Juvenile Salmonid Monitoring in Clear Creek, California, from October 2010 through September 2011

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Abstract.—The U.S. Fish and Wildlife Service (FWS) has been conducting a juvenile salmonid monitoring project in Clear Creek, Shasta County, California, using a rotary screw trap (RST) at river mile (rm) 1.7 since December 1998. This monitoring project has three primary objectives: 1) calculate an annual juvenile passage index (JPI) for Chinook salmon *Oncorhynchus tshawytscha* and steelhead / rainbow trout *O. mykiss*, for inter-year comparisons and analyses of 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 developing baseline markers for the Clear Creek salmonid populations. Chinook run classifications show that late-fall, winter, spring and fall Chinook salmon were captured in our RST. However, due to overlapping spawn timing of spring and fall Chinook, and presence of both, it was problematic to index the juvenile passage using only the RST at rm 1.7. Since 2003, a weir is used to isolate adult spring Chinook upstream of rm 8.2 or in some cases rm 7.5. To better estimate the passage of juvenile spring Chinook, a second RST was placed at rm 8.4. Passage indices with 90% and 95% confidence intervals were generated for late-fall, spring and fall Chinook salmon from Broodyear (BY) 2010 and steelhead / rainbow trout from BY 2010 Age 0+ and BY 2011 Age 0. The spring Chinook index for BY 2010 from the Upper Clear Creek (UCC) RST was 17,359 for redds above the RST and was 19,288 after adjusting for redds below the RST and above the separation weir. The indices of passage for BY 2010 from the Lower Clear Creek (LCC) RST were as follows: 22,853 late-fall, 32,955 spring and 3,566,723 fall-run Chinook salmon. The steelhead / rainbow trout indices from LCC were as follows: 259 BY 2010 Age 0+, and 19,508 BY 2011. Mark and recapture trials were conducted from November 2010 through early April 2011 to determine RST efficiency at both locations and ranged from 2.8% to 16.9%.

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Introduction

The U.S. Fish and Wildlife Service (USFWS), Red Bluff Fish and Wildlife Office (RBFWO) have been monitoring juvenile salmonids in Clear Creek, Shasta County, California using a rotary screw trap (RST) at river mile (rm) 1.7, since December 1998 and with a second trap at rm 8.4 since 2003. This monitoring project has three primary objectives: 1) calculate an annual juvenile passage index (JPI) for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead / rainbow trout (*O. mykiss*) (STT), for inter-year comparisons and analyses of 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 developing baseline markers for the Clear Creek salmonid populations. Rotary screw traps have been used as the primary means to evaluate trends in juvenile salmon abundance. While RSTs have limitations, they can be an effective monitoring tool, and can provide a reliable estimate of juvenile production when used consistently over a number of years (CAMP 2002, sec. 5-1).

Clear Creek is a west side tributary of the Sacramento River in Shasta County. Runs of Chinook salmon from the Sacramento River watershed, including late-fall-run (LFC), spring-run (SCS), and fall-run (FCS) inhabit Clear Creek. Spring Chinook salmon are listed as threatened (1999) under the Federal Endangered Species Act (ESA). Winter Chinook may have historically been present or may spawn opportunistically, however a naturally self-sustaining population of does not exist in Clear Creek. The California Central Valley *O. mykiss* (STT) population includes both anadromous (steelhead) and resident forms. The California Central Valley Steelhead population is listed as threatened by the ESA since March 1998.

LFC salmon migrate into Clear Creek, November through April, with peak migration in December and peak spawning occurring in January and primarily utilize the lower reaches of Clear Creek (Table 1, Reach 6) for all life history phases. SCS generally migrate into Clear Creek before late August, and spawn in the upper reaches (Table 1, Reaches 1-5a1-2; rm 7.4 - 18.1) in September and October (Figure 1). FCS spawning occurs soon after and often overlaps in time with the SCS, with 98-99% taking place in Reach 6 below the gorge cascade (S. Giovannetti, USFWS, personal communication). A picket weir is used to prevent FCS from spawning in the upper reaches.

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

Since 2003, the RBFWO has used a second Upper Clear Creek (UCC) RST at rm 8.4 to index passage of SCS. Passage indices of the SCS using the Lower Clear Creek (LCC) RST rm 1.7 were found to be significantly underestimated (Gaines 2003, Greenwald 2003, and Brown 2007). In August 2010, the Clear Creek picket weir was initially placed instream at river mile 8.2 just below the Upper Clear Creek RST. After identifying additional adult Chinook just below the upper weir site, a second weir was installed at river mile 7.5 to protect a greater percentage of the population from potential spawning superimposition from FCS spawners. The juvenile passage index is adjusted for redds identified above the lowest weir at river mile 7.5. The use of the picket weir has greatly minimized the presence of FCS in the upper watershed. This report presents sampling data from the upper and lower Clear Creek RSTs. All passage data is from brood years whose emigration ended between October 1, 2010 and September 30, 2011.

Study Area

The Clear Creek watershed below Whiskeytown Dam covers an area of approximately 48.9 miles^2 (127 km^2), and receives supplemental water from a cross-basin transfer between Lewiston Lake in the Trinity River watershed and Whiskeytown Reservoir in the Sacramento River watershed. Separated at the Clear Creek Road Bridge, the upper and lower reaches of the creek are geomorphically distinct and support different fish communities. The upper reach flows south from Whiskeytown Reservoir almost 10.1 mi (16.3 rkm). The lower reach heads in an easterly direction to the Sacramento River for a distance of approximately 8.2 mi (13.2 rkm) (Figure 1). In the upper reach the stream is more constrained by canyon walls and a bedrock channel, has a higher gradient, has less spawning gravel and has more deep pools. In the lower reach, the stream meanders through a less constrained alluvial flood plain, has a lower gradient, has more spawning gravel and has fewer deep pools. The lower reach is managed for fall and late-fall Chinook and supports species of the foothills fish community. The upper reach supports coldwater species and is managed for spring Chinook and steelhead / rainbow trout, which require cooler summer water temperatures than the runs downstream. Although once anticipated that Steelhead would predominately be in the uppermost reaches, recent spawning distributions are greater in the lower reach 6. The average flow in Clear Creek is approximately 180 cfs (5.1 m^3/s; USGS, 2012).

Acting as a sediment trap, Whiskeytown Reservoir has starved the lower portion of Clear Creek of its sediment. The coarse sediment deficit and concomitant reduction in habitat quality in Clear Creek below Whiskeytown Dam has been well documented by various investigators (Coots as cited in McBain and Trush 2001, GMA 2003). Effects of reduced coarse sediment supply include riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition and riparian re-generation, and a reduction in the amount and quality of spawning gravels available for anadromous salmonids (GMA 2006). In some areas of the Clear Creek, stream channel only clay hardpan or bedrock remains, thus the need for gravel supplementation.

Ambient air temperatures range from approximately 32°F (0ºC) in winter to summer highs in excess of 115°F (46ºC). Most precipitation falls into this watershed as rainfall. The average rainfall in the Clear Creek watershed ranges from approximately 20 inches (50cm) in the lowest elevations to more than 60 in. (152 cm) in the highest elevations. Most of the watershed's rainfall occurs between November and April, with little or none occurring during the summer months (McBain and Trush et al. 2000).

The upper Clear Creek rotary screw trap is located at rm 8.4 (rkm 13.5) above the confluence with the Sacramento River (latitude 40.491850 dd north, longitude -122.496572 dd west). The lower Clear Creek rotary screw trap is located at rm 1.7 (rkm 2.7) above the confluence (latitude 40.506159 dd north, longitude -122.396079 dd 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 - 1.5 degrees. Canopy cover of the riparian vegetation over the channel in the sampling areas is generally less than 5%.

Methods

Sampling protocol—Sampling for juvenile salmonids in Clear Creek was accomplished by using standardized RST sampling techniques that generally were consistent with the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) standard protocol (CAMP 1997). The RSTs deployed in Clear Creek, are manufactured by E.G. Solutions®, Corvallis, Oregon. This type of trap consists of a 5 ft (1.5 m) diameter cone covered with 1/8 in (3 mm) diameter perforated stainless steel screen. This cone acts as a sieve, which separates fish from the sampled water. The cone is supported between two pontoons and its auger-type action passes water, fish, and debris to the rear of the trap, and directly into a live box. This live box retains fish and debris, and passes water through screens located in its back, sides, and bottom.

Two trees with diameter-at-breast height measurements of approximately 12-18 in. (30 - 46 cm) on opposite banks of the creek are used as attachment points for the traps for securing the RST in the thalweg of Clear Creek. The trees were approximately 200 ft. (60 m) apart and far enough above the flood plain to avoid most flood waters. Using these trees as anchors, the RST is attached to a cable high line and positioned in stream with a system of ropes, and pulleys. The UCC RST was fished during the current reporting period from November 2, 2010 through June 30, 2011. The LCC RST fished from November 24, 2010 through June 30, 2011. An attempt was made to fish the RST 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 banks. However, for crew access during higher flows, the RST was pulled into shallow water for boarding. After being serviced, the RST was returned back to the thalweg as soon as possible to begin fishing again. The RST was serviced once per day unless high flows, heavy debris loads, or high fish densities required multiple trap checks to avoid mortality of captured fish or damage to equipment. At each trap servicing, crews process the collected fish, clear the RST of debris, provide maintenance, and obtain environmental and RST data. 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, the amount and type of debris collected, basic weather conditions, water temperature, current velocity, and water turbidity. Water depths were measured using a graduated staff to the nearest 0.1 feet. The RST cone fishing depth was measured with a gauge that was permanently mounted to the RST frame in front of the cone. The number of rotations of the RST cone was measured with a mechanical stroke counter (MHC Industrial Supply Company, LTD., Shandong, China) that was mounted to the RST railing adjacent to the cone. The amount of debris in the RST was volumetrically measured using a 10-gallon (37.8 l) plastic tub.

Water temperatures were continuously obtained with an instream HOBO® Water Temp Pro v2 Logger (Onset Computer Corp, Bourne, MA). Water velocity was measured from a grab-sample using an Oceanic® Model 2030 flowmeter (General Oceanics, Inc., Miami, Florida). This velocity was measured in the time when the live box of the RST was being cleared of debris and the fish sorted from this debris. Water turbidity was measured from a grab-sample with a Hach® Model 2100D turbidimeter (Hach Company, Ames, Iowa). Daily stream discharge data was collected by the U.S. Geological Survey at the Clear Creek near Igo, CA gauging station (Station #11372000). The gauge site is located approximately 2.6 rm upstream of the UCC trap

(Figure 1). All environmental and biological data were entered into a Panasonic Toughbook® (Model CF-19) at the trap site. The Toughbooks® utilize a stylus touch screen application that is linked directly to our RST Microsoft Access® database; allowing field staff to enter sample environmental and catch data onsite and increase our efficiency by reducing the time necessary for data entry and proofing.

To remove the contents of the RST live well for examination, we used dip nets to scoop debris and fish onto a sorting table. When the number of all fishes collected in the RST was less than approximately 250 individuals, they are counted and measured on the aft deck of the RST. When catch exceeded approximately 250 individuals, fishes were transported to the shore in 5-gallon buckets and put into 10 or 25-gallon buckets for further examination.

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

Chinook salmon—When less than approximately 250 salmon were collected in the RST, all were counted and measured for fork length (FL). The measured juvenile salmon were assigned a life-stage classification of fry, parr, silvery parr, or smolt. For all Chinook salmon that were counted and measured, we also assigned run designations, using length-at-date tables from Greene (1992). These designations included FCS, LFCS, WCS, or SCS. At the UCC RST all Chinook captured were considered to be SCS, due to the use of the weir which blocked FCS from passing upstream of the RST, regardless of their designation by the length-at-date tables.

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

After subsampling the salmon to the appropriate split, all fish in the subsample of approximately 150 - 250 individuals were counted and measured for FL. These salmon were also assigned a life-stage classification and run designation, using the methods previously described above. We proceeded to successively count all salmon in each split, until all salmon were counted. Chinook salmon with forklengths greater than or equal to 50mm were weighed to the nearest 0.01gram using a battery-operated Ohaus Scout® digital scale (Ohaus Corporation, Florham Park, New Jersey). for length / weight relationship analysis.

Steelhead / rainbow trout—We counted and measured the FL of all steelhead / rainbow trout that were collected in the RSTs. Life stages of juvenile trout were classified similarly as salmon (i.e., yolk-sac fry (R1), fry (R2), parr (R3), silvery parr (R4), and smolt (R5)). All live rainbow trout/steelhead > 50 mm that were captured during the daytime sample were weighed to the nearest 0.1 g 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 lamprey *Lampetra spp* and *Entosphenus tridentata.,* sculpin *Cottus spp.*, and western mosquitofish *Gambusia affinis*; 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 first sampling week of the current study was during Week # 44 in 2010 for the UCC, Week #47 for LCC, and the last sampling week was during Week # 26 in 2011 for both locations (Table 2).

Genetic and otolith sampling—Genetic samples were taken on selected Chinook salmon for the purpose of run identification. Samples were taken by removing a 1-mm^2 tissue sample from the top or base 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 ethanol as a preservative. The triplicate samples were taken for; 1) USFWS archive, 2) CDFG archive, and 3) analysis by the Oregon State University's Hatfield Marine Lab in Newport, Oregon or comparable facility. We anticipated sampling up to one hundred otolith samples from LCC steelhead / rainbow trout 50 mm or greater. Samples are stored frozen for eventual otolith removal and anlysis.

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

During periods when juvenile Chinook salmon capture was sufficient and weather permitted, mark-recapture trials were attempted twice weekly. We attempted to mark 400 juvenile Chinook salmon for each trial, with a goal to recapture at least seven marked individuals. In an effort to meet our goal of recapturing a minimum of seven individuals, we generally did not conduct mark-recapture studies during periods when numbers of juvenile salmon captured were less than about 200 individuals.

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

Single-marking technique—Our single-marking technique consisted of immersion staining of salmon with Bismarck brown-Y stain (J.T. Baker Chemical Company, Phillipsburg, New Jersey). The Bismarck brown was applied at a concentration of 1.6 grams / 20 gallons of water and allowed a 45-50 minute contact time.

Dual-marking techniques—To conduct our dual-marking procedures, the fish are anesthetized with an MS-222 solution at a concentration of 60-80 mg/l. After the salmon are anaesthetized, we use either an upper or lower caudal fin clipping to attain a primary mark. To perform the fin clips, we use surgical scalpels, to remove an area of approximately 1 mm^2 or less from the corners of the caudal fin lobe. Alternate upper and lower clips are used to discern mark groups from trial to trial and trap to trap. After the clipping process was complete, the salmon were marked with Bismarck brown, as described above.

When the single-marking or dual-marking procedures were completed, the marked juvenile salmon were placed in a live car and allowed to recover overnight in the RST live well. This overnight detention allowed us to detect salmon with latent injuries and mortalities resulting from the marking procedure, and removed them from use in the recapture trials. On the following evening, weak, injured, and dead fish were removed. The remaining fish were counted and transported 0.2-0.4 river miles upstream of the RST sampling site to be released. We attempted to release fish in the evening no earlier than 15 minutes before sunset. The nighttime releases of marked fish were designed to: 1) reduce the potential for unnaturally high predation on salmon that may be temporarily disorientated by the transportation; and 2) imitate the tendency for natural populations of outmigrating Chinook salmon to move downstream primarily at night (Healey 1998; USFWS, RBFWO, unpublished observations). The stained and marked Chinook salmon that were recaptured later by the RST were counted and measured. After being allowed to recover, they were released downstream of the RST to prevent them from being recaptured again. In most cases when flows would most certainly exceed 2,000 cfs, fish were released downstream of the trap and efficiency trials are not conducted.

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

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

1) Weekly trap efficiencies were generated using a stratified 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 (Whitton et al., 2006).

Weekly trap efficiencies were generated by use of the equation:

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

Where;

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

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

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

Where;

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

The variance, 90% and 95% confidence intervals (CI's) for each week (N_h) are determined by the percentile bootstrap method with 1,000 iterations (Efron and Tibshirani 1986; Buckland and Garthwaite 1991; Thedinga et al. 1994; Steinhorst et al. 2004). Using data with simulated numbers of migrants, and trap efficiencies, Steinhorst et al. (2004) determined the percentile bootstrap method for developing CI's performed the best as it had the best coverage of a 95% CI. The variance for N_h is simply the sample variance of the 1,000 iterations of N_h produced by bootstrapping U_h, E_h and m_h for each week.

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

This final CI was calculated by summing the stratum of each of the 1000 random unordered iterations horizontally on the spreadsheet. The final column was ordered and the 25th, 50th, 950th, and 975th values were used as the 90% and 95% CI. The final JPI CI uses unordered iterations in calculating values, as summing the ordered iterations produce a CI that is comprised of non-random values. To produce a weekly CI, each weekly stratum is ordered and the 25th, 50th, 950th, and 975th values were used as the 90% and 95% CI. The standard error *(SE)* of the sample means of each stratum are also included with 90% and 95% CI's. Juvenile Chinook salmon and STT JPIs were summarized by brood year.

For dates when sampling was not conducted, or when samples were lost or compromised, we used the mean catch of an equal number of days before, and an equal number of days after, the missing number of sample days to create a surrogate value. For example, if we were missing three days of sampling data, we would calculate the average of the three sampled days before and three sampled days after the missing period. This calculated average of six sampled days would then be used as the surrogate value for each of the three days of missing values. On days where more than half of the day was sampled, a proportionate value was given to the remainder of the day the trap did not fish based on the data that was collected.

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

In addition to the half-cone modification described above, we performed several other modifications to the RST equipment and operations to provide for greater protection to collected fishes. Other modifications to RST equipment included enlarging the size of live-box, increasing the size of flotation pontoons. Additionally, a secondary flotation device was added to the rear of the trap to keep it from sinking and getting fish crushed between the live box and cover lids. Inside the live box, we have added a midway fish exclusionary device made of expanded aluminum. This device prevents large predatory fish from harassing and predating smaller salmonids. Modifications to RST operations have included day and night sampling during the peak out migration periods for SCS and FCS. To improve JPI computation, we strived to fish high flow events when juvenile salmonids are thought to out-migrate and increase the frequency of mark-recapture trials during those events from previous years.

Pulse Flow Sampling—In late May and early June of 2011, 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 page 587 (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. 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 SCS adult population would migrate upstream of the UCC RST.

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.

Results

Sampling effort

Upper Clear Creek—The UCC RST was installed on October 15, 2010 and set from November 1, 2010 through June 30, 2011 for 242 days. We expected to catch consistently few or zero emergent salmonids in the period from the beginning of August through mid-November. Although, length-at-date tables suggest we might capture SCS as early as October 16 of each year; using temperature data for 2009 (and surrogate values of water year 2009 from 09/21 - 02/28/11 due to < 1ºF difference) we calculated that SCS emergence would not occur until mid-November. Based on the previous year's (BY 2009) recommendation, traps were set two weeks prior to our estimated emergence, to accommodate any deviations the surrogate temperatures could have from the actual temperature.

The UCC RST did not sample for 59 of the 241days or 24.5%. Only four days were the result of high flows, of which two were during a pulse flow in May the other 55 days the trap was out due to a damaged part that could not be delivered for several weeks. Because of this, the trap did not fish for March 13 through May 6, 2011. Although the trap was out for a significant period, generally 98% of our Chinook pass the RST by February. Due to high juvenile Chinook salmon densities that were anticipated and encountered, we applied the half-cone modification during the entire sampling season.

Lower Clear Creek— The LCC RST was installed on October 15, 2010 and set from November 1, 2010 through June 30, 2011 for 242 days. Due to high flows or debris stopping the trap, twelve days were partially sampled or not sampled at all. The half-cone modification was applied during the entire sampling season similar to the upper trap site.

Physical characteristics

Mean daily flows ranged from a minimum of 152 cubic feet per second (cfs) on June 27, 2011 to a maximum of 1,680 cfs on March 26, 2011. The maximum measured hourly flow was 3,320 cfs, at 1100 on March 26, 2011. The minimum flows were from controlled releases out of the Whiskeytown Lake, while maximums were results of natural storm flow accretions.

Upper Clear Creek—The channel width of Clear Creek at the UCC RST varied from approximately 30 feet at the lowest flows to more than 130 feet at the highest flows. Water depths in Clear Creek at the base of the RST cone varied from 4.5 feet to 7 feet, with an average depth of 5.4 ft. The lowest depths were recorded during May 2011 (avg. 4.9), and the deepest depths were recorded in December 2010 (avg. 5.7).

Turbidity levels ranged from 0.71 nephelometric turbidity units (NTU) on February 13, 2011 to 90.8 NTU on November 7, 2010, with a mean turbidity of 2.6 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 temperatures during the sampling season at UCC ranged from a low of 43.7°F on January 10, 2011 to 60.1°F on June 22, 2011 (Figure 3).

Lower Clear Creek—The channel width of Clear Creek at the LCC RST varied from approximately 40 feet at the lowest flows to more than 150 feet at the highest flows. Water depths in Clear Creek at the base of the RST cone varied from 2.5 feet to 4.8 feet, with an average depth of 3 ft. The lowest depths were recorded during November 2010 (avg. 2.8), and the deepest depths were recorded in early March 2011 (avg. 3.2). The average depths for March is reduced because we did not sample for eight days during the peak flow events for the season.

Turbidity levels ranged from 0.73 NTU on February 6, 2011 to 30 NTU on December 22, 2010, with a mean turbidity of 2.6 NTU. Mean daily water temperatures ranged from a low of 43°F on January 10, 2011 to 64.8°F on June 22, 2011 (Figure 3). Temperatures are measured year round; however, the values above represent temperatures for the days that were actually sampled.

Fish assemblage

Upper Clear Creek—A total of 2,806 fish were collected in the UCC RST during the sampling period. The most abundant fish taxa collected were Chinook salmon, steelhead / rainbow trout, riffle sculpin *Cottus gulosus*, and California roach *Hesperoleucus symmetricus*. The UCC RST capture data is described below.

Chinook salmon—The only species of salmon collected was Chinook salmon. Length-at-date tables of Greene (1992) indicated that we collected SCS, and FCS. We captured 2,059 Chinook during the study period. The data trends for each run of Chinook salmon are summarized below.

Spring-run Chinook salmon—The LCC passage indices relied exclusively on length-at-date tables to separate juvenile SCS from FCS. UCC indices relied on the picket weir to confine adult FCS below the trap and thus assign all length-at-date FCS as SCS. Fork lengths for all BY 2010 spring Chinook salmon captured, ranged from 30 – 102 mm, with a median of 34 mm (Figure 4). Chinook of all life stages were collected (Figure 5). We collected the greatest number of Chinook salmon from the fry size class, with the majority of individuals (97.7%) being 39 mm or less in FL (Figure 6 and Figure 7). The JPI for BY 2010 SCS was 17,359, with upper and lower 95% CI's of 19,910 and 15,228. Peak emigration occurred over a 4-week period from early November 26 2010 through December 24, 2010 (Figure 8 and Table 3).

The JPI recorded at the UCC trap was the lowest to date, however was expected based on the total number of redds observed this season. Ten SCS redds were observed above the separation weir, with one below the UCC RST. The adjusted population (proportionate to juveniles per redd) that includes the redd below the trap and above the separation weir is 19,288 (Figure 23). The seven-year average including all redds above the separation weir is 99,347.

Steelhead / rainbow trout—Indices of passage and confidence intervals for steelhead were not generated from the upper RST because the distribution of spawning was both above and below the trap site, with the majority occurring in the lower reach 6 (Giovannetti and Brown 2007).

Non-Salmonids—We collected 227 non-salmonids in the UCC RST. Ninety-five riffle sculpin, seventy-seven California roach, twenty-three Sacramento sucker, fourteen pacific lamprey ammocoetes, nine unidentified ammocoetes, two cottid fry, two cyprinid fry, and one each of Lampetra fry, small mouth bass, western brook lamprey transformer, white catfish, and white crappie were the non salmonid catch. The common and scientific name key for non-salmonids is described in Appendix 1. All other occurrences of non-salmonid species are summarized in Appendix 2.

Lower Clear Creek—A total of 243,394 individual fish, represented by 23 fish taxa were collected in the LCC RST during the sampling period. The most abundant fish taxa collected were Chinook salmon, followed by steelhead / rainbow trout, micropterus fry *Micropterus spp.,* pacific lamprey ammocoetes *Entosphenus spp*., and pacific lamprey transformers *Lampetra tridentata*. The LCC RST capture data are reported below.

Chinook salmon—Data is summarized by the following dates for BY 2010; late-fall April 1 2010 to March 31, 2011, spring and fall Chinook October 1, 2010 to September 30, 2011. The only species of salmon collected was Chinook salmon. Length-at-date tables of Greene (1992) indicated that we collected individuals from all four Chinook salmon runs known from the Sacramento River basin. Two hundred forty thousand, nine hundred sixty-eight individuals were captured from all runs, during the study period. Fork lengths for all runs of Chinook salmon ranged from 22 – 118 mm, with a median of 36 mm (Figure 9). Chinook of all life stages were collected (Figure 10). We collected a greater number of Chinook salmon from the fry size class, with the majority of individuals being 39 mm or less in FL. Data trends for each run of Chinook salmon are discussed below.

Late-fall-run Chinook salmon—A total of 772 LFC were captured and of those that were measured, 95.8 % were in the 30-39 mm FL range (Figure 11). The most common life stage for LFC was fry at 96.9% (Figure 12). Peak emigration occurred from approximately April 1, 2010 through May 21, 2010, when 95.7% passed (Table 4). The JPI for BY 2010 LFC was 22,853 with upper and lower 95% CI's of 27,111 and 19,929 (Table 4 and Figure 13).

Winter-run Chinook salmon—One juvenile Chinook salmon were designated as winter-run Chinook. Due to the single WCS captured, a passage index was not generated. The WCS displed a similar size and passage timing to that of the LFC, suggesting that most likely they are LFC.

Spring-run Chinook salmon—According to length at date tables, 913 SCS were captured at the LCC RST. Peak emigration occurred from late November through December. The JPI for BY 2010 SCS was 32,955 with upper and lower 95% CI's of 38,763 and 28,564. The passage index for SCS is determined by using the UCC RST. The data presented here for LCC RST is likely overestimated (based on number of redds in the upper watershed), and provided for comparison purposes.

Fall-run Chinook salmon—A total of 238,306 FCS were captured. The JPI for BY 2010 FCS was 3,566,723, with upper and lower 95% CI's of 3,871,986 and 3,305,917 (Table 5). Fall-run Chinook salmon make up > 98% of all Chinook salmon captured. Approximately 91.6% of the 17,240 FCS that were measured were in the 30-39 mm FL range (Figure 14). The most common life stage for FCS was fry 92.6% (Figure 15). Peak emigration occurred from January

2011 through February 2011 (Figure 16). The highest weekly passage occurred during the week of January 22, 2011 where 589,878 individuals were estimated to have passed (Figure 16 and Table 5).

Steelhead / rainbow trout—Passage indices are generated for BY 2011, from January 1 to December 31, 2011. During BY 2011, 1,110 STT were captured from January 1, 2010 to June 30, 2010. Twenty-four additional captures where made from November 3, 2011 through December 31, 2011. Steelhead / rainbow trout during 2011 had forklength measurements ranging from 21-165 mm (Figure 17). Steelhead / rainbow trout were captured from only three life stage classifications yolk-sac fry, fry, parr, (Figure 18), no silvery parr or smolts were captured. Steelhead / rainbow trout fry made up 69.9% of the total catch while, 64.5% of those measured were in the 20-39 mm size range (Figure 19). The JPI for BY 2011 STT is 19,508 with upper and lower 95% CI's of 21,612 and 17,965 (Table 6). The most common life stage for juvenile STT was fry (Figure 20). Peak emigration of juvenile steelhead fry occurred from mid-March through May of 2011 (Figure 21). Twenty-four STT were captured that were considered Age 0+ from BY 2010 or earlier. A passage index of 4,259 was generated on those captures. Brood year passage indicies are summarized from 1999 – 2011in Table 19. Age 0+ passage data from 1998 – 2010 is summarized in Table 20.

Non-salmonids—We collected a total of 1,296 individual non-salmonids from 23 taxa. The most abundant non-salmonids included Bass fry, pacific lamprey ammocoetes, pacific lamprey transformers and riffle sculpin. The common and scientific name key for non-salmonids is presented in Appendix 1. These dominant non-salmonid taxa are discussed below; all others are summarized in Appendix 3.

Micropterus fry—A total of 555 micropterus fry were collected. Micropterus fry were collected throughout the sampling season with peak capture in May and June 2011.

Pacific lamprey ammocoetes—A total of 320 lamprey ammocoetes were collected. Pacific lampreys ammocoetes were collected throughout the sampling season with peaks in December of 2010 and in June 2011.

Pacific lamprey transformers—A total of 220 Pacific lampreys transformers were collected. Pacific lamprey transformers were collected throughout the sampling season with peak passage in December 2010.

Riffle sculpin—A total of 60 riffle sculpin were collected. Riffle sculpin were collected throughout the sampling season.

Genetic and otolith sampling—We collected 166 genetic samples of Chinook salmon during this sampling season. One hundred fifty-eight were collected from UCC and 8 were collected from LCC. Samples at UCC were taken proportionately to the anticipated outmigration distribution, if enough fish were available. Samples from LCC were taken when forklength designated the Chinook as WCS or LFCS silvery parr and smolt life stage classifications. During the genetic sampling process, samples of various forklengths were taken when possible to avoid sampling siblings that might potentially bias the genetic analysis. We collected 54 STT and 9 Chinook otolith samples from LCC and 3 STT from UCC. All samples collected were < 50 mm.

Mark and recapture efficiency estimates

Upper Clear Creek—We conducted six mark-recapture trials to test for RST efficiency. The release of marked fish started on November 30, 2010 and ended on December 23, 2010. Two thousand six hundred forty Chinook salmon were released and 276 were recaptured (Table 8). In five of six trials, Chinook were dual marked with Bismarck Brown and an upper or lower caudal fin clip, to distinguish between multiple weekly release groups and trap locations. During one trial, we released 135 with only Bismarck Brown as a single mark and no clip at all.

The number of individual fish released for each trial ranged from 135 – 647, with an average of 440. Recaptured fish numbers per trial ranged from 19 – 66 with an average of 46. Efficiencies ranged from 6.8% to 16.9% per trial, with an average of 11.4% (Table 9).

Due to low fish collection numbers, we were unable to conduct mark and recapture studies from November 3 until November 29, 2010. As described in the methods, for the periods from November 3 through November 29, 2010 (weeks 47 – 48) we substituted the "season" efficiency. The seasonal efficiency was calculated by dividing the average number of released fish (440+1) of the 6 trials by the average number of recaptures (46+1). Therefore, the seasonal average was 10.45% (46+1)/(440+1).

Lower Clear Creek—We conducted 23 Chinook salmon mark-recapture trials to test for RST efficiency. The release of marked fish started on January 2, 2011 and ended on April 23, 2011. A total of 12,624 Chinook salmon were released, 42 mortalities occurred from the marking procedures, and 793 were recaptured (Table 10). During 21 of 23 trials Chinook were dual marked with Bismarck Brown and either an upper or lower caudal fin clip, to distinguish between multiple weekly release groups and concurrent trials conducted upstream. The number of individual fish marked for each trial ranged from 93 – 818, with an average of 549. Recaptured fish numbers per trial ranged from 7 – 63 with an average of 34. Efficiencies ranged from 3% to 11% per trial, with an average of 6.4% (Table 11).

Due to low fish collection numbers, we were unable to conduct mark and recapture studies from November 24 until January 6, 2010. As described in the methods, for the period from November 2, 2010 through January 7, 2011(weeks 47 – 1), March14 through March 28, 2011 (weeks 11 – 13), April 30 – June 30, 2011 (weeks 18 – 26), we substituted the "season" efficiency. The seasonal efficiency was calculated by dividing the average number of fish released (549) of the 23 trials used, by the average number of recaptures (34). Therefore, the seasonal average was 6.4% (34+1/549+1).

Additionally within the 23 trials, 20 were composed of multiple marks within each group, with either an upper clip or a lower clip. We compared the results of the paired releases using a paired t-test and found there to be no significant difference ($t= 2.10; df=18; P=.12$) between the two clip groups with an α value set at .05. We did observe that in some cases the difference in efficiency was two times higher from 2.7% to 8.5%..

Mortality

Marking mortality—A total of 7 mortalities occurred among the 2,640 marked Chinook salmon at the upper Clear Creek RST, for a total marking mortality (= total marking mortalities / total number of fish released = 7/2,640) of 0.3%. Mortalities resulting from our marking procedures for each efficiency trial ranged from 1 – 3.

A total of 42 mortalities occurred among the 12,624 marked Chinook salmon at the lower Clear Creek RST, for a total marking mortality (= total marking mortalities / total number of fish released = 42/12,624) of 0.3%. Mortalities resulting from our marking procedures for each efficiency trial ranged from 1 – 7.

All mortalities were incidental and no significant marking mortalities occurred (Table 8 and Table 10).

Trapping mortality—A total of 313 mortalities for all runs of Chinook salmon and steelhead / rainbow trout occurred as a result of RST sampling for BY 2010.

Upper Clear Creek spring-run Chinook salmon—There were 2,059 BY 2010 SCS captured in the UCC RST. Of these captures 70 were recorded as mortalities generating a 3.5% mortality rate of fish handled and a 0.4% mortality rate of the total passage index of 17,359. (Table 12).

Lower Clear Creek late-fall-run Chinook salmon—There were 772 BY 2010 LFC captured in the LCC RST. Of these captures 9 were recorded as mortalities generating a 1.2% mortality rate of fish handled and a 0.01% mortality rate of the total passage index of 22,853 (Table 13).

Winter-run Chinook salmon—No WCS mortalities were recorded.

Spring-run Chinook salmon—There were 2,129 BY 2010 SCS captured in the lower Clear Creek RST. Eight SCS mortalities were recorded (Table 14) for a 0.4% catch mortality rate and 0.02% of the total passage of 32,955.

Fall-run Chinook salmon—There were 238,306 BY 2010 FCS captured in the LCC RST. Of these captures 3,047 were recorded as mortalities generating a 1.3% mortality rate of fish handled and a 0.1% mortality rate of the total passage index of 3,566,723 (Table 15).

Steelhead / rainbow Trout—There were 24 BY 2010 and 1,110 BY 2011 STT captured in the LCC RST. Broodyear 2010 had no recorded mortalities. BY 2011 had four fry resulting in .4% mortality of catch and .02% of passage.

Pulse Flow Sampling

In the first pulse flow event we began sampling the LCC RST at 1100 on May 23, 2011 our first Chinook capture was collected at 1600, passage peaked at 2300 with 16 Chinook captured, and concluded at 1000 the following day, for 51 Chinook (Figure 24). On the following day, Chinook outmigration began at 2100, peaked again at 2300 with eight Chinook, and concluded at 1000 the following morning for a total of 26 Chinook captures. STT juveniles responded similarly with fewer fish (Figure 24). Both Chinook and STT tended to move during higher turbidity, readings ranged from 30.1 to 1.28 NTU' s.

During the second pulse flow event, we sampled between June 5 and June 7, 2011. The first sampling day we captured only three Chinook at 2300 for the entire 24-hour period beginning at 1100. Similar to the first pulse flow, out migration began on the second day at 2000 but had a bi-modal peak at 2100 and 0300 the following morning, concluding at 0700. Sixty Chinook were captured on the second day, with 63 for the entire pulse flow event. STT again responded similarly with no fish passing on the first day and passing between the hours of 2200 and 0600.

Discussion and Recommendations

Sampling effort

The trapping conditions during the BY2010 season were good for out-migrant sampling at both locations. Although we missed several sampling days towards the latter part of the season at the UCC RST due to trap damage, we never interpolated catch data. The peak flow events occurred during the time in which the trap was out and at the time, we were catching few to no Chinook in the trap daily. The LCC RST missed few days due to high flows and interpolated less than 1% of FCS catch data. By the time the peak flow events occurred in March, 99% of the FCS had passed and the onset of LFCS passage had not yet begun.

Upper Clear Creek spring-run Chinook salmon abundance—The 10 SCS redds observed was small yet our juvenile passage index of 17,359 yielded a higher number of juveniles per redd than the past two years 1,929 compared to 2009 and 2008 with 1,158 and 1,414 respectively (Figure 23). Having such few redds resulted in our lowest total catch to date of 2,059 individuals.

Lower Clear Creek late-fall-run Chinook salmon abundance —The BY 2010 late-fall JPI decreased from the previous year. There was a 73% decrease in the number of redds resulting in our lowest JPI in the past 5 years, our 11 year average is over 102,000. It is likely that the number of LFC juveniles generated by length-at-date tables is over or underestimated by the large number of FCS juveniles present and the lack of differentiation between the two runs in late-March and early-April.

Recommendation 1: We recommend using an analysis of expected emergence timing for LFC based on 1,850 daily temperature units to emergence to determine the emergence date of LFC fry. Using a temperature-based analysis will allow for more accurate run classification and associated passage indices.

Lower Clear Creek fall-run Chinook salmon abundance —The FCS JPI of 3,566,723 was an improvement from the previous year. however we had a low number of juveniles per female of 972. In the fall of 2008 the Moon wildfire and subsequent erosion has led to significant amounts of sand deposited in to the mainstem fork of Clear Creek from the South Fork of Clear Creek. Excessive amounts of sand may have created less than ideal spawning conditions downstream of the confluence with the south fork. This includes the majority of spawning habitat for fall, late-fall Chinook and steelhead / rainbow trout.

Lower Clear Creek steelhead / rainbow trout abundance—The steelhead / rainbow trout present in Clear Creek exhibit characteristics of a winter-run steelhead, with adults migrating upstream in the late fall and winter and most fry outmigration beginning in late January or early February and peaking during the months of April and May. The BY2011 redd count for adult steelhead of 218 was the third highest on record, surpassed only by the two previous years. The juvenile production per redd increased from 51 to 89 from that of BY2010, however was still low(Table 19). We anticipated that with 218 redds we would estimate passage to be approximately 36,000 juveniles based on our average (2001-10) productivity of 168 juveniles per redd. Conversely, we estimated 89 juveniles per redd. Since 2008, juvenile productivity of steelhead and has been reduced (Table 19), this may be an effect of the Moon Fire.

A multi day high flow that occurred between March 19th and March 28th may have had some effects on our estimate. The highest weekly catch and passage occurred in the days after the event, which may suggest that we missed some of the peak outmigration. Alternatively, many juveniles may have chosen a different rearing strategy and stayed in freshwater as opposed to migrating downstream. If the latter rearing strategy occurred than it would be difficult to measure the spawning success in the population.

Recommendation 2: The Clear Creek Technical Team should continue to pursue the RPA Action I.1.2 from the NMFS 2009 BO, conducting Channel Maintenance Flows. The Action of re-operating Whiskeytown Dam to produce flows of 3,250 cfs will improve the gravel quality by reducing the amount fine sediment. This will likely benefit all spawning populations in the lower watershed, which appear to be experiencing below average production.

Genetic and otolith sampling—Genetic samples of juvenile Chinook salmon are analyzed by the Oregon State University's Hatfield Marine Lab in Newport, Oregon, by Dr. Michael Banks. At the time of this report samples collected during the 2010-2011 sampling seasons have not yet been contracted out and analyzed. We are hoping that advances in the technology used for genetic analysis will continue to improve and assist us in refining our passage indices. Additionally, we hope to develop a Clear Creek genetic baseline from Chinook spawning in Clear Creek.

We collected steelhead / rainbow trout otolith samples for analysis of strontium to calcium ratios to assist in identifying the proportion of juveniles that are of anadromous maternal lineage. Identifying these individuals may allow us to apply anadromous lineage to a proportion of the total *O. mykiss* captures and develop an anadromous and resident estimate. We currently have no other method for determining the proportion of steelhead / rainbow trout that are anadromous.

Mark and recapture efficiency estimates

Upper Clear Creek—The results of mark and recapture trials for the UCC were consistent with all other years (except 2006) ranging from 6.7-16.6%. There were no significant flow events that occurred during the SCS migration from the upper watershed. Mark and recapture trial flows and results were optimal for determining gear efficiency and SCS JPI.

Lower Clear Creek—The 23 trials conducted for FCS using Chinook were successful and within our expected range. The range of efficiency does get greater throughout the season, the last four trials ranged from 4.0% to 11.0% compared to earlier in the season where the range of the first five trials is tighter from 5.4% to 6.4%. Stafford and Brown 2012, described this general pattern that fish may tend to rear when there is less dense populations, suggesting that in a year like BY 2010 where the total population estimated was smaller, more fish may have held versus move out during the trails.

Recommendation 3: We will continue to conduct multiple clip group efficiency trials to test for significant differences amongst release groups and if particular clip methods contribute to fish behavior.

Pulse flow Sampling

Daily sampling suggests that juveniles move out more during natural rain events than during sunny day increases in release from Whiskeytown reservoir (Figure 24). Increased outmigration may be associated with subtle turbidity increases during the pulse events.

Recommendation 4: We will continue to sample pulse flow events and conduct other experiments in 24-hour sampling to better evaluate diel outmigration patterns and interpret which environmental variables contribute more to fish movement.

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Tables

Table 1. The 2010 Clear Creek snorkel survey reach numbers, locations and river miles for reference. In August 2010, the Clear Creek picket weir was initially placed instream at river mile 8.2 just below the Upper Clear Creek RST. After identifying additional adult Chinook just below the upper weir site, a second weir was installed at river mile 7.5 to protect a greater percentage of the population from potential spawning superimposition from fall-run Chinook spawners. The juvenile passage index is adjusted for redds identified above the lowest weir at river mile 7.5.

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
5a1	8.6 - 8.2	Clear Creek Road Bridge to Reading Bar Picket Weir Site
5a2	8.2 - 7.5	Reading Bar Picket Weir Site to Shooting Gallery Picket Weir Site
5b	7.5 - 6.5	Shooting Gallery Picket Weir Site to Old McCormick-Saeltzer DamSite
6	6.5 - 1.7	Old McCormick-Saeltzer Dam Site to USFWS Lower Rotary Screw Trap

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, California, by the U.S. Fish and Wildlife Service from October 1, 2010 through June 30, 2011.

Dates	Corresponding Week	Dates	Corresponding Week
09/30-10/06	40	04/02-04/08	14
10/07-10/13	41	04/09-04/15	15
10/14-10/20	42	04/16-04/22	16
10/21-10/27	43	04/23-04/29	17
10/28-11/03	44	04/30-05/06	18
11/04-11/10	45	05/07-05/13	19
11/11-11/17	46	05/14-05/20	20
11/18-11/24	47	05/21-05/27	21
11/25-12/01	48	05/28-06/03	22
12/02-12/08	49	06/04-06/10	23
12/09-12/15	50	06/11-06/17	24
12/16-12/22	51	06/18-06/24	25
12/23-12/31	52	06/25-07/01	26
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

Table 3. Weekly passage indices with 90% and 95% confidence intervals and standard error (SE) of the weekly strata of Broodyear 2010 spring-run Chinook salmon captured at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
	No	Sampling	From	10/01/10	To	11/01/2010		
3 of 7	44	10/29/10	0	0	0	0	0	0
6 of 7	45	11/05/10	0	0	0	0	0	0
7 of 7	46	11/12/10	0	0	0	0	0	0
7 of 7	47	11/19/10	116	120	150	186	196	0.67
4 of 7	48 Pt. I	11/26/10	1,437	1,510	1,895	2,408	2,475	8.71
3 of 7	48 Pt. II		450	466	653	933	1,004	4.56
4 of 7	49 Pt. I	12/03/10	3,037	3,254	4,556	6,075	7,009	30.90
3 of 7	49 Pt. II		2,609	2,705	3,478	4,427	4,565	16.87
1 of 7	50 Pt. I	12/10/10	593	616	777	989	1,053	3.60
4 of 7	50 Pt. II		1,461	1,504	1,826	2,223	2,324	7.33
2 of 7	50 Pt. III		780	799	966	1,156	1,222	3.52
4 of 7	51 Pt. I	12/17/10	787	806	975	1,166	1,209	3.42
2 of 7	51 Pt. II		909	926	1,178	1,481	1,620	5.56
1 of 7	51 Pt. III		137	141	175	216	227	0.74
7 of 8	52*	12/24/10	236	243	298	368	386	1.21
7 of 7	1	01/01/11	29	30	38	48	50	0.17
7 of 7	2	01/08/11	43	46	56	70	74	0.24
7 of 7	3	01/15/11	29	30	38	48	50	0.17
7 of 7	4	01/22/11	36	37	47	60	61	0.21
7 of 7	5	01/29/11	0	0	0	0	0	0.00
7 of 7	6	02/05/11	7	7	9	12	12	0.04
7 of 7	7	02/12/11	22	22	28	35	37	0.12
7 of 7	8	02/19/11	43	45	56	70	72	0.25
7 of 7	9	02/26/11	51	53	66	83	88	0.30

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	10	03/05/11	37	37	47	58	63	0.22
1 of 7	11	03/12/11	7	7	9	12	13	0.04
0 of 7	12	03/19/11	0	0	0	0	0	0
0 of 7	13	03/26/11	0	0	0	0	0	0
0 of 7	14	04/02/11	0	0	0	0	0	0
0 of 7	15	04/09/11	0	0	0	0	0	0
0 of 7	16	04/16/11	0	0	0	0	0	0
0 of 7	17	04/23/11	0	0	0	0	0	0
0 of 7	18	04/30/11	0	0	0	0	0	0
7 of 7	19	05/07/11	0	0	0	0	0	0
7 of 7	20	05/14/11	29	30	38	48	50	0.17
5 of 7	21	05/21/11	0	0	0	0	0	0
7 of 7	22	05/28/11	0	0	0	0	0	0
7 of 7	23	06/04/11	0	0	0	0	0	0
7 of 7	24	06/11/11	0	0	0	0	0	0
7 of 7	25	06/18/11	0	0	0	0	0	0
7 of 7	26	06/25/11	0	0	0	0	0	0
	No	Sampling	From	07/01/11	To	9/30/2011		
183 of 365			15,228	15,618	17,359	19,416	19,910	38.45

*Week 52 (12/24/10-12/31/10) contains 8 days for keeping Jan. 1 as Julian calendar day 1.

Table 4. Weekly passage indices with 90% and 95% confidence intervals and standard error (SE) of the weekly strata of Broodyear 2010 late-fall-run Chinook salmon captured at the lower rotary screw at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 1, 2010 through March 31, 2011. Sampling of late-fall Chinook was not conducted from 7/1/10 – 11/01/2010.

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	14 ('10)	04/02/10	1,087	1,116	1,524	2,065	2,174	9.26
5 of 7	15	04/09/10	3,459	3,552	4,874	6,571	7,301	30.50
7 of 7	16	04/16/10	4,082	4,423	5,897	7,961	8,845	37.09
7 of 7	17	04/23/10	2,075	2,190	2,921	4,150	4,381	18.88
7 of 7	18	04/30/10	810	855	1,140	1,540	1,711	7.31
7 of 7	19	05/07/10	2,638	2,781	3,811	5,144	5,415	23.56
7 of 7	20	05/14/10	404	426	584	789	830	3.69
7 of 7	21	05/21/10	770	812	1,113	1,502	1,581	7.12
7 of 7	22	05/28/10	231	244	327	451	474	2.00
7 of 7	23	06/04/10	212	223	306	413	459	1.87
7 of 7	24	06/11/10	59	61	83	113	119	0.51
7 of 7	25	06/18/10	40	41	56	75	79	0.34
7 of 7	26	06/25/10	39	41	56	79	83	0.38
	No	Sampling	From	07/01/10	To	11/01/10		
3 of 7	44	10/29/10	23	24	31	41	44	0.17
7 of 7	45	11/05/10	23	24	31	41	42	0.17
7 of 7	46	11/12/10	11	12	16	20	22	0.08
7 of 7	47	11/19/10	11	12	16	20	21	0.08
7 of 7	48	11/26/10	0	0	0	0	0	0.00
7 of 7	49	12/03/10	0	0	0	0	0	0.00
7 of 7	50	12/10/10	46	49	58	85	88	0.34
7 of 7	51	12/17/10	0	0	0	0	0	0.00
7 of 8	52*	12/24/10	0	0	0	0	0	0.00
7 of 7	1 ('11)	01/01/11	0	0	0	0	0	0.00

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	2	01/08/11	0	0	0	0	0	0.00
7 of 7	3	01/15/11	0	0	0	0	0	0.00
7 of 7	4	01/22/11	0	0	0	0	0	0.00
7 of 7	5	01/29/11	0	0	0	0	0	0.00
7 of 7	6	02/05/11	0	0	0	0	0	0.00
7 of 7	7	02/12/11	0	0	0	0	0	0.00
7 of 7	8	02/19/11	0	0	0	0	0	0.00
7 of 7	9	02/26/11	0	0	0	0	0	0.00
7 of 7	10	03/05/11	0	0	0	0	0	0.00
5 of 7	11	03/12/11	0	0	0	0	0	0.00
2 of 7	12	03/19/11	0	0	0	0	0	0.00
4 of 7	13	03/26/11	6	7	9	13	14	0.06
			19,929	20,231	22,853	26,166	27,111	58.77

*Week 52 (12/24/10-12/31/10) contains 8 days for keeping Jan. 1 as Julian calendar day 1.

Table 5. Weekly passage indices with 90% and 95% confidence intervals and standard error (SE) of the weekly strata of Broodyear 2010 fall-run Chinook salmon captured at the lower rotary screw at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
	No	Sampling	From	10/01/10	To	11/01/2010		
3 of 7	44	10/29/10	0	0	0	0	0	0
7 of 7	45	11/05/10	0	0	0	0	0	0
7 of 7	46	11/12/10	0	0	0	0	0	0
7 of 7	47	11/19/10	0	0	0	0	0	0
7 of 7	48	11/26/10	138	147	182	244	264	1.00
7 of 7	49	12/03/10	10,495	11,179	14,686	19,046	20,570	80.31
7 of 7	50	12/10/10	23,638	24,152	31,750	41,148	44,440	171.54
7 of 7	51	12/17/10	32,203	34,303	45,079	60,690	65,748	250.73
7 of 8	52*	12/24/10	129,525	138,160	177,630	230,267	248,688	944.25
7 of 7	1 Pt. I	01/01/11	9,327	9,529	12,517	16,235	17,534	68.75
	1 Pt. II		61,102	62,753	85,995	116,094	122,204	526.39
	1 Pt. III		38,435	40,223	52,409	69,184	75,200	285.84
7 of 7	2 Pt. I	01/08/11	53,800	56,874	76,562	99,530	110,589	457.51
	2 Pt. II		89,320	92,893	119,096	149,827	165,880	599.48
7 of 7	3 Pt. I	01/15/11	144,804	150,838	195,681	258,579	268,156	1031.05
	3 Pt. II		157,986	162,256	196,835	240,138	250,144	750.38
7 of 7	4 Pt. I	01/22/11	259,738	273,653	340,546	437,844	464,380	1597.22
	4 Pt. II		182,844	191,348	249,333	329,119	342,832	1302.50
7 of 7	5 Pt. I	01/29/11	274,141	286,892	373,829	514,014	536,363	2068.32
	5 Pt. II		111,073	115,112	147,236	191,853	197,849	716.23
7 of 7	6 Pt. I	02/05/11	269,251	282,073	370,220	493,627	515,089	2038.91
	6 Pt. II		163,780	168,743	210,133	259,002	271,636	864.01
7 of 7	7 Pt. I	02/12/11	294,431	306,054	369,208	438,869	456,080	1389.40
	7 Pt. II		72,395	76,572	97,116	124,429	132,725	486.79
7 of 7	8 Pt. I	02/19/11	82,852	84,923	113,231	147,693	169,846	709.32
	8 Pt. II		27,120	28,352	37,803	49,900	54,239	222.63

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	9 Pt. I	02/26/11	32,148	33,517	43,766	58,344	60,588	230.59
	9 Pt. II		86,367	89,566	134,339	186,022	201,524	1036.41
7 of 7	10 Pt. I	03/05/11	10,920	11,115	14,146	17,784	18,862	64.11
	10 Pt. II		4,087	4,161	5,323	6,732	7,152	24.52
5 of 7	11	03/12/11	8,151	8,580	13,597	20,377	23,288	133.97
2 of 7	12	03/19/11	6,932	7,394	9,507	12,324	13,310	51.50
4 of 7	13 Pt. I	03/26/11	6,062	6,331	8,140	10,958	11,396	44.75
	13 Pt. II		1,576	1,672	2,207	3,065	3,246	14.17
7 of 7	14	04/02/11	3,197	3,336	4,379	5,683	5,902	23.41
6 of 7	15	04/09/11	653	682	891	1,161	1,206	4.84
7 of 7	16	04/16/11	206	215	283	367	396	1.53
7 of 7	17	04/23/11	483	517	905	1,448	1,810	10.52
7 of 7	18	04/30/11	1,432	1,495	1,964	2,546	2,750	10.39
7 of 7	19	05/07/11	1,077	1,100	1,446	1,874	2,024	7.60
7 of 7	20	05/14/11	1,616	1,723	2,216	2,872	2,983	11.58
7 of 7	21	05/21/11	1,295	1,351	1,776	2,390	2,486	10.25
7 of 7	22	05/28/11	1,043	1,112	1,430	1,854	2,002	7.61
7 of 7	23	06/04/11	1,707	1,782	2,341	3,035	3,152	12.32
7 of 7	24	06/11/11	241	251	330	428	462	1.77
7 of 7	25	06/18/11	401	418	550	713	740	2.82
7 of 7	26	06/25/11	80	86	110	148	154	0.59
		No	Sampling	From	07/01/11	To	9/30/2011	
			3,305,917	3,347,938	3,566,723	3,827,295	3,871,986	4522.12

*Week 52 (12/24/10-12/31/10) contains 8 days for keeping Jan. 1 as Julian calendar day 1.

Table 6. Weekly passage indices with 90% and 95% confidence intervals, standard error (SE) of the weekly strata for BY 2011, steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	1	01/01/11	0	0	0	0	0	0.00
7 of 7	2	01/08/11	0	0	0	0	0	0.00
4 of 7	3 Pt. I	01/15/11	0	0	0	0	0	0.00
3 of 7	3 Pt. II		16	17	20	25	26	0.08
4 of 7	4 Pt. I	01/22/11	65	68	86	111	114	0.41
3 of 7	4 Pt. II		78	80	107	141	153	0.59
4 of 7	5 Pt. I	01/29/11	79	83	110	152	158	0.64
3 of 7	5 Pt. II		0	0	0	0	0	0.00
4 of 7	6 Pt. I	02/05/11	68	71	93	124	129	0.53
3 of 7	6 Pt. II		36	37	46	56	59	0.19
4 of 7	7 Pt. I	02/12/11	38	39	48	58	61	0.19
3 of 7	7 Pt. II		76	79	102	130	139	0.49
4 of 7	8 Pt. I	02/19/11	314	329	439	573	628	2.51
3 of 7	8 Pt. II		366	384	500	634	687	2.61
4 of 7	9 Pt. I	02/26/11	722	737	962	1,237	1,386	5.06
3 of 7	9 Pt. II		932	1,004	1,450	2,175	2,373	11.49
4 of 7	10 Pt. I	03/05/11	861	908	1,135	1,427	1,514	5.27
3 of 7	10 Pt. II		291	308	386	503	519	1.83
5 of 7	11	03/12/11	348	367	581	871	996	5.25
2 of 7	12	03/19/11	374	391	503	652	677	2.60
1 of 7	13 Pt. I	03/26/11	386	395	519	672	756	2.84
3 of 7	13 Pt. II		306	315	429	595	630	2.69
7 of 7	14	04/02/11	1,931	2,017	2,593	3,490	3,630	13.70
6 of 7	15	04/09/11	854	873	1,147	1,487	1,606	6.14
7 of 7	16	04/16/11	355	379	487	656	682	2.66

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	17	04/23/11	376	376	658	1,053	1,316	11.04
7 of 7	18	04/30/11	722	753	990	1,333	1,386	5.62
7 of 7	19	05/07/11	378	395	519	698	726	2.76
7 of 7	20	05/14/11	779	813	1,069	1,385	1,438	5.73
7 of 7	21	05/21/11	597	610	801	1,039	1,079	4.05
7 of 7	22	05/28/11	1,451	1,483	1,949	2,526	2,728	10.11
7 of 7	23	06/04/11	655	670	880	1,141	1,232	4.71
7 of 7	24	06/11/11	80	86	110	143	154	0.59
7 of 7	25	06/18/11	140	147	189	254	264	1.04
7 of 7	26	06/25/11	164	171	220	285	308	1.20
	No	Sampling	From	07/01/11	To	11/01/11		
4 of 7	44	10/29/2011	47	49	63	84	87	0.33
5 of 7	45	11/5/2011	11	12	16	21	22	0.08
7 of 7	46	11/12/2011	47	49	63	81	87	0.33
7 of 7	47	11/19/2011	103	110	142	188	203	0.77
7 of 7	48	11/26/2011	23	24	32	40	43	0.17
7 of 7	49	12/3/2011	24	25	32	40	43	0.16
7 of 7	50	12/10/2011	24	24	32	42	43	0.17
7 of 7	51	12/17/2011	0	0	0	0	0	0.00
7 of 7	52*	12/24/2011	0	0	0	0	0	0.00
			17,965	18,165	19,508	21,127	21,612	

*Week 52 (12/24/11-12/31/11) contains 8 days for keeping Jan. 1 as Julian calendar day 1.

Table 7. Weekly passage indices with 90% and 95% confidence intervals, standard error (SE) of the weekly strata for BY 2010, Age 0+, steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
1 of 7	1 Pt. I ('11)	01/01/11	0	0	0	0	0	0.00
3 of 7	1 Pt. II		11	12	17	22	23	0.10
3 of 7	1 Pt. III		0	0	0	0	0	0.00
4 of 7	2 Pt. I	01/08/11	12	13	18	24	26	0.11
3 of 7	2 Pt. II		0	0	0	0	0	0
7 of 7	3	01/15/11	0	0	0	0	0	0
7 of 7	4	01/22/11	0	0	0	0	0	0
7 of 7	5	01/29/11	0	0	0	0	0	0
7 of 7	6	02/05/11	0	0	0	0	0	0
4 of 7	7 Pt I	02/12/11	0	0	0	0	0	0
3 of 7	7 Pt II		11	11	15	19	20	0.07
7 of 7	8	02/19/11	0	0	0	0	0	0
7 of 7	9	02/26/11	0	0	0	0	0	0
7 of 7	10	03/05/11	0	0	0	0	0	0
7 of 7	11	03/12/11	0	0	0	0	0	0
7 of 7	12	03/19/11	47	49	63	81	88	0.33
4 of 7	13 Pt I	03/26/11	47	48	63	81	88	0.34
3 of 7	13 Pt II		26	28	36	51	54	0.23
7 of 7	14	04/02/11	23	24	31	41	44	0.16
6 of 7	15	04/09/11	11	12	16	20	22	0.08
7 of 7	16	04/16/11	0	0	0	0	0	0
7 of 7	17	04/23/11	0	0	0	0	0	0
7 of 7	18	04/30/11	0	0	0	0	0	0
7 of 7	19	05/07/11	0	0	0	0	0	0
7 of 7	20	05/14/11	0	0	0	0	0	0

Days Sampled	Week	Date	95% LCI	90% LCI	Weekly Passage	90% UCI	95% UCI	S.E.
7 of 7	21	05/21/11	0	0	0	0	0	0
7 of 7	22	05/28/11	0	0	0	0	0	0
7 of 7	23	06/04/11	0	0	0	0	0	0
7 of 7	24	06/11/11	0	0	0	0	0	0
7 of 7	25	06/18/11	0	0	0	0	0	0
7 of 7	26	06/25/11	0	0	0	0	0	0
	No	Sampling	From	07/01/11	To	11/01/11		
4 of 7	44	10/29/2011	0	0	0	0	0	0
5 of 7	45	11/5/2011	0	0	0	0	0	0
7 of 7	46	11/12/2011	0	0	0	0	0	0
7 of 7	47	11/19/2011	0	0	0	0	0	0
7 of 7	48	11/26/2011	0	0	0	0	0	0
7 of 7	49	12/3/2011	0	0	0	0	0	0
7 of 7	50	12/10/2011	0	0	0	0	0	0
7 of 7	51	12/17/2011	0	0	0	0	0	0
8 of 8	52*	12/24/2011	0	0	0	0	0	0
			189	197	259	340	366	2.25

*Week 52 (12/24/11-12/31/11) contains 8 days for keeping Jan. 1 as Julian calendar day 1.

Table 8. Summary of efficiency test data gathered by using mark-recapture trials with juvenile Chinook salmon at the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 29, 2010 through December 23, 2010. The equation for estimating efficiency is E = (R+1)/(M+1).

Trial	Mark Date	Release Date	Fish Released	Mortality	% Mortality	Recapture	Efficiency
1	29-Nov-10	30-Nov-10	135	0	0.00%	19	14.71%
2	6-Dec-10	7-Dec-10	501	3	0.60%	41	8.37%
3	10-Dec-10	11-Dec-10	331	3	0.92%	55	16.87%
4	14-Dec-10	15-Dec-10	562	1	0.17%	66	11.90%
5	21-Dec-10	21-Dec-10	647	0	0.00%	43	6.79%
6	23-Dec-10	23-Dec-10	464	0	0.00%	52	11.40%
	Total		2,640	7	0.27%	276	

Table 9. Mark and recapture efficiency values used for weekly passage indices of Chinook salmon and steelhead / rainbow trout captured in the upper rotary screw trap at river mile 8.4 by the U.S. Fish and Wildlife Service from November 1, 2010 to June 30, 2011. Lightly shaded rows indicate weeks where season efficiency was used. The equation for estimating efficiency is E = (R+1)/(M+1).

Dates	Week	Marks	Recaptures	Efficiency
11/19 – 11/29	47-48	440	46	10.66%
11/30 – 12/02	48	135	19	14.71%
12/03 – 12/06	49	135	19	14.71%
12/07 – 12/10	49	501	41	8.37%
12/11 – 12/14	50	331	55	16.87%
12/15 – 12/20	50-51	562	66	11.90%
12/21 – 12/22	51	647	43	6.79%
12/23 – 12/31	51-52	464	52	11.40%
01/01 – 03/12	1-11	440	46	10.66%
03/13 – 05/06		No Sampling		
05/07 – 06/30	19-26	440	46	10.66%

Table 10. Summary of efficiency test data gathered by using mark-recapture trials with juvenile Chinook salmon at the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from January 6, 2011 through March 4, 2011. The equation for estimating efficiency is E = (R+1)/(M+1).

Trial	Mark Date	Release Date	Fish Released	Mortality	% Mortality	Recapture	Efficiency
1	1-Jan-11	2-Jan-11	445	3	0.67%	26	6.05%
2	4-Jan-11	5-Jan-11	595	2	0.34%	32	5.54%
3	7-Jan-11	8-Jan-11	460	3	0.65%	25	5.64%
4	11-Jan-11	12-Jan-11	595	2	0.34%	38	6.54%
5	14-Jan-11	15-Jan-11	599	0	0.00%	36	6.17%
6	18-Jan-11	19-Jan-11	619	1	0.16%	60	9.84%
7	21-Jan-11	22-Jan-11	644	0	0.00%	44	6.98%
8	25-Jan-11	26-Jan-11	586	0	0.00%	32	5.62%
9	28-Jan-11	29-Jan-11	605	0	0.00%	32	5.45%
10	1-Feb-11	2-Feb-11	580	0	0.00%	42	7.40%
11	4-Feb-11	5-Feb-11	594	0	0.00%	31	5.38%
12	8-Feb-11	9-Feb-11	605	1	0.17%	52	8.75%
13	11-Feb-11	12-Feb-11	601	1	0.17%	62	10.47%
14	16-Feb-11	16-Feb-11	594	3	0.51%	40	6.89%
15	18-Feb-11	19-Feb-11	598	7	1.17%	29	5.01%
16	22-Feb-11	23-Feb-11	588	2	0.34%	32	5.60%
17	25-Feb-11	26-Feb-11	752	0	0.00%	35	4.78%
18	1-Mar-11	2-Mar-11	606	1	0.17%	17	2.97%
19	4-Mar-11	5-Mar-11	818	4	0.49%	43	5.37%
20	8-Mar-11	9-Mar-11	518	6	1.16%	42	8.29%
21	11-Mar-11	12-Mar-11	302	3	0.99%	11	3.96%
22	30-Mar-11	30-Mar-11	227	3	1.32%	24	10.96%
23	23-Apr-11	23-Apr-11	93	0	0.00%	7	8.51%
	Total		12,723	42	0.33%	793	

Table 11. Mark and recapture efficiency values used for weekly passage indices of Chinook salmon and steelhead / rainbow trout captured in the lower rotary screw trap at river mile 1.7 by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Lightly shaded rows indicate weeks where season efficiency was used. The equation for estimating efficiency is E = (R+1)/(M+1).

Dates	Week	Marks	Recaptures	Efficiency
11/01 – 12/31	44-52	549	34	6.36%
01/02 – 01/04	1	445	26	6.05%
01/05 – 01/07	1	595	32	5.54%
01/08 – 01/11	2	460	25	5.64%
01/12 – 01/14	2	595	38	6.54%
01/15 – 01/18	3	599	36	6.17%
01/19 – 01/21	3	619	60	9.84%
01/22 – 01/25	4	644	44	6.98%
01/26 – 01/28	4	586	32	5.62%
01/29 – 02/01	5	605	32	5.45%
02/02 – 02/04	5	580	42	7.40%
02/05 – 02/08	6	594	31	5.38%
02/09 – 02/11	6	605	52	8.75%
02/12 – 02/15	7	601	62	10.47%
02/16 – 02/18	7	594	40	6.89%
02/19 – 02/22	8	598	29	5.01%
02/23 – 02/25	8	588	32	5.60%
02/26 – 03/01	9	752	35	4.78%
03/02 – 03/04	9	606	17	2.97%
03/05 – 03/08	10	818	43	5.37%
03/09 – 03/11	10	518	42	8.29%
03/12 – 03/18	11	302	11	3.96%
03/19 – 03/25	12	549	34	6.36%
03/26 – 03/29	13	549	34	6.36%
03/30 – 04/01	13	227	24	10.96%
04/02 – 04/22	14-16	549	34	6.36%
04/23 – 04/29	17	93	7	8.51%
04/30 – 06/30	18-26	549	34	6.36%

Table 12. Annual mortality of spring-run Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

Week	Date	Weekly Passage	Catch	Mortality	% Passage	% Catch
No sampling 10/01/10 – 11/01/2010 Weeks 40 – 43						
44	10/29/10	0	0	0	0.00%	0.00%
45	11/05/10	0	0	0	0.00%	0.00%
46	11/12/10	0	0	0	0.00%	0.00%
47	11/19/10	150	16	0	0.00%	0.00%
48	11/26/10	2,548	298	2	0.08%	0.67%
49	12/03/10	8,034	961	40	0.50%	4.16%
50	12/10/10	3,569	488	26	0.73%	5.33%
51	12/17/10	2,328	216	2	0.09%	0.93%
52*	12/24/10	298	34	0	0.00%	0.00%
1	01/01/11	38	4	0	0.00%	0.00%
2	01/08/11	56	6	0	0.00%	0.00%
3	01/15/11	38	4	0	0.00%	0.00%
4	01/22/11	47	5	0	0.00%	0.00%
5	01/29/11	0	0	0	0.00%	0.00%
6	02/05/11	9	1	0	0.00%	0.00%
7	02/12/11	28	3	2	7.14%	66.67%
8	02/19/11	56	6	0	0.00%	0.00%
9	02/26/11	66	7	0	0.00%	0.00%
10	03/05/11	47	5	0	0.00%	0.00%
11	03/12/11	9	1	0	0.00%	0.00%
No sampling 03/13/11 – 05/06/2011 Weeks 11 – 18						
19	05/07/11	0	0	0	0.00%	0.00%
20	05/14/11	38	4	0	0.00%	0.00%
21	05/21/11	0	0	0	0.00%	0.00%
22	05/28/11	0	0	0	0.00%	0.00%
23	06/04/11	0	0	0	0.00%	0.00%
24	06/11/11	0	0	0	0.00%	0.00%
25	06/18/11	0	0	0	0.00%	0.00%
26	06/25/11	0	0	0	0.00%	0.00%
No sampling 07/01/11 – 09/30/2011 Weeks 27 – 39						

Table 13. Annual mortality of late-fall-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from April 1, 2010 through March 31, 2011.

Week	Date	Weekly Passage	Catch	Mortality	% Passage	% Catch
14 ('10)	04/02/10	1,524	55	0	0.00%	0.00%
15	04/09/10	4,874	175	1	0.02%	0.57%
16	04/16/10	5,897	212	1	0.02%	0.47%
17	04/23/10	2,921	105	1	0.03%	0.95%
18	04/30/10	1,140	41	0	0.00%	0.00%
19	05/07/10	3,811	137	2	0.05%	1.46%
20	05/14/10	584	21	0	0.00%	0.00%
21	05/21/10	1,113	40	4	0.36%	10.00%
22	05/28/10	327	12	0	0.00%	0.00%
23	06/04/10	306	11	0	0.00%	0.00%
24	06/11/10	83	3	0	0.00%	0.00%
25	06/18/10	56	2	0	0.00%	0.00%
26	06/25/10	56	2	0	0.00%	0.00%
No Sampling 07/01/10 – 11/01/2010 Weeks 27 – 44						
44	10/29/10	31	2	0	0.00%	0.00%
45	11/05/10	31	2	0	0.00%	0.00%
46	11/12/10	16	1	0	0.00%	0.00%
47	11/19/10	16	1	0	0.00%	0.00%
48	11/26/10	0	0	0	0.00%	0.00%
49	12/03/10	0	0	0	0.00%	0.00%
50	12/10/10	58	4	0	0.00%	0.00%
51	12/17/10	0	0	0	0.00%	0.00%
52	12/24/10	0	0	0	0.00%	0.00%
1 ('11)	01/01/11	0	0	0	0.00%	0.00%
2	01/08/11	0	0	0	0.00%	0.00%
3	01/15/11	0	0	0	0.00%	0.00%
4	01/22/11	0	0	0	0.00%	0.00%
5	01/29/11	0	0	0	0.00%	0.00%
6	02/05/11	0	0	0	0.00%	0.00%
7	02/12/11	0	0	0	0.00%	0.00%
8	02/19/11	0	0	0	0.00%	0.00%
9	02/26/11	0	0	0	0.00%	0.00%
10	03/05/11	0	0	0	0.00%	0.00%
11	03/12/11	0	0	0	0.00%	0.00%
12	03/19/11	0	0	0	0.00%	0.00%
13	03/26/11	9	1	0	0.00%	0.00%

Table 14. Annual mortality of spring-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

Week	Date	Weekly Passage	Catch	Mortality	% Passage	% Catch
No Sampling 10/01/10 – 11/01/2010 Weeks 40 – 43						
44	10/29/10	0	0	0	0.00%	0.00%
45	11/05/10	31	2	0	0.00%	0.00%
46	11/12/10	220	14	0	0.00%	0.00%
47	11/19/10	864	55	0	0.00%	0.00%
48	11/26/10	3,165	201	0	0.00%	0.00%
49	12/03/10	12,154	773	4	0.03%	0.52%
50	12/10/10	8,579	546	1	0.01%	0.18%
51	12/17/10	3,981	253	0	0.00%	0.00%
52	12/24/10	634	40	3	0.47%	7.50%
1	01/01/11	657	37	0	0.00%	0.00%
2	01/08/11	275	16	0	0.00%	0.00%
3	01/15/11	0	0	0	0.00%	0.00%
4	01/22/11	0	0	0	0.00%	0.00%
5	01/29/11	0	0	0	0.00%	0.00%
6	02/05/11	0	0	0	0.00%	0.00%
7	02/12/11	1,433	150	0	0.00%	0.00%
8	02/19/11	0		0	0.00%	0.00%
9	02/26/11	583	18	0	0.00%	0.00%
10	03/05/11	0		0	0.00%	0.00%
11	03/12/11	63	3	0	0.00%	0.00%
12	03/19/11	79	5	0	0.00%	0.00%
13	03/26/11	103	7	0	0.00%	0.00%
14	04/02/11	16	1	0	0.00%	0.00%
15	04/09/11	31	2	0	0.00%	0.00%
16	04/16/11	31	2	0	0.00%	0.00%
17	04/23/11	24	2	0	0.00%	0.00%
18	04/30/11	16	1	0	0.00%	0.00%
19	05/07/11	16	1	0	0.00%	0.00%
20	05/14/11	0	0	0	0.00%	0.00%
21	05/21/11	0	0	0	0.00%	0.00%
22	05/28/11	0	0	0	0.00%	0.00%
23	06/04/11	0	0	0	0.00%	0.00%
24	06/11/11	0	0	0	0.00%	0.00%
25	06/18/11	0	0	0	0.00%	0.00%
26	06/25/11	0	0	0	0.00%	0.00%
No Sampling 07/01/2010 – 09/30/2010 Weeks 27 – 39						

Table 15. Annual mortality of fall-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

Week	Date	Weekly Passage	Catch	Mortality	% Passage	% Catch
No Sampling 10/01/10 – 11/01/2010 Weeks 40 – 43						
44	10/29/10	0	0	0	0.00%	0.00%
45	11/05/10	0	0	0	0.00%	0.00%
46	11/12/10	0	0	0	0.00%	0.00%
47	11/19/10	0	0	0	0.00%	0.00%
48	11/26/10	182	12	0	0.00%	0.00%
49	12/03/10	14,686	935	6	0.04%	0.64%
50	12/10/10	31,750	2,020	6	0.02%	0.30%
51	12/17/10	45,079	2,869	5	0.01%	0.17%
52	12/24/10	177,630	11,304	23	0.01%	0.20%
1	01/01/11	150,921	8,904	53	0.04%	0.60%
2	01/08/11	195,658	12,111	26	0.01%	0.21%
3	01/15/11	392,516	31,433	2,566	0.65%	8.16%
4	01/22/11	589,879	37,776	39	0.01%	0.10%
5	01/29/11	521,065	31,254	89	0.02%	0.28%
6	02/05/11	580,353	38,289	54	0.01%	0.14%
7	02/12/11	466,324	45,330	112	0.02%	0.25%
8	02/19/11	151,034	7,789	19	0.01%	0.24%
9	02/26/11	178,105	6,076	21	0.01%	0.35%
10	03/05/11	19,469	1,201	7	0.04%	0.58%
11	03/12/11	13,597	538	3	0.02%	0.56%
12	03/19/11	9,507	605	1	0.01%	0.17%
13	03/26/11	10,347	760	8	0.08%	1.05%
14	04/02/11	4,379	279	1	0.02%	0.36%
15	04/09/11	891	57	1	0.11%	1.75%
16	04/16/11	283	18	0	0.00%	0.00%
17	04/23/11	905	77	0	0.00%	0.00%
18	04/30/11	1,964	125	3	0.15%	2.40%
19	05/07/11	1,446	92	0	0.00%	0.00%
20	05/14/11	2,216	141	1	0.05%	0.71%
21	05/21/11	1,776	113	1	0.06%	0.88%
22	05/28/11	1,430	91	0	0.00%	0.00%
23	06/04/11	2,341	149	1	0.04%	0.67%
24	06/11/11	330	21	1	0.30%	4.76%
25	06/18/11	550	35	0	0.00%	0.00%
26	06/25/11	110	7	0	0.00%	0.00%
No Sampling 07/01/2011 – 09/30/2011 Weeks 27 – 39						

Table 16. Passage indices of spring-run Chinook salmon with 90% and 95% confidence intervals for Broodyear 2003-2010 captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service. The adjusted passage index (proportionate to juveniles per redd) includes redds below the trap, yet above the separation weir.

Broodyear	95% LCI	90% LCI	Passage Index	90% UCI	95% UCI	Adjusted Index	Juveniles per Redd
2003	88,817	90,113	108,338	130,960	137,672	110,422	2,083
2004	87,439	90,417	107,054	131,700	136,701	110,028	2,974
2005	87,516	89,516	104,197	122,580	128,418	106,201	2,004
2006	111,749	113,659	127,197	144,692	148,539	149,318	1,843
2007	92,728	94,472	110,224	130,585	135,069	114,914	2,345
2008	88,834	89,653	96,166	102,920	104,402	121,622	1,414
2009	62,213	63,214	68,296	74,319	75,384	74,084	1,158
2010	15,228	15,618	17,359	19,416	19,910	19,288	1,929

Table 17. Passage indices of late-fall run Chinook salmon with 90% and 95% confidence intervals for Broodyear 1999-2010 captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service.

Broodyear	95% LCI	90% LCI	Passage Index	90% UCI	95% UCI
1999	272,930	275,736	292,323	310,697	314,778
2000	90,576	92,331	101,347	113,299	116,274
2001	68,446	70,733	86,836	107,359	112,386
2002	156,297	158,835	172,708	189,998	192,685
2003	29,432	30,130	33,902	38,705	39,638
2004	9,570	9,915	11,906	14,701	15,644
2005	17,808	18,163	20,401	22,733	23,384
2006	70,716	72,560	86,918	105,130	113,960
2007	149,395	155,897	202,011	279,553	319,016
2008	39,129	39,999	45,903	53,145	54,452
2009	61,181	61,979	68,624	76,913	79,425
2010	19,929	20,231	22,853	26,166	27,111

Table 18. Passage indices of fall-run Chinook salmon with 90% and 95% confidence intervals for Broodyear 1998-2010 captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service.

Broodyear	95% LCI	90% LCI	Passage Index	90% UCI	95% UCI	Females Spawners	Passage per Female
1998	5,656,571	5,760,186	6,395,638	7,150,348	7,303,438	2,486	2,573
1999	5,951,440	6,009,301	6,405,765	6,956,968	7,121,563	4,088	1,567
2000	13,535,844	13,681,994	14,955,182	16,222,612	16,483,244	3,349	4,466
2001	5,577,387	5,602,563	5,788,701	6,007,409	6,042,987	5,615	1,031
2002	3,560,468	3,609,632	3,858,446	4,102,132	4,174,685	8,176	472
2003	5,311,235	5,406,501	6,056,834	6,797,575	7,003,322	5,435	1,114
2004	5,361,896	5,465,198	6,190,757	6,987,786	7,216,897	3,722	1,663
2005	2,570,162	2,609,782	2,969,321	3,444,467	3,566,470	9,607	309
2006	4,275,282	4,359,617	4,929,544	5,667,355	5,832,272	5,208	947
2007	4,816,781	4,906,462	5,545,303	6,359,077	6,614,700	2,634	2,105
2008	7,129,073	7,241,051	8,451,186	10,081,61	10,397,71	4,453	1,898
2009	2,226,170	2,264,739	2,499,990	2,790,382	2,834,759	1,775	1,408
2010	3,305,917	3,347,938	3,566,723	3,827,295	3,871,986	3,668	972

Table 19. Passage indices of steelhead / rainbow trout with 90% and 95% confidence intervals for Broodyear 1999-2011 captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service.

Broodyear	95% LCI	90% LCI	Passage Index	90% UCI	95% UCI	Redds	Juveniles per Redd
1999	3,986	4,025	4,229	4,446	4,506		
2000	7,951	8,074	8,507	9,004	9,162		
2001	8,120	8,226	8,742	9,311	9,424	38	230
2002	11,731	11,926	12,803	13,860	14,193	101	127
2003	8,758	8,910	9,772	10,761	10,954	78	125
2004	24,137	24,697	28,989	34,454	36,746	151	192
2005	22,247	22,670	24,791	28,211	29,454	144	172
2006	9,362	9,547	10,762	12,313	12,632	42	256
2007	27,515	28,349	33,910	41,428	43,292	165	206
2008	33,284	33,677	36,499	40,025	40,983	149	245
2009	28,988	29,316	31,340	33,714	34,318	399	76
2010	10,754	10,854	11,760	12,820	13,038	230	51
2011	17,965	18,165	19,508	21,127	21,612	218	89

Table 20. Passage indices of steelhead / rainbow trout with 90% and 95% confidence intervals for Broodyear 1998-2010 Age 0+ captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service.

Broodyear	95% LCI	90% LCI	Passage Index	90% UCI	95% UCI
1998	603	609	655	709	724
1999	1,036	1,056	1,251	1,521	1,602
2000	Data	not	reported	at this	time
2001	838	846	884	928	939
2002	590	603	692	804	836
2003	194	198	211	267	285
2004	468	476	560	672	712
2005	161	167	203	244	259
2006	16	16	26	39	44
2007	209	214	255	307	329
2008	398	411	537	716	768
2009	360	369	429	499	521
2010	189	196	259	340	366

Figures

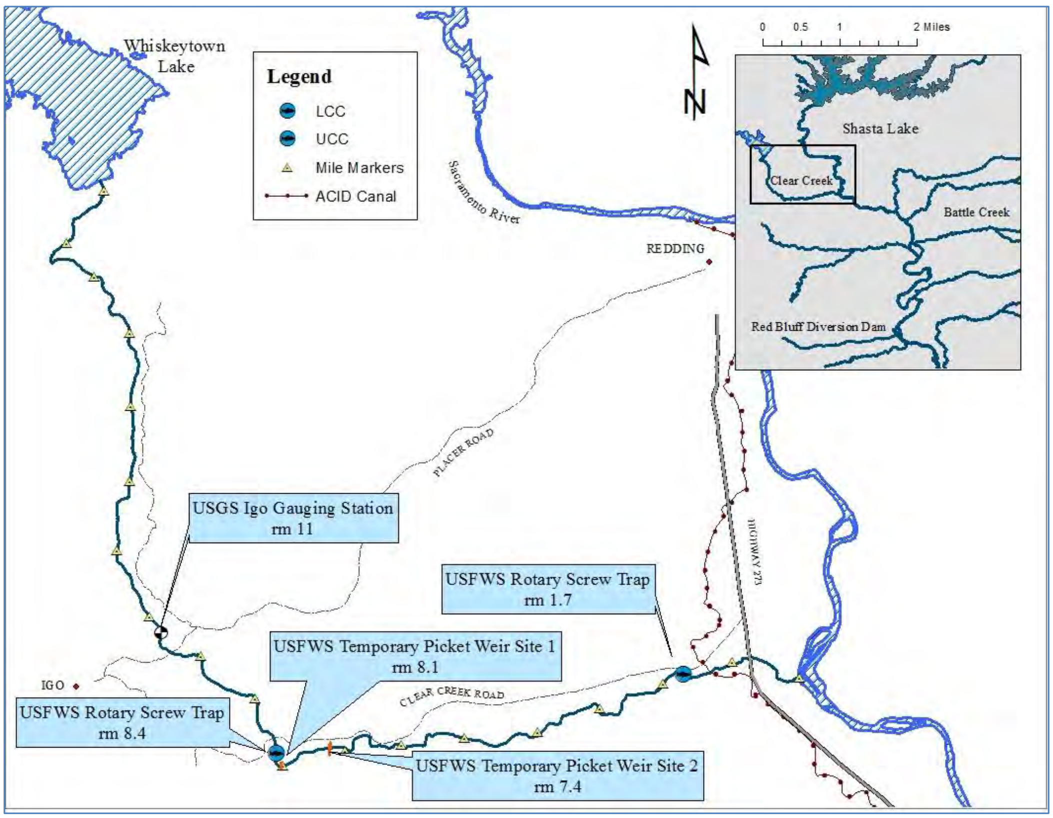

Figure 1. Locations of the upper (UCC) and lower (LCC) rotary screw trap sampling stations used for juvenile salmonid monitoring at river mile 8.4 and 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 2010 through June 2011.

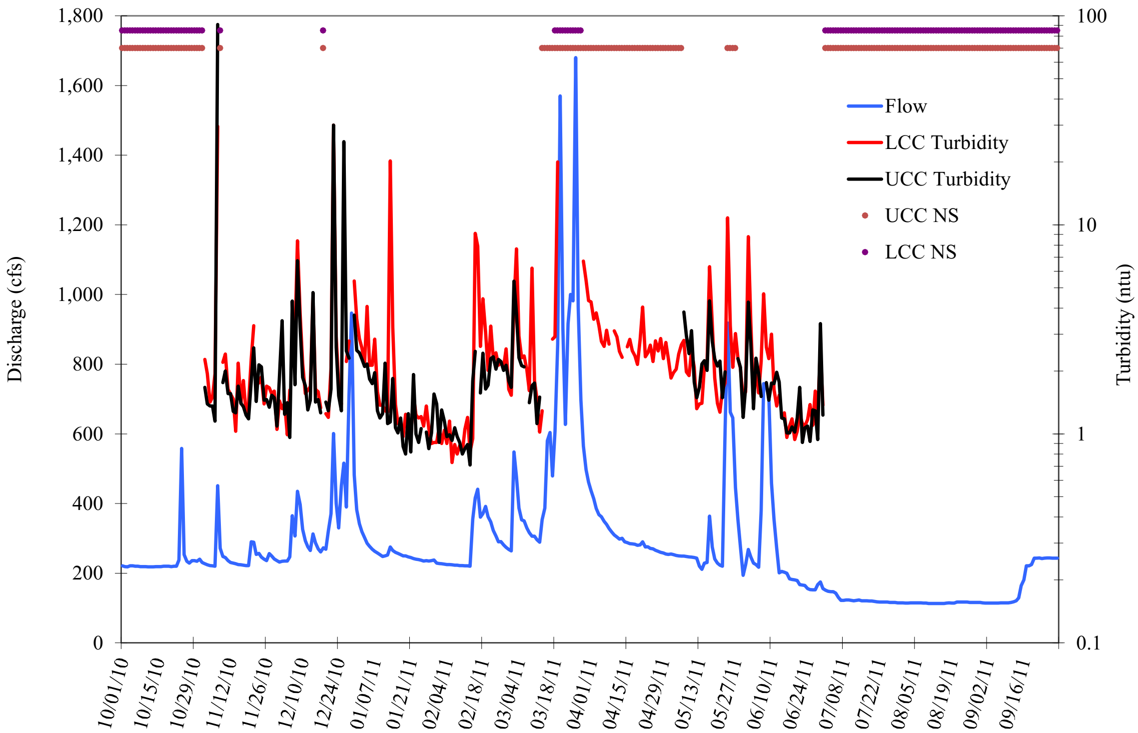

Figure 2. Mean daily flow in cubic feet per second (cfs) measured at the USGS IGO station, non-sampling days (NS), and momentary turbidity in nephelometric turbidity units (NTU's) recorded at the upper and lower rotary screw trap sampling stations at river mile 8.4 and 1.7 in Clear Creek, Shasta County, California by the U S. Fish and Wildlife Service from October 1, 2010 through September 30, 2011.

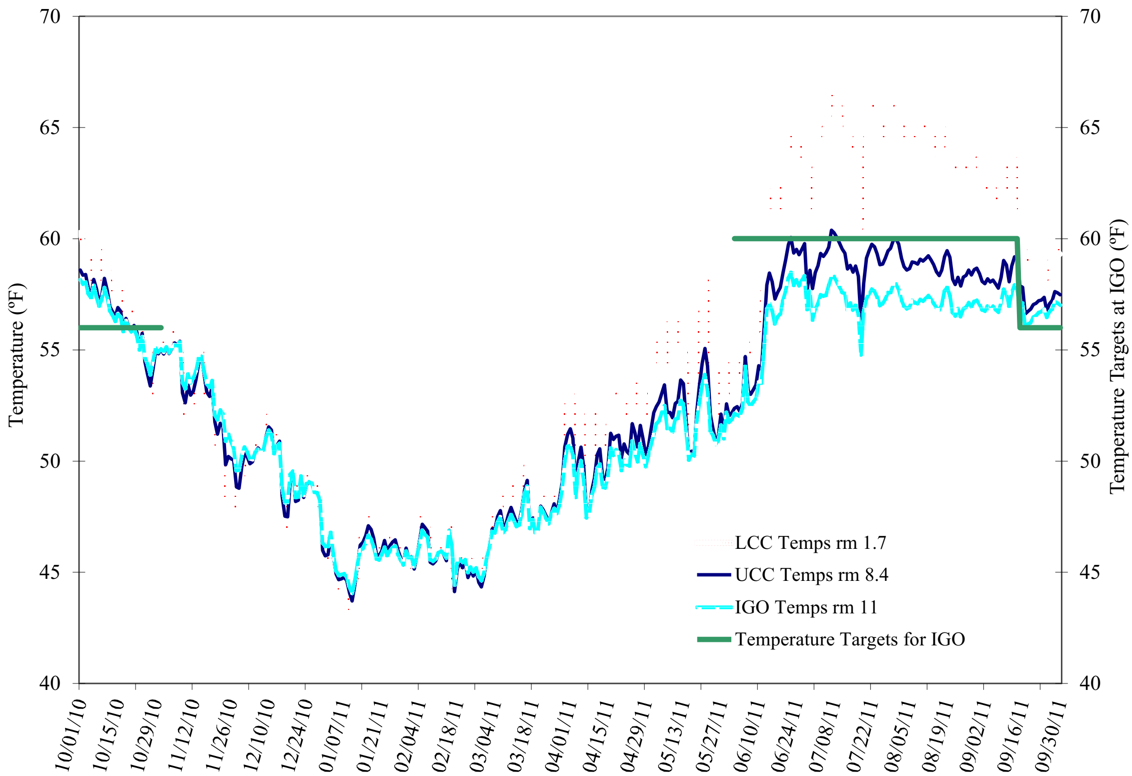

Figure 3. Mean daily water temperatures (°F) recorded at the upper (UCC) and lower (LCC) rotary screw trap sampling stations at river mile 8.3 and 1.7 in Clear Creek, Shasta County, California by the U S. Fish and Wildlife Service from October 1, 2010 through September 30, 2011. Clear Creek Fish Restoration Program temperature targets for fish protection and the temperatures recorded at the Clear Creek IGO gauge are provided for comparison.

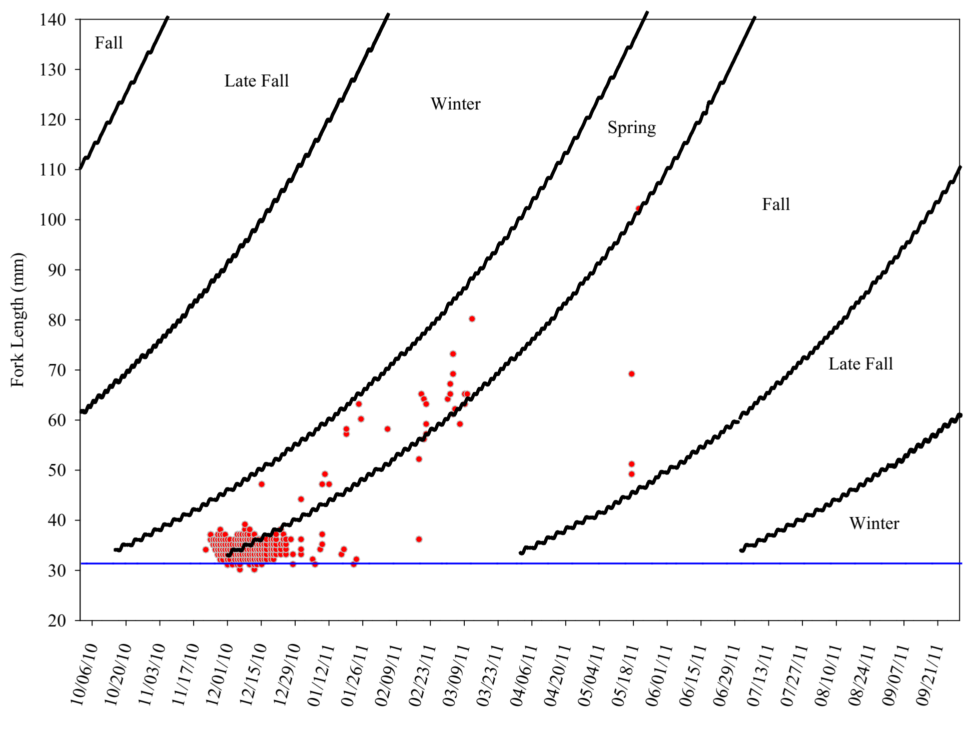

Figure 4. Fork length (mm) distribution by date and run for Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Spline curves represent the maximum fork lengths expected for each run by date, based upon tables of projected annual growth developed by the California Department of Water Resources (Greene 1992).

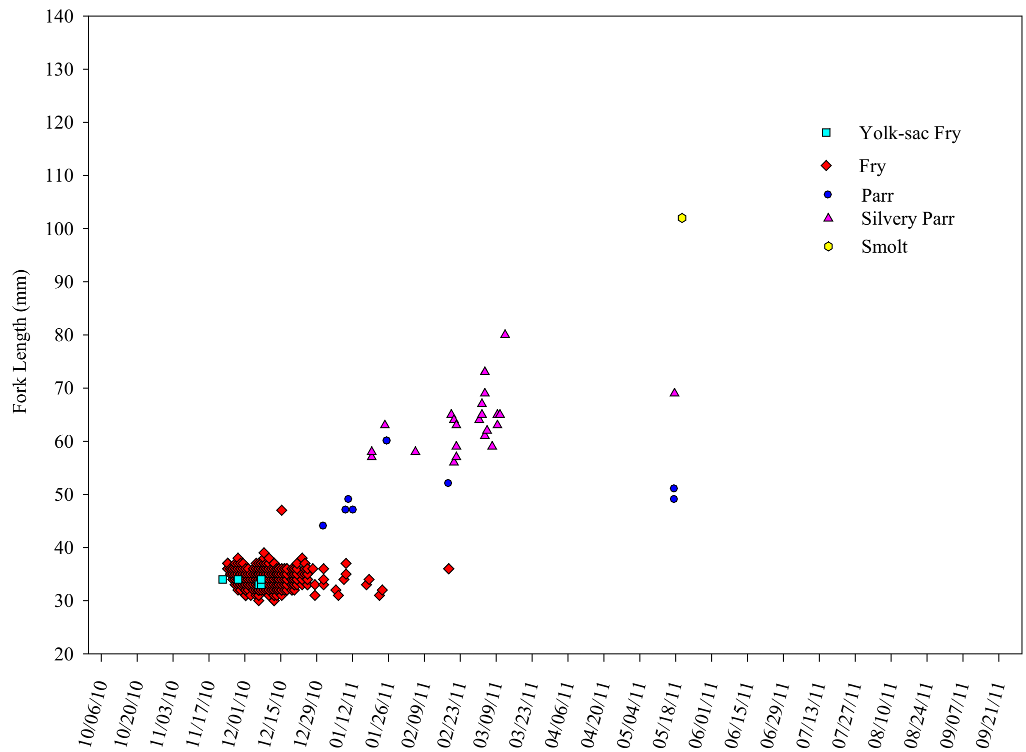

Figure 5. Life stage ratings for BY 2010 juvenile Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

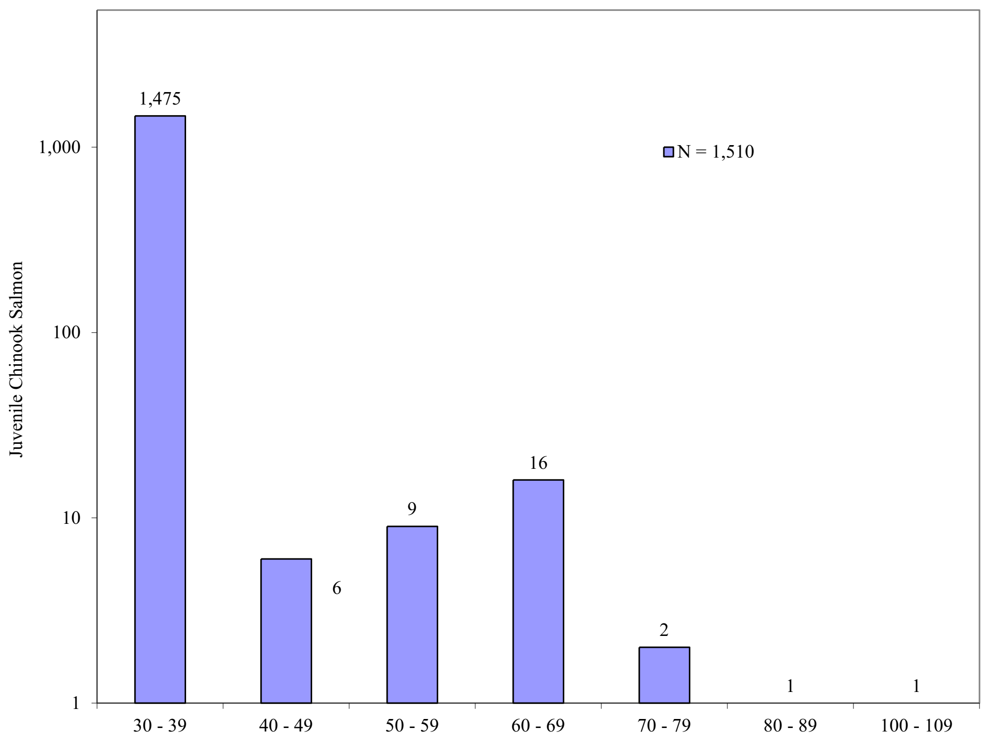

Figure 6. Fork length (mm) frequency distribution of BY 2010 juvenile spring Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments. The Y-axis is graphed in logarithmic values to illustrate distribution of catch outside of the 30-39 mm range.

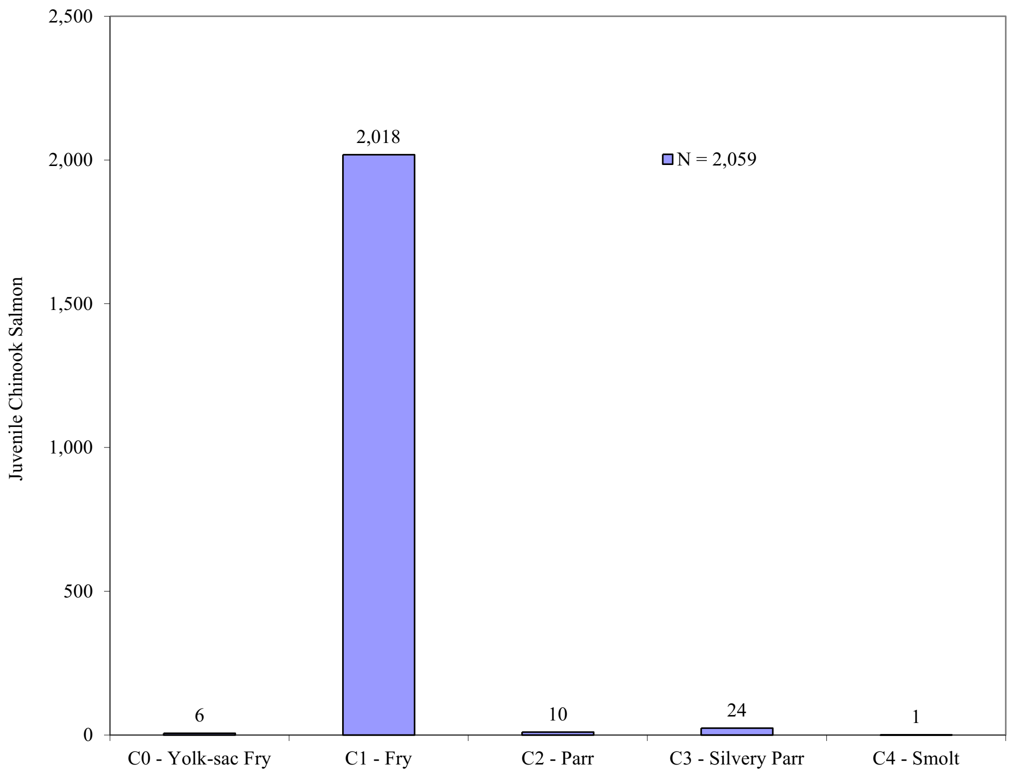

Figure 7. Life stage ratings for BY 2010 juvenile spring-run Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

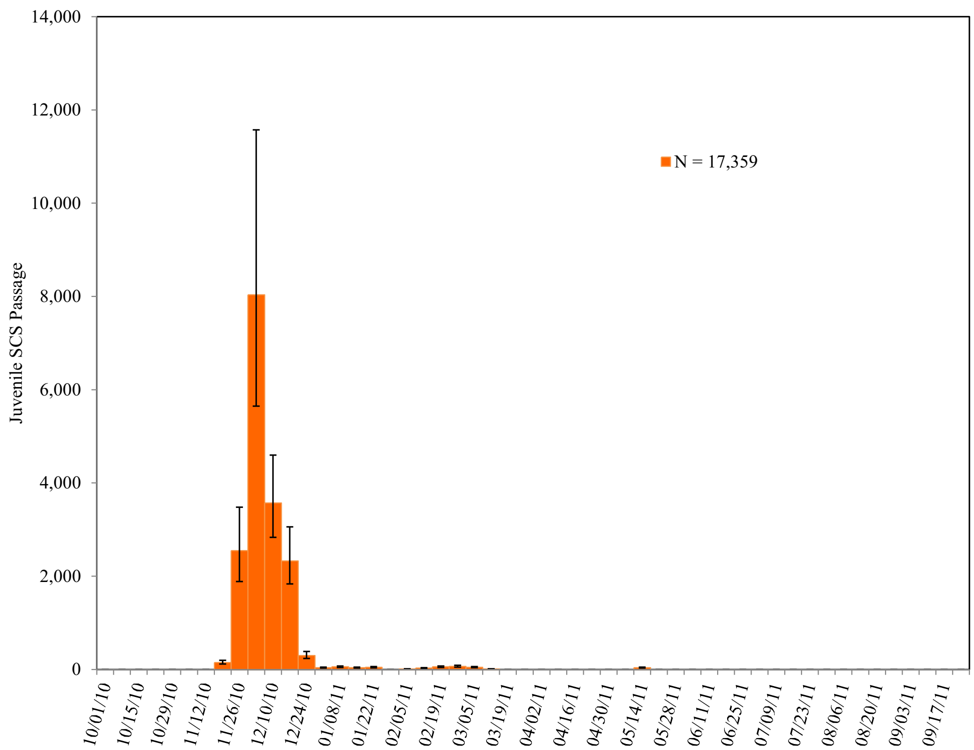

Figure 8. Weekly passage indices with 95% confidence intervals for BY 2010 juvenile spring Chinook salmon captured by the upper rotary screw trap at river mile 8.4 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Spring Chinook passage for Clear Creek is calculated using total catch from the UCC rotary screw trap and weekly trap efficiencies. Confidence intervals from 11/26 to 12/23 are approximate because they are summed from two or more sample strata.

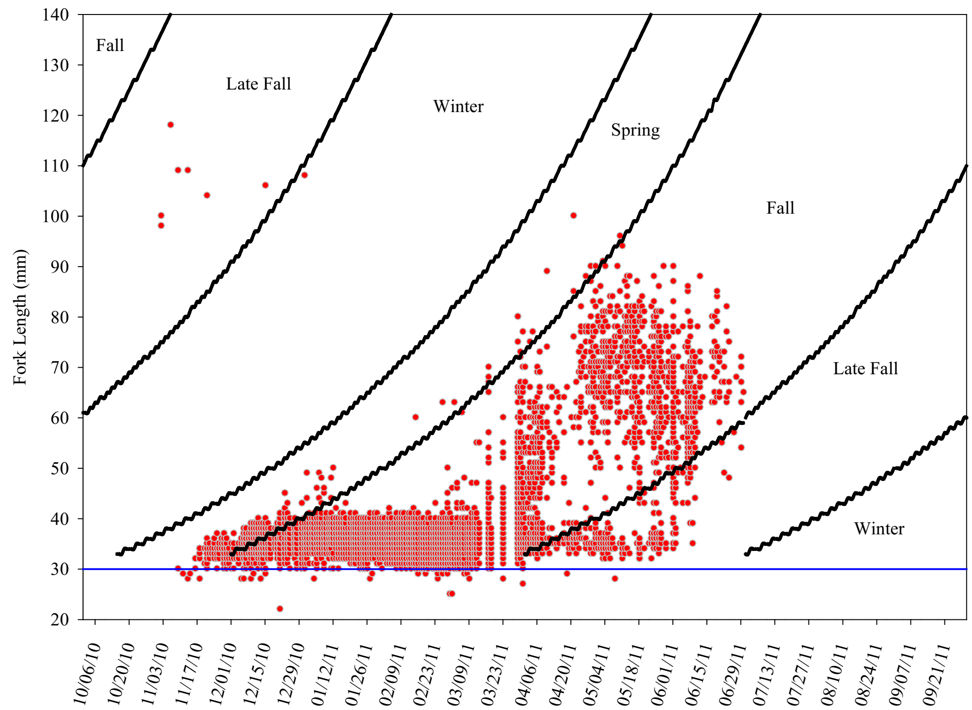

Figure 9. Fork length (mm) distribution by date and run for Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Spline curves represent the maximum fork lengths expected for each run by date, based upon tables of projected annual growth developed by the California Department of Water Resources (Greene 1992).

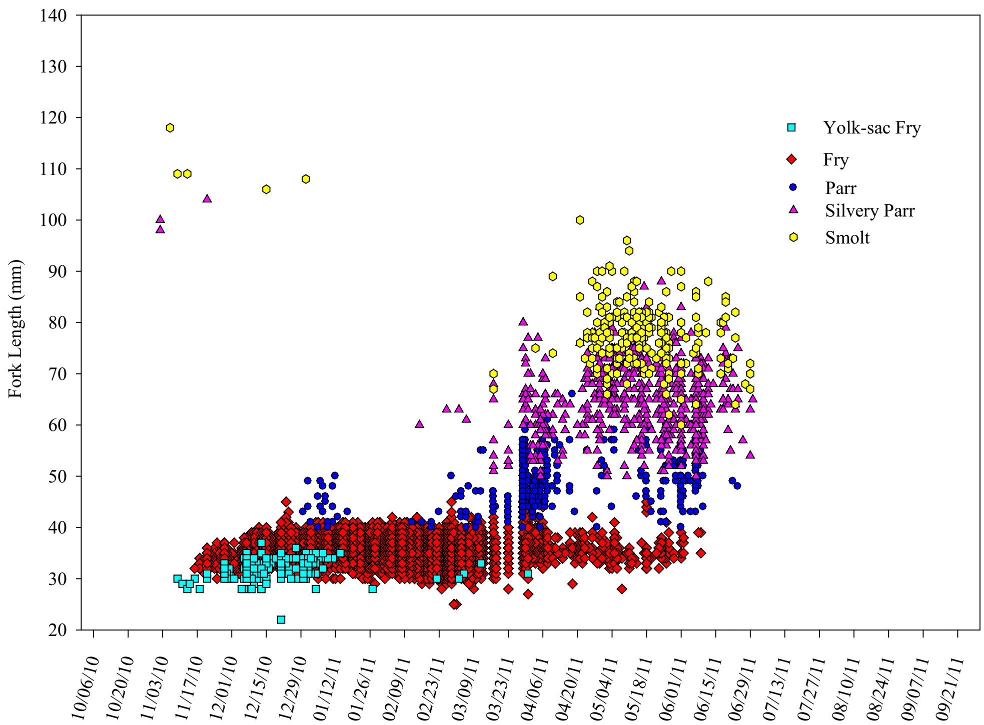

Figure 10. Life stage ratings and forklength distribution for BY 2010 juvenile Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

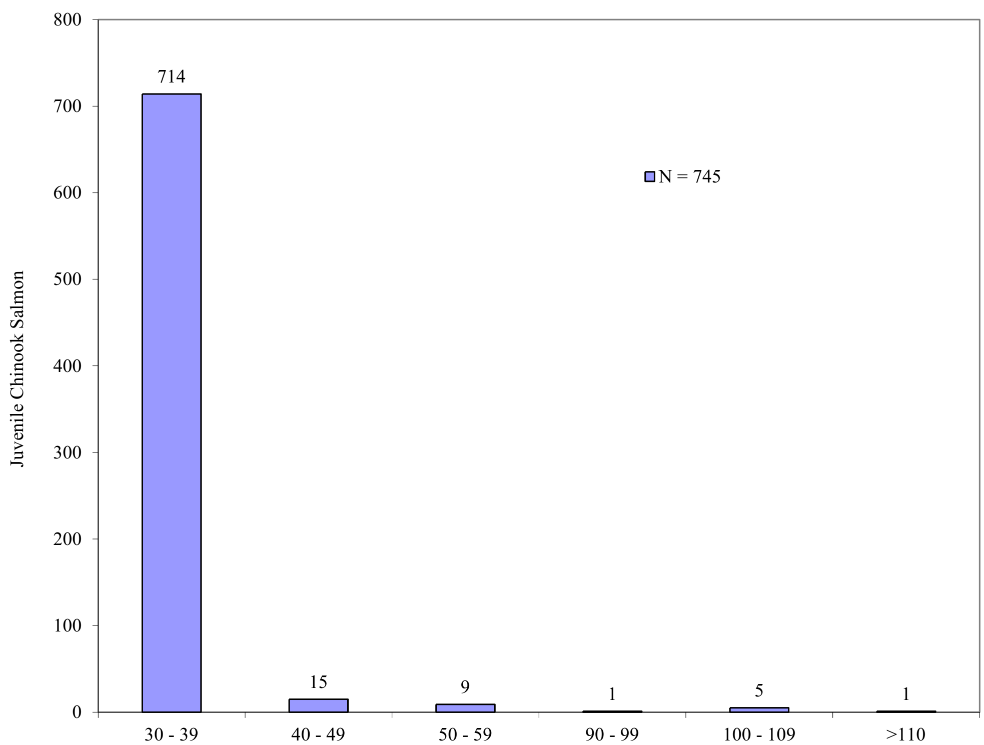

Figure 11. Fork length (mm) frequency distribution of BY 2010 juvenile late fall-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from April 1, 2010 through March 31, 2011. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments.

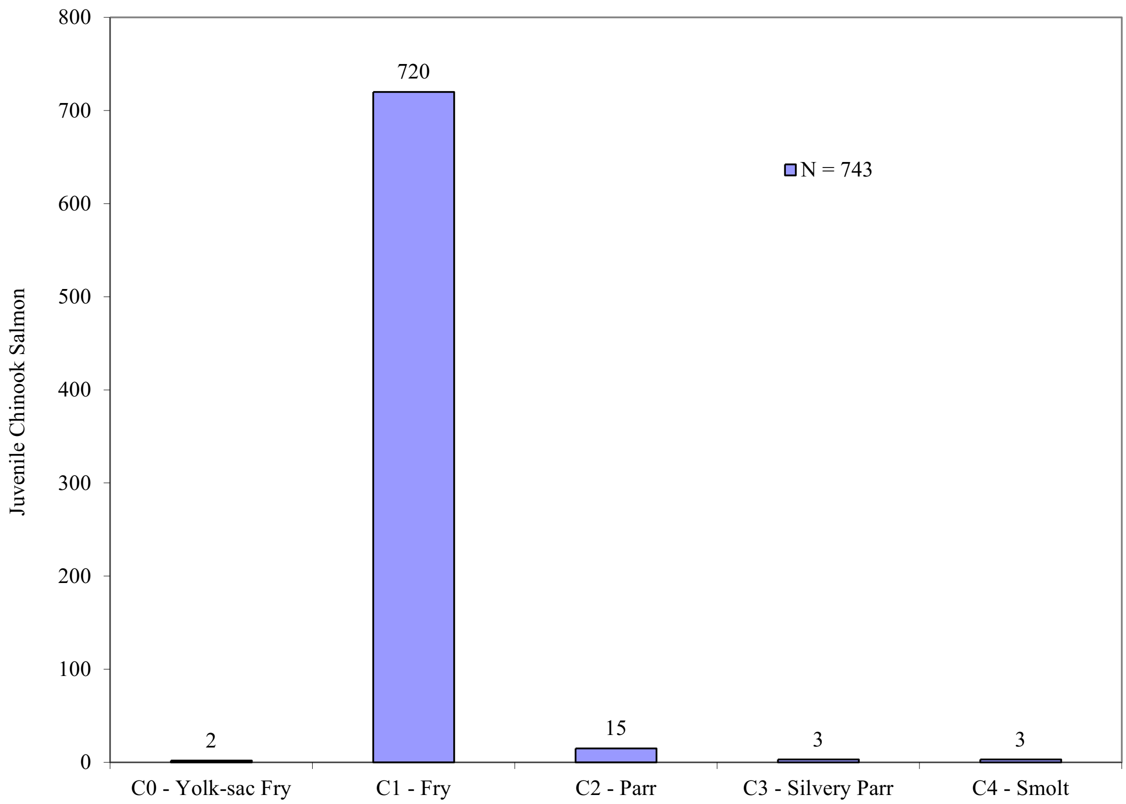

Figure 12. Life stage ratings for BY 2010 juvenile late fall-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from April 1, 2010 through March 31, 2011.

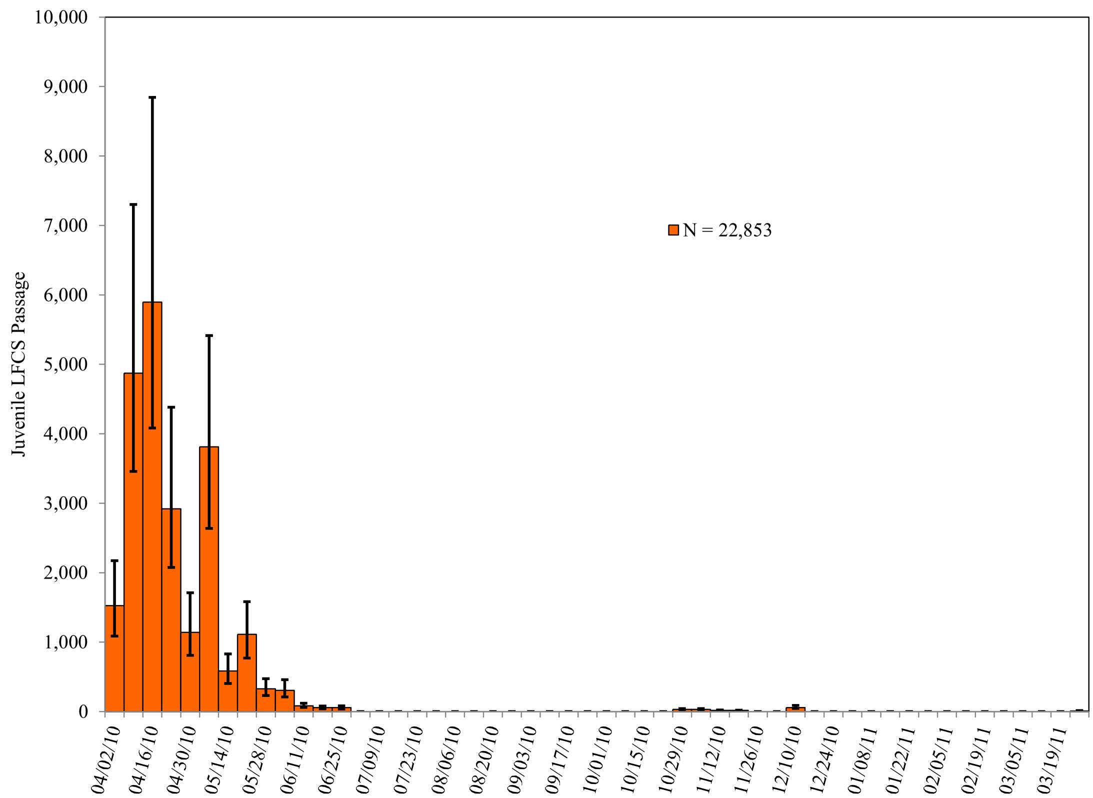

Figure 13. Weekly passage index with 95% confidence intervals of BY 2010 juvenile late-fall run Chinook captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from April 1, 2010 through March 31, 2011.

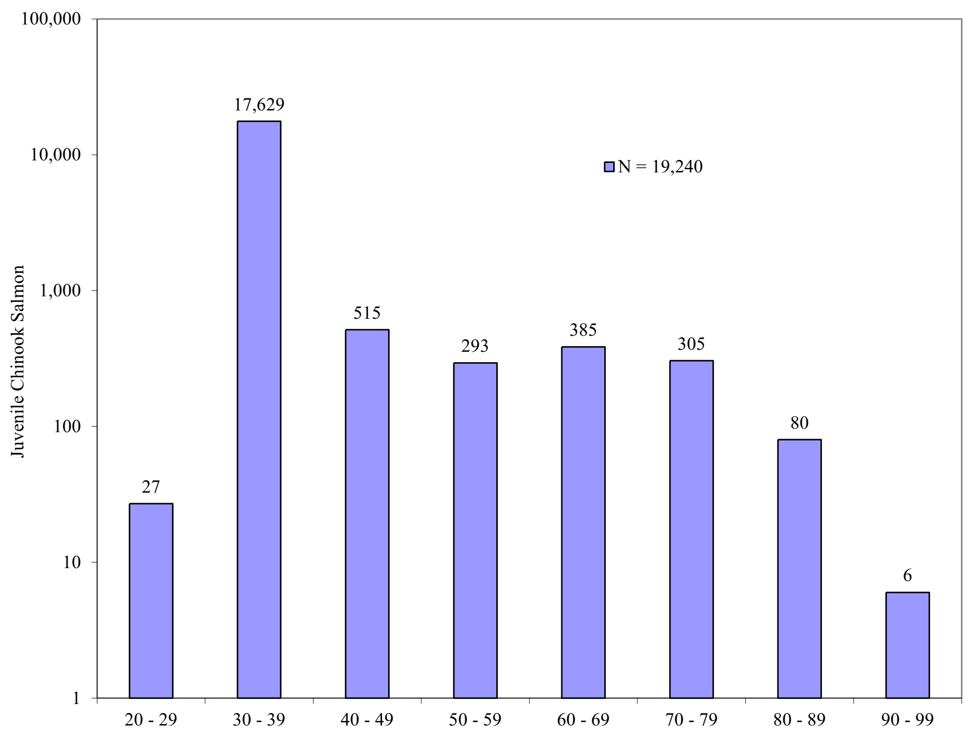

Figure 14. Fork length (mm) frequency distribution of BY 2010 juvenile fall-run Chinook salmon captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Fork length frequencies were assigned based on the proportional frequency of occurrence, in 10 mm increments. The Y-axis is graphed in logarithmic values to illustrate distribution of catch outside of the 30-39 mm range.

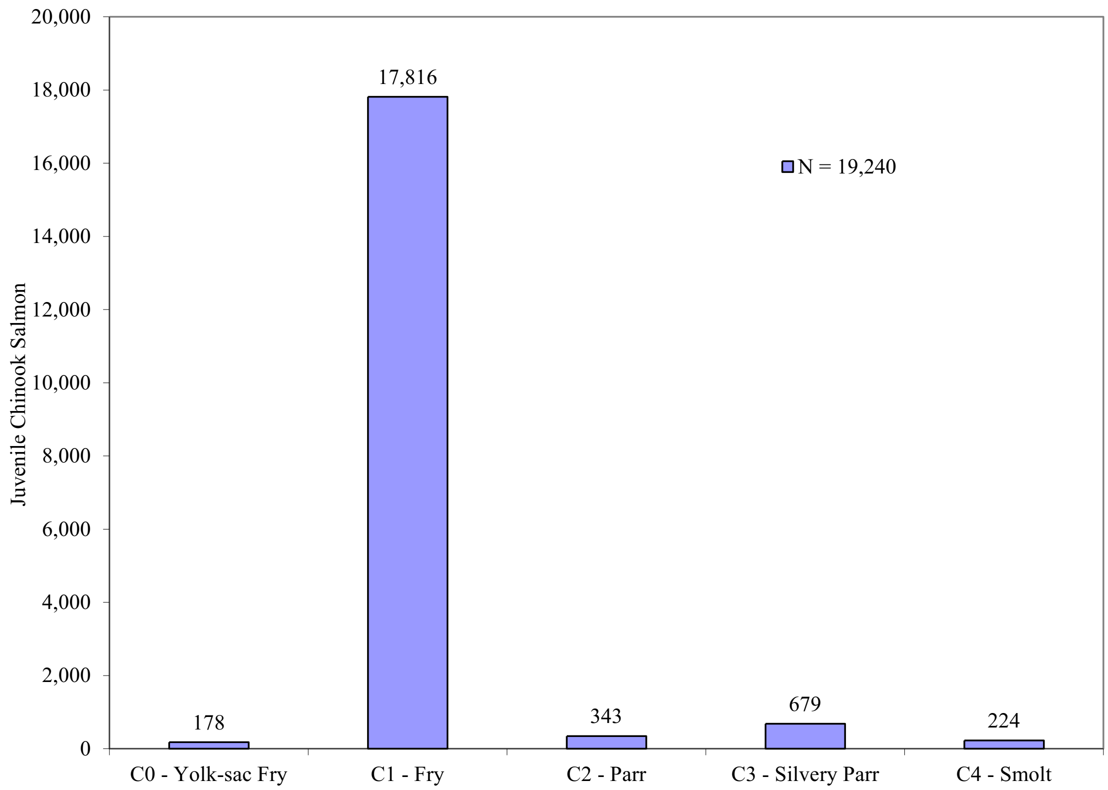

Figure 15. Life stage ratings for juvenile BY 2010 fall-run Chinook salmon by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011.

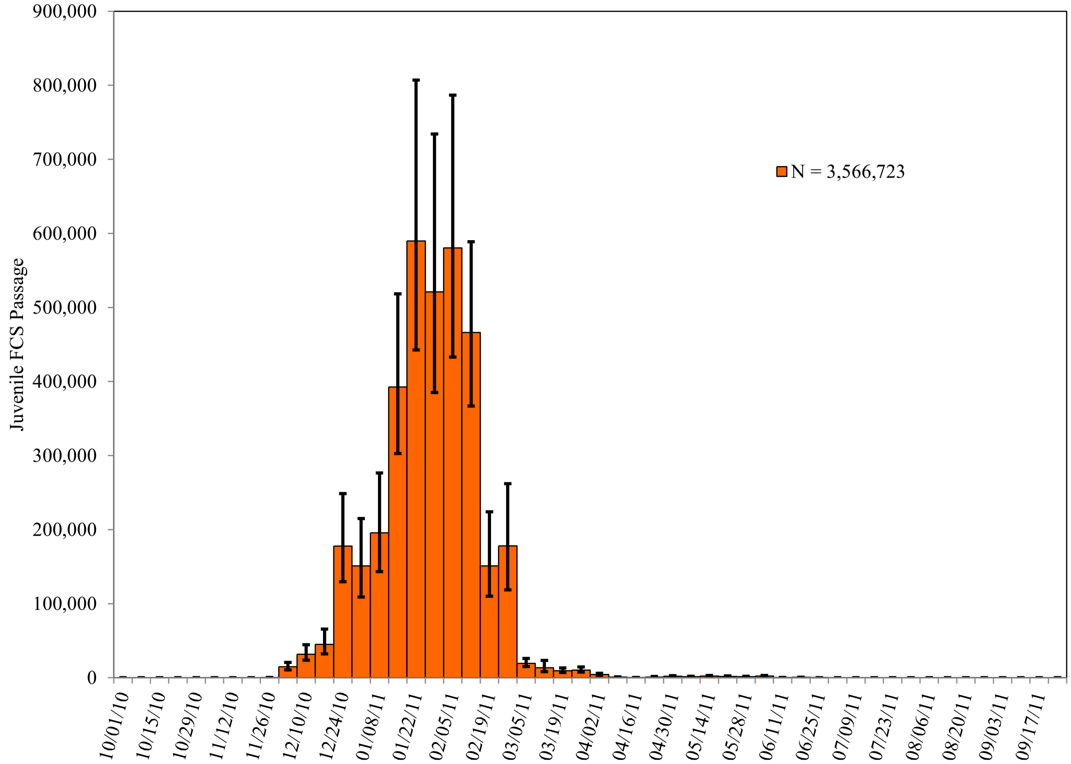

Figure 16. Passage index with 95% confidence intervals of BY 2010 juvenile fall-run Chinook captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from November 1, 2010 through June 30, 2011. Confidence intervals from 01/01 to 03/11 are approximate because they are summed from two or more sample strata.

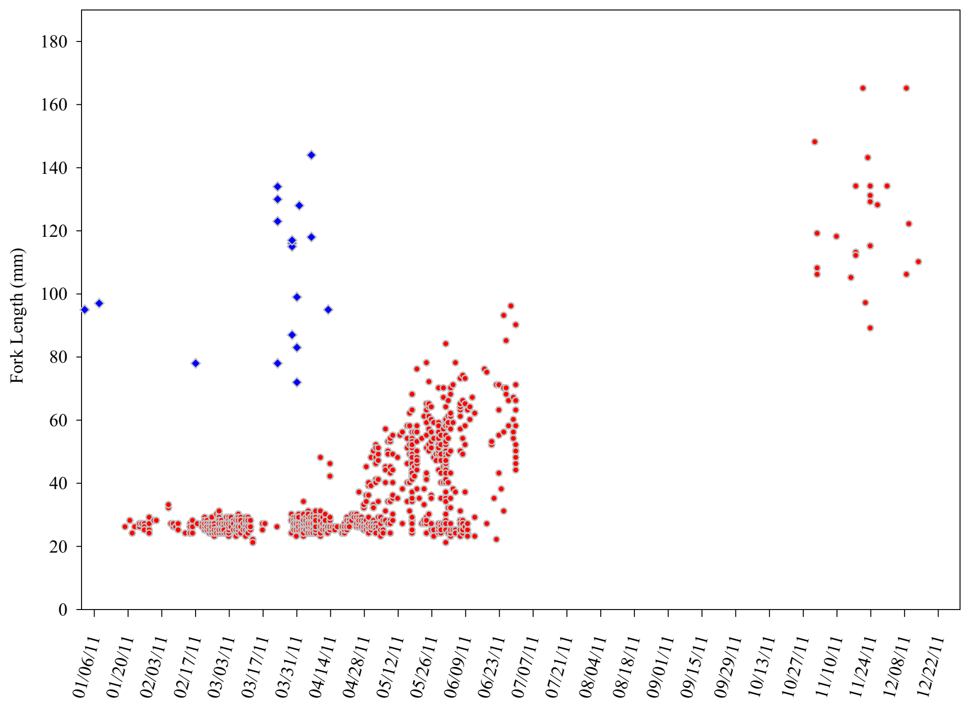

Figure 17. Fork length (mm) distribution by date for BY 2011 and BY 2010 Age 0+ steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011. Blue diamonds represent age 0+ steelhead trout that are of BY 2010 or earlier, while the red dots represent production from BY 2011.

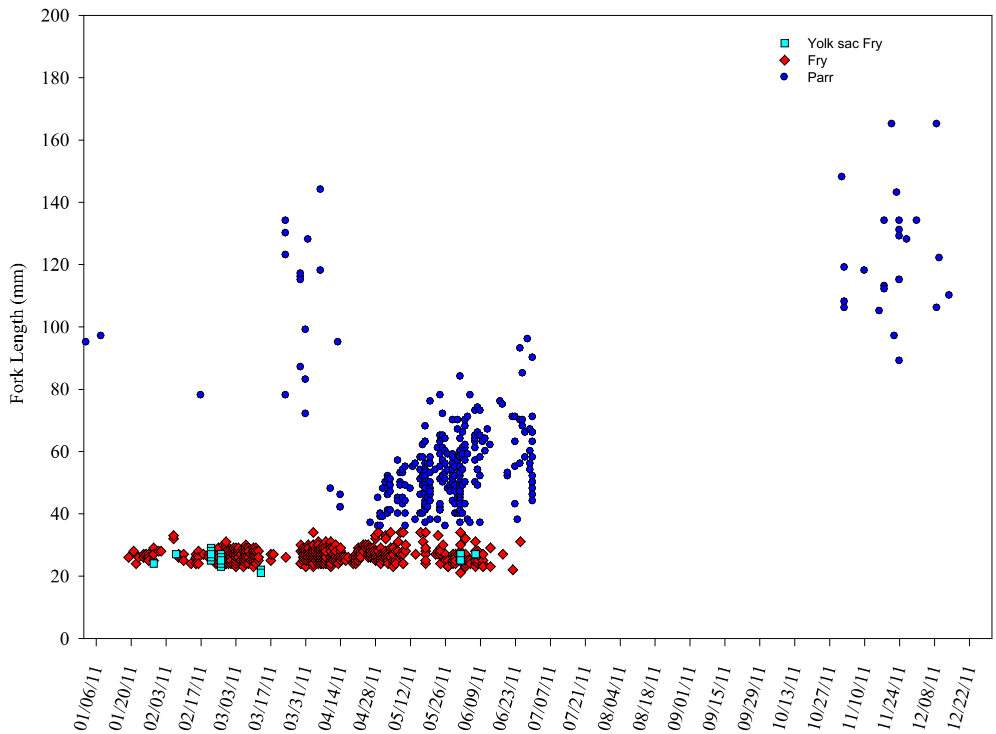

Figure 18. Life stage ratings and forklength distribution for BY 2011 and BY 2010 Age 0+ juvenile steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

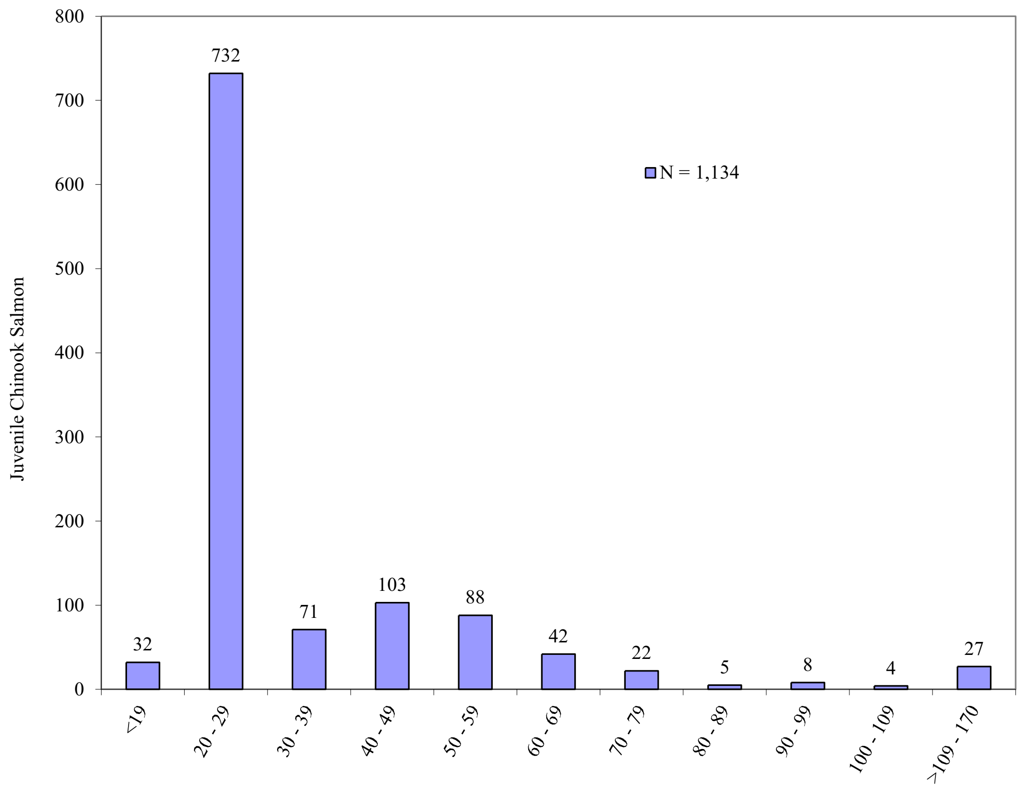

Figure 19. Fork length (mm) frequency distribution for BY 2011 and BY 2010 Age 0+ steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

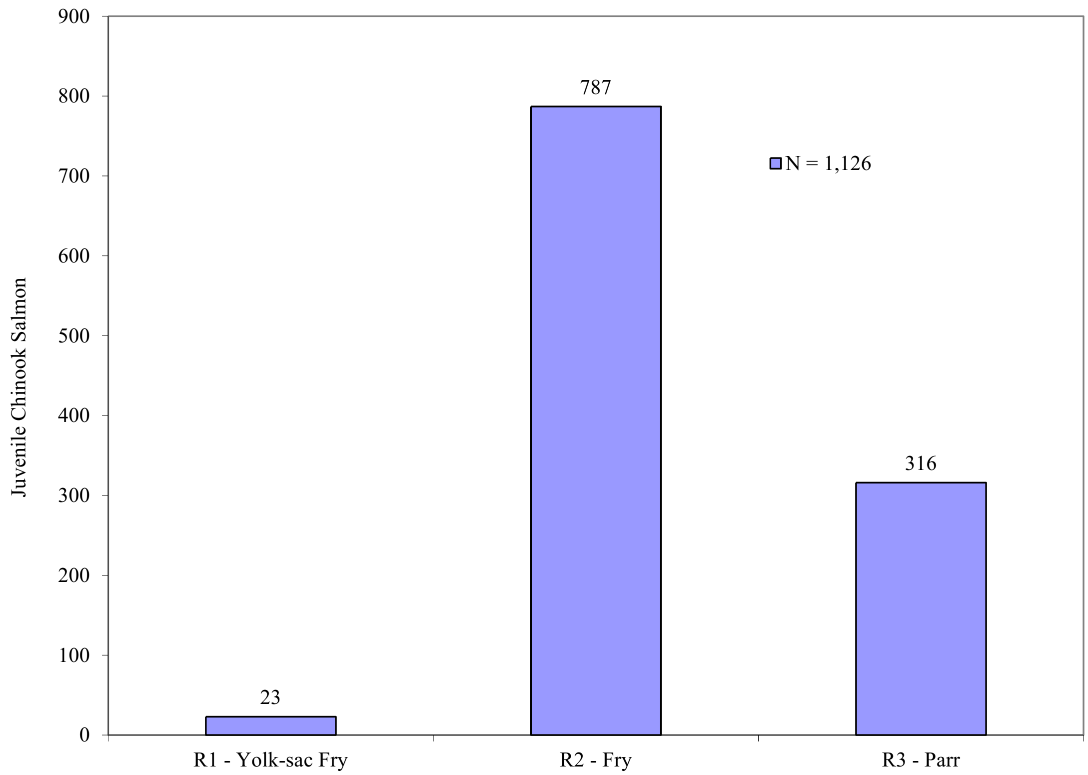

Figure 20. Life stage ratings for BY 2011 and BY 2010 Age 0+ juvenile steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

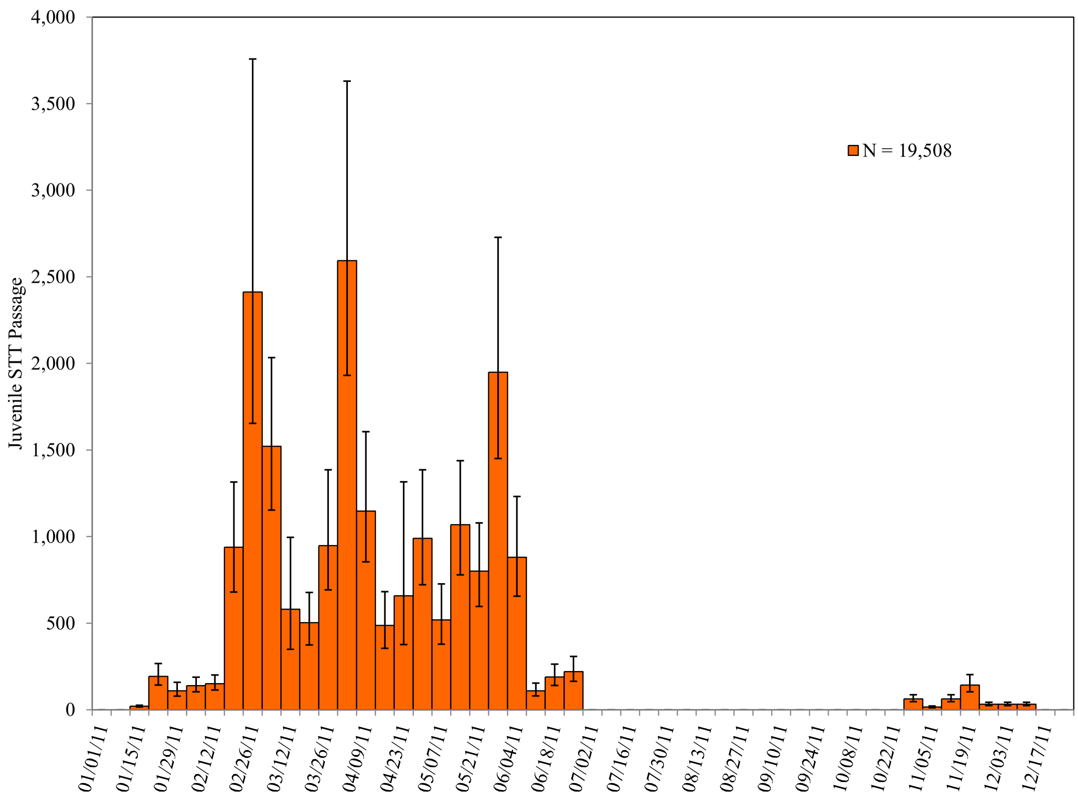

Figure 21. Passage index with 95% confidence intervals of BY 2011 juvenile steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

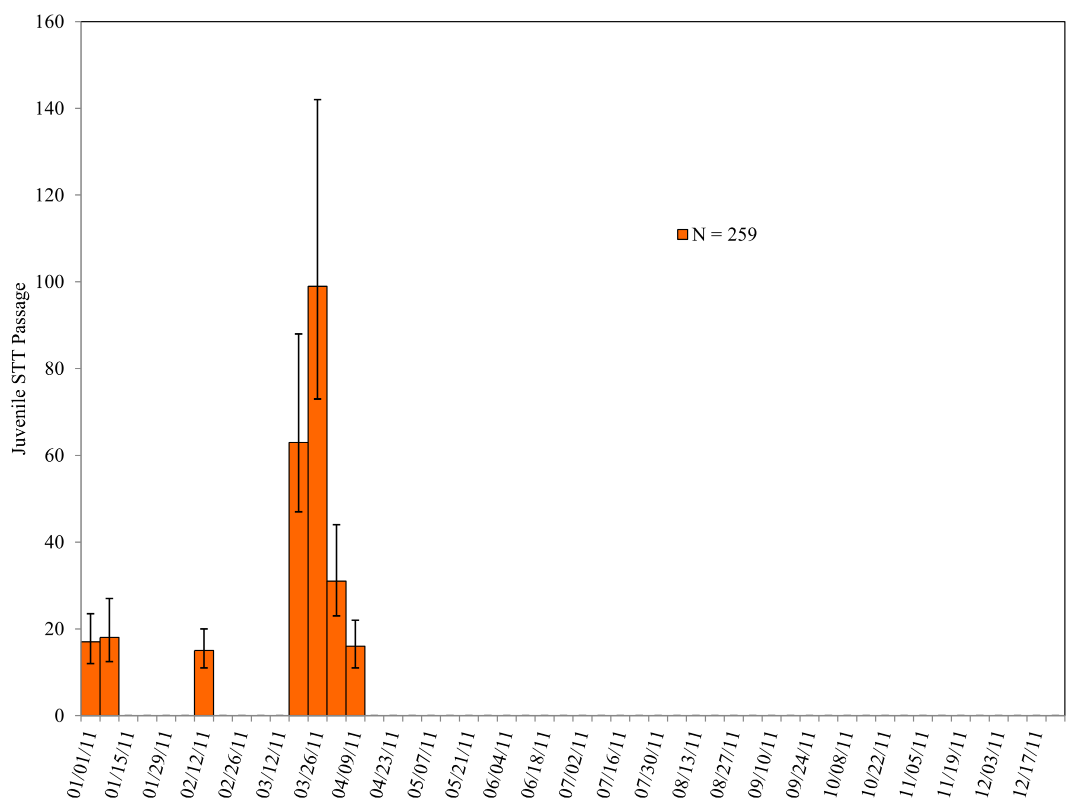

Figure 22. Passage index with 95% confidence intervals of BY 2010 Age 0+ juvenile steelhead / rainbow trout captured by the lower rotary screw trap at river mile 1.7 in Clear Creek, Shasta County, California by the U.S. Fish and Wildlife Service from January 1, 2011 through December 31, 2011.

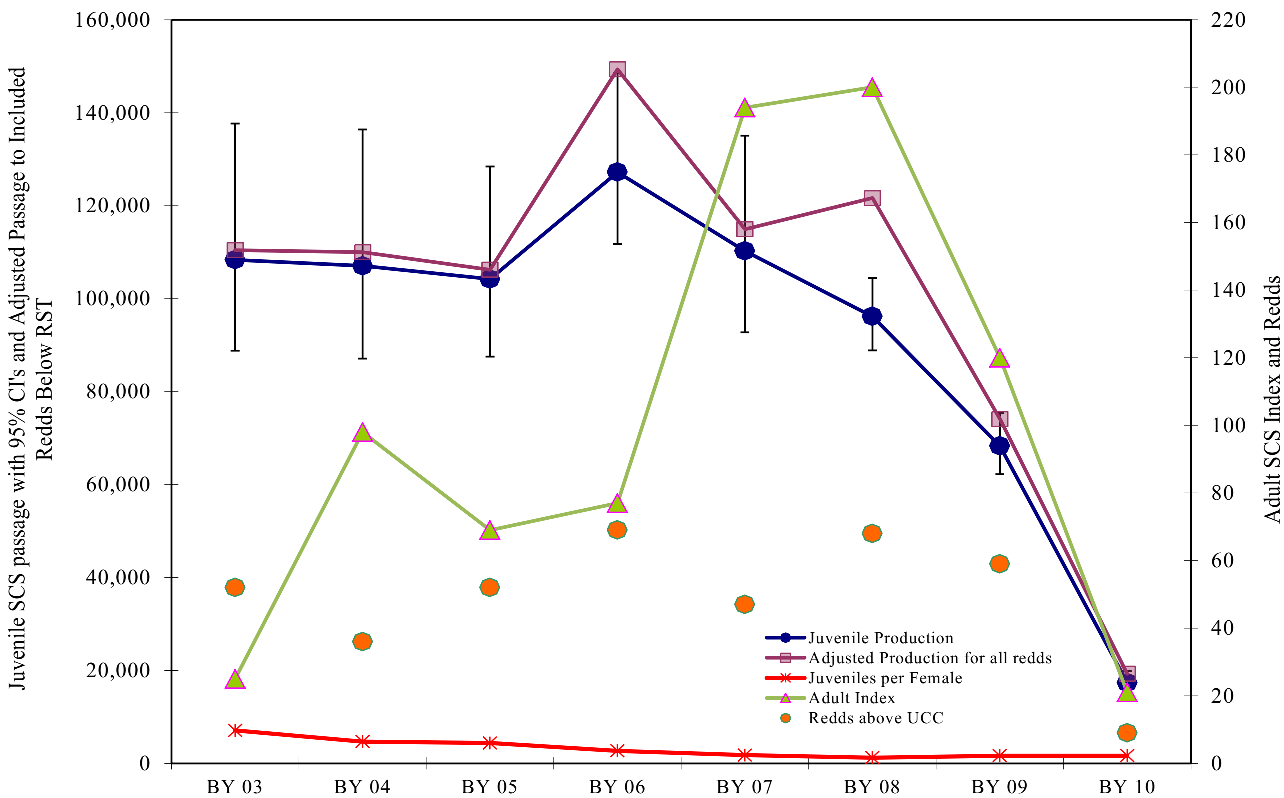

Figure 23. Spring-run Chinook passage indices with 95% Confidence Intervals (CI's), adult escapement and redds observed for BY 2003 - 2010 in Upper Clear Creek. Spring Chinook passage indices were calculated using data from the upper rotary screw trap at rm 8.4.

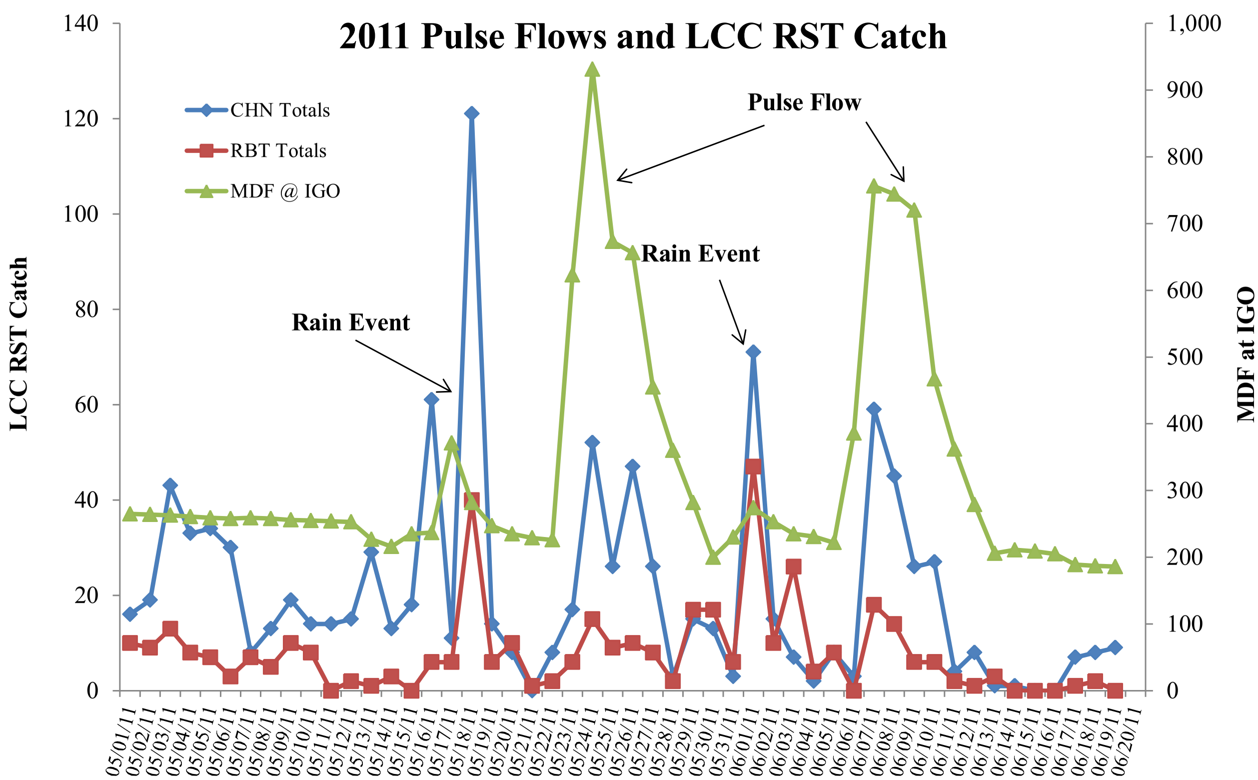

Figure 24. The movement of Chinook and steelhead / rainbow trout was greater in response to natural flow events as seen where lower outmigration occurred during pulse flow events.

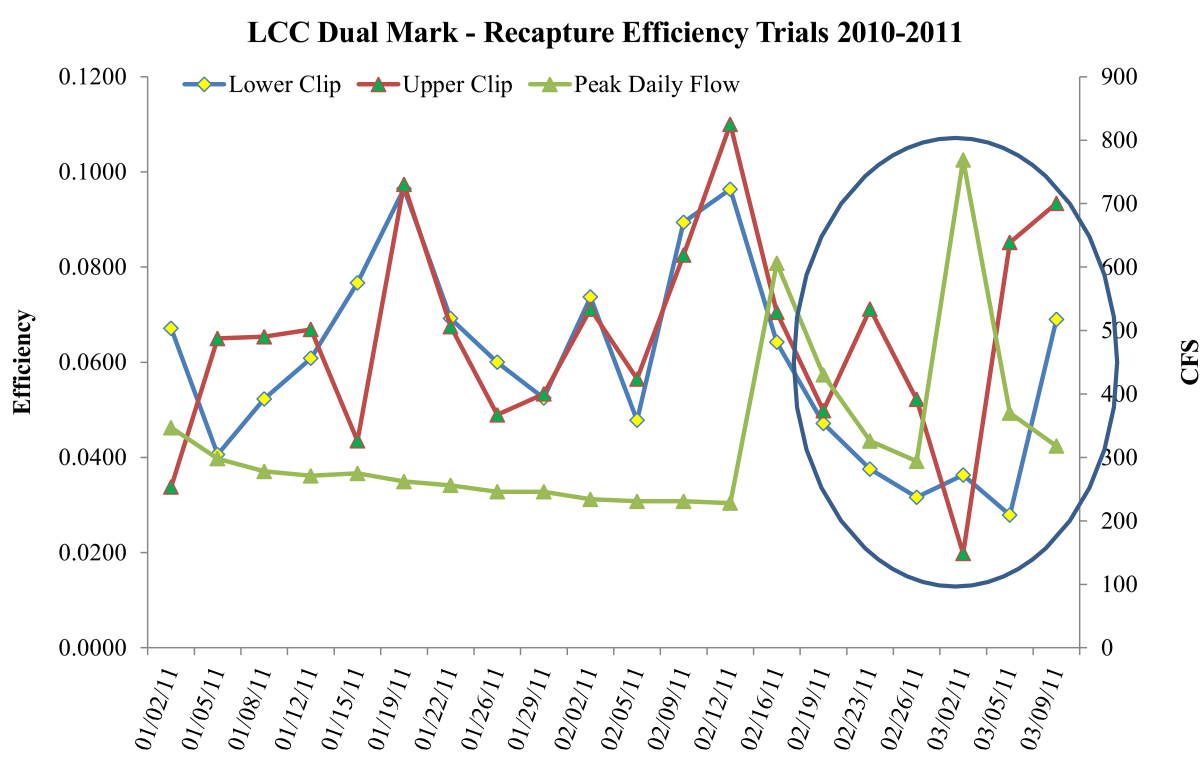

Figure 25. Efficiency trials conducted at the lower Clear Creek RST that included multiple clip groups during late winter 2011. Note the low efficiency associated with the flow event on 03/02/2011 and the range of efficiency of the trial that took place on 03/05/2011.

Appendix

Appendix 1. Name key of non salmonid fish taxa captured by the upper and lower Clear Creek rotary screw traps at river mile 8.4 and 1.7 in, Shasta County, California, by U.S. Fish and Wildlife Service from October 1, 2010 through September 30, 2011.

Abbreviation	Common Name	Scientific Name
BGS	Bluegill	*Lepomis macrochirus*
CAR	California Roach	*Hesperoleucus symmetricus*
CENFRY	Unknown Centrarchidae	*Centrarchidae spp.*
COTFRY	Unknown Cottidae	*Cottus spp.*
CYPFRY	Unknown Cyprinidae	*Cyprinidae spp.*
DACE	Speckled Dace	*Rhinichthys osculus*
EAMMO	Pacific Lamprey Ammocoete	*Entosphenus spp.*
GSF	Green Sunfish	*Lepomis cyanellus*
GSN	Golden Shiner	*Notomigonus crysoleucas*
HH	Hardhead	*Mylopharodon conocephalus*
LAMMO	Lampetra Ammocoete	*Lampetra spp.*
LFRY	Unknown Lampetra	*Lampetra spp.*
MQF	Western Mosquitofish	*Gambusia affinis*
PL	Pacific Lamprey	*Entosphenus tridentata*
PLT	Pacific Lamprey Transfomer	*Entosphenus tridentata*
PRS	Prickly Sculpin	*Cottus asper*
RFS	Riffle Sculpin	*Cottus gulosus*
SASU	Sacramento Sucker	*Catostomus occidentalis*
SMB	Smallmouth Bass	*Micropterus dolomieu*
SPM	Sacramento Pikeminnow	*Ptychocheilus grandis*
TP	Tule Perch	*Hysterocarpus traski*
TSS	Threespine Stickleback	*Gasterosteus aculeatus*
WHC	White Catfish	*Ameiurus catus*
WHS	White Crappie	*Pomoxis annularis*

Appendix 2. Summary of non salmonid fish taxa captured by the upper Clear Creek rotary screw trap at river mile 8.4 in, Shasta County, California, by U.S. Fish and Wildlife Service from October 1, 2010 through September 30, 2011.

Species	Nov '10	Dec	Jan '11	Mar	May	June	Species Totals
RFS	1	1	2	1	42	48	95
CAR	1	5	24	1	30	16	77
SASU	3	5	6		4	5	23
EAMMO		1			3	10	14
UAMMO					3	6	9
COTFRY						2	2
CYPFRY		1			1		2
LFRY					1		1
SMB						1	1
WBLT						1	1
WHC						1	1
WHS			1				1

Appendix 3. Summary of non salmonid fish taxa captured by the lower Clear Creek rotary screw trap at river mile 1.7 in, Shasta County, California, by U.S. Fish and Wildlife Service from October 1, 2010 through September 30, 2011.

Species	Nov '10	Dec	Jan '11	Feb	Mar	Apr	May	Jun	Totals
BGS		2			1	1	1		5
CAR	1	2	1				1	2	7
CENFRY			1		1				2
COTFRY								1	1
CYPFRY		8	7	4	3	3	11	7	43
DACE		2							2
EAMMO	3	69	20	19	59	25	61	64	320
GSF						2		1	2
HH		1	1	1	2	10	9	5	29
LAMMO								1	1
LFRY								1	1
MICFRY							391	164	555
MQF		1				1	1	1	4
PL				1					1
PLT	5	199	3	4	9				220
PRS		1							1
RFS	4	9	14	4	6	13	3	7	60
SASU		5	3			1	1	3	13
SPM	2		3	1	1		3		10
TP		1							1
TSS		1				1			2
UAMMO	1		1	1	1	1	6	2	13
WBLT						1		1	2