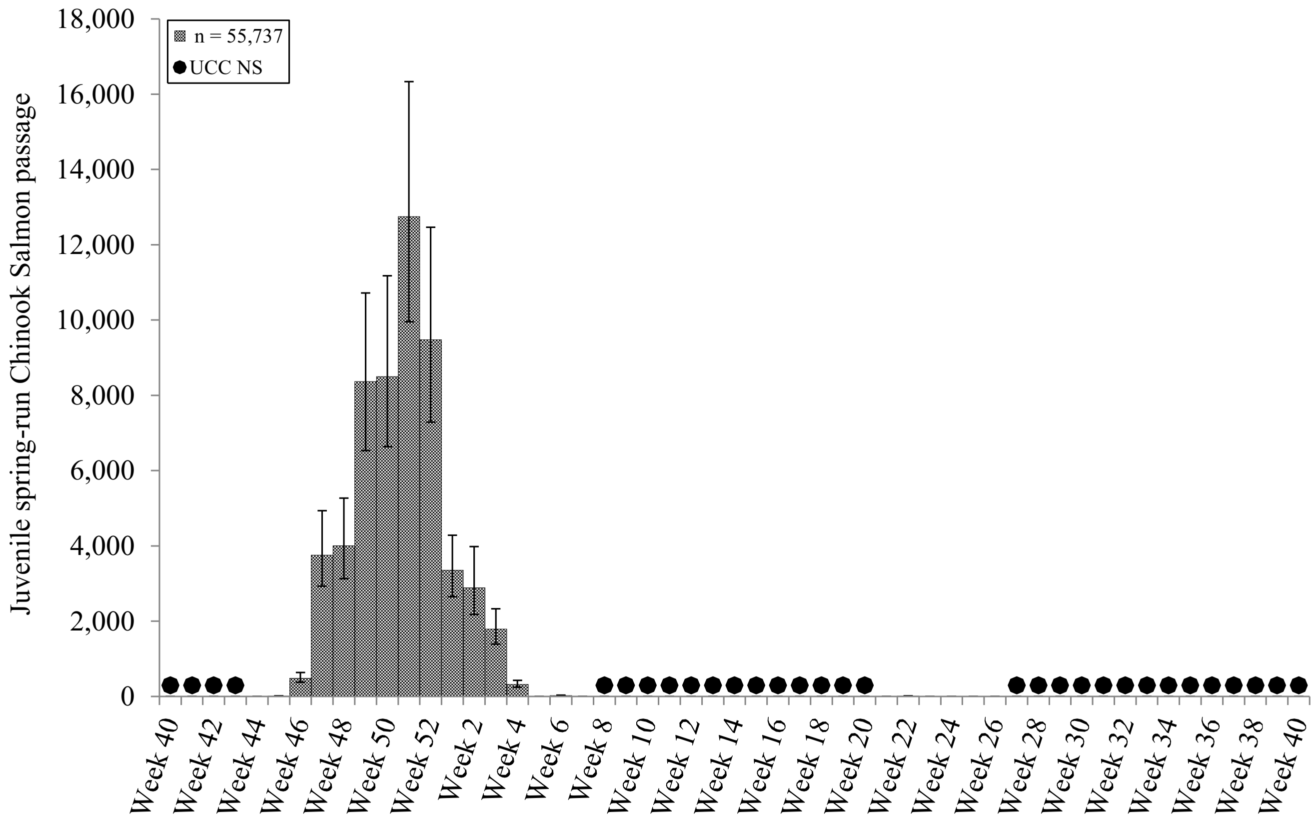

Figure 7. Weekly passage indices with 95% confidence intervals of brood year 2011 juvenile spring-run Chinook Salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Upper Clear Creek non-sampling weeks (UCC NS) are indicated at the bottom of the figure as circles.

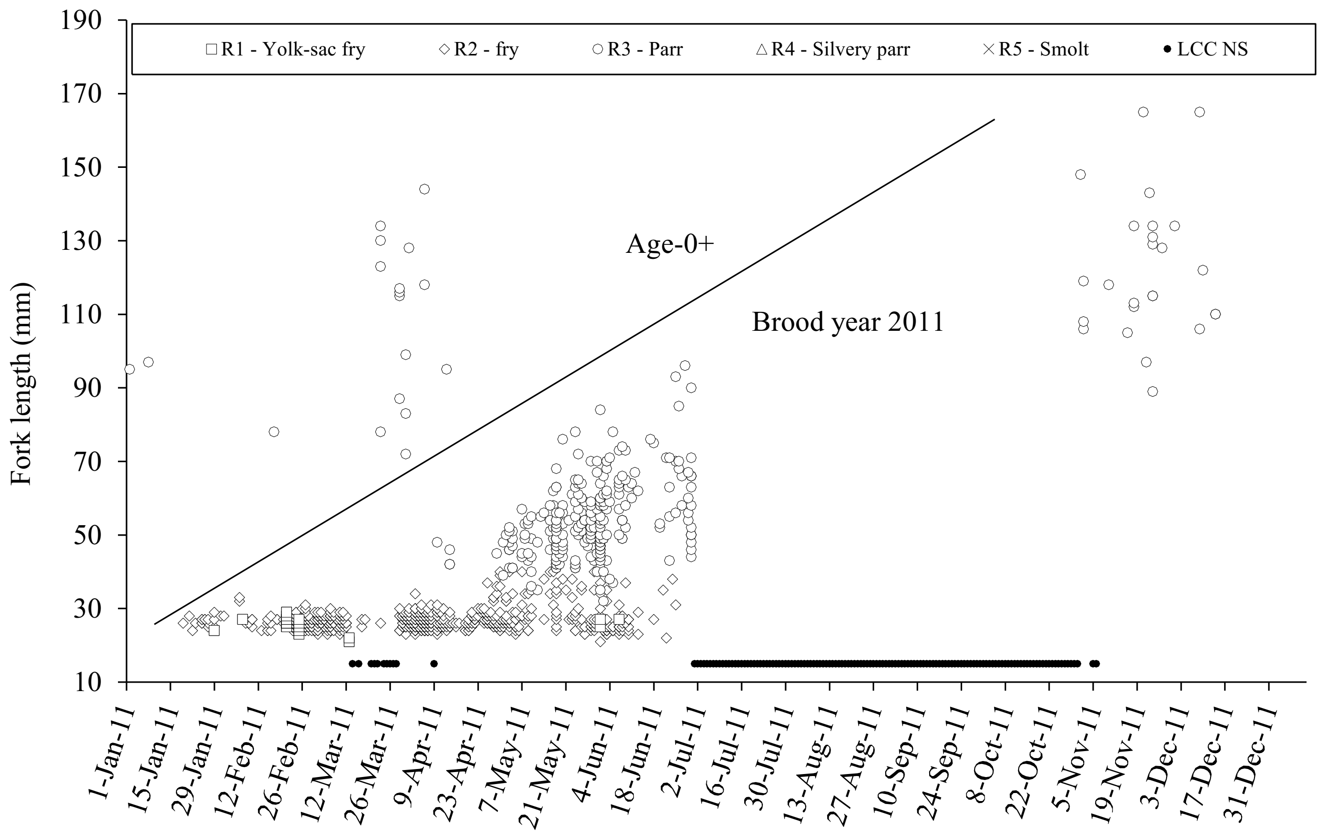

Figure 8. Fork length and life stage distribution by date and life stage for brood year 2011 and brood year 2010 age-0+ juvenile Rainbow Trout / Steelhead captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from January 1 to December 31, 2011. The black line separates age-0+ fish from brood year 2011 fish. Lower Clear Creek non-sampling days (LCC NS) are indicated at the bottom of the figure in black.

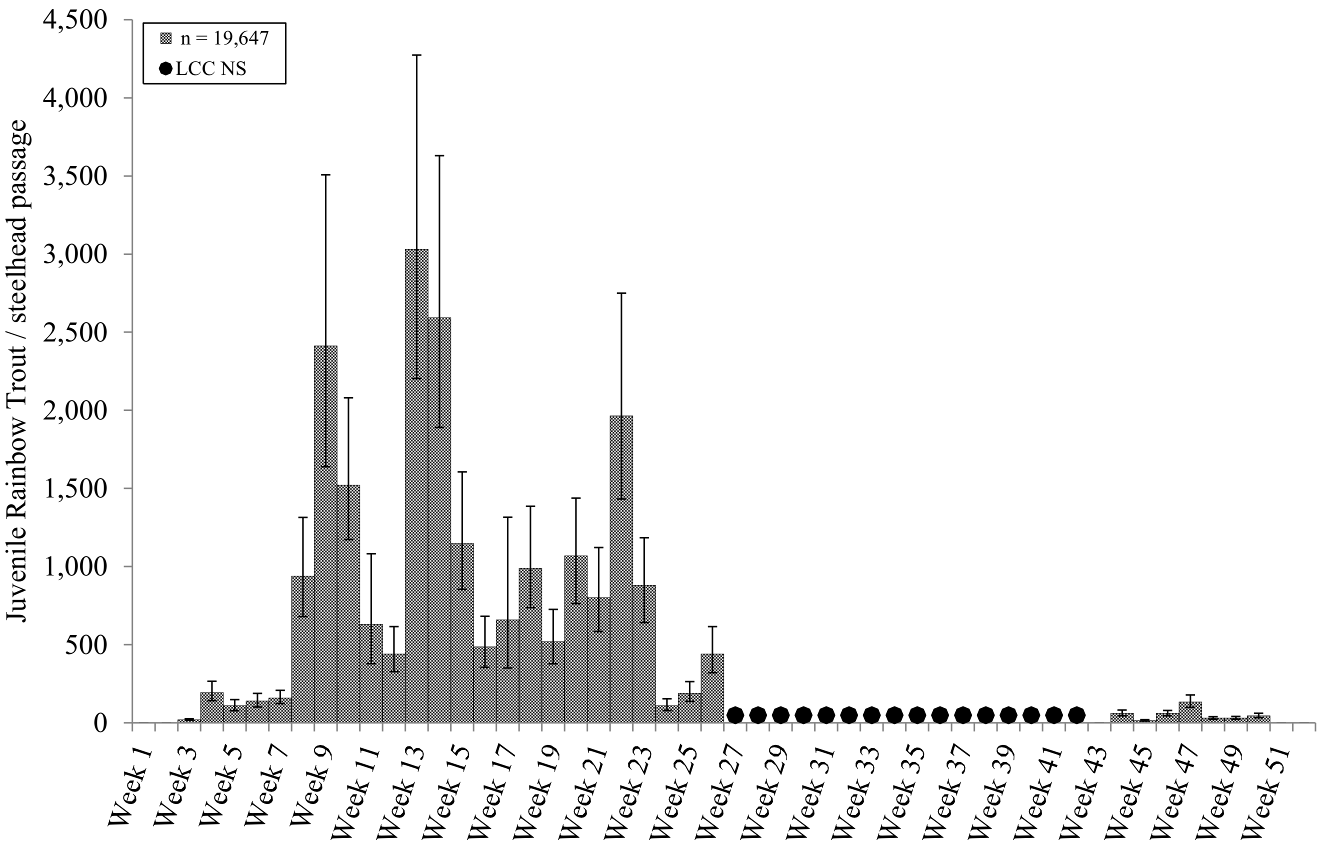

Figure 9. Weekly passage indices with 95% confidence intervals for brood year 2011 juvenile Rainbow Trout / steelhead captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from January 1 through December 31, 2011. Non-sampled weeks (LCC NS) are indicated at the bottom of the figure as circles.

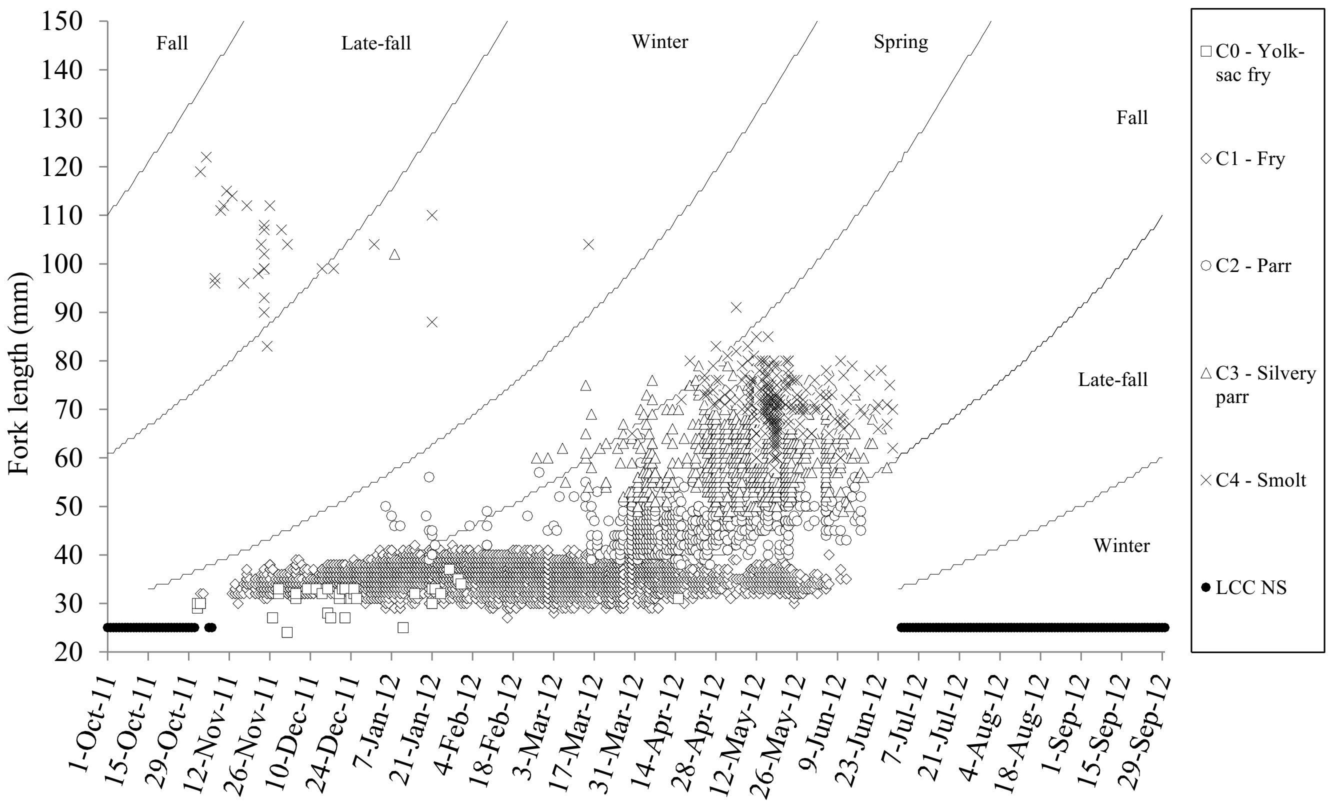

Figure 10. Fork length and life stage distribution by date, life stage, and run for all juvenile Chinook Salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Lower Clear Creek non-sampling days (LCC NS) are indicated at the bottom of the figure in black. Spline curves represent the maximum fork lengths expected for each run by date, and are based upon tables of projected annual growth developed by the California Department of Water Resources (Greene 1992).

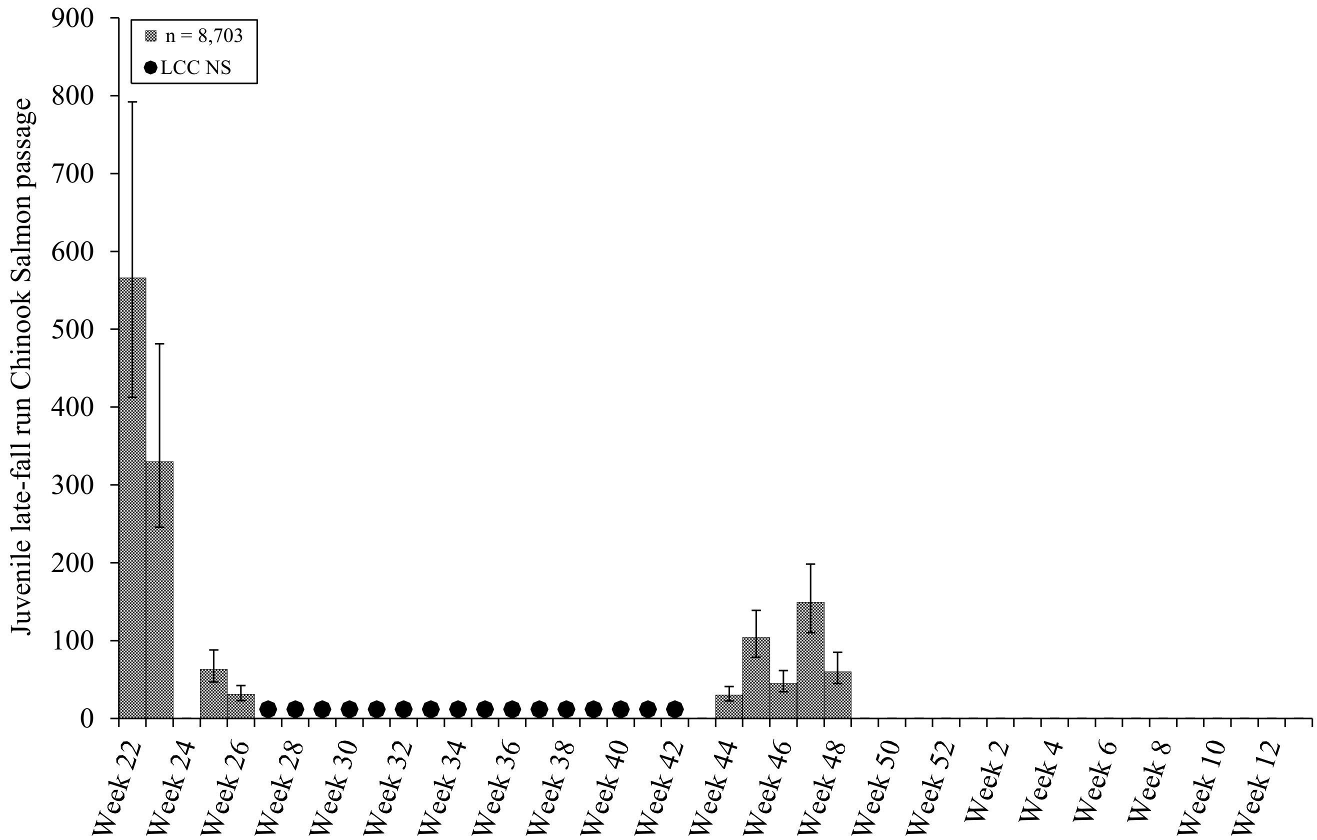

Figure 11. Weekly passage indices with 95% confidence intervals for brood year 2011 juvenile late-fall run Chinook Salmon by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from April 1, 2011, through March 31, 2012. Non-sampled weeks (LCC NS) are indicated at the bottom of the figure as circles.

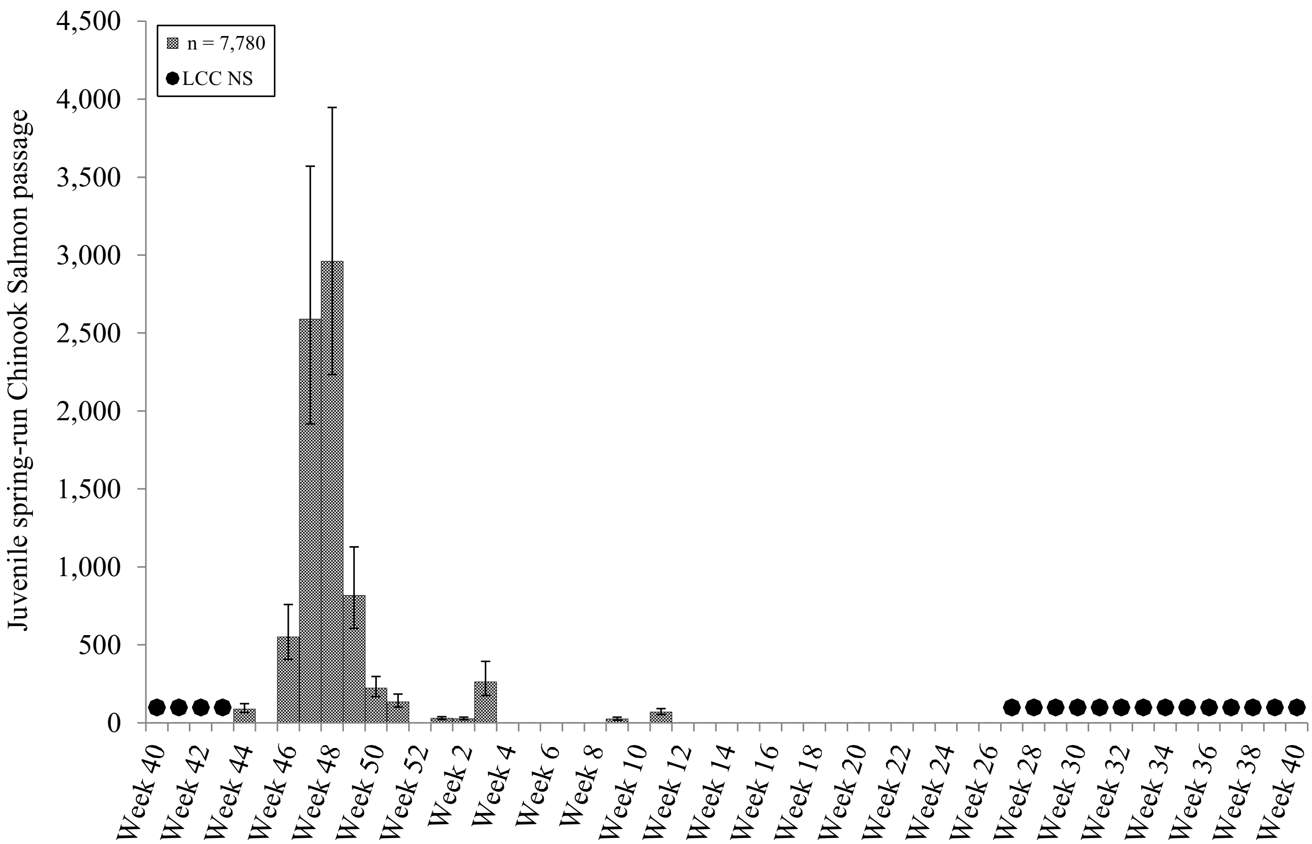

Figure 12. Weekly passage indices with 95% confidence intervals for brood year 2011 juvenile spring-run Chinook Salmon by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from November 1, 2011 through June 30, 2012. Non-sampled weeks (LCC NS) are indicated at the bottom of the figure as circles.

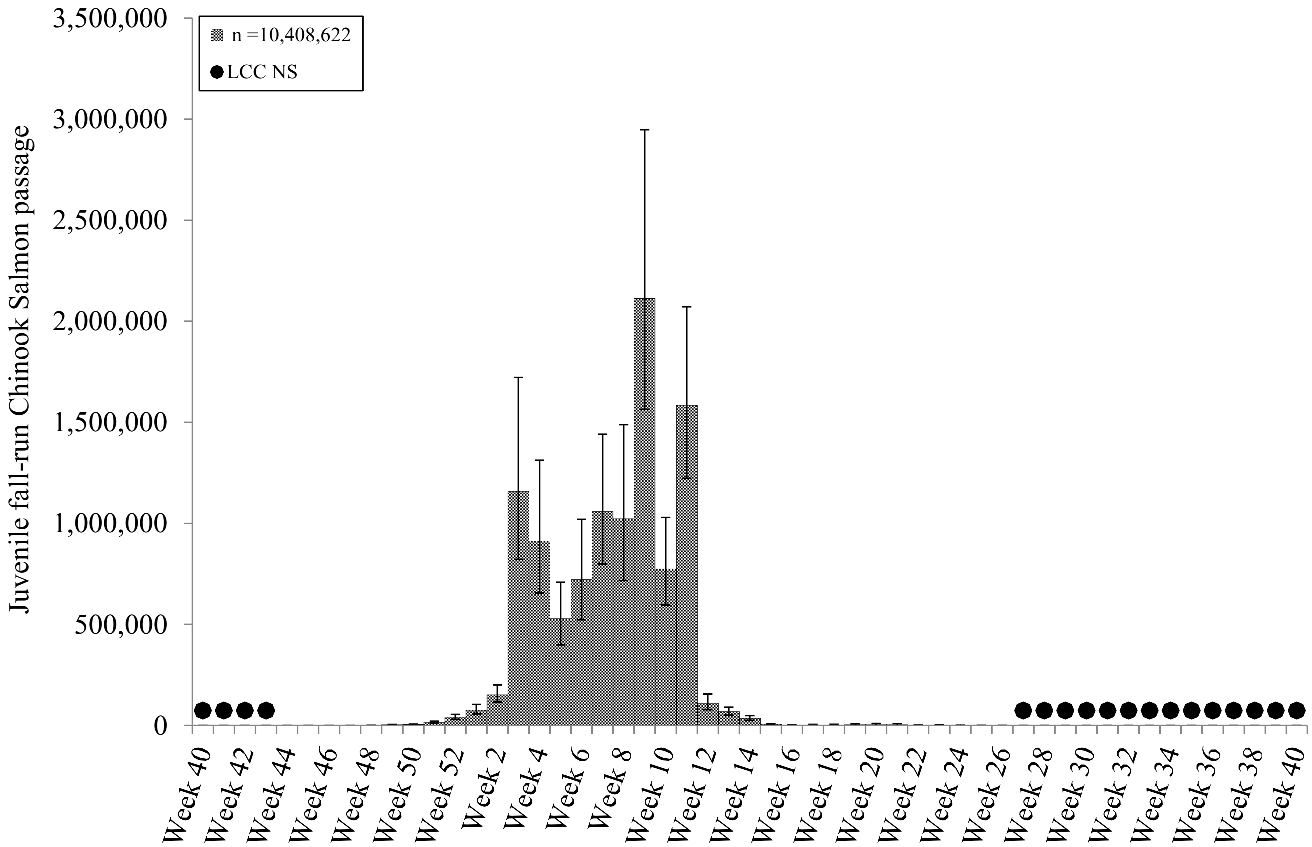

Figure 13. Weekly passage indices with 95% confidence intervals for brood year 2011 juvenile fall-run Chinook Salmon by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County from November 1, 2011, through June 30, 2012. Non-sampled weeks (LCC NS) are indicated at the bottom of the figure as circles.

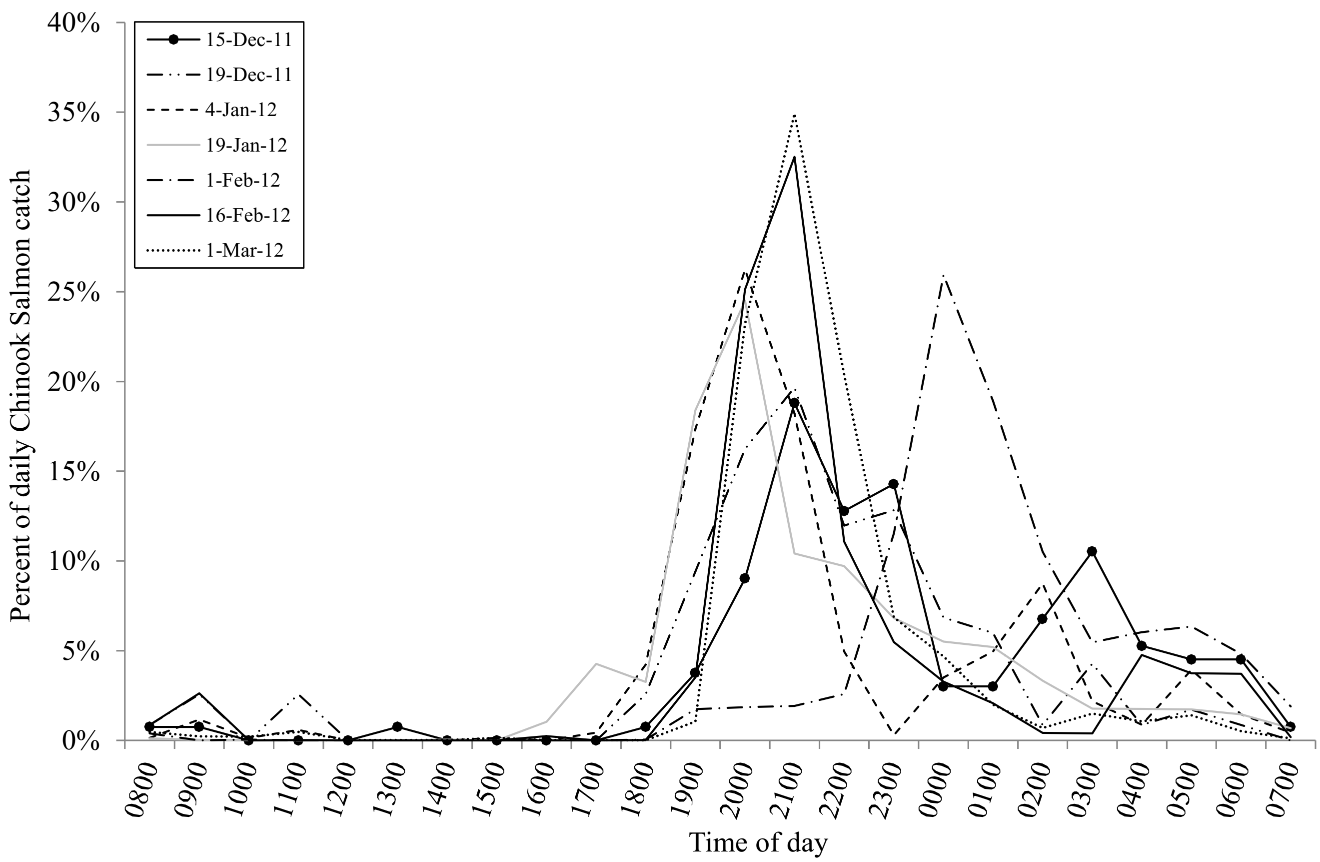

Figure 14. The hourly percent of daily Chinook Salmon catch results from the 24-h interval sampling events at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, from December 15, 2011, through March 4, 2012. Most of these events were during peak out-migration.

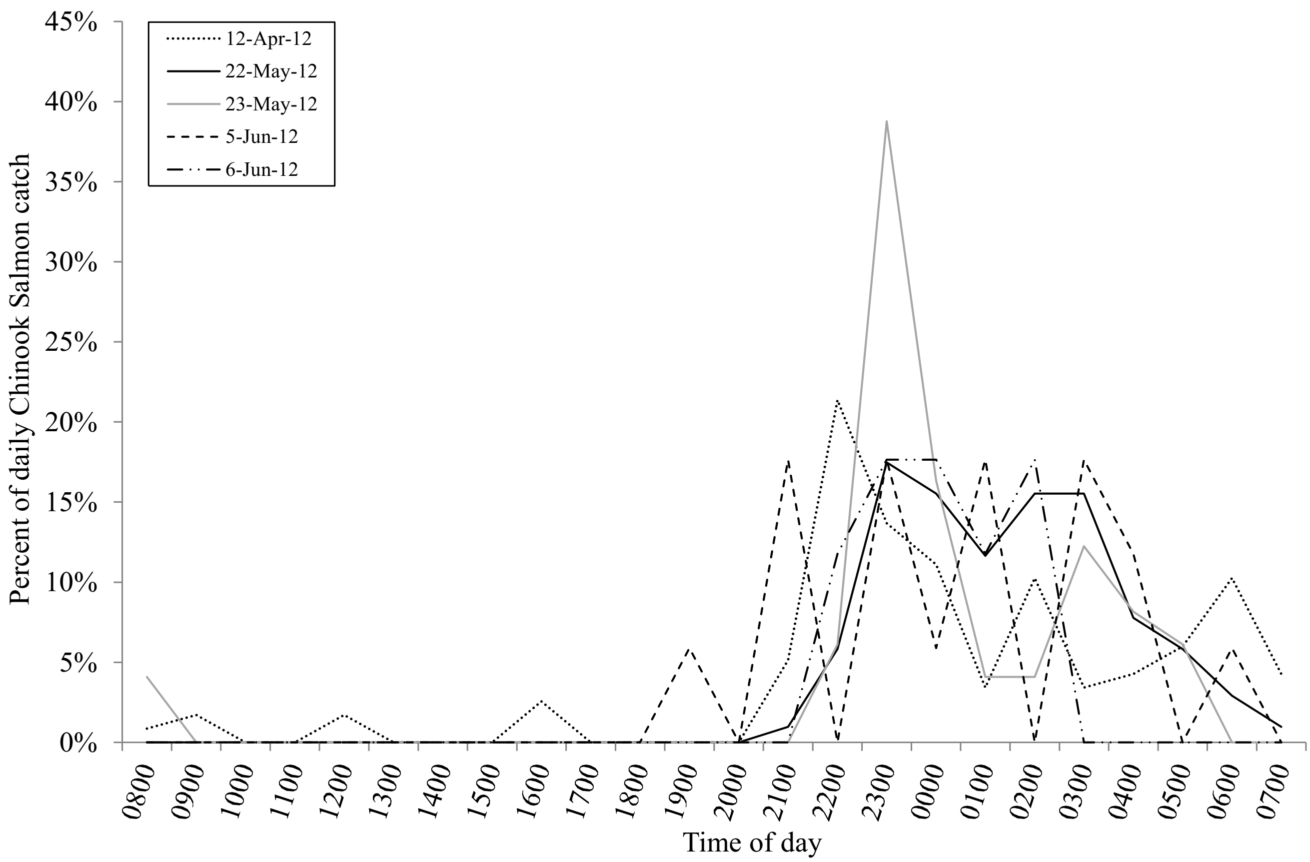

Figure 15. The hourly percent of daily Chinook Salmon catch results from the 1900–0700 hours interval sampling events at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, from April 12 through June 7, 2012. The trap was sampled at 0800 hours and then again at 1900 hours and every hour after that until 0700 hours. These events were not during peak out-migration.

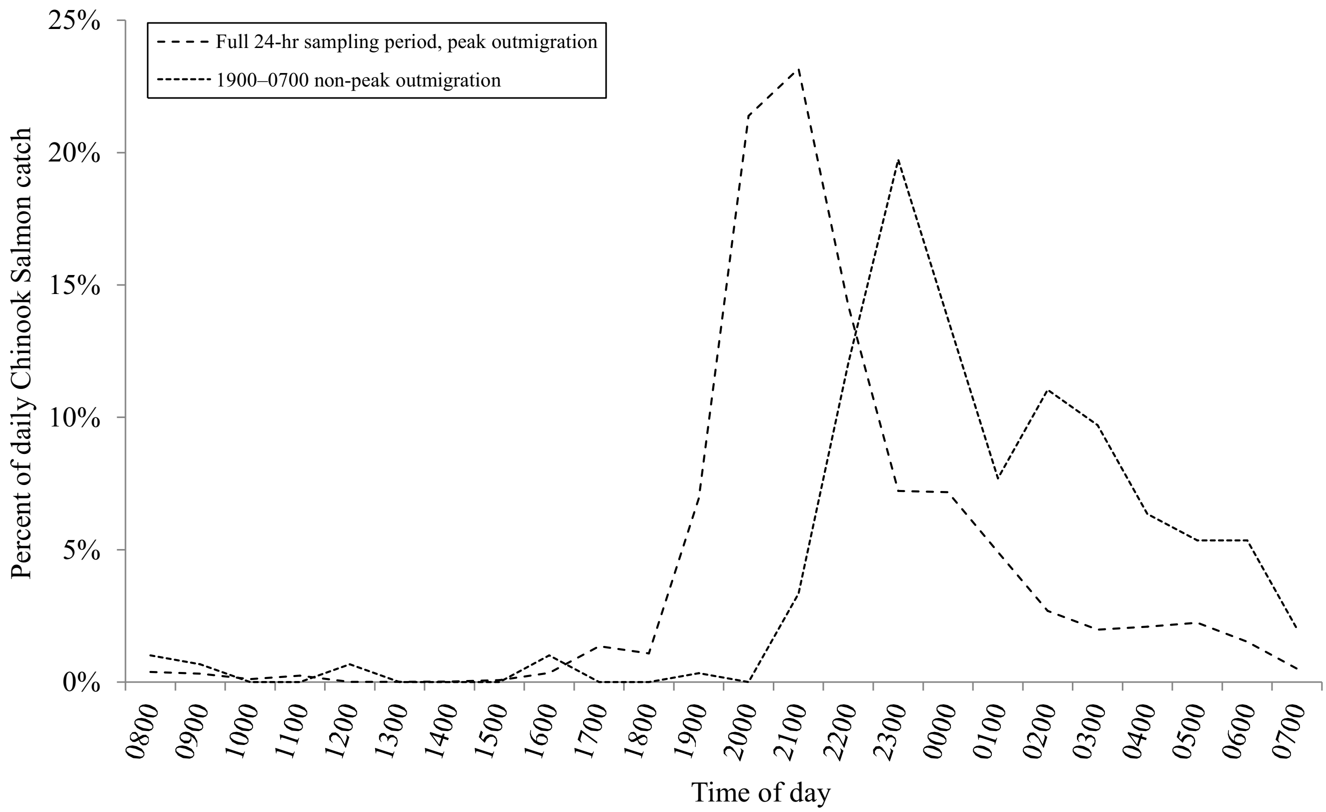

Figure 16. The comparison of hourly percent of daily Chinook Salmon catch results for early and late season interval sampling events at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, from December 15, 2011, through June 7, 2012. The blue line represents the percentage of the daily catch for 24-h sampling early in the trap season and during most of the peak out-migration (December 15, 2011, through March 2, 2012). The red line represents the percentage of the daily catch for the 1900–0700 hours sampling events that occurred late in the season and during non-peak out-migration (April 12, through June 7, 2012).

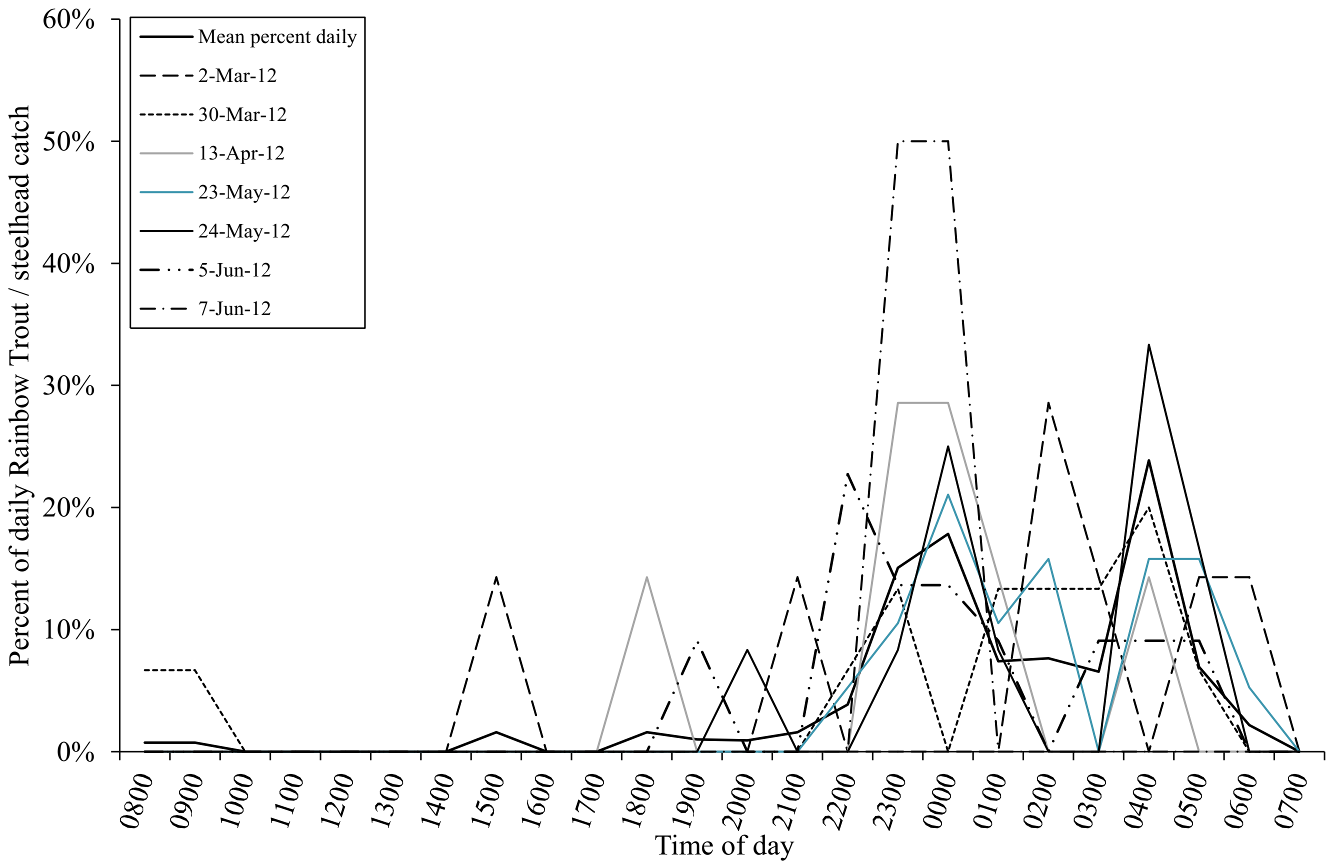

Figure 17. The hourly percent of the daily catch of Rainbow Trout / steelhead for each 24-h interval sampling event and the mean of all the events. The sampling events were conducted from February 16, 2012, through June 6, 2012 at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County.

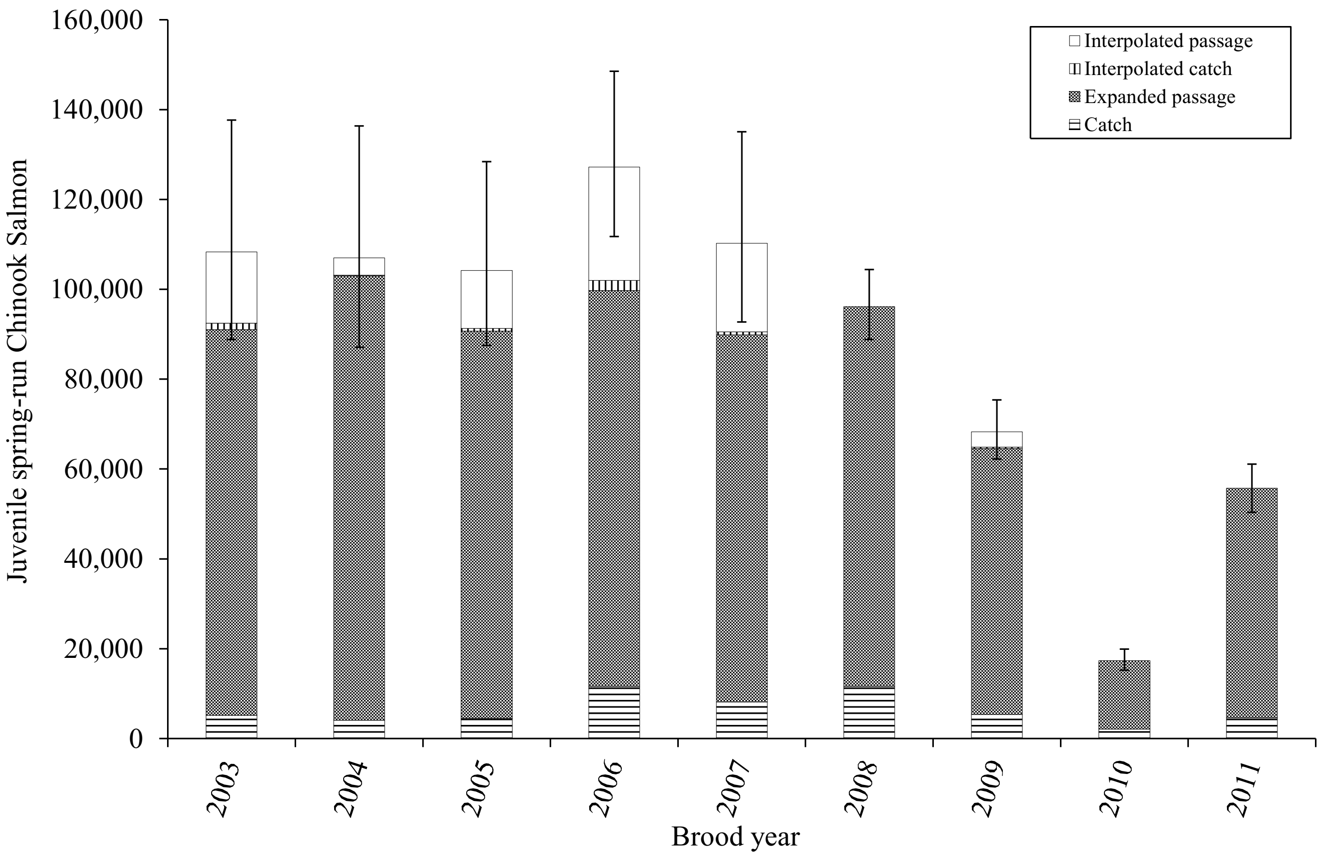

Figure 18. Interpolated passage and catch for spring-run Chinook Salmon for brood years 2003–2011 captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County. The entire bar represents total passage numbers for that brood year and the error bars the 95% confidence interval.

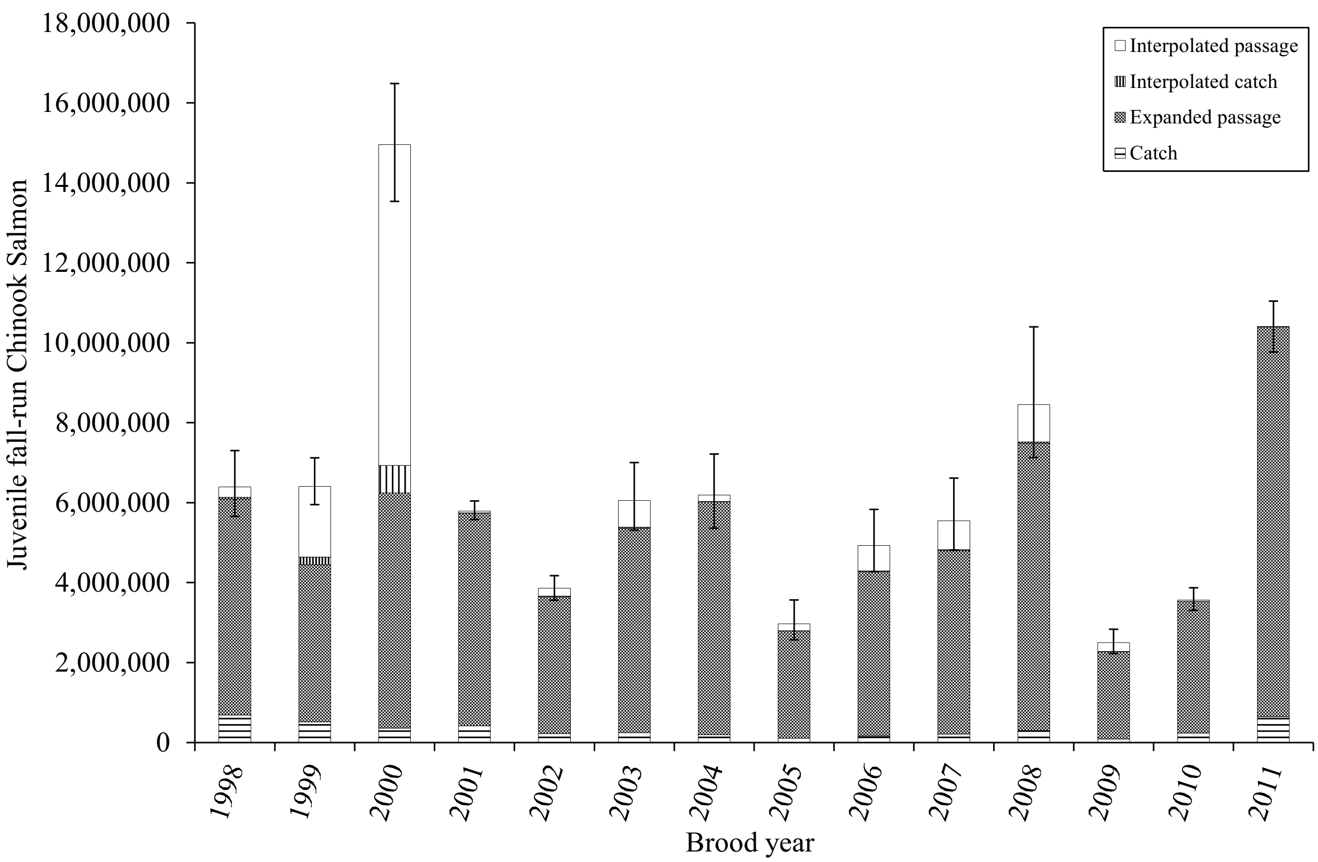

Figure 19. Interpolated passage and catch for fall-run Chinook Salmon for brood years 1998–2011 captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County. The entire bar represents total passage numbers for that brood year and the error bars the 95% confidence interval.

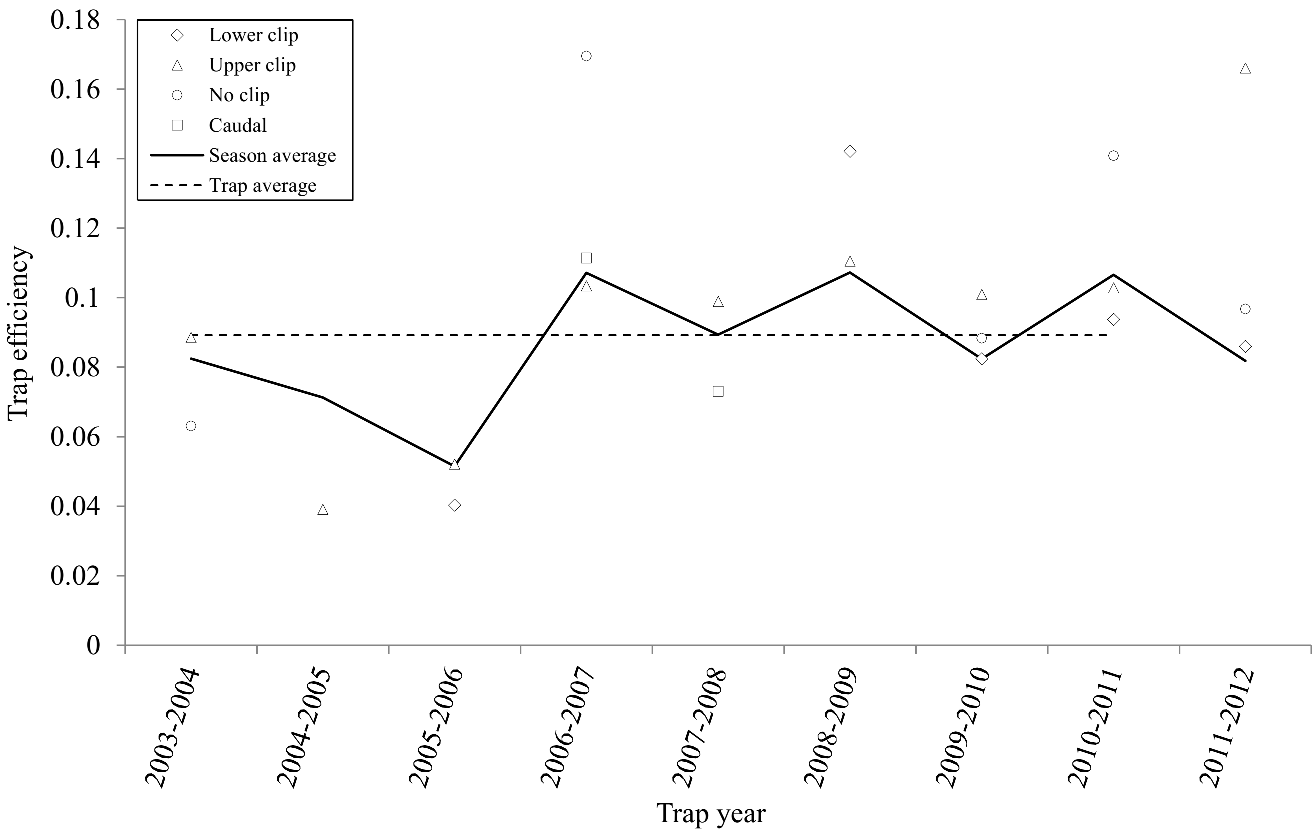

Figure 20. Season average efficiencies by mark types, season, and historic means for mark–recapture trials conducted using juvenile naturally reared fall-run Chinook Salmon at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County by the U.S. Fish and Wildlife Service. Season average efficiencies are calculated as (average number recaptured + 1) / (average number released + 1).

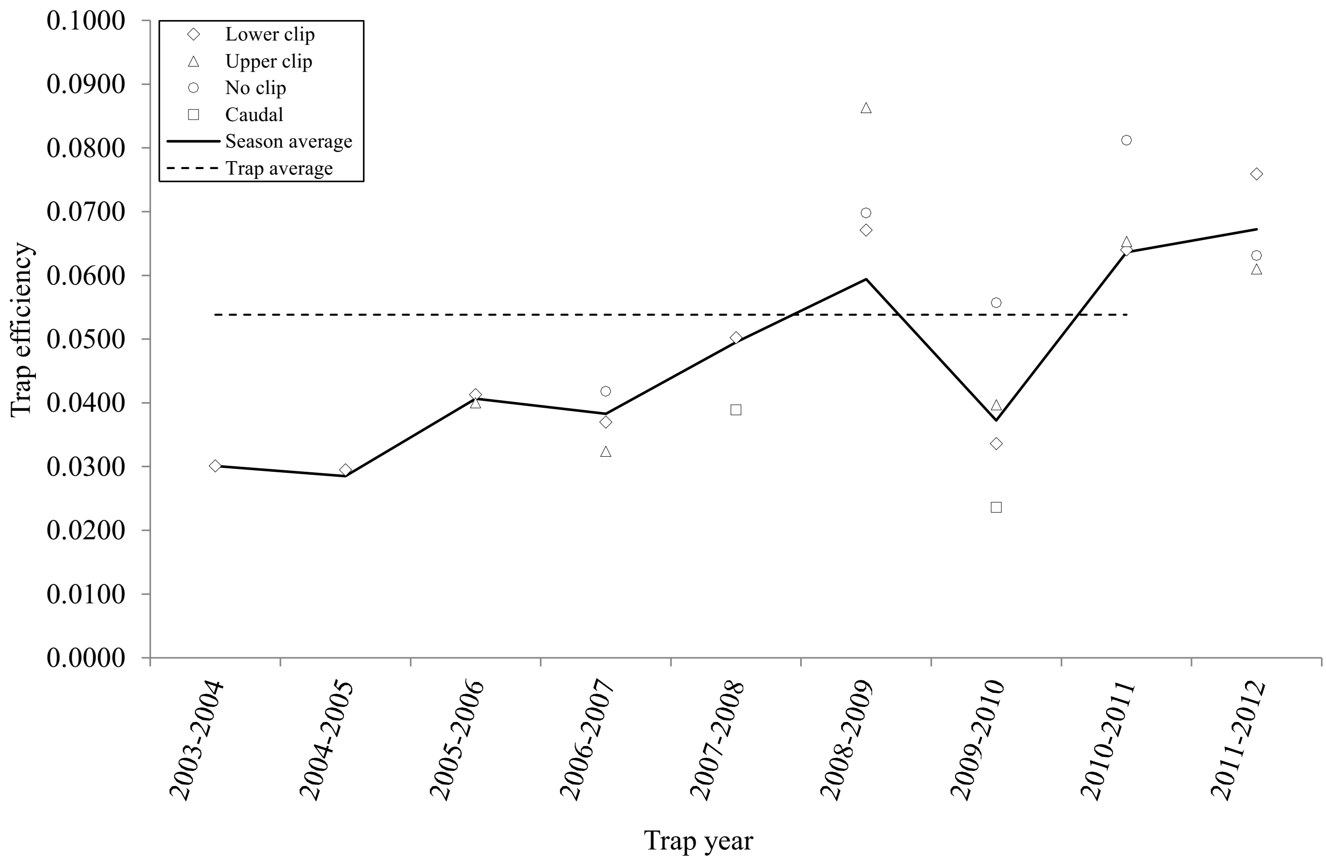

Figure 21. Season average efficiencies by mark types, season, and historic means for mark–recapture trials conducted using naturally reared juvenile fall-run Chinook Salmon at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County by the U.S. Fish and Wildlife Service. Season average efficiencies are calculated as (average number recaptured + 1) / (average number released + 1).

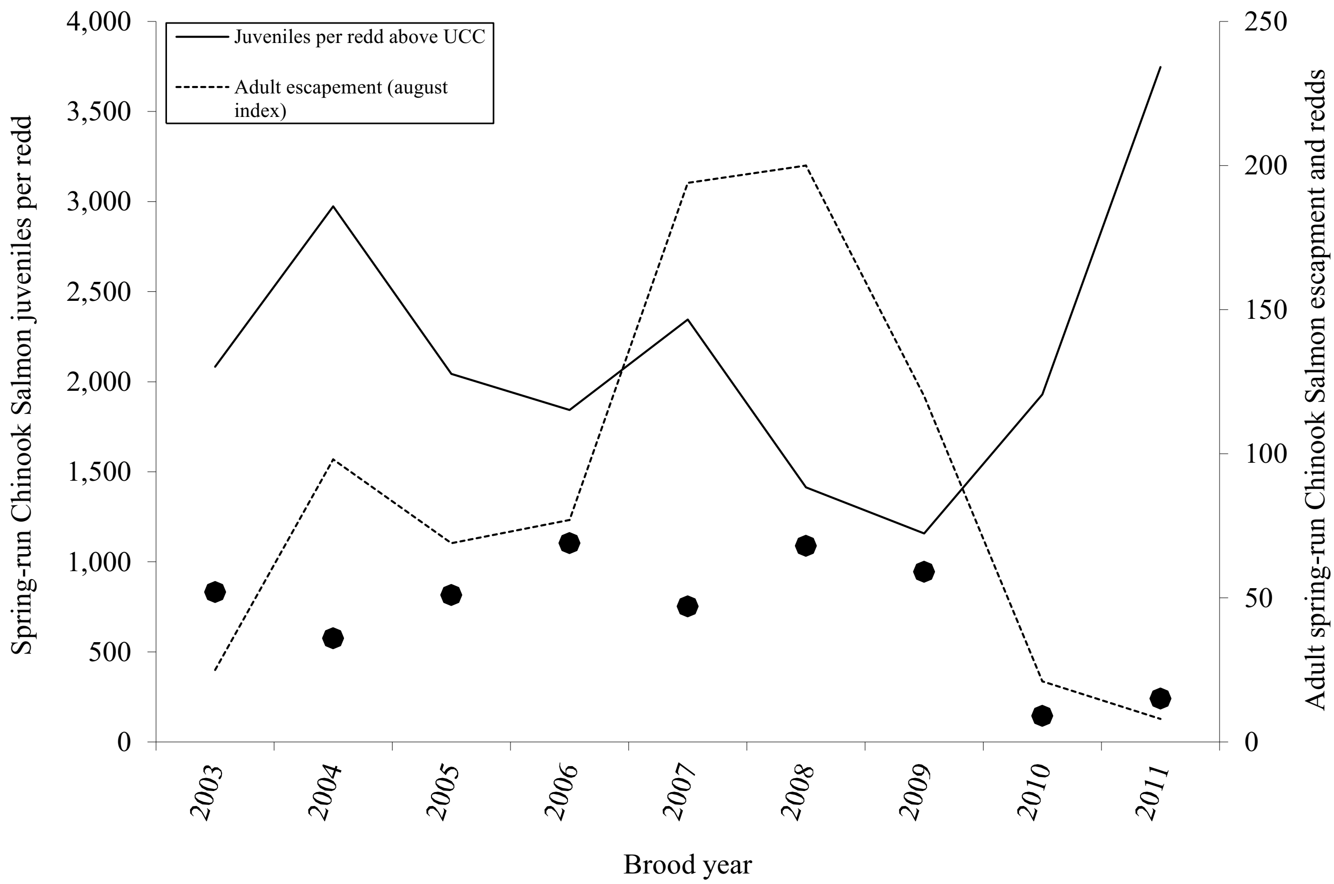

Figure 22. Spring-run Chinook Salmon adult escapement, juveniles per redd and redds above the upper rotary screw trap at river mile 8.4 for brood years 2003–2011 in Clear Creek, Shasta County.

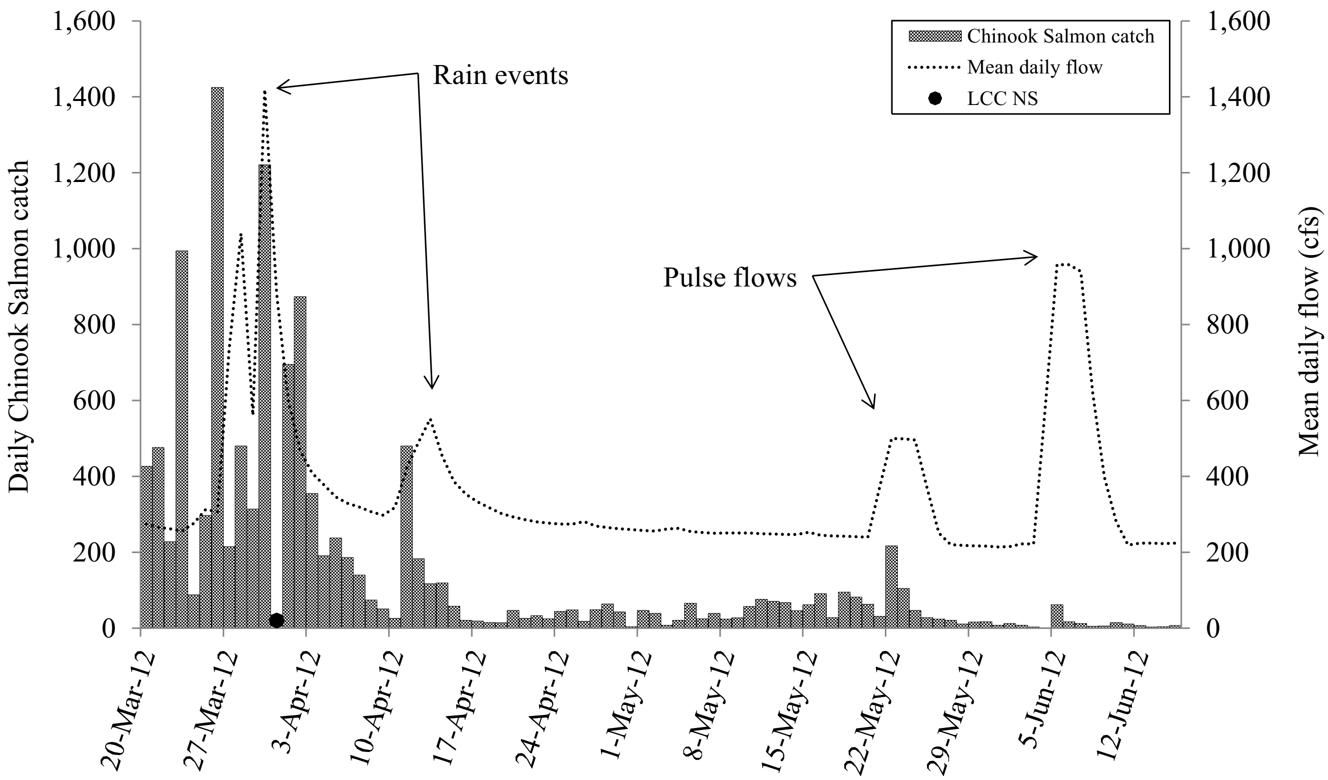

Figure 23. Mean daily flow measured at the USGS IGO station and daily Chinook Salmon catch at the lower Clear Creek rotary screw trap sampling station at river mile 1.7 in Clear Creek, Shasta County from March 20, 2012, through June 15, 2012. Non-sampling weeks (LCC NS) are indicated at the bottom of the figure as a circle. Both natural and artificial high flow events are indicated by the arrows. Chinook Salmon tend to out-migrate in greater numbers during natural as compared to artificial high flows.

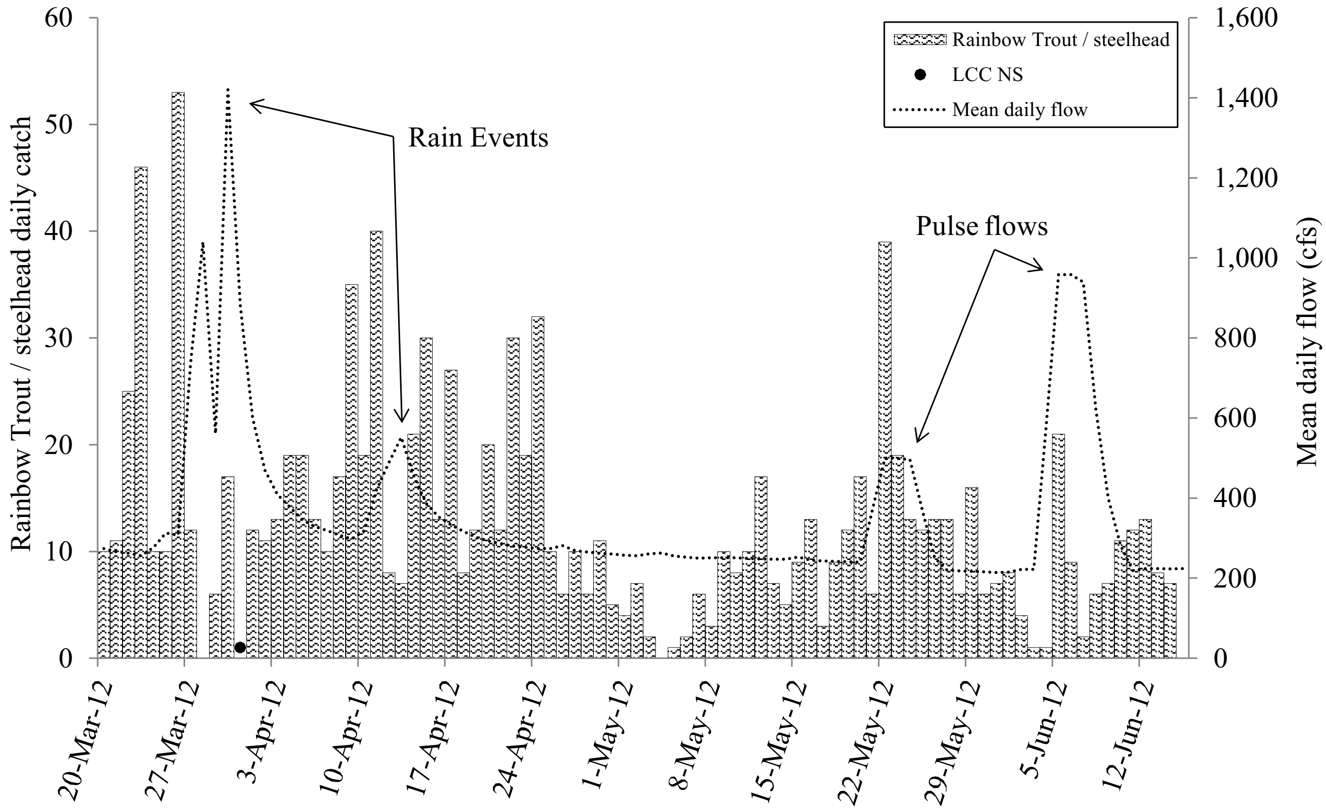

Figure 24. Mean daily flow measured at the USGS IGO station and daily Rainbow Trout / steelhead catch at the lower Clear Creek rotary screw trap sampling station at river mile 1.7 in Clear Creek, Shasta County from March 20, 2012, through June 15, 2012. Non-sampling weeks (LCC NS) are indicated at the bottom of the figureas a circle. Both natural and artificial high flow events are indicated by the arrows.