Juvenile Salmonid Emigration Monitoring in the Lower American River, California

February – June 2017

By

Krista Bouton

Kassie Hickey

Prepared for:

U.S. Fish and Wildlife Service, Comprehensive Assessment and Monitoring Program

and California Department of Fish and Wildlife

by the

Pacific States Marine Fisheries Commission

The suggested citation for this report is:

Bouton, K. and K. Hickey. 2017. Juvenile Salmonid Emigration Monitoring in the Lower American River, California February – June 2017. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California. 62 pp.

Table of Contents

List of Figures

List of Figures (continued)

List of Tables

Abstract

Operation of rotary screw traps on the lower American River in 2017 is part of a collaborative five-year effort by the U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program, Pacific States Marine Fisheries Commission, and the California Department of Fish and Wildlife. The primary objective of the trapping operations is to collect data that can be used to estimate the passage of juvenile fall-run Chinook salmon (Oncorhynchus tshawytscha) and quantify the raw catch of steelhead/rainbow trout (Oncorhynchus mykiss) and three other runs of Chinook salmon. Secondary objectives of the trapping operations focus on collecting fork length and weight data for juvenile salmonids and gathering environmental data that will eventually be used to develop models that correlate environmental parameters with salmonid size, temporal presence, abundance, and production.

For the 2017 survey season, two 2.4 meter (8 foot) rotary screw traps (RSTs) were operated downstream of the Watt Avenue Bridge. Sampling occurred on 86 of the 143 days between 1 February and 23 June. A total of 9,567 fall-run, and one putative spring-run juvenile Chinook salmon were captured. The passage of juvenile fall-run Chinook salmon peaked between 8 March and 23 March, when 43.55 percent of the total (n = 4,166) was captured. The majority of the captured juvenile fall-run Chinook salmon was identified as fry life stage; yolk-sac fry, parr, silvery parr and smolt life stages were also captured. Four trap efficiency tests were used to estimate the passage of juvenile fall-run Chinook salmon. Trap efficiencies during these four tests ranged 0.72 to 2.11 percent, with an average efficiency of 1.40 percent. The number of juvenile fall-run Chinook salmon that were estimated to have emigrated past the Watt Avenue trap site during the 2017 survey season was 788,409 individuals (95 percent confidence intervals = 763,355 – 796,848). Finally, 3,966 individuals belonging to 24 different identifiable non-salmonid species were captured, as well as 277 non-salmonid individuals unable to be identified to species. Production for steelhead, the three other non-fall Chinook salmon runs, and non-salmonid fish taxa were not estimated.

Due to high flows, sampling was suspended between 4 February and 3 March, 27 March and 2 April, 19 April and 25 April, 24 May and 29 May, and 1 June and 12 June causing an unknown and potentially substantial percentage of the emigrating population to remain unobserved. Therefore, the passage estimate for juvenile fall-run Chinook salmon in 2017 is likely biased low.

This annual report also includes eight appendices. Five of those appendices describe different environmental variables and studies related to the trap site or rotary screw trap operations during the 2017 survey season.

Introduction

The American River is the southernmost major tributary to the Sacramento River in California's Central Valley. Historically, the American River supported three runs of Chinook salmon, including fall-, spring-, and possibly late-fall-run Chinook salmon (Yoshiyama et al. 2001). However, during the California Gold Rush in the mid- to late 1800s, hydraulic mining devastated salmon spawning habitat in the upper and lower reaches of the American River (Fisher 1994). Additionally, the construction of Folsom and Nimbus dams in 1955 made it impossible for spring-run Chinook salmon to migrate to the cool water pools they historically used in the upper portions of the American River watershed. To mitigate for the loss of Chinook salmon and steelhead spawning and rearing habitat, the Nimbus Fish Hatchery (NFH) was built in 1958, 0.80 kilometers (km) downstream of the Nimbus Dam. The NFH produces large numbers of fall-run Chinook salmon and steelhead. However, over-harvest, hydropower implementation, introduced species, water diversions and other factors continued to contribute to the decline of these fish populations (Yoshiyama et al 2000, Lindley et al 2006, NMFS 2009). Today, the portion of the American River below Nimbus Dam, known as the Lower American River, provides the only spawning and rearing habitat in the American River watershed for Chinook salmon (Oncorhynchus tshawytscha) and steelhead (Oncorhynchus mykiss), the anadromous form of rainbow trout.

In order to help protect, restore, mitigate and improve the natural production of juvenile Chinook salmon and steelhead in the Central Valley, the Central Valley Project Improvement Act (CVPIA) was established in 1992. One of the primary goals of that legislation was to facilitate efforts that enhance and restore the natural production of juvenile Chinook salmon and steelhead. Pursuant to that act, several programs were established to help recover salmonid populations. The CVPIA programs currently engaged in habitat restoration activities within the American River watershed include the Anadromous Fish Restoration Program (AFRP), Dedicated Project Yield Program, and Spawning Gravel Program.

In an effort to improve salmonid spawning habitat on the Lower American River, the USBR, the California Department of Fish and Wildlife (CDFW), and the CVPIA's AFRP and Spawning Gravel Program have collaborated to implement the Lower American River Gravel Augmentation and Side-Channel Habitat Enhancement Project. This project is ongoing and has in part been integral in increasing and restoring the adult spawning and juvenile rearing habitat that was adversely affected by the construction of the Folsom and Nimbus dams. Habitat restoration activities have occurred at eleven sites from the base of Nimbus Dam (Nimbus Basin) downstream to the Paradise Beach at rkm 8 (USBR 2016).

In addition, the CVPIA's Dedicated Project Yield Program Section (b)(2), commonly referred to as "(b)(2) water", authorizes a portion of the Central Valley Project water yield to be dedicated and managed for the benefit of fish and wildlife. As it pertains to the Lower American River, (b)(2) water can be utilized to augment base flows out of Nimbus Dam to provide improved in-stream conditions for fall-run Chinook salmon and Central Valley steelhead during critical life stage periods such as spawning, egg incubation, fry emergence, juvenile rearing, and emigration. The (b)(2) water's flow augmentation may also contribute towards the AFRP Final Restoration Plan flow objectives for the Lower American River.

Despite all efforts put forth on the Lower American River, continuous restoration, management, and monitoring activities are needed to further aid in the recovery of Chinook salmon and steelhead populations. To this end, in 2014 NOAA's National Marine Fisheries Service (NMFS) developed a recovery plan for California Central Valley salmon and steelhead which put a high priority on habitat restoration activities in the American River.

Rotary screw traps (RSTs) are commonly used to monitor the abundance of emigrating juvenile salmonids and their biological response to such habitat restoration activities. This report describes efforts to monitor juvenile salmonid abundance with RSTs on the lower American River in 2017 as part of a larger effort to determine if habitat restoration activities and flow management practices are positively impacting the Chinook salmon and steelhead production in the American River. Furthermore, this report presents monitoring data assessing the temporal variability in steelhead abundance, as well as providing data that describe the size and abundance of salmonids and other native and non-native fish species in relation to the time of year, river discharge, and environmental conditions.

The 2017 survey season was the continuation of a multi-year juvenile Chinook salmon emigration survey. This year was one of the highest water years on record with Folsom Lake accumulating a higher inflow of water than in 1983, the previous wettest year on record (USBR 2017). Because of the vast differences in weather and water conditions during this emigration period as opposed to previous seasons, many different water years and operational procedures can be compared to surmise which scenarios may be the most productive for juvenile Chinook salmon in the lower American River. In addition to current management practices and fish recovery projects, the RST data collected during the past five years will help to better understand the drought and whether coinciding drought management and flow strategies may impact salmonids and other threatened species on the American River.

Study Area

The American River watershed covers an area of 4,900 square kilometers (km^2), and the upper-most headwaters reach an elevation of 3,170 meters (m) on the western slopes of the Sierra Nevada range (James 1997). This river contains three major forks, including the North, Middle, and South forks that ultimately converge at Folsom Reservoir, which is impounded by the Folsom Dam 32 km northeast of the city of Sacramento (USACE 1991). The water exiting Folsom Reservoir flows immediately into Lake Natoma, which is impounded by Nimbus Dam. The U.S. Bureau of Reclamation (USBR) regulate water management activities for these two dams including fluctuating river discharge and water temperature of the American River to help administer flood protection, provide municipal and agricultural water supplies, generate hydroelectric power, and maintain fish and wildlife habitats.

Water exiting Nimbus Dam flows downstream for 36 km until it reaches the confluence with the Sacramento River. This lower stretch of the American River is currently the only portion that Chinook salmon and steelhead are able to access. Historically ranging in flow from 500 cubic feet per second (CFS) to upwards of 164,035 CFS, it is now constricted and straightened by a levee system that was engineered for flood control during the urban development of Sacramento County. The river contains gravel bar complexes and islands, flat water areas, and side-channel habitat characteristics (Merz and Vanicek 1996), however only a small portion of this possesses suitable substrate for anadromous salmonid spawning activities. The primary salmonid spawning grounds are relegated to the uppermost portion of the lower American River between Sailor Bar (rkm 34.7) and the Lower Sunrise Recreational Area (rkm 31.1) (Phillips and Gahan 2014). A site below the Watt Avenue Bridge (rkm 14.6) was selected by CDFW (Snider and Titus 2001) as the location to install and operate RSTs due to its location downstream of most of this Chinook salmon and steelhead spawning activities in the lower American River yet far enough upstream to not be influenced by tidal fluctuations, or Sacramento River discharges. A summary of the abovementioned points of interest on the lower American River is shown in Appendix 1.

The lower American River RST site is located 0.20 rkm downstream of the Watt Avenue Bridge (Figure 1). During typical flow years, the American River at this location separates into two channels that pass on either side of a gravel island. The north channel carries the majority of the water volume and becomes the only channel with flowing water during flows of less than approximately 500 CFS. This north channel reach possesses a steep gradient that causes relatively high water velocities, while the south channel has a flatter gradient and lower water velocities. During flows above approximately 10,000 CFS the gravel island separating the north and south channels becomes submerged and the American River below Watt Avenue becomes one channel. A pictorial comparison of the lower American River RST site in different flow conditions is provided in Appendix 8.

Figure 1: Lower American River rotary screw trap sites in the north and south channels. Inset map illustrates the trapping location in the state of California.

Two 2.4 meter (8 foot) diameter RSTs were deployed in the north channel in 2017 and were designated as Trap 8.1 and Trap 8.2 (Figure 2). Trap 8.1 was set closer to the north bank of the north channel, while Trap 8.2 was closer to south bank of the north channel.

Figure 2: The two north channel 8 foot traps (8.1 and 8.2) on the lower American River just downstream of the Watt Avenue overcrossing.

Methods

Trap Operations

Monitoring activities for the 2017 survey season started on 1 February and ended on 23 June. The two 8 foot (ft) RSTs were fished in a side-by-side configuration in the north channel. Traps were anchored to large concrete blocks set into the cobble substrate in the river channel using 0.95 centimeter (cm) nylon coated galvanized cable and a 0.95 cm chain bridal attached to the front of each trap's pontoons.

Trap checks were conducted at least once every 24 hours when traps were actively fishing in a cone-down configuration. During large storm events or measurable river flow increases, trap functionality could be hindered by larger sized or higher quantities of debris, creating a high potential for fish mortality. Therefore, in cases where a storm or flow increase was deemed severe enough, traps were taken out of service for an indefinite amount of time until the conditions improved. When traps were out of service, trap cones were raised, live well screens were removed, and sampling was temporarily suspended.

The number of cone rotations between trap visits was monitored using a mechanical lever actuated counter (Trumeter Company Inc.) attached to the port side pontoon on each trap; this data was used to determine how well traps functioned between trap visits. The effect of debris buildup on trap cone rotation rates was quantified by counting the number of revolutions per minute (RPM) before and after each cone was cleaned each day. Cleaning of the cones relied on the use of a scrub brush to clear off algae and other vegetation, and the field crew occasionally had to stop the rotation of a trap cone to remove larger debris. For each trap visit, the extent of cone intake obstruction caused by debris was assigned a category of “none”, “partially blocked”, “completely blocked”, or “backed up into cone.”

Safety Measures

All crew members were trained in RST and boat operation safety. Personal flotation devices were worn at all times when crew members were on the boat or the RSTs. For night operations, crew members were required to attach a strobe light to their personal flotation devices that turned on automatically when submerged in water. Two 12-volt, 1260 lumens, LED flood lights were affixed to each trap. On the jet-boat, navigation lights and a bow mounted 55-watt halogen driving light were also installed for safety during night operations. A coast guard approved flare kit was carried on the boat at all times.

In addition, a variety of devices were installed to keep the public safe and away from the traps. “Keep Away” signs in English and Spanish were installed on the traps, as well as a flashing amber construction lights to alert anyone utilizing the river at night that there was a potential navigation hazard. Orange or reflective buoys were also placed on the chain bridals.

Environmental Parameters

During trap visits when fish were processed, the following environmental data were taken and recorded once per visit. Temperature and dissolved oxygen were measured using a YSI dissolved oxygen meter (YSI; Model 55), velocity in front of each cone was recorded using a Hach flow meter (Hach; Model FH950), and turbidity was measured using a Eutech portable turbidity meter (Eutech; Model TN-100). When water depth was 300 cm or below, a depth rod was used to measure water depth underneath the trap to the nearest centimeter on the port and starboard sides of the two-trap array, in line with the front of the trap cones. Average daily river discharge for the American River was determined using data acquired from the American River at Fair Oaks monitoring station maintained by the U.S. Geological Survey (USGS) (USGS station number 11446500). Average daily temperature was measured 150 m upstream of the RSTs using data from the USGS American River below Watt Avenue Bridge station (USGS station number 11446980).

Catch and Fish Data Collection

After environmental data was collected, the process of clearing out each RST's live well and working-up the fish began. First, all debris was removed from the live well and placed into 68.14 liter (L) tubs where crew members sifted through debris and set aside or enumerated any fish, alive or dead. After all debris was removed, an assessment of debris type and volume was recorded. Next, the crew netted any remaining fish from the live well and placed them in 18.93 L buckets with lids, segregating salmonids from non-salmonids or potential predators. During periods of hot weather, fish were placed in buckets with aerators to provide them with oxygen and an ice pack to keep the water temperature at a safe level. In addition, buckets of fish were placed underneath shade umbrellas, if necessary, to avoid additional heat from direct sunlight. If fish were held in buckets for a prolonged period of time, oxygen-depleted water was regularly exchanged with fresh river water.

On days when less than 100 Chinook salmon were caught per trap, the fork length of each salmon from each trap was measured to the nearest one millimeter (mm), their life stage was assessed using the smolt index rating (Table 1), the presence of marks applied during trap efficiency tests or the absence of adipose fin were noted, and fish mortality status (live or dead) was assessed. If Chinook salmon were ≥ 40 mm in fork length, the first 25 salmon from each trap were weighed to the nearest 0.1 gram (g).

When more than 100 Chinook salmon were caught in a trap, a random sample of 100 live salmon from each trap was collected. The fork length, life stage, mark status, and fin clip status for each of the 100 salmon was assessed. Again, if the individuals were ≥ 40 mm in fork length, the first 25 salmon from each trap were weighed to the nearest 0.1 g after they were measured and assessed for life stage. Live salmon were preferentially used for the random sample of 100, when possible, since decomposition which alters body size, weight, and color, makes dead salmon more difficult to accurately measure and identify to life stage. In those cases, mortalities were considered to be a "mort plus-count;" an unassigned life stage category.

A random sample was achieved by placing a net full of Chinook salmon from the live well into a 68.14 L tub. Debris was removed from the tub with salad tongs/probes, leaving only the subsampled salmon. Then, a random net full of salmon was taken from the tub and placed in a bucket designated for Chinook salmon subsampling. From the subsampled bucket, 100 Chinook salmon were randomly selected for analysis. Additional fall-run Chinook salmon in excess of the 100 that were present in the tub or trap live well were not measured and weighed, but each of these salmon were checked for marks, enumerated, and recorded on data sheets as a “live plus-count tally,” or “mort plus-count tally.” A “plus-count tally” was defined as the total number of fish that were caught in a trap on a given day, and that were not measured, weighed, or assigned a life stage. If the plus-count capture included spring-, winter-, or late-fall-run salmon that differed in size from fall-run Chinook salmon based on length-at-date criteria, individuals belonging to those three salmon runs were counted separately and up to 100 of each run were assessed for fork length, life stage, and color/fin clip mark status. Since Central Valley spring- and winter-run Chinook salmon are federally listed as threatened or endangered taxa, trapping activities attempted to identify every spring- and winter-run Chinook salmon that was captured so those data could be reported to the NMFS.

When steelhead were captured, each individual was counted, fork lengths were measured to the nearest one mm, life stage was assessed using the smolt index rating (Table 1), and mortality status was assessed. In addition, each steelhead was checked for the presence or absence of a mark (i.e., adipose fin clipped) and the weights of each individual ≥ 40 mm in fork length were recorded.

All other individuals belonging to non-salmonid taxa were enumerated and identified to species. For each trap, fork lengths of up to 50 randomly selected individuals of each species were recorded to the nearest mm and their mortality status was assessed. Because multiple entities in the Central Valley have a special interest in juvenile lamprey, an effort was made to distinguish between river lamprey and Pacific lamprey. To distinguish between the two species, the number of lateral circumorals in the mouth was observed. River lampreys have three lateral circumorals, while Pacific lampreys have four (Reid 2012). Because the lateral circumorals in the larval stage of ammocoetes are not well developed, they were not identifiable to species.

Table 1: Smolt index rating for assessing life stage of Chinook salmon and steelhead.

Smolt Index	Life Stage	Morphological Criteria
1	Yolk-sac fry	* Newly emerged with visible yolk-sac
2	Fry	* Recently emerged with yolk sac absorbed (button-up fry) * Seam along mid-ventral line visible * Pigmentation undeveloped
3	Parr	* Seam along mid-ventral line not visible * Scales firmly set * Darkly pigmented with distinct parr marks * No silvery coloration
4	Silvery Parr	* Parr marks visible but faded * Intermediate degree of silvering
5	Smolt	* Parr marks highly faded or absent * Bright silver or nearly white coloration * Scales easily shed (deciduous) * Black trailing edge on caudal fin * Body/head elongating
6	Adult	* $\geq$ 300mm

Prior to collecting fish fork lengths and weights, individuals were anesthetized with sodium bicarbonate tablets (Alka-Seltzer Gold) to reduce stress as they were processed. One Alka-Seltzer tablet was added to one liter of water. Approximately eight to 10 fish were placed in a solution of river water and Alka-Seltzer, then measured and weighed. The crew routinely observed the gill activity of fish immersed in the solution, with reduced gill activity indicating fish were ready to be processed. After fish were measured and weighed, they were placed in an 18.93 L bucket with a mixture of fresh river water and stress coat additive (Poly-Aqua) to help replenish their slime coat as the fish recovered from the anesthetic. As soon as it was determined that the fish had fully recovered from anesthesia, all fish were then released well downstream of the traps to prevent recapture.

Chinook salmon were assigned a salmon run at the time of capture using length-at-date (LAD) criteria that were developed for the Sacramento River by Greene (1992). When Chinook salmon appeared to be winter- or spring-run salmon using the LAD criteria, one to two mm samples were commonly taken from the upper lobe of the caudal fin. These samples were then sent to the staff at the U.S. Fish and Wildlife Service’s Abernathy Fish Technology Center to perform genetic run assignments using the panel of single-nucleotide polymorphism (SNP) markers described by Clemento et al. (2014). This panel of SNPs was developed by staff from the National Oceanic and Atmospheric Administration NOAA Fisheries, and is now used for several applications by the U.S. Fish and Wildlife Service and several partner groups (Christian Smith, USFWS, pers. comm.). Detailed methods for DNA extraction, genotyping, and run assignment are described in Abernathy Fish Technology Center Standard Operating Procedure #034.

The accuracy of genetic run assignments made using the SNP baseline was evaluated using self-assignment tests, and it was reported that winter-run were correctly assigned to run 100 percent of the time, fall-run were correctly assigned to run 85-95 percent of the time, and spring-run were correctly assigned to run 78-93 percent of the time (Clemento et al. 2014). For the purposes of this report, the SNP panel providing the "Genetic Call to three lineages" probability was used, and an arbitrary 50 percent probability threshold was employed to assign the final salmon runs as follows:

1. Individuals for which the probability of assignment was < 50 percent were not assigned based on the genetic data, i.e., assignments based on the LAD criteria were used to assign the final run.
2. Individuals for which the probability of assignment was ≥ 50 percent were assigned based on the genetic data, i.e. if LAD and genetic assignments conflicted, and then final run was assigned using the genetic markers.

Six salmon that had a LAD salmon run assignment of fall at the time of capture were genetically sampled to compare their LAD assignments with run assignments determined using the SNPs. That procedure was implemented to evaluate the similarity between LAD and SNP assignments when the LAD run assignment at time of capture was fall-run.

Trap Efficiency

Trap efficiency trials were conducted to quantify the proportion of the emigrating fall-run Chinook salmon that were passing through the river and were collected by the RSTs; these data were then used to estimate the total number of fall-run Chinook salmon migrating past the RSTs. Trap efficiencies were assessed using two different marking methods.

One method of marking consisted of dying the whole body of a fall-run Chinook salmon with Bismarck Brown Y (BBY) stain when a majority of the juvenile salmon catch were < 50 mm in size. At least 500 salmon were needed to conduct trials with BBY stain. When < 500 Chinook salmon were caught on a given day, they were held overnight and salmon caught the next day were added to the previous day's catch to achieve the minimum number of Chinook salmon required for a trap efficiency test. If the minimum number of salmon needed to conduct a trap efficiency trial were not captured within a 48-hour period, they were not used for an efficiency trial and were released downstream of the traps.

Once enough in-river produced Chinook salmon were available to conduct a trap efficiency trial, they were placed in a 68.14 L tub and stained using a solution of 0.6 g of BBY for every 20 L of river water. The actual amount of stain used varied depending on water turbidity and the number of salmon being stained. Salmon were stained for approximately two hours, and their condition was constantly monitored during the staining process. After staining, salmon were rinsed with fresh river water and placed in a 68.14 L live cart, held overnight, and released at twilight the following evening using the technique described below.

To evaluate the potential that the size distribution of marked and released vs. recaptured in-river produced salmon used during trap efficiency tests was different, 100 fork lengths from the day the in-river produced fish were captured and marked were used as a baseline to compare to the lengths of recaptured salmon.

The trap efficiency release site was approximately 1.29 rkm upstream of the traps. To avoid schooling when Chinook salmon were released, they were scattered across the width of the river channel using small dip nets. When river flows were relatively low (e.g., < 1,250 CFS), the fish were released by wading across the river. When higher river discharges occurred, a boat was used to release the marked fish, keeping the motor upstream of the released fish. Every release of marked Chinook salmon occurred close to evening twilight to mimic natural migration patterns and to avoid predation.

Due to the proximity of the release location to the RSTs, the majority of released fish were found to migrate past the RST location within the first four days following a release. As a result, trial periods were designated as a minimum of four days.

On trap visits following each trap efficiency release, crew members looked carefully for any marked fish in the RST live wells. A random sample of up to 100 recaptured Chinook salmon from each trap efficiency test were measured for fork lengths, assessed for life stage, and evaluated for mortality status. If more than 100 recaptures from a trap efficiency test were found in a RST live well, the marked salmon in excess of 100 were enumerated and classified as a “live recap plus-count tally” or “mort recap plus-count tally”.

Passage Estimates

Fall-run Chinook salmon passage estimates were developed using a generalized additive model (GAM). Passage estimates were not developed for the other Chinook salmon runs because relatively small numbers of individuals from those runs were captured. Passage estimates were not developed for steelhead because Central Valley steelhead fry are believed to rear in-river for one to three years before they immigrate to the ocean as smolts (Moyle et al. 2008), at which point they become more difficult to capture, as their larger size increases their ability to avoid the traps.

The GAM incorporated two elements in the development of the salmon passage estimates; the number of salmon caught by trap *i* on day *j*, and the estimated efficiency of trap *i* on day *j*.

Salmon passage at trap *i* on day *j*, $\hat{N}_{ij}$, was calculated as:

$$\hat{N}_{ij} = \frac{\hat{c}_{ij}}{\hat{e}_{ij}}$$

where $\hat{c}_{ij}$ was either the enumerated or estimated catch of unmarked salmon of a certain life stage at trapping location *i* at that location during the 24-hour period j. For example, c_{23} was estimated catch at the second trapping location during day three; and

$\hat{e}_{ij}$ was estimated trap efficiency at trapping location *i* of the site for a certain life stage during the 24-hour period *j.* For example, e_{23} was estimated efficiency at the second trapping location during day three.

Estimation of ĉ ij

The estimate of catch, $\hat{c}_{ij}$, was computed in one of the following ways. The method used was typically selected in the order listed below, e.g., if a trap fished for more than 22 hours within a 24-hour period, the catch using Method #1 was used to calculate a trap's salmon production estimate. If the trap fished for less than 22 hours within a 24-hour period, Method #2 was used.

Additionally, if the 24-hour period between day *j* and day *j*-1 contained more than two hours of sampling excluded from analysis, as described in the Retention in Analysis section below, this length of time excluded from analysis was treated as a gap in sampling, and Method #2 was used.

Method #1: If the interval between day *j* and day *j* – 1 was 22 hours or more and the trap fished for the entire period, $\hat{c}_{ij}$ was the total catch of unmarked fish for day *j*.

Method #2: If the trap fished for less than 22 hours in the 24-hour period between day *j* and day *j* – 1, the fish count for day *j* was adjusted using a GAM. This model smoothed observed catch rates (fish per hour) through time much like a moving average. The prediction from this model was multiplied by the number of hours the trap was not sampling during the 24-hour period to compile an estimated catch for the day. For example, if the trap fished for 10 hours in the 24-hour period between day j and day j-1, catch for the 14 hours not fished was calculated using the GAM and added to the catch for the 10 hours fished to estimate $\hat{c}_{ij}$.

Estimation of $\hat{e}_{ij}$

Efficiency estimates at trapping location *i* on day *j* were computed from a binomial GAM unless sufficient efficiency trials (≥ 3 per week) had been performed. Thus, if sufficient efficiency trials had been conducted (≥ 3 per week), efficiency from the most recent trial was used for $\hat{e}_{ij}$. When the most recent efficiency was not appropriate (i.e., < 3 trials per week), a binomial GAM was fitted to past and current efficiency trials and used to compute $\hat{e}_{ij}$. The additive portion of this GAM was:

$$\log\left(\frac{E[\hat{e}_{ij}]}{1-E[\hat{e}_{ij}]}\right) = s(j)$$

where *s*(*j*) was a smooth (spline) function of the day index (i.e., smooth function of Julian date).

On sampling days during the portion of the year when trap efficiency tests were not conducted, or if less than 10 efficiency trials were included in analysis, a GAM was not used to estimate trap efficiency, and $\hat{e}_{ij}$ was the average efficiency for the trap efficiency tests that were conducted during the survey season and were included in analysis. For example, if a survey season occurred between 1 January and 30 June and trap efficiency tests were conducted between 1 February and 30 May, a GAM was used to develop the estimated trap efficiencies and expand the daily trap catches between 1 February and 30 May, and the average trap efficiency for the survey season was used to expand the daily trap catches before 1 February and after 30 May. If less than 10 efficiency trials were conducted during the survey season or less than 10 efficiency trials were included in analysis, the average trap efficiency for the survey season was used to expand the daily trap catches.

Estimation of $\hat{N}_{ij}$

Once $\hat{c}_{ij}$ and $\hat{e}_{ij}$ are estimated, abundance estimates for the site were computed by summing over trap locations. The total number of fish passing a particular site on day *j* was computed as:

$$\hat{N}_j = \sum_{t=1}^{n_{ij}} \hat{N}_{ij}$$

where n_{ij} was the number of trapping locations fishing at site *i* during day *j*. Passage on day *j* was then summed over a week, month, or year to produce weekly, monthly, or annual estimates of abundance.

Retention in Analysis

For every sampling period, a determination was made whether to include or exclude the period from analysis. Factors that influenced this decision included success of fishing based on trap functionality, or other factors that might have adversely affected catch.

If fishing was unsuccessful, a calculation was conducted using the clicker total and after cleaning RPMs to estimate the amount of time the trap had been functioning normally. If this calculation indicated the trap had likely been functioning normally for at least 70 percent of the sampling period, the sampling period was kept in analysis. If the trap was estimated to have been functioning normally for less than 70 percent of the sampling period, the period was excluded from analysis. Sampling periods excluded from analysis were treated by the CAMP platform like periods not fished and a catch estimate was produced based on Method #2, as described above. This estimated catch was then compared to the actual catch encompassing that sampling period. Under the assumption that abnormal trap function adversely affects catch, the higher of the two was considered to more accurately represent what would have been caught under normal trap function. Therefore, any period with abnormal trap function was only excluded from analysis if the catch estimate produced was higher than what had actually been caught. Furthermore, if an unsuccessful trapping period was the first or last of the season, the CAMP platform was unable to impute catch. Therefore, the actual catch was assumed to be more accurate and the period was included in analysis.

Confidence Interval Estimates

Confidence intervals were computed using parametric bootstrap or Monte Carlo methods as described in the "Feasibility of Unified Analysis Methods for Rotary Screw Trap Data in the California Central Valley," by McDonald and Banach (2010).

Fulton's Condition Factor

Fall-run Chinook salmon condition was assessed using the Fulton's condition factor. The first 25 Chinook salmon larger than 40 mm captured each day were measured for weight and fork lengths. The ratio of the two was used to calculate their condition factor:

$$K = \left(\frac{W}{FL^3}\right) 100{,}000,$$

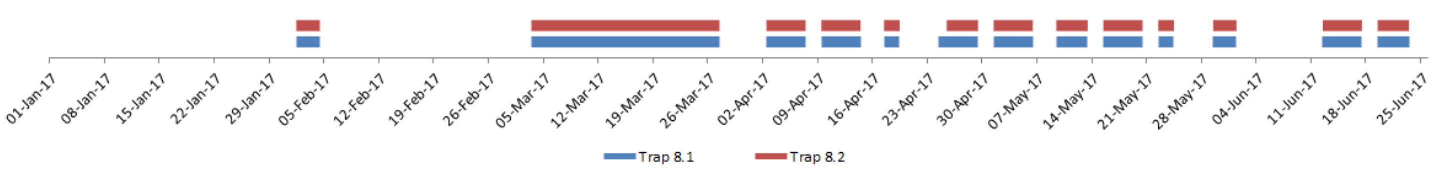
where K was the Fulton's condition factor, W was the weight in grams, and FL was the fork length in mm.

Results

Trap Operations

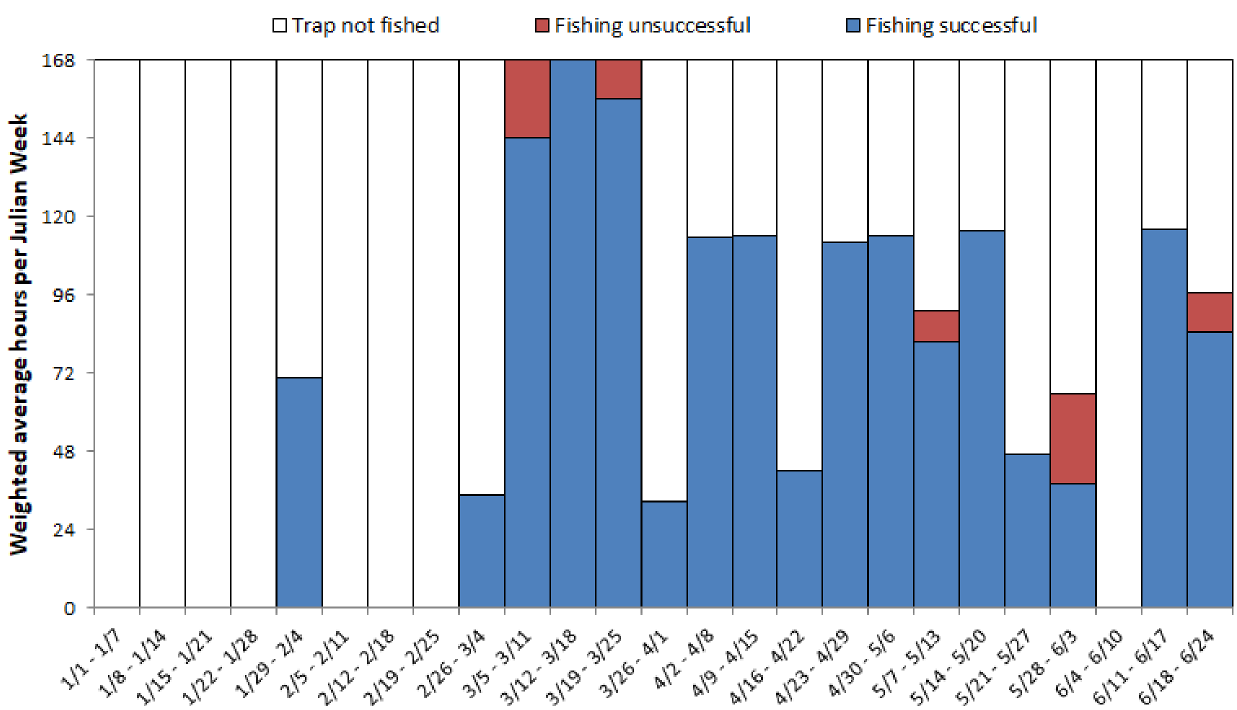
Sampling for the 2017 survey season began on 1 February at river flows of approximately 6,000 CFS. At this time, two 8ft RSTs were deployed in the north channel of the Watt Avenue trapping site. Sampling for both traps was suspended temporarily on 4 February in anticipation of a river flow increase of approximately 73,000 CFS (from approximately 7,000 CFS to approximately 80,000 CFS) and resumed on 3 March when river flows decreased to approximately 11,000 CFS. Sampling for both traps ceased again on 27 March in response to a river flow increase of approximately 10,000 CFS (from approximately 5,000 CFS to approximately 15,000 CFS) and resumed sampling on 2 April at river flows of approximately 9,000 CFS. After 2 April, sampling was reduced to five days a week or less. Sampling was suspended again on 19 April, in anticipation of a flow increase of 5,000 CFS (from approximately 10,000 CFS to approximately 15,000 CFS). Trap 8.1 resumed sampling on 24 April, and Trap 8.2 resumed sampling on 25 April. On 24 May sampling ceased again in anticipation of a release of Chinook salmon from Nimbus Fish Hatchery, and resumed on 29 May. Sampling ceased on 1 June as well, in response to a second release of Chinook salmon from Nimbus Fish Hatchery, and did not resume until 12 June due to high water velocities. Trap operations for the survey season ended on 23 June. The dates each trap sampled is depicted in Figure 3.

Figure 3: Dates sampling occurred per trap during the 2017 lower American River rotary screw trap survey season.



Throughout the 2017 survey season, between 1 February and 23 June, sampling took place on 86 of the 143 days. During this time, the traps fished unsuccessfully (defined as a period of time during which the trap was fishing, but catch was determined to be adversely affected by abnormal trap function) for approximately 86 hours. Traps fished successfully for approximately 1,581 hours and did not fish for approximately 1,739 hours (Figure 4).

Figure 4: Weighted average hours per Julian week that both traps fished successfully, fished unsuccessfully, or did not fish during the 2017 lower American River rotary screw trap survey season.



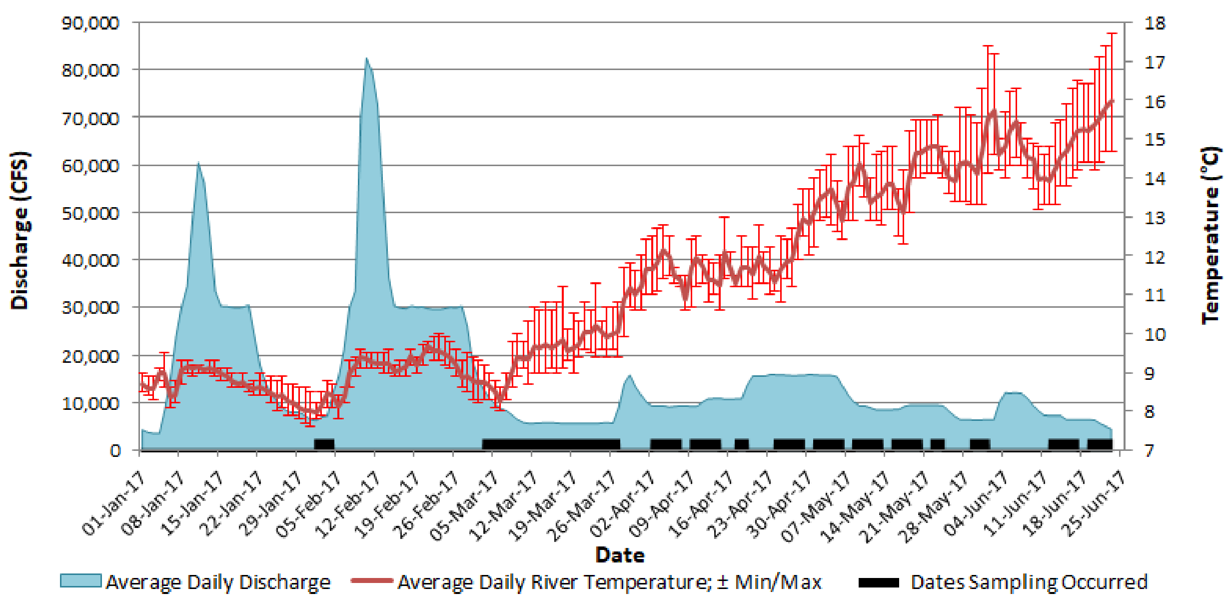
Environmental Summary

Appendix 2 provides a summary of the environmental conditions, averaged by Julian week, starting on January 1 and spanning until the end of the 2017 survey season on 23 June. These dates encompass a typical juvenile fall-run Chinook salmon outmigration survey season, although trapping for the 2017 survey season did not occur throughout this entire date range.

Measurements taken in the field, such as dissolved oxygen content, water turbidity and water velocity reflect only the 2017 survey season (i.e. time period between 1 February, when the traps were first deployed, and 23 June when sampling ended) and may not contain data on days when the traps were not sampling. Maximum and minimum environmental data values quantified below also reflect only the date range of the 2017 survey season, between 1 February and 23 June.

River discharge data, recorded in 15 minute increments, was acquired from the USGS Fair Oaks gaging station on the American River, 21 rkm upstream of the RSTs. River temperature, also recorded in 15 minute increments, was acquired from the USGS Watt Avenue Bridge station on the American River, 0.16 rkm upstream of the RSTs. During the 2017 survey season, between 1 February and 23 June, river discharge reached a high of 85,400 CFS on 10 February and declined to a low of 4,100 CFS on 23 June. Temperatures between 1 February and 23 June ranged from a low of 7.8° Celsius (C) on 1 February and 5 February, to a high of 17.7° C on 23 June. River discharge and water temperature averaged by day throughout the typical juvenile fall-run Chinook salmon outmigration period are shown in Figure 5.

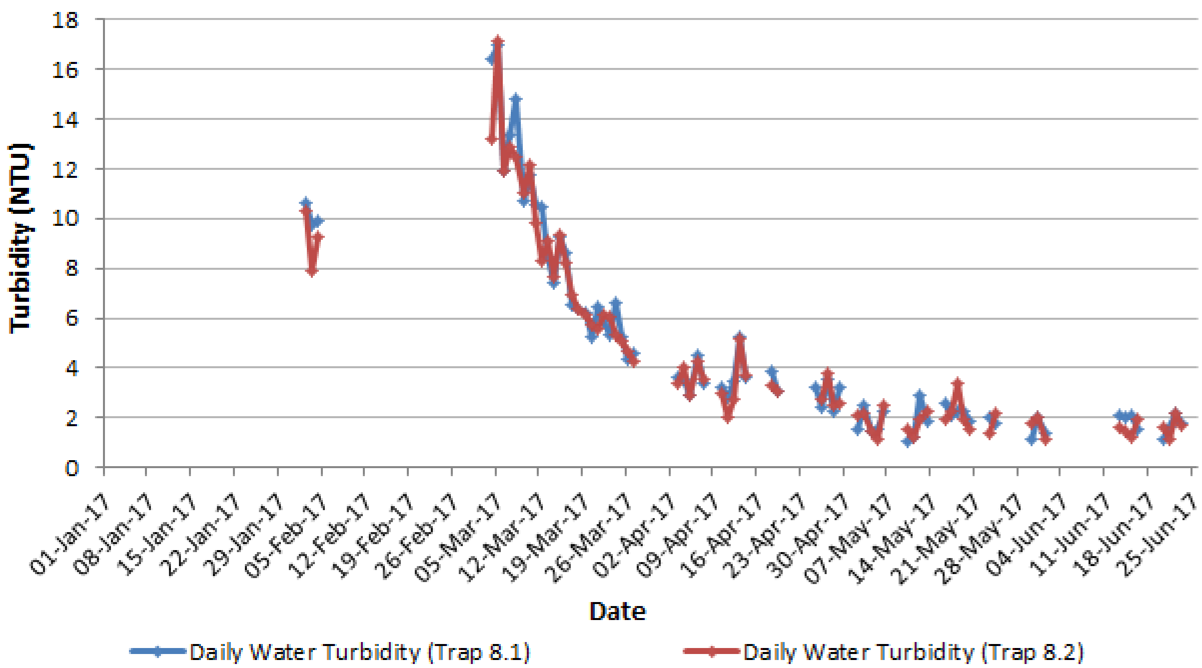
Figure 5: Average daily discharge (CFS) measured at Fair Oaks, and average daily water temperature (°C) measured at Watt Avenue during the 2017 lower American River rotary screw trap survey season.



Note: Discharge and water temperature data for the 1 January to 23 June time period were acquired from the USGS website at http://waterdata.usgs.gov/ca/nwis/uv.

River turbidity was measured in the field, from water samples taken daily from each trap, and remained similar between traps (Figure 6). Turbidity for both traps reached a season maximum on 5 March, with 17.1 Nephelometric Turbidity Units (NTU) for Trap 8.2 and 17.0 NTU for Trap 8.1. Turbidity declined to a low of 1.1 NTU for Trap 8.2 on 5 May, and a low of 1.0 NTU for Trap 8.1 on 10 May. Weekly average turbidity, averaged by Julian week, is shown in Appendix 2. Weekly average turbidity reached a high of 14.8 NTU during the week of 26 February and declined to a weekly average low of 1.6 NTU during the week of 28 May.

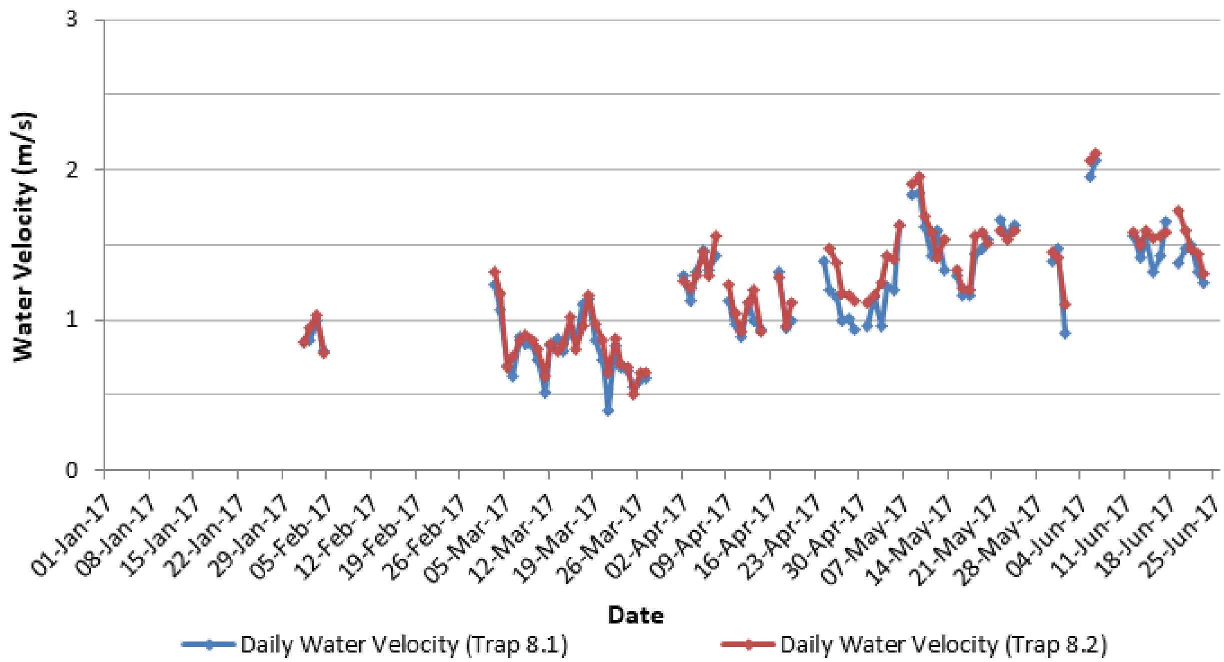
Figure 6: Comparison of daily turbidity measured in the field for each trap, during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Water velocities were also measured for each trap on a daily basis, and were taken from in front of each cone. Velocities for both traps were similar (Figure 7), with velocities for Trap 8.2 slightly higher than for Trap 8.1. Water velocity for Trap 8.1 reached a low of 0.4 m/s on 21 March, while water velocity for Trap 8.2 reached a low of 0.5 m/s on 25 March. Water velocities for both traps reached a season maximum of 2.1 m/s on 6 June. Weekly average water velocity between both traps, averaged by Julian week, is shown in Appendix 2. Weekly average water velocity ranged from a low of 0.6 m/s the week of 26 March to a high of 2.0 m/s the week of 4 June.

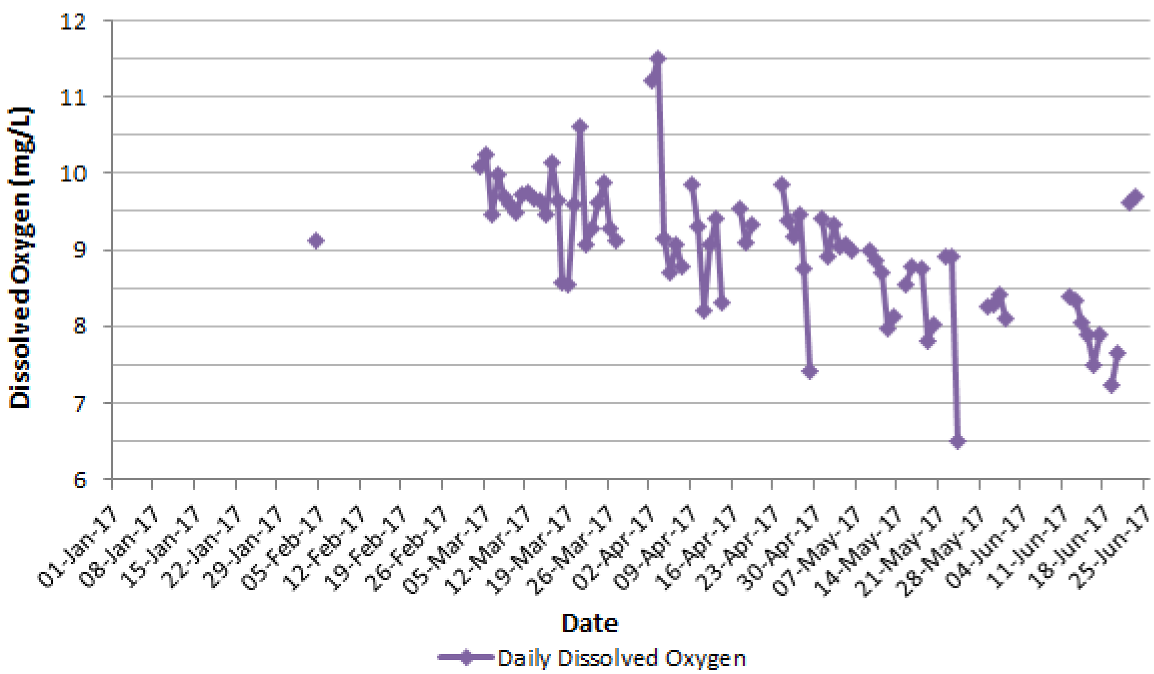
Figure 7: Comparison of daily water velocities, measured in the field in front of each trap, during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Dissolved oxygen (DO) in the river water (Figure 8) was taken in the field as a single daily measurement, and ranged from a high of 11.5 milligrams per liter (mg/l) on 3 April to a low of 6.5 mg/l on 24 May. Weekly average DO, averaged by Julian week (Appendix 2), reached a high of 10.1 mg/l during the week of 26 February and declined to a weekly average low of 8.0 mg/l during the week of 11 June.

Figure 8: Daily dissolved oxygen content measured in the field during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Catch

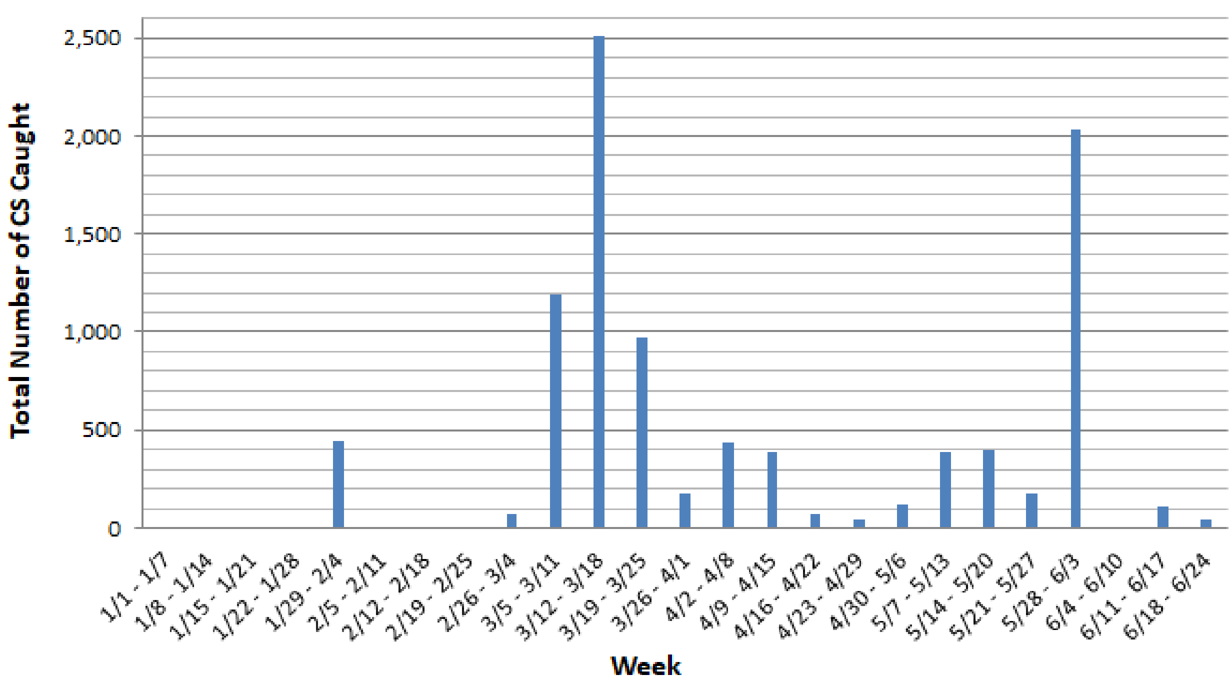
The two rotary screw traps deployed during the 2017 survey season captured a total of 14,242 fish, including 680 hatchery-produced salmonids. Trap 8.1 captured 48.20 percent (n = 6,864) of these fish, and Trap 8.2 captured 51.80 percent (n = 7,378). Salmonid species captured included steelhead and fall-, late-fall-, and spring-run Chinook salmon by length-at-date criteria. However, genetic analysis revealed that the Chinook salmon runs captured did not include late fall-run Chinook salmon (Appendix 4). Twenty four identified non-salmonid species and five unidentified non-salmonid species (Appendix 3) were also captured.

Fall-run Chinook salmon

A total of 9,567 unmarked fall-run Chinook salmon was captured during the 2017 survey season (Figure 9). As these fish did not have an adipose fin clip, they were presumed to be of in-river production. Catch of in-river produced, unmarked fall-run Chinook salmon peaked between 8 March and 23 March, when 43.55 percent (n = 4,166) of the season's total was captured.

Of the in-river produced, unmarked juvenile Chinook salmon captured during the 2017 survey season, a total of 3,234 were unmeasured plus-count tallies and may have included both LAD fall- and late fall-run Chinook salmon. By genetic analysis all LAD late fall-run Chinook salmon captured were determined to be fall-run Chinook salmon by proration of genetic analysis results, therefore all 3,234 unmeasured plus count tallies were determined to be fall-run Chinook salmon. Both the unmeasured plus-count total and the measured totals included mortalities.

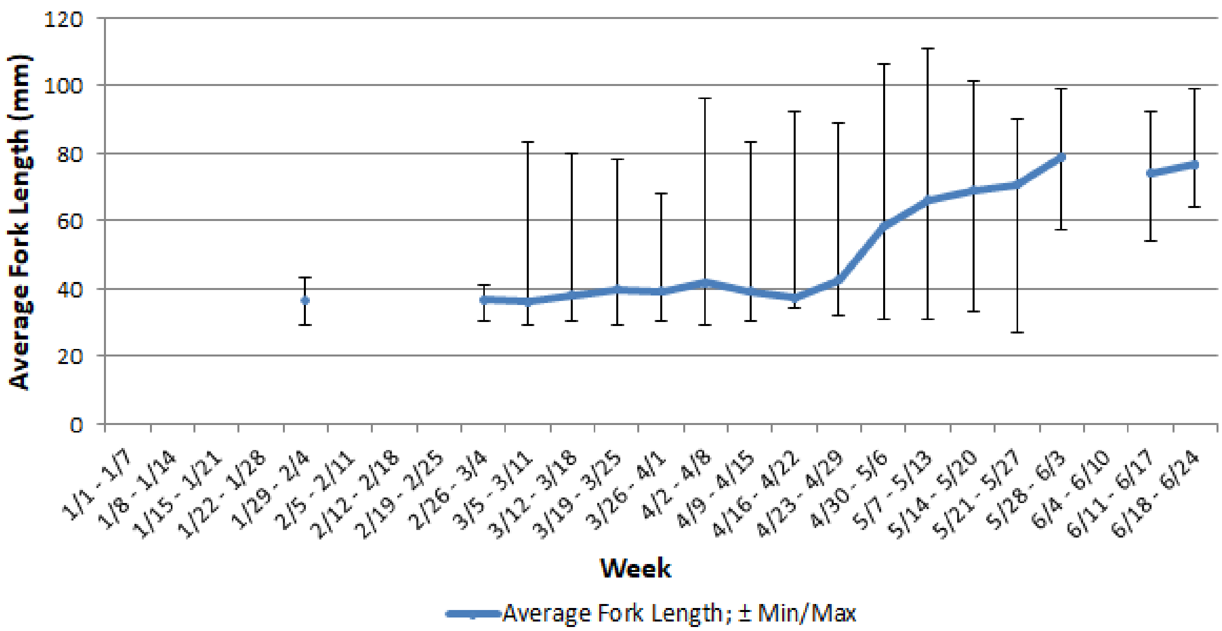
Figure 9: Weekly catch distribution of in-river produced, unmarked fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.



Note: Plus-counted Chinook salmon and mortalities are included in the graph. See Figure 3 for dates sampling occurred. Fall-run Chinook salmon captured on 1 June may include unmarked hatchery produced salmon.

The remaining total of 6,333 in-river produced, unmarked fall-run Chinook salmon were measured for fork length. Weekly average fork lengths throughout the 2017 survey season are depicted in Figure 10 and Table 2. The lowest weekly average fork length was 36 mm, which was seen during the first week of sampling and during the week of 5 March. The highest weekly average fork length was 79 mm, which occurred during the week of 28 May. During the week of 18 June, when trapping was terminated for the season, the weekly average fork length was 77 mm.

Figure 10: Average weekly fork length for fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

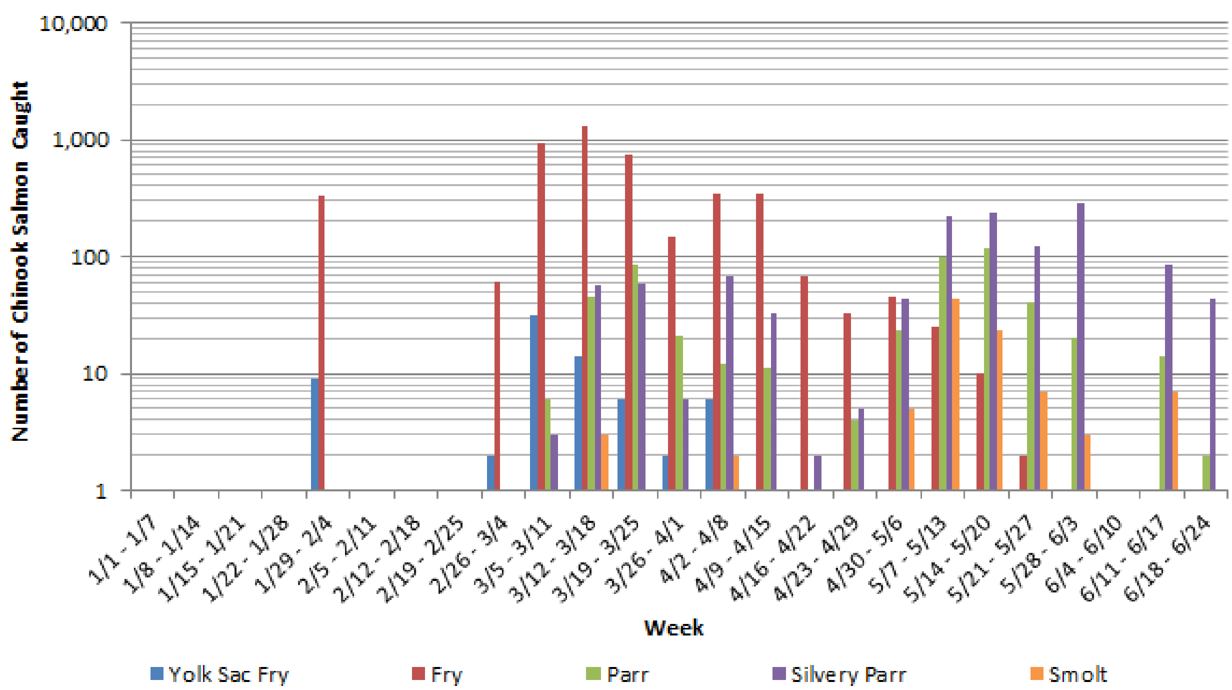
Table 2: Average, minimum, maximum and standard deviations of fork lengths (mm) per week for fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.

Julian Week	Fork Length			
	Average	Min	Max	St. Dev.
1/1 - 1/7				
1/8 - 1/14				
1/15 - 1/21				
1/22 - 1/28				
1/29 - 2/4	36	29	43	1.72
2/5 - 2/11				
2/12 - 2/18				
2/19 - 2/25				
2/26 - 3/4	37	30	41	1.58
3/5 - 3/11	36	29	83	2.99
3/12 - 3/18	38	30	80	7.41
3/19 - 3/25	40	29	78	8.97
3/26 - 4/1	39	30	68	7.49
4/2 - 4/8	42	29	96	14.55
4/9 - 4/15	39	30	83	10.61
4/16 - 4/22	37	34	92	8.54
4/23 - 4/29	42	32	89	15.30
4/30 - 5/6	58	31	106	20.86
5/7 - 5/13	66	31	111	13.72
5/14 - 5/20	69	33	101	10.68
5/21 - 5/27	70	27	90	8.95
5/28 - 6/3	79	57	99	8.17
6/4 - 6/10				
6/11 - 6/17	74	54	92	7.94
6/18 - 6/24	77	64	99	6.48

Note: See Figure 3 for dates sampling occurred.

Of the fall-run Chinook salmon measured for fork length, a total of 6,327 were also assessed for life stage (Figure 11 and Table 3). The majority of this total was salmon identified as fry life stage, which accounted for 69.35 percent (n = 4,388) of the assessed catch. Salmon identified as yolk sac fry comprised 1.11 percent (n = 70), parr made up 7.97 percent (n = 504), silvery parr were 20.09 percent (n = 1,271), and smolt were 1.49 percent (n = 94).

Figure 11: In-river produced, unmarked fall-run Chinook salmon catch by life stage during the 2017 lower American River rotary screw trap survey season.



Note: Since the *y*-axis scale is logarithmic, weeks where one Chinook salmon of a given life stage was captured do not appear in the graph. These are listed as follows: one salmon identified as parr was captured the week of 16 April and one smolt was captured the week of 19 March. Plus-counted fall-run Chinook salmon are not included in the graph. See Figure 3 for dates sampling occurred.

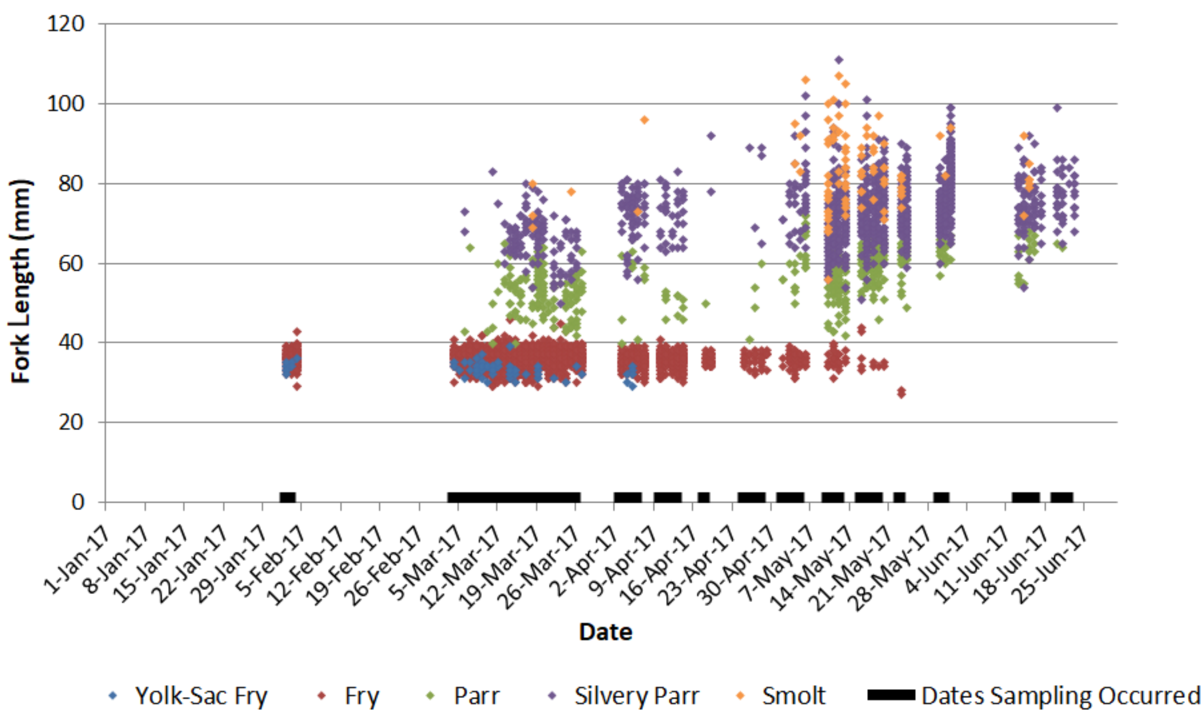
Table 3: Total of in-river produced, unmarked fall-run Chinook salmon by life stage or unassigned life stage during the 2017 lower American River rotary screw trap survey season.

Julian Week	Yolk Sac Fry	Fry	Parr	Silvery Parr	Smolt	Unassigned Life Stage	Total
1/1 - 1/7							
1/8 - 1/14							
1/15 - 1/21							
1/22 - 1/28							
1/29 - 2/4	9	334	0	0	0	103	446
2/5 - 2/11							
2/12 - 2/18							
2/19 - 2/25							
2/26 - 3/4	2	61	0	0	0	10	73
3/5 - 3/11	31	937	6	3	0	215	1,192
3/12 - 3/18	14	1,284	45	56	3	1,112	2,514
3/19 - 3/25	6	750	86	58	1	67	968
3/26 - 4/1	2	145	21	6	0	0	174
4/2 - 4/8	6	345	12	69	2	0	434
4/9 - 4/15	0	348	11	33	0	0	392
4/16 - 4/22	0	68	1	2	0	0	71
4/23 - 4/29	0	33	4	5	0	1	43
4/30 - 5/6	0	46	23	43	5	1	118
5/7 - 5/13	0	25	98	221	43	2	389
5/14 - 5/20	0	10	120	240	23	3	396
5/21 - 5/27	0	2	41	121	7	1	172
5/28 - 6/3	0	0	20	286	3	1,722	2,031
6/4 - 6/10							
6/11 - 6/17	0	0	14	84	7	3	108
6/18 - 6/24	0	0	2	44	0	0	46
Total	70	4,388	504	1,271	94	3,240	9,567

Note: Unassigned life stage includes plus-counts. See Figure 3 for dates sampling occurred. Fall-run Chinook salmon captured on 1 June may include unmarked hatchery produced salmon.

As shown in Figure 12, Chinook salmon identified as yolk-sac fry and fry life stages were captured starting the first day of the 2017 survey season on 2 February. Chinook salmon identified as yolk-sac fry life stage were captured until 5 April, and fry were captured until 23 May. Chinook salmon identified as parr life stage were caught between 6 March and 21 June, salmon identified as silvery parr life stage were captured starting 6 March to the last day of the season on 23 June, and salmon identified as smolt life stage were caught between 18 March and 15 June.

Figure 12: Daily fall-run Chinook salmon fork lengths during the 2017 lower American River rotary screw trap survey season.



For each identified life stage of measured fall-run Chinook salmon, fork length distributions varied (Table 4). Yolk-sac fry life stage had a fork length distribution between 29 mm and 39 mm, while fry ranged from 27 mm to 46 mm. Parr life stage ranged from 40 mm to 73 mm, and silvery parr ranged between 50 mm and 111 mm. Smolt life stage ranged from 56 mm to 107 mm.

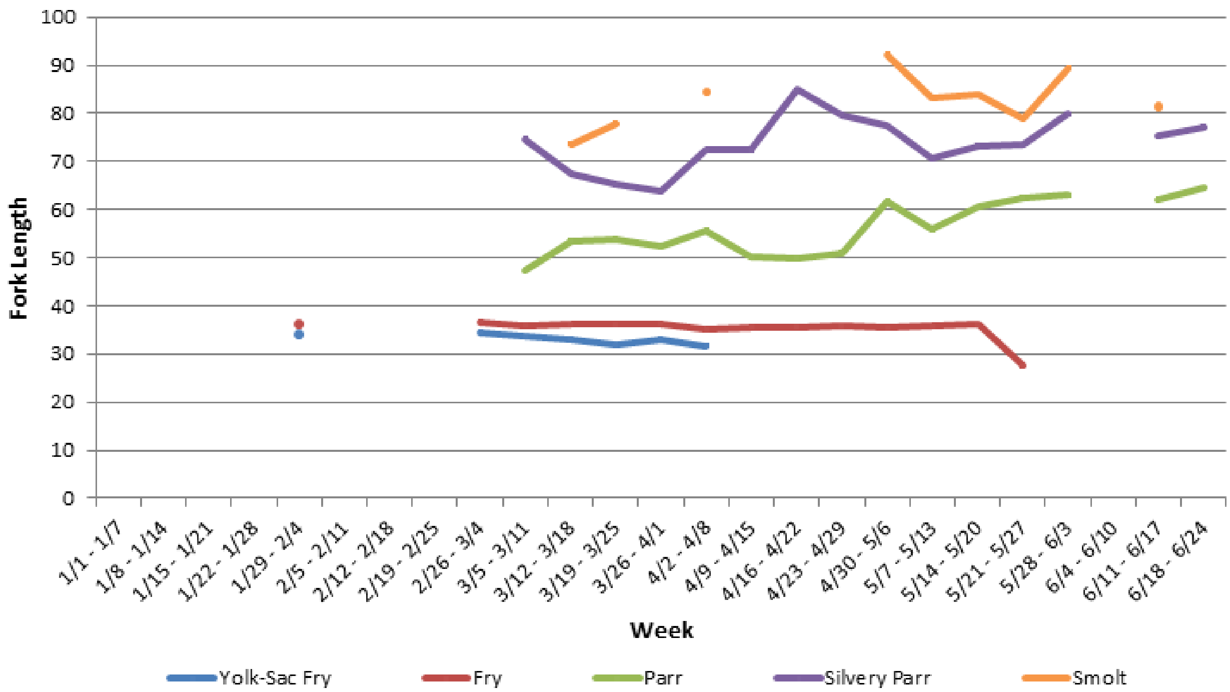
Table 4: Average, minimum and maximum fork lengths (mm) per week for each stage of fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.

Julian Week	Yolk-Sac Fry			Fry			Parr			Silvery Parr			Smolt		
	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
1/1 - 1/7															
1/8 - 1/14															
1/15 - 1/21															
1/22 - 1/28															
1/29 - 2/4	34	32	36	36	29	43									
2/5 - 2/11															
2/12 - 2/18															
2/19 - 2/25															
2/26 - 3/4	35	34	35	37	30	41									
3/5 - 3/11	34	30	37	36	29	42	47	40	64	75	68	83			
3/12 - 3/18	33	30	39	36	30	46	53	40	65	68	54	80	74	69	80
3/19 - 3/25	32	30	34	36	29	45	54	43	64	65	50	78	78	78	78
3/26 - 4/1	33	32	34	36	30	40	52	42	63	64	59	68			
4/2 - 4/8	32	29	34	35	30	39	56	40	66	72	56	81	85	73	96
4/9 - 4/15				36	30	41	50	46	53	72	63	83			
4/16 - 4/22				36	34	38	50	50	50	85	78	92			
4/23 - 4/29				36	32	38	51	41	60	80	65	89			
4/30 - 5/6				35	31	39	62	50	72	77	64	102	92	83	106
5/7 - 5/13				36	31	40	56	42	67	71	54	111	83	56	107
5/14 - 5/20				36	33	44	61	46	73	73	51	101	84	71	97
5/21 - 5/27				28	27	28	62	49	70	73	59	90	79	74	82
5/28 - 6/3							63	57	67	80	60	99	89	82	94
6/4 - 6/10															
6/11 - 6/17							62	55	68	75	54	92	81	72	92
6/18 - 6/24							65	64	65	77	65	99			

Note: See Figure 3 for dates sampling occurred.

Average weekly fork lengths generally increased by life stage progression with yolk-sac fry life stage having the lowest average weekly fork lengths, and smolt life stage having the largest average weekly fork lengths (Figure 13). Overall average fork length for each life stage also increased according to life stage progression. Salmon identified as yolk-sac life stage had a season average fork length of 33 mm and fry had an average folk length of 36 mm. Salmon identified as parr life stage had an average of 57 mm, silvery parr had an average of 74 mm and smolt had an average of 83 mm.

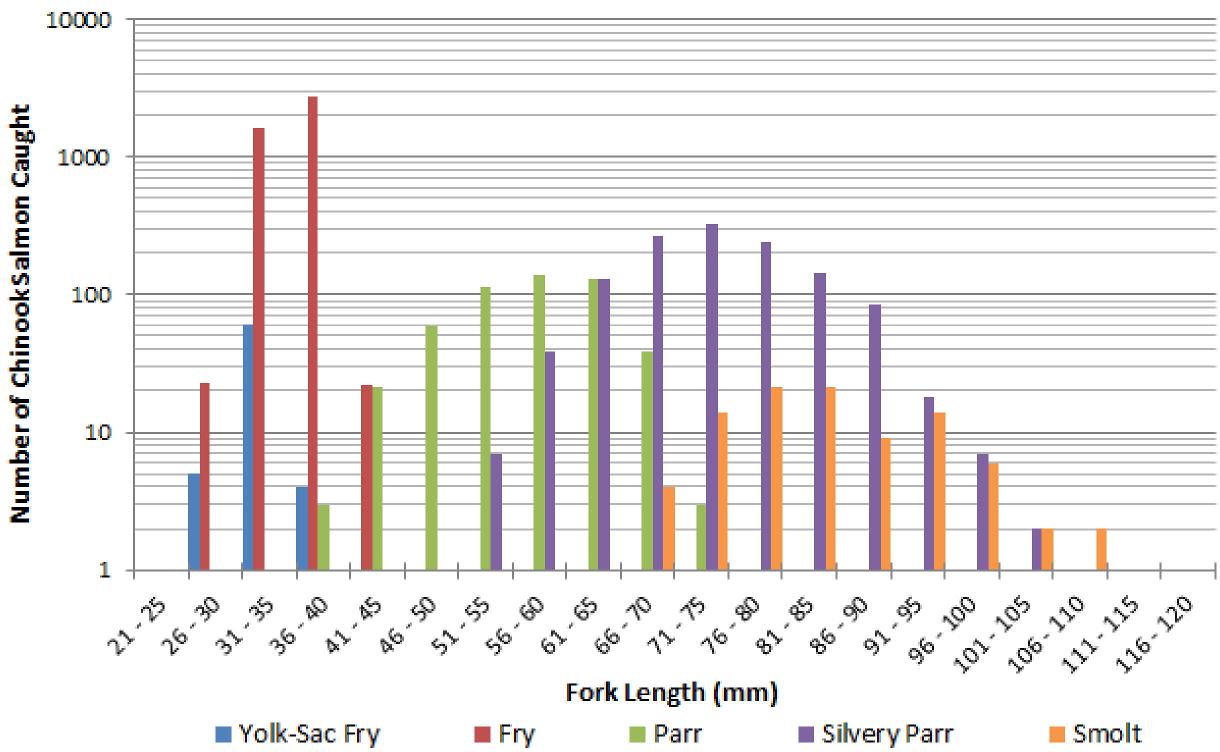
Figure 13: Average weekly fork length by life stage for fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Catch totals of measured in-river produced, unmarked fall-run Chinook salmon divided into 5 mm fork length size classes are shown in Figure 14 and Table 5. Chinook salmon measuring between 31 mm and 40 mm were captured most frequently during the 2017 survey season, encompassing 69.70 percent (n = 4,410) of the season's measured salmon catch. The size class between 36 mm and 40 mm comprised 43.21 percent (n = 2734) of the season's catch and included Chinook salmon identified as yolk-sac fry, fry and parr life stages. The size class between 31 mm and 35 mm comprised 26.49 percent (n = 1,676), and included Chinook salmon identified as yolk-sac fry and fry life stages.

Figure 14: Distribution of fall-run Chinook salmon life stage by fork length during the 2017 lower American River rotary screw trap survey season.



Note: Plus-counted fall-run Chinook salmon are not included in the graph. Since the *y*-axis scale is logarithmic, fork length categories containing only one salmon are not shown in the graph. These are listed as follows: one fall-run Chinook salmon fry was captured at 46 mm, one silvery parr was captured at 50 mm, one silvery parr was captured at 111 mm and one smolt was captured at 56 mm.

Table 5: Distribution of fall-run Chinook salmon life stage by fork length size class during the 2017 lower American River rotary screw trap survey season.

Fork Length Size Class	Yolk-Sac	Fry	Parr	Silvery Parr	Smolt	Total
21 - 25	0	0	0	0	0	0
26 - 30	2	40	0	0	0	42
31 - 35	8	977	5	0	0	990
36 - 40	2	1,150	28	0	0	1,180
41 - 45	0	124	257	0	0	381
46 - 50	0	7	178	7	0	192
51 - 55	0	1	114	22	0	137
56 - 60	0	0	48	36	0	84
61 - 65	0	0	10	54	1	65
66 - 70	0	0	0	37	4	41
71 - 75	0	0	0	22	7	29
76 - 80	0	0	0	5	10	15
81 - 85	0	0	0	2	3	5
86 -90	0	0	0	9	2	11
91 - 95	0	0	0	5	1	6
96 - 100	0	0	0	23	7	30
101 - 105	0	0	0	9	7	16
106 - 110	0	0	0	11	14	25
111 - 115	0	0	0	2	6	8
116 - 120	0	0	0	1	2	3

Fulton’s condition factor (K) for in-river produced, unmarked fall-run Chinook salmon captured in 2017 is shown in Appendix 5. The overall trend line exhibited a positive slope of 0.0022, indicating a slightly increasing trend in condition throughout the survey season. The condition factors of each life stage had positively sloped trend lines as well; fall-run Chinook salmon identified with a life stage of fry showed the greatest increase in condition with a trend line slope of 0.0087, parr had a trend line slope of 0.0065, smolt had a trend line slope of 0.0012, and silvery parr displayed the smallest increase with a trend line slope of 0.0009. Yolk-sac fry captured in 2017 were unable to be accessed for Fulton’s condition factor as every fish identified with this life stage was measured below 40 mm and was therefore not weighed.

Trap Efficiency

Five mark-recapture trap efficiency trials were conducted throughout the 2017 survey season, four of which were included in analysis and used by the CAMP platform to determine passage estimates, and one of which was excluded from analysis (Table 6). These trials used a total of 4,863 fall-run Chinook salmon. Of that total, 958 were in-river produced salmon that were collected with the RSTs and marked with BBY whole body stain, while 3,905 were from Nimbus Fish Hatchery and were marked on the anal fin with bio-photonic dye. A total of 67 released salmon was recaptured. Over the five trials, the average fork length of recaptured fish was approximately 2 mm larger than the average fork length of released fish, and per trial ranged from a difference of approximately 3 mm larger to no difference in fork length. The average trap efficiency of the four trials kept in analysis and used to determine passage estimates was 1.40 percent.

Table 6: Trap efficiency data for mark and recapture trials during the 2017 lower American River rotary screw trap survey season.

Date	Fish Origin	Mark Color	Release ID Code	Included in Analysis	Date	Time	Average FL (mm)	Total Released	Trial Day 1	2	3	4	5	6	7	8	9	10	Total Recaptured	Average FL (mm)	Trap Efficiency	FLOW (CFS) Time of Release
BBY STAINING					RELEASE				RECAPTURES for All Traps Combined										RECAPTURE SUMMARY			
3/14/2017	In-River	Brown	299	Yes	3/15/2017	7:30 PM	36	958	10	0	0	0	0	0	0	-	-	-	10	37	1.04%	5,770
PHOTONIC MARKING					RELEASE				RECAPTURES for All Traps Combined										RECAPTURE SUMMARY			
3/31/2017	Hatchery	Pink	300	Yes	4/3/2017	7:20 PM	61	995	16	5	0	0	-	-	-	-	-	-	21	61	2.11%	9,360
4/14/2017	Hatchery	Green	301	No	4/17/2017	7:35 PM	70	1,000	12	1	-	-	-	-	-	-	-	-	13	73	1.30%	10,800
4/28/2017	Hatchery	Pink	302	Yes	5/1/2017	8:11 PM	79	979	4	1	0	0	0	-	-	0	1	1	7	81	0.72%	15,900
5/12/2017	Hatchery	Green	303	Yes	5/15/2017	7:51 PM	92	931	16	0	0	0	0	-	-	-	-	-	16	94	1.72%	8,570

Note: Fall-run Chinook salmon were used for all trap efficiency trials.

In-River = Lower American River.

Hatchery = Nimbus Fish Hatchery.

BBY = Bismark brown Y whole body stain.

Photonic = Bio-photonic dye mark on anal fin.

Release ID Code: This code is associated with the CAMP RST platform used to store RST data.

Included in Analysis: indicates if the trial was used by the CAMP RST platform to determine passage estimates.

Flow (CFS) is the discharge from the USGS's American River Fair Oaks monitoring station, 21 rkm upstream of the American River RSTs on the day and time of the trap efficiency release.

Passage Estimate for Fall-Run Chinook salmon

According to the CAMP platform "run_passage" report, a total of 788,409 in-river produced fall-run Chinook salmon was estimated to have emigrated past the Watt Ave rotary screw trap location on the lower American River during the 2017 survey season. The 95 percent confidence interval for this estimate was from 763,355 to 796,848 individuals. The CAMP platform "lifestage_passage" report, which subdivides a passage estimate by life stage, estimated 549,528 fry (including both yolk-sac fry and fry life stages), 238,331 parr (including both parr and silvery parr life stages), and 12,340 smolts to have emigrated past the trap location. It is important to note that these are only estimates of Chinook salmon emigration during the time the traps were operating from 2 February to 4 February, from 4 March to 31 May, and from 13 June to 23 June. Potential emigration before the traps started sampling and during the gaps in sampling longer than 7 days is not included in these estimates.

A comparison of weekly passage estimates to weekly discharge at the USGS monitoring station at Fair Oaks is displayed in Figure 15 and Table 7.

Figure 15: Daily passage estimate of fall-run Chinook salmon and daily discharge at Fair Oaks during the 2017 lower American River rotary screw trap survey season.

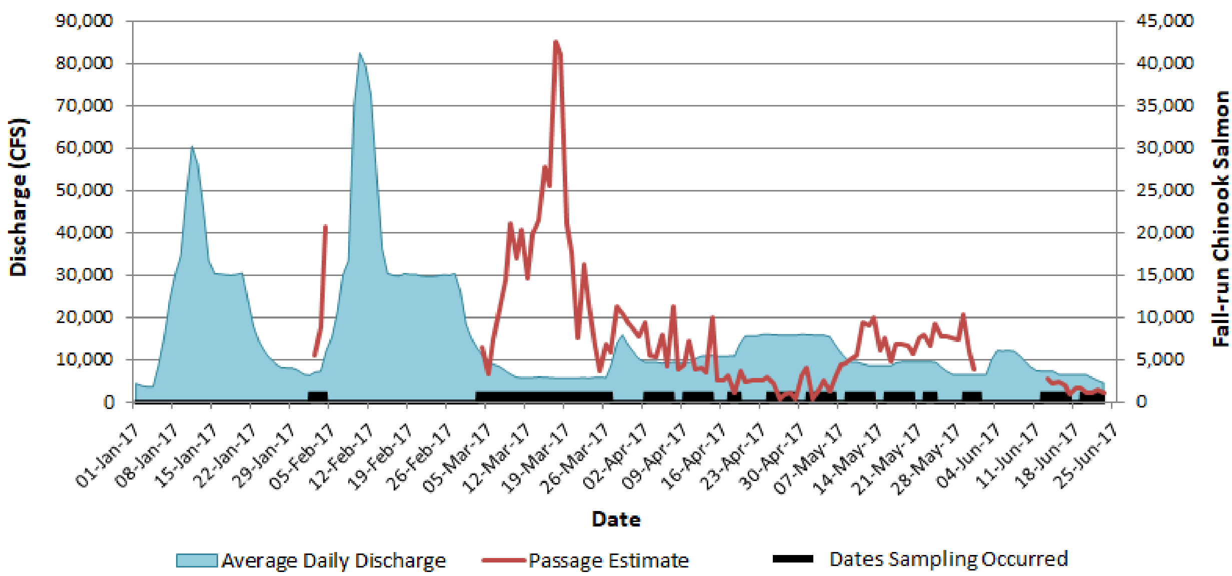


Table 7: Weekly passage estimate of fall-run Chinook salmon and weekly discharge at Fair Oaks during the 2017 lower American River rotary screw trap survey season.

Date	Discharge (CFS)	Passage Estimate
1/1 - 1/7	8,926	-
1/8 - 1/14	44,204	-
1/15 - 1/21	29,301	-
1/22 - 1/28	11,287	-
1/29 - 2/4	7,735	34,820
2/5 - 2/11	47,479	-
2/12 - 2/18	40,412	-
2/19 - 2/25	29,882	-
2/26 - 3/4	20,442	6,331
3/5 - 3/11	7,434	94,435
3/12 - 3/18	5,692	192,345
3/19 - 3/25	5,641	84,428
3/26 - 4/1	11,348	59,694
4/2 - 4/8	9,289	47,553
4/9 - 4/15	10,276	35,400
4/16 - 4/22	13,258	17,609
4/23 - 4/29	15,810	9,819
4/30 - 5/6	15,441	15,265
5/7 - 5/13	9,495	47,483
5/14 - 5/20	9,038	44,151
5/21 - 5/27	8,510	54,228
5/28 - 6/3	6,911	27,287
6/4 - 6/10	10,954	-
6/11 - 6/17	6,912	9,926
6/18 - 6/24	5,710	7,635

Note: See Figure 3 for dates sampling occurred.

Genetic Analysis

During the 2017 survey season, a total of 147 genetic samples taken from juvenile Chinook salmon were analyzed using SNP genetic markers to determine run assignments. The SNP panel's "Genetic Call to three lineages" probabilities for each of the 147 samples exceeded a 50 percent threshold; the final salmon run assignments for the corresponding salmon were therefore made based on genetic data. A complete accounting of the salmon run assignments using LAD criteria and genetic markers is provided in Appendix 4. Of the 147 samples taken, two were from adipose fin-clipped, hatchery produced salmon classified as spring-run Chinook salmon using the LAD criteria. The remaining 145 samples were taken from salmon that did not have an adipose fin clip, and were therefore presumed to be of in-river production.

A total of 128 in-river produced Chinook salmon captured in 2017 were classified as spring-run Chinook salmon using LAD criteria. Genetic samples taken from 120 of these salmon were analyzed to determine run assignments. The analyses indicated 99.16 percent (n = 119) of these individuals were fall-run Chinook salmon, and one was a spring-run Chinook salmon that likely originated from Butte Creek* (Table 8). Because the LAD criteria appeared to incorrectly assign salmon runs at a high frequency, the eight LAD spring-run Chinook salmon that were not analyzed using genetic markers were given a final run assignment of fall-run.

A total of 352 Chinook salmon classified as late fall-run Chinook salmon using LAD criteria were also captured in 2017. Genetic samples taken from 21 of these were analyzed to determine run assignments. Analyses using SNP genetic markers from those samples indicated all 21 individuals (100.00 percent) were fall-run Chinook salmon (Table 8). Because the LAD criteria appeared to incorrectly assign this salmon run, all 331 of the LAD late fall-run Chinook salmon that were not analyzed using genetic markers were given a final run assignment of fall-run.

Genetic samples from four salmon classified as fall-run Chinook salmon using LAD criteria were also analyzed. Analyses using SNP genetic markers from these samples indicated all four of these individuals were fall-run Chinook salmon (Table 8).

Table 8: Comparison of Chinook salmon run assignments using length-at-date (LAD) criteria and SNP genetic markers.

	Genetic salmon run assignment based on a >50 percent genetic probability threshold			
LAD salmon run assignment	Fall	Late Fall	Spring	Winter
Fall	4	0	0	0
Late Fall	21	0	0	0
Spring	119	0	1	0
Winter	0	0	0	0

Note: The table only includes Chinook salmon presumed to be of in-river production: i.e., it does not include salmon with an adipose fin clip, which are known to be hatchery produced.

Spring- , Winter- and Late Fall-run Chinook salmon

The genetic analyses suggest that one in-river produced spring-run Chinook salmon were captured during the 2017 survey season. This was captured on 19 March and was identified as a smolt life stage. This individual had a fork length of 82 mm, which was 39 mm larger than the average fork length of fall-run Chinook salmon captured on that day.

Both LAD criteria and genetic analysis suggest that no winter-run Chinook salmon were captured during the 2017 survey season. The genetic analyses also suggest that no late fall-run Chinook salmon were captured.

Steelhead/Rainbow Trout

During the 2017 survey season, a total of 28 in-river produced steelhead was captured. The day with the highest catch of steelhead was 15 June, when 14.29 percent (n = 4) of the season's total was captured (Figure 16). Weekly steelhead catch peaked the week of 11 June, comprising 32.14 percent (n = 9) of the total steelhead captured (Table 9).

Figure 16: Daily catch totals for in-river produced steelhead during the 2017 lower American River rotary screw trap survey season.

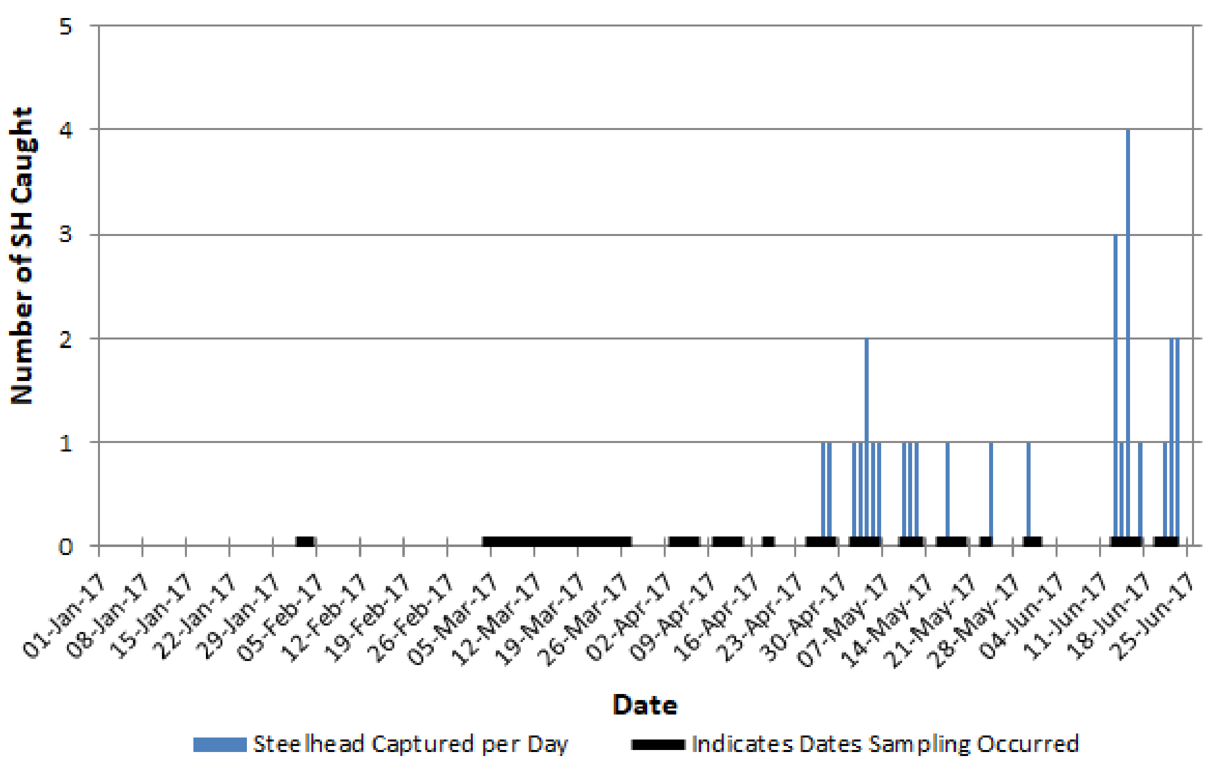


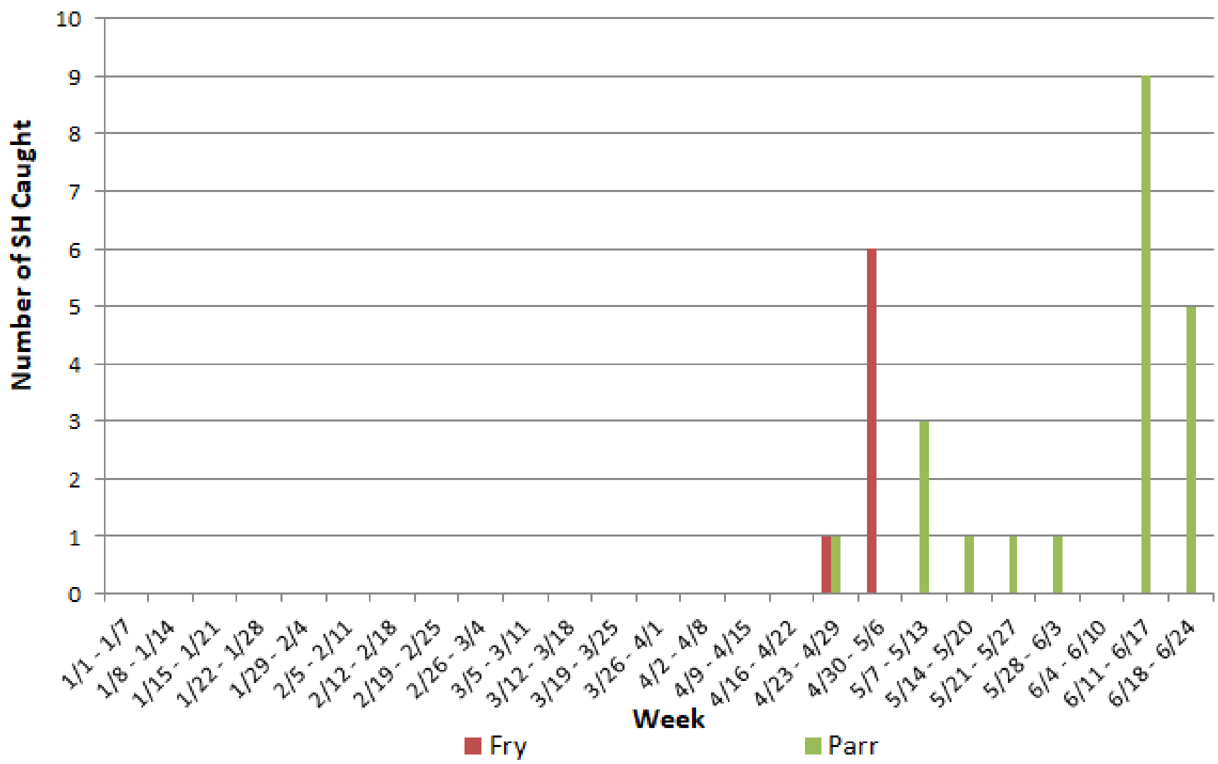
Table 9: Weekly catch totals by life stage for in-river produced steelhead during the 2017 lower American River rotary screw trap survey season.

Julian Week	Yolk-Sac Fry	Fry	Parr	Silvery Parr	Smolt	Adult	Total
1/1-1/7							
1/8-1/14							
1/15-1/21							
1/22-1/28							
1/29-2/4	0	0	0	0	0	0	0
2/5-2/11							
2/12-2/18							
2/19-2/25							
2/26-3/4	0	0	0	0	0	0	0
3/5-3/11	0	0	0	0	0	0	0
3/12-3/18	0	0	0	0	0	0	0
3/19-3/25	0	0	0	0	0	0	0
3/26-4/1	0	0	0	0	0	0	0
4/2-4/8	0	0	0	0	0	0	0
4/9-4/15	0	0	0	0	0	0	0
4/16-4/22	0	0	0	0	0	0	0
4/23-4/29	0	1	1	0	0	0	2
4/30-5/6	0	6	0	0	0	0	6
5/7-5/13	0	0	3	0	0	0	3
5/14-5/20	0	0	1	0	0	0	1
5/21-5/27	0	0	1	0	0	0	1
5/28-6/3	0	0	1	0	0	0	1
6/4-6/10							
6/11-6/17	0	0	9	0	0	0	9
6/18-6/24	0	0	5	0	0	0	5
Total	0	7	21	0	0	0	28

Note: See Figure 3 for dates sampling occurred.

All steelhead captured in 2017 were assessed for a life stage. The life stage composition of these steelhead consisted of seven fry, comprising 25.00 percent of the total, and 21 parr comprising 75.00 percent (Figure 17). No in-river produced steelhead was identified as yolk-sac fry, silvery parr, smolt or adult life stage.

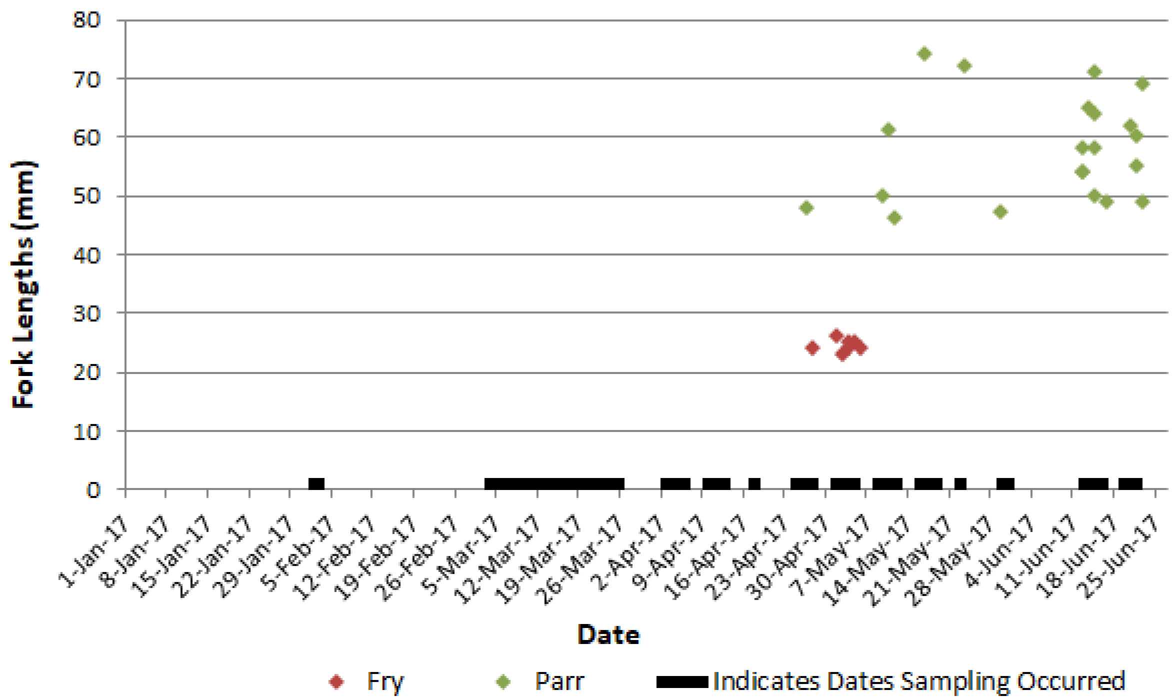
Figure 17: Weekly catch totals by life stage for in-river produced steelhead during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

The steelhead identified as fry life stage were captured between 28 April and 6 May, with fork lengths ranging between 23 mm and 26 mm. Steelhead identified as parr were captured between 27 April and 23 June and ranged in fork length from 46 mm to 74 mm (Figure 18).

Figure 18: Individual fork lengths by date for in-river produced steelhead captured during the 2017 lower American River rotary screw trap survey season.

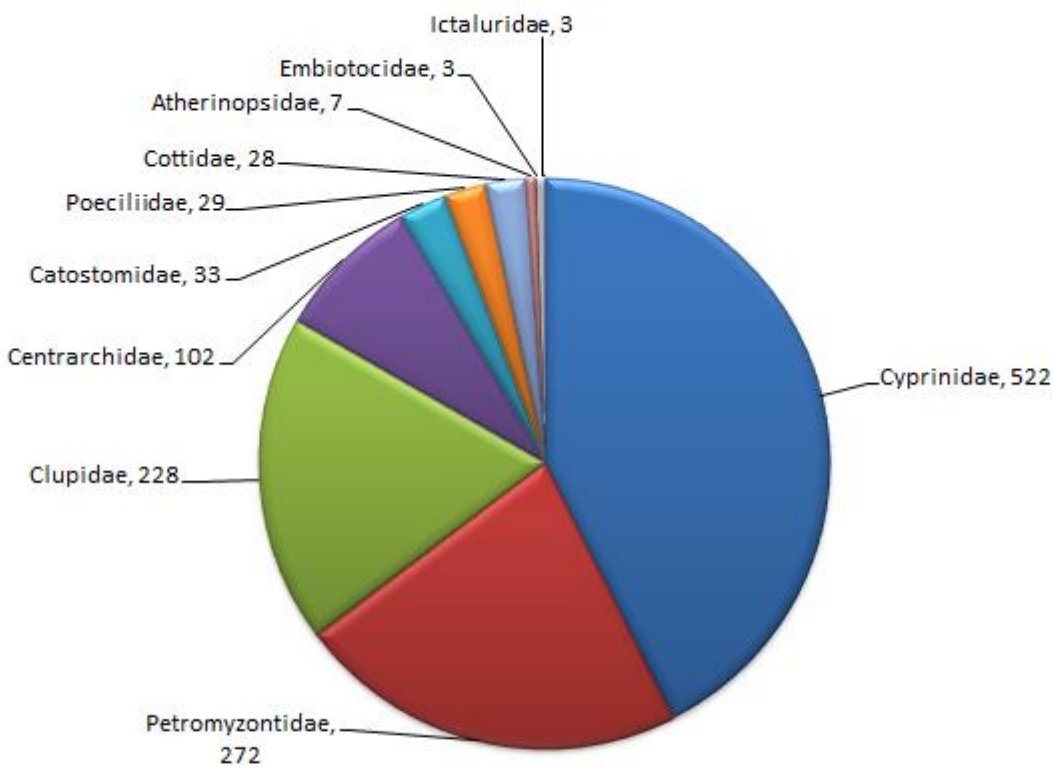


No steelhead marked with clipped adipose fins and therefore presumed to be hatchery-produced were captured in the 2017 survey season.

Non-salmonid Species

In addition to the salmonids, a total of 3,966 non-salmonid fish was captured during the 2017 survey season. The majority (n = 3,689 or 93.02 percent) of these fish belonged to 24 identified species in the following families: *Atherinopsidae* (silverside), *Catostomidae* (sucker), *Centrarchidae* (sunfish/black bass), *Clupeidae* (shad), *Cottidae* (sculpin), *Cyprinidae* (minnow), *Embiotocidae* (Tule perch), *Gasterosteidae* (stickleback), *Ictaluridae* (bullhead/catfish), *Moronidae* (temperate basses), *Osmeridae* (smelt), *Petromyzontidae* (lamprey), and *Poeciliidae* (mosquitofish) (Figure 19). The remaining 6.98 percent (n = 277) were not able to be identified to species level, but belonged to the following families: *Petromyzontidae*, *Cyprinidae*, *Cottidae*, and *Centrarchidae*. A total of 854 (21.53 percent) of the non-salmonid fish captured in 2017 were of species native to Central Valley watersheds, a total of 3,092 (77.96 percent) were of non-native species, and 20 (0.50 percent) were not able to be identified as native or non-native. A complete list of non-salmonid species captured in the 2017 survey season is presented in Appendix 3.

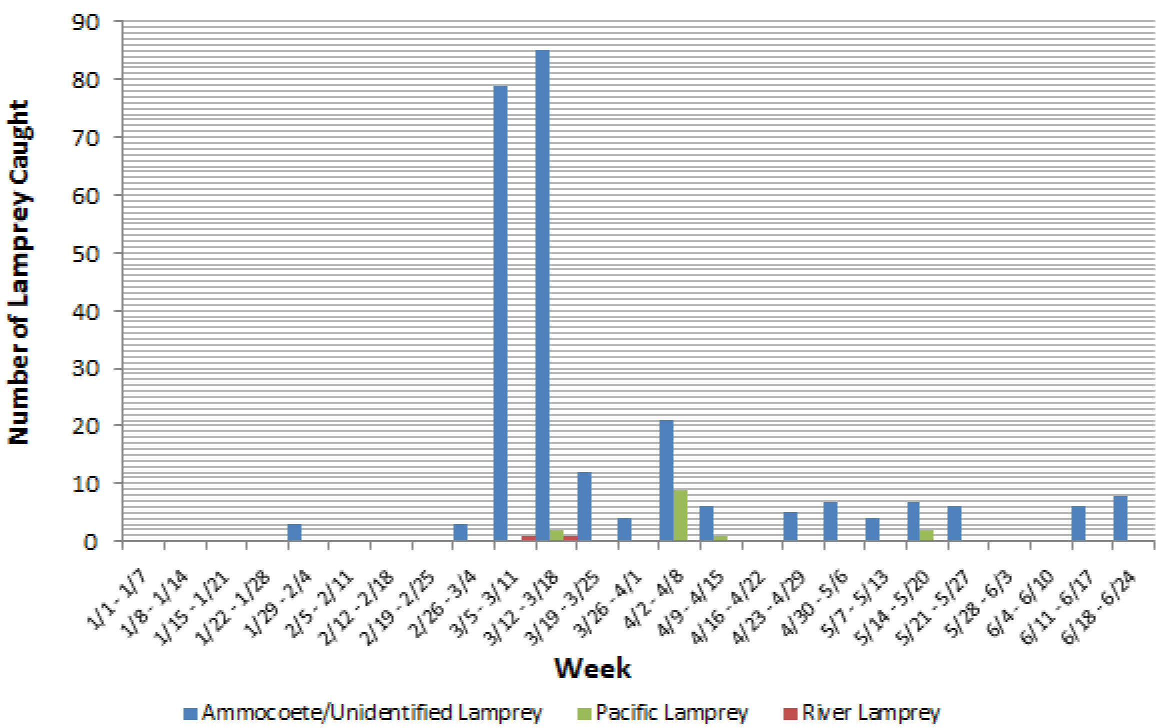
Figure 19: Non-salmonid catch totals for families of fish species collected during the 2017 lower American River rotary screw trap survey season.



Of the 3,966 non-salmonid fish, 272 (6.86 percent) were lamprey species. Individuals identified as Pacific lamprey made up 5.15 percent (n = 14) of captured lampreys and included 13 individuals identified as adult life stage and one individual identified as juvenile life stage. River lamprey comprised 0.74 percent (n = 2) of the lamprey captured and were identified as adult life stage. The remaining 94.12 percent (n = 256) were unidentifiable to the species level, with 255 identified as ammocoete life stage, and one individual identified as a juvenile life stage. Ammocoetes were captured throughout the season, Pacific lamprey were captured between 13 March and 20 May, and the two river lamprey were captured on 8 March and 18 March (Figure 20.)

Catch of Pacific lamprey peaked between 4 April and 7 April. At this time, 64.29 percent (n = 9) of the season's Pacific lamprey total was captured, with 28.57 percent (n = 4) captured on 6 April alone. Of the lamprey identified as ammocoete life stage or otherwise unidentified to species level, 60.94 percent (n=156) were captured between 7 March and 18 March. The peak day of capture for lamprey identified as ammocoete life stage or otherwise unidentified to species level was 9 March, when 22 were captured.

Figure 20: Total weekly lamprey catch during the 2017 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Discussion

When interpreting the data collected during the 2017 survey season on the Lower American River and the juvenile Chinook salmon passage estimate produced from that data, several influential factors must be considered. One of the most significant of these may have been environmental factors, especially fluctuating river flows. During the 2017 survey season, remarkably high flows were experienced, which likely hindered the ability to collect consistent and high quality data by restricting the number of days that the traps could be safely operated and limiting the number of trap efficiency trials that could be conducted.

In 2017, California experienced a record number of atmospheric rivers that transported large quantities of water vapor from the tropics to California (NOAA 2017). The landfall of these atmospheric rivers brought heavy precipitation and high snow levels to the Sierra Nevada, filling many Central Valley reservoirs to near maximum capacity, well above historical averages (NOAA 2017, USBR 2017). These reservoirs included Folsom Lake which had increased to a level that exceeded the historical average by early January. Consequently, American River discharges were increased from 7,000 CFS to 60,000 CFS between 5 January and 10 January for flood control and storage management purposes. Due to safety concerns at such high flows, the Watt Ave RSTs did not begin sampling until 1 February following a flow reduction to 8,000 CFS on 31 January.

On 4 February 2017, due to flood control regulations, discharges from Nimbus Dam were heightened again, increasing American River flows from approximately 7,000 CFS to approximately 80,000 CFS during the week following 4 February. During this flow increase, cones were raised and traps were pulled out of the thalweg, and were unable to be redeployed until 3 March when flows declined to approximately 10,000 CFS and safety concerns were again reduced. This resulted in a four-week gap in sampling between 4 February and 3 March. Since this gap in sampling exceeded the seven day maximum threshold for the CAMP platform to accurately estimate catch, the passage estimate produced for the 2017 survey season also excludes this period of time.

Only one other gap in sampling greater than seven days occurred during the 2017 survey season. This gap, between 1 June and 12 June, was also not able to be included in the 2017 survey season passage estimate.

Since trapping did not start until 1 February, when trapping would typically begin in January, occurred for only three days in February, and did not resume until 3 March, the 2017 survey season passage estimate is likely biased low. Furthermore, during the three days sampled in February, a total of 466 juvenile fall-run Chinook salmon was captured, accounting for 4.87 percent of the total season catch, and comprising 4.42 percent (n = 34,820) of the total passage estimate. Although potential catch between 4 February and 3 March cannot be known, its proximity to the typical peak of a survey season coupled with the continuation of elevated catch when trapping resumed, implies that a peak may have occurred during this four week gap in sampling, further biasing the passage estimate for the 2017 survey season.

Despite bias from lack of sampling at the beginning of the emigration period, low river temperatures, resultant of the high river flows, allowed for trapping to continue much longer than in previous years, therefore likely encompassing most of the emigration period end. During the last seven days of the survey season, a total of 46 juvenile fall-run Chinook salmon was captured, accounting for 0.48 percent of the total season catch and comprising 1.08 percent (n = 8,547) of the total passage estimate.

The total number of in-river produced fall-run Chinook salmon estimated to have emigrated past the rotary screw trap location on the American River during the 2017 survey season was 788,409 individuals, with 95 percent confidence intervals ranging from 763,355 to 796,848 individuals. The relatively small confidence interval width is likely due to a low distribution of daily catch totals throughout the 2017 survey season. Meaningful comparison between the 2017 survey season and previous survey seasons could not be made due to the presumed underestimate of 2017 passage.

In considering the accuracy of the 2017 passage estimate, trap efficiencies must also be considered. For highest accuracy, as many trap efficiency trials as possible should be conducted throughout a survey season. However, since trap efficiencies are inversely affected by the river discharge, trap efficiency trials rely heavily on consistent river discharge throughout the entire trial period to accurately determine efficiencies. In 2017, an attempt was made to conduct trap efficiency trials when river flows stabilized, but with frequent flow increases and rather low numbers of Chinook salmon captured, only five trap efficiency trials were able to be conducted. One of these trials was discarded because traps had to be raised after only two days due to a river flow increase. This trial was excluded from analysis and not used to determine the passage estimate. During another of the trap efficiency trials, trapping was suspended for two days after the fifth day of sampling, and when trapping resumed, associated marked salmon were recaptured. Despite the possibility that recaptures may have occurred during the two day gap, this trap efficiency was kept in analysis because it was conducted for the standard length of time, and it was the only trial conducted during high flows of approximately 15,000 CFS.

Passage estimates were not produced for spring- and winter-run Chinook salmon, since low numbers of these runs were captured. Although 120 Chinook salmon were identified as LAD spring-run, genetic analysis determined only one (0.83 percent) was a spring-run from Butte Creek; the other 119 (99.17 percent) were determined to be fall-run Chinook salmon. Therefore, as in previous years, LAD criteria proved to be inaccurate in determining the run of LAD spring-run Chinook salmon.

Furthermore, between 6 April and 13 April a total of 12 hatchery produced Chinook salmon marked with a clipped adipose fin were captured, five of which were identified as spring-run by LAD criteria. Genetic analysis was conducted on two of the adipose fin clipped LAD spring-run Chinook salmon and both were determined to be fall-run. These may have originated from Coleman Fish Hatchery (CNFH), as part of a release conducted on 22 March, approximately two weeks before the capture of these fish on 6 April. However, Feather River Fish Hatchery (FRFH) also released spring-run Chinook salmon on 20 March, therefore a conclusive determination of the origin and run of the three hatchery produced LAD spring-run that were not genetically sampled was unable to be made. In future studies, genetic samples should be taken from all LAD spring-run Chinook salmon.

On 24 May and 31 May NFH released approximately 606,181 and 553,887 brood year 2016 fall-run Chinook salmon respectively into the lower American River at the Sunrise boat ramp. Of the fish released, only 25 percent were marked with an adipose fin clip, making it impossible to distinguish between in-river produced and unmarked hatchery produced Chinook salmon. Although cones were raised and trapping was suspended for a minimum of five days in response to each release it is still possible that a portion of the unmarked fall-run Chinook salmon captured after 24 May were hatchery produced. Additionally, since trapping continued through 1 June following the release on 31 May, the majority of the salmon captured on 1 June and identified as in-river produced salmon are likely unmarked hatchery produced salmon. Although 1 June was excluded from analysis and not used in calculating the 2017 passage estimates, catch from this day was still included in catch totals and graphics displaying actual catch.

NFH also released brood year 2016 steelhead into the American River at Jiboom Street between 23 February and 25 February. Despite these releases, no hatchery produced steelhead were captured at the Watt Avenue RSTs during the 2017 survey season. Unlike in previous survey seasons, high river flows may have prevented these hatchery produced steelhead from moving upstream to the RST location after the release. However, a total of 28 in-river produced steelhead was captured. This is a relatively low number compared to the previous survey season, likely due to increased distance from a steelhead redd to the RST location or due to reduced trap efficiencies associated with high river discharge.

Management Implications

In order to determine if efforts made by AFRP and others to increase abundance of Chinook salmon and steelhead on the lower American River have been successful, additional monitoring of juvenile salmonid emigration is required. There should also be continued water temperature and flow management to make the river conditions more favorable to anadromous fish. The 2017 data will be coupled with prior and future data to provide crucial information to better understand and improve conditions for Chinook salmon and steelhead on the lower American River. The 2017 data is of particular interest as it was considered a record high water year, and can be contrasted with prior drought years. The comparison of this data can be used to influence water management modifications for the American River to make the river environment more favorable to anadromous fishes in future drought conditions. Management options such as modifications to discharge volume and timing could be adjusted to reduce pre-spawn mortality and minimize redd dewatering and superimposition which have likely had a negative influence on spawning in previous drought years, but likely did not influence spawning in 2017 due to the higher volumes of water.

Acknowledgements

The funding for this project was provided by the USFWS's Comprehensive Assessment and Monitoring Program (CAMP). The Lower American River RST project would like to thank Doug Threloff, Cesar Blanco and staff at USFWS CAMP for their technical support. Thank you also to the Pacific States Marine Fisheries Commission staff: Stan Allen for management support and Amy Roberts and Kathy Ameral for administrative support and purchasing. In addition, recognition goes to the American River RST Project crew members, Brian Crabill, Lee Scheffler, Dylan Whitaker, Nicole Dunkley, Luis Santana, Joel Llamas, Albert Liwanag, Edina Meiners and Brandon Demuth for their hard work and assistance in collecting the data for this report. Additional thanks goes to the PSMFC staff at the Central Valley Steelhead Monitoring Project and Yuba River Monitoring Program for lending assistance with data collection and field work support. Special thanks goes to the staff at the CDFW's Tissue Archive Lab especially Rob Titus, Lea Koerber and the scientific aides for their collaborative effort and guidance in processing the fin-clip samples for further genetic analyses. The project thanks the staff at the Abernathy Fish Technology Center, especially Christian Smith and Jennifer Von Bargen, for the genetic analyses of the fin-clips. Additional gratitude goes to the Nimbus Fish Hatchery staff Paula Hoover and Gary Novak, for setting aside 4,000 fall-run Chinook salmon for use in our efficiency trials, and for their understanding in the changing and unpredictable circumstances. Additionally, the project thanks Amanda Cranford and Shivonne Nesbit from the National Marine Fisheries Service for assistance with the Federal take permit.

References

Allen, L. 2016. Gravel Augmentation Update Recreation and Park Commission for the Sacramento Water Forum. 25 May 2016. PowerPoint file.

California Department of Water Resources (DWR). 2010. California's drought of 2007-2009, an overview.

California Department of Water Resources (DWR). 2016. State Water Project Allocation Increased. 21 April 2016. http://www.water.ca.gov/news/newsreleases/2016/042116.pdf

California Water Science Center: California Drought. USGS. 31 Oct. 2015. https://ca.water.usgs.gov/data/drought/

Clemento A.J., E.D. Crandall, J.C. Garza, E.C. Anderson. 2014. Evaluation of a SNP baseline for genetic stock identification of Chinook salmon (Oncorhynchus tshawytscha) in the California Current large marine ecosystem. Fishery Bulletin 112:112-130.

Cramer Fish Sciences (Cramer). 2016. Lower American River Monitoring. 2016 Steelhead (Oncorhynchus mykiss) Spawning and Stranding Surveys Central Valley Project, American River, California Mid-Pacific Region. 46 pp plus appendix.

Demko, D.B., C. Gemperle, S.P. Cramer, and A. Philips. 1998. Evaluation of juvenile Chinook behavior, migration rate and location of mortality in the Stanislaus River through the use of radio tracking. Prepared by Cramer Fish Sciences for Tri-dam Project. December 1998.

Fisher, F.W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology 8:870-873.

Greene, S. 1992. Estimated winter-run Chinook salmon salvage at the State Water Project and Central Valley Project Delta Pumping Facilities. 8 May 1992. California Department of Water Resources. Memorandum to Randall Brown, California Department of Water Resources. 3 pp. plus 15 pp. tables.

Hammersmark, C. 2014. 2013 Chinook Salmon Potential Redd Dewatering Estimate. Technical Memorandum. CBEC Inc.

Hannon, J. 2013. American River Steelhead (*Oncorhynchus mykiss*) Spawning – 2013, with comparisons to prior years. Unpublished report prepared by the U.S. Department of the Interior, Bureau of Reclamation, Central Valley Project, Mid-Pacific Region. 32 pp.

Healey, T.P. 1977. The Effects of High Temperature on the Survival of Sacramento River Chinook Salmon (Oncorhynchus tshawytcha) Eggs and Fry. California Department of Fish and Game, Anadromous Fisheries Branch. Admin. Rpt. No. 79-10.

Hicks, M. 2000. Evaluating standards for protecting aquatic life in Washington's surface water quality standards. Draft Discussion Paper and Literature Summary. Washington State Department of Ecology, Olympia, Washington.

James, L.A. 1997. Channel incision on the lower American River, California, from stream flow gage records. Water Resources Research 33:485-490.

Kohlhorst, D. W. 1976. Sturgeon spawning in the Sacramento River in 1973, as determined by distribution of larvae. California Fish and Game 62:32-40.

Lindley et al 2006. Historical Population Structure of Central Valley Steelhead and its Alteration by Dams. San Francisco Estuary and Watershed Science. Vol 4, Iss.1 [February 2006], Art. 3

Marine, K. R., and J. J. Cech. 2004. Effects of high water temperatures on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24: 198-210.

Martin, C.D., P. D. Gaines, and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U. S. Fish and Wildlife Service, Red Bluff, CA.

Maslin, P.E., W.R. McKinnev, and T.L. Moore. 1998. Intermittent streams as rearing habitat for Sacramento River Chinook salmon. Unpublished report prepared for the U. S. Fish and Wildlife Service under the authority of the Federal Grant and Cooperative Agreement Act of 1977 and the Central Valley Improvement Act.

McCullough, D. A. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, With Special Reference to Chinook Salmon. Report No. EPA 910-R-99-010. Seattle, WA: EPA, Region 10.

McCullough, D., S. Spalding, D. Sturdevant, M. Hicks. 2001. Issue Paper 5. Summary of technical literature examining the physiological effects of temperature on salmonids. Prepared as part of U.S. EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. EPA-910-D-01-005.

McDonald, T., and M. Banach. 2010. Feasibility of unified analysis methods for rotary screw trap data in the California Central Valley. U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program, Cooperative Agreement No. 81420-8-J163. 18 pp.

Merz, J.E., and D.C. Vanicek. 1996. Comparative feeding habits of juvenile Chinook salmon, steelhead, and Sacramento squawfish in the Lower American River, California. California Fish and Game 82(4):149-159.

Merz, J.E., K. Sellheim, M. Saiki, C. Watry, D. Richards. 2013. Evaluation of gravel placement on habitat conditions for juvenile and adult anadromous salmonids in the lower American River, California. Prepared by Cramer Fish Sciences for the Sacramento Water Forum, U.S. Bureau of Reclamation, and the U.S. Fish and Wildlife Service CVPIA Gravel Program. June 2014.

Moyle, P. 2002. Inland Fishes of California. University of California Press, Berkeley and Los Angeles, California, USA.

Myrick, C.A., J.J. Cech. 2001. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. Bay-Delta Modeling Forum Technical Publication 01-1.

National Marine Fisheries Service (NMFS). 2009. Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project. NMFS, Southwest Region. 844 pp

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

National Marine Fisheries Service (NMFS). 2016. 2016 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. NMFS, West Coast Region. April 2016. 54 pp.

National Oceanic and Atmospheric Administration (NOAA). 2017. Unusually Large Number of Atmospheric Rivers Impacted California this Past Winter. https://hmt.noaa.gov/news/2017/072017.html

Pacific States Marine Fisheries Commission (PSMFC). 2013. Juvenile salmonid emigration monitoring in the lower American River, California January – June 2013. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California.

Pacific States Marine Fisheries Commission (PSMFC). 2014. Juvenile salmonid emigration monitoring in the lower American River, California January – May 2014. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California.

Pacific States Marine Fisheries Commission (PSMFC). 2015. Juvenile salmonid emigration monitoring in the lower American River, California January – May 2015. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California.

Phillips, J., and J.M. Helstab. 2013. Lower American River fall-run Chinook salmon escapement survey October 2012 – January 2013. U.S. Bureau of Reclamation. 22 pp. plus figures and appendix.

Phillips, J., and K.M. Gahan. 2014. Lower American River fall-run Chinook salmon escapement survey October 2013 – January 2014. California Department of Fish and Wildlife. 25 pp. plus figures and appendix.

Phillips, J., and H.S. Kubo. 2015. Lower American River fall-run Chinook salmon escapement survey October 2014 – January 2015. California Department of Fish and Wildlife. 27 pp.

Poole, G. J. Dunham, M. Hicks, D. Keenan, J. Lockwood, E. Materna, D. McCullough, C. Mebane, J. Risley, S. Sauter, S. Spalding, D. Sturdevant. 2001. Scientific issues relating to temperature criteria for salmon, trout, and char native to the Pacific Northwest. Prepared as part of U.S. EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. EPA-910-R-01-007.

Reid, S. 2012. Lampreys of Central California field ID key (a living document). U.S. Fish & Wildlife Pacific Lamprey Conservation Initiative.

Rich, A.A. 1987. Report on studies conducted by Sacramento County to determine the temperatures which optimized growth and survival in juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Prepared for the County of Sacramento.

Sellheim, K., J. Merz, P. Haverkamp, and J. Sweeney. 2015. Lower American River monitoring 2015 steelhead (*Oncorhyncus mykiss*) spawning and stranding survey. Prepared by Cramer Fish Sciences for the Sacramento Water Forum, U.S. Bureau of Reclamation. July 2015.

Snider, B., and R. G. Titus. 2001. Timing, composition, and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing October 1997 – September 1998. Conducted by the Department of Fish and Game. Funded partially by the California Department of Water Resources through the Interagency Ecological Program. Stream Evaluation Program Technical Report No. 00-5. July 2001.

Sogard, S. M.; J. E. Merz, W. H. Satterthwaite, M. P. Beakes, D. R. Swank, E. M. Collins, R. G. Titus and M. Mangel. 2012. Contrasts in Habitat Characteristics and Life History Patterns of Oncorhynchus mykiss in California's Central Coast and Central Valley. Series: Transactions of the American Fisheries Society, Vol. 141, Page(s): 747-760

U.S. Army Corps of Engineers (USACE). 1991. American River watershed investigation, California Lower American River area. United States Department of Interior, Fish and Wildlife Service. Appendix S Part 2, Vol 7:1-460.

U.S. Bureau of Reclamation (USBR). 2017. Daily Central Valley Project Water Supply Report.

United States Department of the Interior (USDOI). 2008. Lower American River salmonid spawning gravel augmentation and side-channel habitat establishment program. Bureau of Reclamation, Mid-Pacific Region Rpt. 27 pp.

Williams, John. 2001. Chinook salmon in the Lower American River, California's largest urban stream. Contributions to the Biology of Central Valley Salmonids, Vol Two. Fish Bulletin 179: 1-38.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Contributions to the Biology of Central Valley Salmonids, Vol 1. Fish Bulletin 179:71-176.

Appendix 1: Points of interest on the lower American River.

Point of Interest	Significance	Operator	River Miles (rkm)
Folsom Dam	Constructed 1956; Power Generation, flood control, water supply, recreation.	U.S. Bureau of Reclamation	29.4 (47.3)
Nimbus Dam	Constructed 1955; Power Generation, flood control, water supply, recreation.	U.S. Bureau of Reclamation	22.3 (35.8)
Nimbus Fish Hatchery	Chinook salmon and Steelhead Hatchery; Fish ladder, weir.	California Department of Fish and Wildlife	22.2 (35.7)
American River at Fair Oaks	River discharge gauging station	U.S. Geological Survey	22.1 (35.6)
Sailor Bar	Habitat improvement; Gravel augmentation		~22 (35.4)
Lower Sunrise	Habitat improvement; Gravel augmentation		~19 (30.6)
Sacramento Bar	Habitat improvement; Gravel augmentation		~18 (29)
La Riviera storm water outflow	Release site for trap efficiency mark-recapture trials (Chinook and Steelhead Trial)		9.7 (15.6)
Above Watt Avenue Bridge	Release site for trap efficiency mark-recapture trials (Steelhead Trial Only)		9.4 (15.1)
Watt Avenue bridge	River temperature monitoring station	U.S. Geological Survey	9.2 (14.8)
North channel RST below Watt Avenue	RST site for monitoring juvenile salmonid abundance and outmigration		9 (14.5)
South channel RST below Watt Avenue	RST site for monitoring juvenile salmonid abundance and outmigration (Site not used in low water years)		8.8 (14.2)
Howe Avenue boat launch	Nimbus Fish Hatchery release site for Chinook salmon and steelhead		7.8 (12.6)
Jabboom St. bridge	Nimbus Fish Hatchery release site for Chinook salmon and steelhead		0.2 (0.3)
Mouth of American River	American-Sacramento River Confluence		0

Appendix 2: **Weekly environmental conditions on the lower American River during the 2017 survey season.**

Julian	Water Temperature (°C)			Discharge (CFS)			DO (mg/l)			Turbidity (NTU)			Velocity (m/s)		
Week	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max
1/1-1/7	8.7	8.1	9.5	8,926	2,990	30,000									
1/8-1/14	9.1	8.7	9.3	44,204	29,600	62,600									
1/15-1/21	8.8	8.4	9.1	29,301	20,200	30,600									
1/22-1/28	8.4	7.9	9.0	11,287	7,890	20,400									
1/29-2/4	8.2	7.6	8.8	7,735	6,050	15,000	9.1	9.1	9.1	9.6	7.9	10.6	0.9	0.8	1.0
2/5-2/11	8.9	7.8	9.6	47,479	15,000	85,400									
2/12-2/18	9.2	8.9	9.6	40,412	29,500	78,000									
2/19-2/25	9.5	9.0	10.0	29,882	29,400	30,500									
2/26-3/4	8.8	8.2	9.6	20,442	10,300	30,700	10.1	10.1	10.1	14.8	13.2	16.4	1.2	1.1	1.3
3/5-3/11	8.9	8.0	10.3	7,434	5,550	10,400	9.7	9.5	10.3	12.7	9.8	17.1	0.8	0.5	0.9
3/12-3/18	9.7	9.0	11.2	5,692	5,100	6,070	9.6	8.6	10.1	8.1	6.3	10.5	0.9	0.8	1.2
3/19-3/25	9.9	9.0	11.3	5,641	4,560	6,280	9.5	8.6	10.6	5.8	5.1	6.6	0.7	0.4	1.0
3/26-4/1	10.8	9.4	12.4	11,348	5,590	16,900	9.2	9.1	9.3	4.5	4.3	4.7	0.6	0.6	0.7
4/2-4/8	11.6	10.6	12.8	9,289	9,010	9,450	9.7	8.7	11.5	3.6	2.9	4.5	1.3	1.1	1.6
4/9-4/15	11.6	10.6	13.0	10,276	9,170	11,400	9.0	8.2	9.8	3.5	2.1	5.3	1.0	0.9	1.2
4/16-4/22	11.7	10.9	12.8	13,258	10,600	16,200	9.3	9.1	9.5	3.3	3.0	3.9	1.1	1.0	1.3
4/23-4/29	12.0	10.8	13.7	15,810	15,500	16,200	8.8	7.4	9.5	3.6	2.3	9.8	1.2	0.9	1.5
4/30-5/6	13.3	12.0	14.6	15,441	11,700	17,500	9.1	8.9	9.4	1.9	1.1	2.5	1.3	1.0	1.6
5/7-5/13	13.8	12.8	15.1	9,495	8,200	11,900	8.5	8.0	9.0	1.7	1.0	2.9	1.6	1.3	2.0
5/14-5/20	13.9	12.3	15.5	9,038	8,500	9,650	8.5	7.8	9.7	2.2	1.5	3.4	1.4	1.2	1.6
5/21-5/27	14.4	13.4	15.8	8,510	6,360	9,520	8.1	6.5	8.9	1.8	1.4	2.2	1.6	1.5	1.7
5/28-6/3	14.8	13.3	17.4	6,911	6,300	12,200	8.3	8.1	8.4	1.6	1.1	2.1	1.3	0.9	1.5
6/4-6/10	14.8	13.2	16.3	10,954	7,230	12,400							2.0	2.0	2.1
6/11-6/17	14.5	13.3	16.5	6,912	6,070	7,360	8.0	7.5	8.4	1.7	1.2	2.1	1.5	1.3	1.7
6/18-6/24	15.5	14.2	17.7	5,710	4,100	6,530	8.5	7.2	9.7	1.7	1.1	2.2	1.4	1.3	1.7

Note: The USGS website provides the discharge and temperature data by day in 15 minute intervals. To calculate the averages by week, the 15 minute intervals were first averaged by day, and then the days were averaged by the seven day Julian week indicated by the "Week" column in the table above. The min and max values for the discharge and temperature data are the highest and lowest values recorded for the week. Dissolved oxygen was calculated by weekly averages from daily values gathered by crew members in the field. Dissolved oxygen min and max values are reflective of the minimum and maximum daily value gathered during the Julian week defined by the "Julian Week" column in the table above. Turbidity and velocity reflect a weekly average of values, gathered per trap by crew members in the field and averaged into a single daily value. Turbidity and velocity min and max values are reflective of the minimum and maximum daily value gathered for each trap during the Julian week defined by the "Julian Week" column in the table above.

Appendix 3: **List of fish species caught during the 2017 season using rotary screw traps on the lower American River.**

Common Name	Family Name	Species Name	Total Number Caught
Chinook salmon	Salmonidae	*Oncorhynchus tshawytscha*	10,248
Steelhead / rainbow trout	Salmonidae	*Oncorhynchus mykiss*	28
American shad	Clupidae	*Alosa Sapidissima*	5
Bluegill	Centrarchidae	*Lepomis macrochirus*	50
Brown Bullhead	Ictaluridae	*Ameiurus nebulosus*	1
Channel catfish	Ictaluridae	*Ictalurus punctatus*	2
Golden shiner	Cyprinidae	*Notemigonus crysoleucas*	10
Goldfish	Cyprinidae	*Carassius auratus*	1
Green sunfish	Centrarchidae	*Lepomis cyanellus*	6
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	206
Inland silverside	Atherinopsidae	*Menidia beryllina*	7
Largemouth bass	Centrarchidae	*Micropterus salmoides*	6
Mosquitofish	Poeciliidae	*Gambusia affinis*	29
Pacific lamprey	Petromyzontidae	*Entosphenus tridentatus*	14
Prickly sculpin	Cottidae	*Cottus asper*	20
Redear sunfish	Centrarchidae	*Lepomis microlophus*	1
Riffle sculpin	Cottidae	*Cottus gulosus*	7
River lamprey	Petromyzontidae	*Lampetra ayresii*	2
Sacramento pikeminnow	Cyprinidae	*Ptychocheilus granelis*	297
Sacramento sucker	Catostomidae	*Catostomus occidentalis*	33
Spotted bass	Centrarchidae	*Micropterus punctulatus*	27
Striped bass	Moronidae	*Morone saxatilis*	1
Threadfin shad	Clupidae	*Dorosoma petenense*	223
Threespine stickleback	Gasterosteidae	*Gasterosteus aculeatus*	15
Tule perch	Embiotocidae	*Hysterocarpus traskii*	3
Wakasagi / Japanese smelt	Osmeridae	*Hypomesus nipponensis*	2723
Unknown Centrarchid	Centrarchidae		11
Unknown lamprey	Petromyzontidae		256
Unknown minnow	Cyprinidae		8
Unknown sculpin (Cottus)	Cottidae		1
Unknown sunfish (Lepomis)	Centrarchidae		1
		Total	**14,242**

Appendix 4: Genetic results for fin-clip samples from Chinook salmon caught in the lower American River during the 2017 survey season.

Sample #: refer to a unique number assigned by field staff, and that allowed the tracking of individual fish samples.

LAD run assignment: Chinook salmon run assignment based on the length-at-date run assignment methodology developed by Greene (1992).

SNP Run Assignment: Chinook salmon run assignment using “Genetic Call to three lineages” single-nucleotide polymorphism (SNP) markers.

SNP Probability: Probability of the correct SNP Chinook salmon run assignment.

Final run assignment: run assignment using a 50 percent threshold based on the SNP probability.

FL: fork length in millimeters.

W: weight in grams.

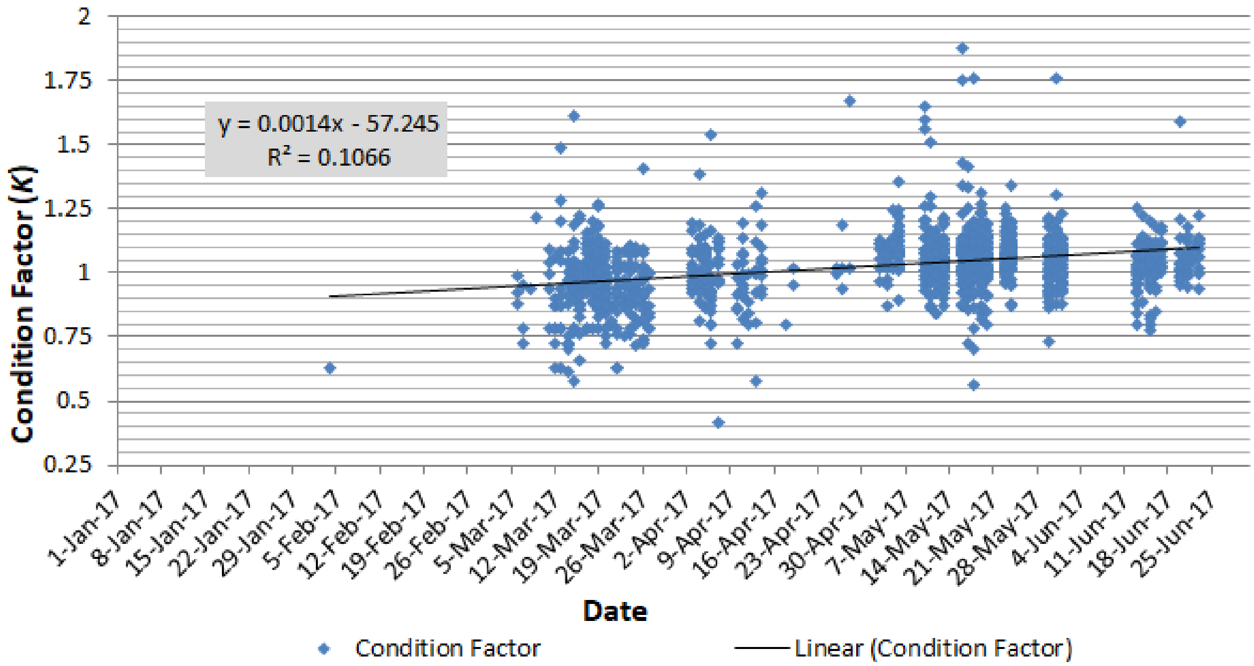
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
6-Mar	3282-008	Spring	Fall	0.998	Fall	68	3.1	
6-Mar	3282-009	Spring	Fall	0.973	Fall	73	3.6	
7-Mar	3282-013	Fall	Fall	1.000	Fall	37		
7-Mar	3282-014	Fall	Fall	1.000	Fall	35		
7-Mar	3282-015	Spring	Fall	1.000	Fall	64	2.5	
11-Mar	3282-027	Spring	Fall	1.000	Fall	83	5.7	
12-Mar	3282-028	Spring	Fall	1.000	Fall	75	3.8	
13-Mar	3282-034	Spring	Fall	1.000	Fall	70	3.6	
13-Mar	3282-035	Spring	Fall	1.000	Fall	65	2.5	
14-Mar	3282-036	Spring	Fall	1.000	Fall	69	3.3	
14-Mar	3282-037	Spring	Fall	1.000	Fall	66		
14-Mar	3282-038	Spring	Fall	1.000	Fall	68	3.4	
15-Mar	3282-039	Spring	Fall	1.000	Fall	68	3.2	
15-Mar	3282-040	Spring	Fall	1.000	Fall	69	3.9	
15-Mar	3282-041	Spring	Fall	1.000	Fall	66	2.8	
15-Mar	3282-042	Spring	Fall	1.000	Fall	68	3.2	
15-Mar	3282-043	Spring	Fall	1.000	Fall	66	2.8	
15-Mar	3282-044	Spring	Fall	1.000	Fall	69	3.3	
15-Mar	3282-045	Spring	Fall	1.000	Fall	67	3.3	
16-Mar	3282-053	Spring	Fall	1.000	Fall	67	3	
16-Mar	3282-054	Spring	Fall	0.999	Fall	72	3.1	

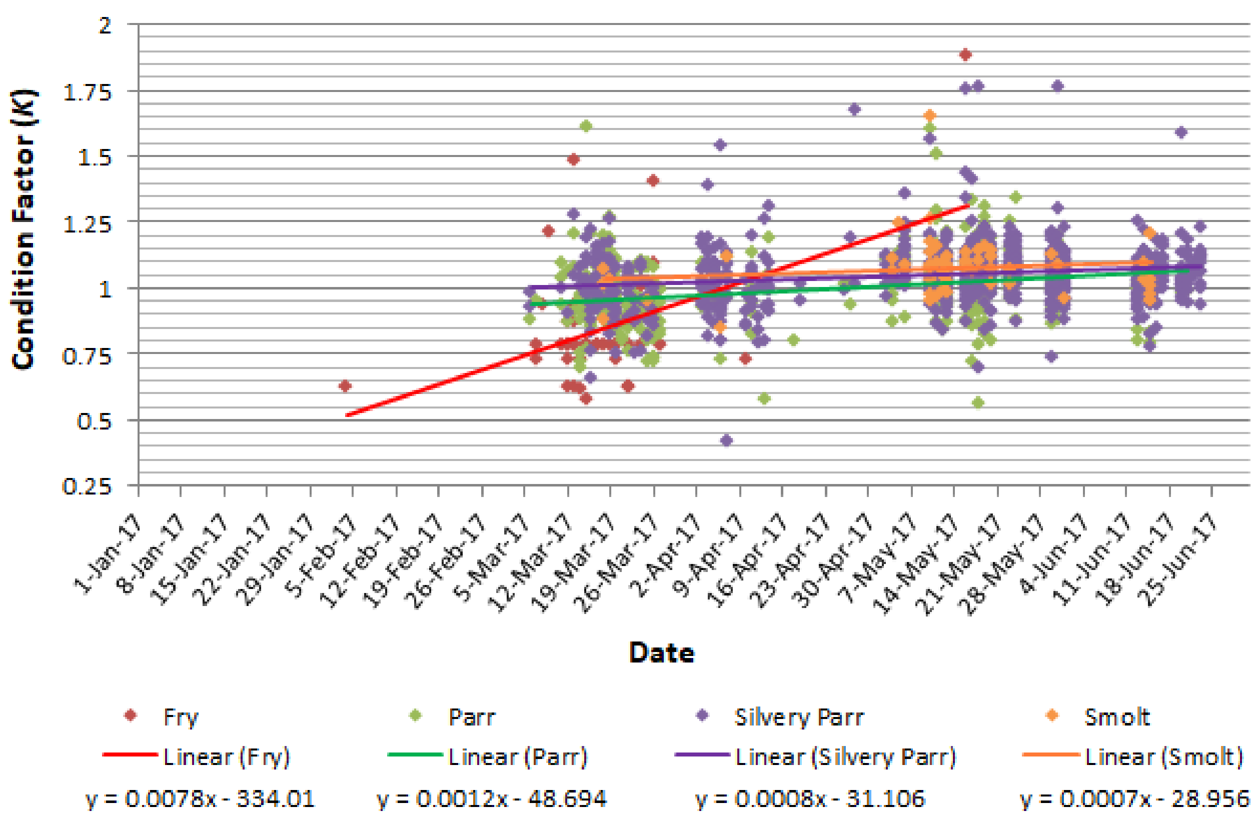
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
16-Mar	3282-055	Spring	Fall	1.000	Fall	72	3.4	
16-Mar	3282-056	Spring	Fall	1.000	Fall	72	3.5	
17-Mar	3282-065	Spring	Fall	1.000	Fall	68	3.2	
17-Mar	3282-066	Spring	Fall	1.000	Fall	77	5.3	
17-Mar	3282-067	Spring	Fall	0.999	Fall	68	3.5	
17-Mar	3282-068	Spring	Fall	1.000	Fall	75	4.7	
17-Mar	3282-069	Spring	Fall	1.000	Fall	80	5.7	
17-Mar	3282-070	Spring	Fall	1.000	Fall	74	4.2	
17-Mar	3282-071	Spring	Fall	1.000	Fall	74	4	
17-Mar	3282-072	Spring	Fall	1.000	Fall	70	3.9	
17-Mar	3282-073	Spring	Fall	0.970	Fall	71	3.9	
17-Mar	3282-074	Spring	Fall	1.000	Fall	68	3.3	
17-Mar	3282-075	Spring	Fall	1.000	Fall	69	3.2	
17-Mar	3282-076	Spring	Fall	0.996	Fall	70	3.4	
18-Mar	3282-077	Spring	Fall	1.000	Fall	67	3.1	
18-Mar	3282-078	Spring	Fall	1.000	Fall	71	4	
18-Mar	3282-079	Spring	Fall	1.000	Fall	70	4	
18-Mar	3282-080	Spring	Fall	1.000	Fall	80	5.2	
18-Mar	3282-081	Spring	Fall	1.000	Fall	70	3.6	
18-Mar	3282-082	Spring	Fall	1.000	Fall	69	2.9	
18-Mar	3282-083	Spring	Fall	1.000	Fall	69	3.4	
18-Mar	3282-084	Spring	Fall	0.986	Fall	79	5	
18-Mar	3282-085	Spring	Fall	1.000	Fall	69	3.5	
18-Mar	3282-086	Spring	Fall	1.000	Fall	69	3.1	
18-Mar	3282-087	Spring	Fall	1.000	Fall	71	3.7	
18-Mar	3282-088	Spring	Fall	1.000	Fall	72	4	
19-Mar	3282-089	Spring	Fall	1.000	Fall	73	4.9	
19-Mar	3282-090	Spring	Fall	1.000	Fall	68	3.7	
19-Mar	3282-091	Spring	Fall	1.000	Fall	68	3.3	
19-Mar	3282-092	Spring	Fall	1.000	Fall	68	3.4	
19-Mar	3282-093	Spring	Fall	1.000	Fall	67	3.2	
19-Mar	3282-094	Spring	Fall	1.000	Fall	68	2.6	
19-Mar	3282-095	Spring	Fall	1.000	Fall	70	3.7	
19-Mar	3282-096	Spring	Spring	1.000	SpringB	82	5.7	Butte Creek
19-Mar	3282-097	Spring	Fall	1.000	Fall	72	3.7	
19-Mar	3282-098	Spring	Fall	1.000	Fall	70	3.4	
19-Mar	3282-099	Spring	Fall	1.000	Fall	70	3.2	
19-Mar	3282-100	Spring	Fall	1.000	Fall	78	4.5	
20-Mar	3283-001	Spring	Fall	1.000	Fall	68	3.1	
20-Mar	3283-002	Spring	Fall	1.000	Fall	70	3.1	

Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
20-Mar	3283-003	Spring	Fall	1.000	Fall	69	3.1	
20-Mar	3283-004	Spring	Fall	1.000	Fall	71	2.7	
20-Mar	3283-005	Spring	Fall	1.000	Fall	76	3.8	
20-Mar	3283-006	Spring	Fall	1.000	Fall	68	3.4	
24-Mar	3283-016	Spring	Fall	1.000	Fall	71	3.7	
24-Mar	3283-017	Spring	Fall	1.000	Fall	71	3.4	
25-Mar	3283-082	Spring	Fall	1.000	Fall	78	4.5	
27-Mar	3283-018	Fall	Fall	1.000	Fall	36		
27-Mar	3283-019	Fall	Fall	1.000	Fall	35		
3-Apr	3283-024	Spring	Fall	1.000	Fall	78	5.1	
3-Apr	3283-025	Spring	Fall	1.000	Fall	79	5.1	
3-Apr	3283-026	Spring	Fall	1.000	Fall	75	4.2	
3-Apr	3283-027	Spring	Fall	1.000	Fall	75	4	
3-Apr	3283-028	Spring	Fall	1.000	Fall	80	5.2	
3-Apr	3283-029	Spring	Fall	1.000	Fall	80	6.1	
4-Apr	3283-030	Spring	Fall	1.000	Fall	81	5.3	
4-Apr	3283-031	Spring	Fall	0.996	Fall	77	5.2	
4-Apr	3283-032	Spring	Fall	1.000	Fall	76	4.8	
4-Apr	3283-033	Spring	Fall	1.000	Fall	81	5.7	
4-Apr	3283-034	Spring	Fall	1.000	Fall	77	4.6	
5-Apr	3283-035	Late fall	Fall	1.000	Fall	33		
5-Apr	3283-036	Spring	Fall	1.000	Fall	79	5	
5-Apr	3283-037	Spring	Fall	1.000	Fall	75	3.9	
5-Apr	3283-038	Spring	Fall	1.000	Fall	77	5	
5-Apr	3283-039	Spring	Fall	1.000	Fall	75	4.6	
5-Apr	3283-040	Spring	Fall	1.000	Fall	76	4.8	
5-Apr	3283-041	Spring	Fall	1.000	Fall	75	4.1	
5-Apr	3283-042	Spring	Fall	1.000	Fall	75	4.5	
6-Apr	3283-050	Spring	Fall	1.000	Fall	88	7	Adipose clipped
6-Apr	3283-051	Spring	Fall	1.000	Fall	79	4.4	
6-Apr	3283-052	Late fall	Fall	1.000	Fall	33		
6-Apr	3283-053	Spring	Fall	1.000	Fall	81	4.7	Adipose clipped
6-Apr	3283-054	Spring	Fall	1.000	Fall	78	3.8	
6-Apr	3283-055	Spring	Fall	1.000	Fall	80	4.1	
6-Apr	3283-056	Spring	Fall	1.000	Fall	77	4.7	
6-Apr	3283-057	Spring	Fall	1.000	Fall	77	4.2	
6-Apr	3283-059	Spring	Fall	1.000	Fall	76	4	
6-Apr	3283-060	Spring	Fall	1.000	Fall	77	4.2	
7-Apr	3283-061	Spring	Fall	1.000	Fall	77	1.9	
7-Apr	3283-062	Late fall	Fall	1.000	Fall	31		

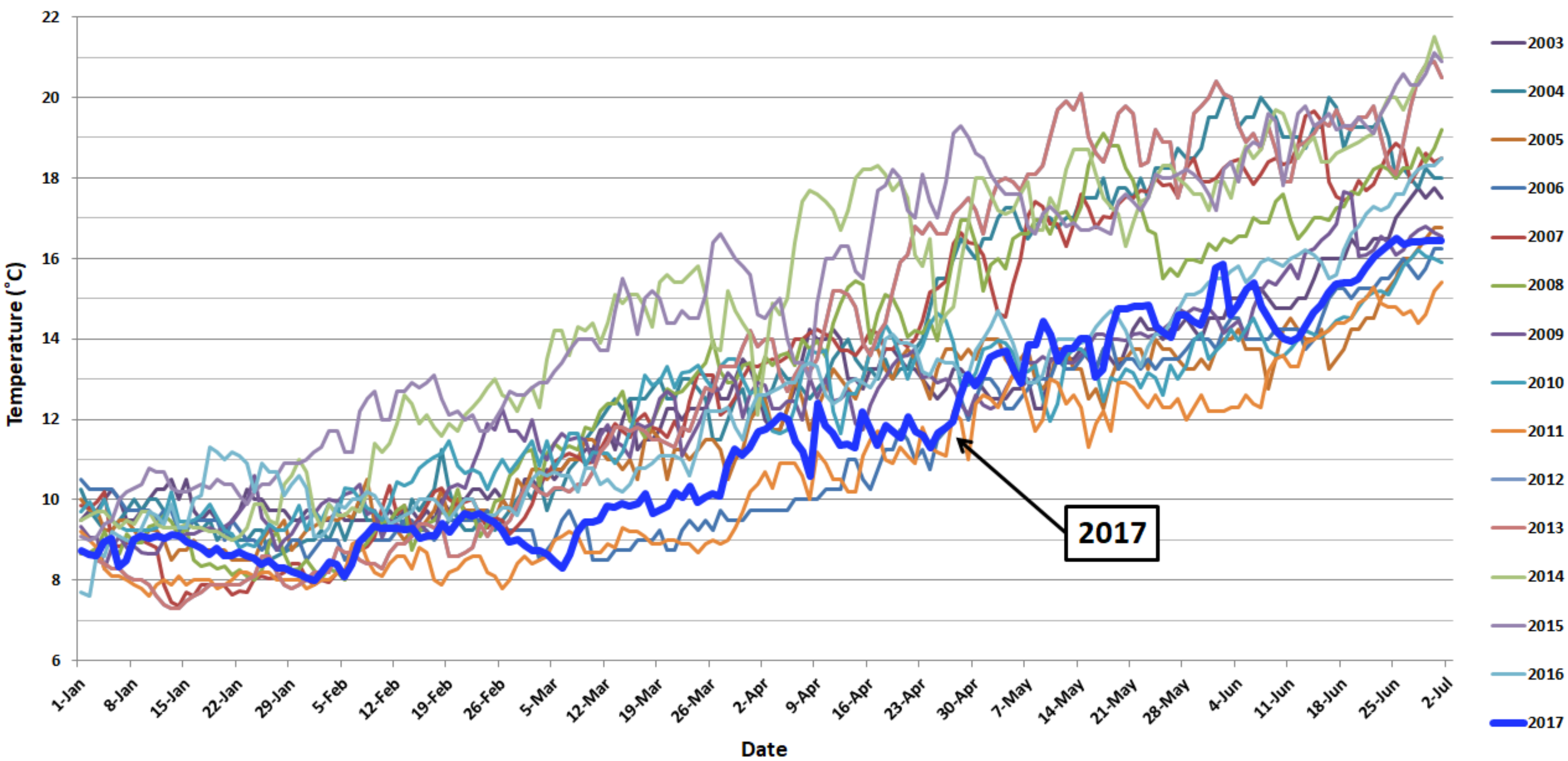
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
7-Apr	3283-064	Spring	Fall	1.000	Fall	96	9.9	
7-Apr	3283-065	Spring	Fall	1.000	Fall	80	5.4	
7-Apr	3283-066	Spring	Fall	1.000	Fall	80	5	
10-Apr	3283-067	Late fall	Fall	1.000	Fall	32		
10-Apr	3283-069	Spring	Fall	1.000	Fall	81	5.2	
11-Apr	3283-070	Spring	Fall	0.998	Fall	79	5.9	
11-Apr	3283-071	Spring	Fall	1.000	Fall	80		
11-Apr	3283-072	Late fall	Fall	1.000	Fall	34		
11-Apr	3283-074	Spring	Fall	1.000	Fall	79	4.7	
12-Apr	3283-075	Late fall	Fall	1.000	Fall	34		
13-Apr	3283-077	Late fall	Fall	1.000	Fall	33		
13-Apr	3283-079	Spring	Fall	1.000	Fall	83	6.4	

Appendix 5: Fulton's condition factor (*K*), overall, and by life-stage, of fall-run Chinook salmon during the 2017 lower American River rotary screw trap survey season.

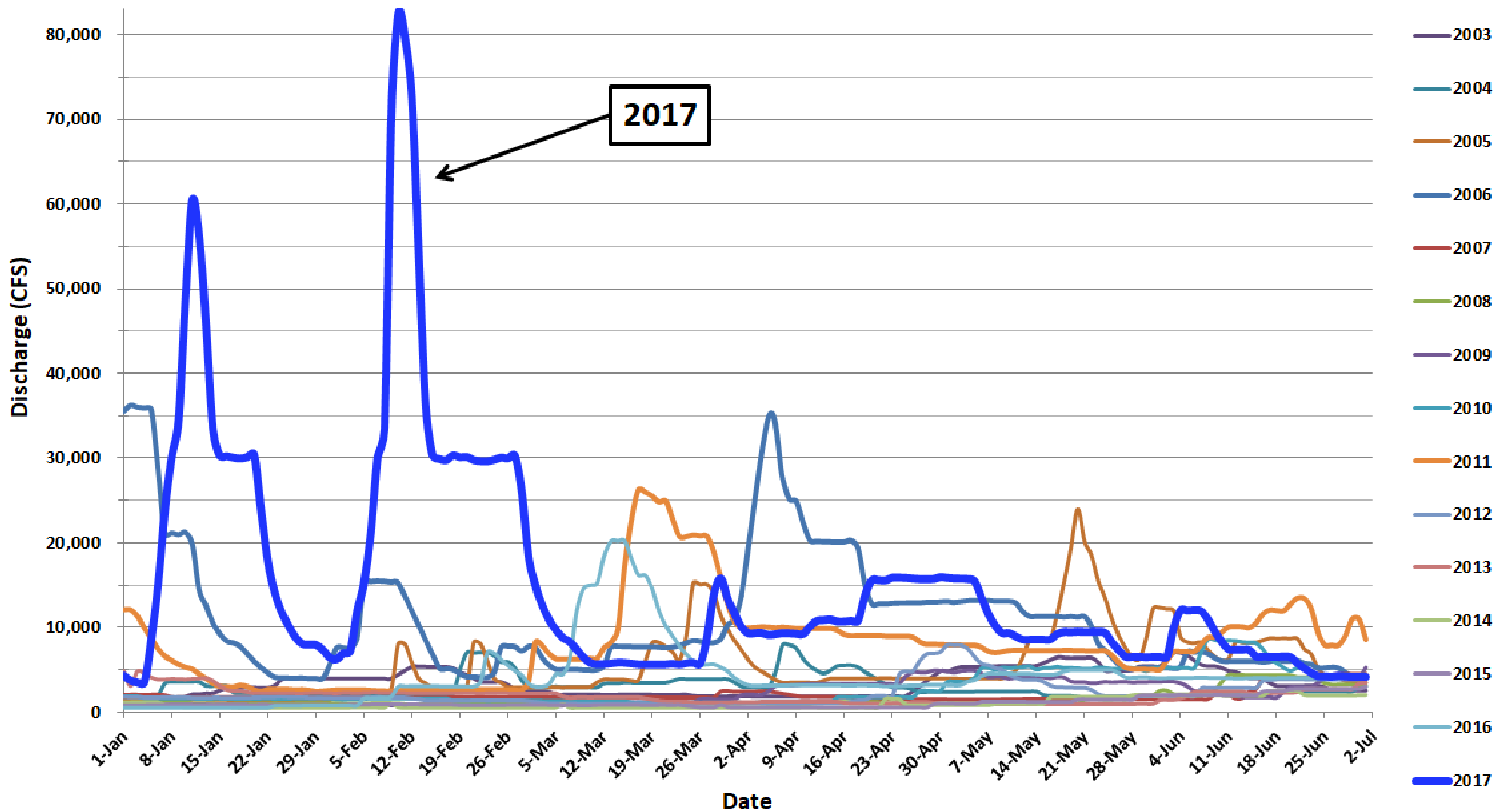




Appendix 6: Daily average water temperature (°C) in the lower American River at Watt Avenue for the 15-year period 2003 – 2017. Data from USGS station number 11446980.



Appendix 7: Daily average discharge (CFS) on the lower American River at Fair Oaks for the 15-year period 2003 – 2017. Data from USGS station number 11446500.



Appendix 8: A view of the American River at Watt Ave under different flow conditions.

500 CFS 3/20/2014

1,500 CFS 4/24/2014

7,000 CFS 2/23/2016

20,000 CFS 3/14/2016

35,000 CFS 12/16/2016

60,000 CFS 1/11/2017

Note: These photos were taken from the Watt Ave Bridge outlook, at UTM Northing NAD83 4269922, and UTM Easting NAD83 640864