Juvenile Salmonid Emigration Monitoring in the Lower American River, California

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Abstract

Operation of rotary screw traps on the lower American River in 2015 is part of a collaborative five-year effort by the U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program, Pacific States Marine Fisheries Commission, and the California Department of Fish and Wildlife. The primary objective of the trapping operations is to collect data that can be used to estimate the production 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 2015 survey season, two 2.4 meter (8 foot) rotary screw traps (RSTs) were operated 120 of the 141 days between 8 January 2015 and 29 May 2015 downstream of the Watt Avenue Bridge. A total of 283,153 fall-run, 19 putative spring-run, 28 winter-run, and four late-fall-run juvenile Chinook salmon was captured. A total of 15 length-at-date winter-run hatchery Chinook salmon, and one length-at-date spring-run hatchery Chinook salmon was also captured. The passage of juvenile fall-run Chinook salmon peaked when ninety-four percent of the total (n = 265,719) were captured between 29 January 2015 and 11 March 2015. The majority of the captured juvenile Chinook salmon belonged to the fry life stage; fewer numbers of the yolk-sac fry, parr, silvery parr, and smolt life stages were also collected. Eleven trap efficiency tests were conducted to collect data that were used to estimate the production of juvenile fall-run Chinook salmon. Trap efficiencies during those 11 tests ranged between 7.54 and 24.30 percent, and the average efficiency was 16.85 percent. The number of juvenile fall-run Chinook salmon that were estimated to have emigrated past the Watt Avenue trap site on the American River during the 2015 survey season was 1,464,697 individuals (95 percent confidence intervals = 1,412,787 - 1,668,506). Eleven in-river produced and one hatchery produced juvenile steelhead were captured in 2015. Finally, 6,139 individuals belonging to 23 different identifiable non-salmonid species and four unidentifiable non-salmonid were also caught, a majority of which were Sacramento sucker (*Catostomus occidentalis*). One juvenile white sturgeon (*Acipenser transmontanus*) was also captured by the RSTs in 2015. Production for steelhead, the three other non-fall Chinook salmon runs, and non-salmonid fish taxa were not estimated. During the 2015 trapping effort on the American River, no substantial logistical or environmental issues interfered with the collection of field data.

This annual report also includes 11 appendices. Five of those appendices describe different environmental variables and studies related to the trap site or rotary screw trap operations during the 2015 survey season.

Introduction

The American River is the southernmost major tributary to the Sacramento River in California's Central Valley. The lower portion of American flows through the highly urbanized Sacramento metropolitan area, and it provides crucial spawning and rearing habitat for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*), the anadromous form of rainbow trout. Historically, the American River supported three runs of Chinook salmon that included fall-, spring-, and possibly late-fall-run Chinook salmon (Yoshiyama et al. 2001). During the mid to late 1800s during the California Gold Rush, hydraulic mining devastated salmon spawning habitat in the upper and lower reaches of the American River (Fisher 1994). Later, the construction of Folsom and Nimbus dams made it impossible for spring-run Chinook salmon to migrate to the coolwater pools they historically used in the upper portions of the American River watershed. To mitigate the loss of fall-run Chinook salmon and steelhead spawning and rearing habitat, the Nimbus Fish Hatchery was built 0.80 kilometers (km) downstream of the Nimbus Dam in 1958. The Nimbus Fish Hatchery is used to produce large numbers of fall-run Chinook salmon and steelhead. Discharges from Folsom and Nimbus dams are regulated by the U.S. Bureau of Reclamation (USBR), and they provide flows that help maintain fish and wildlife habitats, provide municipal and agricultural water supplies, administer flood protection, and generate hydroelectric power.

The Central Valley Project Improvement Act (CVPIA) was authorized in 1992. One of the primary goals of that legislation is to facilitate efforts that enhance/restore the natural production of adult and 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. The Comprehensive Assessment and Monitoring Program (CAMP) was also established by the CVPIA, and that program is designed to monitor the effectiveness of ongoing habitat restoration activities and provide recommendations designed to improve the efficacy of future restoration work.

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 developed to restore adult spawning and juvenile rearing habitat that was adversely affected by the construction of the Folsom and Nimbus dams on the American River. The habitat restoration activities have occurred at seven sites from the base of Nimbus Dam downstream 2.9 river kilometers (rkm) to the Upper Sunrise Recreational Area (USDOI 2008).

Within that area, approximately 57,342 cubic meters (m^3) of gravel have been added to the river between 2008 and 2012.

The CVPIA's Dedicated Project Yield Program 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, that program's 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. Additionally, the Dedicated Project Yield Program's flow augmentation may also contribute towards the AFRP Final Restoration Plan flow objectives for the lower American River.

Rotary screw traps are frequently used to monitor the abundance of juvenile salmonids and their biological response to habitat restoration activities. This report describes efforts to monitor juvenile salmonid abundance with RSTs in 2015 as part of a larger effort to determine if habitat restoration activities are improving Chinook salmon production in the lower American River. Furthermore, this report presents monitoring data quantifying catch of steelhead , as well as providing data that describe the size and abundance of Chinook salmon and other native and non-native fish species in relation to the time of year, river discharge, and environmental conditions.

The 2015 survey season was the continuation of a multi-year juvenile Chinook salmon emigration survey. Since the start of this project in 2013, California has experienced an increasingly severe degree of drought, of which has not been seen in the region for decades. Since the Folsom and Nimbus dams were built, only two droughts as severe as the current one have occurred: those occurred between 1976-1977 and 1987-1992 (CDWR 2010). Because there have only been two recorded drought events of this scale since construction of the Folsom Project, very little is known about how severe droughts affect the biota in this river ecosystem, and how to properly manage water from a biological and economic standpoint. In addition to current management practices and fish recovery projects, the RST data collected during the past three 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. From there, we can better anticipate and manage for future severe droughts.

During the next few years, RST data will continue to be collected such that the new post-2012 data complement the data that were collected by the CDFW between 1992 and 2008. All of the RST data will then be analyzed in 2017 with the goal of understanding how ongoing habitat restoration activities affect juvenile salmonid abundance, and how future habitat restoration activities can be enhanced to increase the production of juvenile Chinook salmon and steelhead.

Based on the aforementioned goal identified in the last paragraph, the primary objective of the American River trapping operations is to collect data that can be used to estimate the production of juvenile fall-run Chinook salmon and observe the presence of steelhead 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, and abundance/production. An ancillary objective of the trapping operations is to collect non-salmonid fish species data that can be used to characterize the fish community in the American River in the vicinity of the RSTs.

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 function of Nimbus Dam and Lake Natoma is to re-regulate flows downstream of the Folsom Dam. The area commonly called the "lower American River" refers to the portion of the American River below Nimbus Dam. Both of these two dams control water release activities including river discharge and water temperature regimes in the lower American River that influence salmonid spawning and rearing.

Water exiting Nimbus Dam flows downstream for 36 km across an alluvial plain until it reaches the Sacramento River. This lower stretch of the American River is now constricted and straightened by a levee system that was engineered for flood control during the urban development of Sacramento County. Currently, fall-run Chinook salmon and steelhead are only able to access and occupy the lower-most 36 km of the American River, and only a small portion of the river possesses suitable substrate for anadromous salmonid spawning activities. The river contains gravel bar complexes and islands, flat water areas, and side-channel habitat characteristics (Merz and Vanicek 1996). Flows in this lower section can range from 500 cubic feet per second (CFS) to upwards of 164,035 CFS. 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). CDFW (Snider and Titus 1995) selected a site 0.20 rkm downstream of the Watt Avenue Bridge (rkm 14.6) as the location to install and operate RSTs because that site is downstream of most of the Chinook salmon and steelhead spawning activities in the lower American River yet far enough upstream to be un-influenced by tidal and river rise from the Sacramento River that backs up into the American River. 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 situated in an area that contains two channels that pass on either side of a gravel island downstream of the Watt Avenue Bridge (Figure 1). The "North Channel" carries the majority of the water volume and becomes the only channel with flowing water during extreme low flows. Water velocities in the North Channel are relatively high because that reach possesses a steep channel gradient. The "South Channel" has a flatter gradient and lower water velocities. In 2015, two RSTs were deployed in the North Channel and no traps were deployed in the South Channel due to the minimal river discharges that year. The two traps deployed in the North Channel were labeled North Channel trap 8.1 and North Channel trap 8.2. Trap 8.1 was set closer to the north bank of the North Channel, while trap 8.2 was closer to south bank of the North Channel.

Figure 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.

Methods

Trap Operations

Monitoring activities for the survey season started on 8 January 2015 and ended on 29 May 2015. The two 2.4 meter (8 foot) diameter RSTs were fished in a side-by-side configuration. Traps were anchored to two large concrete blocks set into the cobble substrate of the river 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. During times of low flows, and a narrow thalweg, a rope was attached from the port side of the traps to the north bank to ensure consistent trap fishing conditions.

Trap checks were conducted at least every 24 hours. When the potential existed for high debris load an increased amount of trap checks were conducted to prevent fish mortality. During peak emigration, or when a potential for a large storm event or a measurable river flow increase occurred, night trap checks were also performed in addition to the regular day time checks. In these cases, trap functionality could be hindered by larger sizes and higher quantities of debris which could stop the trap cone from functioning or clog the cone intakes. These instances can create a high potential for fish mortality. Night checks were only used to clear debris and to keep the traps functioning properly; no fish were processed during these checks. In cases where a storm could be deemed severe enough, traps could be taken out of service for an indefinite amount of time until the conditions improve; this scenario did not occur in 2015. During periods of warm water temperatures and increasing recreational use on the weekends, twice daily trap checks were performed during the weekdays and traps were out of service on the weekends. When traps were out of service, trap cones were raised, live well screens were pulled, and sampling was temporarily suspended.

The number of cone rotations between trap visits was monitored using a mechanical lever actuated counter (Trumeter Company Inc.) attached to the port side pontoon on each trap; this data was used to determine how well traps functioned between trap visits. The effect of debris buildup on trap cone rotation rates was quantified by counting the number of revolutions per minute (RPM) before and after each cone was cleaned each day. Cleaning of the cones relied on the use of a scrub brush to clear off algae and other vegetation, and the field crew occasionally had to stop a trap cone to remove larger debris. The amount of debris in each cone intake during each trap visit 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 members were on the boat or the RSTs. For night operations, crew members were required to affix a strobe light to their personal flotation devices that turns on when submerged in water. Four 12-volt LED flood lights were affixed to the traps and navigation lights with a forward facing spot light were also installed to the jet-boat for night operations. A flare kit was also added to the boat if needed in cases of emergency.

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. A flashing amber construction light was attached to the top of the A-frame on the traps to alert the public at night that there was a potential navigation hazard. Orange or reflective buoys were placed on the chain bridals, and buoys were installed over concrete anchors when the water depth above an anchor was less than 30.5 cm deep. Two signs were installed approximately 106 and 244 m upstream of the RSTs in the North Channel; those signs warned and directed river users and park visitors to pass by the left side of the trap. As visitor use on the river increased during the warmer spring months, a large sign was mounted on the front of the traps warning boaters to pass to the left side of the trap as they moved downstream.

Environmental Parameters

Environmental data were recorded on a daily basis before fish were processed. 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). A depth rod was used to measure water depth underneath the trap to the nearest centimeter on the port and starboard sides of the 2-trap array in line with the front of the trap cones. A staff gauge was also mounted on the traps and was used to measure the water depth inside each trap cone. A staff gauge graduated in inches was installed on the north river shoreline to monitor change in river stage. Average daily river discharge for the American River was determined using data from the U.S. Geological Survey's American River at Fair Oaks monitoring station (USGS station number 11446500). Average daily temperature was measured 150 m upstream of the RSTs using data from the USGS's American River below Watt Avenue Bridge station (USGS station number 11446980).

Catch and Fish Data Collection

After environmental data were collected, the process of clearing out each RST's live well and fish work-up began. First, all debris was removed from a live well and placed into 68.14 liter (L) tubs where crew members sifted through debris and saved 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 that segregated salmonids from non-salmonids and from potential predation. During periods of hot weather, fish were placed in buckets with an aerator to provide them with oxygen and an ice pack to keep the water temperature at a safe level. In addition, the crew placed buckets of fish underneath an umbrella to shade fish from direct sunlight. If fish were held in buckets for a prolonged amount of time, old water was regularly exchanged with fresh river water.

On days when less than 100 Chinook salmon were caught in a 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 in Table 1 below, the presence or absence of marks used during trap efficiency tests was noted, the presence or absence of adipose fin clips was noted, and their mortality status (live vs. dead) was assessed. If Chinook salmon were ≥ 40 mm in fork length, the first 25 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 were weighed to the nearest 0.1 g after they were measured and assessed for life stage. Because dead salmon are difficult to accurately measure and identify to life stage due to varying stages of decomposition that alter body size, weight, and color, live salmon were preferentially used for the random sample of 100, when possible. In those cases, mortalities were considered "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 in the tub. After removing the debris from the tub, a random net full of salmon was taken from the 68.14 L tub and placed in a 18.93 L bucket designated for Chinook salmon subsampling. From the subsampled bucket, 100 Chinook salmon were randomly selected for analysis. Additional fall-run Chinook salmon in excess of the 100 that were present in the tub or trap live well were not measured and weighed, but each of these salmon were checked for marks, enumerated, and recorded on data sheets as a "live plus-count tally," or "mort plus-count tally." A "plus-count tally" was defined as the total number of fish that were caught in a trap on a given day, and that were not measured, weighed, or assigned a life stage. If the plus-count capture included a spring-, winter-, or late-fall-run salmon, they were counted separately and 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, the trapping activities attempted to identify every spring- and winter-run Chinook salmon that was captured so those data could be reported to the NMFS.

During the peak emigration period when fry catch totals appeared to be over 10,000 fall-run Chinook salmon per day, volumetric estimates of plus-counts were performed for each day and trap. Prior to volumetric counting, all marked Chinook salmon, non-fall-run, and non-salmon species were separated from unmarked fall-run Chinook salmon. The following steps were then performed. The unmarked fall-run salmon captured with a small aquarium net were placed into a 100 milliliter (ml) cup used for volumetric measuring, and the cup was filled with unmarked fall-run salmon level to the top with as much water displaced as possible. Then the salmon were poured onto a large measuring board and each individual from that cup was counted. These steps were then performed 10 times and an average Chinook salmon count per 100 ml cup was established for that particular day and trap. After the volumetric calibration was completed, the crew then counted the remaining number of 100 ml cups that were filled with salmon after the initial 10 cups were filled. The average count per cup was then expanded to the number of cups filled and a plus-count estimate for the day was formulated.

On the occasions when steelhead were captured and river temperatures were < 21°C, each individual was counted, fork lengths were measured to the nearest one mm, life stage was assessed using the smolt index rating in Table 1, and mortality status was assessed. In addition, each steelhead was checked for the presence or absence of a mark (i.e., fin clip) and the weights of each individual ≥ 40 mm in fork length were recorded. On days when river temperatures were ≥ 21°C, steelhead were identified, enumerated, checked for the presence or absence of a mark, and then released downstream without being weighed or measured for fork length. This procedure was adopted to minimize handling mortality brought about by higher water temperatures.

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

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

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

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

Chinook salmon were assigned a salmon run at the time of capture using length-at-date (LAD) criteria that were developed for the Sacramento River by Greene (1992). When Chinook salmon appeared to be winter- or spring-run salmon using the LAD criteria, one to two mm samples were commonly taken from the upper caudal fin. These samples were then used by 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 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. Fish captured in 2015 were assigned to one of five salmon runs: 1) winter-run, 2) fall-run, 3) Butte Creek spring-run, and 4) spring-run that may be from Deer or Mill Creek, and 5) salmon with an unknown origin.

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 85-95percent of the time, and spring-run were correctly assigned to run 78-93 percent of the time (Clemento et al. 2014). It was further observed that spring-run fish could be assigned back to population of origin, but with lower accuracy (e.g., Butte Creek = 68 percent, Mill/Deer Creek = 48-50 percent). For the purposes of this report, the SNP panel providing the "Genetic Call to three lineages" probability was used, and we employed an arbitrary 50 percent probability threshold 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, then final run was assigned using the genetic markers.

Seventeen salmon that had a LAD assignment at the time of capture = fall were genetically sampled to compare their LAD assignments with run assignments using the SNPs. That procedure was implemented to evaluate how dissimilar or not the LAD and SNP assignments were when the LAD assignment at time of capture = fall.

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 day using the technique described below.

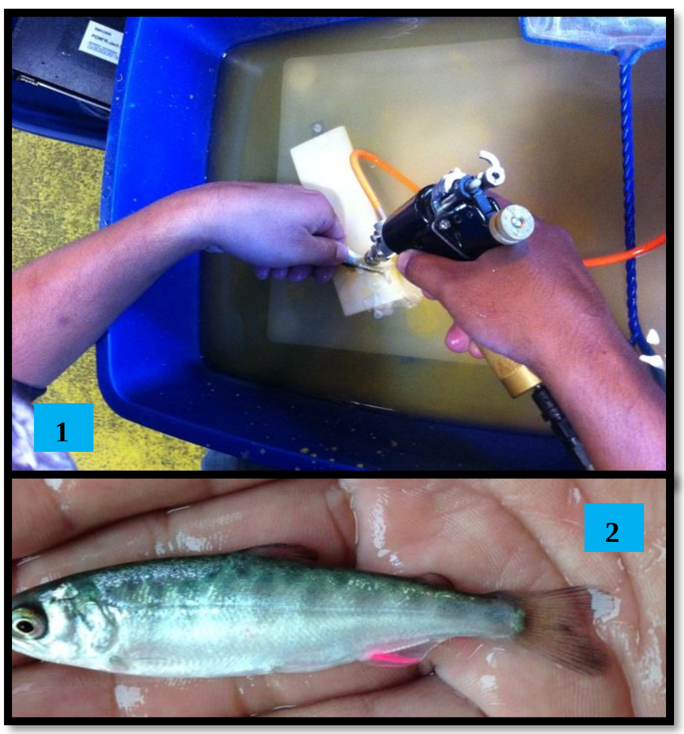
To evaluate the potential that the size distribution of recaptured in-river produced salmon was different than the in-river produced salmon that were released during a trap efficiency test, 100 fork lengths from the day the in-river produced fish were captured were used as a baseline to compare with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

The second method of marking used a BMX2000 POW'R-JECT needleless gun to inject a photonic fluorescent dye into the anal fin of a Chinook salmon (Figure 2). The color dyes used during the 2015 American River trap efficiency trials were pink and green. Since the photonic method of marking Chinook salmon required the availability of individuals ≥ 50 mm in size and fish captures at the trap site did not always meet this size threshold in large enough quantities for a trap efficiency trial during the latter part of the field season, fall-run Chinook salmon from the Nimbus Fish Hatchery were used when fish were photonically marked. Before marking the hatchery salmon, the fish were anesthetized with alka-seltzer and the fork lengths of 100 randomly selected individuals were measured to the nearest mm. After marking, the fish were held at least overnight at the hatchery and allowed to recover. If mortalities were discovered after being held overnight, they were counted and removed from the efficiency trial. The live Chinook salmon were then transported to the release site in coolers with aerators. Upon arrival to the release site, the fish were immediately placed in live cars in the river. Marked fish were held in the live cars in the river for two to four hours, and then released at sunset using the technique described below.

The 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 biologists wading across the river. When higher river discharges occurred, a boat was used to release the marked fish, keeping the motor upstream of the released fish. Every release of marked Chinook salmon occurred close to twilight to mimic natural migration patterns and to avoid predation.

The following days after each trap efficiency release, the crew carefully looked for any marked fish in the RST live wells. A random sample of 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".

Figure 2: (1) Marking a fall-run hatchery Chinook salmon with a BMX2000 POW'R-JECT needleless gun using photonic fluorescent orange dye. (2) Fall-run hatchery Chinook salmon with an anal fin injected with photonic fluorescent pink dye.



Passage Estimates

Fall-run Chinook salmon production estimates were developed using a generalized additive model (GAM). Production estimates were not developed for the other Chinook salmon runs because relatively small numbers of individuals from those runs were captured. Production estimates were not developed for steelhead because Central Valley fishery biologists in general believe steelhead fry typically rear in-river for one to three years before they emigrate from the river to the ocean as smolts, at which point they become more difficult to capture due to their ability to avoid the traps.

For the text below, a trap location is equivalent to Trap 8.1 or 8.2, and a site is equivalent to the site below Watt Avenue where both traps operate.

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

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

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

$\hat{c}_{ij}$ = either the enumerated or estimated catch of unmarked salmon of a certain life stage at trap location *i* during the 24-hour period *j*. For example, c_{23} = estimated catch at the second trap location during day three; and
$\hat{e}_{ij}$ = estimated trap efficiency at trap location *i* of the site for a certain life stage during the 24-hour period *j*. For example, e_{23} = estimated efficiency at the 2nd trap location during day three.

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

The estimate of catch, $\hat{c}_{ij}$ is computed in one of two ways listed below. The selection of the method used is typically in the order that the methods are listed below, e.g., if a trap operated properly for an entire 24-hour period, the catch using Method #1 was used to calculate a trap's salmon production estimate. If the trap operated for less than a full day (±2 hours), Method #2 was used.

Method #1: If the interval between check *j* and check *j* – 1 was 24 ± 2 hours and the trap operated properly for the entire period, $\hat{c}_{ij}$ is the total catch of unmarked fish in the trap at check *j*.

Method #2: If the trap fished for less than 22 hours between check *j* and check *j* – 1, the fish count at time *j* is adjusted using a GAM. This model smoothes observed catch rates (fish per hour) through time much like a moving average. The prediction from this model is multiplied by the number of hours the trap was not operating during the 24 hour period to estimate catch for the day.

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

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

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

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

During sampling days during the portion of the year when trap efficiency tests were not conducted, 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 that were included in the analyses. For example, if a survey season occurred between 1 January 2015 and 30 January 2015 and trap efficiency tests were conducted between 1 February 2015 and 30 May 2015, a GAM was used to develop the estimated trap efficiencies and expand the daily trap catches between 1 February 2015 and 30 May 2015, and the average trap efficiency for the survey season was used to expand the daily trap catches before 1 February 2015 and after 30 May 2015.

Estimation of $\hat{N}_j$

Once $\hat{c}_{ij}$ and $\hat{e}_{ij}$ are estimated, and $\hat{N}_{ij}$ has been computed, abundance estimates for the site should be computed by averaging over trap locations. The total number of fish passing a site on day *j* should be computed as:

$$\hat{N}_j = \sum_{i=1}^{n_{ij}} \hat{N}_{ij} \Big/ n_{ij}$$

where n_{ij} is the number of trap locations fishing at site i during day j. Following computation, estimates $\widehat{N}_j$ can be plotted against j to visually assess trends. $\widehat{N}_j$ can be summed over a week, month, or year to produce weekly, monthly, or annual estimates of abundance. In addition, the time series $\widehat{N}_j$ summaries (e.g., annual or monthly) can be subjected to further analysis to detect and quantify trends.

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:

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

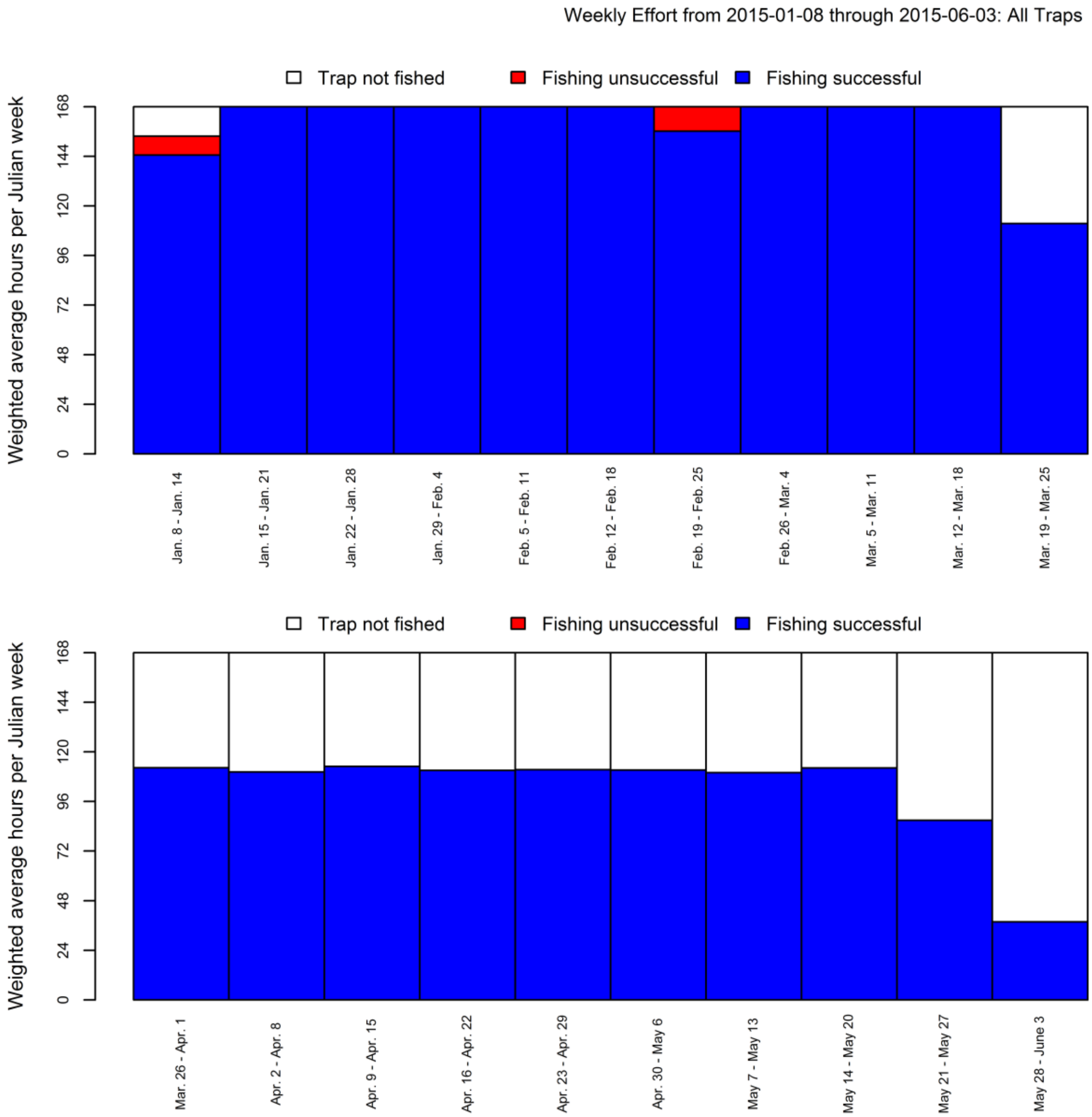
where K is the Fulton's condition factor, W is the weight in grams, and FL is the fork length in mm.

Results

Trap Operations

The RSTs were deployed and began sampling on 8 January 2015 to start the survey season. Sampling occurred continuously until 20 March 2015, after which sampling was performed during the weekdays only. As a result, sampling took place on 120 of the 141 days during the 2015 survey season. During this time, the traps fished successfully for approximately 166,326 hours and 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 1,259.5 hours (Figure 3). In response to increasing water temperatures, trap checks were performed twice daily from 16 March 2015 to the end of the season, with the objective of minimizing salmonid mortality. Trap operations for survey season were terminated on 29 May 2015, due to low fish counts and high river temperature.

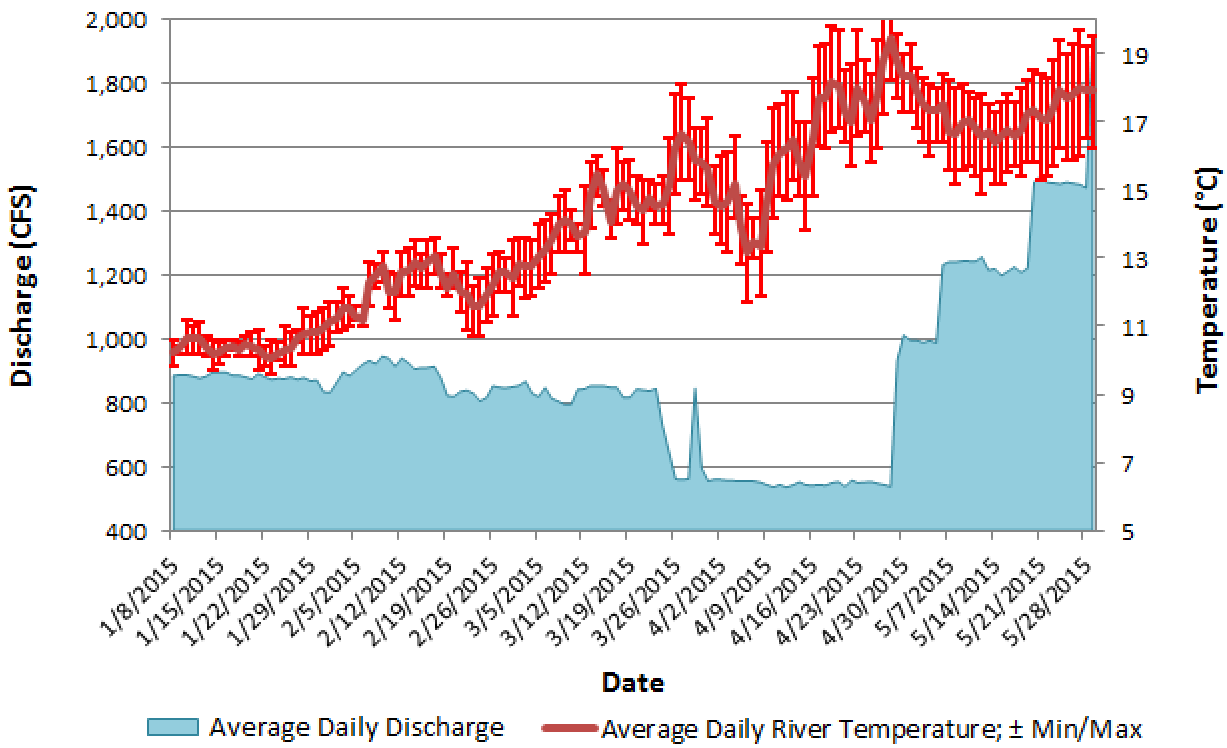
Figure 3: Weighted average hours per Julian week that both traps fished successfully, fished unsuccessfully, or did not fish.



Environmental Summary

A summary of the environmental conditions during the 2015 survey season is provided in Appendix 2. River turbidity, measured in the field, ranged from a low of 0.76 Nephelometric Turbidity Units (NTU) to a high of 3.31 NTU, with fairly consistent weekly averages throughout the season. Dissolved oxygen in the river water, also measured in the field, ranged from a low of 7.57 mg/l to a high of 11.27 mg/l, again with consistent weekly averages. Water velocities measured in front of each trap did not differ much from trap to trap, and ranged from a low of 0.62 meters per sec (m/s) to a high of 1.48 m/s in front of Trap 8.1 (north bank side), and a low of 0.83 m/s to a high of 1.54 m/s in front of Trap 8.2 (south bank side). Mean daily discharge, recorded from the USGS Fair Oaks gaging station on the American River, 21 rkm upstream of the RSTs, reached a low of 296 CFS on 24 February 2015 and a high of 2,010 CFS on 29 May 2015 (Figure 4). Mean daily temperature, recorded from the USGS Watt Avenue Bridge station on the American River, 0.16 rkm upstream of the RSTs, ranged from a low of 9.6° Celsius (C) on 23 January 2015, to a high of 20.8° C on 28 April 2015 (Figure 4).

Figure 4: Average daily discharge (CFS) measured at Fair Oaks, and average daily water temperature (°C) measured at Watt Avenue during the 2015 lower American River rotary screw trap survey season.



Note: Both sets of the 8 January 2015 – 28 May 2015 data were acquired from the USGS website at http://waterdata.usgs.gov/ca/nwis/uv

Catch

During the 2015 survey season, 289,373 fish were captured, including 19 hatchery produced salmonids. Trap 8.1 (north bank side) captured 46.14 percent (n = 133,546) of these fish and 53.85 percent (n = 155,827) were captured in Trap 8.2 (south bank side). These fish included fall-, late-fall-, winter-, and spring-run Chinook salmon and steelhead along with 23 identifiable non-salmonid species and four unidentifiable non-salmonid species (Appendix 3).

Fall-run Chinook salmon

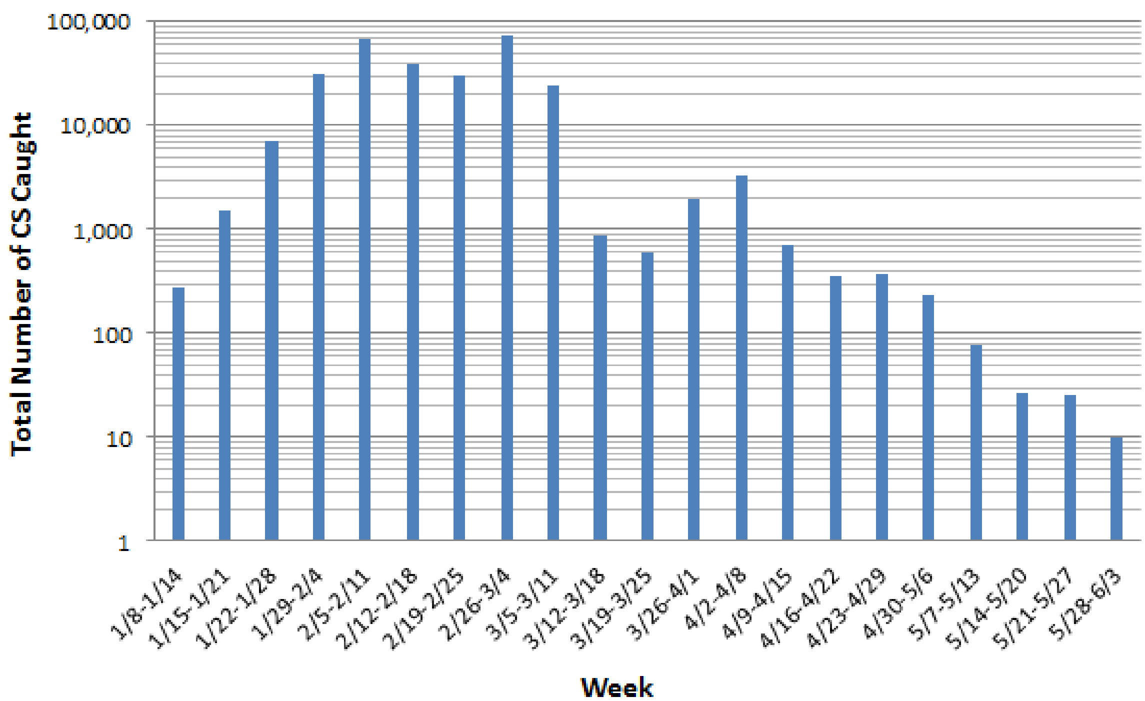
A total of 283,153 in-river produced, unmarked fall-run Chinook salmon was captured during the 2015 survey season (Table 2). Ninety-four percent of that total (n = 265,719) were captured between 29 January 2015 and 11 March 2015, with 21 percent of the entire season's catch (n = 58,440) captured in the three days between 9 February 2015 and 11 February 2015 alone, and 26 percent of the entire season's catch (n = 72,098) captured in the week between 26 February 2015 and 4 March 2015 (Figure 5.)

Table 2: In-river produced, unmarked fall-run Chinook salmon catch totals by life stage during the 2015 lower American River rotary screw trap survey season.

Julian Week	Yolk Sac Fry	Fry	Parr	Silvery Parr	Smolt	Unassigned Life Stage	Total
1/8-1/14	18	255	0	0	0	1	274
1/15-1/21	23	1,156	0	0	0	360	1,539
1/22-1/28	17	1,382	1	0	0	5,697	7,097
1/29-2/4	3	1,392	2	0	0	29,672	31,069
2/5-2/11	5	1,195	0	0	0	67,740	68,940
2/12-2/18	6	1,394	4	17	0	37,106	38,527
2/19-2/25	1	1,398	1	5	0	28,112	29,517
2/26-3/4	0	1,400	2	11	0	72,098	73,511
3/5-3/11	1	1,452	32	9	0	22,661	24,155
3/12-3/18	0	609	189	15	2	79	894
3/19-3/25	0	97	395	94	0	6	592
3/26-4/1	0	14	653	290	45	949	1,951
4/2-4/8	0	4	629	475	51	2,133	3,292
4/9-4/15	0	1	316	324	8	52	701
4/16-4/22	0	0	31	309	13	0	353
4/23-4/29	0	0	22	320	22	2	366
4/30-5/6	0	0	11	206	20	0	237
5/7-5/13	0	0	4	66	6	0	76
5/14-5/20	0	0	0	22	5	0	27
5/21-5/27	0	0	1	21	3	0	25
5/28-6/3	0	0	0	6	4	0	10
Total	74	11,749	2,293	2,190	179	266,668	283,153

Note: Unassigned life stage includes plus-counts.

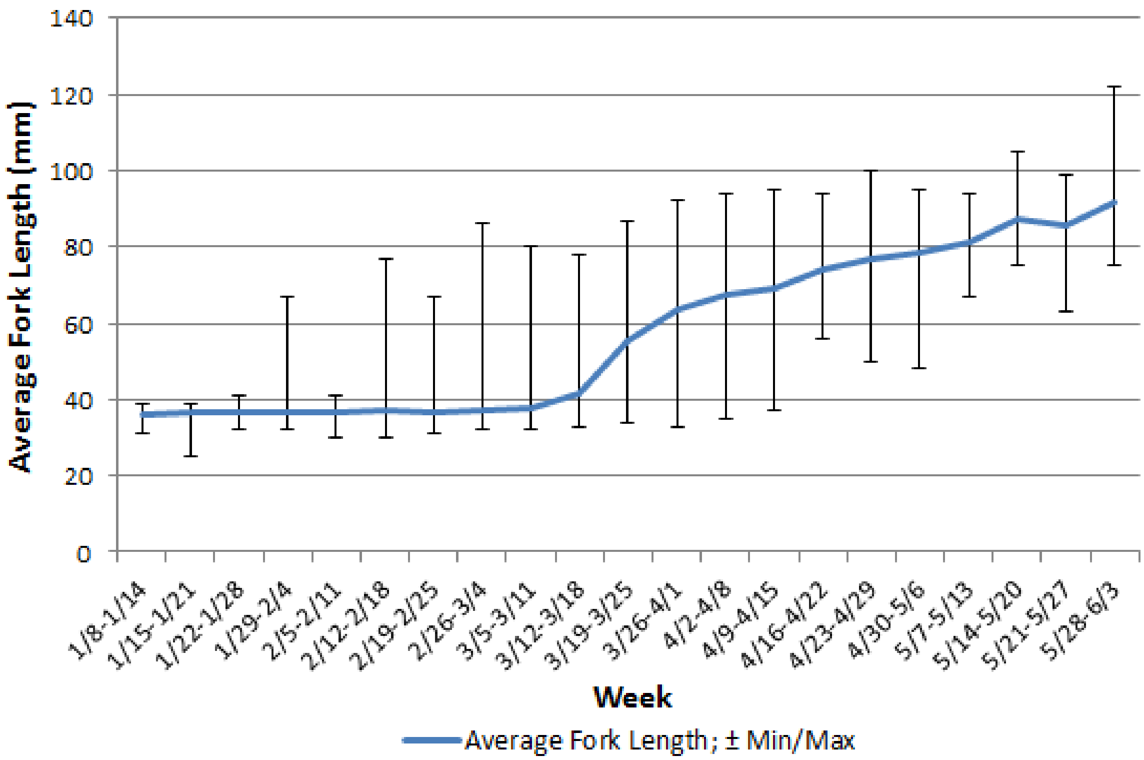
Figure 5: Weekly catch distribution of in-river produced, unmarked fall-run Chinook salmon during the 2015 lower American River rotary screw trap survey season.



Note: Plus-counted Chinook salmon and mortalities are included in the graph.

Of the 283,153 in-river produced, unmarked fall-run Chinook salmon captured in the 2015 survey season, 16,485 were assessed for life stage and measured for fork length. Salmon identified with a life stage of yolk-sac fry comprised 0.44 percent (n = 74) of that total, and fry made up 71.27 percent (n = 11,749). Salmon identified with a life stage of parr were 13.91 percent (n = 2,293), silvery parr made up 13.28 percent (n = 2,190), and smolts comprised 1.09 percent (n = 179). Average weekly fork lengths of juvenile fall-run Chinook salmon stayed consistent from the start of the season on 8 January 2015 until 11 March 2015, varying by no more than a millimeter from the first week of the season (36 mm) to the week of 5 March 2015 – 11 March 2015 (37 mm). There was a brief transition period during the week of 12 March 2015 – 18 March 2015, after which, fork lengths of measured salmon increased substantially to reach an average weekly fork length of 92 mm by the last week of the season (Figure 6 and Table 3). A total of 266,668 fall-run Chinook salmon were plus-count tallies. Both the plus-count total and the measured totals included mortalities.

Figure 6: Average weekly fork length for fall-run Chinook salmon during the 2015 lower American River rotary screw trap survey season.



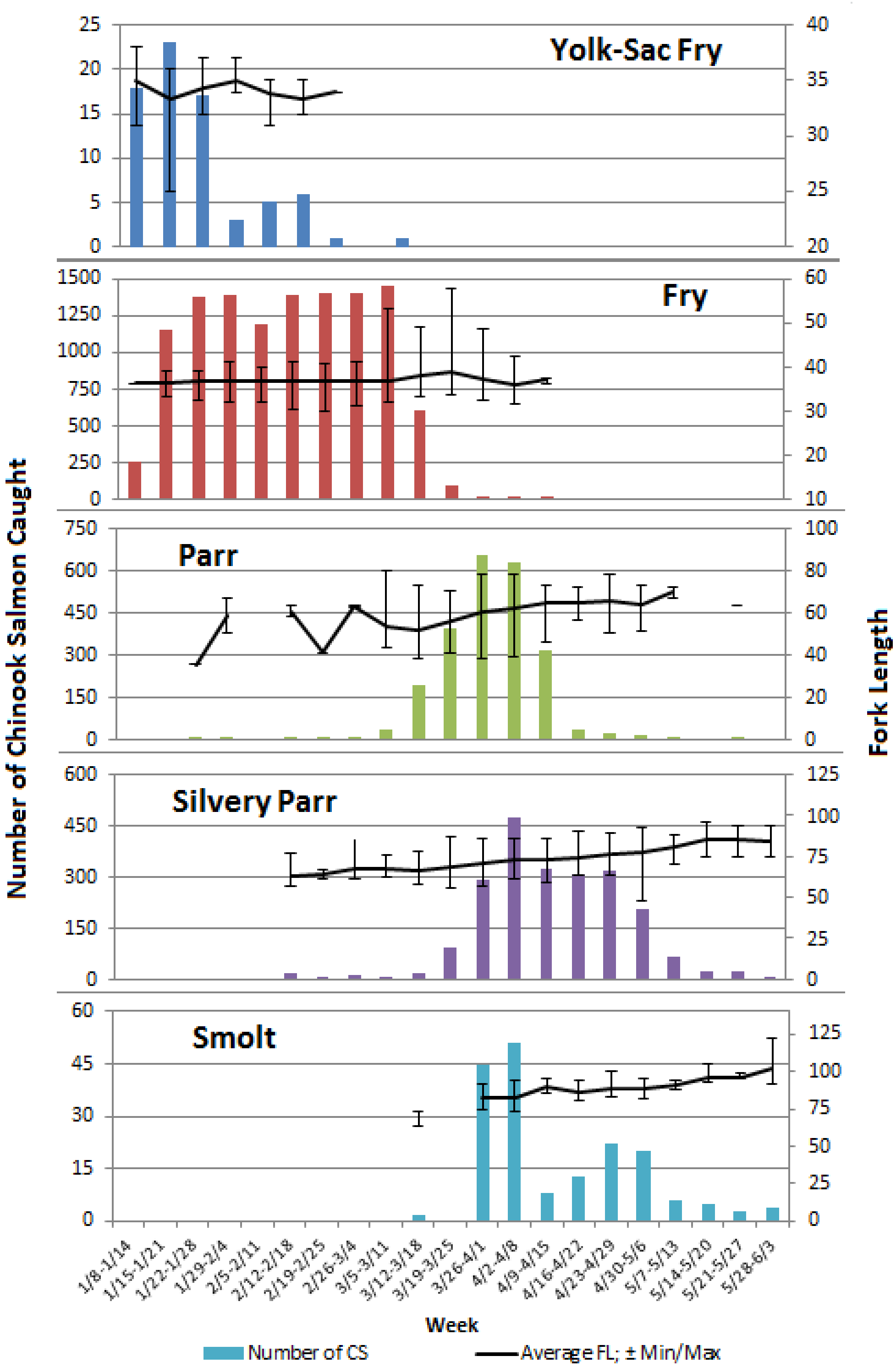
Note: Plus-counted fall-run Chinook salmon are not included in the graph.

Table 3: Average, minimum, maximum and standard deviation fork lengths per week for fall-run Chinook salmon during the 2015 lower American River rotary screw trap survey season.

Julian Week	Fork Length Average	Min	Max	St. Dev.
1/8-1/14	36	31	39	1.45
1/15-1/21	36	25	39	1.20
1/22-1/28	37	32	41	1.20
1/29-2/4	37	32	67	1.52
2/5-2/11	37	30	41	1.37
2/12-2/18	37	30	77	3.43
2/19-2/25	37	31	67	2.13
2/26-3/4	37	32	86	3.33
3/5-3/11	37	32	80	3.86
3/12-3/18	42	33	78	8.15
3/19-3/25	55	34	87	10.60
3/26-4/1	64	33	92	9.27
4/2-4/8	67	35	94	8.26
4/9-4/15	69	37	95	6.67
4/16-4/22	74	56	94	5.76
4/23-4/29	77	50	100	6.26
4/30-5/6	78	48	95	7.07
5/7-5/13	81	67	94	5.83
5/14-5/20	87	75	105	6.90
5/21-5/27	86	63	99	7.79
5/28-6/3	92	75	122	13.39

Juvenile fall-run Chinook salmon identified as yolk-sac fry and fry life stages were caught from the start of the survey season, with the last yolk-sac fry captured on 10 March 2015, and the last fry captured on 9 April 2015. Parr were captured between 26 January 2015 and 27 May 2015. Silvery parr and smolts were caught up to the end of the survey season, with the first silvery parr captured on 12 February 2015, and the first smolt captured on 13 March 2015 (Figure 7). The fork length distributions of the measured juvenile fall-run Chinook salmon caught varied by life stage (Figure 8 and Table 4), and increased in range from life stage to life stage. Yolk-sac fry had a fork length distribution between 25 mm and 38 mm, and fry were between 30 mm and 57 mm. Parr and silvery parr had the most similar width of ranges with parr between 35 mm and 80 mm, and silvery parr between 48 mm and 96 mm. Smolts had the widest range of sizes with fork lengths between 63 mm and 122 mm (Figure 9 and Table 5).

Figure 7: Weekly fall-run Chinook salmon catch by life stage with average weekly fork lengths during the 2015 lower American River rotary screw trap survey season.

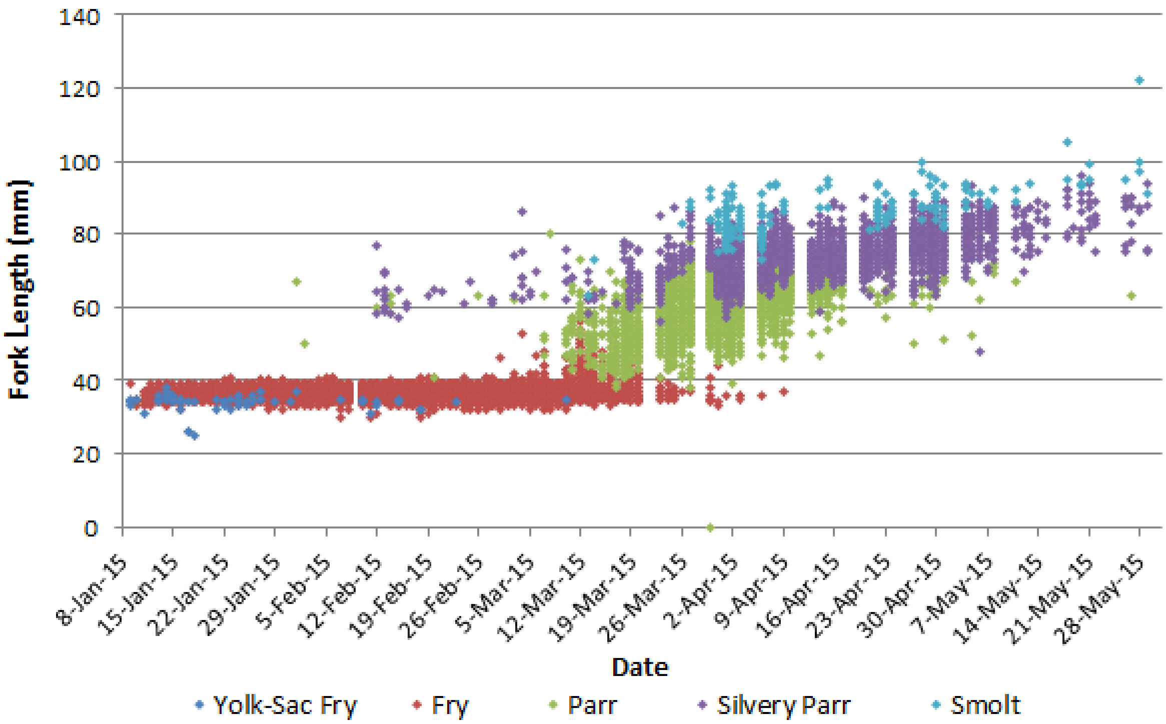


Note: Plus-counted fall-run Chinook salmon are not included in the graph.

Table 4: Average, minimum, maximum fork lengths per week for each stage of fall-run Chinook salmon during the 2015 lower American River rotary screw trap survey season.

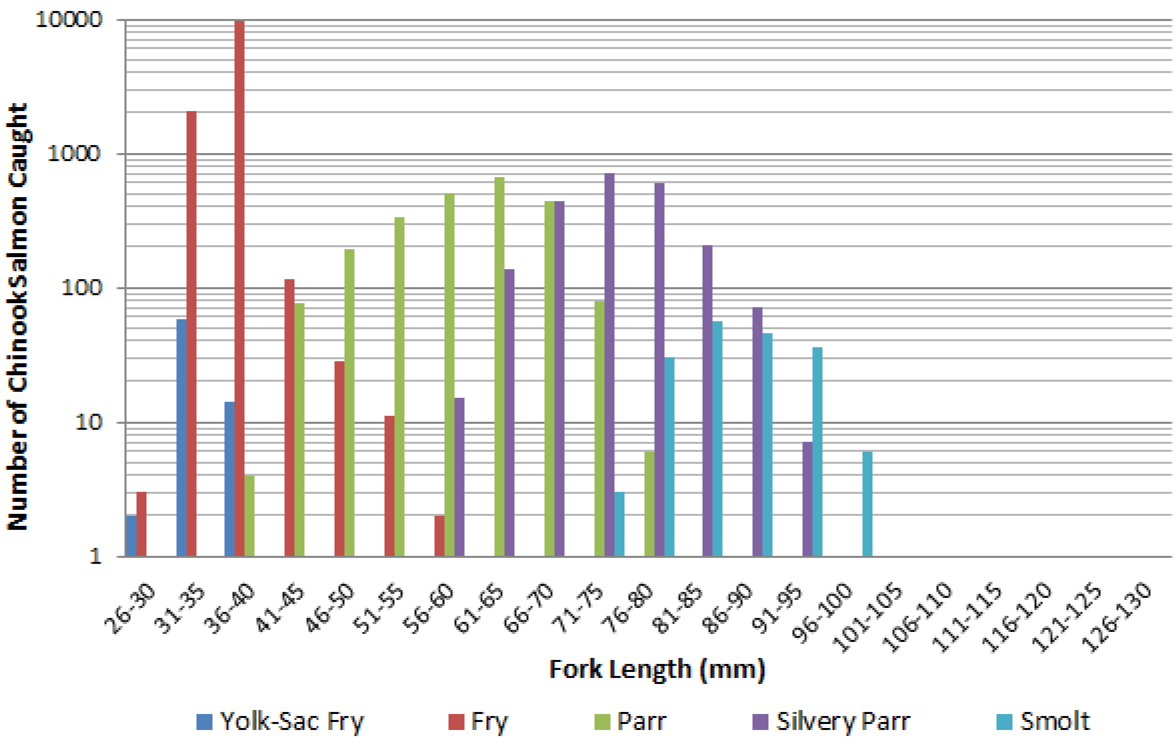
Julian Week	Yolk-Sac Fry			Fry			Parr			Silvery Parr			Smolt		
	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
1/8-1/14	35	31	38	36	33	39									
1/15-1/21	33	25	36	36	32	39									
1/22-1/28	34	32	37	37	32	41	35	35	35						
1/29-2/4	35	34	37	37	32	40	59	50	67						
2/5-2/11	34	31	35	37	30	41									
2/12-2/18	33	32	35	37	30	41	61	58	63	63	57	77			
2/19-2/25	34	34	34	37	31	41	41	41	41	64	61	67			
2/26-3/4	0	0	0	37	32	53	63	62	63	68	61	86			
3/5-3/11	35	35	35	37	32	48	53	43	80	68	62	76			
3/12-3/18				38	33	57	52	38	73	67	58	78	68	63	73
3/19-3/25				39	34	50	56	41	70	69	56	87			
3/26-4/1				37	33	44	60	38	78	71	57	86	83	75	92
4/2-4/8				36	35	36	62	39	78	73	61	86	83	73	94
4/9-4/15				37	37	37	65	46	73	74	59	86	90	86	95
4/16-4/22							64	56	72	75	63	90	86	81	94
4/23-4/29							66	50	78	77	63	89	89	83	100
4/30-5/6							64	51	73	78	48	93	89	82	95
5/7-5/13							70	67	72	81	70	88	91	88	94
5/14-5/20										85	75	96	96	93	105
5/21-5/27							63	63	63	85	75	94	96	95	99
5/28-6/3										84	75	94	103	91	122

Figure 8: Daily fall-run Chinook salmon fork lengths during the 2015 lower American River rotary screw trap survey season.



Note: Plus-counted fall-run Chinook salmon are not included in the graph. Gaps indicate weekends when no sampling occurred.

Figure 9: Distribution of fall-run Chinook salmon life stage by fork length during the 2015 lower American River rotary screw trap survey season.



Note: Plus-counted fall-run Chinook salmon are not included in the graph. Since the *y*-axis scale is logarithmic, fork length categories containing only one salmon are not shown in the graph. These are listed as follows: one fall-run Chinook salmon parr was captured at 35 mm, one silvery parr was captured at 48 mm, one silvery parr was captured at 96 mm, one smolt was captured at 63 mm, one smolt was captured at 105 mm, and one smolt was captured at 122 mm.

Table 5: Distribution of fall-run Chinook salmon life stage by fork length size class during the 2015 lower American River rotary screw trap survey season

Fork Length Size Class	Yolk-Sac	Fry	Parr	Silvery Parr	Smolt
26-30	2	3	0	0	0
31-35	57	2046	1	0	0
36-40	14	9543	4	0	0
41-45	0	116	75	0	0
46-50	0	28	193	1	0
51-55	0	11	332	0	0
56-60	0	2	501	15	0
61-65	0	0	656	136	1
66-70	0	0	445	445	0
71-75	0	0	79	710	3
76-80	0	0	6	597	30
81-85	0	0	0	207	55
86-90	0	0	0	71	46
91-95	0	0	0	7	36
96-100	0	0	0	1	6
101-105	0	0	0	0	1
106-110	0	0	0	0	0
111-115	0	0	0	0	0
116-120	0	0	0	0	0
121-125	0	0	0	0	1
126-130	0	0	0	0	0

For fall-run Chinook salmon captured in the 2015 survey season, Fulton's condition factor (K) (Appendix 5) displayed an overall trend line with a positive slope of 0.0022, implying a slightly increasing trend in condition throughout the season. The condition factors of each life stage had positively sloped trend lines as well; fall-run Chinook salmon identified as a fry life stage showed the greatest increase in condition with a trend line slope of 0.0024, smolt had a trend line slope of 0.0019, silvery parr had a trend line slope of 0.0017, and parr displayed the smallest increase with a trend line slope of 0.0005.

Trap Efficiency

Eleven mark-recapture trap efficiency trials using 19,503 fall-run Chinook salmon were conducted throughout the 2015 survey season (Table 6). Of those salmon, 15,557 were in-river produced salmon that were collected with the RSTs and marked with BBY whole body stain. The remaining salmon (3,946) were from Nimbus Hatchery and marked on the anal fin with a photonic marking gun. A total of 3,670 released salmon was recaptured. The average fork length of released vs. recaptured fish varied by as little as 0.1 mm in some trials to as much as 7.3 mm in other trials. The average trap efficiency for the 11 trials was 16.85 percent (Table 6).

Table 6: Trap efficiency data for mark and recapture trials during the 2015 lower American River rotary screw trap survey season.

Date	Fish Production	Mark Color	Total #	Release ID Code	Date	Time	Average FL (mm)	Total Released	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total Recaptured	Average FL (mm)	Trap Efficiency	FLOW (CFS) Day of Release
BBY STAINING					RELEASE				RECAPTURES for All Traps Combined							RECAPTURE SUMMARY			
1/27/2015	In-River	Yellow	537	284	1/28/2015	5:21 PM	37.000	510	109	3	0	0	0	0	0	112	36.741	21.96%	900
2/3/2015	In-River	Yellow	3010	285	2/4/2015	5:28 PM	36.660	2962	524	11	17	1	0	0	0	553	37.009	18.67%	850
2/10/2015	In-River	Yellow	3000	286	2/11/2015	5:35 PM	36.885	2956	497	25	6	1	1	0	0	530	37.013	17.93%	890
2/17/2015	In-River	Yellow	3000	287	2/18/2015	5:48 PM	36.885	2938	549	9	3	0	0	0	0	561	36.788	19.09%	860
2/24/2015	In-River	Yellow	3000	288	2/25/2015	5:47 PM	36.770	2963	684	16	1	0	0	0	0	701	36.977	23.66%	819
3/3/2015	In-River	Yellow	3000	289	3/4/2015	6:00 PM	36.810	2983	707	18	0	0	0	0	0	725	36.954	24.30%	800
3/10/2015	In-River	Yellow	376	290	3/11/2015	6:58 PM	37.810	245	31	3	0	0	0	0	0	34	36.971	13.88%	839
PHOTONIC MARKING					RELEASE				RECAPTURES							RECAPTURE SUMMARY			
3/27/2015	Hatchery	Pink	1000	291	3/30/2015	7:27 PM	58.31	1000	191	34	2	0	0	0	1	228	60.76	22.80%	506
4/10/2015	Hatchery	Green	1000	292	4/13/2015	7:39 PM	70.10	999	71	7	0	0	0	0	0	78	69.36	7.81%	489
4/24/2015	Hatchery	Pink	1000	293	5/4/2015	8:00 PM	80.19	995	75	0	0	0	0	0	0	75	87.49	7.54%	1000
5/15/2015	Hatchery	Green	958	294	5/18/2015	8:13 PM	98.59	952	71	2	0	0	0	0	0	73	100.33	7.67%	1210

Note: Fall-run Chinook salmon were used for all the salmon 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.
Flow (CFS) is a daily average discharge from the USGS's American River Fair Oaks monitoring station, 21 rkm upstream of the American River RSTs on the day of the trap efficiency release.

Passage Estimate for Fall-Run Chinook salmon

In the 2015 survey season, 1,464,697 fall-run Chinook were estimated to have emigrated past the rotary screw trap location on the lower American River; the 95 percent confidence interval for the point estimate was from 1,412,787 to 1,668,506 individuals. Estimated passage down the lower American River by life stage was 1,388,117 fry (including both yolk-sac fry and button-up fry life stages), 73,813 parr (including both parr and silvery parr life stages), and 2,722 smolts. Figure 10 and Table 7 compare weekly passage estimates to weekly discharge at the USGS monitoring station at Fair Oaks.

Figure 10: Weekly passage estimate of fall-run Chinook salmon and weekly discharge at Fair Oaks during the 2015 lower American River rotary screw trap survey season.

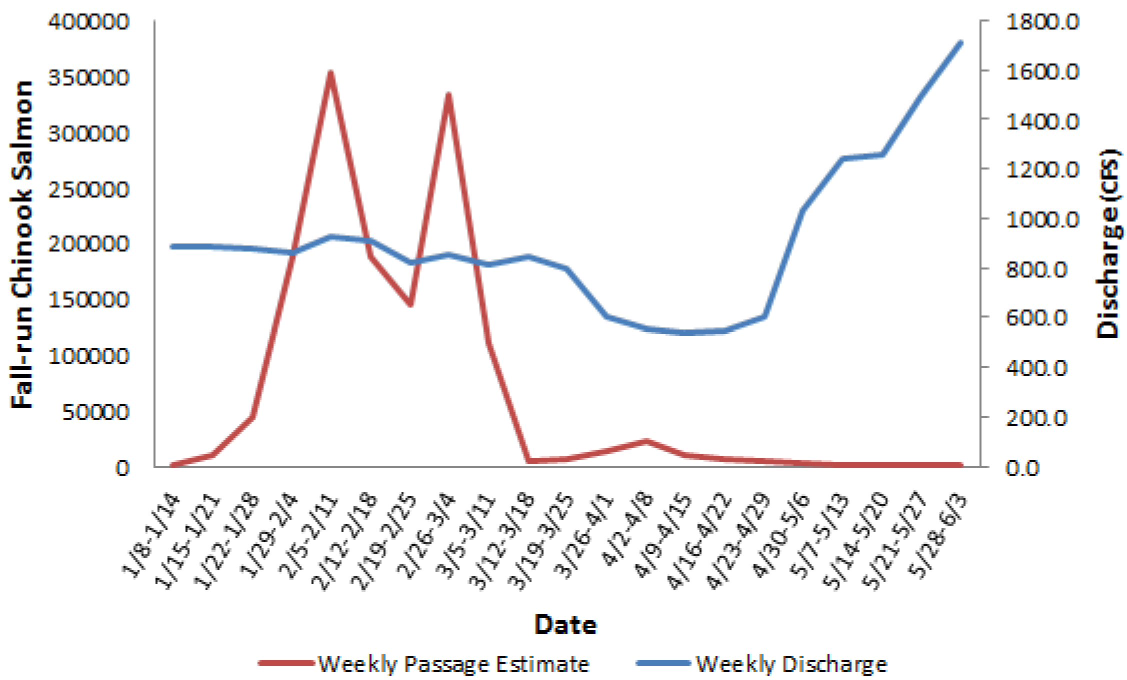


Table 7: Weekly passage estimate of fall-run Chinook salmon and weekly discharge at Fair Oaks during the 2015 lower American River rotary screw trap survey season.

Date	Discharge (CFS)	Passage Estimate
1/8-1/14	885	1,744
1/15-1/21	887	9,559
1/22-1/28	877	44,098
1/29-2/4	864	188,155
2/5-2/11	925	353,347
2/12-2/18	912	187,475
2/19-2/25	824	145,099
2/26-3/4	850	334,170
3/5-3/11	816	110,438
3/12-3/18	845	4,411
3/19-3/25	794	5,603
3/26-4/1	605	12,824
4/2-4/8	555	22,465
4/9-4/15	542	9,140
4/16-4/22	546	5,645
4/23-4/29	602	4,317
4/30-5/6	1,029	3,146
5/7-5/13	1,241	1,270
5/14-5/20	1,254	922
5/21-5/27	1,491	221
5/28-6/3	1,714	62

Genetic Analysis

A total of 152 juvenile Chinook salmon was genetically sampled during the 2015 field season. Of those salmon, four were adipose fin-clipped hatchery produced salmon classified as winter-run Chinook salmon using the LAD criteria. The remaining 148 samples were taken from salmon that did not have an adipose fin clip, and were therefore presumed to be of in-river production.

The SNP panel's "Genetic Call to three lineages" probabilities for each of the 148 samples that were taken from in-river produced Chinook salmon exceeded a 50 percent threshold; the final salmon run assignments for those 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.

Genetic samples were taken from 28 of the 30 in-river produced Chinook salmon that were classified as winter-run by LAD criteria. Analyses using SNP genetic markers from those 28 samples indicate 22 of those individuals were winter-run Chinook salmon, three individuals were fall-run Chinook salmon, one individual was a spring-run Chinook salmon that likely originated from Butte Creek*, and two individuals were spring-run Chinook salmon that may have originated from either Mill or Deer Creek* (Table 8).

A total of 103 genetic samples were taken from the 698 Chinook salmon classified as spring-run Chinook salmon using LAD criteria. Analyses using SNP genetic markers from these samples indicated 89 of these individuals were fall-run Chinook salmon, four were winter-run Chinook salmon, and 10 were spring-run Chinook salmon that likely originated from Butte creek (Table 8).

Before 26 February 2015, 13 of the 30 (43.3 percent) genetically assessed salmon classified as spring-run Chinook using the LAD criteria were also determined to be spring-run Chinook using the SNP genetic markers (Table 8). Because the LAD criteria appeared to produce more accurate spring-run assignments before 26 February 2015 than after, non-assessed salmon classified in the field as spring-run salmon before 26 February 2015 were given a final run assignment that was prorated proportionally by the genetic run assignments of genetically assessed LAD spring-run salmon captured on the same day. For example, on 13 February 2015, 12 LAD spring-run Chinook salmon were caught. Four were sampled for genetic analysis and determined to consist of one putative spring-run and three putative fall-run. The eight unsampled LAD spring-run captured on that day were thus given final run assignments to reflect these proportions such that two were given a final run assignment of spring-run, and six were given a final run assignment of fall-run. A total of 15 salmon that were captured before 26 February 2015 were given a final run assignment using this approach; 10 were given a final run assignment of fall-run, and five were given a final run assignment of spring-run.

After 26 February 2015, 98.6 percent (n = 72) of the 73 genetically assessed salmon classified as spring-run Chinook using the LAD criteria were determined to be fall-run Chinook by genetic analysis (Table 8). Because the LAD criteria appeared to incorrectly assign salmon runs at a high frequency after 26 February 2015, all the LAD spring-run Chinook salmon that were captured after 26 February 2015 and that were not genetically assessed were given a final-run assignment of fall. This resulted in 590 LAD spring-run Chinook salmon that were captured after 26 February 2015 being given a final run assignment of fall.

Seventeen salmon classified as fall-run Chinook salmon using LAD criteria were also sampled for genetic analysis. Analyses using SNP genetic markers from these samples indicated 16 of these individuals were fall-run Chinook salmon, and one individual was a spring-run Chinook salmon of unknown origin (Table 8)

*Butte Creek, Mill Creek, and Deer Creek are located in the northern portion of the Sacramento Valley, and are tributaries to the Sacramento River.

Table 8: Comparison of Chinook salmon run assignments using length-at-date (LAD) criteria and SNP genetic markers. The table only includes Chinook salmon of unknown production (potentially hatchery produced or in-river produced), i.e., it does not include salmon with an adipose fin clip, which are known to be hatchery produced.

	Genetic salmon run assignment based on a >50 percent genetic probability threshold				
LAD salmon run assignment	Fall	Spring (Butte Creek)	Spring (Mill/Deer Butte Creek)	Spring (unknown origin)	Winter
Fall	16	0	0	1	0
Spring (before Feb 26th)	17	10	0	0	3
Spring (after Feb 26th)	72	0	0	0	1
Winter	3	1	2	0	22

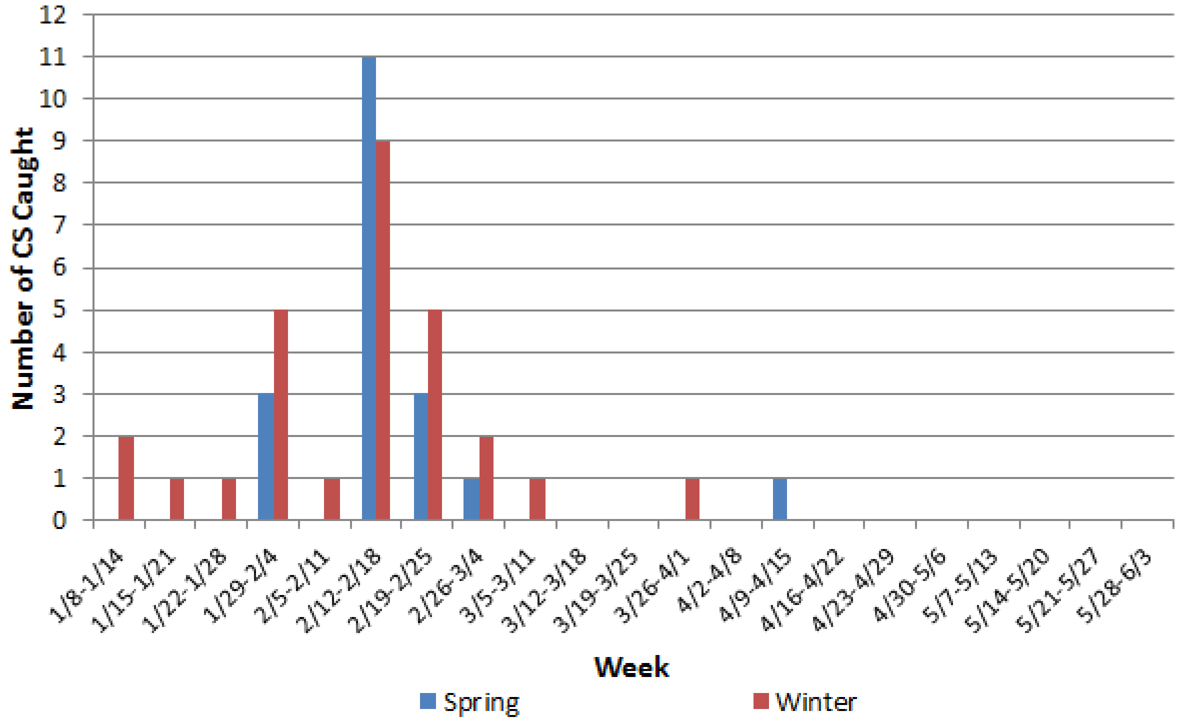
Spring- and Winter-run Chinook salmon

The genetic analyses suggest that 28 in-river produced winter-run Chinook salmon were captured during the 2015 survey season (Figure 11). Those salmon include the 26 winter-run Chinook salmon in Table 8 that were identified with genetic samples, and 2 salmon that were not identified with genetic samples, but were identified using LAD criteria. Those salmon were captured from 11 January 2015 to 26 March 2015 and consisted of two parr, 20 silvery parr, and six smolts.

The genetic analyses and proration of the unsampled Chinook salmon that were classified as spring-run Chinook salmon using the LAD criteria suggest 19 putative spring-run Chinook salmon were captured from 30 January 2015 to 15 April 2015 (14 salmon based on the SNP genetic markers and five salmon based on the prorated unsampled salmon; Figure 11). Eighteen of the 19 putative spring-run Chinook salmon were identified to life stage. These consisted of six parr, 11 silvery parr, and one smolt.

Fifteen adipose clipped hatchery produced LAD winter-run Chinook salmon were captured during the 2015 survey season, and four of those individuals were sampled for genetics analyses and were determined to be winter-run Chinook salmon. One LAD spring-run adipose clipped hatchery produced Chinook salmon was captured as well.

Figure 11: Weekly catch totals of spring- and winter-run Chinook salmon during the 2015 lower American River rotary screw trap survey season.



Late-fall-run Chinook salmon

Only four late-fall-run Chinook salmon were captured during the 2015 survey season, according to LAD criteria. These individuals were captured on 13 April 2015, 17 April 2015, 6 May 2015, and 20 May 2015. All four were fry, with fork lengths ranging from 33 to 37 mm.

Steelhead/Rainbow Trout

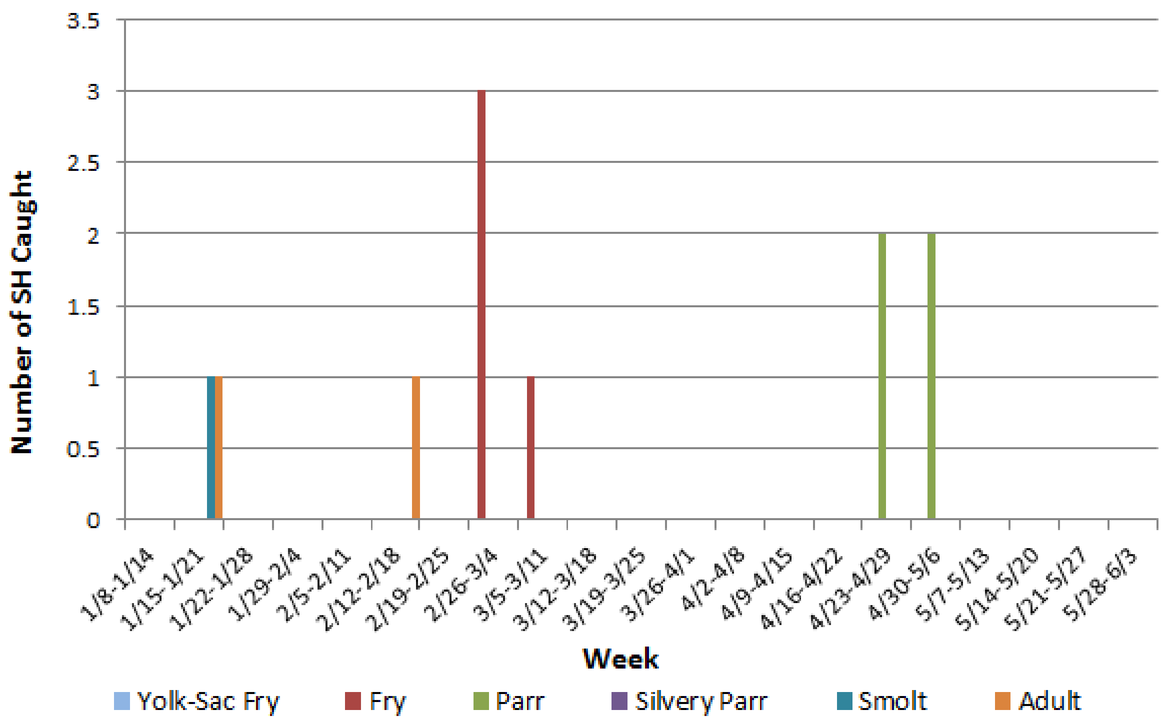
The rotary screw traps captured 11 in-river produced steelhead during the 2015 survey season. The life stage composition of captured steelhead consisted of four fry, four parr, one smolt, and two adults (Table 9 and Figure 12).

Table 9: Weekly catch totals by life stage for in-river produced steelhead during the 2015 lower American River rotary screw trap survey season.

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

Note: No plus-counted steelhead or mortalities were captured.

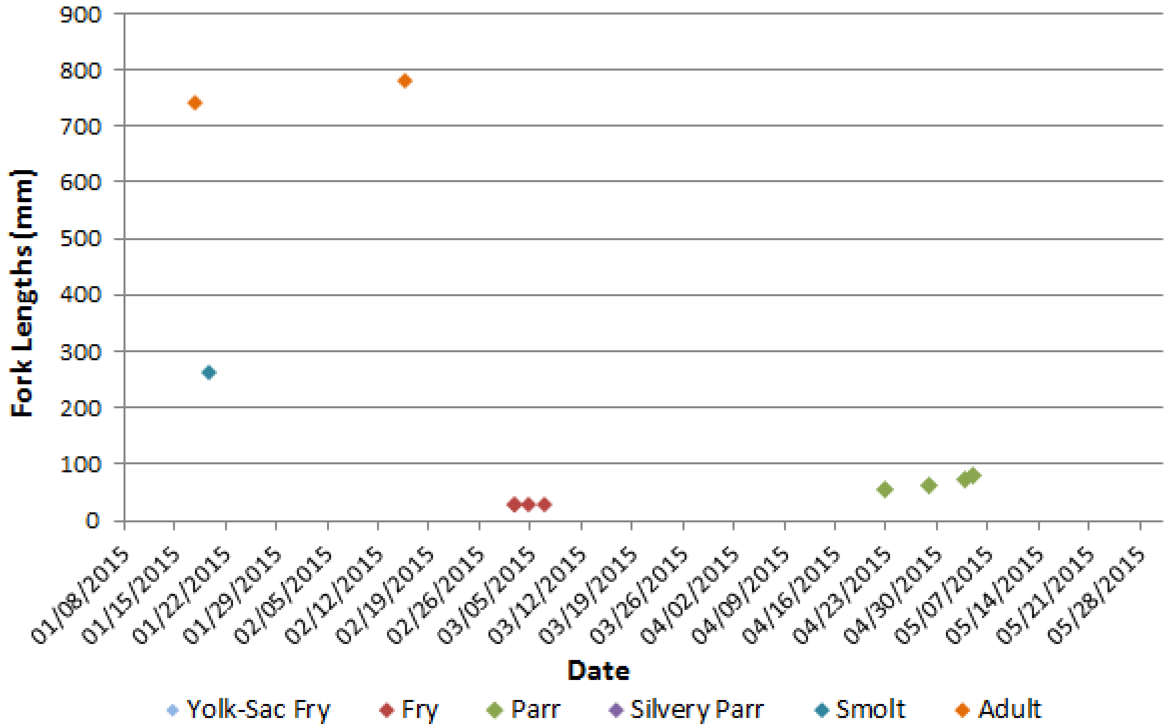
Figure 12: Weekly catch totals by life stage for in-river produced steelhead during the 2015 lower American River rotary screw trap survey season.



Note: No plus-counted steelhead or mortalities were captured.

All four of the in-river produced steelhead fry had fork lengths of 27 mm, with two captured on 3 March 2015, one captured on 5 March 2015, and one captured on 7 March 2015 (Figure 12). The parr were captured on 23 April 2015, 29 April 2015, 4 May 2015, and 5 May 2015, had fork lengths of 54 mm, 61 mm, 73 mm, and 80 mm, respectively. The smolt was captured on 20 January 2015 and had a fork length of 262 mm. The adults were captured on 18 January 2015 and 16 Feburary 2015, with fork lengths of 740 mm and 780 mm, respectively (Figure 12-13). No in-river produced steelhead were identified as yolk-sac fry or silvery parr.

Figure 13: Individual fork lengths by date for in-river produced steelhead captured during the 2015 lower American River rotary screw trap survey season.



Note: No plus-counted steelhead or mortalities were captured.

Three hatchery produced steelhead were also captured. One was a brood year 2014 (BY 2014) yearling hatchery steelhead marked by the Nimbus Fish Hatchery with adipose and left pelvic fin clips. This fish was captured 29 January 2015, identified as a silvery parr and had a fork length of 280 mm. The other two were marked only with an adipose fin clip and were captured on 9 January 2015, and 15 February 2015. These were identified, respectively, as an adult hatchery produced steelhead with a fork length of 685 mm and a smolt with a fork of length 232 mm.

Non-salmonid Species

In addition, a total of 6,139 non-salmonid fish was captured during the 2015 survey season. The majority (n = 5,943, or 97%) of these fish belonged to 23 identifiable, non-salmonid species in the following families: *Acipenseridae* (sturgeon), *Atherinopsidae* (silverside), *Catostomidae* (sucker), *Centrarchidae* (sunfish/black bass), *Clupeidae* (shad), *Cottidae* (sculpin), *Cypinidae* (minnow), *Embiotocidae* (Tule perch), *Gasterosteidae* (stickleback), *Ictaluridae* (bullhead/catfish), *Moronidae* (striped bass), *Osmeridae* (smelt), *Petromysontidae* (lamprey), and *Poeciliidae* (mosquitofish) (Figure 14). The remaining 196 individuals were not able to be identified to species level, but belonged to the following families: *Petromyzontidae*, *Cyprinidae*, *Cottidae*, and *Centrarchidae*. Individuals of species native to Central Valley watersheds comprised 78.5 percent (n = 4,828) of that total, and non-native individuals made up only 18.1 percent (n = 1,115). A complete list of non-target species captured in the 2015 survey season is presented in Appendix 3.

Of the 6,139 non-salmonid fish, 957 (15.6%) were lampreys. Individuals identified as Pacific lamprey made up 62.2 percent (n = 595) of these, and river lamprey comprised 21.6 percent (n = 207). The remaining 16.2 percent (n = 155) were either ammocoetes or were otherwise unidentifiable to the species level. Both identified species of lamprey were caught throughout the season, with peaks in catch occurring in the week from 5 February 2015 to 11 February 2015, and in the week from 2 April 2015 to 8 April 2015 (Figure 15). Pacific lamprey catch peaked twice, with 39.8 percent (n = 237) of the entire season's Pacific lamprey catch occurring on 8 April 2015 and 15.8 percent (n = 94) occurring on 9 February 2015. River lamprey catch peaked on 9 February 2015, when 10.6 percent (n = 22) of the season's river lamprey catch were captured.

Figure 14: Non-salmonid catch totals for fish species collected during the 2015 lower American River rotary screw trap survey season.

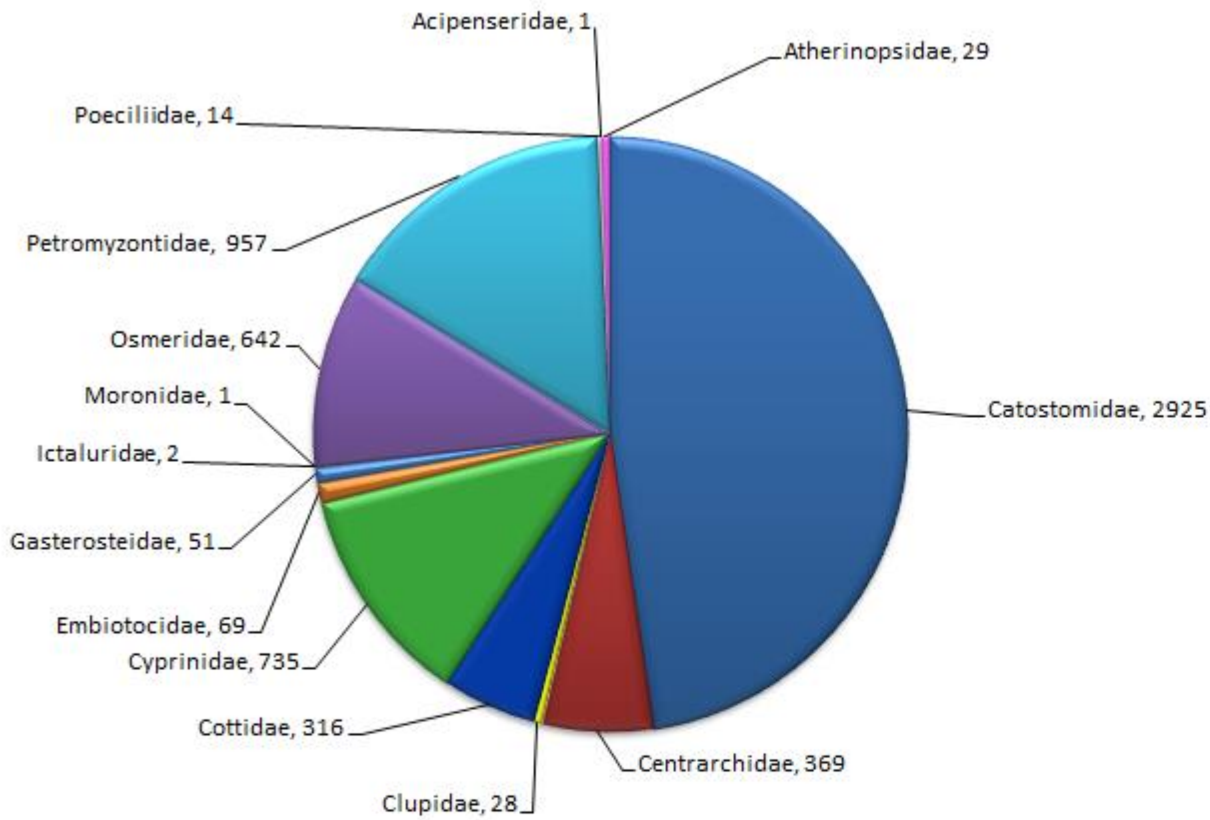
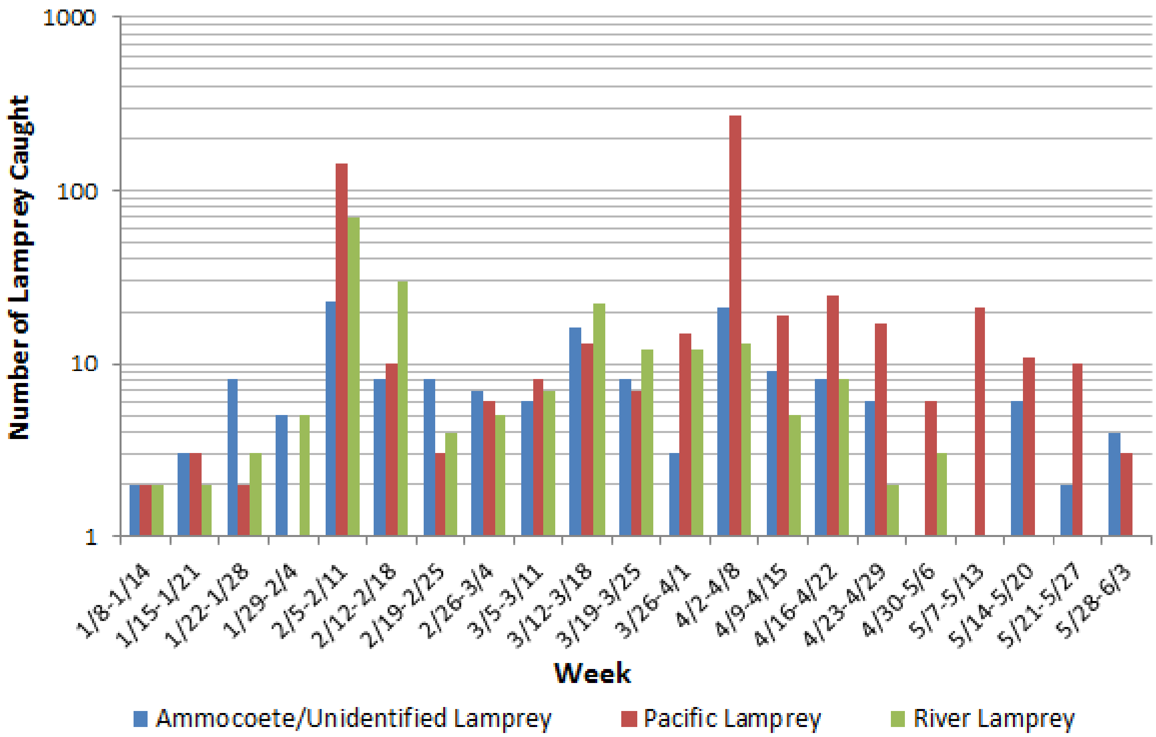


Figure 15: Total weekly lamprey catch during the 2015 lower American River rotary screw trap survey season.



Note: Since the scale is logarithmic, date ranges containing only one individual are not shown in the graph. These are listed as follows: one ammocoete/unidentified lamprey was captured on 5 May 2015 and one was captured on 8 May 2015. One Pacific lamprey was captured on 1 February 2015. One river lamprey was captured on 18 May 2015 and one was captured on 21 May 2015.

One juvenile white sturgeon was also captured during the 2015 survey season. This individual (Figure 16) was captured on 15 February 2015, with a total length of 161 mm.

Figure 16: Juvenile white sturgeon captured in the lower American River rotary screw traps. (1) Lateral view. (2) Ventral view.

Discussion

The 2015 lower American River rotary screw trap survey season did not encompass the entire juvenile Chinook salmon emigration period, but it appears to have encompassed the vast majority of the period when almost all the juvenile Chinook salmon emigrated from the primary salmonid production area. Chinook salmon were present in the catch from the first day of sampling until the final day of the survey season. Our data suggest that only a relatively small percentage of the emigration was not surveyed due to the low catch numbers at the beginning and the end of the season. To confirm that the entire emigration period is sampled, there should be multiple weeks of zero catch before the first and after the last Chinook salmon are captured in a given season. The 2015 survey was concluded before the end of emigration due to increasing water temperatures towards the end of May. Warm water temperatures limit the amount of time Chinook salmon can safely be handled. Nevertheless, the 2015 RST survey on the lower American River produced a high quality data set since no substantial logistical or environmental factors hindered the collection of data during the 5-month sampling period.

During the 2015 season, environmental factors on the American River stayed relatively steady in comparison to the previous seasons. Outflows from Nimbus Dam started at 1,000 CFS in November 2014 to 850 CFS in March 2015. Discharge finally fell to 500 CFS March 26th 2015, but by this time, the majority of fry were already caught, typically signifying the end of emergence from the redds. Water temperatures at Fair Oaks were optimal for growth throughout the period when salmon were rearing and the smolt life stage was present. American River temperatures and flow/discharge in 2015 were fairly identical to the 2014 survey season. Fork lengths on average were 10 to 15 mm higher than in April and May of the two prior years' surveys. This may have been due to optimal water temperatures and good food source in the river to support high growth rate (Marin and Cech 2004).

However, the 2015 survey season's passage estimate of 1,464,697 fall-run Chinook salmon reflects a 16 percent drop from the 2014 season's passage estimate of 1,734,687 salmon. This is the third consecutive year of decreasing juvenile salmon passage at the lower American River RSTs. Causal factors may be related to the ongoing statewide drought California has experienced since 2012, or may be related to a decreasing number of adults returning to the lower American River compared to the 2012-2013 and 2014-2015 survey seasons.

California Department of Fish and Wildlife surveys conducted for the American River estimated an in-river escapement of 24,503 for the 2014-2015 survey, down from 54,259 in the 2013-2014 survey (Phillips and Gahan 2014, Phillips and Kubo 2015). Because of decreased escapement in the American River, redd superimposition may have been less of a detriment to the Chinook salmon. To help tie together the relationship between escapement and juvenile outmigration, we used the escapement data in conjunction with the RST passage estimate to estimate the survival rate of fall-run Chinook salmon between the egg stage to juveniles in the American River in 2015. Using data from the salmon escapement survey that was conducted between October 2014 and January 2015 (Phillips and Kubo 2015), an estimate was produced to quantify the number of adult and grisle females present during the 2014-2015 spawning season (Appendix 8). An expanded adjusted number of females was developed for salmon observed during the 2012-2013 and 2014-2015 spawning seasons to account for the fact that subsampling of salmon typically occurred during some, but not all, the carcass survey sampling periods (PSMFC 2013, PSMFC 2014). Even though it was not necessary to develop an expanded number of females during the 2014-2015 spawning season because subsampling did not occur that field season, the same analytical approach was used all three spawning seasons to establish a standardized approach to data analysis and presentation. Appendix 9 provides tabular data quantifying the percentage of spawned, partially spawned, and unspawned females in the American River during the 2014-2015 spawning season. Appendix 10 displays values used to estimate the total number of salmon eggs produced in the American River during the 2014-2015 spawning season. Using these values, it was estimated that 67,396,366 eggs were produced by 12,429 spawned or partially spawned females on the American River. Using this estimate in conjunction with the 1,464,697 juvenile fall-run Chinook salmon passage estimate from 2015, the survival rate between the egg and combined fry/parr/smolt life stages was 2.17 percent (1,464,697 fry/parr/smolts produced / 67,396,366 eggs). The percent survival estimate assumes 100 percent of the eggs laid were viable and survived to hatching, which is unlikely, and the percent survival estimate is therefore biased in a conservative way. In comparison, the estimate of 137,008,751 eggs during the 2013-14 spawning season and a passage estimate of 1,734,684 fall-run Chinook salmon during 2014 leads to an estimate of only 1.27 percent of eggs survival for BY 2013. Gravel augmentation and enhancement projects over the last decade have likely had a positive effect on increasing areas of desired spawning substrate for Chinook salmon on the lower American River (Merz et al. 2014). The decreased potential of redd dewatering and superimposition may have likely allowed for a larger percentage of egg survival for the 2014-15 fall-run Chinook salmon.

During the 2015 RST survey season, various efforts were undertaken to reduce potential adverse effects to the fish captured in the RSTs. From 8 January 2015 to 20 March 2015, sampling occurred on a daily basis with no planned downtime. During two periods in February and early March, trap checks were also performed at night because of the potential for high debris or peak fish counts. Night checks were necessary to ensure that the traps were functioning correctly. If high debris volumes were not expected, but high fish counts were, unexpected large woody debris or a cluster of urban debris could stop the rotation of the RSTs or plug the intake of the cones. Various man-made items have been trapped by the cones in recent trapping seasons, e.g., basketballs and volleyballs, temporary road barriers and cones, various building and construction debris, wooden pallets, etc. All of these items can and have caused various issues for trap operations and the ability to reliably catch fish. If any of these items were to become lodged in the trap overnight and were not immediately remedied, a large portion of the catch could be killed as fish continued to be entrained into the cones.

After 20 March 2015, traps were taken off-line on weekends due to warming water temperatures in the lower American River. Increased handling and other interactions with salmonids when water temperatures exceed 18°C can cause additional fish stress and mortality (Poole et al. 2001). To reduce potential stresses that might be incurred as rotary screw trap operations on the American River occurred, the field crew opted to perform twice daily trap checks during the weekdays. This lessened the exposure time of fish in the live well, and made for a more manageable number of fish to be worked up during each trap check when ambient air temperatures exceeded 26.7 °C.

As was the case during the 2013 and 2014 field seasons, non-natal winter-run Chinook salmon and putative spring-run Chinook salmon were captured in the American River RSTs during the 2015 field season. True winter- and spring-run Chinook salmon likely originated from the Sacramento River and its upper watershed tributaries. The mainstem Sacramento River above Red Bluff provides spawning habitat for winter-run Chinook salmon. Tributaries to the Sacramento River like Mill, Deer, and Butte creeks have genetically unique spring-run Chinook salmon (Yoshiyama 2001). Prior to March during the 2015 emigration season, strong storms in the upper Sacramento River watershed area caused water from the Sacramento River to back up at least 8 miles into the lower American River, where the rise in water was measured at the H Street USGS staff gauge. Stream and river flow levels in the Sacramento River watershed rose rapidly during storms, which coincided with winter- and spring-run juvenile downstream movement. When such pulses of river flow reach the lower American River, Chinook salmon emigrating within that pulse may venture upstream into the American River as the river backflows (Maslin et al. 1998). Typically around and after these flow events, winter- and spring-run Chinook salmon are captured by the rotary screw traps and their presence and identity in the lower American River is confirmed with genetic markers. Winter- and spring- run Chinook salmon may be captured over a week after the waters recede from the Sacramento River, possibly due to feeding and establishment of territories in the American River (Martin et al. 2001).

As with previous years of above normal water temperatures on the lower American River during the spring, juvenile fall-run Chinook salmon may have experienced faster-than-normal growth rates. Provided that food is not a limiting factor, the optimum growth rate in Central Valley Chinook salmon occurs around 15 to 18 degrees Celsius (Marine and Cech 2004). The lower American River at Watt Avenue averaged 15 degrees Celsius by mid-March and increased steadily to an average of 18 degrees Celsius by late April. With suitable thermal conditions, along with a typical abundance of food (Sogard et al. 2012), estimates of individual growth rates of juvenile fall-run Chinook salmon on the lower American range as high as 0.9 mm per day, which is fast growth for river rearing Chinook salmon in the Sacramento Basin (Robert Titus, CDFW, *in prep*.). Such a fast growth rate may have caused some fall-run Chinook salmon to exceed the fall-run LAD threshold and extend into the spring-run LAD criteria. This resulted in many Chinook salmon that were classified as spring-run initially using the LAD criteria and later reclassified as fall-run Chinook salmon, based on genetic analyses (PSMFC 2014).

The LAD criteria appeared to be relatively more accurate in 2015 than in previous years, however. There was concern that applying the methodology used in 2014 (i.e., giving all the unclipped LAD spring-run Chinook that were not subject to genetic analysis a final designation of fall-run) would underestimate the number of true spring-run Chinook in the lower American River in 2015. After examining the data, and because the LAD criteria appeared to be more accurate earlier in the 2015 season, unclipped LAD spring-run Chinook captured after 26 February 2015 were given a final run designation following the same method used in 2014, while final run designations of unclipped LAD spring-run Chinook captured before 26 February 2015 were determined by alternative methods. For the greatest probability of accuracy, unclipped LAD spring-run Chinook captured before 26 February 2015 were randomly assigned a final run designation to match, as nearly as possible, the proportion of final runs determined by genetic analysis on that same day.

We concluded that fork length was not a significant factor in the accuracy of LAD criteria describing genetically designated spring-run Chinook salmon. Thus fork lengths did not influence final run assignments of unclipped LAD indicated spring-run Chinook. However, fork lengths did appear to be correlated with Chinook salmon that were classified as winter-run using genetic markers but as spring-run using LAD criteria, such that only the largest fork lengths of LAD spring-run were determined by genetic analysis to actually be winter-run. Since all unclipped LAD spring-run were smaller than those determined by genetic analysis to be winter-run, no unclipped LAD spring run were given a final designation of winter-run.

A total of 16 adipose fin-clipped, hatchery produced, Chinook salmon was captured in the 2015 survey season. Fifteen of those adipose fin-clipped captures fell within the winter-run LAD criteria. The one remaining adipose fin-clipped Chinook salmon fell within the spring-run LAD criteria. Livingston Stone National Fish Hatchery (LSNFH) released a total of 612,056 BY 2014 hatchery winter-run Chinook salmon into the Sacramento River, at Cadwell Park, between 4 February 2015 and 6 February 2015. The first adipose clipped, winter-run sized Chinook salmon was captured in the lower American River RST 10 days later on 13 February 2015. As in the case of the in-river produced winter-run Chinook salmon captures, adipose clipped winter-run Chinook salmon were likely directed by the backflow of the Sacramento River into the lower American River during a storm flow pulse. The one spring-run sized, adipose fin-clipped Chinook salmon was likely an undersized winter-run LSNFH Chinook salmon from the BY 2014 release. The only likely source of adipose fin-clipped spring-run Chinook salmon would be from Feather River Hatchery (FRH); however, FRH released its first group of spring-run Chinook at Boyd’s Pump and Gridley on the Feather River just one day before the adipose fin-clipped spring-run capture on the lower American River. It is unlikely this individual fish made it from the closest release location of Boyd’s Pump and traveled 51 RM to the lower American River RST location within 24 hours. Additionally, 9 RM of that route would have been an upstream journey from the mouth of the lower American River to the traps, which would likely slow the fish’s movement considerably. On average, Central Valley Chinook salmon emigrate downstream at a rate of 7-10 RM a day, without the assistance of an increased pulse flow (Demko et al. 1998; Snider and Titus 2001).

Only nine in-river produced juvenile steelhead were captured by the lower American River RSTs in 2015. This was the lowest catch total in the last three years of RST trap operations. In previous years, there have been catches of 2,201 young of the year (YOY) steelhead in 2013, and 533 YOY steelhead in 2014. These highly variable steelhead catches could be explained by many causal factor(s): difference in trapping methods, gear size and number of traps in relation to the size of river channel, gravel augmentation activities designed to enhance spawning activities, abundance of spawning adults in-river, or the proximity of redds to the traps. Redd proximity seems to have the largest correlation to YOY steelhead catch with the RSTs. Cramer Fish Sciences performed a steelhead redd survey on the American River in 2015 and observed the lowest total number of redds since 2002. Only 69 redds were observed from 21 January 2015 to 20 March 2015 and the closest redd to the RSTs was at Gristmill Bar, roughly 2.75 RM upstream of the RSTs (Sellheim et al. 2015). In 2013, 314 redds were counted during steelhead redd surveys conducted by the Bureau of Reclamation (Hannon 2013). These differences in spawning steelhead adults may be the largest causal factor in juvenile steelhead RST catch variability from 2013 to 2015. Zero in-river produced yearling smolts were captured in the RSTs this season. In general, lower flows on the lower American River would tend to result in an increased potential to capture yearling steelhead because the traps would sample a greater proportion of the river discharge. In 2013, during the peak of the steelhead catch, Nimbus Dam discharge ranged from 2,500 to 1,200 CFS and only two in-river produced yearling steelhead were captured. In contrast, during 2014, discharge ranged from 700 to 500 CFS, resulting in the capture of 31 yearling steelhead in the RSTs. In 2015, discharge was consistently at 900 CFS during the time when yearling steelhead smolt catch numbers would typically peak, and zero were captured.

Two hatchery produced juvenile steelhead was captured by the RSTs in 2015; One of those individual was marked with an adipose and left pelvic fin clip and it was captured on 29 January 2015. In 2014, staff at the Nimbus Fish Hatchery had concerns that because of the drought, their coldwater source from Lake Natoma would be compromised by record low water levels and an ever shrinking coolwater pool in Folsom Lake. Therefore, a total of 320,039 Nimbus Hatchery BY 2014 steelhead fingerlings were evacuated from the hatchery in May and June of 2014 and released into the lower American River at the Sunrise Boulevard crossing (G. Novak, CDFW, pers. comm., 21 August 2014). These evacuated BY 2014 steelhead were given an adipose and left pelvic fin clip. The left pelvic fin clip was used as a unique identifier to the BY 2014 emergency release. The single hatchery produced steelhead yearling captured by the RSTs in 2015 lacked the adipose and left pelvic fin, thereby suggesting that this individual remained in the American River for a period of at least seven months. No hatchery produced steelhead were released into the American River during the 2015 survey season.

One white sturgeon was captured in the RSTs during the 2015 survey season, most likely the first sturgeon to ever be captured by a rotary screw trap on the American River (Robert Titus, CDFW, pers. comm., 17 February 2015). Since field crews lacked experience and training in identifying juvenile sturgeon species, Bill Poytress with the U.S. Fish and Wildlife Service's Red Bluff Fish and Wildlife Office reviewed the pictures of the sturgeon caught on 15 February 2015. Mr. Poytress manages the rotary screw trap operations at the Red Bluff Diversion Dam on the Sacramento River and has extensive experience collecting and identifying juvenile sturgeon. Based on his review of the two pictures, he concluded that the juvenile sturgeon captured in the American River RSTs was a white sturgeon based on the lack of scutes behind the dorsal fin (Bill Poytress, USFWS – Red Bluff, pers. comm., 17 February 2015). This sturgeon was likely non-natal from the mainstem Sacramento River, where white sturgeon often spawn and rear as they emigrate to the Sacramento-San Joaquin River Delta (Kohlhorst 1976). The capture coincided with the peak capture week of spring- and winter-run Chinook salmon, which also spawn on the mainstem Sacramento River. The high flow pulse on the Sacramento River that backflowed into the American River, and which may have increased winter-run Chinook salmon catches in the RST, may have also been the same driver associated with the occurrence of this white sturgeon 9 RM upstream on the American River.

Management Implication

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. The 2015 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. Water management modifications for the American River may be needed to make the river environment more favorable to anadromous fishes in years of severe drought. Management options such as modifications to discharge volume and timing could be adjusted to reduce pre-spawn mortality and minimize redd dewatering and superimposition.

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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 2015 survey season.

Week	Water Temperature °C			Discharge (CFS)			DO (mg/L)			Turbidity (NTU)		
	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max
1/8-1/14	10.4	9.7	11.2	885.4	839.0	942.0	10.2	10.1	10.4	1.4	1.1	1.9
1/15-1/21	10.4	9.7	10.9	887.0	849.0	1360.0	10.4	10.1	10.8	1.3	1.2	1.5
1/22-1/28	10.4	9.6	11.5	876.6	703.0	1000.0	10.4	10.2	10.5	1.4	1.0	1.6
1/29-2/4	11.1	10.2	12.1	863.9	800.0	921.0	10.3	10.1	10.4	0.9	0.8	1.4
2/5-2/11	12.0	11.0	13.2	925.0	584.0	1230.0	9.8	9.4	10.5	2.0	1.1	3.3
2/12-2/18	12.8	11.9	13.6	911.6	849.0	973.0	9.4	8.9	10.0	1.7	1.2	2.3
2/19-2/25	12.0	10.7	13.3	823.6	296.0	880.0	9.3	8.2	10.1	1.4	0.9	1.6
2/26-3/4	12.6	11.3	13.6	849.7	732.0	1050.0	9.2	8.3	9.7	1.4	1.2	1.7
3/5-3/11	13.7	12.1	15.0	816.4	575.0	984.0	9.3	8.9	9.6	1.2	0.8	1.5
3/12-3/18	14.8	12.5	16.2	844.9	761.0	880.0	9.4	8.8	10.2	1.4	1.2	1.6
3/19-3/25	14.7	13.4	16.5	793.6	638.0	900.0	8.6	7.6	11.1	1.3	0.8	1.6
3/26-4/1	15.9	13.7	18.1	605.4	456.0	890.0	10.1	9.5	11.1	1.2	1.0	1.6
4/2-4/8	14.0	11.7	16.6	555.2	531.0	575.0	10.5	9.9	11.3	1.5	0.9	2.5
4/9-4/15	15.8	13.2	17.9	541.6	497.0	575.0	10.0	9.2	11.2	1.2	0.8	1.5
4/16-4/22	17.5	14.8	19.8	545.7	489.0	722.0	9.6	8.9	10.6	1.1	0.9	1.4
4/23-4/29	18.2	15.8	20.8	601.7	472.0	1000.0	9.4	8.4	10.6	1.1	0.9	1.5
4/30-5/6	17.8	16.0	19.3	1029.5	963.0	1250.0	9.4	8.5	10.6	1.5	0.9	1.8
5/7-5/13	16.8	14.9	18.2	1240.9	963.0	1730.0	9.4	8.3	10.8	1.4	1.0	2.4
5/14-5/20	16.8	15.2	18.5	1253.9	1140.0	1570.0	9.6	8.7	10.8	1.2	0.8	1.7
5/21-5/27	17.6	15.3	19.7	1491.1	1430.0	1690.0	9.4	8.4	10.6	1.3	1.1	1.6
5/28-6/3	17.9	16.2	19.5	1713.6	1460.0	2010.0	9.6	8.5	10.5	1.4	1.1	1.6

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 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 and turbidity were calculated by weekly averages from daily values gathered from crew members in the field. Dissolved oxygen and turbidity min and max values are reflective of the minimum and maximum daily value gathered during the week defined by the "Week" column in the table above.

Appendix 3: List of fish species caught during the 2015 season using rotary screw traps on the lower American River.

Common Name	Family Name	Species Name	Total Number Caught
Chinook salmon	Salmonidae	Oncorhynchus tshawytscha	283,220
Steelhead/Rainbow Trout	Salmonidae	Oncorhynchus mykiss	14
American shad	Clupeidae	Alosa Sapidissima	9
Black bullhead	Ictaluridae	Ameiurus melas	0
Bluegill	Centrarchidae	Lepomis macrochirus	45
Channel catfish	Ictaluridae	Ictalurus punctatus	0
Fathead minnow	Cyprinidae	Pimephales promelas	2
Golden shiner	Cyprinidae	Notemigonus crysoleucas	32
Goldfish	Cyprinidae	Carassius auratus	0
Green sunfish	Centrarchidae	Lepomis cyanellus	5
Hardhead	Cyprinidae	Mylopharodon conocephalus	262
Inland silverside	Atherinopsidae	Menidia beryllina	29
Largemouth bass	Centrarchidae	Micropterus salmoides	311
Mosquitofish	Poeciliidae	Gambusia Affinis	14
Pacific lamprey	Petromyzontidae	Entosphenus tridentata	595
Prickly sculpin	Cottoidea	Cottus asper subspecies	181
Redear sunfish	Centrarchidae	Lepomis microlophus	4
Riffle sculpin	Cottoidea	Cottus gulosus	104
River lamprey	Petromyzontidae	Lampetra ayresii	207
Sacramento pikeminnow	Cyprinidae	Ptychocheilus grandis	433
Sacramento sucker	Catostomidae	Catostomus occidentalis occidentalis	2,925
Smallmouth bass	Centrarchidae	Micropterus dolomieu	0
Striped bass	Moronidae	Morone saxatilis	1
Threadfin shad	Clupeidae	Dorosoma petenense	19
Threespine stickleback	Gasterosteidae	Gasterosteus aculeatus	51
Tule perch	Embiotocidae	Hysterocarpus traskii traskii	69
Unknown/Ammocoete lamprey	Petromyzontidae	(Entosphenus or Lampetra)	155
Unknown minnow	Cyprinidae		6
Unknown sculpin	Cottoidea	(Cottus)	31
Unknown sunfish	Centrarchidae	(Lepomis)	4
Wakasagi / Japanese smelt	Osmeridae	Hypomesus nipponensis	642
White catfish	Ictaluridae	Ameiurus catus	2
White sturgeon	Acipenseridae	Acipenser transmontanus	1
		Total Cumulative	**289,373**

Note: The total number caught includes mortalities. Chinook salmon and steelhead totals also include adipose fin clipped hatchery produced fish. These fish were not included in abovementioned tables totaling in-river produced fish.

Appendix 4: Genetic results for fin-clip samples from Chinook salmon caught in the lower American River during the 2015 survey season.

Sample #: refer to a unique number assigned by field staff, and that allowed the tracking of individual fish samples.
LAD run assignment: Chinook salmon run assignment based on the length-at-date run assignment methodology developed by Greene (1992).
SNP Run Assignment: Chinook salmon run assignment using "Genetic Call to three lineages" single-nucleotide polymorphism (SNP) markers.
SNP Probability: Probability of the correct SNP Chinook salmon run assignment.
Final run assignment: run assignment using a 50 percent threshold based on the SNP probability.
FL: fork length in millimeters.
W: weight in grams.

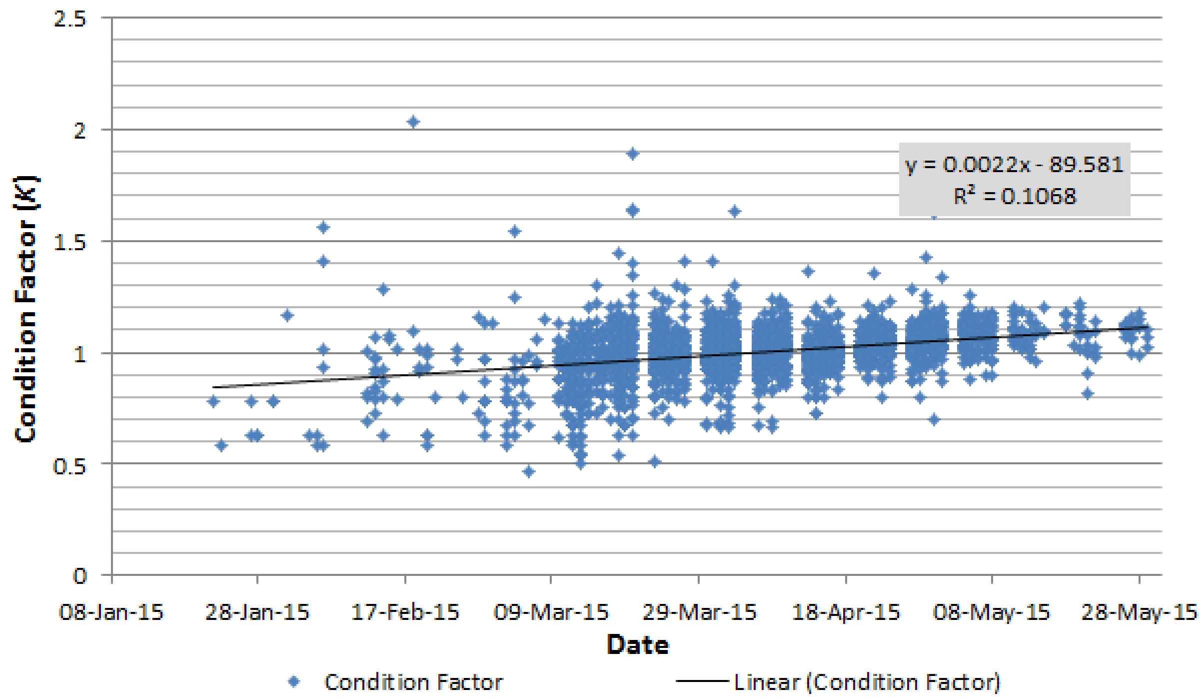
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
11-Jan	2978-001	Winter	Winter	1.000	Winter	97	10.3	
16-Jan	2978-002	Spring	Winter	1.000	Winter	59	2.1	
22-Jan	2978-003	Winter	Winter	1.000	Winter	68	6.4	
30-Jan	2978-004	Spring	Spring	1.000	Spring	60	1.8	Butte Creek
30-Jan	2978-005	Winter	Winter	1.000	Winter	116	15.8	
31-Jan	2978-006	Spring	Spring	0.912	Spring	59	1.5	Butte Creek
1-Feb	2978-007	Winter	Winter	1.000	Winter	84	6.6	
1-Feb	2978-008	Winter	Winter	1.000	Winter	103	12.8	
1-Feb	2978-009	Winter	Winter	1.000	Winter	79	5.5	
1-Feb	2978-010	Spring	Spring	0.846	Spring	57	1.9	Butte Creek
1-Feb	2978-011	Winter	Fall	0.831	Fall	67	3.5	
2-Feb	2978-012	Winter	Winter	1.000	Winter	105	-	
2-Feb	2978-013	Spring	Fall	1.000	Fall	50	0.9	
11-Feb	2978-014	Winter	Winter	1.000	Winter	109	-	
12-Feb	2978-015	Spring	Fall	0.943	Fall	64	2.1	
12-Feb	2978-016	Winter	Winter	1.000	Winter	80	4.2	
12-Feb	2978-017	Spring	Fall	0.984	Fall	60	1.5	
12-Feb	2978-018	Spring	Fall	0.986	Fall	58	1.6	
12-Feb	2978-019	Spring	Winter	1.000	Winter	67	2.7	
12-Feb	2978-020	Winter	Spring	0.548	Spring	73	3.6	Mill / Deer Cr.
12-Feb	2978-021	Winter	Fall	0.993	Fall	77	4.6	
12-Feb	2978-022	Winter	Winter	1.000	Winter	78	4.5	
12-Feb	2978-023	Spring	Spring	1.000	Spring	64	1.8	Butte Creek
13-Feb	2978-024	Fall	Fall	0.977	Fall	34	-	
13-Feb	2978-025	Fall	Fall	0.989	Fall	38	-	
13-Feb	2978-026	Spring	Spring	0.997	Spring	65	-	Butte Creek
13-Feb	2978-027	Spring	Fall	0.999	Fall	62	2.3	
13-Feb	2978-028	Winter	Winter	1.000	Winter	75	3.6	Adipose clipped
13-Feb	2978-029	Winter	Winter	1.000	Winter	76	3.4	Adipose clipped
13-Feb	2978-030	Spring	Fall	1.000	Fall	69	2.7	

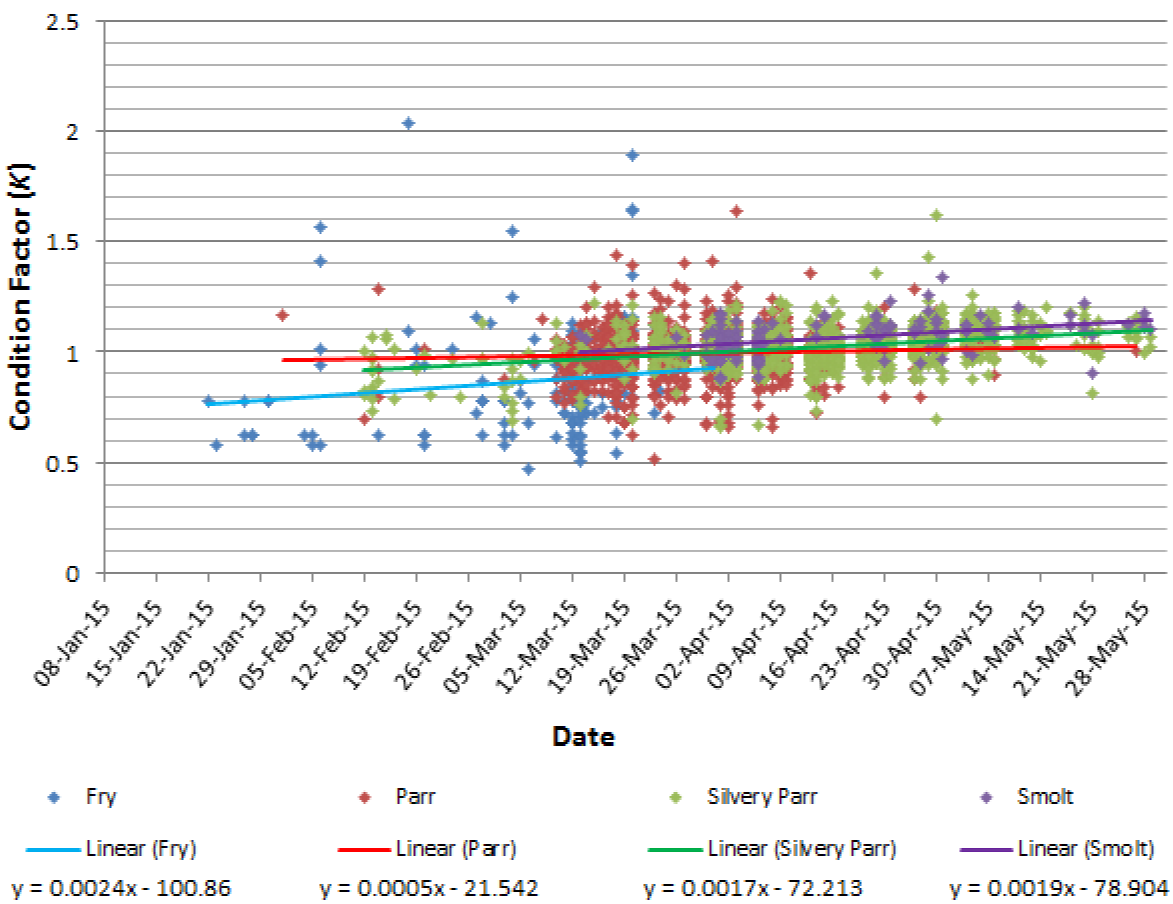
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
13-Feb	2978-031	Spring	Fall	1.000	Fall	60	2.0	
14-Feb	2978-032	Winter	Winter	1.000	Winter	93	9.2	
14-Feb	2978-033	Winter	Winter	1.000	Winter	100	10.9	
14-Feb	2978-034	Spring	Spring	1.000	Spring	57	2.7	Butte Creek
14-Feb	2978-035	Spring	Fall	0.999	Fall	58	2.5	
14-Feb	2978-036	Spring	Fall	0.636	Fall	63	2.0	
14-Feb	2978-037	Winter	Winter	1.000	Winter	76	3.7	
14-Feb	2978-038	Spring	Winter	1.000	Winter	72	3.0	
15-Feb	2978-039	Winter	Winter	1.000	Winter	144	33.2	
15-Feb	2978-040	Winter	Winter	0.952	Winter	91	7.8	
15-Feb	2978-041	Spring	Fall	0.926	Fall	65	2.9	
15-Feb	2978-042	Spring	Spring	1.000	Spring	64	2.8	Butte Creek
16-Feb	2978-043	Winter	Winter	1.000	Winter	113	15.1	Adipose clipped
16-Feb	2978-044	Winter	Winter	0.978	Winter	89	8.6	Adipose clipped
16-Feb	2978-045	Spring	Fall	1.000	Fall	61	2.3	
16-Feb	2978-046	Spring	Spring	0.929	Spring	68	3.1	Butte Creek
19-Feb	2978-047	Spring	Fall	1.000	Fall	63	2.3	
19-Feb	2978-048	Spring	Spring	0.873	Spring	61	2.2	Butte Creek
19-Feb	2978-049	Fall	Fall	1.000	Fall	37	-	
19-Feb	2978-050	Fall	Fall	0.917	Fall	35	-	
20-Feb	2978-051	Spring	Fall	0.816	Fall	65	2.7	
21-Feb	2978-052	Winter	Winter	1.000	Winter	104	10.0	
21-Feb	2978-053	Winter	Spring	0.654	Spring	108	14.6	Mill / Deer Cr.
21-Feb	2978-054	Spring	Fall	0.627	Fall	64	2.1	
23-Feb	2978-055	Winter	Winter	1.000	Winter	138	30.4	
24-Feb	2978-056	Spring	Fall	0.999	Fall	61	2.2	
24-Feb	2978-057	Winter	Winter	1.000	Winter	121	20.3	
24-Feb	2978-058	Winter	Winter	1.000	Winter	109	20.3	
24-Feb	2978-059	Fall	Fall	1.000	Fall	37	-	
24-Feb	2978-060	Fall	Fall	0.999	Fall	36	-	
25-Feb	2978-061	Spring	Fall	0.999	Fall	67	2.4	
25-Feb	2978-062	Spring	Spring	0.996	Spring	62	2.1	Butte Creek
25-Feb	2978-063	Winter	Winter	1.000	Winter	95	6.8	
26-Feb	2978-064	Winter	Winter	1.000	Winter	129	21.9	
26-Feb	2978-065	Spring	Fall	1.000	Fall	63	8.5	
28-Feb	2978-066	Spring	Fall	1.000	Fall	62	2.7	
28-Feb	2978-067	Spring	Fall	1.000	Fall	61	2.2	
3-Mar	2978-068	Spring	Fall	0.994	Fall	74	3.4	
3-Mar	2978-069	Spring	Fall	0.998	Fall	63	2.0	
4-Mar	2978-070	Spring	Fall	0.999	Fall	68	2.3	
4-Mar	2978-071	Spring	Fall	0.999	Fall	68	2.9	
4-Mar	2978-072	Winter	Fall	0.991	Fall	86	4.9	
4-Mar	2978-073	Spring	Fall	1.000	Fall	62	2.3	
5-Mar	2978-074	Spring	Fall	0.998	Fall	64	2.3	
6-Mar	2978-075	Spring	Fall	0.998	Fall	70	3.4	
8-Mar	2978-076	Winter	Winter	1.000	Winter	125	25.3	
8-Mar	2978-077	Spring	Fall	1.000	Fall	80	5.9	
10-Mar	2978-078	Spring	Fall	0.997	Fall	76	4.4	

Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
10-Mar	2978-079	Spring	Fall	1.000	Fall	71	3.6	
12-Mar	2978-080	Spring	Fall	1.000	Fall	73	3.6	
13-Mar	2978-081	Spring	Fall	0.988	Fall	70	3.4	
14-Mar	2978-082	Spring	Fall	0.999	Fall	73	4.1	
18-Mar	2978-083	Spring	Fall	1.000	Fall	77	5.1	
18-Mar	2978-084	Spring	Fall	0.998	Fall	78	4.7	
18-Mar	2978-085	Spring	Fall	1.000	Fall	73	4.1	
18-Mar	2978-086	Spring	Fall	0.994	Fall	75	4.8	
19-Mar	2978-087	Spring	Fall	1.000	Fall	73	3.8	
19-Mar	2978-088	Spring	Fall	0.999	Fall	77	4.7	
20-Mar	2978-089	Spring	Fall	1.000	Fall	75	3.9	
20-Mar	2978-090	Spring	Fall	0.993	Fall	76	5.3	
23-Mar	2978-091	Fall	Fall	1.000	Fall	59	2.0	
23-Mar	2978-092	Fall	Fall	1.000	Fall	56	1.5	
23-Mar	2978-093	Spring	Fall	1.000	Fall	75	4.9	
23-Mar	2978-094	Spring	Fall	1.000	Fall	85	5.6	
24-Mar	2978-095	Spring	Fall	0.998	Fall	79	5.1	
24-Mar	2978-096	Spring	Fall	1.000	Fall	77	5.0	
24-Mar	2978-097	Spring	Fall	1.000	Fall	77	5.1	
25-Mar	2978-098	Spring	Fall	1.000	Fall	87	6.5	
25-Mar	2978-099	Spring	Fall	1.000	Fall	77	4.7	
26-Mar	2978-100	Spring	Winter	1.000	Winter	88	6.8	
26-Mar	2979-01	Spring	Fall	0.999	Fall	77	5.0	
26-Mar	2979-02	Spring	Fall	0.999	Fall	83	6.1	
26-Mar	2979-03	Winter	Spring	0.990	Spring	106	13.1	Butte Creek
27-Mar	2979-04	Spring	Fall	0.994	Fall	85	6.1	
27-Mar	2979-05	Spring	Fall	0.870	Fall	79	4.8	
27-Mar	2979-06	Spring	Fall	1.000	Fall	80	4.8	
27-Mar	2979-07	Spring	Fall	1.000	Fall	87	6.5	
30-Mar	2979-08	Spring	Fall	0.866	Fall	84	5.9	
30-Mar	2979-09	Spring	Fall	1.000	Fall	84	6.4	
30-Mar	2979-10	Spring	Fall	0.995	Fall	81	5.8	
30-Mar	2979-11	Spring	Fall	1.000	Fall	84	5.9	
31-Mar	2979-12	Spring	Fall	0.935	Fall	83	5.4	
31-Mar	2979-13	Spring	Fall	1.000	Fall	81	5.8	
1-Apr	2979-14	Spring	Fall	0.968	Fall	86	7.3	
1-Apr	2979-15	Spring	Fall	1.000	Fall	87	6.5	
2-Apr	2979-16	Spring	Fall	1.000	Fall	82	5.6	
2-Apr	2979-17	Spring	Fall	0.997	Fall	82	5.1	
3-Apr	2979-18	Spring	Fall	0.929	Fall	85	7.0	
3-Apr	2979-19	Spring	Fall	1.000	Fall	86	6.8	
6-Apr	2979-20	Spring	Fall	0.951	Fall	80	5.6	
6-Apr	2979-21	Spring	Fall	0.970	Fall	82	5.5	
6-Apr	2979-22	Fall	Fall	1.000	Fall	51	1.4	
6-Apr	2979-23	Fall	Fall	1.000	Fall	54	1.6	
7-Apr	2979-24	Spring	Fall	1.000	Fall	93	8.9	
7-Apr	2979-25	Spring	Fall	0.999	Fall	85	6.4	
8-Apr	2979-26	Spring	Fall	1.000	Fall	86	6.5	

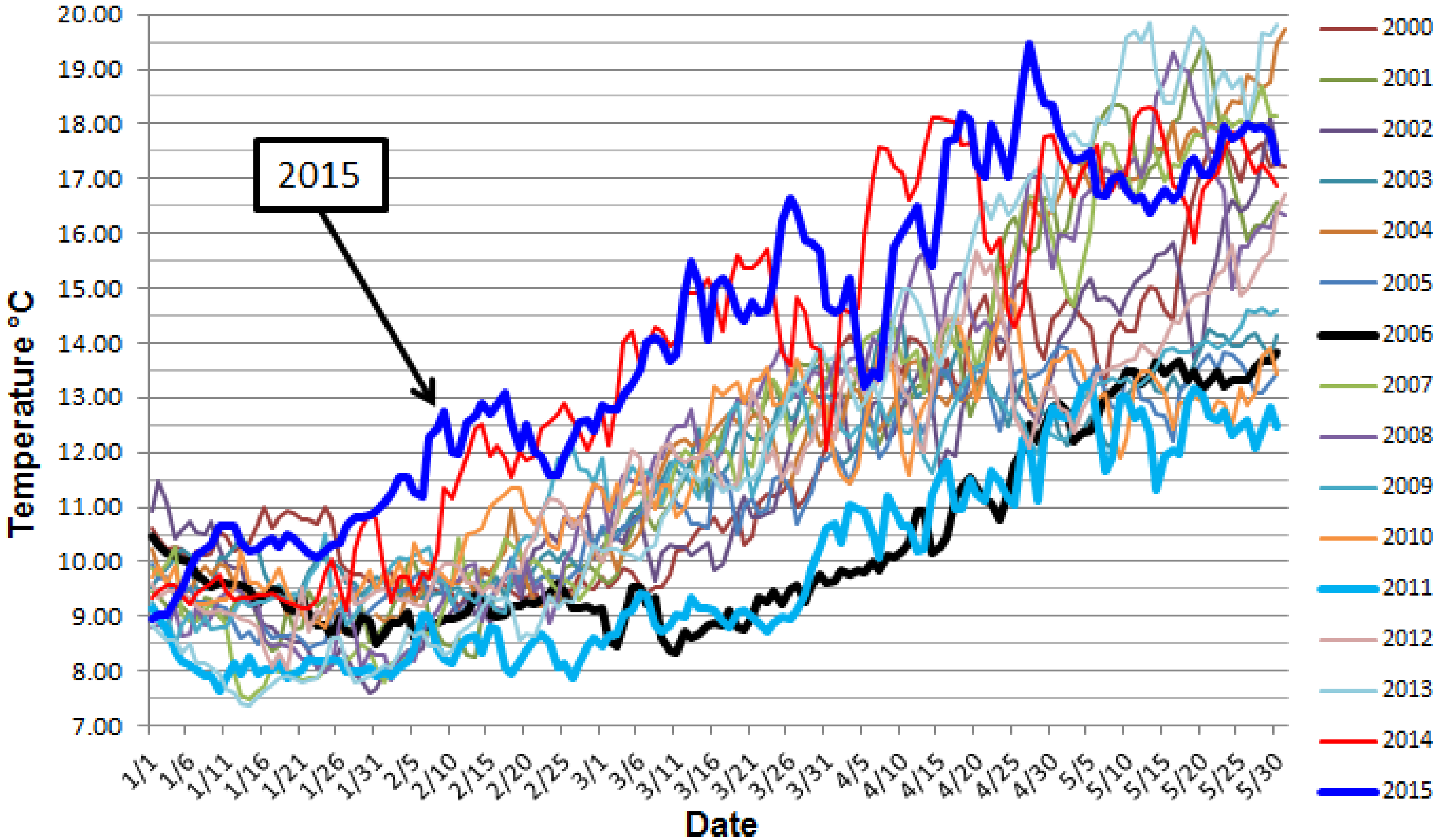
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)	Comments
8-Apr	2979-27	Spring	Fall	1.000	Fall	93	9.1	
9-Apr	2979-28	Spring	Fall	1.000	Fall	82	5.2	
9-Apr	2979-29	Spring	Fall	1.000	Fall	82	5.6	
14-Apr	2979-30	Spring	Fall	1.000	Fall	87	7.4	
14-Apr	2979-31	Spring	Fall	1.000	Fall	85	7.4	
15-Apr	2979-32	Spring	Fall	1.000	Fall	93	9.4	
15-Apr	2979-33	Fall	Spring	0.524	Spring	68	3.2	Unknown origin
15-Apr	2979-34	Fall	Fall	1.000	Fall	77	4.8	
15-Apr	2979-35	Spring	Fall	1.000	Fall	95	9.9	
16-Apr	2979-36	Spring	Fall	1.000	Fall	88	7.1	
16-Apr	2979-37	Spring	Fall	1.000	Fall	89	7.5	
17-Apr	2979-38	Spring	Fall	0.999	Fall	87	7.7	
20-Apr	2979-39	Spring	Fall	1.000	Fall	90	8.0	
22-Apr	2979-40	Spring	Fall	0.998	Fall	94	8.9	
22-Apr	2979-41	Spring	Fall	1.000	Fall	93	8.5	
23-Apr	2979-42	Spring	Fall	1.000	Fall	91	8.3	
23-Apr	2979-43	Fall	Fall	0.999	Fall	57	1.9	
23-Apr	2979-44	Fall	Fall	0.976	Fall	72	3.3	
23-Apr	2979-45	Fall	Fall	1.000	Fall	83	5.8	
28-Apr	2979-46	Spring	Fall	1.000	Fall	100	11.1	
28-Apr	2979-47	Spring	Fall	0.998	Fall	97	10.4	
29-Apr	2979-48	Spring	Fall	1.000	Fall	93	10.1	
29-Apr	2979-49	Fall	Fall	1.000	Fall	81	5.8	
29-Apr	2979-50	Fall	Fall	1.000	Fall	77	4.9	
29-Apr	2979-51	Spring	Fall	0.996	Fall	96	9.0	
18-May	2979-52	Spring	Fall	0.993	Fall	105	13.0	

Appendix 5: Fulton's condition factor (*K*), overall, and by life-stage, of fall-run Chinook salmon during the 2015 survey season.

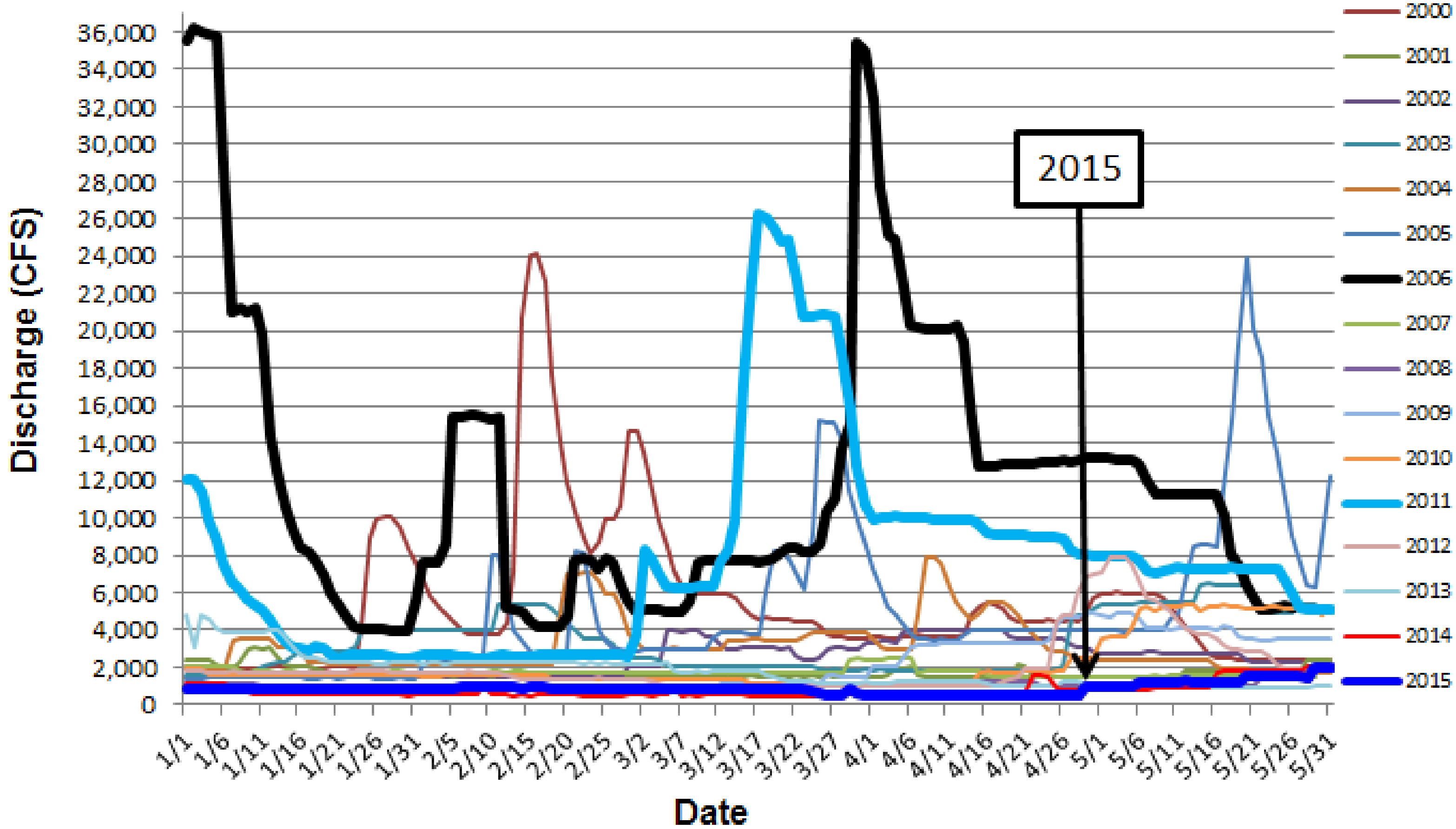




Appendix 6: Daily average water temperature (°C) in the lower American River at Watt Avenue for the 15-year period 2000 – 2015. Data from USGS station number 11446980.



Appendix 7: Daily average discharge (CFS) on the lower American River at Fair Oaks for the 15-year period 2000 – 2015. Data from USGS station number 11446500.



Appendix 8: Total number of fall-run Chinook salmon carcasses by age class and sex from the lower American River according to the 2014-2015 Escapement Survey.

Survey Period	Female Grilse	Male Grilse	Female Adults	Adult Males	Total Salmon
October 20 - 23	0	1	6	2	9
October 27 - 30	0	0	4	3	7
November 3 - 6	0	0	10	2	12
November 10 - 13	0	3	25	25	53
November 17 - 20	1	15	144	93	253
November 24 - 26	6	44	286	251	587
December 1 - 4	8	69	547	388	1,012
December 8 - 10	6	49	448	308	811
December 15 - 18	11	38	232	178	459
December 22 - 24	6	34	90	89	219
December 29 - 31	1	8	13	21	43
January 5 - 8	2	1	5	4	12
January 12 - 14	0	1	4	0	5
Total	41	263	1,814	1,364	3,482
Percent of Total Population	1.2%	7.6%	52.1%	39.2%	100.0%
	Total # of Salmon During the Escapement Survey Assessed for Sex and Life Stage				3,482

Appendix 9: Egg retention for fall-run Chinook salmon carcasses on the lower America River according to the 2014-2015 Escapement Survey.

	EGG RETENTION		
	spawned 0 to <=30%	**partially spawned** >30 to 70%	**unspawned** >70%
Survey Period	**Escapement Survey**[a] # of salmon	**Escapement Survey**[a] # of salmon	**Escapement Survey**[a] # of salmon
October 20 - 23	0	1	4
October 27 - 30	0	0	3
November 3 - 6	2	1	6
November 10 - 13	21	2	1
November 17 - 20	115	11	10
November 24 - 26	265	12	10
December 1 - 4	494	27	22
December 8 - 10	411	24	17
December 15 - 18	219	8	11
December 22 - 24	88	4	3
December 29 - 31	14	0	0
January 5 - 8	7	0	0
January 12 - 14	4	0	0
	1,640	90	87
	90.3%	5.0%	4.8%
	# of total salmon in the escapement report assessed for egg condition		1817

Appendix 10: Summary of values used to estimate the total number of eggs produced by female fall-run Chinook salmon during the 2014-2015 spawning season.

PARAMETER	Number of Salmon
Adult Salmon Escapement Estimate For The 2014-2015 Field Season[a]	24,503
Expanded Total Number of Salmon Assessed For Sex And Life Stage[b]	3,482
Expanded Total Number Of Female Salmon[c]	1,855
Percent Of The Total Expanded Number Of Salmon That Were Females[d]	53.3%
Percent Of Expanded Female Salmon (Grilse and Adults) That Spawned Or Partially Spawned[e]	95.2%
Total Expanded Number Of Grilse Female Salmon[f]	289
Total Expanded Number Of Adult Female Salmon[g]	12,765
Total Number Of Expanded Grilse Female Salmon That Spawned Or Partially Spawned[h]	275
Total Number Of Expanded Adult Female Salmon That Spawned Or Partially Spawned[i]	12,154
Lower Average Number Of Eggs Per Adult Fall-run Chinook Salmon Female (Moyle 2002)[j]	2,000
Average Number Of Eggs Per Adult Fall-run Chinook Salmon Female (Moyle 2002)[k]	5,500
Total Number Of Eggs Produced By Grilse Female Salmon[l]	549,409
Total Number Of Eggs Produced by Adult Female Salmon[m]	66,846,957
Estimated Number Of Eggs Produced by Female Chinook salmon In The American River In 2014 - 2015[n]	**67,396,366**

a	The adult fall-run Chinook salmon in-river escapement estimate derived from a Cormack-Jolly-Seber mark and recapture model (Phillips and Kubo 2015).
b – d	Numbers derived from Appendix 8.
e	Total Percentage Of Expanded Female Salmon (Grisle And Adults) That Spawned Partially Spawned (Appendix 9).
f	Total Expanded Number Of Grilse Female Salmon: (a * expanded percentage of grisle female salmon in the total population) (Appendix 8).
g	Total Expanded Number Of Adult Female Salmon: (a * expanded percentage of adult female salmon in the total population) (Appendix 8).
h	Total Number Of Expanded Grilse Female Salmon That Spawned Or Partially Spawned: (e * f).
i	Total Number Of Expanded Adult Female Salmon That Spawned Or Partially Spawned: (e * g).
j	Lower Average Number Of Eggs Per Adult Fall-run Chinook Salmon Female (Moyle 2002).
k	Average Number Of Eggs Per Adult Fall-run Chinook Salmon Female (Moyle 2002).
l	Total Number Of Eggs Produced by Grilse Female Salmon: (h * j).
m	Total Number Of Eggs Produced by Adult Female Salmon: (i * k).
n	Estimated Number Of Eggs Produced by Female Chinook salmon In The American River In 2014 - 2015: (l + m).