Juvenile Salmonid Emigration Monitoring in the Lower American River, California

January – June 2022

By

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Acronyms and Abbreviations

Acronym	Definition
AFRP	Anadromous Fish Restoration Program
BBY	Bismarck Brown Y
C	Celsius
CAMP	Comprehensive Assessment and Monitoring Program
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CI	confidence interval
cm	centimeter
CVPIA	Central Valley Project Improvement Act
DO	dissolved oxygen
g	gram
km	kilometers
L	liter
LAD	length-at-date
m	meters
m/s	meters per second
mg/L	milligrams per liter
mm	millimeter
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
rkm	river kilometer
RPM	revolutions per minute
RST	rotary screw trap
SNP	single-nucleotide polymorphism
St. Dev.	Standard Deviation
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VIE	Visual Implant Elastomer

Abstract

Operation of rotary screw traps on the lower American River in 2022 is part of a collaborative effort by the U.S. Fish and Wildlife Service's Comprehensive Assessment and Monitoring Program, Pacific States Marine Fisheries Commission, and the California Department of Fish and Wildlife. The primary objectives of the study are to collect data that can be used to estimate the passage of juvenile fall-run Chinook Salmon *Oncorhynchus tshawytscha* and to quantify the raw catch of steelhead *O. mykiss* as well as winter, spring, and late fall runs of Chinook Salmon. Secondary objectives of the trapping operations focus on collecting fork length and weight data for juvenile salmonids, collecting fin clips from juvenile salmonids to determine genetic run assignment, and gathering environmental data that will be used to develop models that correlate environmental parameters with salmonid size, temporal presence, abundance, and production.

For the 2022 survey season, two 2.4 meter (8 foot) rotary screw traps were operated downstream of the Watt Avenue Bridge. Sampling occurred on 120 of the 138 day season (87%) beginning January 15 and concluding on June 1. Following genetic analysis, it was determined that a total of 31,581 fall-run, 1 winter-run, and 1 spring-run Chinook Salmon were captured, as well as 404 steelhead. The majority of the juvenile salmon captured were identified as button-up fry followed by silvery parr, parr, yolk-sac fry and smolt life stages. Six trap efficiency trials were used to estimate the passage of juvenile fall-run Chinook Salmon. Trap efficiencies during these six trials ranged from 5.66% to 21.69%, with an average efficiency of 14.46%. The number of juvenile fall-run Chinook Salmon that were estimated to have emigrated past the Watt Avenue trap site during the 2022 survey season was 180,224 individuals (95 percent confidence intervals = 165,500 to 199,800). The passage of juvenile fall-run Chinook Salmon peaked the week of February 16, when 5% (n = 9,082) of the total was captured. Passage estimates for steelhead, winter-run Chinook Salmon, spring-run Chinook Salmon, and non-salmonid fish taxa were not assessed due to minimal catch.

This annual report also includes nine appendices to describe different environmental variables and studies related to the trap site and rotary screw trap operations during the 2022 survey season.

Introduction

The American River is the southernmost major tributary to the Sacramento River in California's Central Valley. Historically, the American River supported three runs of salmon, including fall (fall-run), spring (spring-run), and possibly late fall (late fall-run) Chinook Salmon (*Oncorhynchus tshawytscha,* Yoshiyama et al. 2001). However, during the California Gold Rush in the mid- to late 1800s, hydraulic mining devastated salmonid spawning habitat in the upper and lower reaches of the American River (Fisher 1994). Additionally, the construction of Folsom and Nimbus Dams in 1955 made passage impossible for salmonids to migrate into the upper portions of the American River watershed. Nimbus Fish Hatchery was constructed in 1958 to mitigate the loss of spawning and rearing habitat for Chinook Salmon and Central Valley steelhead *O. mykiss*. Located 0.8 kilometers (km) downstream of Nimbus Dam, the hatchery continues to produce large numbers of fall-run Chinook Salmon and steelhead. However, hydropower implementation, over-harvest, introduced species, loss of preferential habitat, and other factors continue to contribute to the decline of these salmonid populations (Yoshiyama et al 2001, Lindley et al 2006, NMFS 2019). Today, the portion of the American River below Nimbus Dam, known as the lower American River, provides the only spawning and rearing habitat in the American River watershed for Chinook Salmon and steelhead.

In order to help protect, restore, mitigate, and improve the natural production of salmonids in the Central Valley, the Central Valley Project Improvement Act (CVPIA) was established in 1992. One of the primary goals of the legislation was to facilitate efforts that enhance and restore the natural production of juvenile Chinook Salmon and steelhead. Pursuant to that act, several programs were established to help recover salmonid populations. In 1997, the Comprehensive Assessment and Monitoring Program (CAMP) Implementation Plan was developed to evaluate the effectiveness of CVPIA actions in restoring anadromous fish production. The CVPIA programs are currently engaged in habitat restoration activities within the American River watershed including the Anadromous Fish Restoration Program (AFRP), Dedicated Project Yield Program, and Spawning Gravel Programs (USBR 2019).

In an effort to improve salmonid spawning habitat on the lower American River, the U.S. Bureau of Reclamation (USBR), the California Department of Fish and Wildlife (CDFW), and the CVPIA's AFRP and Spawning Gravel Programs have collaborated to implement the lower American River Gravel Augmentation and Side-Channel Habitat Enhancement Project (USDOI 2008). This project is ongoing and has been integral in increasing and restoring the adult spawning and juvenile rearing habitat that was adversely affected by the construction of the Folsom and Nimbus Dams. Habitat restoration activities are ongoing and have occurred at the base of Nimbus Dam (Nimbus Basin) downstream to River Bend at river kilometer (rkm) 20.9 (USBR 2019).

In addition, the CVPIA's Dedicated Project Yield Program Section (b)(2), commonly referred to as "(b)(2) water," authorizes a portion of the Central Valley Project water yield to be dedicated and managed for the benefit of fish and wildlife. As it pertains to the lower American River, (b)(2) water can be utilized to augment base flows out of Nimbus Dam to improve in-stream conditions for fall-run Chinook Salmon and Central Valley steelhead during critical life stage periods. The (b)(2) water's flow augmentation may also contribute to the AFRP Final Restoration Plan flow objectives for the lower American River (USBR Section 3406).

Continuous restoration, management, and monitoring activities are needed to preserve healthy populations and further aid in the recovery of species listed under the U.S. Endangered Species Act (ESA). These listed species include rearing *Endangered* Sacramento River winter-run Chinook Salmon as well as the *Threatened* Central Valley Spring-run Chinook Salmon and steelhead populations. To this end, in 2014 the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) developed a recovery plan which places a high priority on salmonid habitat restoration activities in the American River (NMFS 2014).

The lower American River rotary screw traps (RSTs) monitor juvenile salmonid abundance to help determine if habitat restoration activities and flow management practices are resulting in a positive impact for fall-run Chinook Salmon and steelhead production. Furthermore, this report presents monitoring data assessing the temporal variability in steelhead, winter-run, and spring-run abundance, and describes biological data of salmonids and other native and non-native fish species in relation to environmental conditions.

Study Area

The American River watershed covers an area of 4,900 square kilometers (km^2). The upper-most headwaters reach an elevation of 3,170 meters (m) on the western slopes of the Sierra Nevada range (James 1997). The river contains three major forks (North, Middle, and South forks) that 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 into Lake Natoma, which is impounded by Nimbus Dam. The USBR regulates water management activities for these two dams including river discharge and water temperature to help administer flood protection, provide municipal and agricultural water supplies, generate hydroelectric power, and maintain fish and wildlife habitats.

Water exiting Nimbus Dam flows downstream through the lower American River for 36 km until it reaches the confluence with the Sacramento River. This lower stretch of the American River is currently the only portion that salmonids are able to access. Historically ranging in flows from 500 cubic feet per second (cfs) to upwards of 164,000 cfs, the lower American River is now constricted and straightened by a levee system that was engineered for flood control during the urban development of Sacramento County. The river contains gravel bar complexes, islands, flat-water areas, and side-channel habitat characteristics (Merz and Vanicek 1996). However, only a small portion of the lower American River possesses quality rearing habitat for juvenile salmonids and substrate that is suitable for anadromous salmonid spawning. 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; Kelly and Phillips 2020). A site below the Watt Avenue Bridge (rkm 14.6) was selected by CDFW as the optimal location to install and operate RSTs. The site was chosen for its distance downstream of most salmonid spawning activities on the lower American River and its distance upstream from the Sacramento River (Snider and Titus 2001). A summary of the points of interest on the lower American River is shown in Appendix 1.

The lower American River RST site is located 0.20 rkm downstream of the Watt Avenue Bridge (Figure 1). During typical flow years, the American River at this location separates into two channels that pass on either side of a gravel island. The north channel carries the majority of the water volume and becomes the only channel with flowing water during flows of less than approximately 500 cfs. The north channel has a steep gradient that causes relatively high water velocities, while the south channel has a flatter gradient and lower water velocities. During flows above approximately 10,000 cfs the gravel island separating the north and south channels becomes submerged and the lower American River below Watt Avenue becomes one channel. A comparison of the RST site in different flow conditions is provided in Appendix 2.

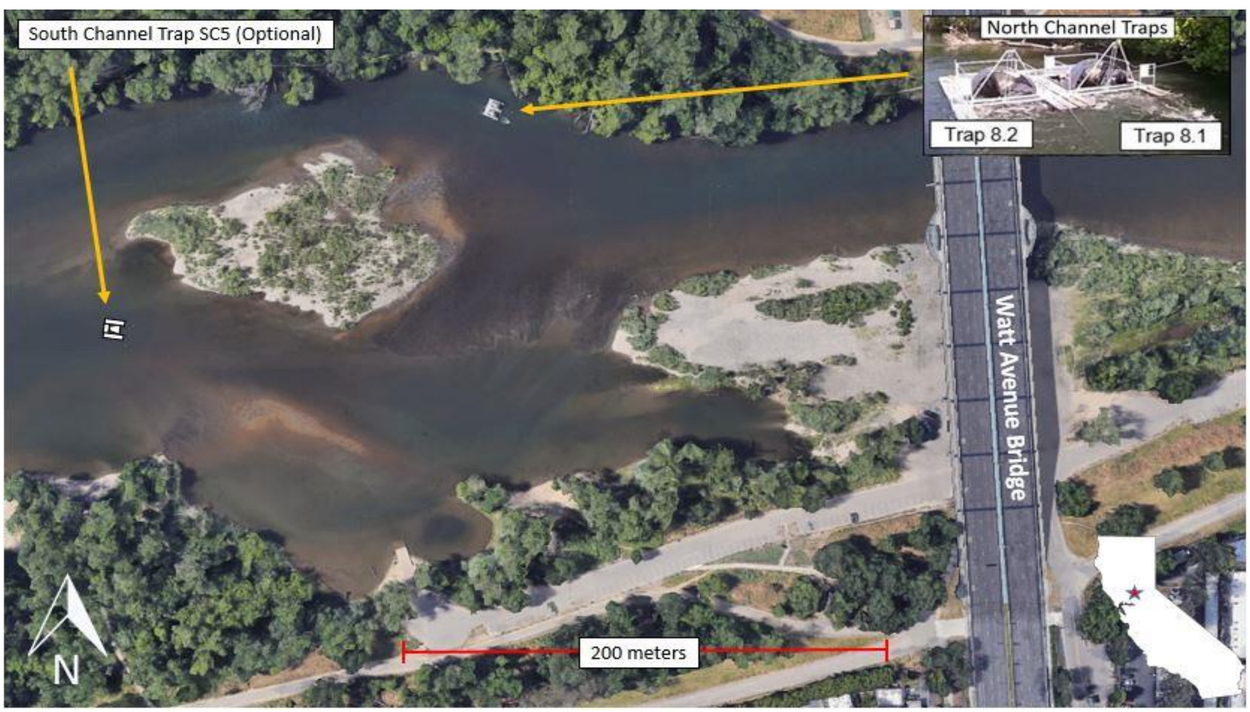

Figure 1: Rotary screw trap locations in the north and south channels of the lower American River. Inset image illustrates the side-by-side trapping configuration in the north channel.

Methods

Safety Measures

All crew members were trained in RST and boat operation safety. Each crew member was required to read the PSMFC Safety Manual (PSMFC 2021), acknowledge the PSMFC Safety Orientation Checklist, and was required to complete California's boating safety course prior to operating a motorized vessel.

For night operations, each crew member was required to attach a strobe light (ACR HemiLight 3) to their personal flotation devices that would turn on automatically if submerged in water. Navigation lights and a bow mounted 55-watt halogen driving light were also installed on the jet boat during night operations.

Public safety measures were also taken. Signage warning river recreationalists to "Keep Away" in English and Spanish were affixed to the traps as well as to the bank 100 and 150 m upstream of the traps. Reflective orange and yellow buoys were placed on the anchor lines and chain bridals to help prevent boaters from crossing in front of or over the anchor lines. Weekend sampling was suspended at the beginning of May to allow river recreationalists the safest passage during periods of peak river use. This included raising both trap cones, removing live well screens, and shifting traps out of the thalweg until the following Monday.

Trap Operations

Two 2.4 meter (8 foot) diameter RSTs were deployed in the north channel in a side-by-side orientation and were designated as Trap 8.1 and Trap 8.2 (Figure 2). Trap 8.1 was set closer to the north side of the north channel, while Trap 8.2 was set closer to the south side of the north channel. Traps were anchored to large concrete blocks set into the river channel's cobble substrate 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.

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

Trap checks were conducted at least once every 24 – 28 hours while traps were actively sampling in the cone-down configuration. During large storm events or measurable discharge events, increases in debris size or quantity could hinder trap functionality and potentially increase fish mortality. Therefore, in cases where storms, flow increases, or debris loads were deemed severe enough, traps were taken "out of service" (i.e., cones raised, live well screens removed, and traps removed from the thalweg) until conditions improved.

On daily trap visits, trap function was assessed as "functioning normally," "functioning, but not normally," or "stopped functioning." If the trap was functioning, the revolutions per minute (RPM) was recorded. Subsequently, intakes were checked and recorded as "clear," "partially blocked," "completely blocked," or "backed up into cone." If the trap was not functioning upon arrival, the trap was restored to its normal function without raising the cone. After collecting environmental data and cleaning the trap, time and total cone rotations were recorded using an electronic hubodometer (Veeder-Root TR 1000-000) mounted to the axle inside of the live well.

Environmental Parameters

During trap visits, various environmental parameters were recorded at least once per visit. Temperature (C) and dissolved oxygen (DO; mg/L) were measured using a YSI Model 55 meter (Yellow Springs Instruments), velocity (m/s) was measured in front of each cone using a Global Water FP111 flow probe, and turbidity (NTU) was collected in front of each cone and measured using a portable turbidity meter (Eutech; Model TN-100). When water depth was less than 3 m, a depth rod was used to record water depth to the nearest centimeter on the port and starboard side pontoons in line with the front of the trap cones. Average daily river discharge (cfs) was calculated from instantaneous measurements recorded 21 rkm upstream of the RSTs from the U.S. Geological Survey (USGS) American River at Fair Oaks monitoring station (USGS station number 11446500). Additionally, average daily river temperature (C) was calculated from instantaneous measurements recorded 0.16 rkm upstream of the RSTs from the USGS American River below Watt Avenue Bridge station (USGS station number 11446980).

Catch and Fish Data Collection

Fish Collection

Before clearing the live well of debris and fish, one or two work stations were set up per trap. A work station included an 18 gallon (68.14 liter) tub and multiple 5 gallon (18.93 liter) holding buckets filled with fresh river water, a measuring board, and tongs. To begin, a rake was used to incrementally remove debris from the live well by placing approximately 2 or 3 scoops (3 - 5 gallons) into the 18 gallon tub. Then, a smaller scoop (approximately 0.25 gallons) of debris was removed from the 18 gallon tub and placed onto the measuring board. Tongs were then used to spread out the debris to carefully scan and ensure any fish trapped in debris were removed and placed into their respective 5 gallon holding bucket.

Fish were separated based on species, race, and marks. Length-at-date (LAD) criteria developed for the Sacramento River was used to assign the run at capture for Chinook Salmon to separate suspected ESA listed winter- and spring-run (Greene 1992). Additionally, salmonids were assessed for marks. Ultimately, fish were separated into different buckets for: 1) all spring- and winter-run Chinook Salmon, 2) all steelhead, 3) unmarked fall-run and late fall-run Chinook Salmon, 4) marked fall-run Chinook Salmon, and 5) all other fish. Salmonids with an intact adipose fin were presumed to be natural origin, whereas, salmonids with a clipped adipose fin were classified as hatchery origin. The Nimbus fish hatchery follows the standard constant fractional marking rate (adipose clipped) of twenty-five percent for hatchery origin Chinook Salmon and one-hundred percent of hatchery origin steelhead (CDFW 2017).

Maintaining fish health by keeping stress and handling to a minimum was a top priority. Each 5 gallon holding bucket was setup to allow for fast and easy water exchange with the top quarter of each bucket perforated with 3/16” holes. Additionally, dissolved oxygen and temperature was maintained utilizing 12V aerators, frozen water bottles, and umbrellas for shade to keep holding buckets within 2 degrees Celsius (C) of the river temperature. Overcrowding was also avoided by placing no more than 120 fry, 80 parr, or 50 smolts in a single bucket. Upon reaching capacity, a perforated screw top lid was secured so each holding bucket could be submerged in the river to ensure safe DO and temperature until the fish were ready to be processed.

The total debris quantity was recorded after the live well was cleared of debris. To avoid a size bias, fish that were collected while sorting debris were only included in the subsample if not enough fish could be netted from the live well for a complete subsample (Table 1). Fish that were not held for the subsample were assessed for marks, enumerated, and designated as either a "live plus-count tally" or "mort plus-count tally," an unassigned life stage category.

Table 1: Subsample size for winter, spring and fall runs of Chinook Salmon, steelhead, and non-salmonid species captured for each trap on the Lower American River.

	Winter Chinook	Spring Chinook	Fall Chinook	steelhead	Hatchery Salmonids	Non-Salmonid Species
Enumerate	All	All	All	All	All	All
Life Stage	50	50	100	100	50	50
Measure	50	50	100	100	50	50
Weigh	25	25	25	25	0	0
Mortality	All	All	All	All	All	All

Fish Processing

Fish were processed 0.2 rkm downstream of the traps on an island with adequate shade and secluded from the general public. Upon arriving, fish condition was checked before buckets were secured to the boat and re-submerged in the river. A fish work station was then setup with a 1 gallon (3.79 liter) anesthetic tank, 5 gallon recovery bucket, digital scale (OHAUS Scout Pro), measuring board, and genetic sampling equipment. When processing fish began, one holding bucket would be removed from the river and affixed with a 12v aerator and frozen water bottle. Species that were identified through the length-at-date criteria as ESA listed (winter-run and spring-run) and natural origin steelhead were always processed and released first, followed by unmarked fall-run or late fall-run, marked salmonids, and all other non-salmonid species. Fish were anesthetized to reduce stress during handling using a solution of 0.5 – 2 tabs of Alka Seltzer Gold and 1 milliliter (ml) stress coat (API Stress Coat Plus) per gallon of river water. Dosage was adjusted dependent upon fish size, species, DO, and water temperature. The crew diligently monitored operculum activity of fish immersed in the anesthetic solution, with reduced gill activity indicating fish were ready to be processed.

Data was collected on all species and is detailed by species and run in Table 1. Fork length or total length was recorded to the nearest millimeter (mm). Weight was recorded to the nearest 0.1 gram (g) for up to 25 natural salmonids greater than or equal to 40 mm. Salmonid life stages were assessed by following the criteria of the smolt index rating (Table 2). Lamprey life stages were identified as ammocoete (larval), macrophthalmia (juvenile), or adult. All other non-salmonid species were identified as either a juvenile or adult life stage. When applicable, the presence of marks from past trap efficiency trials or the absence of an adipose fin on a fish was noted. The mortality status (live or dead) for each fish was recorded. Whenever possible, live fish were used for the subsample, since decomposition can alter body size, weight, and color, making accurately measuring and identifying life stages more difficult. In those cases, mortalities were considered to be a “mort plus-count.” Additionally, genetic samples were also collected for a subsample of winter-run, spring-run, fall-run, and late fall-run Chinook Salmon. After being processed, each fish was placed into an aerated recovery bucket containing 5 ml stress coat before being released downstream of the RSTs.

Table 2: Smolt index rating for assessing life stage of Chinook Salmon and steelhead adapted from CAMP (2008).

Smolt Index	Life Stage	Morphological Criteria
1	Yolk-sac fry	* Newly emerged with visible yolk-sac
2	Button-up Fry	* Recently emerged with yolk-sac absorbed * 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 * Minimal 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	* ≥ 300mm

Fin Clip Collection

To evaluate the accuracy of the LAD criteria, Chinook Salmon fin clips were collected to accurately determine run assignment through genetic analysis. Fin clips approximately 1 - 2 mm^2 were taken from the upper caudal lobe using disinfected dissection scissors. Clips were stored in 2 ml vials filled with 100% ethanol in a cool location away from direct sunlight. To establish a genetic baseline, up to 5 clips per week were taken from LAD fall-run Chinook Salmon. Due to the highly variable annual catch of LAD winter-run, spring-run, and late fall-run Chinook Salmon, up to 20 clips per week from non-fall run were collected upon capture.

The fin clips were split and the genetic samples were sent to the CDFW Tissue Archive for storage and to U.S. Fish and Wildlife Service’s (USFWS) Abernathy Fish Technology Center to assign genetic run using the panel of single-nucleotide polymorphism (SNP) markers described by Clemento et al. (2014). This panel of SNPs was developed by staff from NOAA Fisheries and is now used for several applications by the USFWS 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.

After receiving genetic results, the SNP panel's probabilities were used to assign final run assignment for all genetically sampled fish. For all LAD fall-run Chinook Salmon that were not genetically sampled, a final run assignment of fall-run was applied as the LAD criteria continued to accurately assign this run. Conversely, for all LAD spring-run Chinook Salmon that were not genetically sampled, a final run assignment of fall-run was applied as the LAD criteria continued to inaccurately assign this run (PSMFC 2013 – 2021).

In coordination with the UC Davis Genomic Variation Laboratory (GVL), opportunistic fin clips from adult and juvenile Pacific Lamprey *Lampetra tridentata* and River lamprey *Lampetra ayresii* were collected for genetic analysis to better understand gene flow and population structure. Details and protocols for the GVL lamprey project can be found under California SCP #10509.

Trap Efficiency

Trap efficiency trials were conducted to quantify the proportion of fall-run Chinook Salmon captured by the RSTs to estimate the total passage of fall-run migrating past the site. Trap efficiency was measured using two different marking methods on the lower American River. When possible, efficiency trials were conducted with Chinook Salmon captured in the RSTs. When catches were too low, Chinook Salmon were provided by CDFW.

One method of marking consisted of dyeing the whole body of a Chinook Salmon with Bismarck Brown Y (BBY) stain when the average fork length was less than 60 mm. Chinook Salmon used in the trial were placed into an aerated 37 gallon insulated tub and stained using a solution of 0.6 g of BBY for every 20 gallons of water. Fish were stained for approximately two hours with fish condition constantly monitored during the staining process. After staining, the marked fish were placed in a 50 gallon live car attached to the rear of the traps and held until twilight before being transported to the release site and released.

The second method consisted of using a Visual Implant Elastomer (VIE) tag when the majority of the Chinook Salmon had a fork length greater than 60 mm. VIE tagging consisted of inserting a syringe and injecting a small amount of colored elastomer just under the skin of the snout of an anesthetized Chinook Salmon. After tagging, marked Chinook Salmon were placed in a 50 gallon live car attached to the rear of the traps and held until twilight before being transported to the release site and released. Tagging supplies, mixing procedures, and protocols for VIE tags were provided by Northwest Marine Technology, Inc.

At least 500 Chinook Salmon were used to conduct each trap efficiency trial with BBY stain or VIE tags. If less than 500 fish were captured on a given day, fish were held overnight and the fish captured the following day were added to the previous day's catch total to acquire the target number of fish. If daily catch totals continued to be too low, Chinook Salmon were provided by the Nimbus Fish Hatchery.

The trap efficiency release site was approximately 1.29 rkm upstream of the traps. Marked salmon were evenly scattered across the width of the river in small groups using dip nets to avoid schooling during release. When river flows were less than 1,200 cfs, fish were released off the bow while rowing an inflatable boat. When flows were greater than 1,200 cfs, a jet boat was used to release fish off the bow while keeping the motor upstream of the released fish. All releases occurred close to dusk to minimize predation.

On trap visits following release, crew members looked carefully for any BBY or VIE marked fish in the RST live wells. Due to the proximity of the release location to the RSTs, the majority of released fish were found to migrate past the site within four days. As a result, trial periods were designated as a minimum of four days. During this period, a subsample of 100 recaptured Chinook Salmon from each trap were measured for fork lengths, assessed for life stage, and evaluated for mortality status. If more than 100 recaptures from a trap efficiency trial 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.”

Retention in Analysis

Under ideal circumstances, the rotary screw traps function normally and continuously between trap visits. However, trap stoppages and abnormal trap functionality can adversely affect catch which ultimately would misrepresent passage estimates. To account for this, if the trap was stopped upon arrival, determined to have been functioning normally for less than 70% of the sampling period, and the West Inc. model imputed a catch greater than the actual catch during the trap visit, the data was excluded from the analysis and the imputed catch was used to calculate passage estimates. This threshold was calculated by using the trap revolutions per hour after cleaning the trap, the total revolutions of the cone, and the duration of the sampling period. The normal functioning percent (Equation 2) is a proportion of the actual total revolutions to the estimated total revolutions (Equation 1) the trap had been functioning normally during that sampling period.

$$Equation\ 1: \quad Hours\ Fished * Revolutions\ (per\ hour) = Estimated\ Total\ Revolutions$$

$$Equation\ 2: \quad \frac{Actual\ Total\ Revolutions}{Estimated\ Total\ Revolutions} * 100 = Normal\ Functioning\ Percent$$

Exclude from Analysis: Normal Functioning Percent < 70% AND Imputed Catch > Actual Catch

Passage Estimates

Fall-run Chinook Salmon passage estimates were developed using an enhanced efficiency model developed by West Inc. that includes raw catch, trap efficiency, and other parameters. The model description from West Inc. is provided in Appendix 3. Confidence intervals were computed using parametric bootstrap or Monte Carlo methods as described in McDonald and Banach (2010).

Fulton's Condition Factor

Fall-run Chinook Salmon condition was assessed using Fulton's condition factor. The first 25 Chinook Salmon greater than or equal to 40 mm were measured for weight and fork length each day. The higher the condition factor value indicates a larger and healthier fish relative to its fork length. The condition factor was calculated using the following equation:

$$Fulton's\ Condition\ Factor = \left(\frac{Weight\ (g)}{Fork\ Length\ (mm)^3}\right) * 100{,}000$$

Results

Trap Operations

Trap 8.1 began sampling on January 15 and concluded June 1 with 120 days of sampling effort in the 138-day season (87%; Figure 3). Of the 120 days of sampling effort, the trap sampled successfully for approximately 2,817 hours (99.16%) and sampled unsuccessfully for approximately 24 hours (0.84%; Figure 4). Trap 8.2 did not begin sampling until February 7 due to anchor line failure. Trap 8.2 concluded sampling on June 1 with 103 days of sampling effort in the 115-day season (90%; Figure 3). Of the 103 days of sampling effort, the trap sampled successfully for approximately 2,413 hours (99.02%), and sampled unsuccessfully for approximately 24 hours (0.98%; Figure 4). Sampling was suspended for a total of 18 days with no outages greater than seven days. This included suspending sampling operations for weekend shutdowns (9), Nimbus Fish Hatchery steelhead smolt release (6), and a wind storm (3).

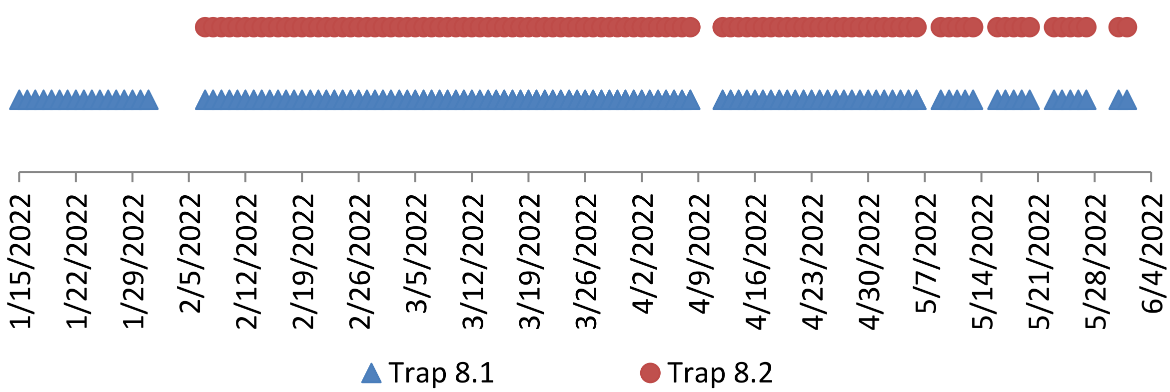

Figure 3: Dates sampling occurred during the 2022 lower American River rotary screw trap survey season.

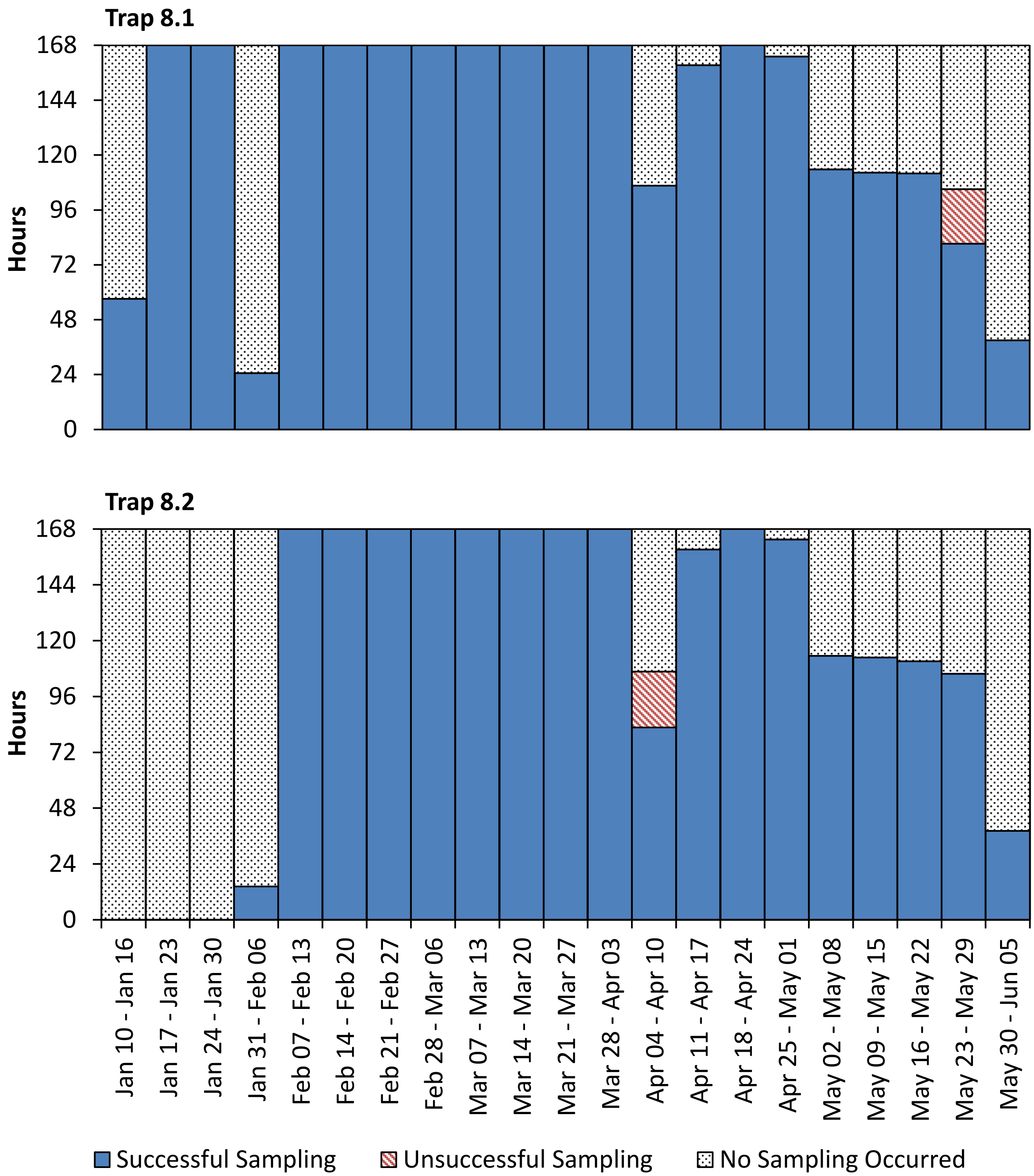

Figure 4: Weighted average hours per Julian week that each trap sampled successfully, sampled unsuccessfully, or did not sample during the 2022 lower American River rotary screw trap survey season.

Environmental Summary

Appendix 4 provides a summary of the environmental conditions, averaged by Julian week, starting on January 15 and spanning through the last week of the 2022 survey season. Measurements taken in the field, such as DO, turbidity, and velocity only reflect days when sampling occurred. Instantaneous river discharge, recorded in 15-minute intervals by USGS, reached a minimum on April 19 and a maximum on January 16 (range: 930 – 4,100 cfs; Figure 5). Additionally, the daily average discharge reached a minimum on April 20 and a maximum on January 16 (range: 1,003 – 4,018 cfs). Instantaneous river temperature, also recorded in 15-minute intervals by USGS at the Watt Avenue gauge station, recorded a minimum on February 2 and a maximum on May 25 (range: 7.4 – 19.5 °C; Figure 5).

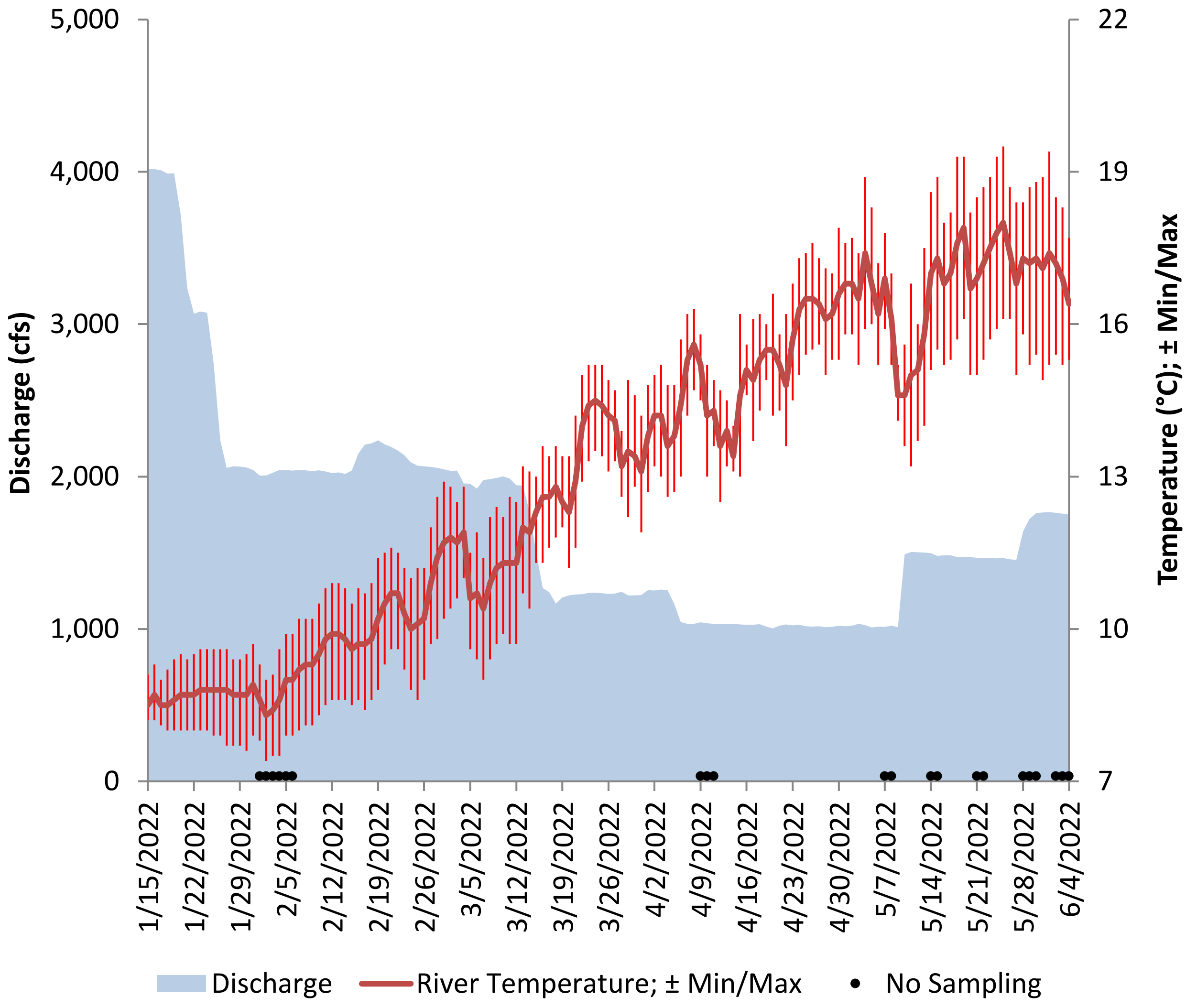

Figure 5: Daily average discharge (cfs) measured at Fair Oaks, and the daily minimum, maximum, and average water temperature (°C) measured at Watt Avenue, and dates no sampling occurred during the 2022 lower American River rotary screw trap survey season.

Velocity, turbidity, and dissolved oxygen were measured during trap visits throughout the season (Figure 6). Water velocity for Trap 8.1 reached a minimum on March 16 and a maximum on January 24 with a range of 0.40 – 1.90 m/s, while Trap 8.2 reached a minimum on March 16, March 20, and May 13, and a maximum on February 6 and February 22 with a range of 0.50 – 1.70 m/s. The mean velocity for Trap 8.1 and Trap 8.2 was similar at 1.10 and 1.19 m/s respectively during the sampling periods when both traps were operating. The maximum velocity for Trap 8.1 is higher than Trap 8.2 likely due to the higher discharge observed at the beginning of the sampling season when only Trap 8.1 was operating. Turbidity for Trap 8.1 reached a minimum on February 11 and a maximum on January 17 with a range of 0.40 – 9.57 NTU. Turbidity for Trap 8.2 reached a minimum on February 11 and a maximum on May 20 with a range of 0.22 – 2.69 NTU. The mean turbidity for Trap 8.1 and Trap 8.2 was similar at 1.27 and 1.05 NTU respectively during the sampling periods when both traps were operating. The maximum turbidity for Trap 8.1 is significantly higher than Trap 8.2 due to the storms and higher discharge observed at the beginning of the sampling season when only Trap 8.1 was operating. Dissolved oxygen reached a minimum on April 26 and a maximum on January 17 with a range of 8.19 to 13.19 mg/L.

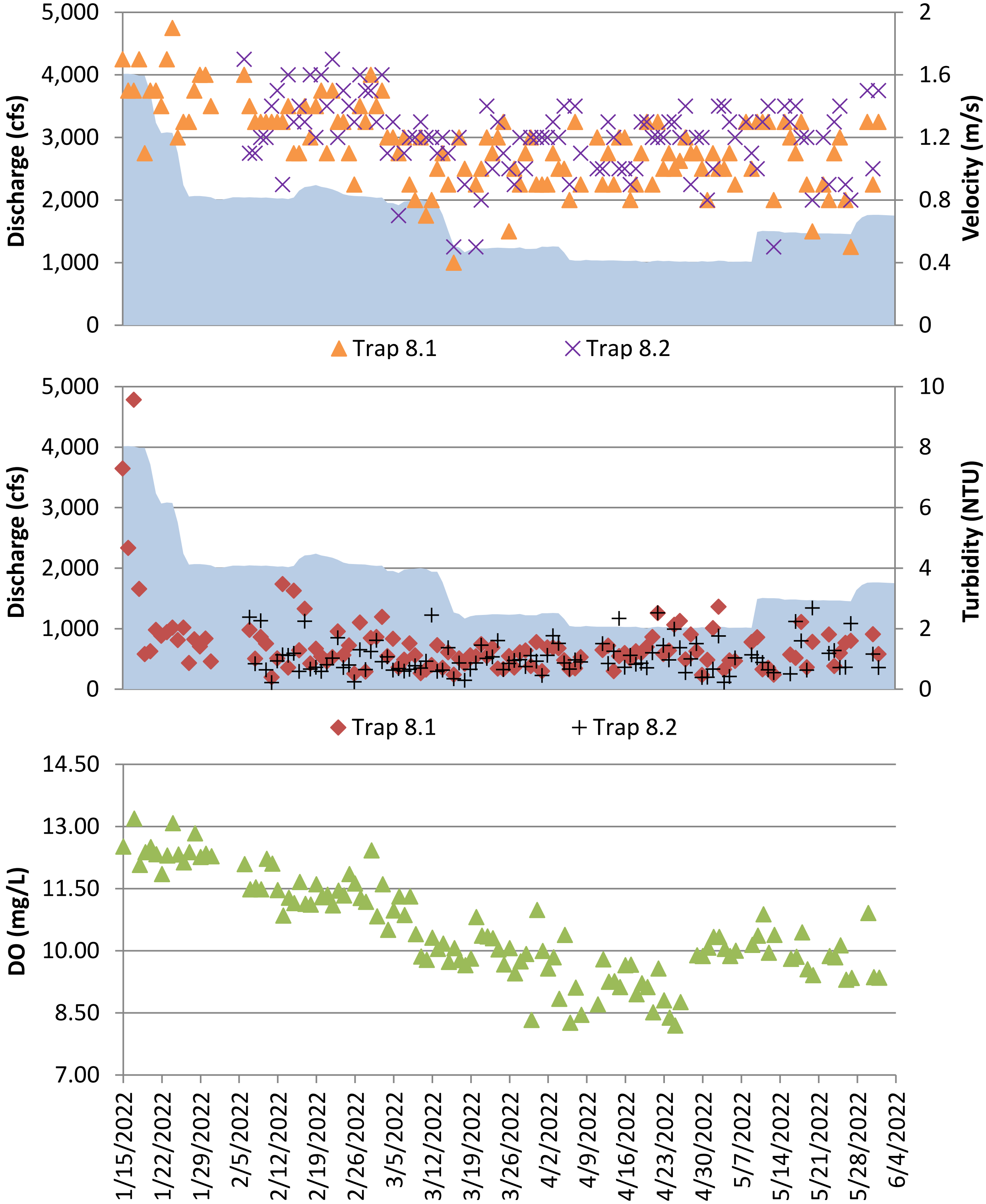

Figure 6: Daily average velocity (m/s), turbidity (NTU), discharge (cfs) measured at Fair Oaks, and dissolved oxygen (DO) (mg/L), for both traps during the 2022 lower American River rotary screw trap survey season.

Catch

The two rotary screw traps deployed during the 2022 survey season captured 39,497 natural origin fish and 105 hatchery-produced salmonids. The trap furthest from the thalweg, Trap 8.1, captured 61.7% (*n* = 24,428) of these fish, while Trap 8.2 captured 38.3% (*n* = 15,174). Additionally, 7,269 non-salmonid species were captured and identified to at least the genus level (Appendix 5).

Fall-run Chinook Salmon

Natural origin fall-run Chinook Salmon encompassed the majority of all natural origin fish captured during the 2022 survey season with 31,581 determined to be fall-run based on results of genetic analysis. Because these fish did not have an adipose fin clip, they were presumed to be of natural origin. Catch of fall-run peaked on February 16, when 7.12% (*n* = 2,248) of these fish were captured (Figure 7). Of all fall-run captured during the 2022 survey season, 18,188 were classified as unmeasured plus-count tallies. Cumulative fall-run catch exceeded 95% on April 22 (Table 3).

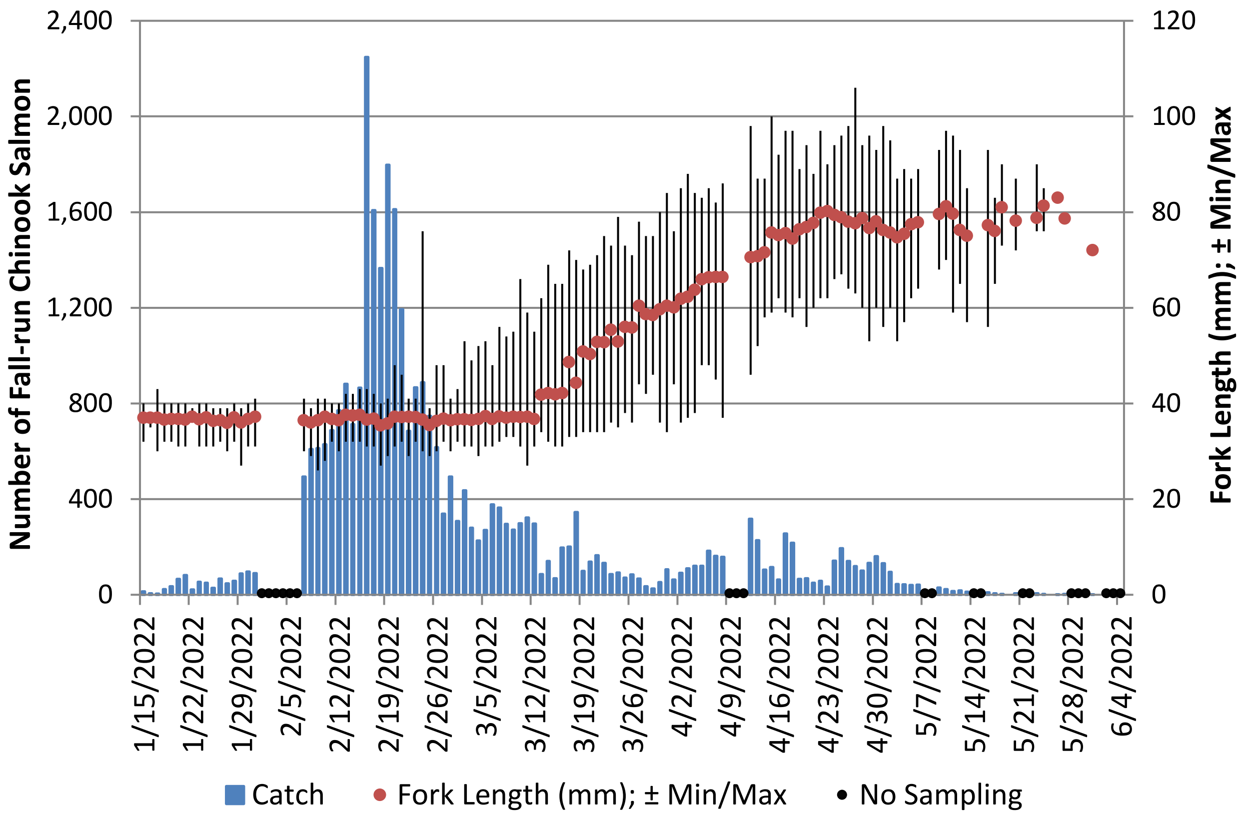

Figure 7: Daily minimum, maximum, and average fork length (mm) and total catch of natural origin fall-run Chinook Salmon during the 2022 lower American River rotary screw trap sampling season.

Table 3: Dates cumulative catch of natural origin fall-run Chinook Salmon exceeded twenty-five, fifty, seventy-five, and ninety-five percent during the 2022 lower American River rotary screw trap sampling season.

Proportion of Catch	Dates
25%	February 16th
50%	February 21st
75%	March 7th
95%	April 22nd

A total of 13,393 natural origin fall-run were measured for fork length. The weekly minimum, maximum, and average fork lengths throughout the 2022 survey season are displayed in Table 4. The lowest weekly average fork length of 37 mm was seen during the first week of sampling and the weekly average remained at 37 mm through the week of March 5. The smallest natural origin fall-run was 26 mm and was observed on February 9. Fork lengths slowly increased throughout the season with the weekly average reaching a maximum of 80 mm the week of May 21. The largest natural origin fall-run was 106 mm and was observed on April 27.

Table 4: Weekly average (Avg), minimum and maximum (range), and the standard deviation (St. Dev.) of fork lengths (mm) and total weekly catch (n) for natural origin fall-run Chinook Salmon captured during the 2022 lower American River rotary screw trap sampling season.

Julian Week	Avg	Range	n	St. Dev.
1/15 - 1/21	37	30 - 43	230	1.78
1/22 - 1/28	37	30 - 40	324	1.82
1/29 - 2/4	37	27 - 41	274	1.89
2/5 - 2/11	37	26 - 41	3,031	2.00
2/12 - 2/18	37	27 - 43	8,451	2.12
2/19 - 2/25	37	29 - 76	7,789	2.28
2/26 - 3/4	37	29 - 53	2,698	2.17
3/5 - 3/11	37	27 - 66	2,199	2.94
3/12 - 3/18	42	31 - 72	1,335	8.03
3/19 - 3/25	53	34 - 79	782	9.32
3/26 - 4/1	59	34 - 84	433	8.09
4/2 - 4/8	65	36 - 88	946	7.74
4/9 - 4/15	72	46 - 100	765	7.15
4/16 - 4/22	76	56 - 97	775	6.20
4/23 - 4/29	78	53 - 106	863	5.95
4/30 - 5/6	77	53 - 98	554	6.37
5/7 - 5/13	79	57 - 97	96	7.65
5/14 - 5/20	78	56 - 93	23	10.04
5/21 - 5/27	80	76 - 90	12	4.56
5/28 - 6/3	72	72	1	-

The subsample of fall-run that were measured for fork length, were also assessed for life stage (Figure 8; Table 5). The majority of these fish were identified as button-up fry and accounted for 62.2% (*n* = 8,326) of the assessed catch. The remaining life stage catch composition consisted of yolk-sac fry (0.5%, *n* = 71), parr (10.5%, *n* = 1,408), silvery parr (26.4%, *n* = 3,536), and smolts (0.4%, *n* = 52). Fall-run Chinook Salmon identified as yolk-sac fry were captured between January 15 and March 24. Button-up fry were captured between January 15 and April 12. Parr were captured between February 20 and May 16, and silvery parr were caught from February 24 through May 31. Lastly, 52 fall-run were identified as smolts and were captured between March 27 and May 18.

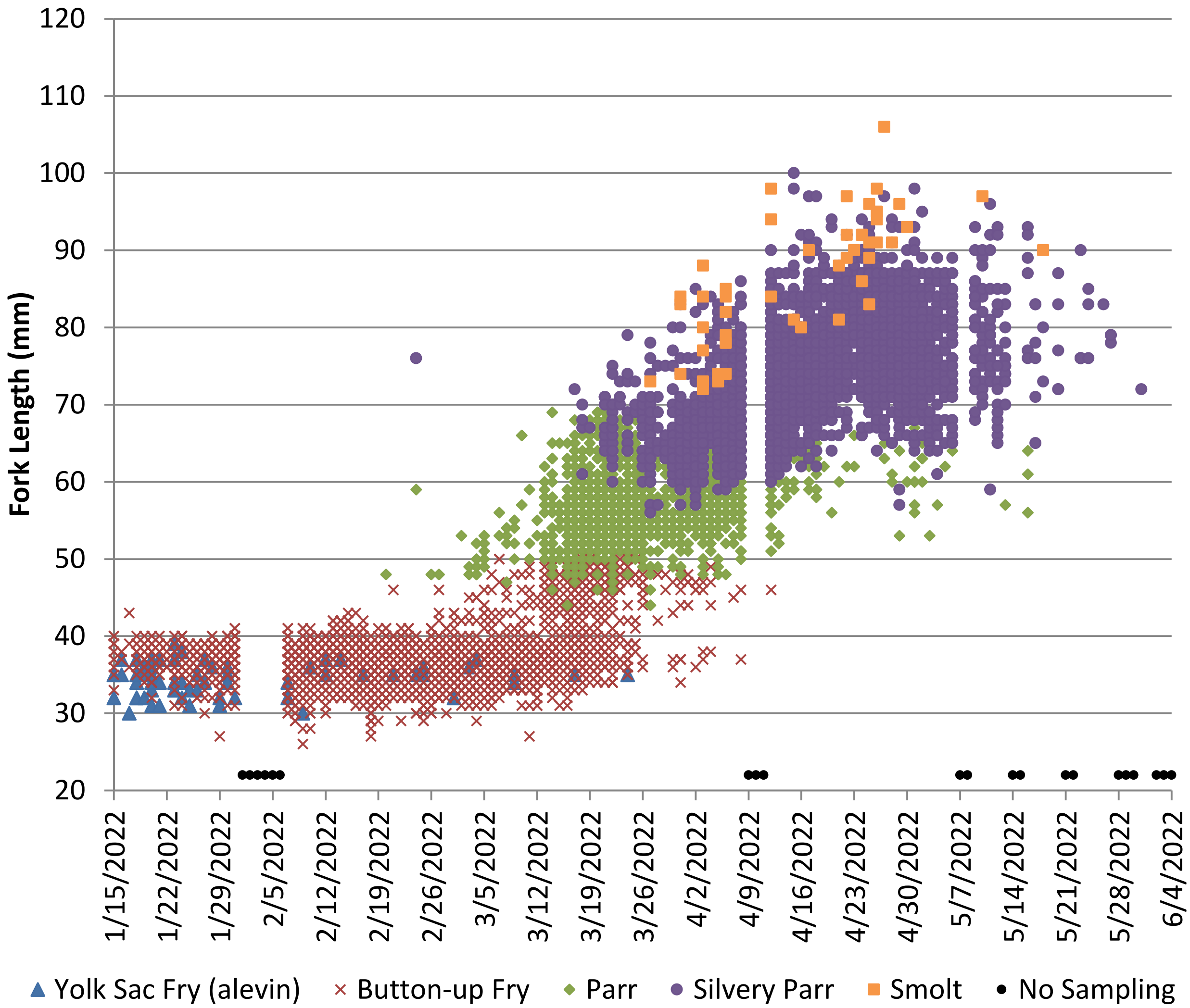

Figure 8: Daily fork length distribution by life stage of natural origin fall-run Chinook Salmon measured during the 2022 lower American River rotary screw trap survey season.

For each identified life stage of measured fall-run Chinook Salmon, fork length distributions varied (Table 5). Fork lengths ranged from 30 – 39 mm for yolk-sac fry, 26 – 50 mm for button-up fry, 44 – 74 mm for parr, 56 – 100 mm for silvery parr, and 72 – 106 mm for smolt life stages.

Average weekly fork lengths generally increased with life stage progression with yolk-sac fry having the lowest average weekly fork length, and smolts having the largest average weekly fork lengths. Fork lengths for the fall-run with life stages identified averaged 34 mm for yolk-sac fry, 37 mm for button-up fry, 57 mm for parr, 74 mm for silvery parr, and 86 mm for smolts (Table 5).

Table 5: Weekly average fork length in millimeters (Avg), minimum and maximum fork lengths (range), and sample size (n) for each identified life stage of natural origin fall-run Chinook Salmon captured during the 2022 lower American River rotary screw trap survey season.

Julian Week	Yolk-sac Fry Avg (range, n)	Button-up Fry Avg (range, n)	Parr Avg (range, n)	Silvery Parr Avg (range, n)	Smolt Avg (range, n)
1/15 - 1/21	34 (30 - 37, *n* = 26)	37 (32 - 43, *n* = 203)	-	-	-
1/22 - 1/28	35 (31 - 39, *n* = 18)	37 (30 - 40, *n* = 299)	-	-	-
1/29 - 2/4	33 (31 - 36, *n* = 7)	37 (27 - 41, *n* = 266)	-	-	-
2/5 - 2/11	34 (30 - 36, *n* = 5)	37 (26 - 41, *n* = 995)	-	-	-
2/12 - 2/18	36 (35 - 37, *n* = 4)	37 (27 - 43, *n* = 1,396)	-	-	-
2/19 - 2/25	35 (35 - 36, *n* = 4)	37 (29 - 46, *n* = 1,395)	54 (48 - 59, *n* = 2)	76 (76, *n* = 1)	-
2/26 - 3/4	35 (32 - 37, *n* = 3)	36 (29 - 46, *n* = 1,345)	49 (48 - 53, *n* = 10)	-	-
3/5 - 3/11	34 (34 - 35, *n* = 2)	37 (27 - 50, *n* = 1,354)	53 (47 - 66, *n* = 22)	-	-
3/12 - 3/18	35 (35, *n* = 1)	39 (31 - 50, *n* = 776)	55 (44 - 69, *n* = 231)	68 (61 - 72, *n* = 5)	-
3/19 - 3/25	35 (35, *n* = 1)	42 (34 - 50, *n* = 245)	57 (46 - 69, *n* = 472)	67 (60 - 79, *n* = 54)	-
3/26 - 4/1	-	44 (34 - 48, *n* = 34)	56 (44 - 66, *n* = 213)	66 (56 - 83, *n* = 178)	78 (73 - 84, *n* = 4)
4/2 - 4/8	-	44 (36 - 49, *n* = 17)	59 (48 - 73, *n* = 338)	69 (57 - 86, *n* = 563)	79 (72 - 88, *n* = 18)
4/9 - 4/15	-	46 (46, *n* = 1)	60 (51 - 68, *n* = 57)	73 (60 - 100, *n* = 601)	89 (81 - 98, *n* = 4)
4/16 - 4/22	-	-	63 (56 - 74, *n* = 32)	76 (62 - 97, *n* = 683)	88 (80 - 97, *n* = 7)
4/23 - 4/29	-	-	62 (53 - 66, *n* = 8)	78 (57 - 97, *n* = 804)	93 (83 - 106, *n* = 16)
4/30 - 5/6	-	-	61 (53 - 67, *n* = 19)	77 (61 - 98, *n* = 521)	93 (93, *n* = 1)
5/7 - 5/13	-	-	57 (57, *n* = 1)	79 (59 - 96, *n* = 94)	97 (97, *n* = 1)
5/14 - 5/20	-	-	60 (56 - 64, *n* = 3)	80 (65 - 93, *n* = 19)	90 (90, *n* = 1)
5/21 - 5/27	-	-	-	80 (76 - 90, *n* = 12)	-
5/28 - 6/3	-	-	-	72 (72, *n* = 1)	-
Entire Season	**34 (30 - 39, *n* = 71)**	**37 (26 - 50, *n* = 8,326)**	**57 (44 - 74, *n* = 1,408)**	**74 (56 - 100, *n* = 3,536)**	**86 (72 - 106, *n* = 52)**

Fulton's Condition Factor

Fulton's condition factor (K) for natural origin fall-run Chinook Salmon captured in 2022 is shown in Figure 9. The trend line slopes were positive for button-up fry (0.0060), parr (0.0020), silvery parr (0.0013), and smolt (0.0010) life stages. Yolk-sac fry captured in 2022 were unable to be accessed for Fulton's condition factor as every fish identified with this life stage measured less than 40 mm and was therefore not weighed. Average Fulton's condition factor (K) increased with the life stage progression (Table 6).

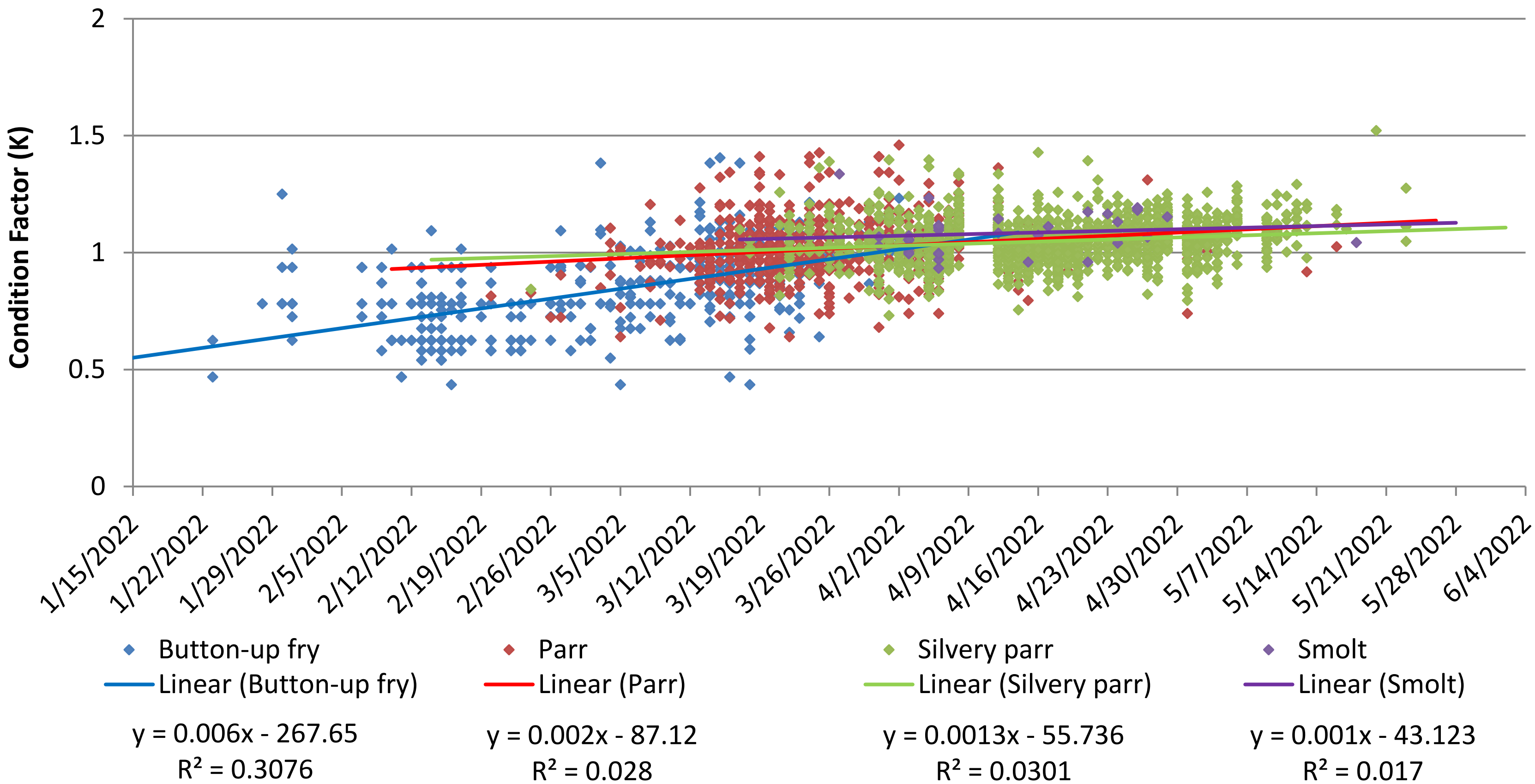

Figure 9: Fulton's condition factor (K) by life stage of fall-run Chinook Salmon during the 2022 lower American River rotary screw trap survey season.

Table 6: Average Fulton's condition factor (K) and minimum and maximum condition factor (range) by life stage for natural origin fall-run Chinook Salmon during the 2022 lower American River rotary screw trap sampling season.

Life stage	Condition Factor Avg (range)
Button-up fry	0.8355 (0.4353 – 1.4063)
Parr	1.0149 (0.6400 – 1.4607)
Silvery Parr	1.0495 (0.7315 - 1.5215)
Smolt	1.0831 (0.9330 – 1.3367)

Trap Efficiency

Six trap efficiency trials were conducted during the 2022 survey season. The six trials used a total of 4,488 fall-run Chinook Salmon. Of these fish, 1,591 were natural origin salmon collected from the RSTs and marked with BBY. The remaining 2,897 were collected from Nimbus Fish Hatchery and marked with either BBY or VIE depending on fork length. The average trap efficiency across the six trials was 14.46% with a total of 649 marked salmon being recaptured within seven days of each release. Additionally, the average fork length of the recaptured fish was approximately the same size as the average fork length of the released fish.

Table 7: Trap efficiency mark, release, and recapture data acquired during the 2022 lower American River rotary screw trap survey season.

				Release Data					Recapture Data	
Date Marked	Fish Origin	Mark Type	Included	Date	Release Time	Flow (cfs)	Avg FL (mm)	n	Capture Efficiency	Avg FL (mm)
2/15/22	Natural	BBY	Yes	2/15/22	17:23	2,040	37	937	10.0%	37
3/2/22	Natural	BBY	Yes	3/2/22	17:50	2,040	36	654	5.7%	37
3/16/22	Hatchery	BBY	Yes	3/17/22	19:00	1,250	56	724	13.0%	57
3/29/22	Hatchery	VIE	Yes	3/30/22	19:09	1,130	61	687	21.7%	61
4/13/22	Hatchery	VIE	Yes	4/13/22	18:36	1,020	67	722	21.6%	69
4/26/22	Hatchery	VIE	Yes	4/26/22	19:56	1,040	76	764	15.6%	77

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

Included: Indicates if the trial was used in determining passage estimates.
Flow (cfs) = discharge from the USGS gauge 11446500 at time of release.
Avg FL (mm) = Average fork length in millimeters for released or recaptured salmon.
n = Total number of marked salmon released for the efficiency trial.
Natural = Unmarked (adipose intact) fish caught in the lower American River RSTs.
Hatchery = Nimbus Fish Hatchery.
BBY = Bismark brown Y whole body stain.
VIE = Visual Implant Elastomer dye, marked on the snout.

Passage Estimate for Fall-Run Chinook Salmon

The passage estimate model developed by West Inc. estimated that 180,224 natural origin fall-run Chinook Salmon were estimated to have emigrated past the Watt Ave rotary screw trap location during the 2022 survey season (95% CI 165,000 to 199,800; Figure 10). The highest weekly passage estimate occurred the week of February 12 with approximately 34,112 fall-run estimated to have emigrated past the rotary screw traps (Table 8). Cumulative fall-run passage exceeded 95% on April 25 (Table 9).

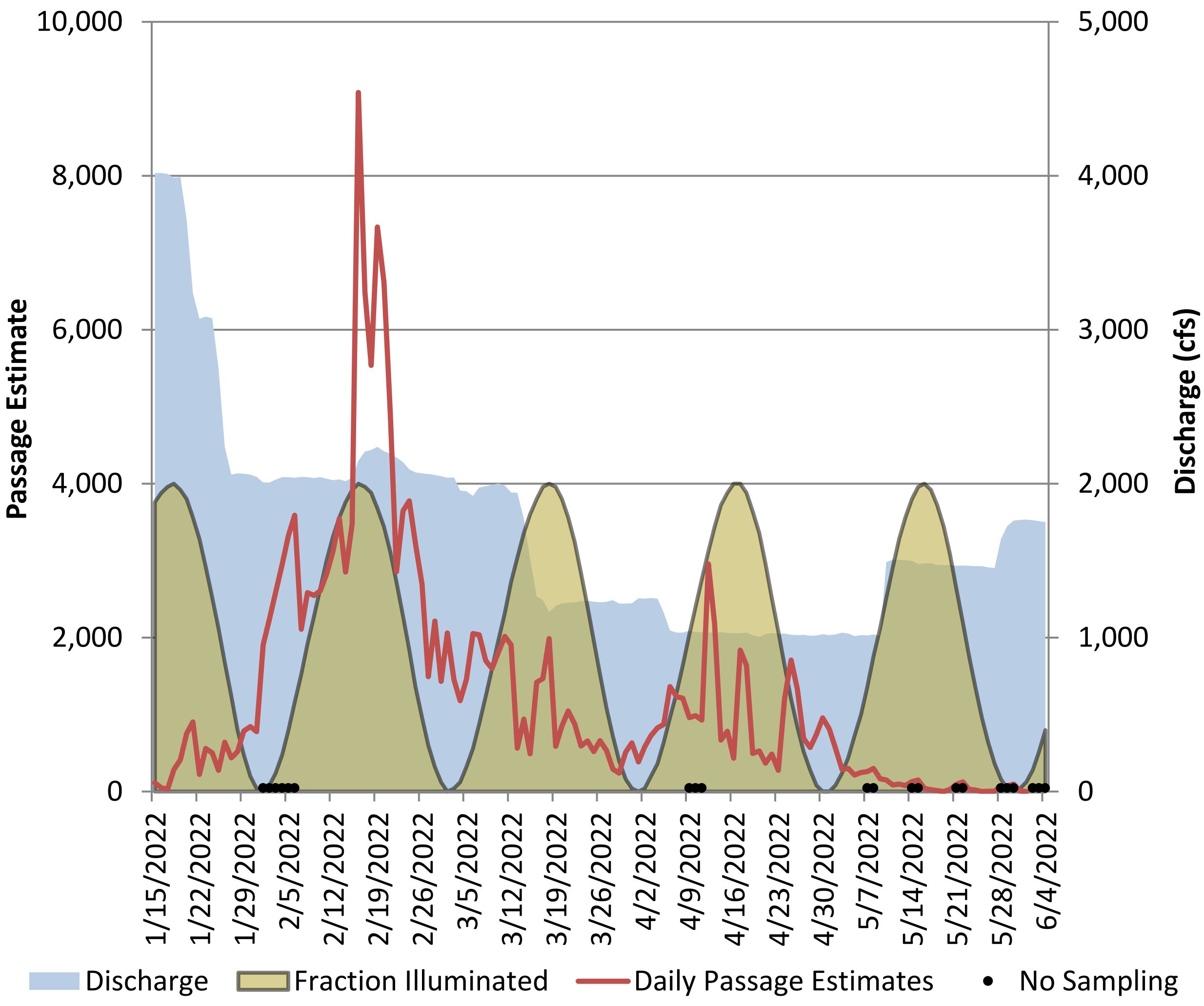

Figure 10: Daily passage estimate of natural origin fall-run Chinook Salmon and daily average discharge at Fair Oaks during the 2022 lower American River rotary screw trap survey season.

Table 8: Weekly passage estimate of natural origin fall-run Chinook Salmon with 95% confidence intervals (CI) and weekly average discharge at Fair Oaks during the 2022 lower American River rotary screw trap survey season.

Julian Week	Discharge (cfs)	Passage Estimate	95% CI
1/15 - 1/21	3,854	2,550	(1,680 - 4,039)
1/22 - 1/28	2,620	3,159	(2,270 - 4,661)
1/29 - 2/4	2,036	12,097	(9,527 - 15,538)
2/5 - 2/11	2,040	19,587	(17,077 - 22,720)
2/12 - 2/18	2,098	34,112	(31,000 - 38,931)
2/19 - 2/25	2,160	32,379	(29,089 - 36,107)
2/26 - 3/4	2,038	12,526	(10,966 - 14,368)
3/5 - 3/11	1,973	12,657	(10,305 - 15,892)
3/12 - 3/18	1,546	8,778	(6,736 - 11,681)
3/19 - 3/25	1,227	5,130	(4,278 - 6,354)
3/26 - 4/1	1,232	3,250	(2,643 - 4,233)
4/2 - 4/8	1149	6,810	(5,707 - 8,447)
4/9 - 4/15	1,035	9,463	(7,323 - 12,650)
4/16 - 4/22	1,023	5,783	(4,641 - 7,947)
4/23 - 4/29	1,018	6,524	(4,930 - 8,956)
4/30 - 5/6	1,021	3,383	(2,448 - 4,660)
5/7 - 5/13	1,293	1,135	(870 - 1,462)
5/14 - 5/20	1,480	379	(285 - 527)
5/21 - 5/27	1,463	272	(223 - 348)
5/28 - 6/3	1,739	250	(201 - 325)
Total	**1,702**	**180,224**	**(165,500 - 199,800)**

Table 9: Dates cumulative passage of natural origin fall-run Chinook Salmon exceeded twenty-five, fifty, seventy-five, and ninety-five percent during the 2022 lower American River rotary screw trap sampling season.

Proportion of Passage	Dates
25%	February 14th
50%	February 21st
75%	March 17th
95%	April 25th

Genetic Analysis

A total of 178 genetic samples were taken from Chinook Salmon (80 LAD fall-run and 98 LAD spring-run) and analyzed using SNP genetic markers to determine final run assignments (Appendix 6). All salmon sampled for genetics did not have a clipped adipose fin and were presumed to be of natural origin. The SNP panel's probabilities of the samples exceeded the 50 percent threshold for all 178 samples and the corresponding run assignments for salmon were assigned based on genetic analysis.

A total of 31,189 natural origin Chinook Salmon captured were classified as fall-run using the LAD criteria. Genetic samples were collected from 80 LAD fall-run throughout the 2022 sampling season. Analyses using SNP genetic markers for these samples indicated that 100% (*n* = 80) were correctly identified as fall-run Chinook Salmon (Table 10). Because the LAD criteria continued to be highly accurate when assigning this run, a final run assessment of fall was applied to the remaining 31,109 LAD fall-run that were not genetically sampled.

A total of 394 natural origin Chinook Salmon captured were classified as spring-run using the LAD criteria. Genetic samples were collected from 98 of the LAD spring-run throughout the 2022 sampling season. Analyses using SNP genetic markers for these samples indicated that 97.96% (*n* = 96) of these individuals were fall-run, 1.02% (*n* = 1) was a spring-run, and 1.02% (*n* = 1) was a winter-run (Table 10). Because the LAD criteria appeared to incorrectly assign this run for the majority of these individuals, the remaining 296 of the LAD spring-run that were not genetically sampled were given a final run assignment of fall-run.

No LAD late fall-run and winter-run Chinook Salmon were captured during the 2022 sampling season (Table 10).

Table 10: Comparison of Chinook Salmon run assignments using length-at-date criteria and SNP genetic markers.

Length-at-Date Run Assignment	Genetic Run Assignment			
	Fall	Late Fall	Spring	Winter
Fall	80	0	0	0
Late Fall	0	0	0	0
Spring	96	0	1	1
Winter	0	0	0	0

Note: Genetic salmon run assignment was based on a > 50 percent genetic probability threshold. The table only includes Chinook Salmon presumed to be of natural origin (i.e. presence of an adipose fin).

Spring-run and Winter-run Chinook Salmon

Genetic analyses suggest that one natural origin spring-run and one natural origin winter-run Chinook Salmon were captured during the 2022 survey season. The genetically confirmed spring-run was captured on January 23 when the LAD spring-run fork length range was between 47 and 63 mm (Greene 1992). The spring-run was identified as a button-up fry with a fork length of 50 mm with the fish measuring 10 mm longer than the largest fall-run captured that day. The genetically confirmed winter-run was captured on February 15 when the LAD winter-run fork length range was between 74 and 148 mm (Greene 1992). The fish was identified as a silvery parr with a fork length of 73 mm with the fish measuring 30 mm longer than the largest fall-run captured that day (Appendix 6).

Steelhead

A total of 404 natural origin steelhead were captured during the 2022 survey season. Catch peaked on May 11, comprising 5.69% (*n* = 23) of the total natural origin steelhead captured (Figure 11). The majority of captured steelhead were assessed for life stage. The life stage composition consisted of 3 yolk-sac fry, 186 button-up fry, 194 parr, 17 silvery parr, 1 yearling, 1 adult, and 2 that were not assigned a life stage. Fork lengths ranged from 24 – 26 mm for yolk-sac fry, 20 – 45 mm for button-up fry, 36 – 80 mm for parr, 59 – 90 mm for silvery parr, 247 mm for the yearling, and 787 for the adult (Figure 12). Cumulative catch of natural origin steelhead exceeded 95% on May 13 (Table 11).

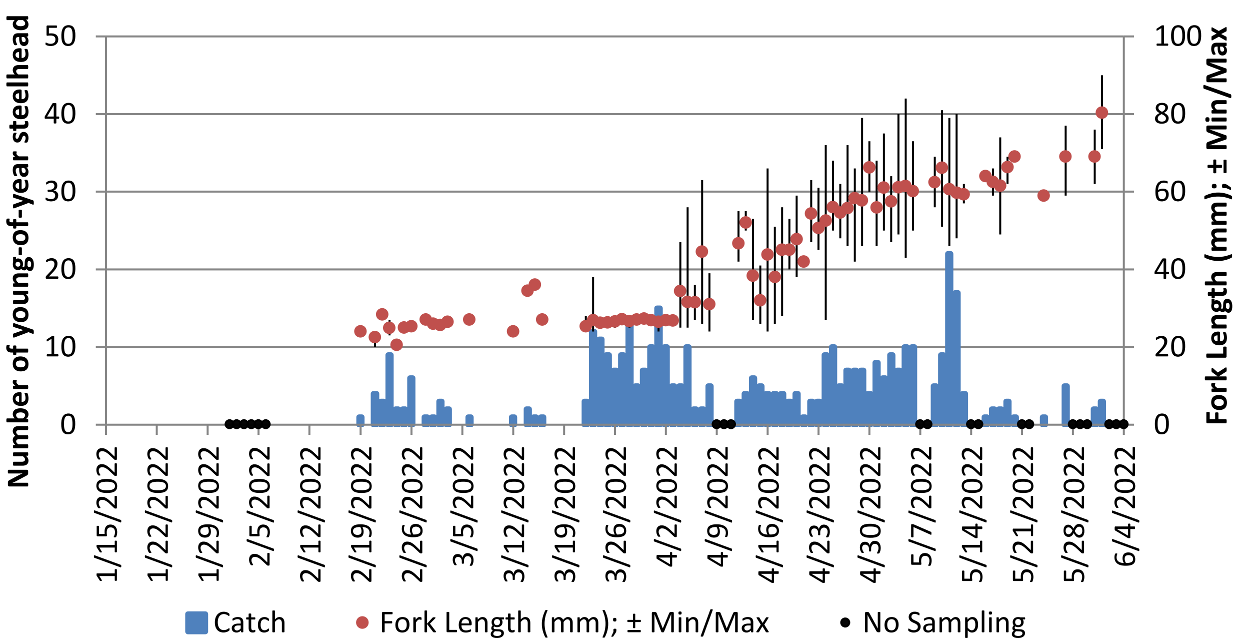

Figure 11: Daily minimum, maximum, and average fork length (mm) and catch distribution of natural origin young-of-year (YOY) steelhead captured during the 2022 lower American River rotary screw trap survey season.

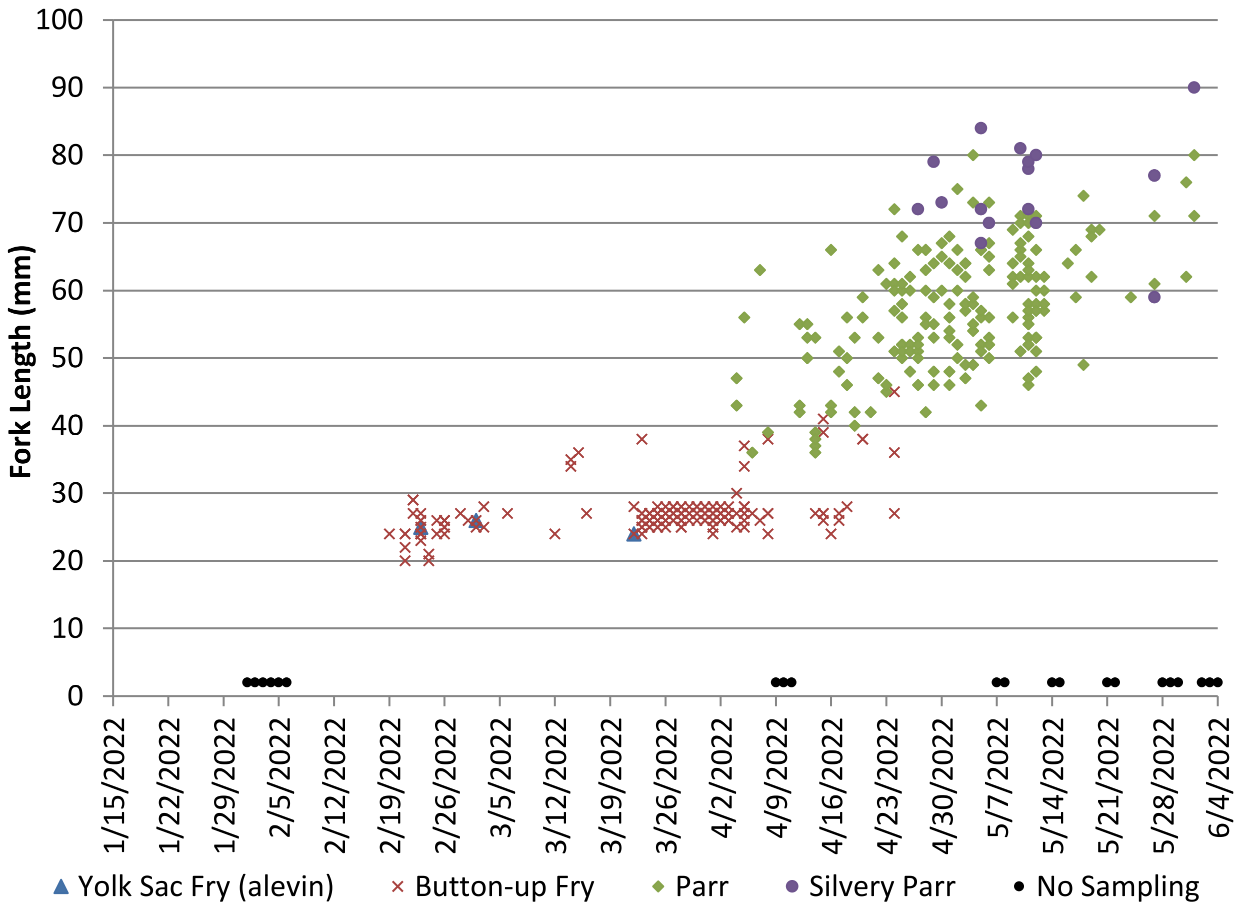

Figure 12: Daily fork length distribution by life stage of natural origin young-of-year steelhead measured during the 2022 lower American River rotary screw trap survey season.

Table 11: Dates cumulative catch of natural origin steelhead exceeded twenty-five, fifty, seventy-five, and ninety-five percent during the 2022 lower American River rotary screw trap sampling season.

Proportion of Catch	Dates
25%	March 28th
50%	April 16th
75%	May 4th
95%	May 13th

In addition to the natural origin steelhead catch, 105 adipose clipped hatchery origin steelhead were also captured. These fish were caught between February 7 and May 6, with an average fork length of 183 mm and range of 126 – 710 mm. Daily catch peaked on February 7 (*n* = 20).

Non-salmonid Species

A total of 7,510 non-salmonid fish were captured during the 2022 survey season. The majority (*n* = 7,269, 96.79%) of these fish belonged to 20 identified species in the following families: Catostomidae (suckers), Centrarchidae (sunfish), Clupeidae (shad), Cottidae (sculpins), Cyprinidae (minnows), Embiotocidae (Tule Perch), Gasterosteidae (sticklebacks), Ictaluridae (catfish), Osmeridae (smelts), Petromyzontidae (northern lampreys), and Poeciliidae (mosquitofish; Figure 13). The remaining 3.21% (*n* = 241) were not able to be identified to species level, but belonged to the following families: Centrarchidae (*n* = 59), Cottidae (*n* = 8), Cyprinidae (*n* = 4), and Petromyzontidae (*n* = 170). The majority of non-salmonid fish captured were native to the Central Valley watershed (*n* = 5,346, 71.19%) with the remaining individuals (*n* = 2,164, 28.81%) being non-native species. Appendix 5 contains a complete list of species captured in the 2022 survey season.

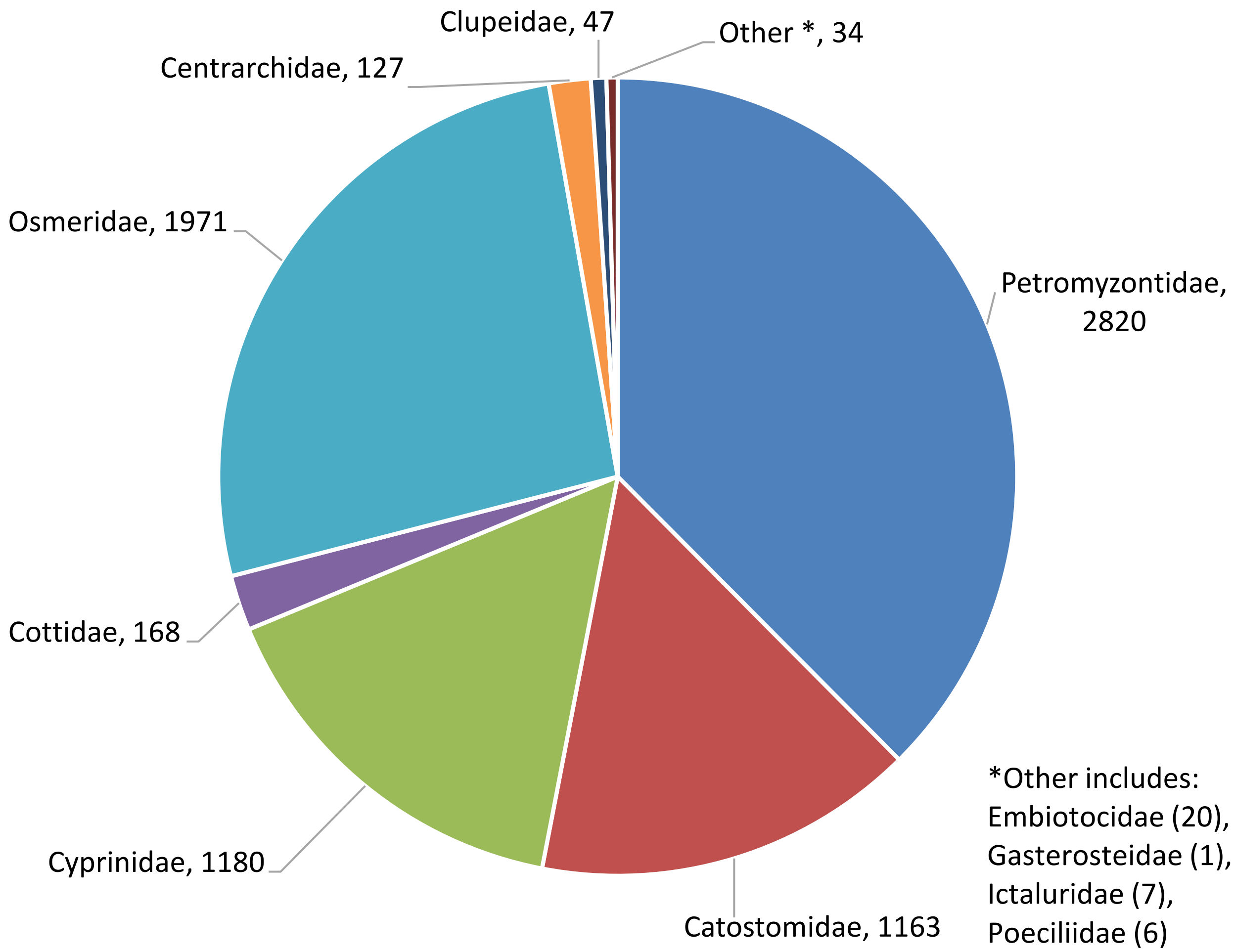

Figure 13: Non-salmonid catch totals for each family of species collected during the 2022 lower American River rotary screw trap survey season.

Of the 7,510 non-salmonid fish captured, 2,820 (37.55%) were identified as Petromyzontidae spp. (northern lampreys); 2,607 (34.71%) of which were identified as Pacific Lamprey, consisting of 18 adults and 2,589 juveniles. 43 (0.57%) were identified as juvenile River Lamprey. The remaining 170 (2.26%) captured were identified as Petromyzontidae ammocoetes and were not identified to a species level. Catch of Pacific Lamprey macropthalmia peaked on April 22 when 510 (19.56%) of the total Pacific Lamprey were captured. Catch of River Lamprey peaked on March 29 when four (9.30%) were captured. Catch of ammocoetes peaked on March 29 when 16 (9.41%) of the total was captured. (Figure 14).

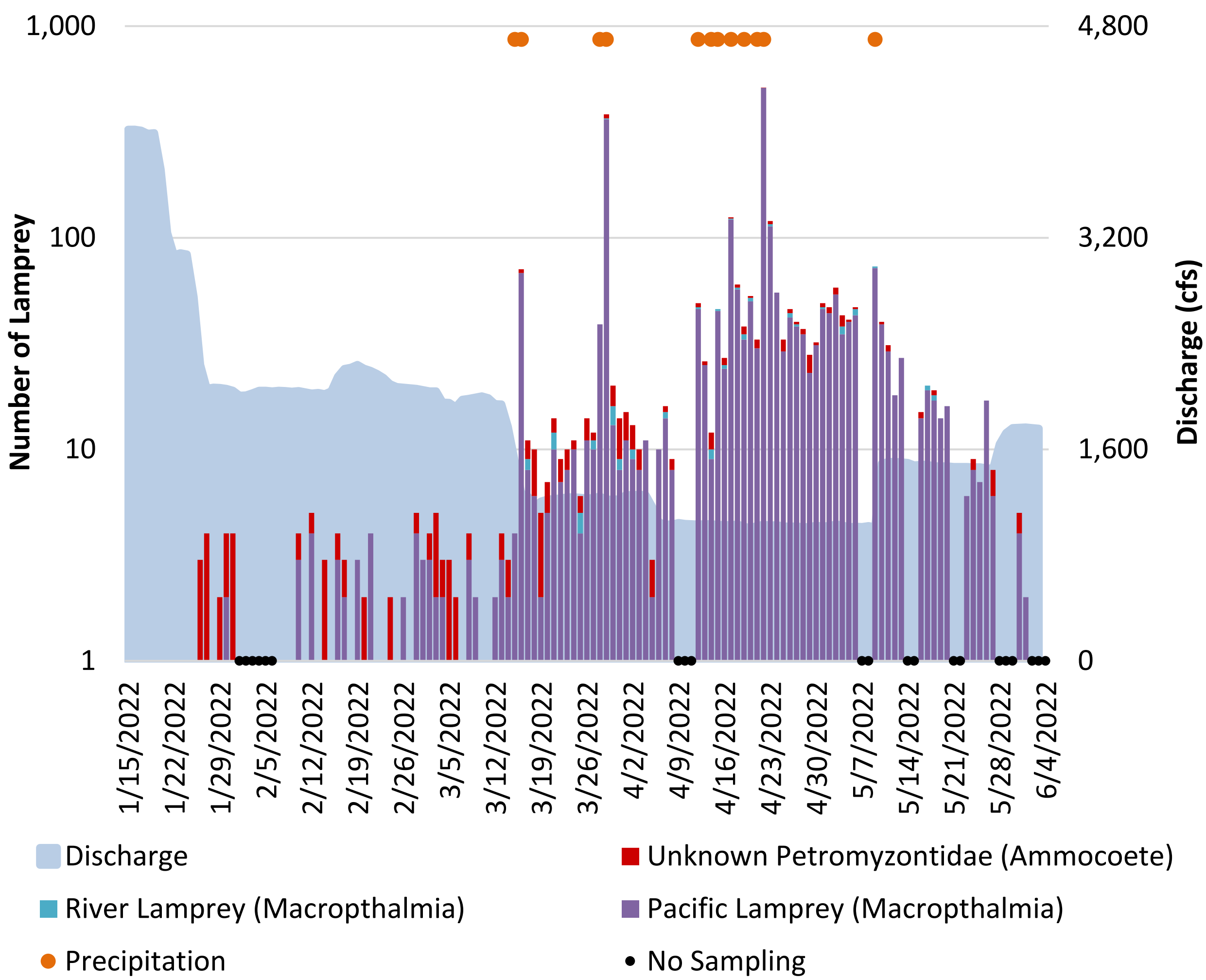

Figure 14: Daily lamprey catch and daily discharge at Fair Oaks during the 2022 lower American River rotary screw trap survey season.

Discussion

Project Scope

The continued operation of the lower American River rotary screw traps during the 2022 survey season provided valuable biological monitoring data for emigrating Chinook Salmon and steelhead. Primary objectives of the study were met by developing fall-run Chinook Salmon passage estimates and accurately quantifying catch of steelhead, winter-run, and spring-run Chinook Salmon. Secondary objectives were met by collecting biological data from captured salmonids that can be used to determine how populations respond to various environmental parameters. This data will continue to strengthen the understanding of lower American River salmonids by expanding on findings from previous CDFW emigration surveys (1992-2012) and PSMFC rotary screw trap emigration surveys (2013-2021).

Passage Estimate and Catch

Several factors must be considered when interpreting catch and passage estimates of fall-run Chinook Salmon and the quantity of steelhead, winter-run, and spring-run Chinook Salmon captured during the 2022 sampling season.

The first significant factor is whether the sampling season encompassed the entirety of the juvenile salmonid emigration period. Through the first seven days of sampling a total of 230 fall-run were captured and a passage of 2,550 fall-run was estimated, accounting for 0.73% of the total fall-run catch and 1.41% of the total fall-run passage estimate. Furthermore, through the last seven days of sampling a total of 13 fall-run were captured and a passage of 60 fall-run was estimated, accounting for 0.04% of the total fall-run catch and 0.03% of the total fall-run passage estimate. It is important to note that Trap 8.2 did not begin sampling until February 7, likely biasing the fall-run catch and passage estimates low during the first seven days of sampling. However, due to the low catch and passage estimate during the first and last seven days of sampling, it is likely that the sampling season encompassed the vast majority of the juvenile salmonid emigration period.

Trap operation is another critical factor when interpreting annual catch and passage estimates. Ideally, the RSTs continuously operate to the furthest extent possible throughout the full length of the salmonid emigration period to accurately enumerate salmonid catch and estimate passage. During the 2022 sampling season, sampling was suspended for a total of 18 days (13.04%) of the 138 day season (Figure 3 and 4). Since no fish were captured when the RSTs were not sampling, the CAMP model imputed an estimate of daily fall-run catch to estimate daily passage during the 18 days no sampling occurred. Additionally, since there were no gaps in sampling greater than seven days in duration, the CAMP platform was able to estimate passage for the full length of the 2022 sampling season.

Salmonid catch and fall-run passage estimates are also dependent on the quantity, quality, and recapture efficiencies obtained through the trap efficiency trials. All six efficiency trials conducted during the 2022 sampling season were included for data analysis. The capture efficiencies during the first two trials in February and March averaged 7.9% (range: 5.7– 10.0%), while the last four trials in March and April averaged 18.0% (range: 13.0 – 21.7%). The increase in capture efficiency could be explained by the reduction in discharge beginning March 14 through March 16 (Figure 5). This is because the north channel carries a larger proportion of the water volume with a reduction in flow, thus enabling the RSTs to fish a larger proportion of the river and evidently result in a higher capture efficiency (Table 12, Appendix 8).

Table 12: Number of efficiency trials (n), average trap efficiency (Avg Efficiency), and efficiency range (Range) acquired from 2013 – 2022 lower American River rotary screw trap survey season.

Discharge (cfs)	n	Avg Efficiency	Range
< 500	3	26.19%	(17.98% - 34.17%)
500 - 999	26	18.08%	(4.40% - 28.80%)
1,000 - 1,999	20	10.15%	(1.90% - 21.69%)
2,000 - 4,999	10	7.03%	(2.70% - 12.98%)
>= 5000	9	1.86%	(0.46% - 3.71%)

Effective efficiency trials are also dependent upon adequate, stable flow and successful trap operation during the entirety of the efficiency trial period (USFWS 2008). The ideal velocity of 1.5 m/s for 8-foot RSTs is occasionally seen on the lower American River and was observed on a handful of occasions in 2022 with velocity averaging 1.2 m/s and a range of 0.4 – 1.9 m/s (USFWS 2008). Additionally, flows remained relatively stable throughout the duration of each trap efficiency trial (Figure 5). Trap 8.2 was only stopped on one occasion during the first and fourth trap efficiency trial. This occurred on the sixth and fifth day after the release, respectively. However, between all the efficiency trials, all but one test fish was captured within four days after the initial release. Though it is possible that the efficiency percentages biased low due to the short periods of trap stoppages during each efficiency trial, it is likely that the efficiency percentages are highly representative of the trap efficiency.

Biological Observations

Biological data were collected throughout the season to assist development of models that correlate environmental parameters with temporal presence and abundance of salmonids. The data were collected for a subsample of all salmonids in order to evaluate potential changes in health, growth, and life history strategies. As seen in previous years of biological sampling on the lower American River, the majority of the fall-run Chinook Salmon population emigrated as age-0 fry from the American River (PSMFC 2013 – 2021, Snider and Titus 2001). In the Central Valley, this emigration timing is highly representative of an ocean-type life history where recently emerged fry emigrate from their natal stream prior to the summer season before entering the ocean (Kjelson and Raquel 1981). The ocean-type life history strategy remained the primary life history strategy used in 2022 with 90% (*n* = 28,492) of the season's fall-run catch being captured before April 9. During this period, fork lengths averaged 42 mm with 80% of the subsampled fish identified as alevin or button up fry. After April 9, a steady increase in temperature, average fish length, and the ratio of parr, silvery parr, and smolt life stages were observed.

The fall-run emigration also experienced one unique peak capture period in February. The peak in emigration coincided with the full moon in February (Figure 10). This emigration trend was observed over the course of the season with 66% (*n* = 20,980) of the fall-run being captured while fraction of the moon illuminated was greater than or equal to 50%, and 33% (*n* = 10,562) being captured while fraction of the moon illuminated was greater than or equal to 90%. While correlations between moon illumination and Chinook Salmon emigration have been previously documented, a negative correlation is most frequently observed (Roper and Scarnecchia 1999, Schroeder et. al 2008, Williams 2006). Because discharge, a primary environmental cue for emigration, remained relatively constant in 2022 (Appendix 8), lunar cycles could be a significant factor in determining the emigration timing of fall-run Chinook Salmon from the lower American River. However, because lunar cycles cannot be isolated from other key environmental cues (e.g., temperature, turbidity, discharge), further research is needed to determine the significance of this trend.

California Central Valley steelhead were also assessed for life stage, fork length, and weighed if greater than 40 mm. Between 2013 and 2021, 4,052 steelhead have been captured (annual mean: 450) with 2,206 of these fish being captured in 2013. During the 2022 season, 404 steelhead were captured consisting of 402 age-0 juveniles, one yearling, and one spawned-out carcass (kelt). As seen in previous years, the number of redds observed within a close upstream proximity of the trap as well as the total number of steelhead redds observed on the lower American River has an influence on the quantity of juveniles captured (PSMFC 2013 – 2021). The 2022 American River steelhead redd surveys conducted by Cramer Fish Sciences

(CFS, 2022) helped explain the increase catch of juvenile steelhead as 87 redds were identified in 2022. Additionally, the most redds observed between 2013 and 2021 occurred in 2013 when 316 redds were identified coinciding with the highest catch of juvenile steelhead in the RSTs. The life stage composition observed in 2022 also coincides with what has been previously observed on the American River with the majority of steelhead captured being recently emerged, age-0 juveniles.

Conclusion

The 2022 rotary screw trap sampling effort to quantify catch and estimate passage of emigrating juvenile salmonids met all study objectives. However, we acknowledge several limitations and challenges when interpreting the data collected in previous years due to differences in sampling methodologies.

Juvenile salmonid emigration monitoring will continue on the lower American River in 2023. In order to obtain the highest accuracy for passage estimates and maintain the highest level of safety, adjustments are recommended for future seasons. Firstly, timely coordination with the Bureau of Reclamation during large discharge events will allow ample time to effectively and safely schedule personnel to maintain continuous sampling and accurately enumerate raw catch to estimate fall-run passage. Secondly, should COVID-19 protocols allow, multiple daily trap visits or nightly trap operations should be considered during large discharge and debris events to maintain continuous and consistent sampling. We believe these efforts will strengthen the future of the lower American River RST project by continuing to improve our understanding of juvenile salmonids while maintaining focus on safe sampling practices for our staff and the public.

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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 1955; 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 Salmon 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)
Jibboom 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: **A view of the American River at Watt Ave under different flow conditions.**

500 cfs 3/20/2014

1,500 cfs 4/24/2014

7,000 cfs 2/23/2016

20,000 cfs 3/14/2016

35,000 cfs 12/16/2016

60,000 cfs 1/11/2017

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

Appendix 3: Enhanced efficiency model description by West Inc.

The CAMP Rotary Screw Trap platform utilizes a trap efficiency model to adjust upward the number of captured fish for those that were not captured. Prior to implementation of enhanced efficiency models, the Platform estimated daily passage by dividing daily catch by a daily estimate of efficiency derived from efficiency trials conducted during the season. To estimate efficiency every day of the season, the Platform utilized a b-spline smoothing method to model daily efficiency.

Recently, the Platform added an option to use an enhanced model of trap efficiency in passage estimation. The enhanced efficiency models utilized efficiency trials conducted during multiple seasons and covariates such as stream flow and temperature to estimate efficiency.

This document describes methods used to estimate the enhanced efficiency models, as well as the final models being used in the latest version of the Platform.

Methods

Catch Estimation

To estimate catch within a fishing year, all valid fishing durations are recorded and tabulated. Within each fishing episode (typically one day), catch is counted, measured, assigned a size class, and assigned a run. In cases when a large number of fish are captured, a subsample of the catch may be counted instead, with proportions of size class and run applied to the bulk of uncounted fish, so as to obtain a so-called "plus-count," which is then added to that day's count of catch.

In order to estimate passage for days when fishing did not take place, a daily catch estimate is imputed from the catch data. Catch is assumed to follow a Poisson distribution from which a generalized linear model is fit. The resulting curve of catch over time is then used to impute catch for days with missing data. Typically, the number of missing catch days is few and only missing days use imputed catch. Actual catch is used for all other days.

Simple Efficiency Estimation

Typically, only a few efficiency trials are available at any one site or sub-site. To estimate simple efficiency models, only efficiency trials *conducted within a fishing year are utilized. For each efficiency trial, both the number of released fish and captured fish are tabulated. Efficiency (proportion of fish passing that are caught) is assumed to follow a binomial distribution, with the number of released fish the number of independent Bernoulli trials and the number of caught fish from the release group as a Bernoulli "success". If at least ten efficiency trials were conducted in a year, the Platform's simple efficiency model is estimated using a logistic regression (binomial generalized linear) model that contains b-spline-derived smoothing splines. If fewer than ten trials were conducted, the smoothing splines are dropped and a constant (intercept-only) model is estimated. The resulting curve of efficiency over time is then used to impute efficiency on every day of the season. Efficiency models are fit for each sub-site for which efficiency-trial data are available.*

Enhanced Efficiency Estimation

Enhanced efficiency models incorporate two additional pieces of information into the model, when compared to simple models. First, efficiency-trial data from all years at a site are used to estimate the model. Collapsing efficiency-trial data from multiple years dramatically increases sample sizes for model estimation. Second, the enhanced models incorporate environmental covariates measured at the time of each trial. Like simple efficiency models, enhanced efficiency logistic regression models were fit to data from each sub-site when possible. Different models were allowed at different sub-sites to incorporate different covariates and effects at distinct sites.

Covariates considered for inclusion in the enhanced models are one of four types: efficiency-trial, environmental, CAMP, and percent-Q. Each covariate type, along with included variables, is described below. Backwards variable selection was used to establish the best fitting and hence enhanced efficiency model used in passage estimation. Backwards variable selection proceeded as follows. Initially, all covariates were included in the enhanced efficiency logistic regression model. The predictive utility associated with each covariate in the model was then assessed by computing the number of standard deviations away from zero of each coefficient estimate (i.e., the coefficient's Wald t-ratio) and associated p-value from the t-distribution. The covariate associated with the highest p-value greater than 0.10 was removed and the model was re-fit. The same drop-one procedure was repeated until p-values of all covariates were less than 0.10. Covariates utilized daily values *coincident with enhanced-efficiency trial days. When a covariate was not available on the day of an efficiency trial, its historical mean was used instead.*

Efficiency-trial Covariates

Efficiency-trial covariates included mean fork-length, proportion of time spent fishing during night-time, and proportion of time spent fishing during moon-time. Here, moon-time reflects the portion of a day when the moon was above the horizon, and it varies by day through the year. For estimation, values for these three covariates were calculated over the duration of each efficiency trial, typically a week, via weighted means, so as to obtain a daily estimate coincident with an efficiency trial.

Environmental Covariates

Environmental covariates included water temperature and flow, as measured at stream gauges operated by either the United States Geological Survey (USGS) or California Data Exchange Center (CDEC). The particular USGS or CDEC gauge used to derive temperature and flow varied by sub-site. Some gauges recorded daily values while other recorded hourly flow and temperature. To ensure consistency across fitted models, as well to fill gaps in the USGS or CDEC data, a smoothing spline was fit to both the temperature and flow data series. The optimal number of smoothing splines to include in the temperature and flow model was chosen by cross-validation. The smoothed data series of temperature and flow were used in all subsequent modeling.

CAMP Covariates

CAMP covariates included flow, water depth, air temperature, turbidity, water velocity, water temperature, and light penetration. These covariates generally reflected environmental conditions at the time of a rotary-screw trap visit and were collected by biologists at the sub-site. The number of CAMP covariates available for enhanced model estimation varied from sub-site to sub-site. When flow or water-temperature data were collected by CAMP biologists at the time of their visit, but USGS or CDEC data were available, the USGS or CDED data were used for modeling. Similar to the two environmental covariates, smoothing splines were applied to all CAMP covariates collected at a sub-site in order to estimate missing values *and to dampen measurement error. The smoothed versions of all variables were then used in subsequent modeling efforts.*

Percent-Q Covariates

At the Red-Bluff Diversion Dam (RBDD), percent-Q was computed and utilized as a potential covariate in each sub-site's enhanced-efficiency model. Different sub-sites, or dam Gates in the case of the RBDD, may or may not include percent-Q as a potential covariate, depending on whether percent-Q was chosen in the final model by backwards selection. Because percent-Q depends on both stream velocity and flow, these two covariates were not considered as covariates in enhanced efficiency models developed for RBDD Gates. Estimates of percent-Q incorporate water loss due to both the Colusa and Tehama canal diversions.

Application of Enhanced Efficiency Models

Ultimately, a unique enhanced efficiency model was estimated for each sub-site based on its own data (Table 1). Estimation of passage utilized daily efficiency from these sub-site specific enhanced efficiency covariate models to adjust daily catch at the sub-site. In this way, passage estimates utilized year-specific catch data but efficiency estimates used data obtained from all available information at the sub-site.

Table 1: Final enhanced efficiency logistic regression covariate models established for use at each sub-site in the Platform. Temporal splines not included.

Stream	Name (Sub-site)	Covariate Model
American	*North Channel 8.1 (57001)*	*–5.459 + 4.539(night proportion) + 0.03(forklength) – 0.0009(flow)*
	North Channel 8.2 (57004)	*–4.698 + 0.048(forklength) – 0.0004(flow)*

Note: The above description of the enhanced efficiency model is excerpted from West Inc.'s description of the model. Further questions about this model should be sent to Trent McDonald at West Inc.

Appendix 4: **Weekly environmental conditions on the lower American River during the 2022 survey season.**

Julian Week	Water Temperature (C°) Avg (range)	Discharge (cfs) Avg (range)	Dissolved Oxygen (mg/L) Avg (range)	Turbidity (NTU) Avg (range)	Velocity (m/s) Avg (range)
1/15 - 1/21	8.6 (8.0 - 9.5)	3,854 (3,050 - 4,100)	12.50 (12.07 - 13.19)	4.18 (1.16 - 9.57)	1.5 (1.1 - 1.7)
1/22 - 1/28	8.7 (7.7 - 9.6)	2,620 (2,010 - 3,150)	12.41 (11.85 - 13.08)	1.70 (0.87 - 2.04)	1.5 (1.2 - 1.9)
1/29 - 2/4	8.6 (7.4 - 9.7)	2,036 (1,940 - 2,200)	12.29 (12.26 - 12.34)	1.34 (0.92 - 1.68)	1.5 (1.4 - 1.6)
2/5 - 2/11	9.3 (7.9 - 10.8)	2,040 (1,960 - 2,170)	11.82 (11.48 - 12.22)	1.30 (0.22 - 2.38)	1.3 (1.1 - 1.7)
2/12 - 2/18	9.8 (8.4 - 10.9)	2,098 (1,940 - 2,350)	11.23 (10.85 - 11.66)	1.51 (0.59 - 3.48)	1.3 (0.9 - 1.6)
2/19 - 2/25	10.4 (8.6 - 11.6)	2,160 (2,070 - 2,260)	11.42 (11.09 - 11.85)	1.09 (0.59 - 1.91)	1.4 (1.1 - 1.7)
2/26 - 3/4	11.4 (9.0 - 12.9)	2,038 (1,930 - 2,080)	11.35 (10.50 - 12.42)	1.23 (0.25 - 2.39)	1.4 (0.9 - 1.6)
3/5 - 3/11	10.9 (9.0 - 12.6)	1,973 (1,860 - 2,150)	10.64 (9.78 - 11.31)	0.87 (0.53 - 1.67)	1.1 (0.7 - 1.3)
3/12 - 3/18	12.2 (9.7 - 13.6)	1,546 (1,070 - 1,990)	9.96 (9.65 - 10.31)	0.94 (0.30 - 2.45)	1.0 (0.4 - 1.2)
3/19 - 3/25	13.6 (11.2 - 15.2)	1,227 (1,040 - 1,310)	10.19 (9.67 - 10.81)	1.06 (0.65 - 1.61)	1.1 (0.5 - 1.4)
3/26 - 4/1	13.6 (11.9 - 14.9)	1,232 (942 - 1,460)	9.78 (8.33 - 10.98)	0.95 (0.46 - 1.56)	1.0 (0.6 - 1.2)
4/2 - 4/8	14.4 (12.6 - 16.3)	1,149 (1,000 - 1,290)	9.21 (8.26 - 10.38)	1.09 (0.66 - 1.77)	1.1 (0.8 - 1.4)
4/9 - 4/15	14.2 (12.5 - 16.2)	1,035 (979 - 1,080)	9.22 (8.70 - 9.79)	1.30 (0.60 - 2.34)	1.1 (0.9 - 1.3)
4/16 - 4/22	15.2 (13.6 - 16.6)	1,023 (930 - 1,070)	9.24 (8.51 - 9.66)	1.31 (0.71 - 2.53)	1.1 (0.8 - 1.3)
4/23 - 4/29	16.2 (14.5 - 17.6)	1,018 (979 - 1,110)	8.81 (8.19 - 9.89)	1.41 (0.55 - 2.26)	1.1 (0.9 - 1.4)
4/30 - 5/6	16.7 (15.2 - 18.9)	1,021 (979 - 1,080)	10.07 (9.87 - 10.33)	0.98 (0.23 - 2.73)	1.1 (0.8 - 1.4)
5/7 - 5/13	15.5 (13.2 - 17.8)	1,293 (979 - 1,560)	10.52 (9.95 - 12.29)	0.94 (0.48 - 1.72)	1.1 (0.5 - 1.4)
5/14 - 5/20	17.2 (15.0 - 19.3)	1,480 (1,420 - 1,530)	9.81 (9.41 - 10.44)	1.44 (0.51 - 2.69)	1.1 (0.6 - 1.4)
5/21 - 5/27	17.4 (15.0 - 19.5)	1,463 (1,410 - 1,520)	9.70 (9.30 - 10.13)	1.30 (0.72 - 2.17)	1.0 (0.5 - 1.4)
5/28 - 6/3	17.2 (14.9 - 19.4)	1,739 (1,410 - 1,800)	9.87 (9.35 - 10.91)	1.21 (0.72 - 1.82)	1.3 (0.9 - 1.5)

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

Appendix 5: List of natural origin fish species caught during the 2022 season using rotary screw traps on the lower American River.

Common Name	Family Name	Species Name	Total
Chinook Salmon	Salmonidae	*Oncorhynchus tshawytscha*	31,583
Rainbow Trout / steelhead	Salmonidae	*Oncorhynchus mykiss*	404
American Shad	Clupeidae	*Alosa sapidissima*	16
Bluegill	Centrarchidae	*Lepomis macrochirus*	49
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*	2
Green Sunfish	Centrarchidae	*Lepomis cyanellus*	1
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	737
Largemouth Bass	Centrarchidae	*Micropterus salmoides*	8
Pacific Lamprey	Petromyzontidae	*Lampetra tridentata*	2,607
Prickly Sculpin	Cottidae	*Cottus asper*	22
Redear Sunfish	Centrarchidae	*Lepomis microlophus*	7
Riffle Sculpin	Cottidae	*Cottus gulosus*	138
River Lamprey	Petromyzontidae	*Lampetra ayresii*	43
Sacramento Pikeminnow	Cyprinidae	*Ptychocheilus grandis*	437
Sacramento Sucker	Catostomidae	*Catostomus occidentalis*	1,163
Spotted Bass	Centrarchidae	*Micropterus punctulatus*	3
Threadfin Shad	Clupeidae	*Dorosoma petenense*	31
Threespine Stickleback	Gasterosteidae	*Gasterosteus aculeatus*	1
Tule Perch	Embiotocidae	*Hysterocarpus traskii*	20
Unknown bass	Centrarchidae	*Micropterus sp.*	58
Unknown lamprey	Petromyzontidae	*Entosphenus or Lampetra*	170
Unknown minnow	Cyprinidae		4
Unknown sculpin	Cottidae	*Cottus spp.*	8
Unknown sunfish	Centrarchidae	*Lepomis spp.*	1
Wakasagi	Osmeridae	*Hypomesus nipponensis*	1,971
Western Mosquitofish	Poeciliidae	*Gambusia affinis*	6
White Catfish	Ictaluridae	*Ameiurus catus*	7

Appendix 6: Genetic results for fin-clip samples from Chinook Salmon caught in the lower American River during the 2022 survey season.

Note:
Sample #: refers 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)
1/23/2022	3883-001	Spring	Spring	0.63	Spring	50	1.0
1/31/2022	3883-002	Fall	Fall	1.00	Fall	37	-
1/31/2022	3883-003	Fall	Fall	1.00	Fall	37	-
1/31/2022	3883-004	Fall	Fall	1.00	Fall	38	-
1/31/2022	3883-005	Fall	Fall	1.00	Fall	39	-
1/31/2022	3883-006	Fall	Fall	1.00	Fall	37	-
2/8/2022	3883-007	Fall	Fall	1.00	Fall	38	-
2/8/2022	3883-008	Fall	Fall	1.00	Fall	36	-
2/8/2022	3883-009	Fall	Fall	1.00	Fall	38	-
2/8/2022	3883-010	Fall	Fall	1.00	Fall	37	-
2/8/2022	3883-011	Fall	Fall	1.00	Fall	39	-
2/15/2022	3883-012	Spring	Winter	1.00	Winter	73	-
2/16/2022	3883-013	Fall	Fall	1.00	Fall	36	-
2/16/2022	3883-014	Fall	Fall	1.00	Fall	37	-
2/16/2022	3883-015	Fall	Fall	1.00	Fall	36	-

2/16/2022	3883-016	Fall	Fall	1.00	Fall	39	-
2/16/2022	3883-017	Fall	Fall	1.00	Fall	36	-
2/20/2022	3883-018	Fall	Fall	1.00	Fall	36	-
2/20/2022	3883-019	Fall	Fall	1.00	Fall	40	0.4
2/20/2022	3883-020	Fall	Fall	1.00	Fall	41	0.4
2/20/2022	3883-021	Fall	Fall	1.00	Fall	39	-
2/20/2022	3883-022	Fall	Fall	1.00	Fall	36	-
2/24/2022	3883-023	Spring	Fall	1.00	Fall	76	3.7
2/24/2022	3883-024	Spring	Fall	1.00	Fall	59	1.7
2/27/2022	3883-025	Fall	Fall	1.00	Fall	36	-
2/27/2022	3883-026	Fall	Fall	1.00	Fall	32	-
2/27/2022	3883-027	Fall	Fall	0.95	Fall	39	-
2/27/2022	3883-028	Fall	Fall	1.00	Fall	37	-
2/27/2022	3883-029	Fall	Fall	1.00	Fall	37	-
3/6/2022	3883-032	Fall	Fall	1.00	Fall	38	-
3/6/2022	3883-033	Fall	Fall	1.00	Fall	36	-
3/6/2022	3883-034	Fall	Fall	1.00	Fall	35	-
3/10/2022	3883-035	Spring	Fall	1.00	Fall	66	2.7
3/13/2022	3883-036	Fall	Fall	1.00	Fall	38	-
3/13/2022	3883-037	Fall	Fall	1.00	Fall	37	-
3/13/2022	3883-038	Fall	Fall	1.00	Fall	41	0.6
3/13/2022	3883-039	Fall	Fall	0.97	Fall	37	-
3/13/2022	3883-040	Fall	Fall	1.00	Fall	38	-
3/14/2022	3883-042	Spring	Fall	1.00	Fall	65	2.8
3/14/2022	3883-041	Spring	Fall	1.00	Fall	69	3.2
3/17/2022	3883-043	Spring	Fall	1.00	Fall	72	4.1
3/17/2022	3883-044	Spring	Fall	1.00	Fall	68	2.9
3/18/2022	3883-045	Spring	Fall	1.00	Fall	67	3.0
3/18/2022	3883-047	Spring	Fall	1.00	Fall	70	3.5
3/18/2022	3883-049	Spring	Fall	1.00	Fall	68	3.3
3/19/2022	3883-050	Spring	Fall	1.00	Fall	68	3.5

3/19/2022	3883-051	Spring	Fall	1.00	Fall	68	3.6
3/20/2022	3883-048	Spring	Fall	1.00	Fall	69	3.4
3/20/2022	3883-052	Fall	Fall	1.00	Fall	66	-
3/20/2022	3883-053	Fall	Fall	1.00	Fall	44	-
3/20/2022	3883-054	Fall	Fall	1.00	Fall	51	-
3/20/2022	3883-055	Spring	Fall	1.00	Fall	68	-
3/20/2022	3883-056	Fall	Fall	1.00	Fall	41	-
3/20/2022	3883-057	Fall	Fall	1.00	Fall	44	-
3/21/2022	3883-064	Spring	Fall	1.00	Fall	70	2.8
3/21/2022	3883-058	Spring	Fall	1.00	Fall	71	3.2
3/21/2022	3883-059	Spring	Fall	0.83	Fall	71	4.5
3/21/2022	3883-060	Spring	Fall	1.00	Fall	68	3.4
3/21/2022	3883-061	Spring	Fall	1.00	Fall	69	3.0
3/21/2022	3883-062	Spring	Fall	1.00	Fall	69	3.0
3/21/2022	3883-063	Spring	Fall	1.00	Fall	71	4.0
3/27/2022	3883-068	Spring	Fall	1.00	Fall	78	5.0
3/27/2022	3883-069	Fall	Fall	1.00	Fall	70	-
3/27/2022	3883-070	Fall	Fall	1.00	Fall	60	2.4
3/27/2022	3883-071	Fall	Fall	1.00	Fall	65	2.8
3/27/2022	3883-072	Spring	Fall	1.00	Fall	73	5.2
3/27/2022	3883-074	Fall	Fall	1.00	Fall	56	1.8
3/27/2022	3883-075	Spring	Fall	1.00	Fall	71	3.7
3/27/2022	3883-065	Spring	Fall	1.00	Fall	74	4.5
3/27/2022	3883-066	Spring	Fall	1.00	Fall	76	4.5
3/27/2022	3883-067	Spring	Fall	1.00	Fall	74	4.3
3/28/2022	3883-076	Spring	Fall	1.00	Fall	75	-
3/29/2022	3883-077	Spring	Fall	1.00	Fall	75	-
3/30/2022	3883-078	Spring	Fall	1.00	Fall	80	6.2
3/31/2022	3883-079	Spring	Fall	1.00	Fall	83	6.1
4/2/2022	3883-080	Spring	Fall	1.00	Fall	85	6.4
4/3/2022	3883-082	Spring	Fall	1.00	Fall	88	7.2

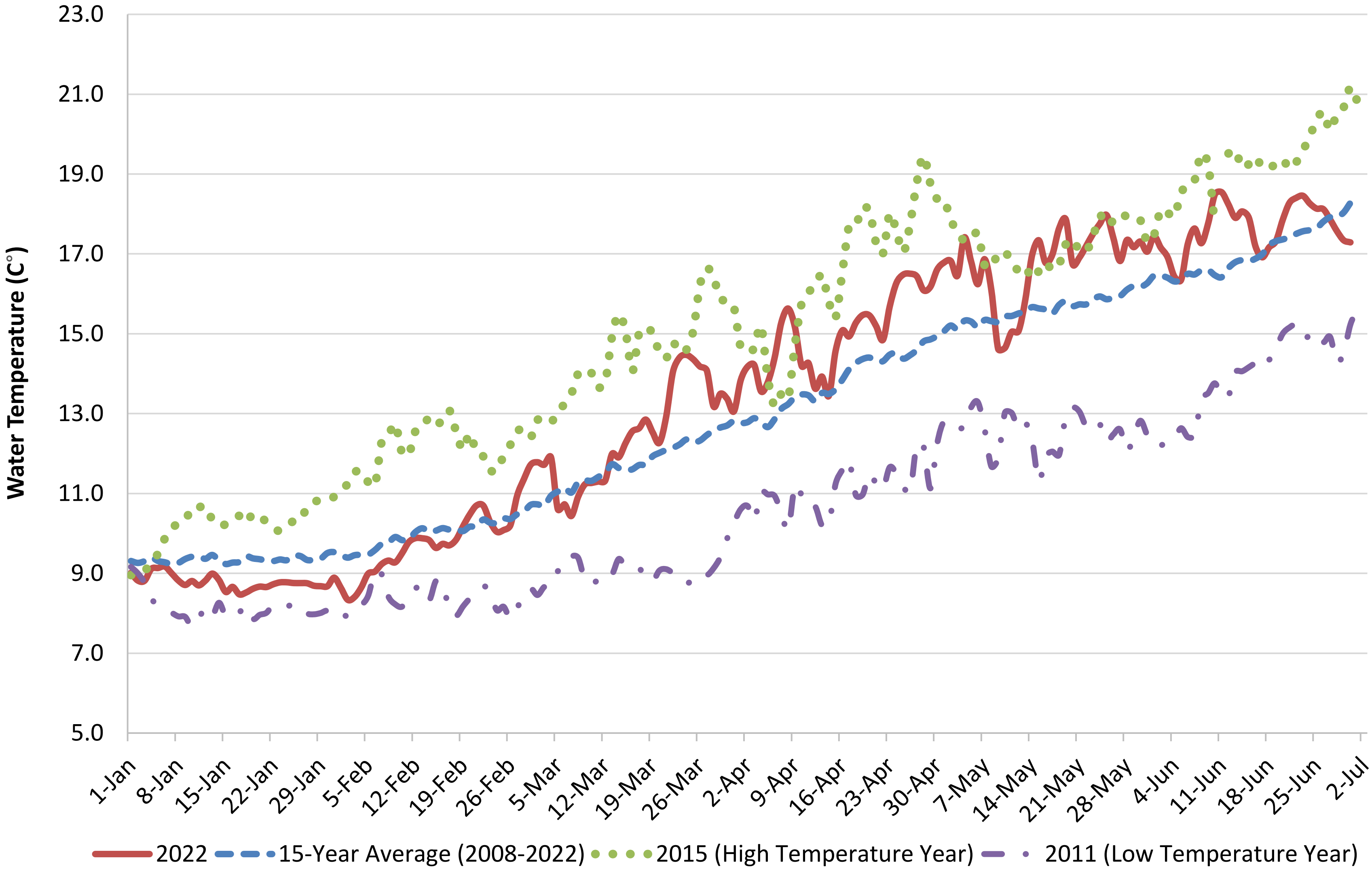
4/3/2022	3883-083	Fall	Fall	1.00	Fall	72	4.0
4/3/2022	3883-084	Spring	Fall	1.00	Fall	77	4.8
4/3/2022	3883-085	Spring	Fall	1.00	Fall	83	5.4
4/3/2022	3883-086	Spring	Fall	1.00	Fall	80	5.2
4/3/2022	3883-081	Spring	Fall	1.00	Fall	84	5.9
4/4/2022	3883-089	Spring	Fall	1.00	Fall	76	-
4/4/2022	3883-096	Spring	Fall	1.00	Fall	78	-
4/4/2022	3883-088	Spring	Fall	1.00	Fall	78	-
4/4/2022	3883-090	Spring	Fall	1.00	Fall	84	6.1
4/4/2022	3883-091	Spring	Fall	1.00	Fall	76	4.0
4/4/2022	3883-092	Fall	Fall	1.00	Fall	73	-
4/4/2022	3883-093	Fall	Fall	1.00	Fall	62	-
4/4/2022	3883-094	Fall	Fall	1.00	Fall	57	-
4/4/2022	3883-095	Fall	Fall	1.00	Fall	59	-
4/4/2022	3883-097	Spring	Fall	1.00	Fall	79	4.7
4/4/2022	3883-099	Spring	Fall	1.00	Fall	79	5.7
4/7/2022	3882-001	Spring	Fall	1.00	Fall	78	5.6
4/7/2022	3882-002	Spring	Fall	1.00	Fall	82	6.1
4/7/2022	3882-003	Spring	Fall	1.00	Fall	81	6.2
4/7/2022	3882-004	Spring	Fall	1.00	Fall	81	5.8
4/7/2022	3882-005	Spring	Fall	1.00	Fall	77	4.9
4/8/2022	3882-006	Spring	Fall	0.99	Fall	80	-
4/8/2022	3882-007	Spring	Fall	1.00	Fall	78	-
4/12/2022	3882-017	Spring	Fall	1.00	Fall	80	-
4/12/2022	3882-018	Spring	Fall	1.00	Fall	83	-
4/12/2022	3882-019	Spring	Fall	1.00	Fall	82	-
4/12/2022	3882-008	Spring	Fall	1.00	Fall	84	-
4/12/2022	3882-009	Spring	Fall	0.99	Fall	82	-
4/12/2022	3882-010	Spring	Fall	1.00	Fall	98	10.2
4/12/2022	3882-011	Spring	Fall	1.00	Fall	83	6.2
4/12/2022	3882-012	Spring	Fall	1.00	Fall	84	7.1

4/12/2022	3882-013	Spring	Fall	1.00	Fall	79	5.0
4/12/2022	3882-014	Spring	Fall	1.00	Fall	83	6.2
4/12/2022	3882-015	Spring	Fall	1.00	Fall	81	5.8
4/12/2022	3882-016	Spring	Fall	1.00	Fall	83	6.1
4/12/2022	3882-020	Spring	Fall	1.00	Fall	79	-
4/12/2022	3882-021	Spring	Fall	1.00	Fall	79	-
4/13/2022	3882-022	Fall	Fall	1.00	Fall	63	-
4/13/2022	3882-023	Fall	Fall	1.00	Fall	52	-
4/13/2022	3882-024	Fall	Fall	1.00	Fall	64	-
4/13/2022	3882-025	Fall	Fall	1.00	Fall	60	-
4/13/2022	3882-026	Fall	Fall	1.00	Fall	73	-
4/17/2022	3882-028	Spring	Fall	1.00	Fall	97	9.2
4/17/2022	3882-029	Spring	Fall	1.00	Fall	86	6.3
4/17/2022	3882-030	Spring	Fall	0.99	Fall	92	7.7
4/17/2022	3882-035	Fall	Fall	0.98	Fall	77	5.2
4/17/2022	3882-036	Fall	Fall	1.00	Fall	75	4.3
4/17/2022	3882-037	Fall	Fall	1.00	Fall	77	4.6
4/17/2022	3882-038	Fall	Fall	1.00	Fall	73	4.3
4/17/2022	3882-039	Fall	Fall	1.00	Fall	75	4.4
4/17/2022	3883-098	Spring	Fall	1.00	Fall	84	6.4
4/17/2022	3883-100	Spring	Fall	1.00	Fall	82	5.4
4/17/2022	3882-031	Spring	Fall	1.00	Fall	89	7.9
4/17/2022	3882-032	Spring	Fall	1.00	Fall	90	8.1
4/17/2022	3882-033	Spring	Fall	1.00	Fall	85	6.2
4/17/2022	3882-034	Spring	Fall	1.00	Fall	83	6.1
4/18/2022	3882-057	Spring	Fall	1.00	Fall	84	-
4/21/2022	3882-040	Spring	Fall	1.00	Fall	85	-
4/22/2022	3882-041	Spring	Fall	1.00	Fall	92	-
4/22/2022	3882-042	Spring	Fall	1.00	Fall	85	-
4/22/2022	3882-043	Spring	Fall	1.00	Fall	86	-
4/23/2022	3882-044	Spring	Fall	1.00	Fall	87	-

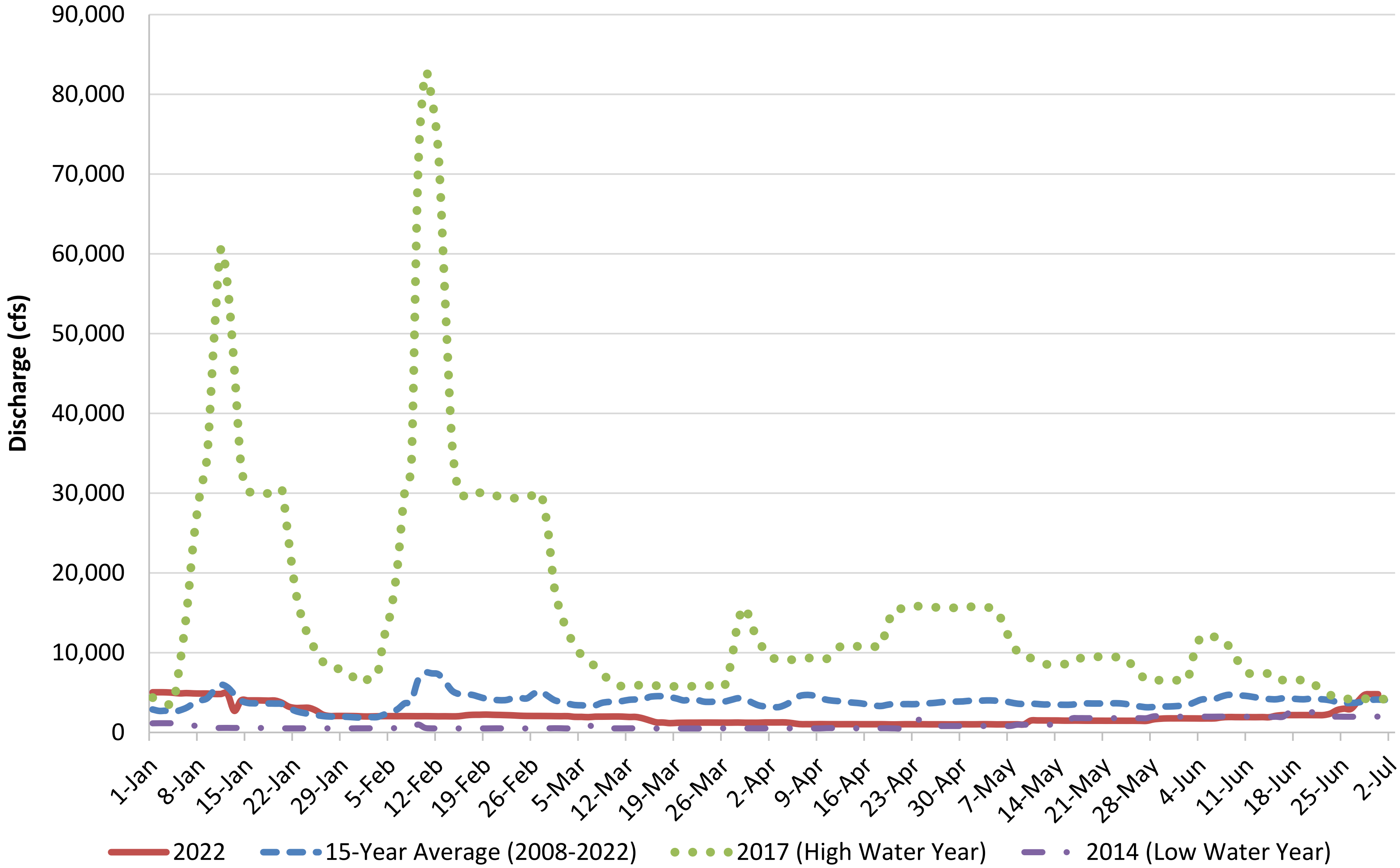
4/24/2022	3882-045	Fall	Fall	1.00	Fall	74	-
4/24/2022	3882-046	Fall	Fall	1.00	Fall	83	-
4/24/2022	3882-047	Fall	Fall	1.00	Fall	74	-
4/24/2022	3882-048	Fall	Fall	1.00	Fall	80	-
4/24/2022	3882-049	Fall	Fall	1.00	Fall	74	-
4/24/2022	3882-050	Spring	Fall	1.00	Fall	87	-
4/25/2022	3882-051	Spring	Fall	1.00	Fall	90	-
4/25/2022	3882-052	Spring	Fall	1.00	Fall	88	-
4/26/2022	3882-053	Spring	Fall	1.00	Fall	95	-
4/26/2022	3882-054	Spring	Fall	1.00	Fall	95	-
4/26/2022	3882-055	Spring	Fall	1.00	Fall	89	-
4/26/2022	3882-056	Spring	Fall	1.00	Fall	88	-
4/28/2022	3882-058	Spring	Fall	1.00	Fall	91	-
4/28/2022	3882-059	Spring	Fall	1.00	Fall	93	-
5/1/2022	3882-060	Spring	Fall	1.00	Fall	98	10.2
5/1/2022	3882-061	Fall	Fall	1.00	Fall	84	6.1
5/1/2022	3882-062	Fall	Fall	1.00	Fall	78	5.1
5/1/2022	3882-063	Fall	Fall	1.00	Fall	83	6.1
5/1/2022	3882-064	Fall	Fall	0.99	Fall	75	4.2
5/1/2022	3882-065	Fall	Fall	1.00	Fall	80	5.9
5/1/2022	3882-066	Spring	Fall	0.99	Fall	90	8.1
5/1/2022	3882-067	Spring	Fall	1.00	Fall	93	8.6
5/1/2022	3882-068	Spring	Fall	1.00	Fall	91	8.5
5/2/2022	3882-069	Spring	Fall	1.00	Fall	95	8.8
5/9/2022	3882-071	Fall	Fall	1.00	Fall	74	3.9
5/9/2022	3882-072	Fall	Fall	1.00	Fall	73	3.9
5/9/2022	3882-073	Fall	Fall	1.00	Fall	86	6.9
5/9/2022	3882-074	Fall	Fall	1.00	Fall	77	4.8
5/10/2022	3882-075	Spring	Fall	1.00	Fall	97	-
5/11/2022	3882-076	Spring	Fall	1.00	Fall	96	10.3
5/16/2022	3882-078	Fall	Fall	0.97	Fall	92	-

5/16/2022	3882-079	Fall	Fall	1.00	Fall	76	-
5/16/2022	3882-080	Fall	Fall	1.00	Fall	61	-
5/16/2022	3882-081	Fall	Fall	1.00	Fall	64	-
5/16/2022	3882-077	Fall	Fall	1.00	Fall	77	-
5/23/2022	3882-085	Fall	Fall	1.00	Fall	76	4.6
5/23/2022	3882-082	Fall	Fall	1.00	Fall	76	-
5/23/2022	3882-083	Fall	Fall	1.00	Fall	90	8.1
5/23/2022	3882-084	Fall	Fall	1.00	Fall	76	5.6

Appendix 7: **Daily average water temperatures (°C) in the lower American River at Watt Avenue for the 15 year period 2008 - 2022, the highest temperature year (green round dots), lowest temperature year (purple dash dots), the 15 year average (blue dashes) and the current year (2022, red line). Data from USGS station number 11446980.**



Appendix 8: **Daily average discharge (cfs) on the Lower America River at Fair Oaks for the 15-year period 2008 – 2022, the highest water year (green round dots), the lowest water year (purple dash dots), 15 year average (blue dashes) and the current year (2022, red line). Data from USGS station number 11446500.**



Appendix 9: **Median seasonal discharge (cfs), total catch of fall-run Chinook Salmon, winter-run Chinook Salmon, spring-run Chinook Salmon, steelhead, and lamprey, and the associated passage estimate with 95% confidence intervals (CI) for fall-run Chinook Salmon from the 2013 – 2022 lower American River rotary screw trap sampling seasons.**

Year	Discharge (cfs)	Total Catch					Passage Estimate	
		Fall-run	Winter-run	Spring-run	steelhead	Lamprey	Fall-run	95% CI
2013	1,897	262,589	39	14	2,206	1,917	5,692,376	(4,843,254 - 6,032,358)
2014	560	379,542	13	5	592	1,525	1,726,298	(1,681,326 - 2,171,375)
2015	881	283,153	28	19	11	953	1,459,122	(1,417,136 - 1,620,575)
2016	3,776	80,626	1	2	332	1,217	2,394,719	(1,803,134 - 2,907,545)
2017	9,459	9,567	0	1	28	269	788,409	(763,355 - 796,848)
2018	2,857	90,104	11	0	162	1,093	1,287,000	(1,245,000 - 1,426,000)
2019	7,726	15,056	18	9	337	176	348,100	(256,900 - 466,700)
2020	1,853	152,378	203	16	101	1,361	1,883,000	(1,635,000 - 2,215,000)
2021	1,172	35,433	3	4	283	2,153	499,502	(395,200 – 648,600)
2022	1,490	31,581	1	1	404	2,820	180,224	(165,500 – 199,800)

Note: Discharge is based on the annual median discharge between January 1 and June 30 from USGS at Fair Oaks, Station #11446500.
Lamprey: Includes adult and all juvenile life stages of Petromyzontidae.