Juvenile Salmonid Emigration Monitoring in the Lower American River, California

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By

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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 2018 is part of a collaborative 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 2018 survey season, two 2.4 meter (8 foot) rotary screw traps (RSTs) were operated downstream of the Watt Avenue Bridge. Sampling occurred on 99 of the 131 days between 12 January and 22 May. A total of 90,104 fall-run, and eleven winter-run juvenile Chinook salmon were captured. The passage of juvenile fall-run Chinook salmon peaked between 29 January and 4 February, when 29.17 percent of the total (n = 26,287) was captured. The majority of the captured juvenile fall-run Chinook salmon were identified as button-up 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 3.30 to 9.54 percent, with an average efficiency of 7.62 percent. The number of juvenile fall-run Chinook salmon that were estimated to have emigrated past the Watt Avenue trap site during the 2018 survey season was 1,287,000 individuals (95 percent confidence intervals = 1,245,000 to 1,426,000). Finally, 2,054 individuals belonging to 20 different identifiable non-salmonid species were captured, as well as 480 non-salmonid individuals unable to be identified to species. Production for steelhead, the other non-fall Chinook salmon runs, and non-salmonid fish taxa were not estimated.

Due to high flows, sampling was suspended between 28 February and 4 March, 20 March and 29 March, and 5 April and 14 April 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 2018 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 2018 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 are ongoing and have occurred at multiple sites from the base of Nimbus Dam (Nimbus Basin) downstream to 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 2018 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 2018 survey season was the continuation of a multi-year juvenile Chinook salmon emigration survey. California experienced a relatively late and low amount of precipitation during the wet season; 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 six 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 2018 and were designated as Trap 8.1 and Trap 8.2 (Figure 2). Trap 8.1 was set closer to the north side of the north channel, while Trap 8.2 was closer to the south side 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 2018survey season started on 11 January and ended on 22 May. 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 24-28 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 an electronic hubometer (Veeder-Root RT 1000-000) mounted to the axle of the cone inside of the live well; 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 fall-run 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.

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

All other individuals belonging to non-salmonid taxa were enumerated and identified to species. For each trap, fork lengths or total lengths (species dependent) 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.

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 the 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, which did not occur during the 2018 season. When higher river discharges occurred, a boat was used to release the marked fish, keeping the motor upstream of the released fish while a crew member released fish downstream. Every release of marked Chinook salmon occurred close to dusk 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 $\hat{c}_{ij}$

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, or if there were seven or more consecutive days of unsuccessful trapping 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:

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

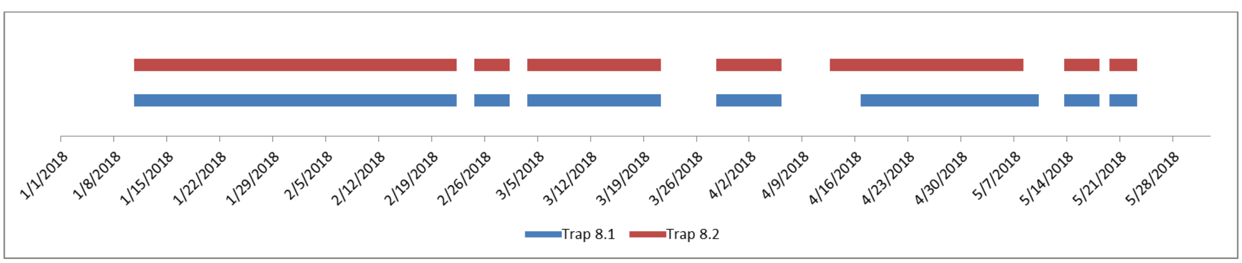
where *K* was the Fulton's condition factor, *W* was the weight in grams, and *FL* was the fork length in mm.

Results

Trap Operations

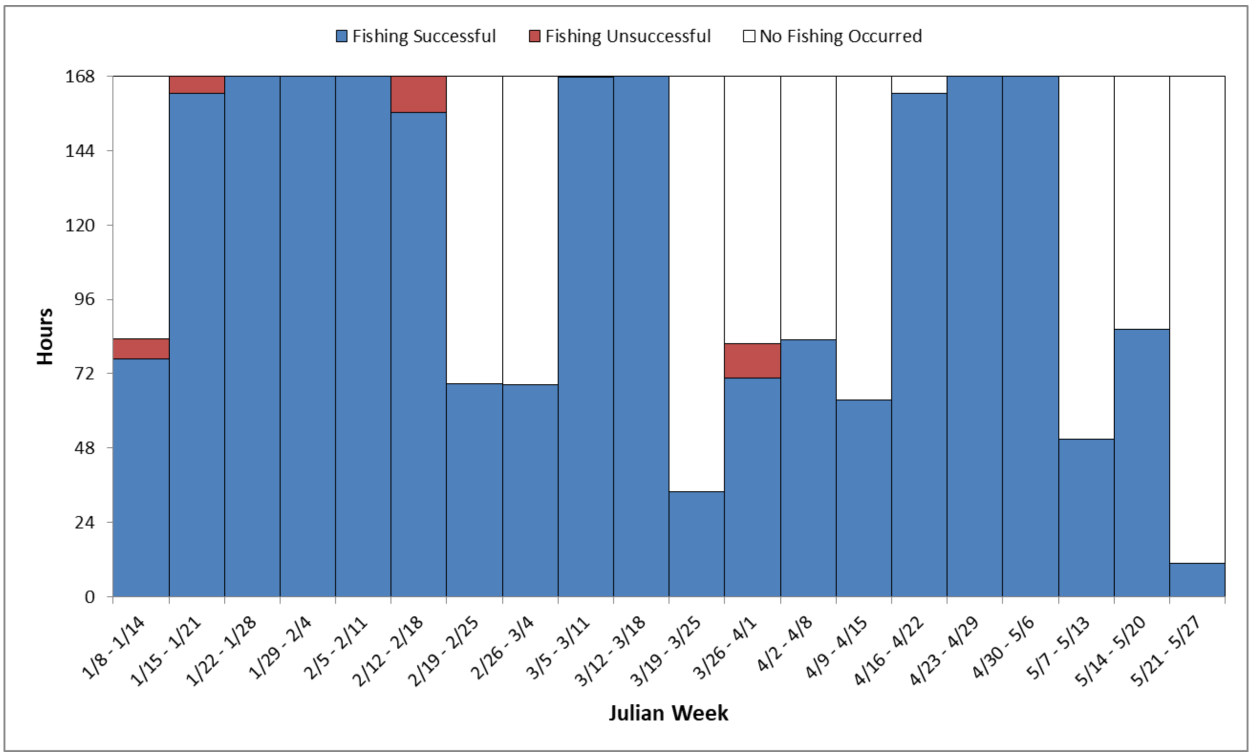
Sampling for the 2018 survey season began on 11 January at river flows of approximately 3,000 CFS. At this time, two 8ft RSTs were deployed into the north channel of the Watt Avenue trapping site. Sampling for both traps was suspended temporarily between 21 February and 25 February in response to a hatchery release of brood year 2017 steelhead to allow the majority of the fish to move out of the system. Trapping ceased again on 28 February when cones were raised in anticipation of a large storm event with potential of increased flows and high debris levels. Trapping resumed on 4 March and fished continually until 20 March when cones were raised in response to a scheduled increase in river flow from 1,750 CFS to 9,750 CFS. River flows began decreasing on 29 March to a low of 7,300 CFS and trapping resumed. Sampling for both traps ceased again on 5 April in response to a river flow increase of 17,700 CFS (from 7,300 CFS to 25,000 CFS) and resumed on 14 April when river flows reached approximately 8,000 CFS. On 9 May sampling ceased again in anticipation of a release of Chinook salmon from Nimbus Fish Hatchery, and resumed on 14 May. The cones were lifted from 18 May through 20 May due to increased weekend recreational activities on the river. Trapping operations for the 2018 survey season ended on 22 May. The dates each trap sampled is depicted in Figure 3.

Figure 3: Dates sampling occurred per trap during the 2018 lower American River rotary screw trap survey season.



Throughout the 2018 survey season, between 11 January and 22 May, sampling took place on 99 of 131 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 35 hours. Traps fished successfully for approximately 2,269 hours and did not fish for approximately 813 hours (Figure 4).

Figure 4: Weighted average hours per Julian week that both traps fished successfully, fished unsuccessfully, or did not fish during the 2018 lower American River rotary screw trap survey season.



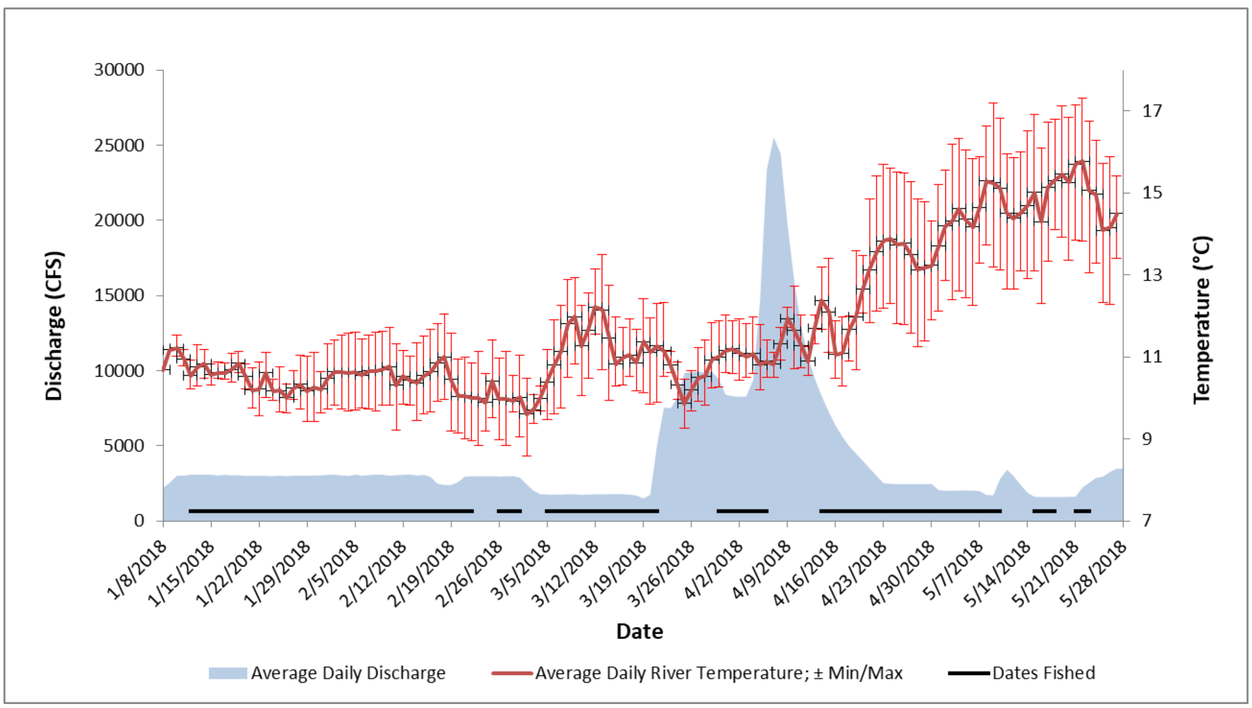
Environmental Summary

Appendix 2 provides a summary of the environmental conditions, averaged by Julian week, starting on January 8 and spanning until the last Julian week of the 2018 survey season. These dates encompass a typical juvenile fall-run Chinook salmon outmigration survey season, although trapping for the 2018 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 2018 survey season (i.e. time period between 11 January, when the traps were first deployed, and 22 May 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 2018 survey season, between 11 January and 22 May.

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 2018 survey season, between 11 January and 22 May, river discharge reached a high of 25,600 CFS on 7 April and a low of 1,170 CFS on 19 March. Temperatures between 11 January and 22 May ranged from a low of 8.8° Celsius (C) on 3 March and 4 March, to a high of 17.4° C on 21 May. River discharge and water temperature averaged by day throughout the typical juvenile fall-run Chinook salmon outmigration period are shown in Figure 5.

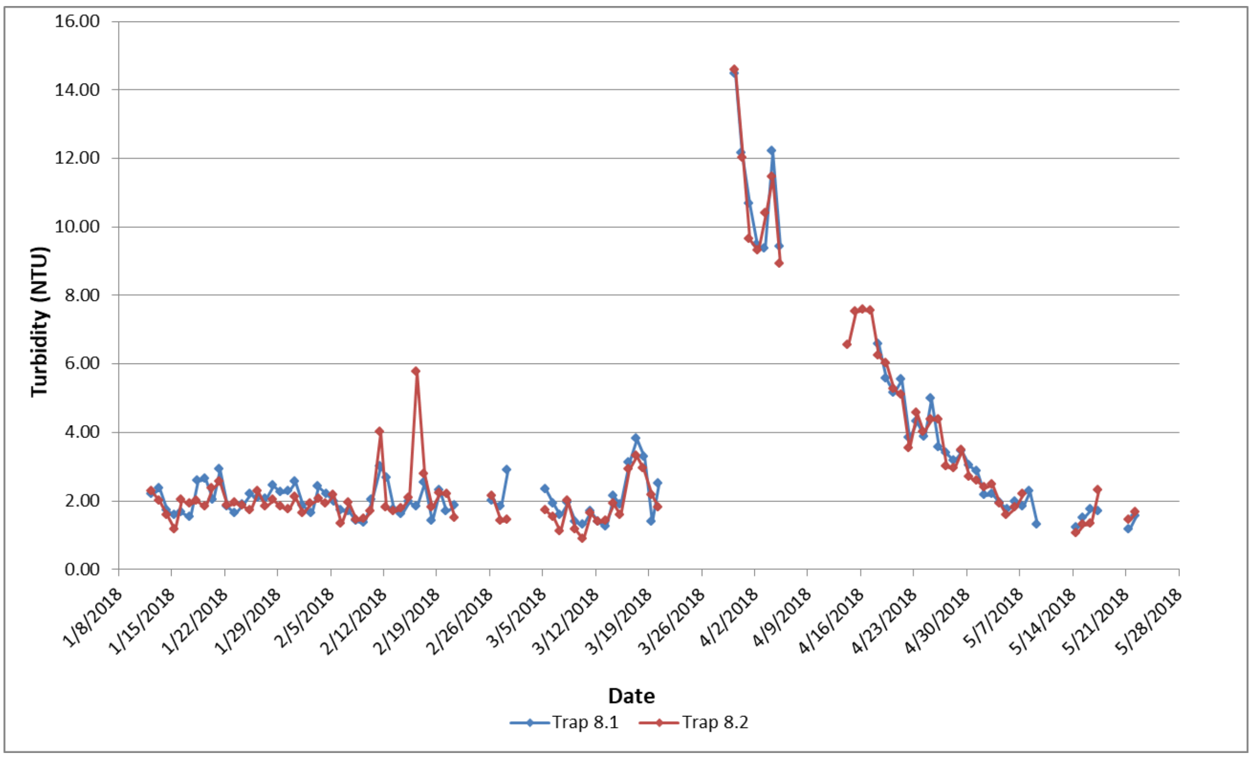
Figure 5: Average daily discharge (CFS) measured at Fair Oaks, and average daily water temperature (°C) measured at Watt Avenue during the 2018 lower American River rotary screw trap survey season.



Note: Discharge and water temperature data for the 8 January to 28 May 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 the two traps (Figure 6). Turbidity for both traps reached a season maximum on 30 March, with 14.57 Nephelometric Turbidity Units (NTU) for Trap 8.2 and 14.47 NTU for Trap 8.1. Turbidity declined to a low of 0.86 NTU for Trap 8.2 on 10 March, and a low of 1.15 NTU for Trap 8.1 on 21 May. Weekly average turbidity, averaged by Julian week, is shown in Appendix 2. Weekly average turbidity reached a high of 12.25 NTU during the week of 26 March and declined to a weekly average low of 1.44 NTU during the week of 21 May.

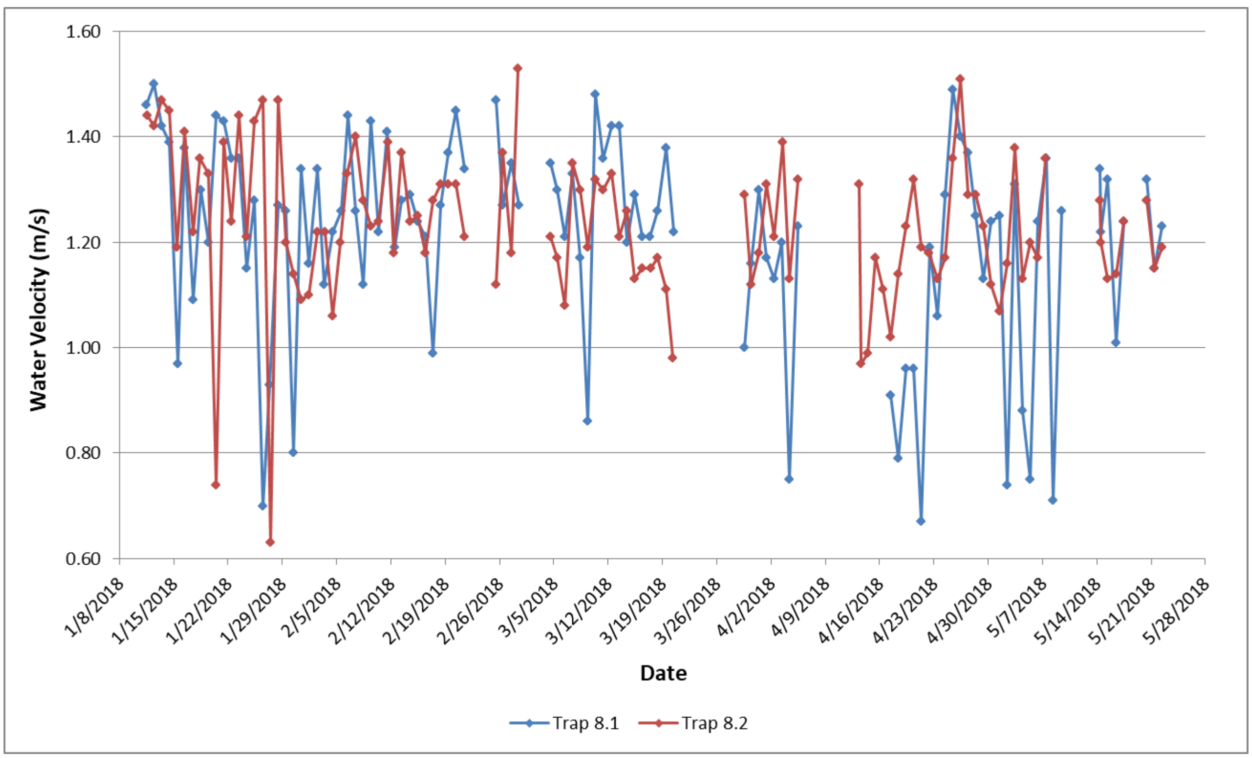
Figure 6: Comparison of daily turbidity measured in the field for each trap, during the 2018 lower American River rotary screw trap survey season.



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 throughout the survey season (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 0.67 m/s on 21 April, while water velocity for Trap 8.2 reached a low of 0.63 m/s on 27 January. Water velocity for Trap 8.1 reached a high of 1.50 m/s on 12 January and water velocity for Trap 8.2 reached a high of 1.53 m/s on 28 February. Weekly average water velocity between both traps, averaged by Julian week, is shown in Appendix 2. Weekly average water velocity began with a high of 1.44 m/s the week of 8 January and fell to a low of 1.06 m/s the week of 16 April.

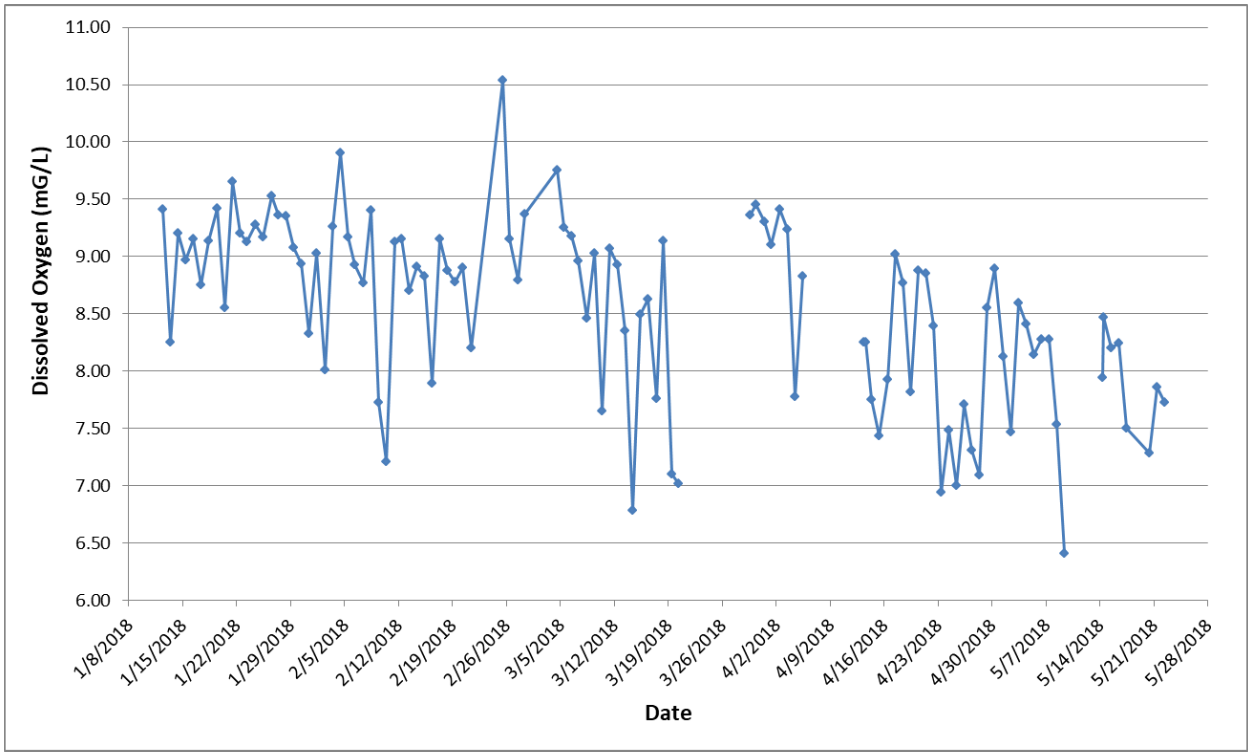
Figure 7: Comparison of daily water velocities, measured in the field in front of each trap, during the 2018 lower American River rotary screw trap survey season.



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 10.54 milligrams per liter (mg/l) on 25 February to a low of 6.41 mg/l on 9 May. Weekly average DO, averaged by Julian week (Appendix 2), reached a high of 9.30 mg/l the week of 26 March and had a weekly average low of 7.06 mg/l the week of 19 March.

Figure 8: Daily dissolved oxygen content measured in the field during the 2018 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Catch

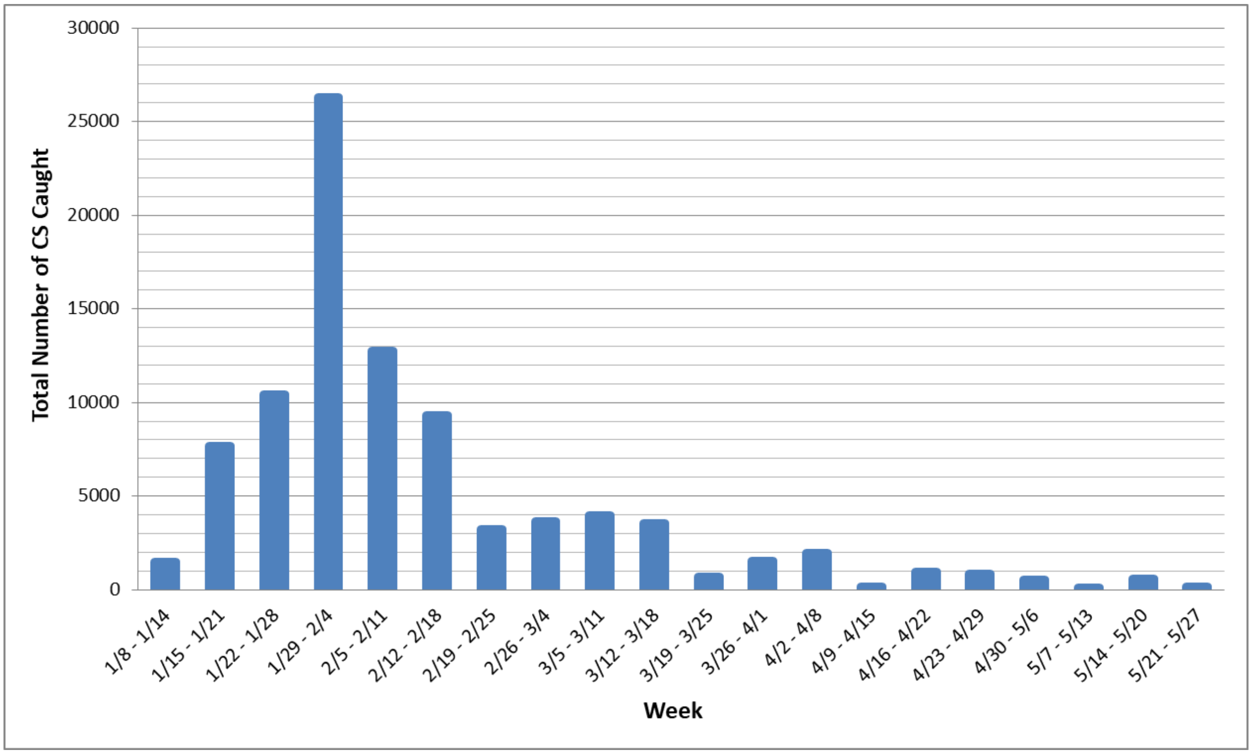
The two rotary screw traps deployed during the 2018 survey season captured a total of 93,169 fish, including 357 hatchery-produced salmonids. Trap 8.1 captured 54.70 percent (n = 50,960) of these fish, and Trap 8.2 captured 45.30 percent (n = 42,209). Salmonid species captured included steelhead and fall-, late-fall-, spring-run and winter-run Chinook salmon by length-at-date criteria. However, genetic analysis revealed that the Chinook salmon runs captured did not include late fall-run or spring-run Chinook salmon (Appendix 4). Twenty identified non-salmonid species as well as 480 non-salmonid individuals unable to be identified to species (Appendix 3) were also captured.

Fall-run Chinook salmon

A catch total of 90,104 unmarked Chinook salmon were determined to be fall-run based on the genetic analysis results. 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 29 January and 4 February, when 29.17 percent (n =26,287) of the season's total was captured (Figure 9).

Of the in-river produced, unmarked juvenile Chinook salmon captured during the 2018 survey season, a total of 73,203 were unmeasured plus-count tallies and may have included both LAD fall- and late fall-run Chinook salmon. However, 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 73,203 unmeasured plus count tallies were determined to be fall-run Chinook salmon.

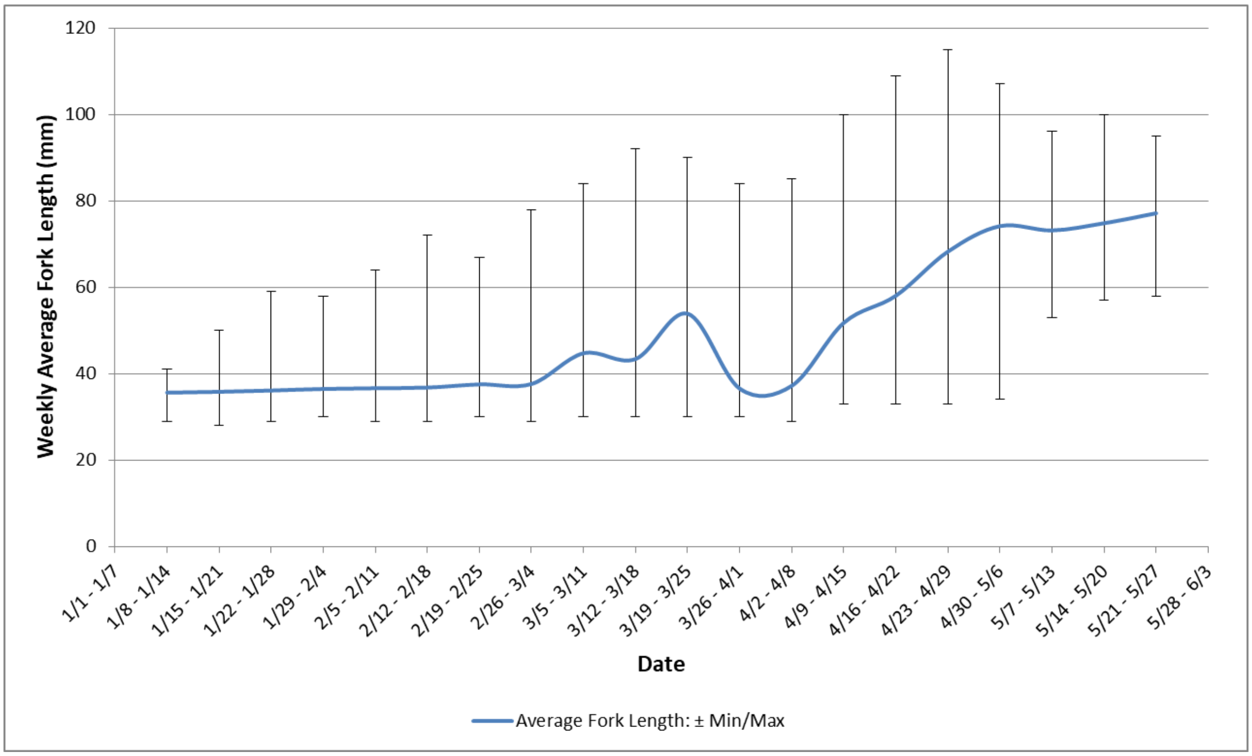
Figure 9: Weekly catch distribution of in-river produced, unmarked fall-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.



Note: Plus-counted Chinook salmon and mortalities are included in the graph. See Figure 3 for dates sampling occurred. Fall-run Chinook salmon captured after 9 May may include unmarked hatchery produced salmon.

A total of 16,901 in-river produced, unmarked fall-run Chinook salmon was measured for fork length. Weekly average fork lengths throughout the 2018 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. The highest weekly average fork length was 77 mm, which occurred during the last week of sampling.

Figure 10: Average weekly fork length for fall-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

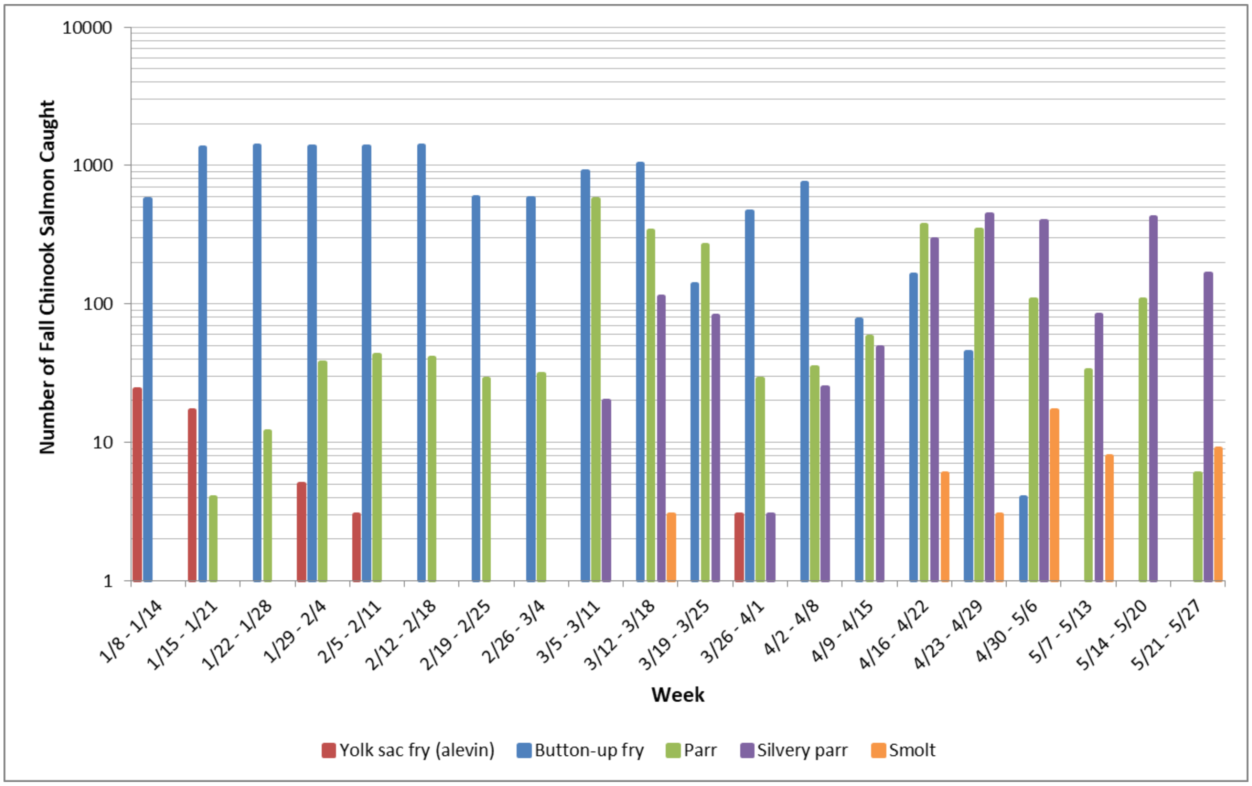
Table 2: Average, minimum, maximum and standard deviations of fork lengths (mm) per week for fall-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.

Julian Week	Fork Length			
	Average	Min	Max	St. Dev.
1/8 - 1/14	36	29	41	1.61
1/15 - 1/21	36	28	50	1.57
1/22 - 1/28	36	29	59	2.05
1/29 - 2/4	36	30	58	2.74
2/5 - 2/11	37	29	64	3.33
2/12 - 2/18	37	29	72	3.75
2/19 - 2/25	38	30	67	4.88
2/26 - 3/4	38	29	78	6.13
3/5 - 3/11	45	30	84	11.95
3/12 - 3/18	43	30	92	12.91
3/19 - 3/25	54	30	90	14.05
3/26 - 4/1	37	30	84	5.93
4/2 - 4/8	37	29	85	8.07
4/9 - 4/15	52	33	100	16.83
4/16 - 4/22	58	33	109	17.01
4/23 - 4/29	68	33	115	15.40
4/30 - 5/6	74	34	107	11.47
5/7 - 5/13	73	53	96	8.18
5/14 - 5/20	75	57	100	6.47
5/21 - 5/27	77	58	95	5.96

Note: See Figure 3 for dates sampling occurred.

The fall-run Chinook salmon measured for fork length, 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 76.13 percent (n = 12,238) of the assessed catch. Salmon identified as yolk sac fry comprised 0.34 percent (n = 54), parr made up 12.96 percent (n = 2,083), silvery parr were 10.39 percent (n = 1,671), and smolt were 0.19 percent (n = 30).

Figure 11: In-river produced, unmarked fall-run Chinook salmon catch by life stage during the 2018 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. See Table 3 for weeks with a catch total of one. Plus-counted fall-run Chinook salmon are not included in the graph. See Figure 3 for dates sampling occurred.

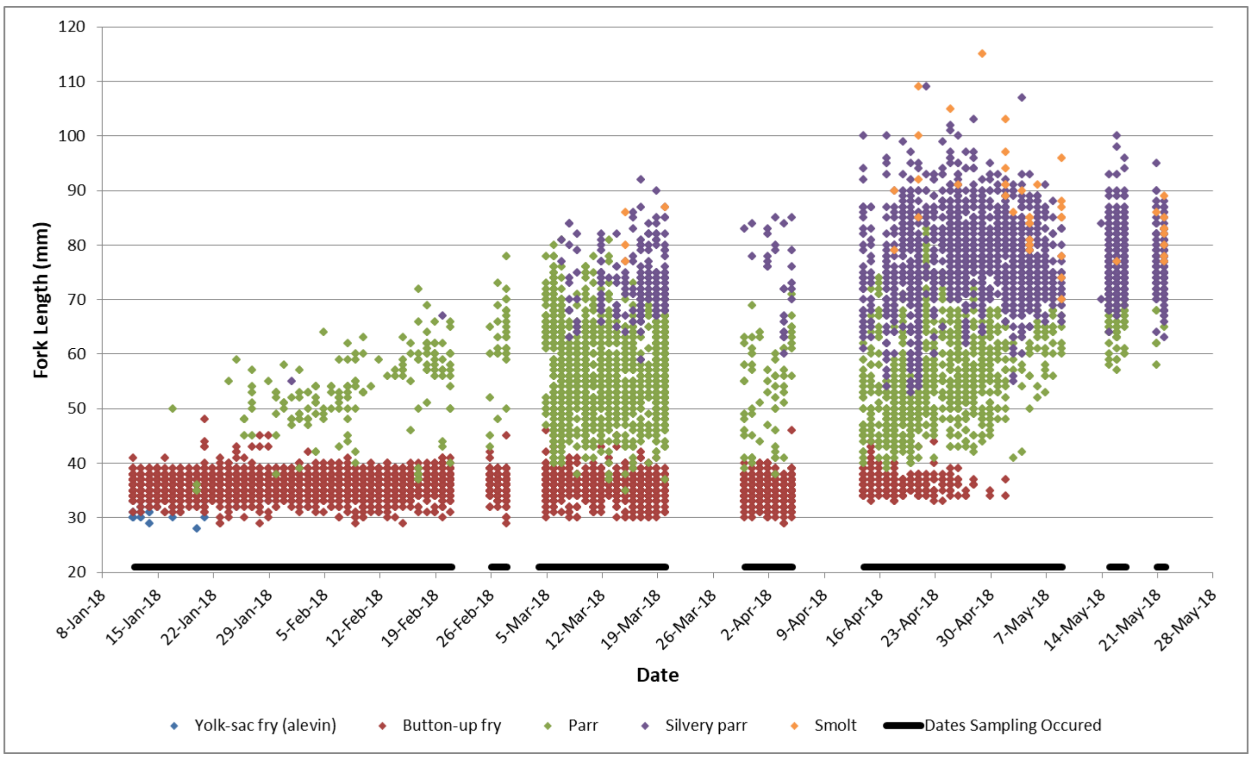
Table 3: Total of in-river produced, unmarked fall-run Chinook salmon by life stage or unassigned life stage during the 2018 lower American River rotary screw trap survey season.

Julian Week	Yolk sac fry	Button-up fry	Parr	Silvery parr	Smolt	Unassigned Life Stage	Total
1/8 - 1/14	24	576	0	0	0	910	1,510
1/15 - 1/21	17	1,358	4	0	0	6,305	7,684
1/22 - 1/28	1	1,397	12	0	0	9,031	10,441
1/29 - 2/4	5	1,379	38	1	0	24,864	26,287
2/5 - 2/11	3	1,383	43	0	0	11,342	12,771
2/12 - 2/18	1	1,387	41	0	0	7,910	9,339
2/19 - 2/25	0	593	29	1	0	2,614	3,237
2/26 - 3/4	0	584	31	0	0	3,062	3,677
3/5 - 3/11	0	910	569	20	0	2,479	3,978
3/12 - 3/18	0	1,024	337	113	3	2,070	3,547
3/19 - 3/25	0	139	268	82	1	228	718
3/26 - 4/1	3	465	29	3	0	1,035	1,535
4/2 - 4/8	0	755	35	25	0	1,138	1,953
4/9 - 4/15	0	77	58	49	0	1	185
4/16 - 4/22	0	163	372	292	6	128	961
4/23 - 4/29	0	45	344	442	3	32	866
4/30 - 5/6	0	4	107	395	17	2	525
5/7 - 5/13	0	0	33	83	8	1	125
5/14 - 5/20	0	0	108	425	1	48	582
5/21 - 5/27	0	0	6	165	9	3	183
Total	54	12,239	2,464	2,096	48	73,203	90,104

Note: Unassigned life stage includes plus-counts. See Figure 3 for dates sampling occurred. Fall-run Chinook salmon captured after 9 May 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 survey day of the 2018 season on 12 January. Chinook salmon identified as yolk-sac fry life stage were captured until 1 April, and fry were captured until 2 May. Chinook salmon identified as parr life stage were caught between 17 January and 21 May, salmon identified as silvery parr life stage were captured starting 1 February to the last day of the season on 22 May, and salmon identified as smolt life stage were caught between 15 March and 22 May.

Figure 12: Daily fall-run Chinook salmon fork lengths during the 2018 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 28 mm and 36 mm, while fry ranged from 29 mm to 48 mm. Parr life stage ranged from 35 mm to 83 mm, and silvery parr ranged between 53 mm and 109 mm. Smolt life stage ranged from 70 mm to 115 mm.

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. 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 54 mm, silvery parr had an average of 70 mm and smolt had an average of 84 mm.

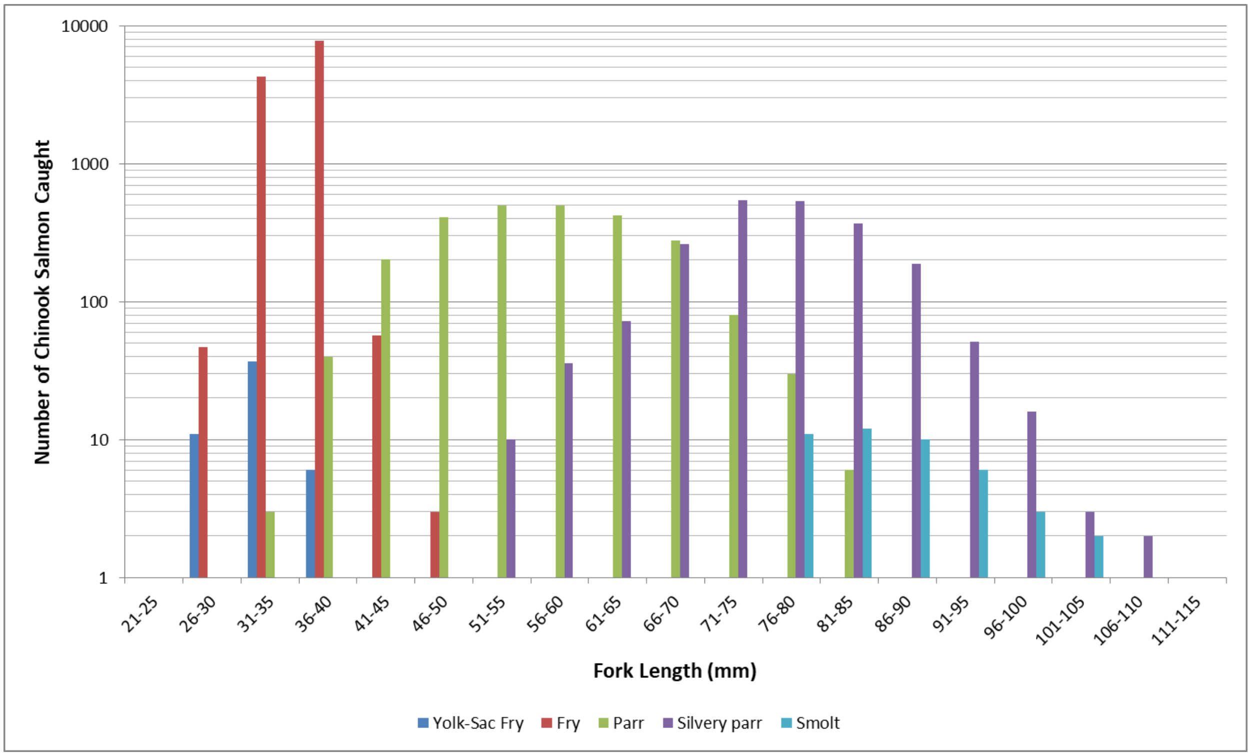
Table 4: Average, minimum and maximum fork lengths (mm) per week for each stage of fall-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.

Julian Week	Yolk-Sac Fry			Fry			Parr			Silvery Parr			Smolt		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
1/8 - 1/14	32	29	36	36	31	41									
1/15 - 1/21	33	28	36	36	31	48	39	35	50						
1/22 - 1/28	32	32	32	36	29	45	51	45	59						
1/29 - 2/4	33	32	35	36	30	45	50	38	58	55	55	55			
2/5 - 2/11	34	33	36	36	29	41	53	40	64						
2/12 - 2/18	31	31	31	36	29	40	54	37	72						
2/19 - 2/25				37	30	41	57	40	66	67	67	67			
2/26 - 3/4				36	29	45	62	43	78						
3/5 - 3/11				36	30	46	57	38	81	73	63	84			
3/12 - 3/18				36	30	45	56	35	81	73	59	92	81	77	86
3/19 - 3/25				36	30	41	57	37	71	74	67	90	87	87	87
3/26 - 4/1	33	31	34	35	30	40	52	39	69	82	78	84			
4/2 - 4/8				35	29	46	55	38	71	74	60	85			
4/9 - 4/15				37	33	44	51	40	72	76	61	100			
4/16 - 4/22				36	33	43	54	39	83	75	53	109	93	79	109
4/23 - 4/29				36	33	44	57	41	80	80	60	103	104	91	115
4/30 - 5/6				35	34	37	58	41	71	78	55	107	88	79	103
5/7 - 5/13							63	53	71	76	66	91	83	70	96
5/14 - 5/20							67	57	72	77	64	100	77	77	77
5/21 - 5/27							64	58	68	77	63	95	83	77	89

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 13 and Table 5. Chinook salmon measuring between 31 mm and 40 mm were captured most frequently during the 2018 survey season, encompassing 72.29 percent (n = 12,218) of the season's measured salmon catch. The size class between 36 mm and 40 mm comprised 46.58 percent (n =7,873) 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 25.71 percent (n = 4,345), and included Chinook salmon identified as yolk-sac fry, fry and parr life stages.

Figure 13: Distribution of fall-run Chinook salmon life stage by fork length during the 2018 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. See Table 5 for fork length categories that contain only one individual.

Table 5: Distribution of fall-run Chinook salmon life stage by fork length size class during the 2018 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	11	47	0	0	0	58
31 - 35	37	4,305	3	0	0	4,345
36 - 40	6	7,827	40	0	0	7,873
41 - 45	0	57	204	0	0	261
46 - 50	0	3	410	0	0	413
51 - 55	0	0	495	10	0	505
56 - 60	0	0	497	36	0	533
61 - 65	0	0	420	72	0	492
66 - 70	0	0	279	261	1	541
71 - 75	0	0	80	547	1	628
76 - 80	0	0	30	538	11	579
81 - 85	0	0	6	371	12	389
86 - 90	0	0	0	189	10	199
91 - 95	0	0	0	51	6	57
96 - 100	0	0	0	16	3	19
101 - 105	0	0	0	3	2	5
106 - 110	0	0	0	2	1	3
111 - 115	0	0	0	0	1	1

Fulton's Condition Factor

Fulton's condition factor (K) for in-river produced, unmarked fall-run Chinook salmon captured in 2018 is shown in Appendix 5. The overall trend line exhibited a positive slope of 0.0013, indicating a slightly increasing trend in condition throughout the survey season. The trend line slopes were positive for parr (0.0013), silvery parr (0.0006) and smolt (0.0013) life stages; however the fry life stage had a slightly negative slope of -0.0009. Yolk-sac fry captured in 2018 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 2018 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 four trials used a total of 5,264 fall-run Chinook salmon. Of that total, 4,355 were in-river produced salmon that were collected with the RSTs and marked with BBY whole body stain, while 909 were from Nimbus Fish Hatchery and were marked on the anal fin with bio-photonic dye. A total of 415 released salmon was recaptured. Over the four trials, the average fork length of recaptured fish was approximately 3 mm smaller than the average fork length of released fish, and per trial ranged from a difference of approximately 4 mm larger to approximately 2 mm smaller in fork length. The average trap efficiency of the four trials kept in analysis and used to determine passage estimates was 7.62 percent.

Table 6: Trap efficiency data for mark and recapture trials during the 2018 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	11	Total Recaptured	Average Fl (mm)	Trap Efficiency	Flow (CFS) Time of Release
BBY Staining					Release				Recaptures for all Traps Combined											Recapture Summary			
1/17/2018	In-river	Brown	304	Yes	1/17/2018	16:55	36	1139	107	0	0	1	0	0	0	-	-	-	-	108	35	9.48%	3010
1/31/2018	In-river	Brown	305	Yes	1/31/2018	17:42	36	2126	167	5	1	0	0	0	0	-	-	-	-	173	36	8.14%	3040
3/6/2018	In-river	Brown	306	Yes	3/6/2018	17:55	39	1090	99	4	1	0	0	0	0	-	-	-	-	104	38	9.54%	1780
Photonic Marking					Release				Recaptures for all Traps Combined											Recapture Summary			
4/3/2018	Hatchery	Orange	307	No	4/3/2018	18:55	60	969	12	1	-	-	-	-	-	-	-	-	-	13	60	1.34%	8290
4/17/2018	Hatchery	Orange	308	Yes	4/18/2018	19:02	71	909	18	2	2	0	1	2	1	2	0	1	1	30	74	3.30%	5020

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 1,287,000 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 2018 survey season. The 95 percent confidence interval for this estimate was from 1,245,000 to 1,426,000 individuals. The CAMP platform "lifestage_passage" report, which subdivides a passage estimate by life stage, estimated 1,183,000 fry (including both yolk-sac fry and fry life stages), 103,500 parr (including both parr and silvery parr life stages), and 686 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 11 January to 20 March, from 30 March to 5 April, and from 18 April to 22 May. Potential emigration before the traps started sampling and during the gaps in sampling longer than seven 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 14 and Table 7.

Figure 14: Daily passage estimate of fall-run Chinook salmon and daily discharge at Fair Oaks during the 2018 lower American River rotary screw trap survey season.

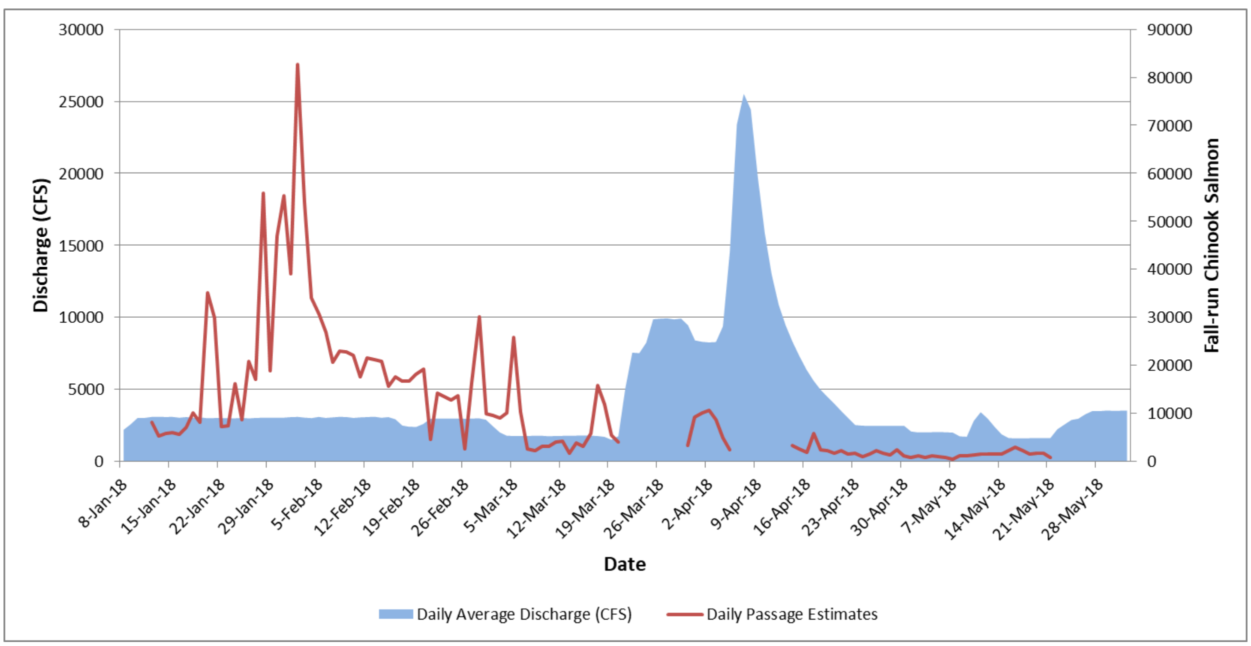


Table 7: Weekly passage estimate of fall-run Chinook salmon and weekly discharge at Fair Oaks during the 2018 lower American River rotary screw trap survey season.

Date	Discharge (CFS)	Passage Estimate
1/8 - 1/14	2,868	19,313
1/15 - 1/21	3,046	101,952
1/22 - 1/28	3,012	133,509
1/29 - 2/4	3,047	330,898
2/5 - 2/11	3,062	163,810
2/12 - 2/18	2,874	130,388
2/19 - 2/25	2,840	95,991
2/26 - 3/4	2,581	87,747
3/5 - 3/11	1,772	51,526
3/12 - 3/18	1,774	46,569
3/19 - 3/25	5,930	9,376
3/26 - 4/1	9,399	22,526
4/2 - 4/8	16,265	26,739
4/9 - 4/15	12,087	5,870
4/16 - 4/22	4,567	17,939
4/23 - 4/29	2,480	12,122
4/30 - 5/6	2,099	6,959
5/7 - 5/13	2,438	8,766
5/14 - 5/20	1,649	13,812
5/21 - 5/27	2,718	774

Note: See Figure 3 for dates sampling occurred.

Genetic Analysis

During the 2018 survey season, a total of 314 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 314 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. The 314 samples that were processed 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 826 in-river produced Chinook salmon captured in 2018 were classified as spring-run Chinook salmon using LAD criteria. Genetic samples taken from 255 of these salmon were analyzed to determine run assignments. The analyses indicated 99.61 percent (n = 254) of these individuals were fall-run Chinook salmon, and one was a winter-run Chinook salmon (Table 8). Because the LAD criteria appeared to incorrectly assign salmon runs at a high frequency, the 571 LAD spring-run Chinook salmon that were not analyzed using genetic markers were given a final run assignment of fall-run.

A total of 11 Chinook salmon classified as winter-run Chinook salmon using LAD criteria were captured during the 2018 survey season. Genetic samples were taken from all 11 fish and were analyzed to determine run assignments. Analyses using SNP genetic markers from those samples indicated that 90.91 percent (n=10) were winter-run Chinook salmon and the remaining one individual was determined to be a fall-run Chinook salmon.

A total of 306 Chinook salmon classified as late fall-run Chinook salmon using LAD criteria were also captured in 2018. Genetic samples were taken from 46 of these and were analyzed to determine run assignments. Analyses using SNP genetic markers from those samples indicated all 46 individuals (100.00 percent) were fall-run Chinook salmon (Table 8). Because the LAD criteria appeared to incorrectly assign this salmon run, all 260 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 two salmon classified as fall-run Chinook salmon using LAD criteria were also analyzed. Analyses using SNP genetic markers from these samples indicated all two 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.

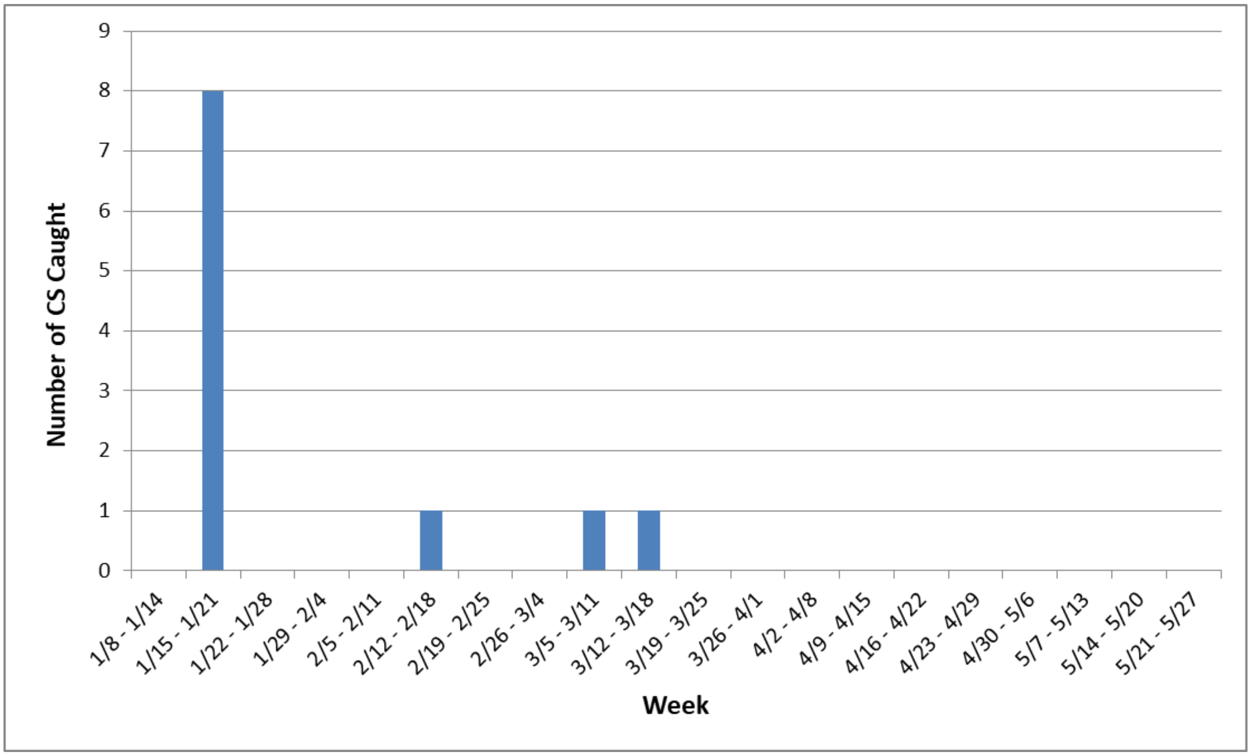
	Genetic Run Assignment			
Length-at-Date Run Assignment	**Fall**	**Late Fall**	**Spring**	**Winter**
Fall	2	0	0	0
Late Fall	46	0	0	0
Spring	254	0	0	1
Winter	1	0	0	10

Note: Genetic salmon run assignment was based on a >50 percent genetic probability threshold. 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.

Winter-run Chinook salmon

The genetic analyses suggest that 11 in-river produced winter-run Chinook salmon were captured during the 2018 survey season. Eight of the 11 caught were captured on the second week of trapping (15 January – 21 January). The remaining three were captured on 18 February, 5 March and 13 March (Figure 15). Six of these fish were identified to be silvery parr life stage, four were identified as parr life stage and one was identified as smolt life stage. Fork lengths ranged from 69 mm to 117 mm with the average fork length being 85 mm.

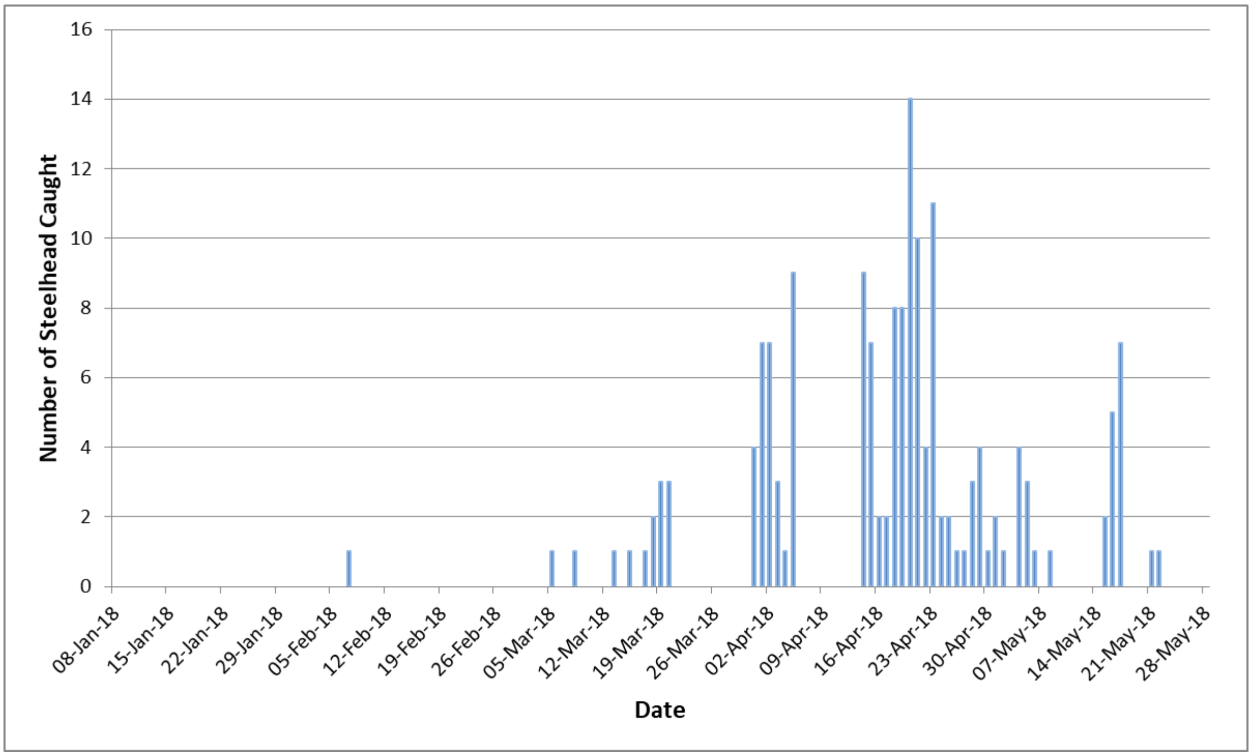
Figure 15: Weekly catch totals for in-river produced winter-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.



Steelhead/Rainbow Trout

During the 2018 survey season, a total of 162 in-river produced steelhead was captured. The day with the highest catch of steelhead was 20 April, when 8.64% (n = 14) of the season's total was captured (Figure 16). Weekly steelhead catch peaked the week of 16 April, comprising 29.63% (n = 48) of the total steelhead captured (Table 9).

Figure 16: Daily catch totals for in-river produced steelhead during the 2018 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

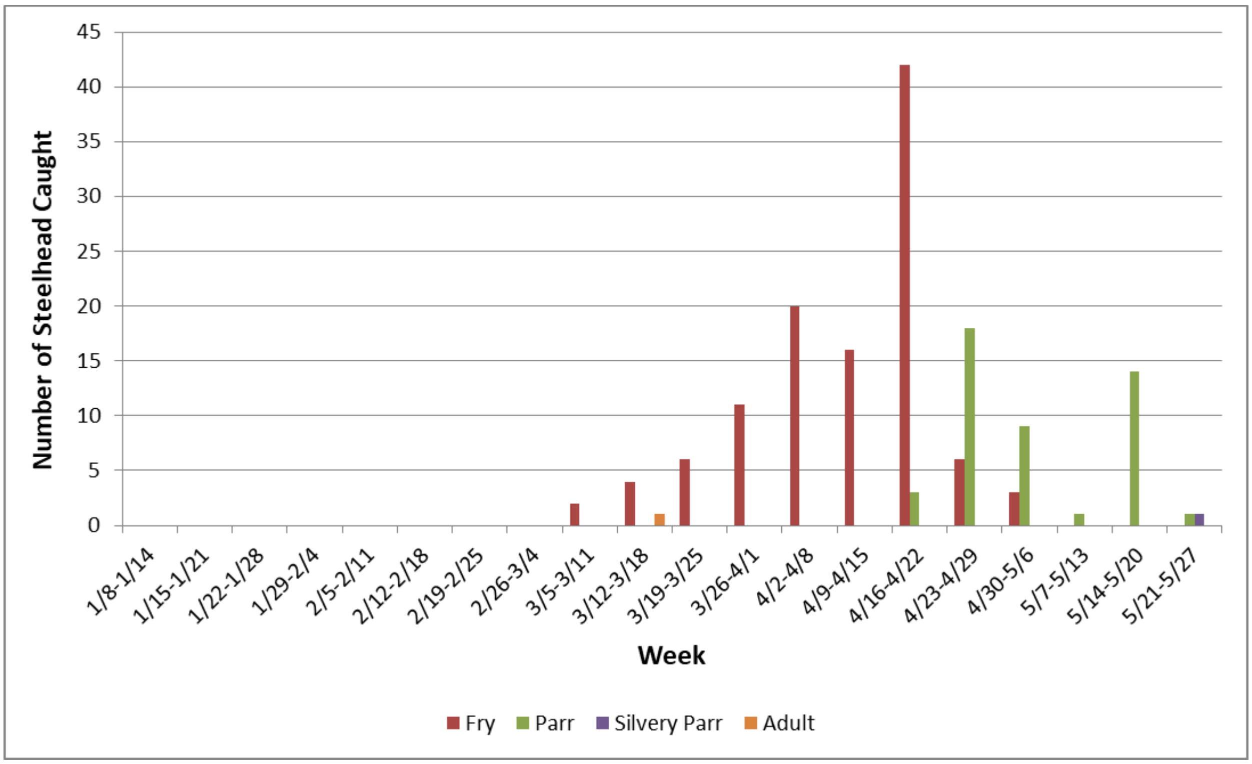
Table 9: Weekly catch totals by life stage for in-river produced steelhead during the 2018 lower American River rotary screw trap survey season.

Julian Week	Yolk-Sac Fry	Fry	Parr	Silvery Parr	Smolt	Adult	Total
1/8-1/14	0	0	0	0	0	0	0
1/15-1/21	0	0	0	0	0	0	0
1/22-1/28	0	0	0	0	0	0	0
1/29-2/4	0	0	0	0	0	0	0
2/5-2/11	0	0	0	0	0	0	0
2/12-2/18	0	0	0	0	0	0	0
2/19-2/25	0	0	0	0	0	0	0
2/26-3/4	0	0	0	0	0	0	0
3/5-3/11	0	2	0	0	0	0	2
3/12-3/18	0	4	0	0	0	1	5
3/19-3/25	0	6	0	0	0	0	6
3/26-4/1	0	11	0	0	0	0	11
4/2-4/8	0	20	0	0	0	0	20
4/9-4/15	0	16	0	0	0	0	16
4/16-4/22	0	42	3	0	0	0	45
4/23-4/29	0	6	18	0	0	0	24
4/30-5/6	0	3	9	0	0	0	12
/7-5/13	0	0	1	0	0	0	1
5/14-5/20	0	0	14	0	0	0	14
5/21-5/27	0	0	1	1	0	0	2
Total	0	110	46	1	0	1	158

Note: See Figure 3 for dates sampling occurred.

All steelhead captured in 2018 were assessed for a life stage. The life stage composition of these steelhead consisted of 110 fry, comprising 69.62% of the total, 46 parr comprising 29.1%, 1 silvery parr (0.63%) and 1 adult (0.63%) (Figure 17). No in-river produced steelhead were identified as yolk-sac fry or smolt life stages.

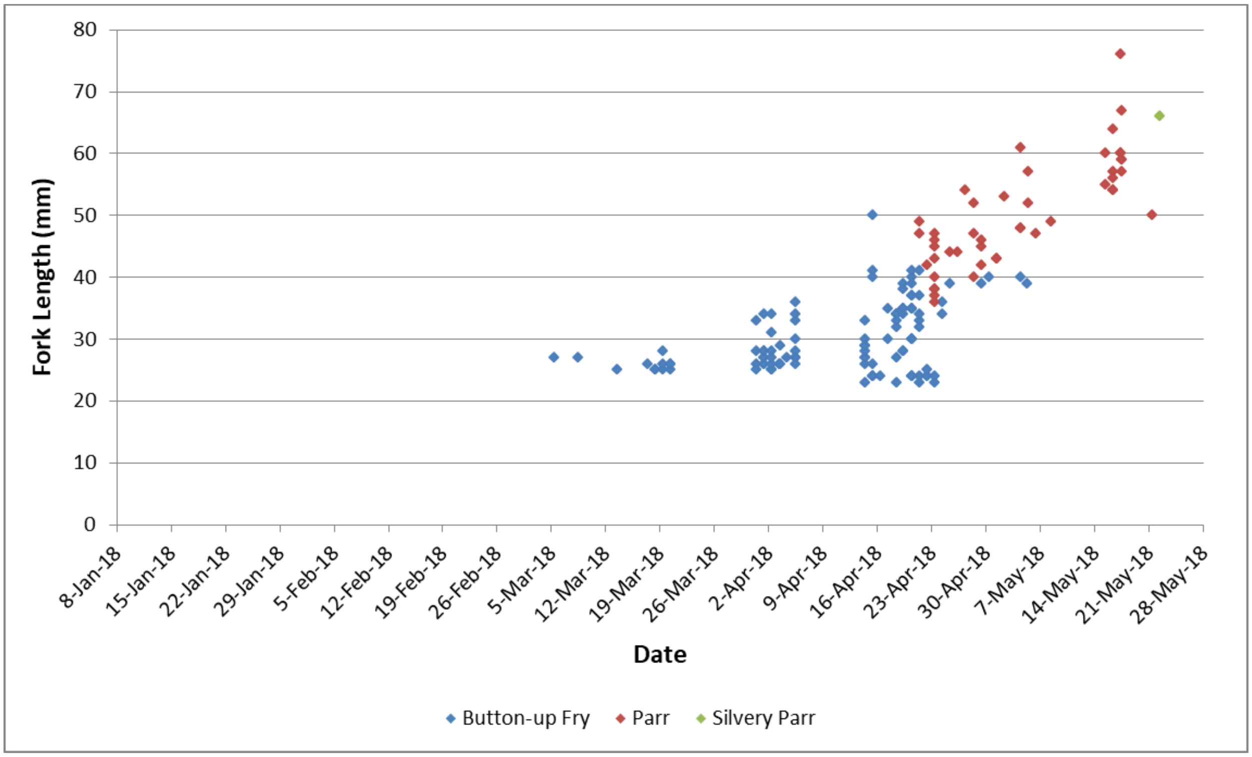
Figure 17: Weekly catch totals by life stage for in-river produced steelhead during the 2018 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

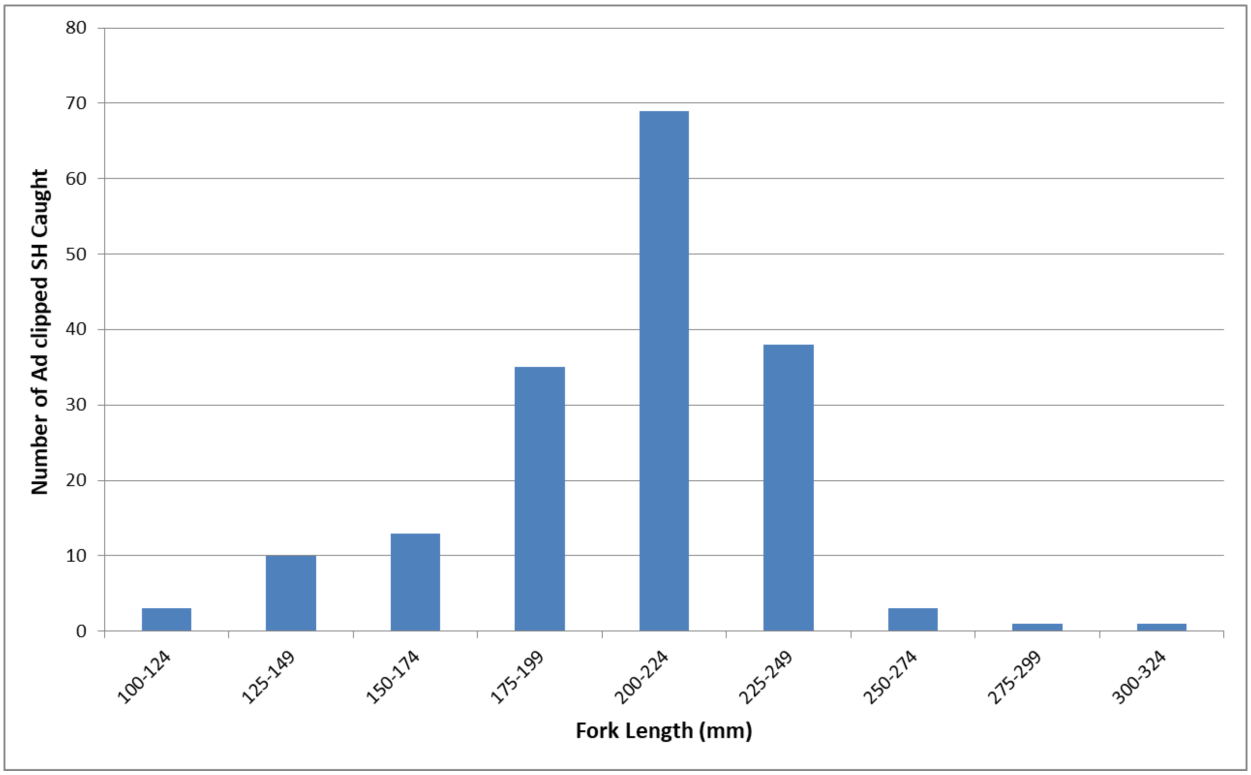
The steelhead identified as fry life stage were captured between 5 March and 5 May, with fork lengths ranging between 23 mm and 50 mm. Steelhead identified as parr were captured between 21 April and 21 May and ranged in fork length from 36 mm to 76 mm (Figure 18).

Figure 18: Individual fork lengths by date for in-river produced steelhead captured during the 2018 lower American River rotary screw trap survey season.



In addition to the in-river produced steelhead catch there was a catch total of 336 hatchery produced fish marked with clipped adipose fins. These fish were caught from 7 February through 5 May with a peak catch of 281 steelhead comprising 83.63% of total catch occurring on 21 February. The minimum fork length recorded was 113 mm, the maximum was 316 mm and the average was 204 mm (Figure 19). The hatchery produced steelhead were assessed for life stage with smolts comprising 98.28% (n=171) of the catch. One adult was caught (0.57%) as well as two Silvery parr (1.15%).

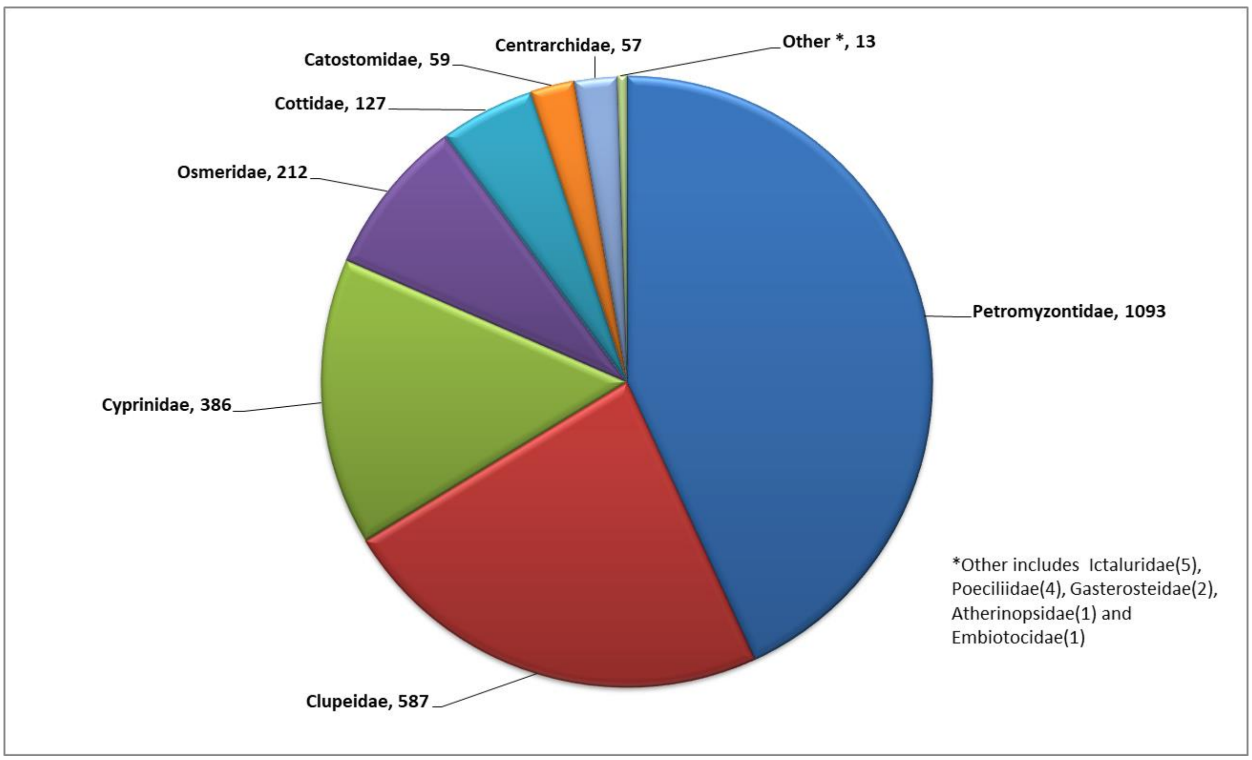
Figure 19: Fork length distribution of adipose fin clipped steelhead during the 2018 lower American River rotary screw trap survey season.



Non-salmonid Species

In addition to the salmonids, a total of 2,534 non-salmonid fish was captured during the 2018 survey season. The majority (n = 2054 or 81.06%) of these fish belonged to 20 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), *Osmeridae* (smelt), *Petromyzontidae* (lamprey), and *Poeciliidae* (mosquitofish) (Figure 20). The remaining 18.94% (n =480) were not able to be identified to species level, but belonged to the following families: *Centrarchidae*, *Cyprinidae*, and *Petromyzontidae*. A total of 1655 (65.31%) of the non-salmonid fish captured in 2018 were of species native to Central Valley watersheds, a total of 879 (34.69%) were of non-native species. A complete list of non-salmonid species captured in the 2018 survey season is presented in Appendix 3.

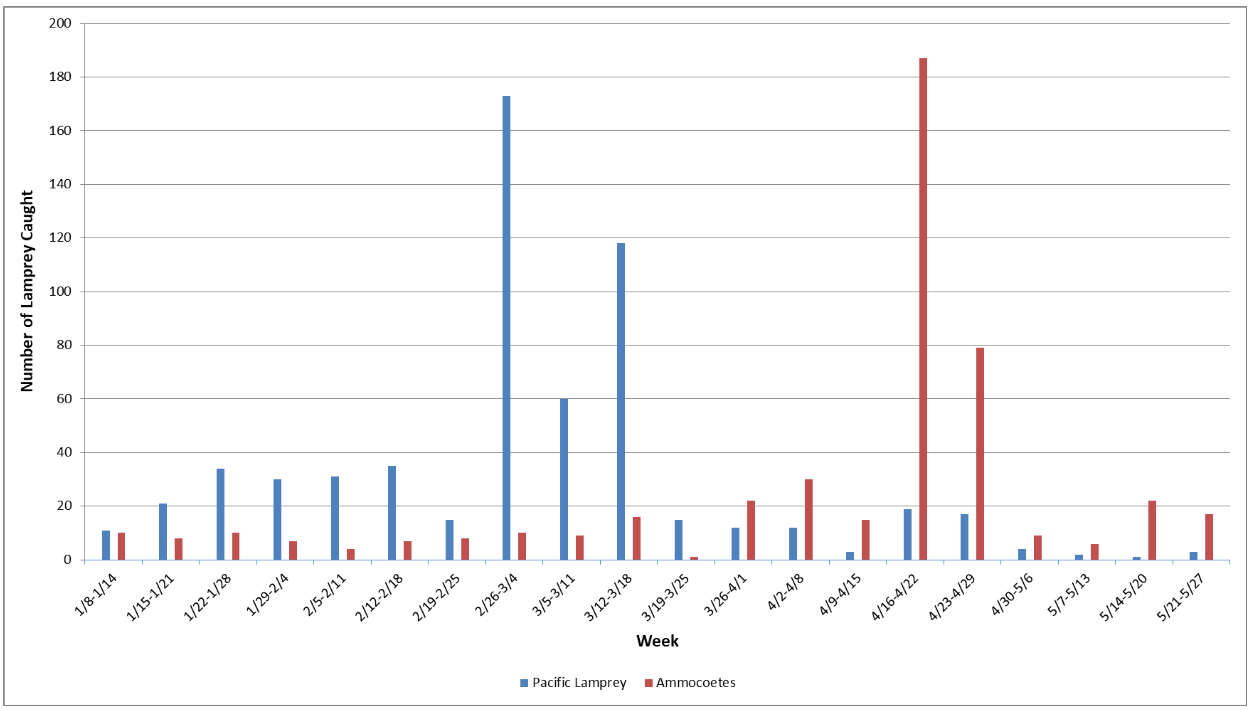
Figure 20: Non-salmonid catch totals for families of fish species collected during the 2018 lower American River rotary screw trap survey season.



Of the 2,534 non-salmonid fish, 43.13% (n=1093) were lamprey species. Individuals identified as Pacific lamprey made up 56.36 percent (n =616) of captured lampreys and included 30 individuals identified as adult life stage and 586 individual identified as juvenile life stage. The remaining 43.64 percent (n = 477) were identified as ammocoetes, unidentifiable to the species level. No River lamprey were captured.

Both Pacific lamprey and ammocoetes were captured throughout the season. Catch of Pacific lamprey peaked between 26 February and 4 March. At this time, 28.08% (n = 173) of the season's Pacific lamprey total was captured, with 25.65% (n = 158) captured on 27 February alone. Of the lamprey identified as ammocoete life stage or otherwise unidentified to species level, 39.2% (n=187) were captured between 16 April and 22 April. The peak day of capture for lamprey identified as ammocoete life stage or otherwise unidentified to species level was 20 April, when 38 were captured (Figure 21).

Figure 21: Total weekly lamprey catch during the 2018 lower American River rotary screw trap survey season.



Note: See Figure 3 for dates sampling occurred.

Discussion

When interpreting the data collected during the 2018 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. Despite 2018 being a below-average water year, high flows were experienced on multiple occasions which 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.

Increased flows, like those seen during the 2018 survey season, increase the amount of debris in the water column, which can affect the successful operation of the rotary screw traps by stopping the rotation of the cone or can increase the potential for damage to traps and sampling equipment. Increased debris associated with high flows can also cause fish mortality by crushing fish within the debris or by causing fish trapped within a stopped cone to become pummeled by incoming water. In cases where debris was too high to manage with multiple checks per day cones were raised and sampling was temporarily suspended. This occurred four times during the 2018 survey season, where two of those periods of suspended sampling exceeded seven days. Since these gaps in sampling exceeded the seven day maximum threshold for the CAMP Platform to accurately estimate catch, the passage estimate produced for the 2018 survey season also excludes those periods of time likely biasing the passage estimate low.

Another factor to consider while interpreting the data is whether the survey season encompassed the entire fall-run Chinook salmon emigration period. During the first seven days of the 2018 survey season, a total of 3,570 juvenile fall-run Chinook salmon was captured, accounting for 3.96 percent of the total season catch and comprising of 3.72 percent (n=47,972) of the total passage estimate. Although trapping typically begins in early January, the relatively high catch the first week of trapping reflects that the 2018 survey season did not encompass the beginning of the fall-run Chinook salmon emigration period. Alternatively, during the last seven days of the survey season, including days where traps were not sampling, a total of 587 juvenile fall-run Chinook salmon was captured accounting for 0.65 percent of the total season catch. The last seven days of the survey season comprised 1.02 percent (n=13,136) of the total passage estimate, which includes three days of imputed catch when trapping did not occur. Therefore, the 2018 survey season likely encompassed the end of the emigration period.

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 2018 survey season was 1,287,000 individuals, with 95 percent confidence intervals ranging from 1,245,000 to 1,426,000 individuals. The relatively small confidence interval width is likely due to a low distribution of daily catch totals throughout the 2018 survey season.

In considering the accuracy of the 2018 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 2018, an attempt was made to conduct trap efficiency trials when river flows stabilized, but with multiple 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 were raised after only two days due to a river flow increase. This trial was excluded from analysis and was not used to determine the passage estimate.

Passage estimates were not produced for winter-run Chinook salmon, since low numbers of this run were captured. Of the 826 Chinook salmon identified as LAD spring-run, genetic analysis was conducted on 254 and determined one (0.39 percent) was a winter-run; the other 253 (99.61 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. Additionally, 11 Chinook salmon were identified as LAD winter-run and genetic analysis determined that ten were winter-run, therefore proving that LAD criteria is accurate in determine the run of winter-run Chinook salmon. As seen in previous years as well as in isotopic studies, these winter-run are thought to be using the American River as non-natal rearing habitat (Phillis 2017).

On 10 May NFH released approximately 671,021 and 670,456 brood year 2017 fall-run Chinook salmon into the lower American River at the Sunrise boat ramp and Jibboom Street respectively. Of those 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 four days in response to the release at the Sunrise boat ramp to allow for the majority of the fish to pass by the traps, it is still possible that a portion of the unmarked fall-run Chinook salmon captured after 10 May were hatchery produced, therefore likely biasing the 2018 passage estimate high.

A total of 164 in-river produced steelhead was captured. This is a relatively low number compared to previous survey seasons, which is likely due to either increased distance from the steelhead redds to the RST location or due to reduced trap efficiencies associated with high river discharge. Weekly surveys were conducted on the lower American River by Cramer Fish Sciences to determine the number and distribution of spawning redds. There were six identified steelhead redds near Watt Avenue (Figure 22) located in or near the South Channel (Cramer 2018).

Figure 22: Steelhead redd locations on the lower American River, depicted by the markers, during the 2018 survey conducted by Cramer Fish Sciences.

Additionally, NFH released approximately 212,143 brood year 2017 steelhead, marked with a clipped adipose fin, into the American River at the Sunrise boat ramp between 20 February and 21 February. A total of 334 hatchery produced steelhead was captured at the Watt Avenue RSTs during the 2018 survey season. Unlike in previous survey seasons when hatchery releases occurred at Jibboom Street (below the Watt Avenue RSTs), the location of this release during the 2018 season allowed for a higher probability of capturing hatchery produced steelhead. However, six hatchery produced steelhead were captured a few days prior to the NFH release which are likely from the Feather River Hatchery where releases occurred between 12 February and 15 February although no genetics were taken from these captured fish.

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 2018 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 comparison of this data to previous years 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 2018 due to the higher volumes of water.

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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 2018 survey season.**

Julian Week	Water Temperature (C°)			Discharge			Dissolved Oxygen (mg/L)			Turbidity (NTU)			Velocity (m/s)		
	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max
1/8-1/14	10.9	10.2	11.6	2868	2180	3370	9.0	8.3	9.4	2.0	1.6	2.2	1.4	1.4	1.5
1/15-1/21	10.6	9.6	11.4	3046	2700	3700	9.1	9.6	9.6	2.0	1.4	2.7	1.2	1.1	1.4
1/22-1/28	10.3	9.4	11.2	3012	2300	3200	9.3	9.1	9.5	2.0	1.8	2.2	1.2	0.8	1.4
1/29-2/4	10.4	9.4	11.6	3047	2980	3160	8.9	8.0	9.9	2.0	1.7	2.3	1.2	1.0	1.3
2/5-2/11	10.6	9.6	11.7	3062	2970	3200	8.6	7.2	9.4	1.9	1.4	3.5	1.3	1.2	1.4
2/12-2/18	10.6	9.4	12	2874	2380	3170	8.8	7.9	9.1	2.2	1.6	3.8	1.2	1.1	1.3
2/19-2/25	10.1	8.9	11.6	2840	2350	3110	9.1	8.2	10.5	2.0	1.7	2.3	1.3	1.3	1.4
2/26-3/4	9.9	8.8	11.1	2581	1730	3220	9.3	8.8	9.8	1.9	1.6	2.2	1.3	1.3	1.4
3/5-3/11	11.3	9	13	1772	1480	2340	8.8	7.7	9.3	1.6	1.1	2.0	1.2	1.0	1.4
3/12-3/18	11.4	9.6	13.5	1774	1510	2440	8.3	6.8	9.1	2.3	1.3	3.5	1.2	1.2	1.4
3/19-3/25	10.8	9.3	12.4	5930	1170	9900	7.1	7.0	7.1	2.0	1.8	2.1	1.2	1.1	1.2
3/26-4/1	10.8	9.5	12	9399	8230	9970	9.3	9.1	9.4	12.3	10.2	14.5	1.2	1.1	1.2
4/2-4/8	11.0	10.4	12.4	16265	8100	25600	8.8	7.8	9.4	10.1	9.2	11.8	1.2	0.9	1.3
4/9-4/15	11.7	10.2	13.2	12087	6740	20100	7.9	7.4	8.3	7.0	6.5	7.5	1.1	1.0	1.2
4/16-4/22	12.2	9.8	15.3	4567	2820	6820	8.5	7.8	9.0	5.9	3.7	7.6	1.1	0.9	1.2
4/23-4/29	13.6	11.6	15.6	2480	2440	2820	7.4	6.9	8.6	3.8	3.1	4.7	1.3	1.1	1.5
4/30-5/6	14.1	11.8	16.3	2099	1870	2490	8.3	7.5	8.9	2.2	1.7	2.9	1.1	0.9	1.3
5/7-5/13	14.8	12.6	17	2438	1640	3770	7.4	6.4	8.3	1.9	1.3	2.3	1.1	0.7	1.4
5/14-5/20	15.0	12.7	16.9	1649	1530	2030	7.9	7.3	8.5	1.5	1.1	2.0	1.2	1.1	1.3
5/21-5/27	14.9	12.8	17.4	2718	1580	3620	7.8	7.7	7.9	1.4	1.3	1.6	1.2	1.1	1.2

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 2018 season using rotary screw traps on the lower American River.

Common Name	Family Name	Species Name	Total Number Caught
Chinook salmon	Salmonidae	*Oncorhynchus tshawytscha*	90,138
Steelhead / rainbow trout	Salmonidae	*Oncorhynchus mykiss*	497
American shad	Clupeidae	*Alosa Sapidissima*	5
Bluegill	Centrarchidae	*Lepomis macrochirus*	48
Channel catfish	Ictaluridae	*Ictalurus punctatus*	5
Common carp	Cyprinidae	*Cyprinus carpio*	1
Golden shiner	Cyprinidae	*Notemigonus crysoleucas*	11
Green sunfish	Centrarchidae	*Lepomis cyanellus*	3
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	183
Inland silverside	Atherinopsidae	*Menidia beryllina*	1
Largemouth bass	Centrarchidae	*Micropterus salmoides*	1
Pacific lamprey	Petromyzontidae	*Entosphenus tridentatus*	616
Prickly sculpin	Cottidae	*Cottus asper*	45
Riffle sculpin	Cottidae	*Cottus gulosus*	82
Sacramento pikeminnow	Cyprinidae	*Ptychocheilus grandis*	190
Sacramento sucker	Catostomidae	*Catostomus occidentalis*	59
Spotted bass	Centrarchidae	*Micropterus punctulatus*	3
Threadfin shad	Clupeidae	*Dorosoma petenense*	582
Threespine stickleback	Gasterosteidae	*Gasterosteus aculeatus*	2
Tule perch	Embiotocidae	*Hysterocarpus traskii*	1
Wakasagi / Japanese smelt	Osmeridae	*Hypomesus nipponensis*	212
Western mosquitofish	Poeciliidae	*Gambusia affinis*	4
Unknown Centrarchid	Centrarchidae		2
Unknown lamprey	Petromyzontidae		477
Unknown minnow	Cyprinidae		1
		Total	**93,169**

Appendix 4: **Genetic results for fin-clip samples from Chinook salmon caught in the lower American River during the 2018 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 Probablity	Final Run Assignment	FL (mm)	W (g)
15-Jan	3430-001	Winter	Winter	1.000	Winter	72	4.2
16-Jan	3430-003	Winter	Winter	1.000	Winter	80	5.6
16-Jan	3430-002	Winter	Winter	1.000	Winter	80	5.3
17-Jan	3430-006	Spring	Fall	0.970	Fall	50	1.2
17-Jan	3430-004	Winter	Winter	1.000	Winter	97	9.3
17-Jan	3430-005	Winter	Winter	1.000	Winter	69	3
18-Jan	3430-007	Winter	Winter	1.000	Winter	70	6
18-Jan	3430-008	Winter	Winter	1.000	Winter	90	7.6
21-Jan	3430-010	Spring	Fall	1.000	Fall	48	0.9
21-Jan	3430-009	Winter	Winter	1.000	Winter	85	6.1
24-Jan	3430-011	Spring	Fall	0.940	Fall	55	1.7
25-Jan	3430-012	Spring	Fall	1.000	Fall	59	2.5
26-Jan	3430-013	Spring	Fall	1.000	Fall	48	1
26-Jan	3430-014	Spring	Fall	1.000	Fall	48	1.1
26-Jan	3430-015	Spring	Fall	1.000	Fall	48	1.6
27-Jan	3430-016	Spring	Fall	1.000	Fall	54	2.5
27-Jan	3430-017	Spring	Fall	0.720	Fall	57	1.8
27-Jan	3430-018	Spring	Fall	0.990	Fall	51	1.7
27-Jan	3430-019	Spring	Fall	1.000	Fall	53	1.4
27-Jan	3430-020	Spring	Fall	1.000	Fall	50	1.3

29-Jan	3430-021	Spring	Fall	0.690	Fall	55	1.6
30-Jan	3430-025	Spring	Fall	1.000	Fall	53	1.4
30-Jan	3430-022	Spring	Fall	1.000	Fall	53	2.8
30-Jan	3430-023	Spring	Fall	1.000	Fall	52	1.3
30-Jan	3430-024	Spring	Fall	1.000	Fall	49	1
31-Jan	3430-027	Spring	Fall	1.000	Fall	51	1.4
31-Jan	3430-028	Spring	Fall	0.900	Fall	51	1.3
31-Jan	3430-029	Spring	Fall	1.000	Fall	50	1.1
31-Jan	3430-026	Spring	Fall	1.000	Fall	58	1.8
1-Feb	3430-030	Spring	Fall	1.000	Fall	52	1.1
1-Feb	3430-031	Spring	Fall	1.000	Fall	55	1.6
2-Feb	3430-033	Spring	Fall	1.000	Fall	52	1.2
2-Feb	3430-034	Spring	Fall	1.000	Fall	57	1.4
2-Feb	3430-032	Spring	Fall	1.000	Fall	53	0.8
3-Feb	3430-035	Spring	Fall	1.000	Fall	53	1.2
3-Feb	3430-036	Spring	Fall	1.000	Fall	53	1.4
3-Feb	3430-037	Spring	Fall	1.000	Fall	50	1.1
4-Feb	3430-038	Spring	Fall	1.000	Fall	51	1.5
4-Feb	3430-039	Spring	Fall	0.990	Fall	52	1.4
4-Feb	3430-040	Spring	Fall	1.000	Fall	51	1.6
4-Feb	3430-041	Spring	Fall	1.000	Fall	54	1.7
4-Feb	3430-042	Spring	Fall	1.000	Fall	54	1.5
5-Feb	3430-044	Spring	Fall	1.000	Fall	64	2.3
6-Feb	3430-047	Spring	Fall	1.000	Fall	53	1.3
6-Feb	3430-045	Spring	Fall	1.000	Fall	54	1.5
6-Feb	3430-046	Spring	Fall	0.900	Fall	54	1.1
7-Feb	3430-052	Spring	Fall	0.970	Fall	52	1.9
7-Feb	3430-051	Spring	Fall	1.000	Fall	59	2.2
7-Feb	3430-053	Spring	Fall	1.000	Fall	52	1.7
7-Feb	3430-054	Spring	Fall	0.990	Fall	53	1.4
7-Feb	3430-055	Spring	Fall	1.000	Fall	52	1.1
8-Feb	3430-057	Spring	Fall	1.000	Fall	54	1.9
8-Feb	3430-058	Spring	Fall	1.000	Fall	62	2.2
8-Feb	3430-060	Spring	Fall	1.000	Fall	59	1.7
8-Feb	3430-061	Spring	Fall	1.000	Fall	54	1.4
8-Feb	3430-062	Spring	Fall	1.000	Fall	54	1.4
8-Feb	3430-063	Spring	Fall	1.000	Fall	53	1.2
8-Feb	3430-064	Spring	Fall	1.000	Fall	52	1.5
9-Feb	3430-065	Spring	Fall	1.000	Fall	55	1.5
9-Feb	3430-066	Spring	Fall	1.000	Fall	59	1.7
9-Feb	3430-067	Spring	Fall	0.990	Fall	54	1.3
9-Feb	3430-068	Spring	Fall	0.960	Fall	55	1.4
9-Feb	3430-069	Spring	Fall	1.000	Fall	54	1.5

9-Feb	3430-070	Spring	Fall	1.000	Fall	60	1.7
10-Feb	3430-076	Spring	Fall	1.000	Fall	53	1.6
10-Feb	3430-059	Spring	Fall	1.000	Fall	53	1.4
10-Feb	3430-072	Spring	Fall	1.000	Fall	53	1.4
10-Feb	3430-073	Spring	Fall	1.000	Fall	53	1.3
10-Feb	3430-074	Spring	Fall	0.990	Fall	63	2.4
10-Feb	3430-075	Spring	Fall	1.000	Fall	60	2
11-Feb	3430-078	Spring	Fall	0.940	Fall	54	1.5
12-Feb	3430-080	Spring	Fall	1.000	Fall	59	2
13-Feb	3430-085	Spring	Fall	1.000	Fall	56	1.7
14-Feb	3430-087	Spring	Fall	1.000	Fall	57	1.7
14-Feb	3430-086	Spring	Fall	1.000	Fall	56	1.8
15-Feb	3430-089	Spring	Fall	1.000	Fall	59	2.5
15-Feb	3430-090	Spring	Fall	1.000	Fall	58	1.8
15-Feb	3430-091	Spring	Fall	0.810	Fall	56	1.5
15-Feb	3430-092	Spring	Fall	1.000	Fall	63	
15-Feb	3430-093	Spring	Fall	1.000	Fall	57	
15-Feb	3430-094	Spring	Fall	1.000	Fall	57	
16-Feb	3430-096	Spring	Fall	1.000	Fall	60	2.1
16-Feb	3430-097	Spring	Fall	0.990	Fall	55	1.8
16-Feb	3430-099	Spring	Fall	1.000	Fall	62	2.2
17-Feb	3430-100	Spring	Fall	1.000	Fall	66	2.5
17-Feb	3431-001	Spring	Fall	1.000	Fall	59	1.9
17-Feb	3431-003	Spring	Fall	1.000	Fall	59	1.9
17-Feb	3431-004	Spring	Fall	1.000	Fall	60	2.1
17-Feb	3431-005	Spring	Fall	1.000	Fall	72	3.1
18-Feb	3431-006	Spring	Fall	1.000	Fall	69	3.1
18-Feb	3431-007	Winter	Winter	1.000	Winter	117	17.7
18-Feb	3431-008	Spring	Fall	1.000	Fall	57	1.8
18-Feb	3431-009	Spring	Fall	0.990	Fall	62	2.3
18-Feb	3431-010	Spring	Fall	1.000	Fall	64	2.3
19-Feb	3431-014	Spring	Fall	1.000	Fall	58	1.8
19-Feb	3431-011	Spring	Fall	1.000	Fall	66	2.6
19-Feb	3431-012	Spring	Fall	1.000	Fall	60	2
20-Feb	3431-016	Spring	Fall	1.000	Fall	56	2
20-Feb	3431-017	Spring	Fall	1.000	Fall	62	2.3
20-Feb	3431-015	Spring	Fall	1.000	Fall	67	3.7
21-Feb	3431-020	Spring	Fall	1.000	Fall	66	3
21-Feb	3431-018	Spring	Fall	1.000	Fall	58	1.7
21-Feb	3431-019	Spring	Fall	1.000	Fall	60	1.9
26-Feb	3431-021	Spring	Fall	1.000	Fall	65	2.6
26-Feb	3431-022	Spring	Fall	0.990	Fall	60	1.8
27-Feb	3431-023	Spring	Fall	1.000	Fall	60	2.1

27-Feb	3431-024	Spring	Fall	1.000	Fall	66	2.5
27-Feb	3431-025	Spring	Fall	1.000	Fall	60	1.9
28-Feb	3431-027	Spring	Fall	1.000	Fall	60	2.2
28-Feb	3431-028	Spring	Fall	1.000	Fall	78	4.8
28-Feb	3431-029	Spring	Fall	1.000	Fall	61	2.3
28-Feb	3431-030	Spring	Fall	1.000	Fall	63	2.5
5-Mar	3431-033	Spring	Winter	1.000	Winter	82	5.6
5-Mar	3431-034	Spring	Fall	1.000	Fall	73	3.8
5-Mar	3431-031	Spring	Fall	1.000	Fall	62	2.2
6-Mar	3431-035	Spring	Fall	1.000	Fall	72	3.6
6-Mar	3431-036	Spring	Fall	0.980	Fall	73	4
6-Mar	3431-037	Spring	Fall	0.990	Fall	78	4.4
6-Mar	3431-038	Spring	Fall	1.000	Fall	74	3.9
7-Mar	3431-041	Spring	Fall	1.000	Fall	72	3.5
7-Mar	3431-042	Spring	Fall	1.000	Fall	67	3
7-Mar	3431-039	Spring	Fall	0.990	Fall	81	5.2
7-Mar	3431-040	Spring	Fall	1.000	Fall	69	3.4
8-Mar	3431-044	Spring	Fall	0.990	Fall	84	6.1
8-Mar	3431-045	Spring	Fall	0.990	Fall	65	2.9
8-Mar	3431-043	Spring	Fall	1.000	Fall	80	5.3
8-Mar	3431-100	Spring	Fall	0.810	Fall	68	3.5
9-Mar	3431-046	Spring	Fall	1.000	Fall	71	4.4
9-Mar	3431-047	Spring	Fall	1.000	Fall	69	3.1
9-Mar	3431-048	Spring	Fall	0.980	Fall	65	2.9
9-Mar	3431-049	Spring	Fall	1.000	Fall	65	3
10-Mar	3431-053	Spring	Fall	1.000	Fall	67	2.8
10-Mar	3431-054	Spring	Fall	1.000	Fall	76	4
10-Mar	3431-050	Spring	Fall	1.000	Fall	64	2.7
10-Mar	3431-051	Spring	Fall	1.000	Fall	64	2.6
11-Mar	3431-058	Spring	Fall	1.000	Fall	68	2.8
11-Mar	3431-059	Spring	Fall	1.000	Fall	68	3.3
11-Mar	3431-055	Spring	Fall	1.000	Fall	78	4.7
11-Mar	3431-056	Spring	Fall	1.000	Fall	64	2.4
12-Mar	3431-065	Spring	Fall	1.000	Fall	73	3.8
12-Mar	3431-066	Spring	Fall	1.000	Fall	79	5
12-Mar	3431-067	Spring	Fall	1.000	Fall	77	4.8
12-Mar	3431-068	Spring	Fall	0.990	Fall	65	2.8
13-Mar	3431-070	Spring	Fall	1.000	Fall	77	4.3
13-Mar	3431-071	Spring	Fall	0.990	Fall	65	2.7
13-Mar	3431-072	Winter	Winter	1.000	Winter	91	7.4
14-Mar	3431-075	Spring	Fall	1.000	Fall	73	3.9
14-Mar	3431-076	Spring	Fall	1.000	Fall	67	3.1
14-Mar	3431-077	Spring	Fall	1.000	Fall	76	4.6

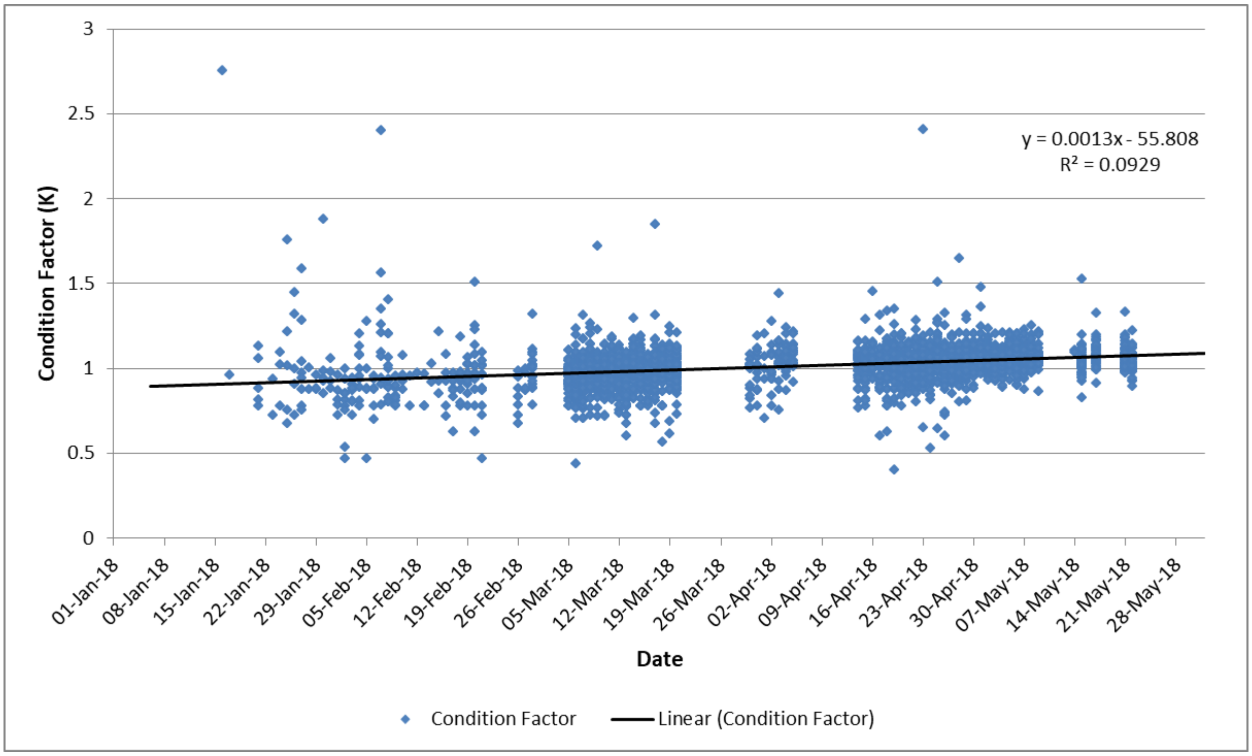
14-Mar	3431-078	Spring	Fall	0.990	Fall	65	3
15-Mar	3431-083	Spring	Fall	0.990	Fall	77	4.5
15-Mar	3431-084	Spring	Fall	1.000	Fall	74	4
15-Mar	3431-081	Spring	Fall	1.000	Fall	86	7.1
15-Mar	3431-082	Spring	Fall	1.000	Fall	80	5.2
16-Mar	3431-085	Spring	Fall	1.000	Fall	73	3.7
16-Mar	3431-086	Spring	Fall	1.000	Fall	83	5.5
16-Mar	3431-087	Spring	Fall	1.000	Fall	85	6.2
16-Mar	3431-088	Spring	Fall	1.000	Fall	68	3.3
17-Mar	3431-090	Spring	Fall	0.870	Fall	70	3.7
17-Mar	3431-091	Spring	Fall	0.990	Fall	80	5.1
17-Mar	3431-092	Winter	Fall	1.000	Fall	92	
17-Mar	3431-093	Spring	Fall	0.990	Fall	87	7.1
17-Mar	3431-094	Spring	Fall	0.990	Fall	72	4.9
17-Mar	3431-095	Spring	Fall	1.000	Fall	71	
17-Mar	3431-096	Spring	Fall	1.000	Fall	71	
17-Mar	3431-097	Spring	Fall	1.000	Fall	72	
17-Mar	3431-098	Spring	Fall	1.000	Fall	75	
17-Mar	3431-099	Spring	Fall	1.000	Fall	68	
18-Mar	1-003	Spring	Fall	1.000	Fall	84	6.4
18-Mar	1-004	Spring	Fall	1.000	Fall	82	5.6
18-Mar	1-001	Spring	Fall	1.000	Fall	77	4.6
18-Mar	1-002	Spring	Fall	1.000	Fall	82	5.6
19-Mar	1-005	Spring	Fall	1.000	Fall	81	5.7
19-Mar	1-006	Spring	Fall	1.000	Fall	75	4.4
19-Mar	1-007	Spring	Fall	1.000	Fall	82	6.1
19-Mar	1-008	Spring	Fall	1.000	Fall	72	4.1
20-Mar	1-012	Spring	Fall	1.000	Fall	69	3.4
20-Mar	1-013	Spring	Fall	1.000	Fall	74	4
20-Mar	1-009	Spring	Fall	1.000	Fall	85	6.9
20-Mar	1-010	Spring	Fall	0.990	Fall	87	6.2
20-Mar	1-011	Spring	Fall	1.000	Fall	72	
30-Mar	1-014	Spring	Fall	0.990	Fall	83	6
31-Mar	1-015	Spring	Fall	1.000	Fall	84	6.5
31-Mar	1-016	Spring	Fall	1.000	Fall	78	5.3
1-Apr	1-017	Fall	Fall	1.000	Fall	34	
1-Apr	1-018	Fall	Fall	1.000	Fall	36	
2-Apr	1-019	Spring	Fall	1.000	Fall	83	6.2
2-Apr	1-020	Spring	Fall	1.000	Fall	82	5.4
2-Apr	1-021	Late fall	Fall	1.000	Fall	31	
2-Apr	1-022	Late fall	Fall	1.000	Fall	30	
2-Apr	1-023	Spring	Fall	0.990	Fall	76	4.3
2-Apr	1-024	Spring	Fall	1.000	Fall	76	4.8

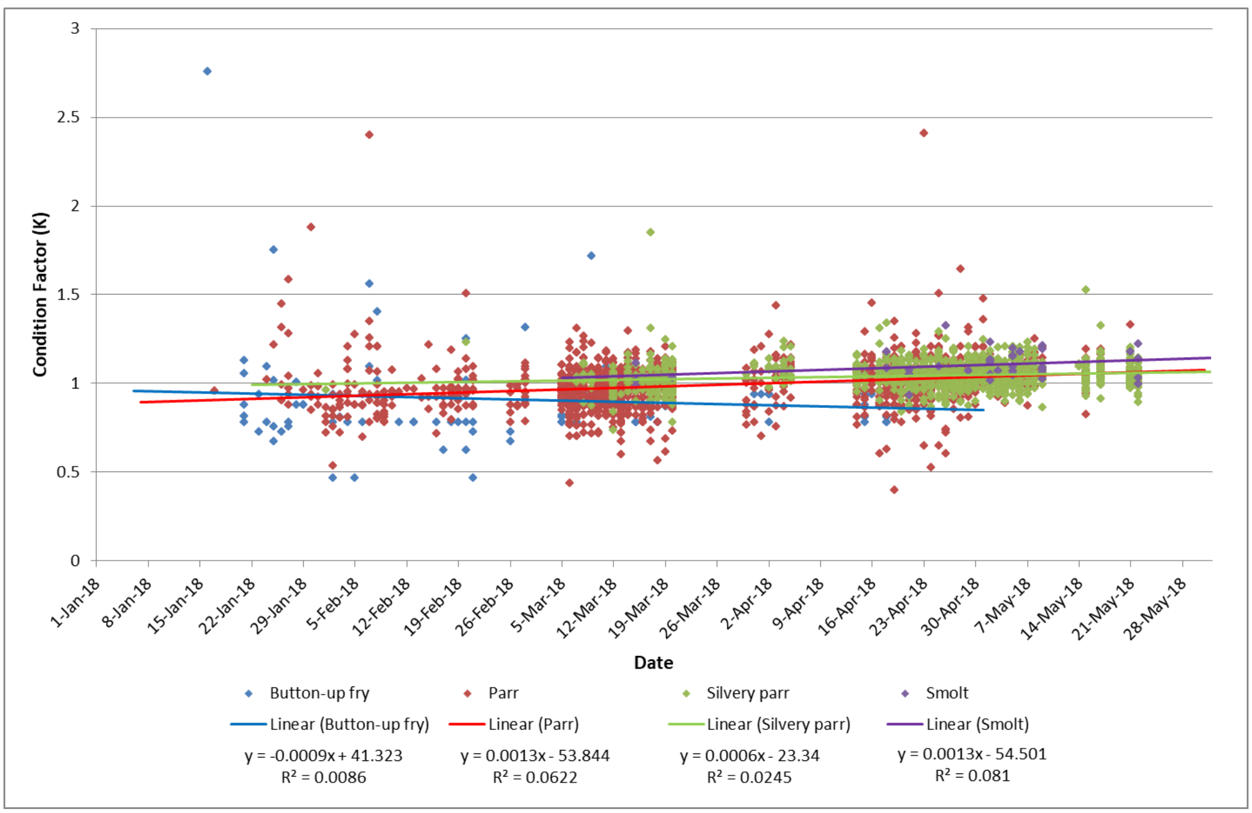
2-Apr	1-025	Late fall	Fall	0.840	Fall	30	
2-Apr	1-026	Late fall	Fall	1.000	Fall	30	
3-Apr	1-027	Spring	Fall	1.000	Fall	85	6.3
3-Apr	1-028	Spring	Fall	1.000	Fall	79	5.3
3-Apr	1-029	Late fall	Fall	1.000	Fall	33	
3-Apr	1-030	Late fall	Fall	1.000	Fall	32	
3-Apr	1-031	Late fall	Fall	1.000	Fall	31	
3-Apr	1-032	Spring	Fall	1.000	Fall	80	5.6
3-Apr	1-033	Late fall	Fall	1.000	Fall	33	
4-Apr	1-034	Late fall	Fall	1.000	Fall	33	
4-Apr	1-035	Late fall	Fall	1.000	Fall	32	
4-Apr	1-036	Late fall	Fall	1.000	Fall	32	
4-Apr	1-037	Late fall	Fall	1.000	Fall	33	
4-Apr	1-038	Spring	Fall	1.000	Fall	84	6.3
5-Apr	1-039	Late fall	Fall	1.000	Fall	31	
5-Apr	1-040	Late fall	Fall	1.000	Fall	32	
5-Apr	1-041	Spring	Fall	1.000	Fall	85	6.2
5-Apr	1-042	Late fall	Fall	1.000	Fall	33	
5-Apr	1-043	Late fall	Fall	1.000	Fall	33	
5-Apr	1-044	Spring	Fall	1.000	Fall	76	4.6
5-Apr	1-045	Spring	Fall	1.000	Fall	79	5.1
14-Apr	1-046	Spring	Fall	1.000	Fall	80	5.6
14-Apr	1-047	Spring	Fall	1.000	Fall	87	7.1
15-Apr	1-048	Spring	Fall	1.000	Fall	87	6.9
15-Apr	1-049	Spring	Fall	1.000	Fall	83	6.3
15-Apr	1-051	Late fall	Fall	1.000	Fall	35	
16-Apr	1-052	Late fall	Fall	1.000	Fall	35	
16-Apr	1-053	Late fall	Fall	1.000	Fall	35	
17-Apr	1-054	Late fall	Fall	1.000	Fall	35	
17-Apr	1-055	Spring	Fall	1.000	Fall	95	8.2
17-Apr	1-056	Late fall	Fall	1.000	Fall	35	
17-Apr	1-057	Spring	Fall	1.000	Fall	87	7.1
18-Apr	1-058	Late fall	Fall	1.000	Fall	36	
18-Apr	1-059	Spring	Fall	1.000	Fall	86	
18-Apr	1-060	Late fall	Fall	1.000	Fall	34	
18-Apr	1-061	Spring	Fall	1.000	Fall	90	7.9
18-Apr	1-062	Spring	Fall	1.000	Fall	87	6.9
19-Apr	1-066	Spring	Fall	1.000	Fall	84	6
19-Apr	1-068	Spring	Fall	1.000	Fall	88	7.1
19-Apr	1-063	Spring	Fall	1.000	Fall	86	6.5
19-Apr	1-064	Late fall	Fall	1.000	Fall	36	
19-Apr	1-065	Spring	Fall	1.000	Fall	87	7.4
20-Apr	1-069	Spring	Fall	0.760	Fall	89	7.6

20-Apr	1-070	Spring	Fall	1.000	Fall	84	6.1
20-Apr	1-071	Late fall	Fall	1.000	Fall	36	
20-Apr	1-072	Late fall	Fall	1.000	Fall	35	
20-Apr	1-073	Spring	Fall	1.000	Fall	97	9.7
20-Apr	1-074	Spring	Fall	1.000	Fall	85	6.9
21-Apr	1-078	Spring	Fall	1.000	Fall	85	6.4
21-Apr	1-079	Late fall	Fall	1.000	Fall	37	
21-Apr	1-080	Spring	Fall	1.000	Fall	95	9.8
21-Apr	1-081	Spring	Fall	1.000	Fall	85	
21-Apr	1-075	Spring	Fall	1.000	Fall	86	6.7
21-Apr	1-076	Late fall	Fall	1.000	Fall	37	
21-Apr	1-077	Spring	Fall	1.000	Fall	85	6.6
22-Apr	1-082	Spring	Fall	1.000	Fall	109	13.9
22-Apr	1-083	Late fall	Fall	1.000	Fall	36	
22-Apr	1-084	Spring	Fall	1.000	Fall	90	7.4
22-Apr	1-085	Spring	Fall	1.000	Fall	84	6.4
22-Apr	1-086	Late fall	Fall	1.000	Fall	36	
23-Apr	1-087	Spring	Fall	1.000	Fall	86	6.8
23-Apr	1-088	Spring	Fall	1.000	Fall	87	6.7
23-Apr	1-089	Late fall	Fall	1.000	Fall	37	
23-Apr	1-090	Late fall	Fall	1.000	Fall	35	
23-Apr	1-091	Spring	Fall	1.000	Fall	89	7.6
24-Apr	1-093	Spring	Fall	1.000	Fall	87	7.1
24-Apr	1-094	Spring	Fall	1.000	Fall	93	8.2
24-Apr	1-095	Late fall	Fall	1.000	Fall	37	
24-Apr	1-096	Spring	Fall	1.000	Fall	90	7.2
24-Apr	1-097	Spring	Fall	1.000	Fall	85	6.2
24-Apr	1-098	Late fall	Fall	1.000	Fall	35	
25-Apr	2-002	Late fall	Fall	1.000	Fall	38	
25-Apr	2-003	Spring	Fall	0.990	Fall	88	7.3
25-Apr	2-004	Spring	Fall	0.980	Fall	91	8.1
25-Apr	1-099	Spring	Fall	1.000	Fall	101	13.3
25-Apr	1-100	Spring	Fall	0.990	Fall	90	6.8
25-Apr	2-001	Late fall	Fall	0.990	Fall	36	
26-Apr	2-008	Spring	Fall	1.000	Fall	87	6.2
26-Apr	2-009	Spring	Fall	1.000	Fall	90	7.7
26-Apr	2-010	Late fall	Fall	1.000	Fall	36	
26-Apr	2-005	Spring	Fall	1.000	Fall	91	7.3
26-Apr	2-006	Spring	Fall	1.000	Fall	88	6.7
26-Apr	2-007	Late fall	Fall	1.000	Fall	36	
27-Apr	2-011	Late fall	Fall	1.000	Fall	35	
27-Apr	2-012	Spring	Fall	1.000	Fall	97	9.5
27-Apr	2-013	Spring	Fall	1.000	Fall	94	9.9

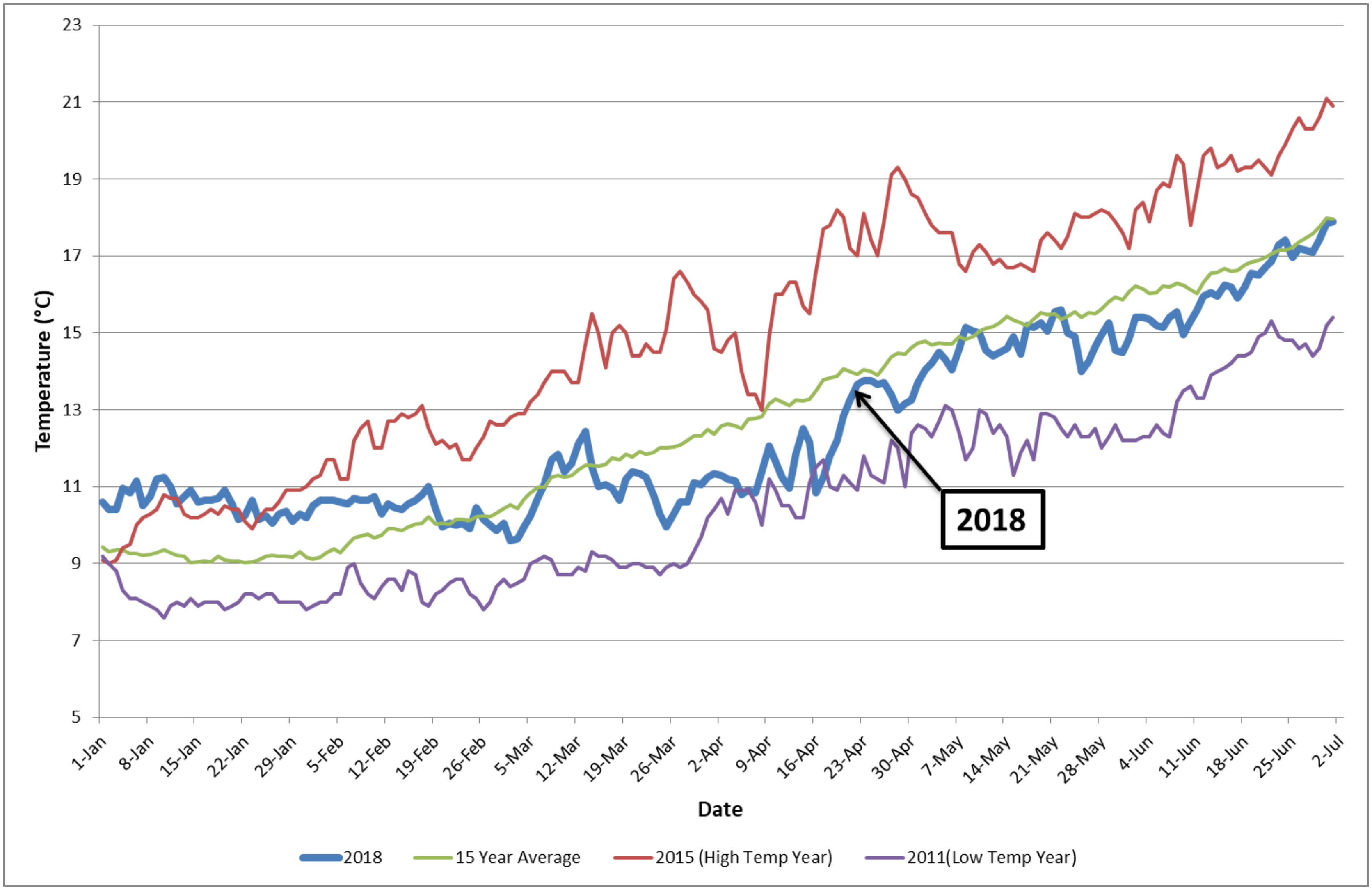
27-Apr	2-014	Spring	Fall	1.000	Fall	90	7.8
28-Apr	2-020	Spring	Fall	1.000	Fall	89	7
28-Apr	2-021	Spring	Fall	1.000	Fall	94	8.7
28-Apr	2-022	Late fall	Fall	1.000	Fall	36	
28-Apr	2-015	Late fall	Fall	1.000	Fall	36	
28-Apr	2-017	Spring	Fall	1.000	Fall	94	9
28-Apr	2-018	Spring	Fall	1.000	Fall	97	9.4
28-Apr	2-019	Late fall	Fall	0.560	Fall	37	
29-Apr	2-024	Spring	Fall	1.000	Fall	90	8.4
29-Apr	2-025	Spring	Fall	1.000	Fall	90	8.8
29-Apr	2-026	Spring	Fall	1.000	Fall	115	16.3
29-Apr	2-016	Spring	Fall	1.000	Fall	88	6.7
29-Apr	2-023	Spring	Fall	1.000	Fall	88	7.8
30-Apr	2-027	Spring	Fall	1.000	Fall	90	7.8
30-Apr	2-028	Late fall	Fall	1.000	Fall	35	
30-Apr	2-029	Spring	Fall	1.000	Fall	92	8.9
30-Apr	2-030	Spring	Fall	1.000	Fall	95	9.2
30-Apr	2-031	Spring	Fall	1.000	Fall	93	8
30-Apr	2-032	Late fall	Fall	1.000	Fall	34	
1-May	2-033	Spring	Fall	1.000	Fall	90	9.1
1-May	2-034	Spring	Fall	1.000	Fall	90	7.5
1-May	2-035	Spring	Fall	1.000	Fall	91	8.1
1-May	2-036	Spring	Fall	1.000	Fall	93	9
2-May	2-037	Spring	Fall	0.990	Fall	91	8.5
2-May	2-038	Spring	Fall	1.000	Fall	90	7.7
2-May	2-039	Late fall	Fall	1.000	Fall	37	
2-May	2-040	Late fall	Fall	1.000	Fall	34	
2-May	2-041	Spring	Fall	1.000	Fall	103	11.5
2-May	2-042	Spring	Fall	1.000	Fall	97	9.3
3-May	2-043	Spring	Fall	1.000	Fall	91	8.1
4-May	2-045	Spring	Fall	0.920	Fall	107	13.2
4-May	2-046	Spring	Fall	1.000	Fall	91	7.8
4-May	2-044	Spring	Fall	0.970	Fall	93	8.7
5-May	2-047	Spring	Fall	1.000	Fall	93	8.6
9-May	2-048	Spring	Fall	1.000	Fall	96	9.1
16-May	2-049	Spring	Fall	1.000	Fall	100	

Appendix 5: Fulton's condition factor (K), overall, and by life-stage, of fall-run Chinook salmon during the 2018 lower American River rotary screw trap survey season.

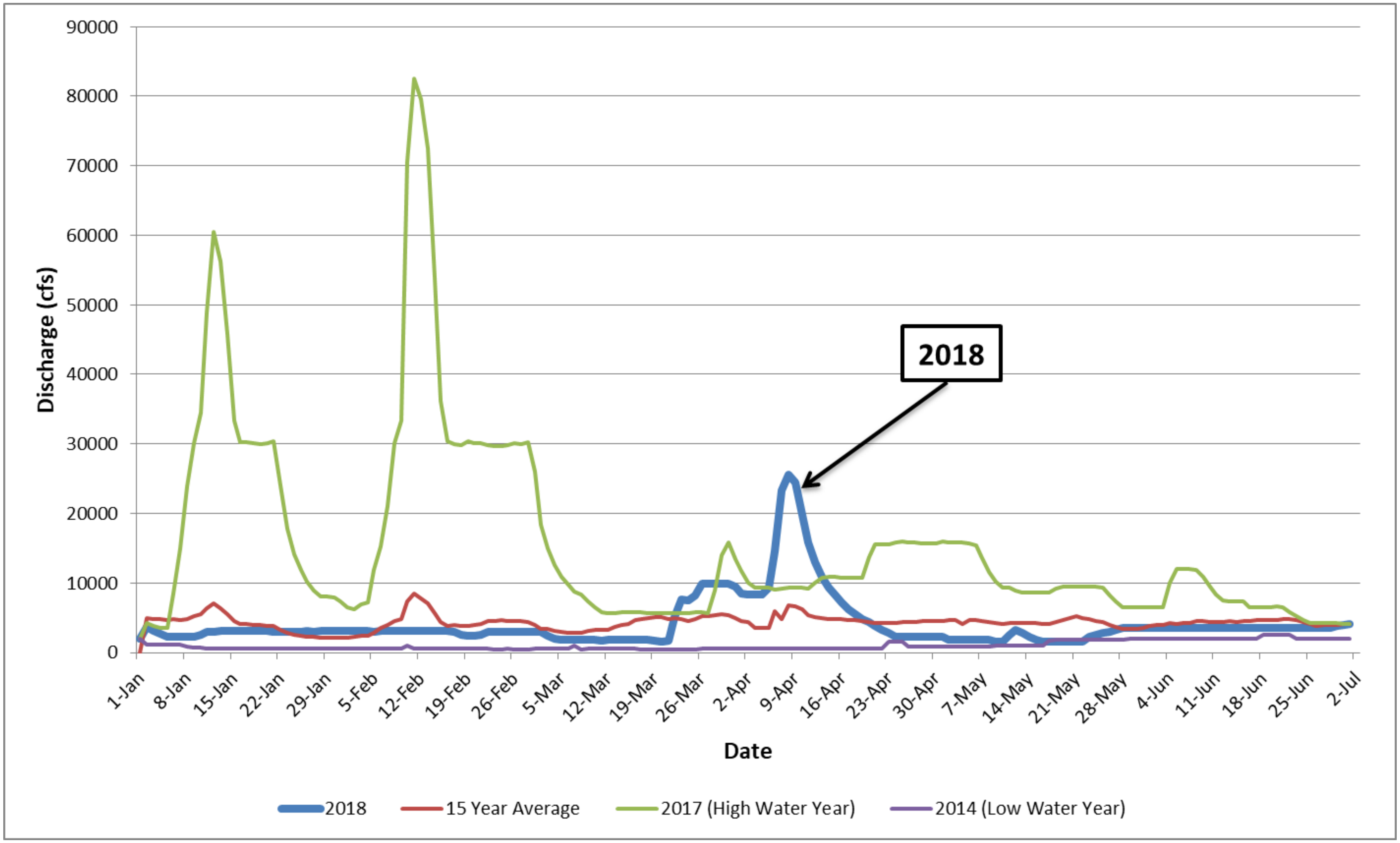




Appendix 6: Daily average water temperature (°C) in the lower American River at Watt Avenue for the 15 year period 2004-2018, the highest temperature year, the lowest temperature year, the 15 year average and the current year (2018). Data obtained from USGS station number 11446980.



Appendix 7: Daily average discharge (CFS) on the lower American River at Fair Oaks for the 15-year period 2004 – 2018, the highest water year, the lowest water year, 15 year average and the current year (2018). Data obtained 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