Juvenile Salmonid Out-migration Monitoring at Caswell Memorial State Park in the Lower Stanislaus River, California

2010-2011 Biannual Report

Prepared by:

Clark Watry, Ayesha Gray, Kris Jones, Kirsten Sellheim, and Joseph Merz

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SUMMARY

We operated two rotary screw traps (RST) from 11 January to 17 June 2010, and 15 December 2010 to 8 July 2011 in the lower Stanislaus River, California at Caswell Memorial State Park (Caswell; N 37°42'7.533", W 121°10'44.882"; river kilometer 13.8). Since 1996, Cramer Fish Sciences has conducted annual operations at this location to monitor emigrating juvenile fall-run Chinook salmon Oncorhynchus tshawytscha and steelhead/rainbow trout *O. mykiss* to the San Joaquin River as part of the U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program (AFRP) and Comprehensive Assessment and Monitoring Program (CAMP). The objectives of this ongoing project are to estimate annual abundance of juvenile Chinook salmon out-migrants in the lower Stanislaus River; and, gather data to determine and evaluate patterns of timing, size, and abundance of juvenile Chinook salmon and *O. mykiss* relative to time of year, flow and other environmental conditions. In this report we provide annual passage estimates and compare timing, size and abundance between sampling years. A more detailed analysis of juvenile Chinook salmon population dynamics in relation to environmental variation requires more years of out-migration data and is beyond the scope of this biannual report. In 2010-2011, two traps were operated. The primary trap positioned in the thalweg, sampling >30% of channel flow, by volume, at flows less than 250 ft^3/s (7.1 m^3/s). Only the primary trap was used in determining passage estimates. We determined trap efficiency with a series of mark-recapture tests by tagging and releasing salmon upstream of the primary trap. We operated a secondary trap at the same river position along the opposite bank and performed beach seining adjacent to the site to supplement catch of juvenile Chinook salmon, to collect fish size and life stage data, to increase available fish for use in determining trap efficiency, and to substantiate presence/absence of salmonids when trap captures were low or zero. During the 2010 sampling period, we captured 1,098 juvenile Chinook salmon and one *O. mykiss* by RST and another 77 juvenile Chinook salmon by beach seine. In 2011, we captured 609 juvenile Chinook salmon and two *O. mykiss* by RST and 42 additional juvenile Chinook salmon by beach seine. As in previous years, we developed abundance estimates for out-migrating Chinook salmon using our trap efficiency and cumulative passage data; however, no estimates can be made for *O. mykiss* due to low catch (same as all previous years). In 2010-2011, a predictive logistic regression model was developed using efficiency data from previous years, and results of 11 efficiency tests conducted in 2010-2011. The abundance estimate of juvenile Chinook salmon passing Caswell in 2010 was 219,919 (95% C. I. = 26,803 – 884,313) and in 2011 was 328,541 (95% C. I. = 37,221 – 1,288,847) compared to 7,953 (95% C. I. = 2,237 – 21,349) in 2009. We also tested hypotheses about emigration timing and size differences between sampling years. In 2010 and 2011, we observed a significantly higher proportion of juvenile salmon emigrating as parr and smolts compared to fry, and pre-smolts and smolts were both significantly smaller in 2010 compared to 2011. Monitoring at Caswell continues to provide critical data on Stanislaus River salmonid life history diversity and population abundance to help AFRP and CAMP track success of their California Central Valley salmon recovery program.

TABLES OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* and steelhead (the anadromous component of the steelhead/rainbow trout complex) *O. mykiss* populations in California's Central Valley are at the southernmost extent of their range in North America, and are among numerous native California fish species undergoing widespread decline (Moyle et al. 2008). Chinook salmon and steelhead/rainbow trout have important economic as well as cultural and ecological value, and both historically supported robust fisheries (CDFG 2001; Merz and Moyle 2006). Precipitous declines in the past century are linked to a variety of anthropogenic impacts, including mining (e.g., gold, gravel, and copper), over-harvest, logging, hydropower development, flood protection, introduced species, hatchery fish interactions, pollution, and corresponding urban and agriculture development (Nehlsen et al. 1991; Yoshiyama et al. 2001; Williams 2006; NMFS 2009). Dams and other impediments have prevented passage to important staging areas and spawning grounds with greater relative impacts to spring-run Chinook salmon and steelhead populations which historically made extensive use of higher elevation habitats (Moyle 2002; May and Brown 2002). Hatchery supplementation has only compounded the problem by compressing run timing and stock complexity (Lichatowich 1999; Augerot et al. 2005; Bottom et al. 2005), and likely has significant management implications in the Central Valley (Barnett-Johnson et al. 2007). Moyle et al. (2008) identify inadequate flows, habitat reduction and elimination, and genetic degradation from hatchery supplementation as the primary stressors affecting salmonid populations in California.

In late 2007, an Emergency Action under Magnusson-Stevens Act authority declared a commercial fishery failure for the West Coast Chinook salmon fishery due to historically low returns (National Oceanic and Atmospheric Administration (NOAA) 2008). Changing ocean conditions (i.e., shifting ocean temperatures and food sources) may be a causal factor contributing to poor juvenile salmon survival (NOAA 2008). Additionally, the report states cumulative impacts to freshwater habitats have "made salmon populations more susceptible to the occasional poor ocean conditions" (NOAA 2008). Return abundance continued to decline in fall 2008. The Pacific Fishery Management Council (PFMC) reported 66,264 salmon adults returned to the Sacramento River in 2008—well below the 90,000 in 2007 (PFMC 2009). Commercial ocean harvest and recreational fisheries for Central Valley Chinook salmon remained closed through 2009 (CDFG 2009; PMFC 2009). Beginning in 2009, new regulations designated Central Valley rivers and streams, including the San Joaquin River and its tributaries, closed to salmon fishing year-round and prohibited catch and release fishing that intentionally targeted salmon (CDFG 2009). These regulations were also effective through 2010.

The National Marine Fisheries Service (NMFS) finalized a biological and conference opinion (Opinion) in June 2009 after review of the proposed long-term operations of the Central Valley Project (CVP) and the State Water Project (SWP). The Opinion (NMFS 2009) discusses the effects the CVP/SWP operations might have on listed anadromous fishes and marine mammals in accordance with Section 7 of the Endangered Species Act of 1973 (ESA). The Opinion includes two main objectives for the Stanislaus River: 1) Provide sufficient definition of operational criteria to ensure the viability of the steelhead population on the Stanislaus River, including freshwater migration routes to and from the Delta; and, 2) halt or reverse adverse modifications of steelhead critical habitat (Available: http://swr.nmfs.noaa.gov/ocap.htm).

The 1992 Central Valley Project Improvement Act (CVPIA) granted authority to the U.S. Fish and Wildlife Service (USFWS) to develop and implement a series of restoration programs, with the goal of doubling the natural production of anadromous fish in Central Valley streams. The U.S. Bureau of Reclamation and USFWS are responsible for implementing provisions outlined in the CVPIA (Available: http://www.usbr.gov/mp/cvpia/title_34/index.html). To support this goal, USFWS established the Anadromous Fish Restoration Program (AFRP) and the Comprehensive Assessment and Monitoring Program (CAMP). These programs set anadromous fish production targets, recommended fishery restoration actions for Central Valley streams, and formed a juvenile Chinook salmon and *O. mykiss* monitoring program to assess the relative effectiveness of fishery restoration actions. The two programs support informed feedback on population dynamics of target species that allow adjustments or improvements to adaptive management plans and approaches.

The Stanislaus River, a major tributary to the San Joaquin River, still provides valuable spawning and rearing habitat for Central Valley fall-run Chinook salmon, considered species of concern, and the steelhead component of *O. mykiss* listed as threatened, under the federal ESA (NOAA 2004). Additionally, multiple habitat improvement projects have been implemented while others are currently in development. Juvenile out-migration monitoring is an important component of fisheries habitat restoration and management in the Stanislaus River. Since 1996, the USFWS has supported Cramer Fish Sciences (CFS) to monitor juvenile salmonid out-migration in the Stanislaus River. The current monitoring program determines annual juvenile Chinook salmon production using RSTs at Caswell Memorial State Park (Caswell; N 37°42'7.533", W 121°10'44.882") (river kilometer (rkm) 13.8), and quantifies emigrants to the San Joaquin River. Because of the difficulty in separating anadromous and non-anadromous *O. mykiss* and their low capture rates within the Stanislaus River, RST monitoring provides general information on *O. mykiss* timing and presence. This long-term data set provides a valuable source of information for evaluating fish responses to in-river management actions. The primary objectives of this project were to:

1) Estimate annual abundance of juvenile Chinook salmon out-migrants in the lower Stanislaus River using RSTs operated near Caswell; and,
2) Determine and evaluate patterns of timing, size, and abundance of juvenile Chinook salmon and *O. mykiss* relative to time of year, flow and other environmental conditions.

In this report we provide catch details from RST operations, determine trap efficiency, develop annual passage estimates and compare timing, size and abundance between the 2010-2011 juvenile Chinook salmon monitoring program. A more detailed analysis of juvenile Chinook salmon population dynamics in relation to environmental variation requires more years of out-migration data and is beyond the scope of this biannual report. Our analyses are designed to compare key factors between years and test the following null and alternate hypothesis:

$H1_0$: There is no significant difference in the fry to combined parr/smolt ratio between years (2010-2011).

$H1_a$: There is a significant difference in the fry to combined parr/smolt ratio between years (2010-2011).

$H2_0$: There is no significant difference in the fry and combined parr/smolt mean fork length (FL) between years (2010-2011).

$H2_a$: There is a significant difference in the fry and combined parr/smolt mean FL between years (2010-2011).

$H3_0$: There is no significant difference in monthly juvenile Chinook salmon abundance between years (2010-2011).

$H3_a$: There is a significant difference in monthly juvenile Chinook salmon abundance between years (2010-2011).

And, to address the following question:

Was there a difference in life history strategies, size or abundance of emigrants between the two sampling years?

This juvenile salmonid monitoring program helps AFRP and CAMP address their goals to track population dynamics, evaluate the results of past and future habitat restoration efforts, and to understand the impacts of instream flow schedules and management on the fall-run Chinook salmon and *O. mykiss* populations. This annual report details results from 2010-2011 RST operations at Caswell in the lower Stanislaus River and provides critical details to address these goals.

STUDY AREA

The Stanislaus River, a major tributary to the San Joaquin River, flows southwest from the western slopes of the Sierra Nevada Mountains with a drainage area of approximately 240,000 ha and approximately 40% of its basin above snowline (Kondolf et al. 2001) (Figure 1). The confluence of the Stanislaus and San Joaquin rivers is located near the southern end of the Sacramento-San Joaquin River Delta. The basin has a Mediterranean climate with dry summers and about 90% of the annual precipitation occurs between November and April (Schneider et al. 2003). More than 40 dams exist on the Stanislaus River. Collectively, these dams have the capacity to store 240% of the average annual runoff in the basin. Approximately 85% of this total storage capacity is in New Melones Reservoir (Schneider et al. 2003). Dams control the Stanislaus River for flood protection, power generation, irrigation and municipal water. The river is also used for whitewater recreation and off-channel gravel mining. Goodwin Dam (GDW), located at rkm 94 of the Stanislaus River, is the upstream migration barrier to adult Chinook salmon (see Figure 1; Appendix 1). Most salmon spawning in the Stanislaus River is by fall-run Chinook salmon and occurs in the 29 km reach below GDW; however, spawning has been observed as far downstream as rkm 53.1. Additionally, rare observations of early-migrating (i.e., May to June) adult Chinook salmon in the Stanislaus River do exist (Anderson et al. 2007); however, their origin is unclear. Little work has been gathered on *O. mykiss* migration timing, abundance or spawning parameters within the Stanislaus River to date (CFS 2009). See Appendix 2 for complete species list.

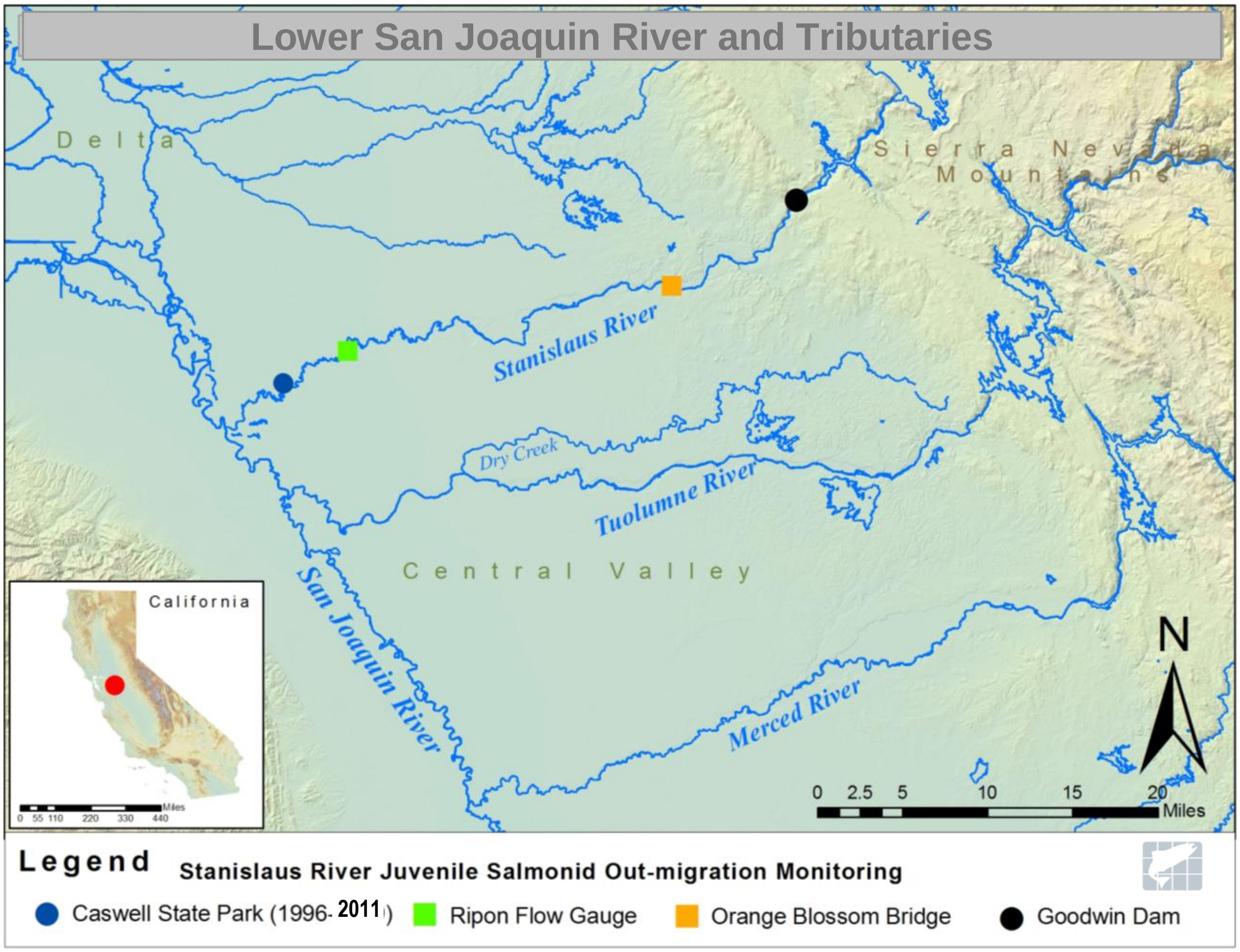


Figure 1. Map of the Stanislaus River below Goodwin Dam in relationship to other San Joaquin River tributaries and relative landmarks.

METHODS

Trap Operations

In 2010-2011, we continued out-migration monitoring operations in the Stanislaus River at Caswell. This site was selected as the furthest downstream location with suitable channel characteristics and access to install and monitor traps. Due to low flow and changes to channel conditions at the site, we relocated the trapping operation ~50 m downstream in 2009 (Watry et al. 2009), and used the same trap locations in 2010 and 2011. As in 2009, the primary trap (Trap 1) was operated to track juvenile salmonid out-migration, and develop passage abundance estimates for Chinook salmon (Figure 3). The secondary trap (Trap 2) was operated during increased flow periods to collect additional information on the out-migrant population (i.e., fish size, life stage composition) and secure additional individuals to increase mark-release group sizes for determining the efficiency of Trap 1. Traps were secured with 6.35 mm galvanized steel cable leaders fastened to large trees, and state park permits allowed CFS access to the trap by land or boat as necessary. We monitored trap operation following guidelines outlined in standard protocols (CAMP 2008; Gray et al. 2011). Trap rotations were enumerated by a mechanical counter (Redington Counters, Inc.; Model 29) secured to the pontoon adjacent to the leading edge of the cone. Similar to our primary objectives, several authors have used this methodology to monitor population dynamics and abundance for salmonid out-migrations (e.g., Thedinga et al. 1994; Fleming 1997; Roper and Scarnecchia 1998; Sparkman 2001; Workman 2002–2006; Seesholtz et al. 2004; Bottom et al. 2005; Rayton 2006; Johnson and Rayton 2007; Workman et al. 2007). Trap cones were raised and non-operational on days when sampling did not occur. We terminated sampling when at least seven consecutive days of trapping with zero juvenile Chinook salmon catch occurred in June or July, typically the end of emigration (Gray et al. 2011).

Safety Measures

All trap personnel were trained in RST operational safety, and safety signs were posted to warn river users and park visitors of the inherent dangers of the operations. We placed signs in conspicuous places at the trap site and on each side of the trap, and upstream of the trap. The upstream sign stated “Danger Ahead – Stay Left” with a large arrow pointing in the direction of the best side of the river channel for boaters to pass the traps. Flashing lights and flagging were placed on the traps and along the rigging. All signs were in English and Spanish.

Additional Seining

We sampled two locations on the Stanislaus River (upper and lower) adjacent to Caswell downstream of the RST site during periods of low or zero juvenile Chinook salmon catch to supplement catch for use in determining trap efficiency. A 15.25 m x 1.8 m beach seine with a 0.64 cm mesh size with 38 mm diameter wooden support poles was used to make one to three hauls (typically three) during daylight within each sample site (Figure 2). Seining was conducted in water less than 1.2 m deep with velocities less than 0.92 m/s, and we attempted to seine areas with substrates free of large obstructions to effectively dragging the seine through an area. Two people walked the seine into the river, deployed the net and the distance from shore was noted. One person began moving downstream to deploy the seine as the upstream team member remained stationary. The seine was then pulled onto shore and two markers were placed where the two ends of the seine first reached the bank. The measurement of site length multiplied by the distance out from shore provides an estimate of area seined. The two people pull the ends of the seine onshore while keeping the lead line down. When the net was completely retrieved, captured fish were removed from the net and placed in a large container of river water. They were enumerated, weighed and held for use in trap efficiency tests.

Figure 2. Beach seining was used to supplement catch of fish used for efficiency tests and to evaluate juvenile Chinook salmon presence/absence during periods of low RST catch.

Fish Handling and Data Collection

We generally checked traps once a day, and twice a day (or more) as conditions required (i.e., debris loads due to freshets or during scheduled flow release increases). Fish handling procedures used during trap and seine sampling followed the methods of Gray et al. (2011). We used tricaine methanesulfonate (Tricaine-S; Western Chemical, Inc.) to anesthetize fish for safe handling. To limit handling injury and stress, all captured fish were anesthetized in groups of 5 – 10 individuals immediately prior to handling using a solution of river water and Tricaine-S at a 26.4 mg/L concentration. The solution was cooled with frozen river water bottles to reduce thermal stress of captured fish. Litmus strips were used to check pH and baking soda was added to buffer the acidity of the solution. The effectiveness of Tricaine-S varies with changes in temperature and fish density; therefore, all solutions were tested with a few fish to determine potency and adjusted if necessary. StressCoat (Aquarium Pharmaceuticals, Inc.), which helps fish replace their slime coat and scales, was added to the Tricaine-S solution and recovery buckets at a rate of 2.5 ml per 9.5 L. Processed fish were returned to a bucket with fresh river water to recover prior to release. Water temperature and dissolved oxygen (DO) levels were monitored and maintained above critical levels (Gray et al. 2011). Life stage was determined by assigning a smolt index value based on morphological characteristics (Table 1). For Chinook salmon and *O. mykiss*, we recorded fork length (FL, mm), weight (g), and life stage for 25 randomly-selected fish each day; any additional fish were counted. The silvery parr designation was only used for *O. mykiss*; it was not applied to juvenile Chinook salmon (CAMP 1997). All captured fish were released approximately 150 m downstream of the traps below a large, deep pool in an attempt to decrease risk of predation and prevent recapture. Night check procedures were identical to daytime checks, with the exception of only measuring the first 20 fish of each species and counting the remainder.

Table 1. Smolt index rating adapted from (CAMP 2008).

Smolt Index	Life Stage	Criteria
1	Yolk-sac fry	-Newly emerged with visible yolk sac
2	Fry	-Recently emerged with sac absorbed; pigment undeveloped
3	Parr	-Darkly pigmented with distinct parr marks; no silvery coloration; scales firmly set
4*	Silvery parr	-Parr marks visible but faded, or completely absent; intermediate degree of silvering
5	Sub-yearling smolt	-Parr marks highly faded or absent; bright silver or nearly white coloration; scales easily shed; black trailing edge of caudal fin; more slender body
Yearling	Yearling smolt	-All the same characteristics as a sub-yearling smolt; generally larger than 110 mm FL

**Silvery parr life stage was only used for O. mykiss.*

Environmental Variables

We measured instantaneous physical variables once daily. We recorded instantaneous water temperature and dissolved oxygen using an YSI Handheld Dissolved Oxygen Instrument (YSI; Model 550A). We measured instantaneous water velocity using a Marsh-McBirney flow meter (Global Water Instrumentation, Inc.; Model FP101) in front of the trap cone to monitor local flow conditions affecting trap rotations. Instantaneous turbidity was measured in Nephelometric Turbidity Units (NTU) using a turbidity meter (LaMott Company; Model 2020). We obtained average daily flow data from three U.S. Geological Survey (USGS) gauging stations from the California Data Exchange Center (CDEC), including Goodwin Dam (GDW; rkm 94), Orange Blossom Bridge (OBB; rkm 75.5), and Ripon (RIP; rkm 25.4). We determined trap effort by measuring the rate of cone revolution during each trap check and recording revolutions between checks from counters. Our results were summarized in tables and data for flow was used in our passage abundance analysis.

Catch

We recorded and summarized data on daily catch of juvenile Chinook salmon and *O. mykiss* and determined recaptures from trap efficiency tests. We identified and enumerated non-target species and measured the first 20 individuals of each species each day. We developed a length histogram from our data to evaluate size classes, and compared the histogram with catch date to assess emigration timing and life history patterns. Species composition charts were developed to demonstrate the relative abundance of all fish caught. We summarized our weekly catch by life stage (smolt index) and size.

Trap Efficiency

In order to derive accurate estimates of abundance, it was first necessary to determine the catch rates (or efficiencies) for the RST. We determined trap efficiency with mark and recapture of juvenile Chinook salmon to estimate the number of natural migrants passing Trap 1 (passage). In both years, different marks were used for each release group due to the close time proximity of releases and subsequent overlapping recaptures. Fish were dye-marked using a photonic marking gun (Meda-E-Jet; A1000) with pink dye on the caudal or anal fin (Figure 3). Releases occurred approximately 430 m upstream of the traps from the north bank at a narrow (~20 m) and deep area of the river. Fish releases occurred approximately one hour after dark in small groups (5 – 10 individuals) to encourage mixing with unmarked, natural Chinook salmon in the river, reduce extent of schooling, and mimic pulses in natural passage during nighttime migration. When water depth and flow prevented wading into the channel, marked fish were released using a long-handled (3 m) dip net to release fish across the channel at various points away from the bank. Traps were processed one hour after completing release activities. Additional recaptures were recorded with the subsequent days' catch.

Figure 3. Biologist marking fish with pink photonic dye.

Following methods from previous years (Watry et al. 2007, 2008, 2009), we utilized our 160 experimental mark-recapture release groups across years (1996 – 2011) and used a logistic regression to develop a predictive model to determine daily trap efficiencies at Caswell (Appendix 3). Environmental factors that were originally considered in our analyses included the natural log of flow (denoted log(flow)), temperature, and turbidity. We considered the natural logarithm of flow, denoted log(flow), as previous work has shown non-linear effects of flow on similar parameters, such as migration speed and survival (Kjelson and Brandes 1989; Williams and Matthews 1995; Newman and Rice 2002; Newman 2003). Fork length at release was also considered, as was the categorical variable 'year', to control for between year differences in trap efficiency (e.g., due to differences in trap placement, channel morphology, bank vegetation etc.). We used a backward stepwise regression procedure to determine the 'best fitting' model, which was then used to estimate daily trap efficiencies. Logistic regression is used for predicting the probability of occurrence of an event by fitting data to a logistic curve (Zar 1999). It is essentially a generalized linear model that is applicable to binomial data (McCullach and Nelder 1989; Dobson 2002); in this case, binomial data would refer to the potential outcomes of fish collection (i.e., either the fish is caught or not). Like many forms of regression analysis, it makes use of several predictor variables that may be either numerical or categorical. Here, the binomial probability of interest is the observed trap efficiency (q):

(1) $$q = \frac{m}{R},$$

where m is number of observed recaptures (a binomial variable) of a given release group of size R. The logistic model with n explanatory variables (x) can be expressed in linear form as:

(2) $$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n,$$

where y is the "logit" transform of the observed trap efficiency (q):

(3) $$y = \text{logit}(q) = \log\left(\frac{q}{1-q}\right).$$

The coefficients (β), which are estimated via maximum likelihood, provide predicted values of trap efficiency ($\hat{q}$) via the following back-transformation of the logit function:

(4) $$\hat{q} = \frac{\exp(y)}{1+\exp(y)}.$$

In the first step, a model was fit with an intercept (β_0), and then each explanatory variable was entered one at a time. The variable with the greatest explanatory power was then included in the model, and the remaining variables were again entered one at a time. The procedure was terminated when none of the remaining variables had a statistically significant effect on survival at the $\alpha = 0.05$ significance level. An alternative approach to model selection was also examined, in which the "best fitting" model was determined using the Akaike Information Criterion (AIC), adjusted for over-dispersion (Burnham and Anderson 2002). However, the stepwise regression and AIC procedures provided the same "best" model in all analyses. The statistical significance of explanatory variables in the "best fitting" model was tested using analysis of deviance (McCullach and Nelder 1989; Venables and Ripley 1999). Under the binomial assumption, a logistic model that adequately explains variability in trap efficiencies will have a deviance roughly equal to the residual degrees of freedom. However, in our analyses, model deviances were much greater than expected due to binomial sampling error alone. Such extra-binomial variation, which may arise from either over-dispersion or inadequate model structure (i.e., when key processes affecting trap efficiencies are missing from the model), must be accounted for when testing variables and estimating confidence intervals. Extra-binomial variation is represented by a dispersion parameter, Φ, which is a scalar of the assumed binomial variance. To conduct statistical tests and compute confidence intervals, we multiplied the variance-covariance matrix for the logistic coefficients by the dispersion parameter, which is easily estimated from the fit of a logistic regression (Venables and Ripley 1999).

Passage Estimates

The daily passage abundance (*n*) of migrating juvenile Chinook salmon was estimated as follows:

(5) $$\hat{n} = \frac{c}{\hat{q}} ,$$

where *c* was observed daily count and $\hat{q}$ was the estimated trap efficiency for that day based on the "best" logistic model. Annual passage was estimated by summing the daily abundance estimates. Standard errors (SE) and confidence intervals for measures of total monthly and annual passage were computed using the methods described in Watry et al. (2008). During some years, there were periods when traps were not fished. To estimate a missing value of daily count (*c*) within a sampling period, we used the weighted average of all observed counts for the five days before and five days after the missing value. The weights were equal to one through five, where values that were directly adjacent to the missing day were weighted as five, values that were two days before and after the missing day were weighted as four, and so on.

Life Stage, Size and Abundance Analysis

To standardize data for our analyses, we defined two general life stage classes from our smolt index (see Table 1); i.e., fry and combined parr/smolts. Since the transition in size from fry to parr/smolt is more distinct than the transition from parr to smolt, fry are defined as sac-fry and fry, while parr and sub-yearling smolts are combined. Fry, parr, sub-yearling smolt and yearling smolt juveniles identified as non-fall-run origin, based on length and date of capture, were excluded from the following analyses. In order to address our hypotheses and questions, we compared: timing with a Chi-squared analysis to determine if there was a significant difference in the fry to combined parr/smolt ratio between years; size (FL) by life stage of captured juvenile Chinook salmon in 2010 and 2011 using Analysis of Variance (ANOVA); and, differences in monthly juvenile abundance between years with a paired t-test.

RESULTS

Trap Operations

For the 2010 season, sampling began on 12 January 2010 after the trap was installed and terminated on 17 June 2010 at the end of the migration period. For the 2011 season, sampling began on 15 December 2010 and ended on 8 July 2011. We sampled seven days a week for the majority of both seasons, which resulted in 105 trapping days in 2010 and 202 days in 2011. Sampling occurred with additional seining on five different dates from 10 February through 5 May 2010 and on three dates from 23 – 31 March 2011. In both years, the primary purpose of seining was to supplement the catch for use in testing trap efficiency.

Environmental Variables

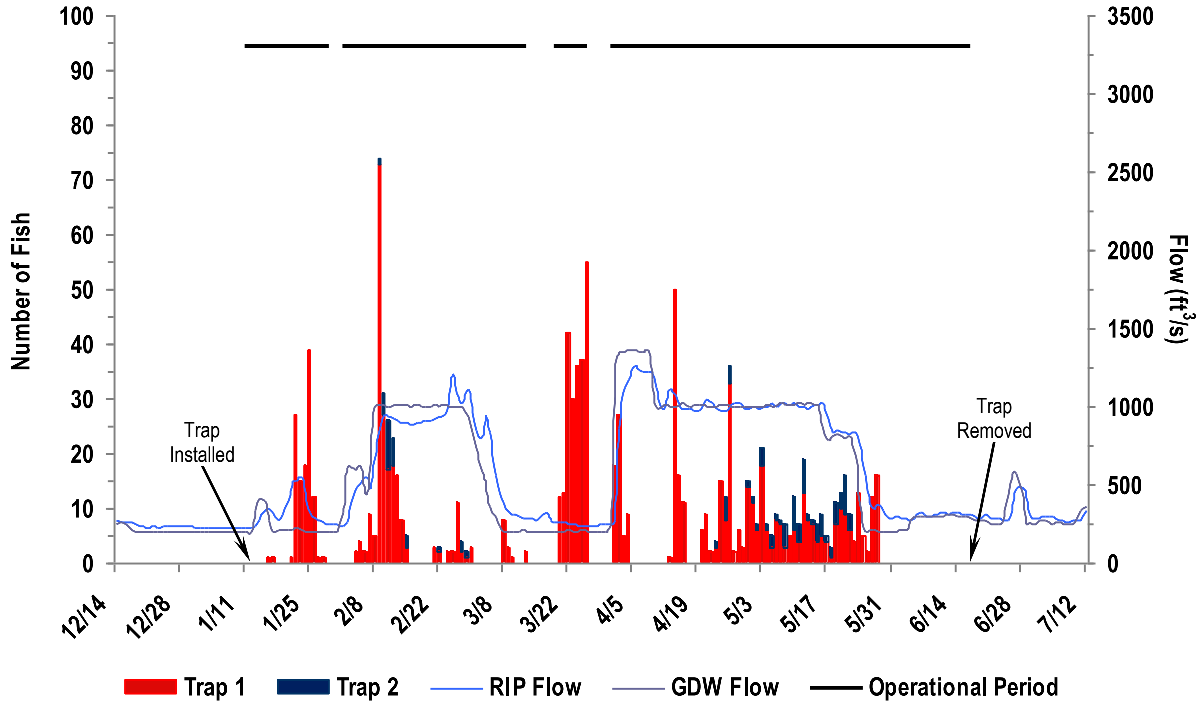
In 2010, mean daily flow at RIP ranged from 225 – 1,260 ft^3/s (8.3 – 46.7 m^3/s) during the season, while flow ranged from 229 – 2,883 ft^3/s (8.5 – 106.8 m^3/s) in 2011 (Appendix 4). Daily temperature ranged from 8.2°C – 23.2°C in 2010 and from 7.8°C – 16.6°C in 2011. In both years, turbidity (NTU) was greatest in the early part of the out-migration season, but decreased with the onset of spring and summer. Instantaneous DO never measured below 7.53 mg/L in 2010 and 9.34 mg/L in 2011. Controlled flow releases for the Vernalis Adaptive Management Program (VAMP) were effective from early April to late May 2010, and from early April through the end of the season in July 2011 (Figure 4 a and b, respectively). It is important to note flow conditions in 2011 were substantially higher over a longer duration compared to 2010, effectively reducing the proportion of flow sampled and affecting overall catch abundance, species composition, and trap efficiency.

Catch

Salmonids

During the 2010 trapping season we captured a total of 1,098 natural, unmarked Chinook salmon (Figure 4a) and one *O. mykiss* in the Caswell RSTs (Appendix 6). In all, 74 Chinook salmon were captured by seine (Table 2). The first Chinook salmon was observed on 16 January 2010 and the last was observed on 28 May 2010. Peak weekly catches (n = 183 and 200) at the Caswell RST occurred the week of 8 - 14 February (both traps in operation) and 22 - 28 March 2010 (single trap in operation), respectively. The overall mortality rate was 2.09% (n = 23) of the total juvenile Chinook salmon catch; 74% of the mortalities occurred during a two-day period from 22 – 23 March 2010. During the 2011 trapping season we captured a total of 609 natural, unmarked Chinook salmon (Figure 4b) and two *O. mykiss* in the Caswell RSTs (Appendix 7). Another 42 Chinook salmon were captured by seine (Table 2). The first Chinook salmon of the 2011 season were captured on 21 December 2010 and the last was observed on 22 June 2011. Peak weekly catches (n = 209) during the fry period occurred from 21 – 27 February 2011 (both traps in operation). An early, smaller peak (n = 72) also occurred from 3 - 9 January. There were no discernable peaks during the parr or smolt periods with weekly catch ranging from 4 to 31 juveniles between 7 March and 26 June. There were nine mortalities (1.48% of the total juvenile Chinook salmon catch), and these occurred sporadically throughout the trapping season.

(a) **2010**



(b) **2011**

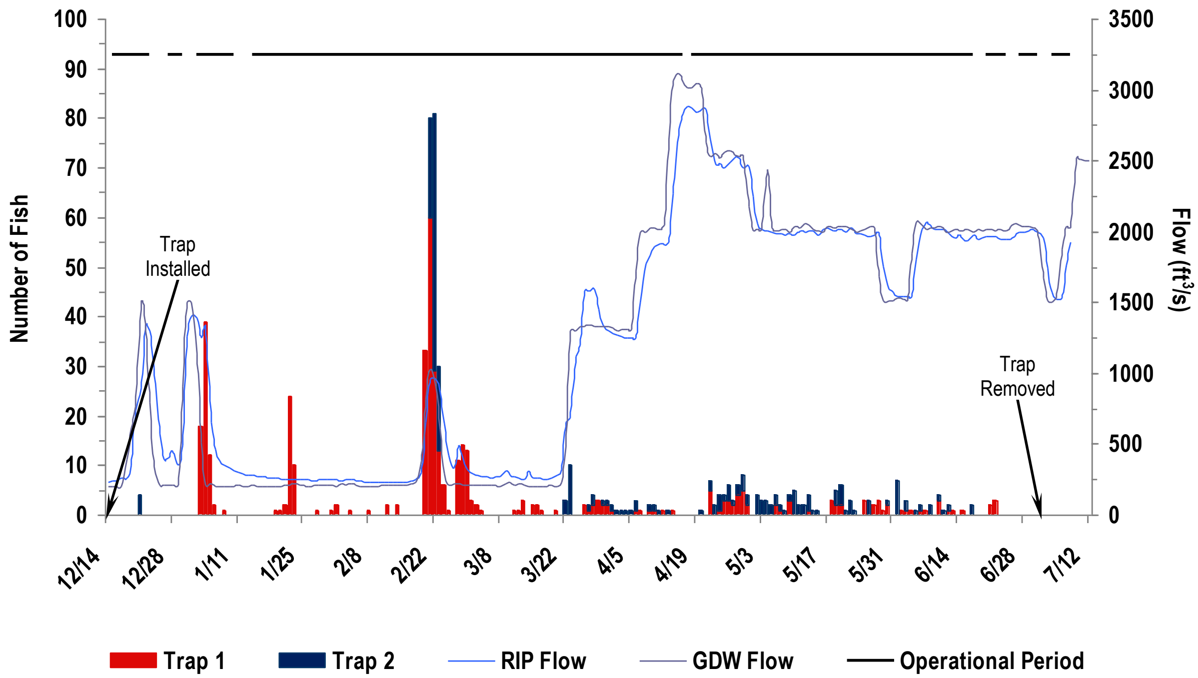


Figure 4. Daily Chinook salmon and catch in the Caswell RSTs and flow (ft^3/s) at Ripon (RIP) in 2010 (a) and 2011 (b). The operational period includes all days when the traps were checked, regardless of trap function. Note distinct difference in 2011 spring-time flows. See Appendices 6 and 7 for trap-specific catch summaries.

Table 2. Juvenile Chinook salmon seine catch at Caswell, 2010 and 2011.

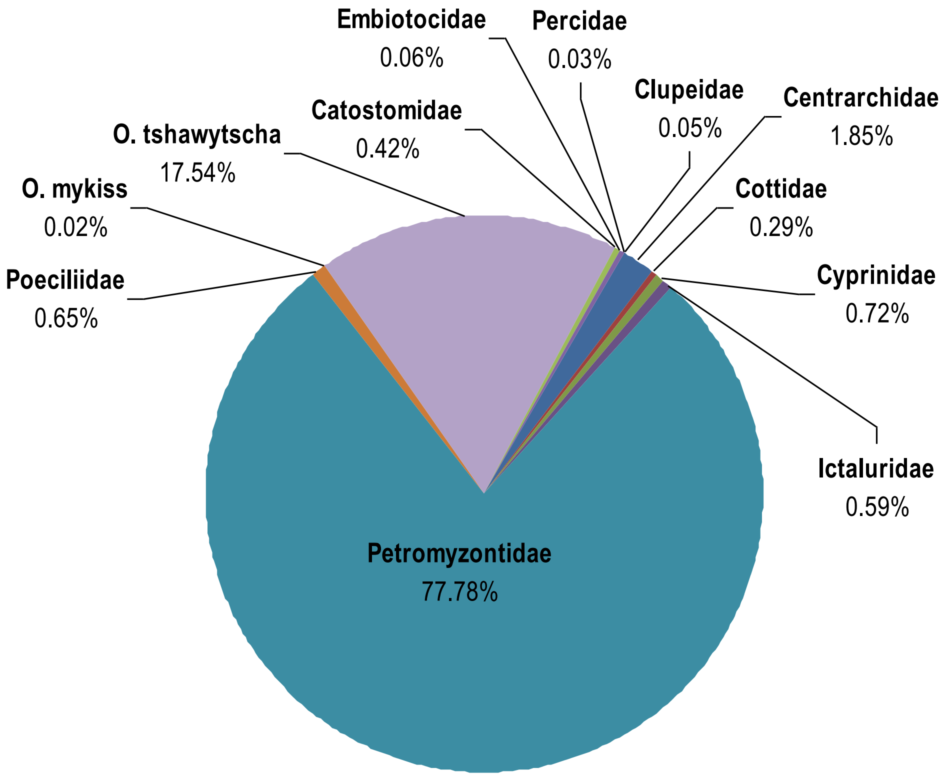
Sample Date	Total	Fry	Parr	Smolt	Size Range (mm FL)
2/10/2010	9	9	0	0	34 - 46
2/24/2010	59	47	12	0	33 - 58
3/12/2010	5	5	0	0	47 - 55
4/19/2010	1	0	0	1	78
2010 Totals	**74**	**61**	**12**	**1**	**33 - 78**
3/23/2011	23	0	11	12	55 - 98
3/24/2011	11	0	5	6	49 - 100
3/31/2011	8	0	8	0	72 - 98
2011 Totals	**42**	**0**	**24**	**18**	**49 - 100**

Non-Target Species

In 2010, we captured 5,162 incidental (non-target) fish of 23 identifiable species, including the following families: Petromyzontidae (lamprey), Centrarchidae (sunfishes and bass), Poeciliidae (western mosquitofish), Percidae (Bigscale logperch), Catostomidae (Sacramento sucker), Embiotocidae (Tule perch), Clupeidae (Threadfin shad), Cyprinidae (Sacramento pikeminnow and other minnows), Ictaluridae (catfishes), and Cottidae (sculpin) (Figure 5a). We observed 74 bass (*Micropterus* spp.), 20 sunfish (*Lepomis* spp.), 4,834 lamprey (*Lampetra* spp.), 25 minnows (Cyprinidae), and two catfish that could not be identified in the field.

In 2011, we captured 252 incidental (non-target) fish of 14 identifiable species, including the following families: Petromyzontidae (lamprey), Centrarchidae (sunfishes and bass), Poeciliidae (Western mosquitofish), Cyprinidae (Sacramento pikeminnow and other minnows), Ictaluridae (catfishes), and Cottidae (sculpin) (Figure 5b). We observed 8 bass (*Micropterus* spp.), one sunfish (*Lepomis* spp.) and 14 lamprey (*Lampetra* spp.) that could not be identified in the field. A species list for 2010 and 2011 is provided in Appendix 2.

(a) **2010**



(b) **2011**

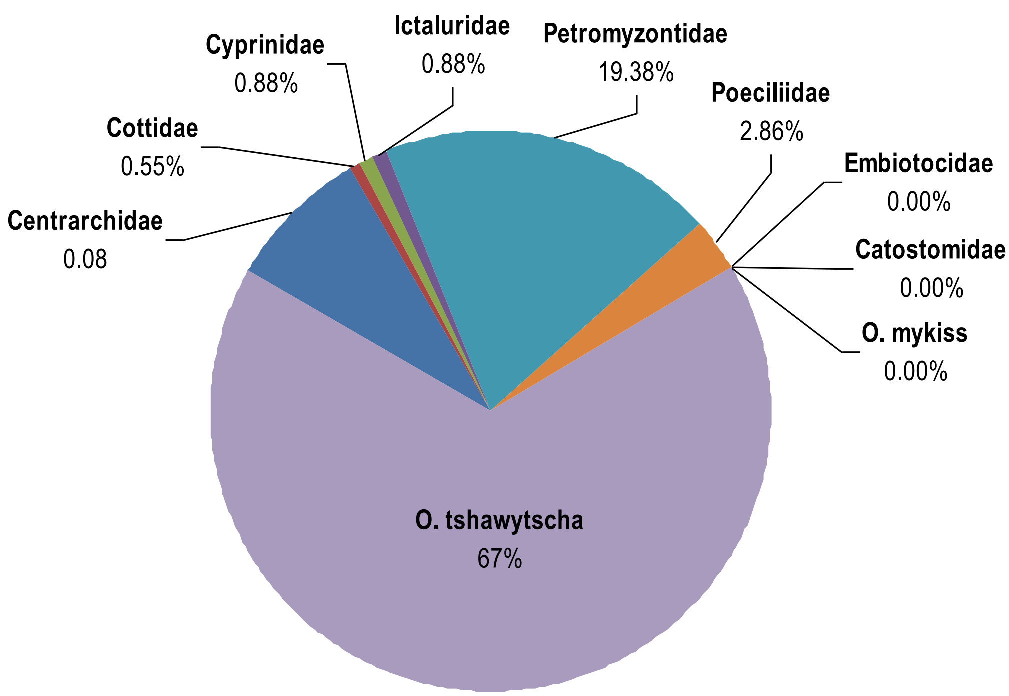


Figure 5. Relative abundance of all taxonomic groups captured in the Caswell RSTs in 2010 (a) and 2011 (b). Note, high flows in 2011 resulted in low overall catch and a change in catch composition from 2010.

Summary of Life Stage Data

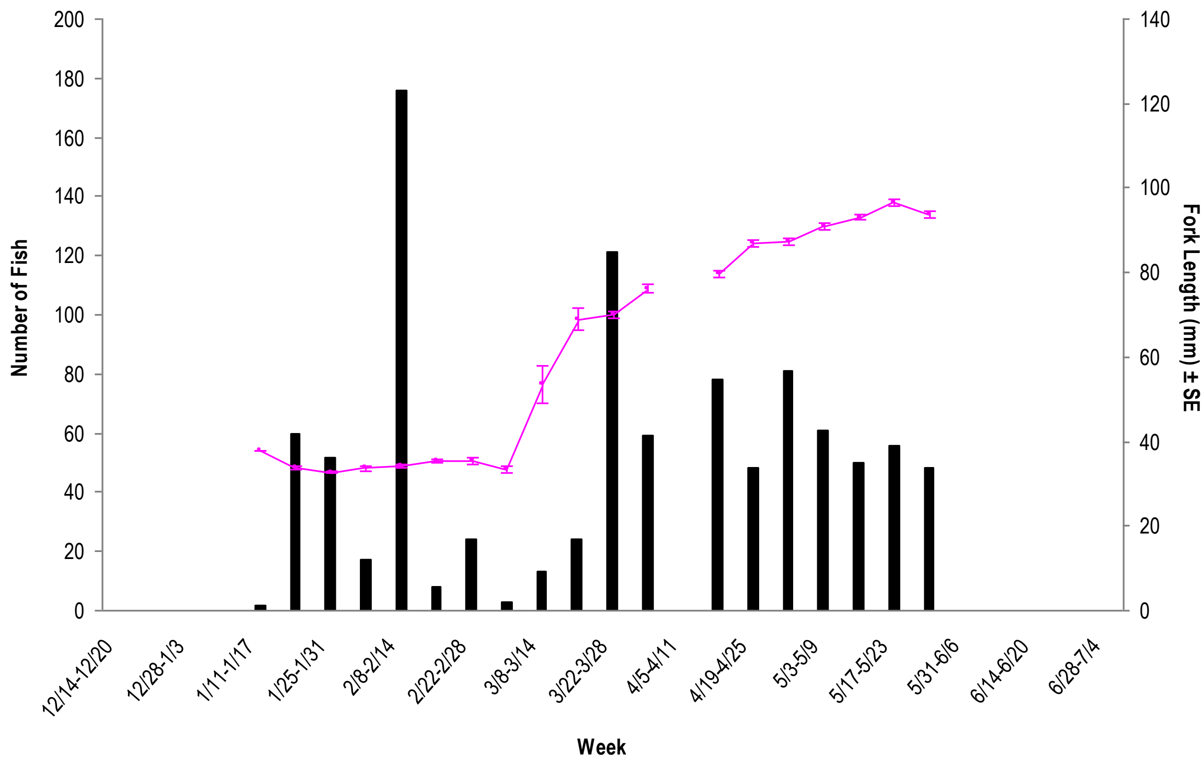
We observed four of the identified juvenile Chinook salmon life stages during the 2010 sampling (fry, parr, sub-yearling smolt, and yearling smolt) (Table 3). In 2011, we captured all five juvenile Chinook salmon life stages. In both years, fall-run Chinook salmon emigration was generally represented by two groups of fish present from mid-January to mid-March (yolk-sac fry, fry) and from late April through May (parr, sub-yearling smolt) (Figure 6). In 2010, the majority of the out-migration catch was composed of sub-yearling smolts (54.9%); but in 2011, the fry life stage was most abundant (63.0%). In both years, the parr life stage contributed minimally to the total migrant population (9.5% in 2010 and 4.1% in 2011). Yearling smolt fish exhibit the spring-run life history strategy, and made up 0.3% and 1.3% of total catch in 2010 and 2011, respectively. Each life stage has different size distributions and timing patterns (Table 3; Figures 7 and 8).

Table 3. Percent of juvenile Chinook salmon catch by life stage (according to smolt index) from the Caswell RSTs, 2010-2011. Note, totals do not include "plus-counted" fish where life stage by smolt index was not recorded.

Year	Life Stage	Number*	Percent of Catch	Date Range	Median Passage	Mean FL (mm) ± CI
2010	Yolk-sac fry	0	0%	-	-	-
	Fry	346	35.3%	1/16-3/21	2/9	34.0 ± 0.3
	Parr	93	9.5%	2/24-4/16	3/24	64.0 ± 1.3
	Sub-yearling smolt	539	54.9%	3/9-5/28	4/26	86.3 ± 0.8
	Yearling smolt	3	0.3%	2/9-3/21	3/9	98.7 ± 28.7
	Cumulative Total	**981**		**1/16-5/28/2010**		
2011	Yolk-sac fry	2	0.4%	1/3-1/3	1/3	33.0 ± 12.7
	Fry	341	63.0%	12/21-3/26	2/21	35.5 ± 0.2
	Parr	22	4.1%	2/14-5/10	3/28	67.8 ± 4.0
	Sub-yearling smolt	169	31.2%	3/20-6/22	5/9	95.0 ± 1.3
	Yearling smolt	7	1.3%	2/21-4/20	3/12	95.9 ± 24.2
	Cumulative Total	**541**		**1/3 - 6/22/2011**		

**93 fish in 2010 and 11 in 2011 were plus-counted and not assigned a smolt index value*

(a) **2010**



(b) **2011**

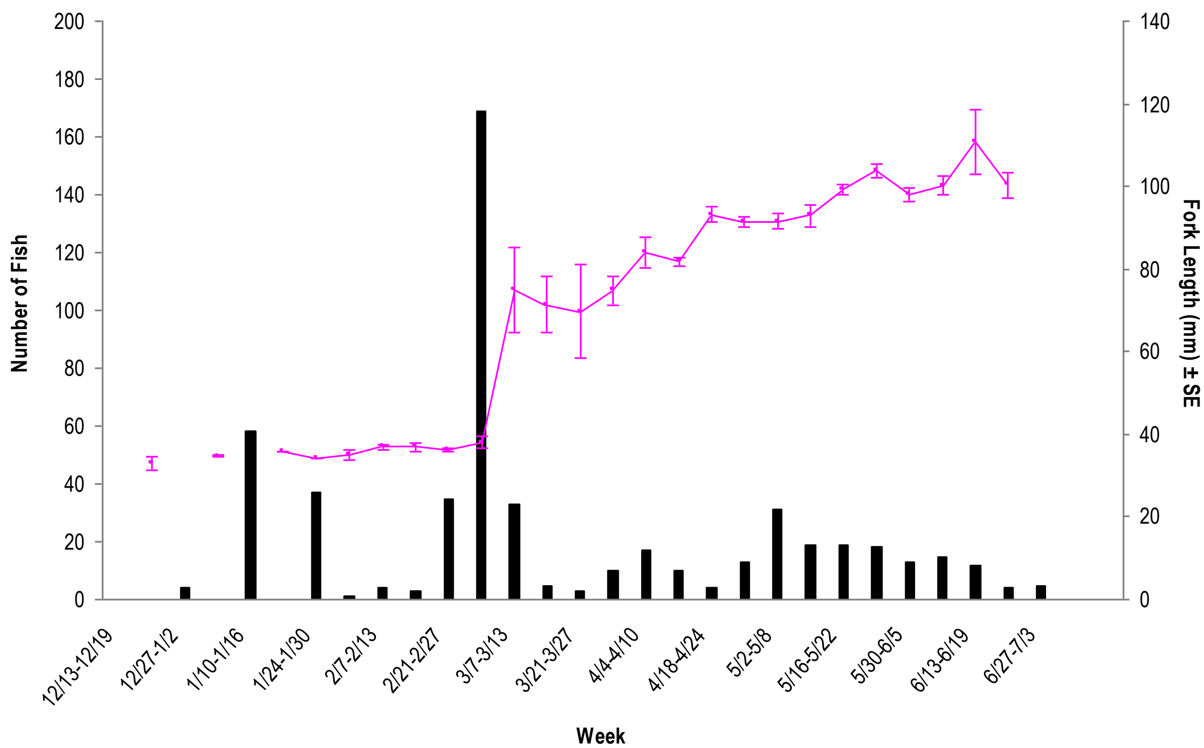
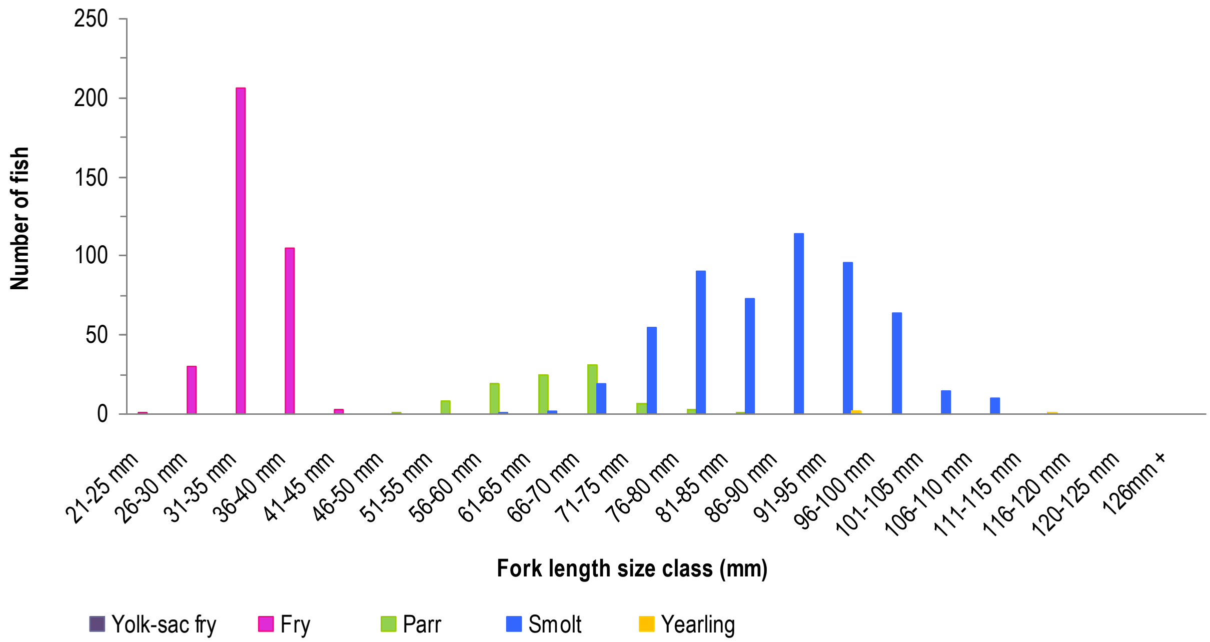


Figure 6. Weekly catch and mean weekly fork length (mm) for juvenile Chinook salmon caught in the Caswell RSTs, 2010 (a) and 2011 (b).

(a) **2010**



(b) **2011**

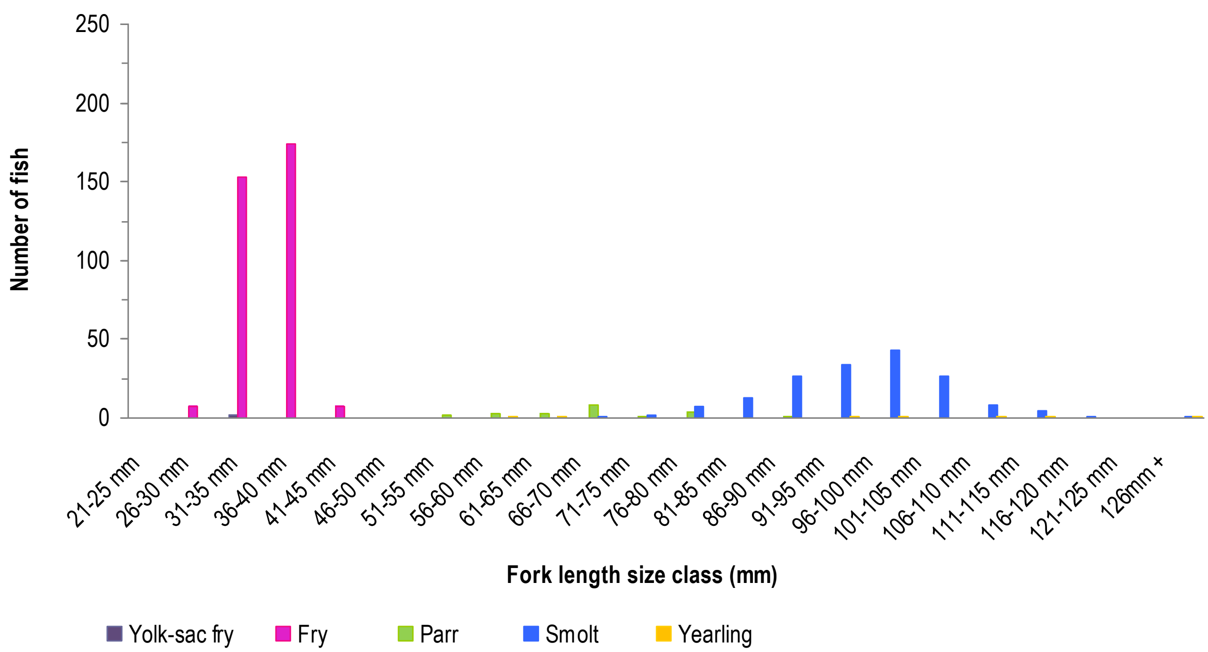
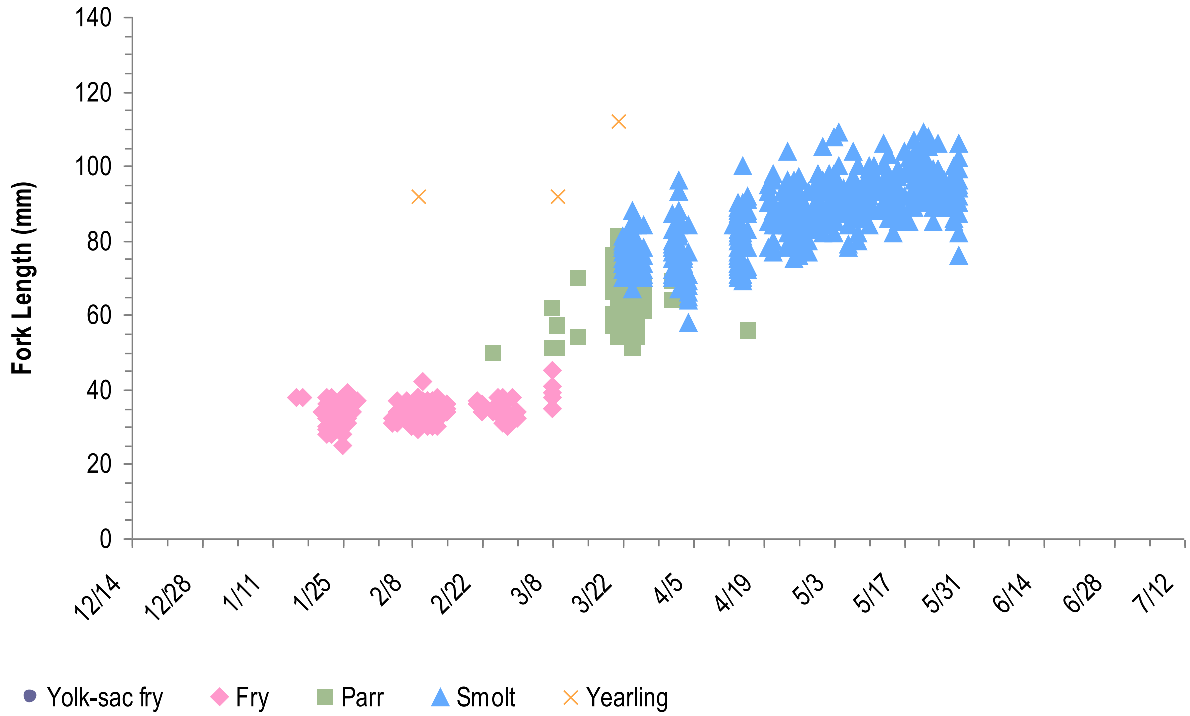


Figure 7. Fork length (mm) distributions for juvenile Chinook salmon caught in the Caswell RST, 2010 (a) and 2011 (b).

(a) **2010**



(b) **2011**

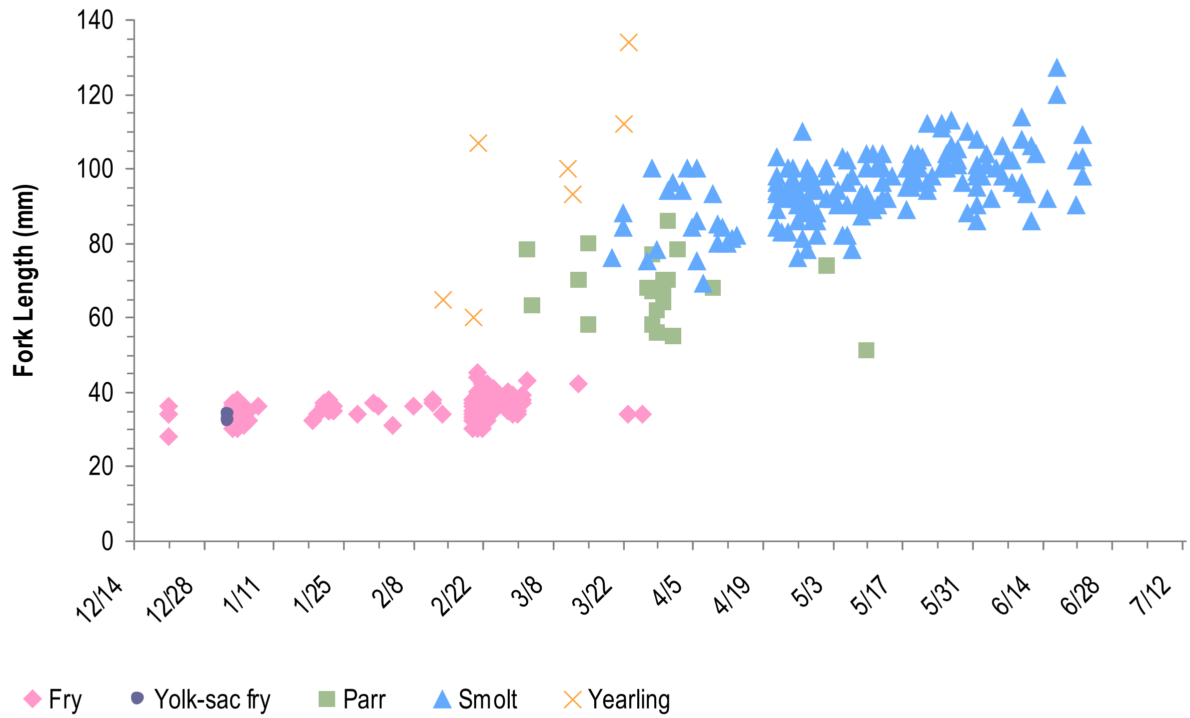


Figure 8. Fork length (mm) distributions for juvenile Chinook salmon caught in the Caswell RSTs, 2010 (a) and 2011 (b).

Trap Efficiency

In 2010, 190 wild-caught, dye-marked Chinook salmon were released among four tests in groups of 32 – 64 fish (Table 4). In 2011, 193 wild-caught and 605 fall-run Chinook salmon from the Merced River Fish Facility were dye-marked and released among seven tests in groups of 20 – 93 fish and 186 – 225 fish (Table 4), respectively.

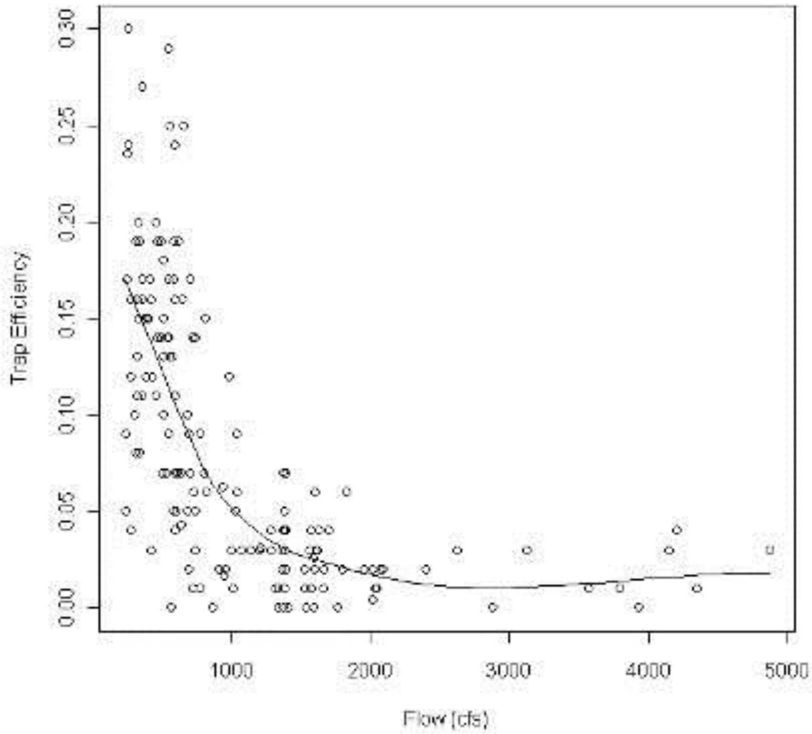
Table 4. Summary of RST efficiency releases at Caswell, 2010 and 2011.

Date	Flow (ft^3/s)*	Release Code	Mark Code**	Origin of fish	Avg. FL (mm)	SD	No. Released	No. Recap	% Efficiency
2/9/2010	879	C1	CFP	wild	33.1	2.17	60	3	5.0%
2/10/2010	949	C2	TCP	wild	35.1	2.32	32	3	9.4%
2/24/2010	1030	C3	BCP	wild	NA	NA	64	2	3.1%
3/22/2010	244	C4	TCP	wild	68.8	7.61	34	8	23.5%
2010 Total							**190**	**16**	**8.4%**
1/22/2011	255	C1	CFP	wild	36.1	0.76	20	6	30.0%
2/21/2011	956	C2	TCP	wild	34.9	1.99	41	3	7.3%
2/22/2011	958	C3	BCP	wild	35.8	2.67	93	8	8.6%
3/24/2011	1115	C4	BCP	wild	73.9	15.20	39	2	5.1%
5/28/2011	1995	C5	TCP	hatchery	90.3	5.63	186	0	0.0%
6/2/2011	1542	C6	BCP	hatchery	92.8	0.38	194	0	0.0%
6/9/2011	2018	C7	TCP	hatchery	95.3	0.88	225	1	0.4%
2011 Total							**798**	**20**	**2.5%**

**Ripon flow on release date at 18:00. **CFP = caudal fin pink; BCP = bottom caudal pink; TCP = top caudal pink.*

For the Caswell site, the best fit model for predicting trap efficiencies included log(flow), fork length (at release), and year. We observed a strong negative trend between trap efficiencies and flow at the Caswell site across all years of trapping (1996 – 2011) (Figure 9; Table 5). A negative trend was also apparent between trap efficiencies and average fish length. However, there was no significant trend between trap efficiencies and turbidity ($p = 0.79$).

(a) **Flow**



(b) **Fish Length**

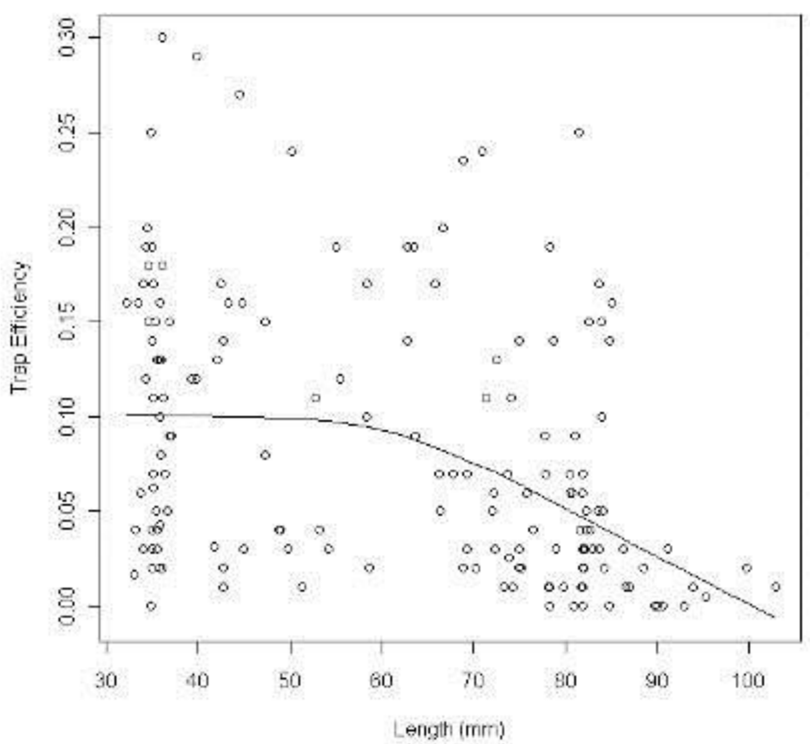


Figure 9. Trap efficiencies as a function of flow and fish length, and turbidity for the 160 mark-recapture releases at the Caswell RSTs (1996 – 2011). Note, solid lines are exploratory fits of smoothing splines (see Table 5 for related statistics).

The logistic regression analysis indicated trap efficiencies were significantly related to the variables log(flow), length, and year (Table 5). The dominant explanatory variable was log(flow), accounting for 83.2% of the total deviance. Fish length at release, which accounted for 6.3% of the deviance, had a moderate negative effect on trap efficiencies. The categorical variable ‘year’ accounted for 10.5% of the deviance, and indicated that trap efficiencies from 2006 – 2009 were lower on average than during the previous five years (2001 – 2005).

Table 5. Analysis of deviance for the logistic model fit to trap efficiencies of 160 mark-recapture releases at the Caswell trap site (1996-2011). Note, Df = degrees of freedom.

Variable	Df	Deviance	Residual Df	Residual Deviance	*F*-value	Pr (F)
Intercept			158	4774.0		
log(flow)	1	3086.82	157	1687.2	395.97	< 0.001
Length	1	235.11	141	1060.4	30.16	< 0.001
Year	15	391.68	142	1295.5	3.35	< 0.001
Total	**17**	**3713.61**	**440**	**4043.1**		

Passage Estimates

Estimates of the total abundance of juvenile Chinook salmon passing the Caswell trap site from 1996 – 2011 are presented in Table 6. Total annual passage estimates for all sample years ranged from 7,953 – 2,049,722 (mean = 420,011) with the lowest abundance occurring in 2009, and the highest in 2000. The estimated precision is called coefficient of variation (CV) and is an indicator of reliability, and is reported along with the confidence interval (CI) for the total passage estimate for 2010 (95% CI: 26,803 – 884,313; CV = 111.3%) and 2011 (95% CI: 37,221 – 1,288,847; CV = 109.8%) suggests that the estimates are imprecise; the coefficient of variation for both years were the highest among all available years (Table 6). The 5% and 95% relative passage dates (based on the operational period for each season separately) at Caswell were 7 February and 24 May 2010 and 20 February and 12 June 2011, respectively (Figure 10). In both years, the estimated proportion of parr/smolt abundances was greater than fry abundances (Table 7).

Relative measures of precision (i.e., CV) were poor for years 2006 – 2011 compared to 1996 – 2005 (2006 operations started late and are not representative of seasonal abundances), and exceeded 100% in 2010 and 2011. Low catch over this same time period resulted in fewer efficiency tests, while those tests that were performed were often made up of small release group sizes, with few recaptures. Hatchery fish were not available in all years, further complicating efforts to determine trap efficiency. In 2011, when hatchery fish were obtained from CDFG for releases in May, high flow conditions (1,542 – 2,018 ft^3/s) likely contributed to tests with no fish recaptured, increasing error estimates. In general, the low number of replicate tests, small release group sizes, and low number of recaptures all likely contributed to the low relative precision attributed to passage estimates in those years.

*Table 6. Estimated total number of juvenile Chinook salmon passing Caswell, 1996-2011. SE = standard error of the estimate. CV = (SE/Passage Estimate)*100. 95% confidence intervals are reported for both normal and lognormal error distributions.*

Year	Passage Estimate	Median	SE	CV	Lower 95% CI	Upper 95% CI
1996	70,908	70,604	7,791	11.0%	56,716	87,250
1997*	92,703	90,088	20,142	21.7%	59,310	135,931
1998	1,085,158	1,072,071	171,487	15.8%	786,522	1,447,572
1999	1,478,890	1,459,864	229,171	15.5%	1,090,845	1,978,055
2000	2,049,722	2,030,570	271,452	13.2%	1,560,823	2,640,653
2001	166,741	165,531	20,193	12.1%	130,020	210,243
2002	91,010	89,681	12,817	14.1%	69,326	118,839
2003	144,474	143,061	17,690	12.2%	114,774	183,166
2004	406,541	398,601	66,995	16.5%	298,388	559,941
2005	256,652	253,439	33,650	13.1%	196,705	331,034
2006*	228,983	210,047	98,701	43.1%	96,846	490,839
2007	75,596	63,529	44,561	58.9%	23,298	186,121
2008	16,377	14,907	7,977	48.7%	5,806	36,129
2009	7,953	6,729	5,044	63.4%	2,237	21,349
2010	219,919	141,436	244,758	111.3%	26,803	884,313
2011	328,541	212,013	360,786	109.8%	37,221	1,288,847

**Trap only operated during part of the out-migration due to high water conditions, estimates are not comparable.*

Table 7. Estimated total number of juvenile Chinook salmon, by lifestage, passing Caswell in 2010 and 2011. Upper and lower confidence limits could not be calculated due to insufficient lifestage-specific efficiency data.

Year	Fry	Parr	Smolt	Parr+Smolt	Total	Proportion Fry	Proportion Parr/Smolt
2010	35,750	6,785	106,958	113,743	149,493	0.24	0.76
2011	70,817	9,958	127,403	137,361	208,178	0.34	0.66

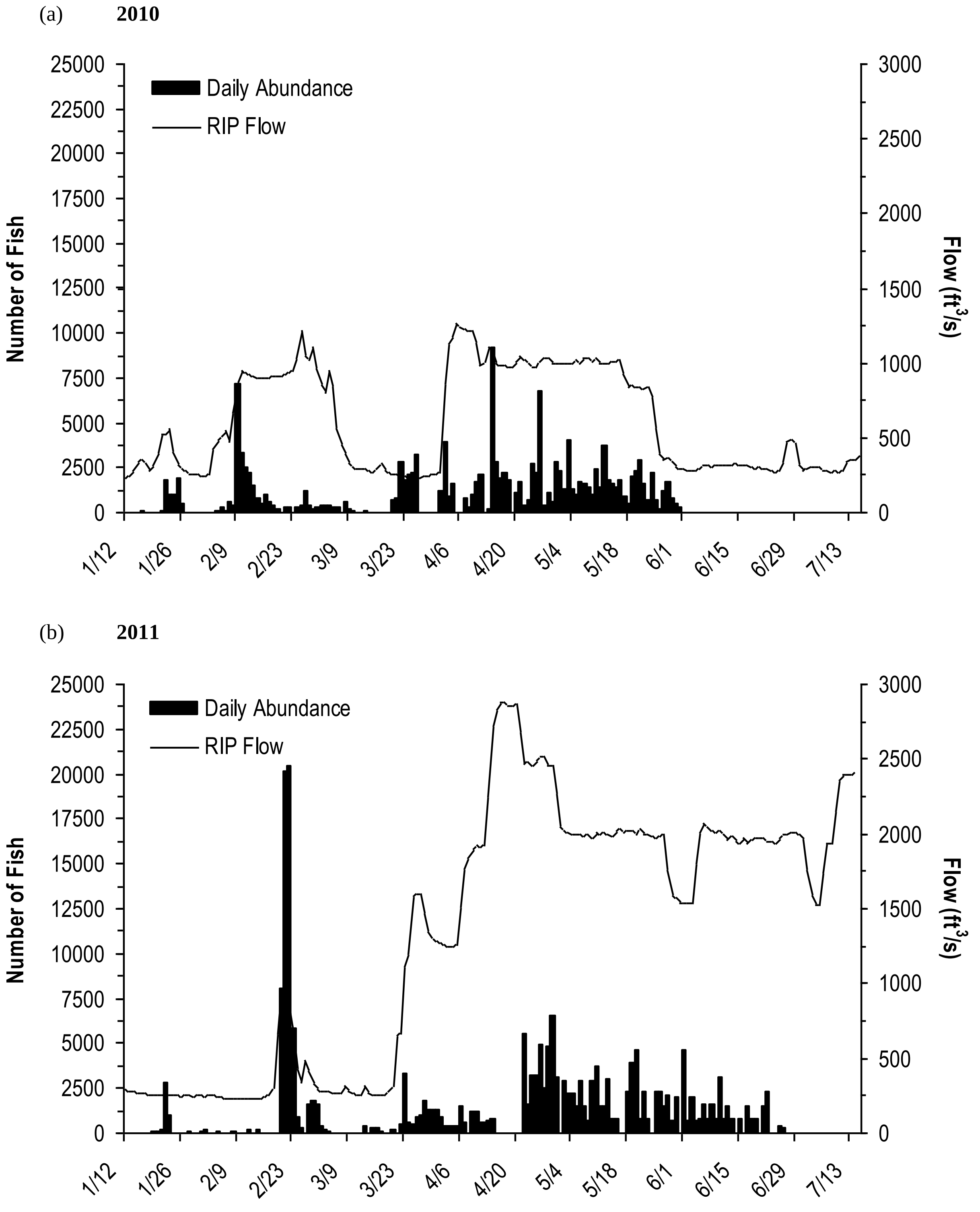


Figure 10. Estimated daily passage of juvenile Chinook salmon at Caswell and flow at Ripon in the Stanislaus River at Caswell, 2010 (a) and 2011 (b).

Life Stage, Size and Abundance Analysis

We detected significant differences in the proportion of fry and parr/smolt among years (2010 – 2011) (Table 8). Within years, the overall proportion of parr/smolt was greater than fry, and the proportion of parr/smolt was significantly higher (X^2 = 4309.3; df = 357670, 1; p < 0.0001) in 2010 compared to 2011.

Table 8. Contingency table for Chi-squared analysis of the fry to parr/smolt ratio among years (2010 – 2011) for Chinook salmon captured in the Caswell RSTs.

Year	Stage	Estimate	Expected Freq.	Observed Freq.
2010	Fry	35,750	0.298	0.239
2010	Parr/Smolt	113,743	0.702	0.761
2011	Fry	70,817	0.298	0.340
2011	Parr/Smolt	137,361	0.702	0.660

We also detected significant differences in the mean FL of fry and parr/smolt between years (Table 9). In 2010, fry and parr/smolt were both significantly smaller compared to 2011 (Figure 11). Although the mean size difference between fry in 2010 and 2011 was only 1.5 mm FL, fry mean lengths were significantly higher in 2011. In 2011, parr/smolt were larger than parr/smolt in 2010 by a mean difference of 8.9 mm FL.

Table 9. Summary of Chinook salmon capture results for fry and parr/smolt size among years (2010-2011) in the Caswell RSTs.

Lifestage	Year	Mean FL (mm)	*n*	SE	Mean FL (mm) ± CI	*F*-ratio	*p*-value
Fry	2010	34.0	346	0.14	34.0 ± 0.3	57.54	**< 0.0001**
	2011	35.5	343	0.14	35.5 ± 0.3		
Parr/Smolt	2010	83.0	632	0.48	83.0 ± 0.9	79.89	**< 0.0001**
	2011	91.9	191	0.87	91.9 ± 1.7		

(a) **Fry** (b) **Parr/Smolt**

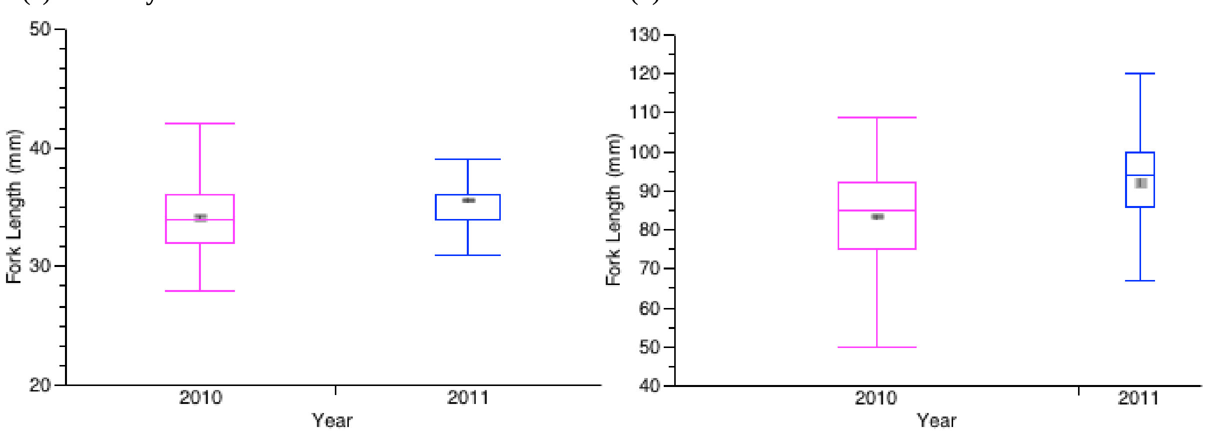


Figure 11. Comparison of mean fry (a) and parr/smolt (b) FL among years (2010-2011) for juvenile Chinook salmon captured in the Caswell RSTs. Solid, inner box represents the mean with 95% confidence; outer lines (whiskers) indicate 1% and 99% quantiles, while outer boxes represent 25%, median and 75% quantiles. Box width indicates relative sample size.

Mean monthly abundance was 36,653 and 54,757 in 2010 and 2011, respectively (Table 10). We found no significant difference in monthly juvenile abundance between years (t = -1.719; df = 5; one-tail p-value = 0.073; two-tail p-value = 0.146).

Table 10. Passage estimates from monthly bootstrap analysis for 2010 and 2011 at Caswell.

	2010				2011			
Month	**Mean**	**SE**	**Lower C.I.**	**Upper C.I.**	**Mean**	**SE**	**Lower C.I.**	**Upper C.I.**
Jan	9,299	10,387	1,092	36,838	6,551	7,653	627	27,277
Feb	37,222	42,730	4,177	153,628	91,778	97,875	10,856	358,399
Mar	23,600	24,669	3,140	90,196	24,578	28,007	2,342	108,097
Apr	78,166	91,929	8,582	333,232	73,073	90,979	6,064	317,531
May	71,631	81,866	7,931	284,214	87,463	108,600	8,701	375,210
Jun	0	0	0	0	45,099	59,321	3,249	204,434
Mean	**36,653**				**54,757**			

DISCUSSION

Median 2011 passage dates were 12 days later for fry and 15 days later for smolts compared to 2010. In both years, peaks in passage during the pre-smolt period generally corresponded with flow pulses. Out-migration abundances in 2010 (219,919 ± 244,758 SE) and 2011 (328,541 ± 212,013 SE) were considerably higher than the previous three years: 75,596 ± 44,561 SE in 2007; 16,377 ± 7,977 SE in 2008; and, 7,953 ± 5,004 SE in 2009 (i.e., the lowest estimated abundance since monitoring began at Caswell in 1996). Record low juvenile abundances in 2009 also corresponded to the second lowest adult escapement on record for 2008. There were a higher proportion of smolt emigrants than pre-smolts in both years, a higher mean size of pre-smolts and smolts in 2011, and no detectable difference in monthly juvenile abundance estimates between years. We have addressed our hypotheses and the question about if significant difference in life history strategies, size and abundance existed between years. Further investigations into the potential effects of flow and other environmental variation on juvenile out-migration population dynamics are possible with these additional years of data. Understanding the relationship of out-migration characteristics to flow, temperature, and other environmental variables is important to properly evaluate salmonid populations in the lower Stanislaus River.

Out-migration timing and emigrant size and abundance is influenced by a variety of factors including the abundance of adult spawners, timing of their return, temperatures during early development, ultimately affecting the timing of fry emergence, conditions during juvenile rearing, etc. (Groot and Margolis 1991; Quinn 2005). Growth and developmental rates for young-of-the-year juveniles are related to water temperatures (Hanson 1997), among other influences. Interannual differences in these factors and conditions, in addition to variable flow regimes, have potentially important implications on growth, life history strategies and survival. Size differences detected between 2010 and 2011 may have been attributable to the dramatic difference in outflow conditions. Beginning in early April 2011, high flows exceeding 1,500 ft^3/s (42.5 m^3/s) may have inundated an increasing area of floodplain habitats known to promote favorable growth conditions (Ahearn et al. 2006; Grosholz and Gallo 2006; Jeffres et al. 2008, Moyle 2007) for salmonids in the Central Valley, including the lower Stanislaus River. In contrast, flow did not exceed 1,260 ft^3/s (35.7 m^3/s) in 2010, potentially limiting the total area of inundated habitats with appropriate conditions for rearing.

Although the proportion of fry, parr, and smolt caught at the RST in 2010 and 2011 differed, the trends in passage were similar between years whereby a greater proportion of emigrants passed during the smolt period beginning in early March. Fisheries management in the Central Valley has focused on the smolt out-migration strategy (e.g., VAMP). Although some studies have reported the importance of the smolt life history strategy (Brandes and McLain 2001; Williams 2006), other data have emerged about the contribution of the fry and parr life history types to commercial-caught adult population of Central Valley Chinook salmon (Miller et al. 2010). Diversity in salmon early life history is an important factor affecting the adaptability (Thorpe 1989; Mangel 1994a, b) and fitness (Healey and Prince 1995) of salmonid populations. Biological diversity plays a critical role in stabilizing ecosystem processes and services by dampening the variance in communities, much like diversity protects the stability of financial portfolios (Schindler et al. 2010). This portfolio effect has also been found to be important in salmon fisheries with degraded biodiversity, such as California, which underscores the importance of maintaining multiple stocks even within degraded systems and highlights the alternative of managing systems by fostering biocomplexity (Carlson and Satterthwaite 2011). Miller et al. (2010) also concludes that management and recovery efforts for salmon populations should focus on maintenance of life-history variation rather than the promotion of a particular life history strategy. Ecosystem management rarely considers heterogeneity and disturbance regimes, and management plans commonly focus on habitat requirements of single species; however with a broader framework that aims to maintain and promote life history diversity and stabilize variance in adult returns a better resilience in populations can be achieved (Schindler et al. 2010).

Further analyses of the influence of environmental variables on juvenile out-migration population dynamics is beyond the scope of this biannual report. However, this work does provide additional foundation for such analyses to be completed. Results from the 2010 and 2011 monitoring seasons provide critical information to CAMP, AFRP and other natural resource management agencies. These data coupled with previous years' datasets provide information to better understand and improve conditions for Chinook salmon and *O. mykiss* within the lower Stanislaus River.

Fish Health Update

We continued our qualitative fish health assessments in 2010 and 2011 to monitor and document episodes of observed poor fish health, and worked with AFRP and the USFWS CA-NV Fish Health Center in Anderson, CA. In 2010, a majority (74%) of all mortalities observed in 2010 (n = 23) occurred on 22 and 23 March; however, no episodes of poor fish health or condition were encountered when handling fish. No specimens from this group were collected for histological analysis since the fish died before handling. In 2011, overall mortality rates were similar and occurred sporadically throughout the season. Since 2007, there were two years when affected fish were collected and tested for numerous causes. In 2007, columnaris (infection by *Flavobacterium columnare*) was suspected (Watry et al. 2007), and in 2009, signs of increased urine flow (i.e., diuresis) were detected although results indicated no definitive cause for morbidity (Watry et al. 2009); however, it was noted that this condition can occur with exposure to elevated ammonia concentrations (Appendix 6). More information is required to determine and track episodes of poor fish health and evaluate potential causes in the lower Stanislaus River.

RECOMMENDATIONS

We continue to work closely with AFRP, CAMP and the Juvenile Monitoring Project Work Team to make recommendations and adapt our operational protocols to be consistent with program objectives. In addition to the previously implemented protocol changes (Gray et al. 2011), we suggest the following:

1) Continue operation of a single trap at the current trapping location. Trap efficiencies with a single trap operating under typical flow conditions were improved compared to 2006 – 2008 at the upstream trap location using the tandem trap configuration. These results indicate that a single trap can be effectively operated at this site.
2) Improve passage estimation and reduce error by performing a greater number of replicate mark-capture releases with larger group sizes to provide a better foundation for determining trap efficiency. We will request hatchery fish from CDFG well in advance of the trapping season.
3) Continue to evaluate fish health and water quality standards at Caswell; and,
4) As part of a separate grant agreement with AFRP, and with CDFG approval, continue to acoustically tag out-migrating O. mykiss smolts to improve our understanding of O. mykiss population dynamics and the resulting migratory tendencies of tagged individuals. The RSTs at Caswell offer the best opportunity to capture potentially out-migrating O. mykiss in the lower Stanislaus River and serve as an important component of that project. This information will inform management actions as they relate to requirements for the Stanislaus River and San Joaquin Delta listed in NMFS' Biological and Conference Opinion (NMFS 2009).

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- Joanne Karlton of State Parks for granting access to Caswell Memorial State Park;

- Oakdale Wastewater Treatment Plant for providing space to store RST equipment; and,

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APPENDIX 1: STANISLAUS RIVER POINTS OF INTEREST

Point	Purpose/Significance	Operator	rkm (RM)
New Melones Dam	Constructed in 1978; Flood control, water supply, power generation, recreation	U.S. Bureau of Reclamation	96.6 (60)
Tulloch Dam	Constructed in 1957; Flood control, water supply, recreation	TriDam	88.5 (55)
Goodwin Dam	Constructed in 1913; Irrigation water diversion canals	U.S. Bureau of Reclamation	93.9 (58.4)
Knights Ferry Covered Bridge	Historic feature	Army Corps of Engineers	87.4 (54.3)
Knights Ferry Gravel Augmentation	Habitat improvement	CDFG	87.4 – 86.6 (54.3 – 53.8)
Orange Blossom Bridge	Temperature gauging station	CA Dept of Water Resources	75.5 (46.9)
Oakdale Rotary Screw Traps	Juvenile salmonid abundance and out-migration timing	Oakdale Irrigation District	64.5 (40.1)
Stanislaus River Weir	Adult passage and timing	AFRP/TriDam	49.9 (31)
Hwy 99 Bridge (Ripon)	Temperature, discharge and DO	USGS	25.4 (15.8)
Caswell Memorial State Park	Juvenile salmonid abundance and out-migration timing	AFRP	13.8 (8.6)
Two Rivers Trailer Park	San Joaquin-Stanislaus confluence	—	0 (0)

APPENDIX 2: STANISLAUS RIVER FISH SPECIES LIST

Common Name	**Species Name**	**Native? (Yes or No)**	**Predator* (Yes or No)**	**Number Captured 2010**	**Number Captured 2011**
Bigscale Logperch	*Percina macrolepida*	No	No	2	0
Bluegill Sunfish	*Lepomis macrochirus*	No	Yes	6	40
Brown Bullhead	*Ameiurus nebulosus*	No	Yes	1	0
Chinook Salmon	*Oncorhynchus tshawytscha*	Yes	Yes	1098	609
Common Carp	*Cyprinus carpio*	No	No	1	0
Golden Shiner	*Notemigonus crysoleucas*	No	No	6	1
Goldfish	*Carassius auratus*	No	No	0	1
Green Sunfish	*Lepomis cyanellus*	No	Yes	3	0
Hardhead	*Mylopharodon conocephalus*	Yes	No	0	2
Largemouth Bass	*Micropterus salmoides*	No	Yes	3	20
Pacific Lamprey	*Lampetra tridentate*	Yes	No	36	162
Prickly Sculpin	*Cottus asper*	Yes	Yes	18	5
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*	Yes	Yes	1	0
Redear Sunfish	*Lepomis microlophus*	No	Yes	1	1
Sacramento Pikeminnow	*Ptychochelius grandis*	Yes	Yes	13	4
Sacramento Sucker	*Catostomus occidentalis*	Yes	No	26	0
Smallmouth Bass	*Micropterus dolomieu*	No	Yes	6	5
Spotted Bass	*Micropterus punctulatus*	No	Yes	3	0
Threadfin Shad	*Dorosoma petenense*	No	Yes	3	0
Tule Perch	*Hysterocarpus traski*	No	No	4	0
Western Mosquitofish	*Gambusia affinis*	No	No	41	26
White Catfish	*Ictalurus catus*	No	Yes	34	7
White Crappie	*Pomoxis annularis*	No	Yes	0	1
Unidentified sunfish	*Lepomis* spp.	No	Yes	20	1
Unidentified bass	*Micropterus* spp.	No	Yes	74	8
Unidentified catfish	*Ictalurus* spp.	No	Yes	2	1
Unidentified lamprey	*Lampetra* spp.	Yes	No	4834	14
Unidentified minnow	Cyprinidae spp.	n/a	No	25	0

**Native and predator designations developed from Moyle (2002)*

APPENDIX 3: ANNUAL MARK-RECAPTURE RESULTS AT CASWELL, 1996 – 2011

Year	Release Groups	Average Number Released / Group	Total Released	Total Recaptures
1996	8	2,720	21,757	1,000
1997	2	3,391	6,781	187
1998	7	2,714	18,996	463
1999	8	1,964	15,713	407
2000	15	1,011	15,166	456
2001	12	1,085	13,014	1,330
2002	11	800	8,804	973
2003	35	109	3,823	495
2004	8	255	2,039	263
2005	16	238	3,802	489
2006	6	1,017	6,102	58
2007	9	77	697	28
2008	7	626	4,383	59
2009	5	37	187	23
2010	4	47	190	16
2011	7	114	798	20
Total	**149**	**1,146**	**121,264**	**6,231**

APPENDIX 4: STANISLAUS RIVER ENVIRONMENTAL CONDITIONS BY WEEK, 2010

	Daily Flow (ft^3/s)		Daily Temperature (°C)			DO (mg/L)		Turbidity (NTU)	
Week	**Min**	**Max**	**Min**	**Max**	**Average**	**Min**	**Average**	**Max**	**Average**
1/11-1/17	225	353	9.6	10.8	10.2	10.20	10.55	3.77	2.16
1/18-1/24	278	553	8.2	10.4	9.6	10.32	10.43	41.70	21.43
1/25-1/31	245	321	8.5	10.1	9.1	9.79	9.97	18.40	8.78
2/1-2/7	239	548	10.3	11.4	11.0	10.10	10.18	7.51	5.93
2/8-2/14	662	949	10.3	11.0	10.7	10.60	10.80	11.50	5.80
2/15-2/21	896	928	10.8	16.1	11.9	10.65	10.85	4.91	4.15
2/22-2/28	932	1210	10.3	11.4	11.0	10.10	10.68	10.39	4.95
3/1-3/7	450	960	11.5	13.3	12.1	9.28	9.99	5.86	5.27
3/8-3/14	283	385	10.7	12.7	11.8	9.15	9.86	5.60	2.39
3/15-3/21	257	322	15.1	15.3	15.2	9.41	9.61	4.39	4.14
3/22-3/28	234	246	14.0	17.2	15.6	9.49	9.67	6.56	4.84
3/29-4/4	248	1180	11.2	15.2	12.7	9.75	10.22	5.62	4.59
4/5-4/11	971	1260	10.9	15.0	13.4	9.91	10.15	16.10	5.29
4/12-4/18	234	1260	8.2	17.2	11.6	9.15	10.42	41.70	6.84
4/19-4/25	970	1050	12.3	15.0	13.8	9.87	9.97	4.81	3.32
4/26-5/2	990	1030	13.0	15.7	14.3	9.76	10.03	3.28	2.56
5/3-5/9	997	1030	15.0	16.2	15.6	9.81	10.16	4.54	2.58
5/10-5/16	993	1030	12.8	16.1	14.9	9.52	10.07	5.37	2.78
5/17-5/23	830	925	13.9	15.9	15.2	0.00	8.26	2.28	2.10
5/24-5/30	348	763	15.4	17.1	16.1	8.28	8.88	0.00	n/a
5/31-6/6	278	321	20.4	23.2	21.9	7.53	7.90	4.57	2.97
6/7-6/13	306	320	19.5	22.1	20.9	7.72	8.05	4.20	2.36
6/14-6/20	314	325	20.8	22.1	21.4	7.89	8.26	3.43	2.99

APPENDIX 5: STANISLAUS RIVER ENVIRONMENTAL CONDITIONS BY WEEK, 2011

	Daily Flow (ft^3/s)		Daily Temperature (°C)			DO (mg/L)		Turbidity (NTU)	
Week	Min	Max	Min	Max	Average	Min	Average	Max	Average
12/13-12/19	235	354	10.4	11.1	10.7	9.95	10.43	9.16	4.53
12/20-12/26	394	1345	11.1	11.9	11.5	9.71	10.04	13.90	11.82
12/27-1/2	353	1397	9.2	10.3	10.0	9.42	9.97	53.20	28.20
1/3-1/9	329	1336	8.3	10.1	9.1	9.55	10.22	43.70	17.53
1/10-1/16	270	312	7.8	9.7	8.9	10.75	11.00	5.06	3.46
1/17-1/23	255	266	9.3	10.6	10.2	10.28	10.64	3.38	2.72
1/24-1/30	245	256	9.4	10.0	9.7	10.81	11.00	3.46	2.64
1/31-2/6	243	254	8.3	9.9	9.1	10.68	11.24	3.26	2.48
2/7-2/13	229	234	9.1	11.5	10.1	10.72	11.11	2.97	2.24
2/14-2/20	229	659	9.2	12.3	10.7	10.68	10.87	12.40	3.74
2/21-2/27	332	958	9.3	10.6	10.0	9.78	10.47	10.90	5.33
2/28-3/6	266	401	9.0	14.2	11.6	9.95	10.25	28.00	9.27
3/7-3/13	249	310	13.5	14.4	13.9	9.39	9.88	5.61	3.97
3/14-3/20	250	316	11.6	15.0	13.9	9.34	9.71	10.50	5.42
3/21-3/27	318	1588	10.2	11.3	10.7	9.83	10.19	31.90	16.46
3/28-4/3	1259	1598	11.1	13.6	12.4	9.48	9.62	19.30	11.27
4/4-4/10	1254	1899	11.4	13.3	12.5	9.74	9.90	7.91	7.00
4/11-4/17	1907	2883	12.0	13.2	12.6	9.67	10.15	10.40	7.06
4/18-4/24	2470	2877	11.3	12.4	11.9	10.08	10.19	6.73	5.61
4/25-5/1	2247	2520	11.2	12.6	11.7	10.30	10.53	6.36	4.04
5/2-5/8	1976	2053	12.3	13.0	12.7	10.05	10.40	5.65	3.93
5/9-5/15	1972	2011	11.9	13.3	12.7	10.07	10.46	5.36	3.90
5/16-5/22	2002	2027	11.4	13.7	12.3	10.11	10.34	4.93	3.84
5/23-5/29	1757	1995	12.4	13.5	12.9	9.79	10.13	4.57	3.24
5/30-6/5	1539	1801	12.8	13.8	13.3	9.87	10.17	4.72	3.94
6/6-6/12	1987	2071	12.6	14.6	13.8	9.83	10.11	4.32	3.69
6/13-6/19	1935	1978	14.0	15.3	14.6	9.60	9.91	4.63	3.78
6/20-6/26	1943	1971	14.9	15.6	15.2	9.46	9.91	4.07	3.21
6/27-7/3	1743	2014	14.4	15.0	14.7	9.64	9.84	4.77	4.16
7/4-7/8	1526	1930	16.2	16.6	16.4	9.35	9.62	5.31	4.86

APPENDIX 6: WEEKLY CATCH AT CASWELL BY LIFE STAGE, 2010

Sample Week	Number of Days		Weekly Catch		Catch by Life History Type					*O. mykiss*
	Trap 1	Trap 2	Total	Trap 1 (Trap 2)	Fry	Parr	Sub-yearling smolt	Yearling smolt	Not assigned	
1/11-1/17	2	0	2	2	2	0	0	0	0	0
1/18-1/24	4	0	61	61	61	0	0	0	0	0
1/25-1/31	6	0	53	53	53	0	0	0	0	0
2/1-2/7	7	0	17	17	17	0	0	0	0	0
2/8-2/14	7	5	183	164 (19)	182	0	0	1	0	0
2/15-2/21	2	3	8	6 (2)	8	0	0	0	0	0
2/22-2/28	6	6	24	20 (4)	23	1	0	0	0	0
3/1-3/7	2	0	3	3	3	0	0	0	0	0
3/8-3/14	5	0	14	14	5	7	0	1	1	0
3/15-3/21	7	0	25	25	0	23	0	1	1	0
3/22-3/28	7	0	200	200	0	61	67	0	72	0
3/29-4/4	7	0	59	59	0	2	57	0	0	0
4/5-4/11	-	-	-	-	-	-	-	-	-	-
4/12-4/18	4	0	78	78	0	1	77	0	0	0
4/19-4/25	6	5	48	43 (5)	0	0	48	0	0	0
4/26-5/2	7	6	81	75 (6)	0	0	81	0	0	0
5/3-5/9	7	7	62	50 (12)	0	0	62	0	0	0
5/10-5/16	7	7	71	47 (24)	0	0	52	0	19	1
5/17-5/23	7	6	61	41 (20)	0	0	61	0	0	0
5/24-5/30	5	0	48	48	0	0	48	0	0	0
5/31-6/6	6	-	0	0	0	0	0	0	0	0
6/7-6/13	5	-	0	0	0	0	0	0	0	0
6/14-6/20	4	-	0	0	0	0	0	0	0	0
1/12/2010 – 6/17/2010	**105**	**45**	**1098**	**1006 (92)**	**354**	**95**	**553**	**3**	**93**	**1**

APPENDIX 7: WEEKLY CATCH AT CASWELL BY LIFE STAGE, 2011

Sample Week	Number of Days		Weekly Catch		Catch by Life History Type						*O. mykiss*
	Trap 1	Trap 2	Total	Trap 1 (Trap 2)	Yolk-sac fry	Fry	Parr	Sub-yearling smolt	Yearling smolt	Not assigned	
12/13-12/19	5	1	0	0	0	0	0	0	0	0	0
12/20-12/26	7	4	4	0 (4)	0	4	0	0	0	0	0
12/27-1/2	7	0	0	0	0	0	0	0	0	0	0
1/3-1/9	7	0	72	72	2	70	0	0	0	0	0
1/10-1/16	7	0	0	0	0	0	0	0	0	0	0
1/17-1/23	7	0	38	38	0	38	0	0	0	0	0
1/24-1/30	7	0	1	1	0	1	0	0	0	0	0
1/31-2/6	7	0	4	4	0	4	0	0	0	0	0
2/7-2/13	7	0	3	3	0	3	0	0	0	0	0
2/14-2/20	7	1	35	35	0	33	0	0	2	0	0
2/21-2/27	7	3	209	120 (89)	0	208	0	0	1	0	0
2/28-3/6	7	0	33	33	0	30	2	0	0	1	0
3/7-3/13	7	0	5	5	0	1	2	0	2	0	0
3/14-3/20	7	0	6	6	0	0	3	1	0	2	0
3/21-3/27	7	7	17	3 (14)	0	4	1	3	2	7	1
3/28-4/3	7	7	17	10 (7)	0	0	12	5	0	0	0
4/4-4/10	7	7	10	4 (6)	0	0	1	9	0	0	0
4/11-4/17	7	7	4	2 (2)	0	0	0	4	0	0	0
4/18-4/24	7	7	14	6 (8)	0	0	0	13	1	0	0
4/25-5/1	7	7	31	19 (12)	0	0	0	31	0	0	0
5/2-5/8	7	7	19	3 (16)	0	0	1	18	0	0	0
5/9-5/15	7	7	19	4 (15)	0	0	1	18	0	0	0
5/16-5/22	7	7	18	7 (11)	0	0	0	18	0	0	0
5/23-5/29	7	7	13	9 (4)	0	0	0	13	0	0	0
5/30-6/5	7	7	22	5 (11)	0	0	0	15	0	1	0
6/6-6/12	7	7	12	6 (6)	0	0	0	12	0	0	0
6/13-6/19	5	5	4	2 (2)	0	0	0	4	0	0	1
6/20-6/26	5	5	5	5	0	0	0	5	0	0	0
6/27-7/3	7	7	0	0	0	0	0	0	0	0	0
7/4-7/10	5	5	0	0	0	0	0	0	0	0	0
12/15/2010-7/8/2011	**202**	**115**	**609**	**402 (207)**	**2**	**396**	**23**	**169**	**8**	**11**	**2**

APPENDIX 8: FISH HEALTH PATHOLOGY REPORT

PATHOLOGY REPORT

US Fish & Wildlife Service
CA-NV Fish Health Center
24411 Coleman Hatchery Rd
Anderson, CA 96007

phone 530-365-4271
fax 530-365-7150

FHC Case No. : 09-047
Submittal date: 3/30/2009
Sample Collector: Cramer assoc.
209-847-7786 phone
Sample Site(s): Stanislaus R, Caswell RST
Histological specimen examiner: J. Scott Foott
Species: Fall-run Chinook smolts
Age: 0-1+

Tissues:
Six whole fish in sample group. Gill, liver, acinar/pyloric cecae, kidney, lower intestine removed and sectioned

Fixative: Davidson (X), PREFER-ETOH (), 10%BF ( ), ZFIX ( ), Bouins ( )

Stains: Hematoxylin & eosin (X), PAS ( ), Iron ( )
Block No. 6105 - 6110 Block / slide deposition: FHC

Blood Smear (Number): ND Bloodsmear Stain: Lieshman-Giemsa ( ), DiffQuick( )
Clinical chemistry: ND

Summary
One fish was dead prior to fixation (6107) with necrotic tissues and another had post-morteum changes suggestive of death prior to fixation (6110) – no results on tissue lesions but no macroparasites observed.

Tissue from the other 4 specimens were similar.
- *Gills – normal , no parasites or significant lesion*
- *Liver – low glycogen level in hepatocytes but no lesions*
- *Heart (2) – normal*
- *Lower/small intestine, pyloric ceca, acinar cell – normal*

Kidney - varying degrees of particulate matter (protein?) observed in the glomerulus and tubules. No inflammation or necrosis. No parasites observed.

No definitive diagnosis for morbidity. Nephron precipitate could be related to increased urine flow (diuresis). This condition can occur in elevated ammonia conditions. Was water quality tested at collection site?