Juvenile Salmonid Emigration Monitoring in the Lower American River, California

January – June 2023

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
cm	centimeter
CVPIA	Central Valley Project Improvement Act
DO	dissolved oxygen
ESA	Endangered Species Act
FL	fork length
g	gram
GVL	Genomic Variation Laboratory
km	kilometers
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
PBT	Parentage-based tagging
PSMFC	Pacific States Marine Fisheries Commission
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 2023 is part of a collaborative effort by the United States 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 late fall, spring, and winter runs of Chinook Salmon. Secondary objectives of trapping operations focus on collecting fork lengths and weights of juvenile salmonids, collecting fin clips 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 2023 sampling season, two 2.4 meter (8-foot) rotary screw traps were operated downstream of the Watt Avenue Bridge on the lower American River. The 2023 Water Year was one of the wettest years on record, with high and variable flows experienced throughout the 2023 sampling season. Evidently, sampling began later than normal and occurred on 104 of the 155-day season (67%) beginning January 25 and concluding on June 28. Following genetic analysis, it was determined that a total of 70,348 fall-run, 4 spring-run, and 13 winter-run Chinook Salmon were captured, as well as 260 steelhead. Most of the juvenile salmon captured were identified as button-up fry followed by yolk-sac fry, silvery parr, parr, and smolt life stages. Five trap efficiency trials will be used for future estimation of juvenile fall-run Chinook Salmon passage once new efficiency models are developed. Trap efficiencies during these five trials ranged from 0.4% to 13.5%, with an average efficiency of 3.5%. Passage estimates for steelhead, spring-run and winter-run Chinook Salmon, and non-salmonid fish taxa will not be assessed due to minimal catch.

This annual report also includes 11 appendices to describe different environmental variables and studies related to the trap site and rotary screw trap operations.

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 United States 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 (Figure 1, 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 used 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 United States 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, spring-run, and winter-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 (Figure 1). 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).

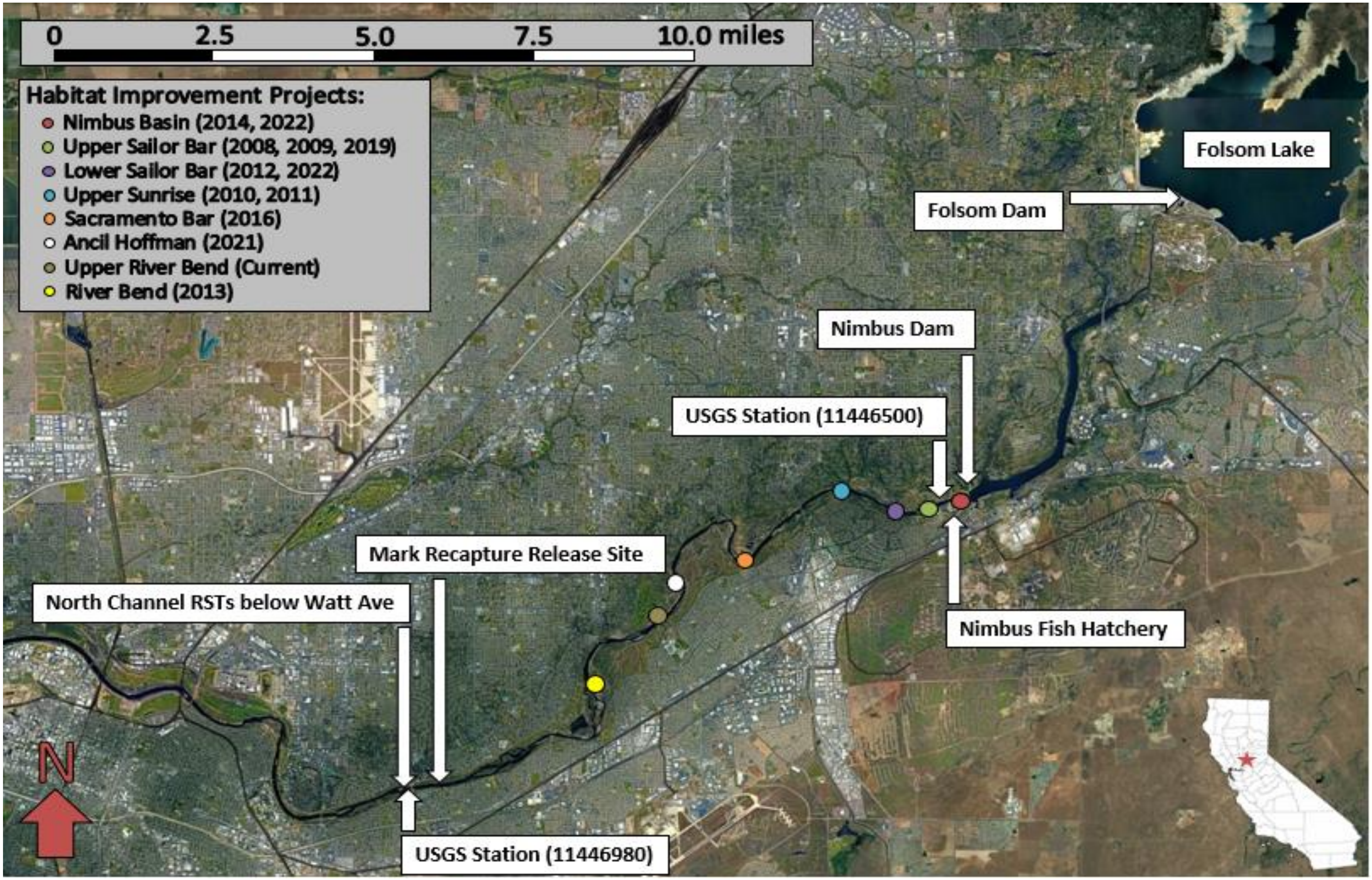

Figure 1: Points of interest on the lower American River.

The lower American River RST site is located 0.2 rkm downstream of the Watt Avenue Bridge (Figure 2). 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 most 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 (Appendix 1).

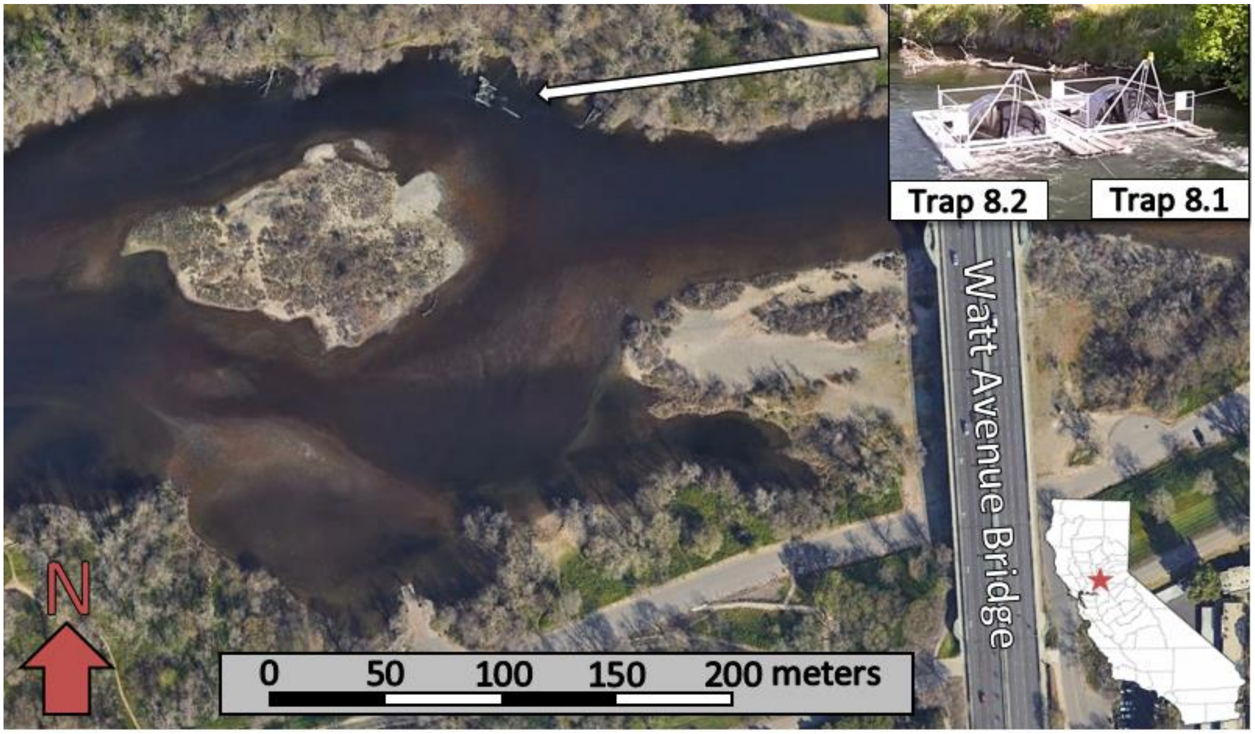

Figure 2: RST location in the north channel of the lower American River captured by Google Earth in February of 2022. Inset image illustrates the side-by-side trap configuration.

Methods

Safety Measures

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

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 125 and 250 m upstream of the traps. Solar-powered amber strobe lights, that automatically turn on in low light conditions, were attached to the outermost railings of each trap to alert the public at night of the navigational hazard. 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 in the middle 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 (hereafter referred to as “take out of service”) until the following Sunday evening.

Trap Operations

Two 2.4 m (8-foot) diameter RSTs (EG Solutions) were deployed in the north channel in a side-by-side orientation and were designated as Trap 8.1 and Trap 8.2 (Figure 3). 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 3: The two north channel 8-foot RSTs, Trap 8.1 (river right) and Trap 8.2 (river left), on the lower American River downstream of the Watt Avenue Bridge.

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 exceptionally high discharge events when increases in debris size or quantity could hinder trap functionality and potentially increase fish mortality, multiple trap checks were conducted in a 24-hour period.

However, in cases where storms, flow increases, or debris loads were deemed severe enough, traps were taken out of service until conditions improved. In addition, the traps were not operated in the cone-down configuration at flows greater than 10,000 cfs, for the safety of the field staff, as well as for the protection of sampling equipment and captured fish.

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. If the trap was not functioning upon arrival, the trap was restored to its normal function without raising the cone. Subsequently, trap intakes were checked and recorded as “clear,” “partially blocked,” “completely blocked,” or “backed up into 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 of the trap inside of the live well.

Environmental Parameters

During trap visits, various environmental parameters were recorded at least once per visit. Temperature degrees Celsius (C) and dissolved oxygen (DO; milligrams per liter [mg/L]) were measured using a YSI Model 55 or YSI Ecosense DO 200A meter (Yellow Springs Instruments), velocity (meters per second [m/s]) was measured in front of each cone using a Global Water FP111 flow probe, and turbidity (nephelometric turbidity unit [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 cm on the port and starboard side pontoons in line with the front of the trap cones. Average daily river discharge (cubic feet per second [cfs]) was calculated from instantaneous measurements recorded 21 rkm upstream of the RSTs from the United States 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, Figure 1).

Catch and Fish Data Collection

Fish Collection

Before clearing the live well of debris and fish, one or two workstations were set up per trap. A workstation included an 18-gallon (68.1 liter) tub and multiple 5-gallon (18.9 liter) holding buckets filled with fresh river water, a measuring board, a net, and tongs (Figure 4). 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 0.3 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. All aquatic or terrestrial debris was placed into a separate 5-gallon bucket to measure and record the total debris quantity of each live well before being discarded downstream.

Figure 4: Trap workstation, consisting of an 18-gallon tub, multiple 5-gallon holding buckets, a measuring board, and tongs, on the lower American River.

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 spring- and winter-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 25% for hatchery origin Chinook Salmon and 100% 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, DO and temperature were maintained utilizing 12V aerators, frozen water bottles, and umbrellas for shade to keep holding buckets within 2 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.

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 fall, spring and winter runs of Chinook Salmon, *O. mykiss*, and non-salmonid species captured for each trap on the Lower American River.

	Winter Chinook	Spring Chinook	Fall Chinook	*O. mykiss*	Hatchery Salmonids	Recaptured Chinook	Non-Salmonid Species
Enumerate	All	All	All	All	All	All	All
Life Stage	50	50	100	100	50	50	50
Measure	50	50	100	100	50	50	50
Weigh	25	25	25	25	0	0	0
Mortality	All	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 workstation was then setup with a 1-gallon (3.8 liter) anesthetic tank, 5-gallon recovery bucket, digital scale (OHAUS Scout Pro), measuring board, and genetic sampling equipment (Figure 5). 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 LAD criteria as ESA listed (spring-run and winter-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.

Figure 5: Fish processing station, consisting of an anesthetic tank, 5-gallon recovery bucket, digital scale, measuring board, and genetic sampling equipment.

Data was collected on all species but varied by species and run (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 origin salmonids greater than or equal to 40 mm. Salmonid life stages were assessed by following the criteria of the smolt index rating (Table 2, Figure 6). 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.” Genetic samples were collected from all LAD spring-run and winter-run Chinook Salmon. Additionally, genetic samples were collected from a subsample of LAD 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

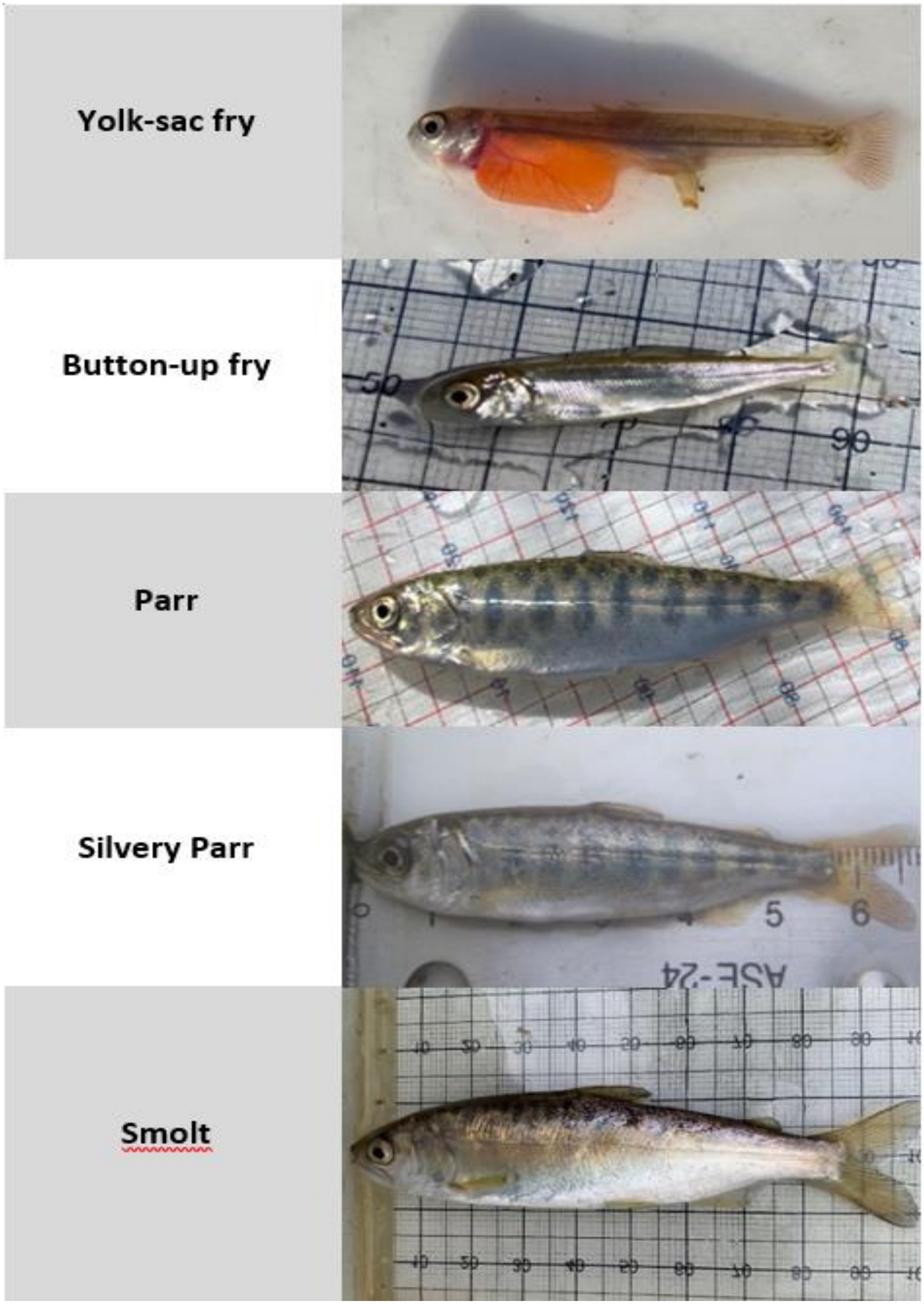

Figure 6: Examples of life stages for Chinook Salmon according to the smolt index rating.

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 3 clips per week were taken from LAD fall-run Chinook Salmon. Due to the highly variable annual catch of LAD late fall-run, spring-run, and winter-run Chinook Salmon, up to 20 clips per week from non-fall run were collected upon capture.

Each fin clip sample was split, with half the genetic sample sent to the CDFW Tissue Archive for storage and the other half to the United States 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 multiple 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 that exceeded the 50% threshold 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 late fall-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 – 2022).

In collaboration with CDFW, 100 upper caudal Chinook Salmon fin clips were randomly collected from February through May as part of the CDFW parentage-based tagging (PBT) study following the Nimbus Fish Hatchery release of approximately 1.1 million hatchery Chinook Salmon fry on February 23. The fin clips were collected for genetic analysis and sent to the CDFW Tissue Archive. The fin clips were collected to determine if the hatchery released fry are following the same migratory cues and timing as natural origin Chinook Salmon, and evidently, will help estimate how many of these released fish will return for spawning as adults.

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 for future estimation of 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 50 mm (Figure 7). 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 15 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 into a 50-gallon live car attached to the rear of the traps and held overnight until twilight of the following evening before being transported and released at the release site (Figure 1).

Figure 7: A group of unmarked Chinook Salmon and whole body BBY stained Chinook Salmon.

The second method consisted of using a Visual Implant Elastomer (VIE) tag when most of the Chinook Salmon had a fork length greater than 50 mm (Figure 8). 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, the marked fish were placed into a 50-gallon live car attached to the rear of the traps and held overnight until twilight of the following evening before being transported and released at the release site. Tagging supplies, mixing procedures, and protocols for VIE tags were provided by Northwest Marine Technology, Inc.

Figure 8: Chinook Salmon marked with a pink VIE tag on the snout.

At least 450 Chinook Salmon were used to conduct each trap efficiency trial with BBY stain or VIE tags. If less than 450 fish were captured on a given day, Chinook Salmon were provided by the Nimbus Fish Hatchery.

The trap efficiency release site was approximately 1.3 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. 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 twilight 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, most 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 50 recaptured Chinook Salmon from each trap were measured for fork lengths, assessed for life stage, and evaluated for mortality status. If more than 50 recaptures from each trap in an efficiency trial were found in a RST live well, the marked salmon in excess of 50 were enumerated and classified as a "live recap plus-count tally" or "mort recap plus-count tally."

Retention in Analysis

Under ideal circumstances, the RSTs 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 but determined to have been functioning normally for less than 70% of the sampling period, the data was excluded from the analysis. 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%

Passage Estimates

Fall-run Chinook Salmon passage estimates are not yet available for 2023. Past passage estimates were calculated using an enhanced efficiency model developed for CAMP by West Inc. However, there is an effort underway to develop a new efficiency model and the USFWS decided to immediately discontinue use of the old model. Future reports will include updated passage estimates for all sampling years for which data are available.

Fulton's Condition Factor

Fall-run Chinook Salmon condition was assessed using Fulton's condition factor. Each day, the first 25 Chinook Salmon greater than or equal to 40 mm were measured for weight and fork length. Higher condition factor values indicate healthier fish relative to their 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

Traps 8.1 and Trap 8.2 began sampling on January 25 and concluded June 28 with 104 days of sampling effort in the 155-day season (67%, Figure 9). Of the 104 days of sampling effort, Trap 8.1 sampled successfully for approximately 2,416 hours (98%) and sampled unsuccessfully for approximately 49 hours (2%; Figure 10), while Trap 8.2 sampled successfully for approximately 2,357 hours (96%) and sampled unsuccessfully for approximately 102 hours (4%; Figure 11). Sampling was suspended for a total of 51 days with two outages greater than seven days. This included suspending sampling operations for flows greater than 10,000 cfs (28 days), weekend shutdowns (11 days), windstorms (7 days), Nimbus Fish Hatchery Chinook Salmon release (4), and a permit take exceedance (1 day).

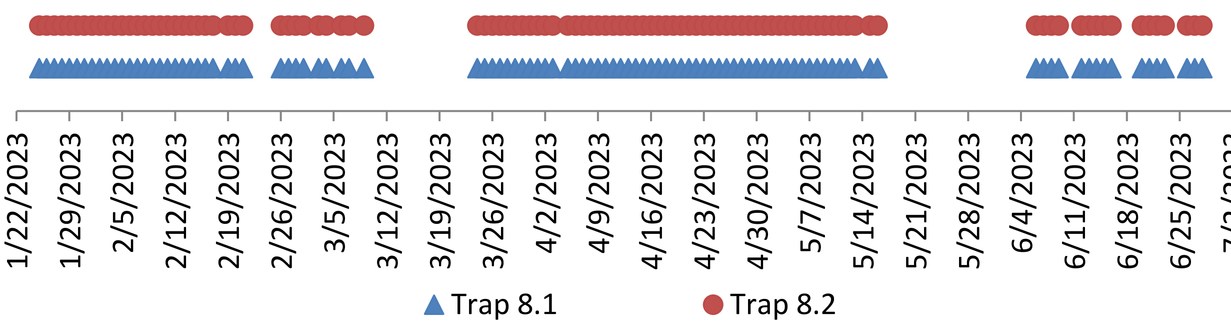

Figure 9: Dates sampling occurred during the 2023 lower American River RST sampling season.

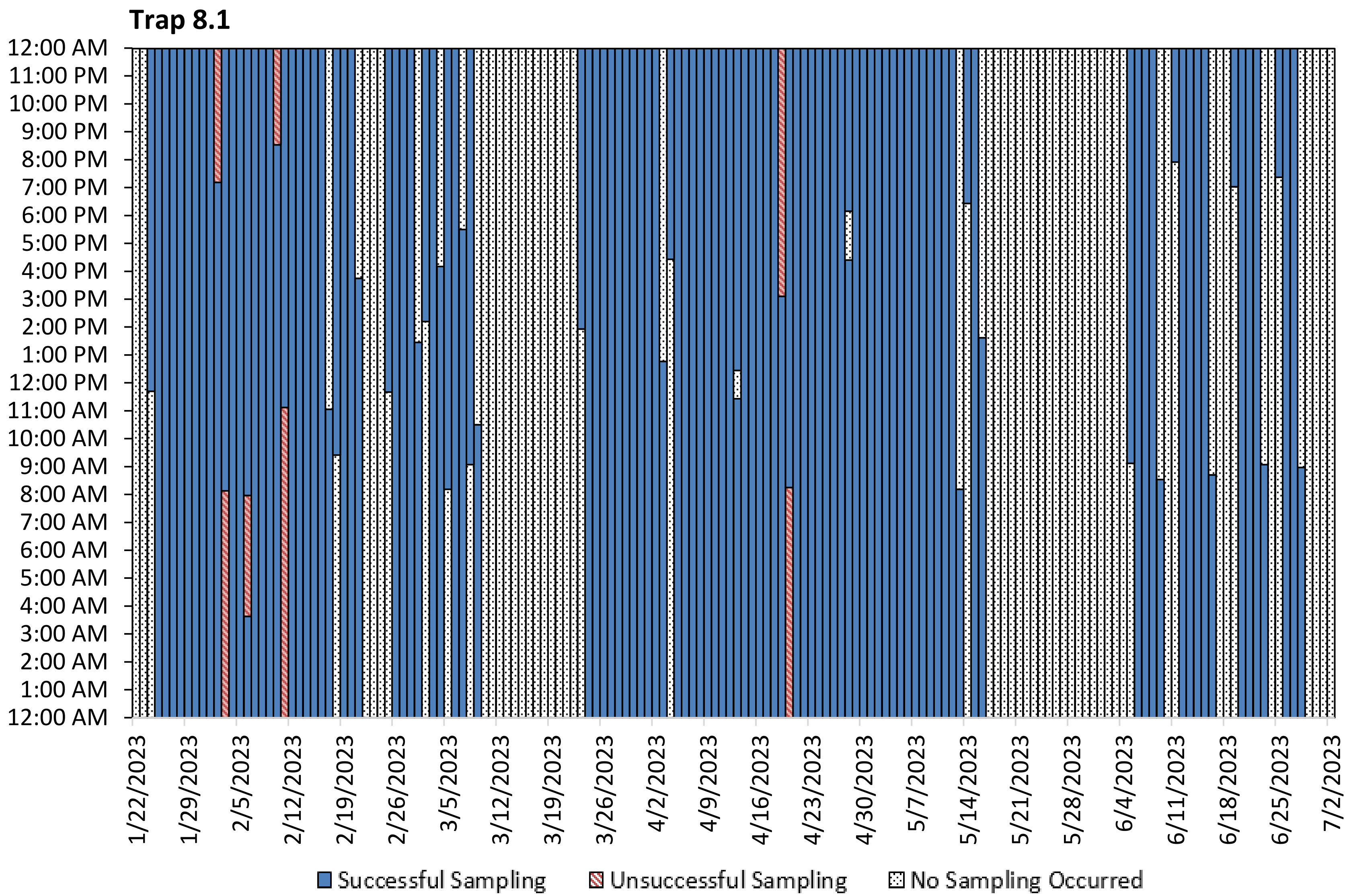

Figure 10: Daily hours Trap 8.1 sampled successfully, sampled unsuccessfully, or did not sample during the 2023 lower American River RST sampling season.

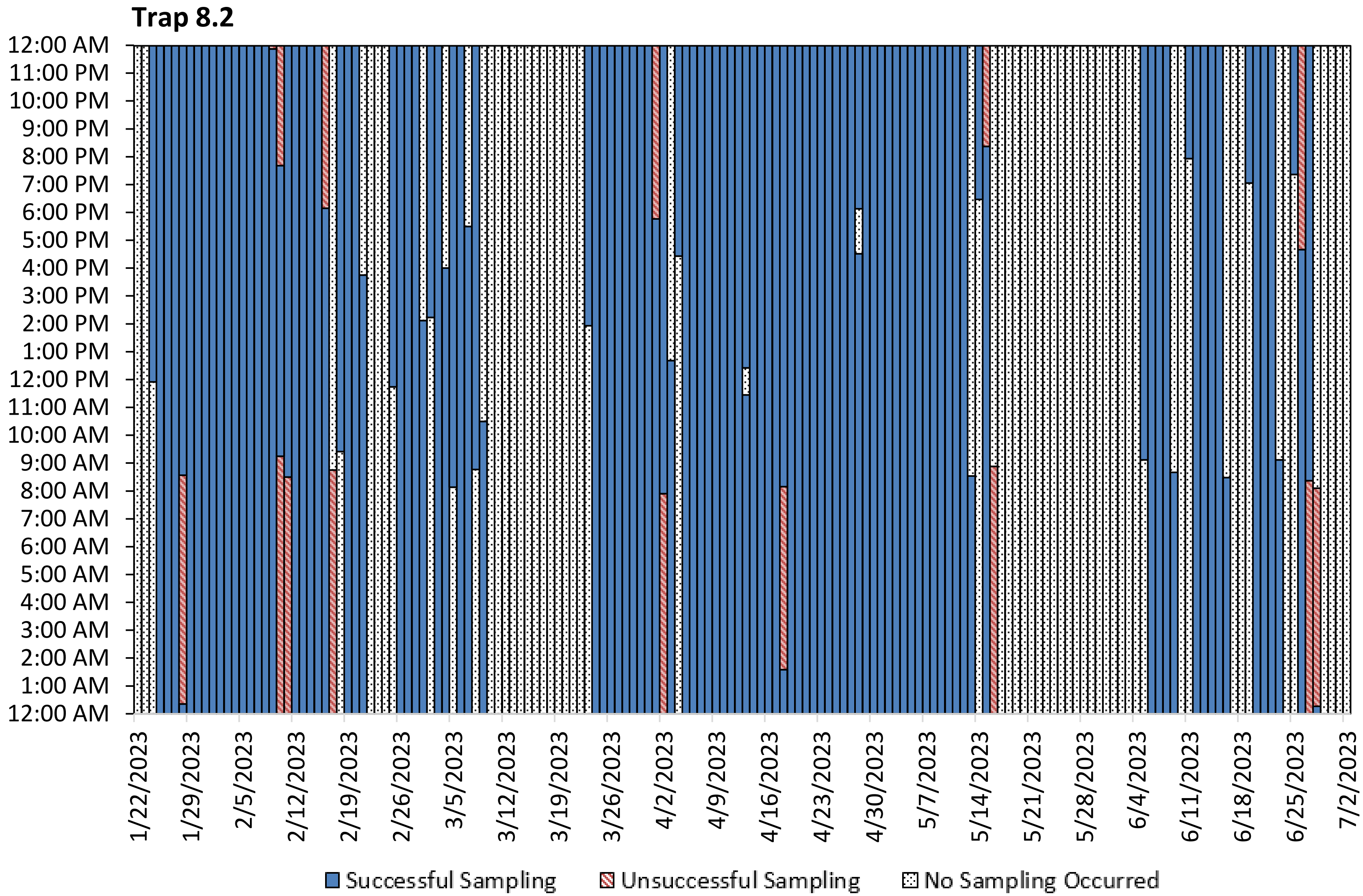

Figure 11: Daily hours Trap 8.2 sampled successfully, sampled unsuccessfully, or did not sample during the 2023 lower American River RST sampling season.

Environmental Summary

The 2023 sampling season was met with high and variable flows, evidently, resulting in gaps of environmental data collection. However, though this year was wet with occasionally high flows, environmental parameters remained relatively ordinary (Appendix 2). 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 February 16 and a maximum on March 10 (range: 2,970 – 32,900 cfs; Figure 12). Instantaneous river temperature, also recorded in 15-minute intervals by USGS at the Watt Avenue gauge station, recorded a minimum on February 15 and a maximum on July 1 (range: 6.7 – 18.0 °C; Figure 12).

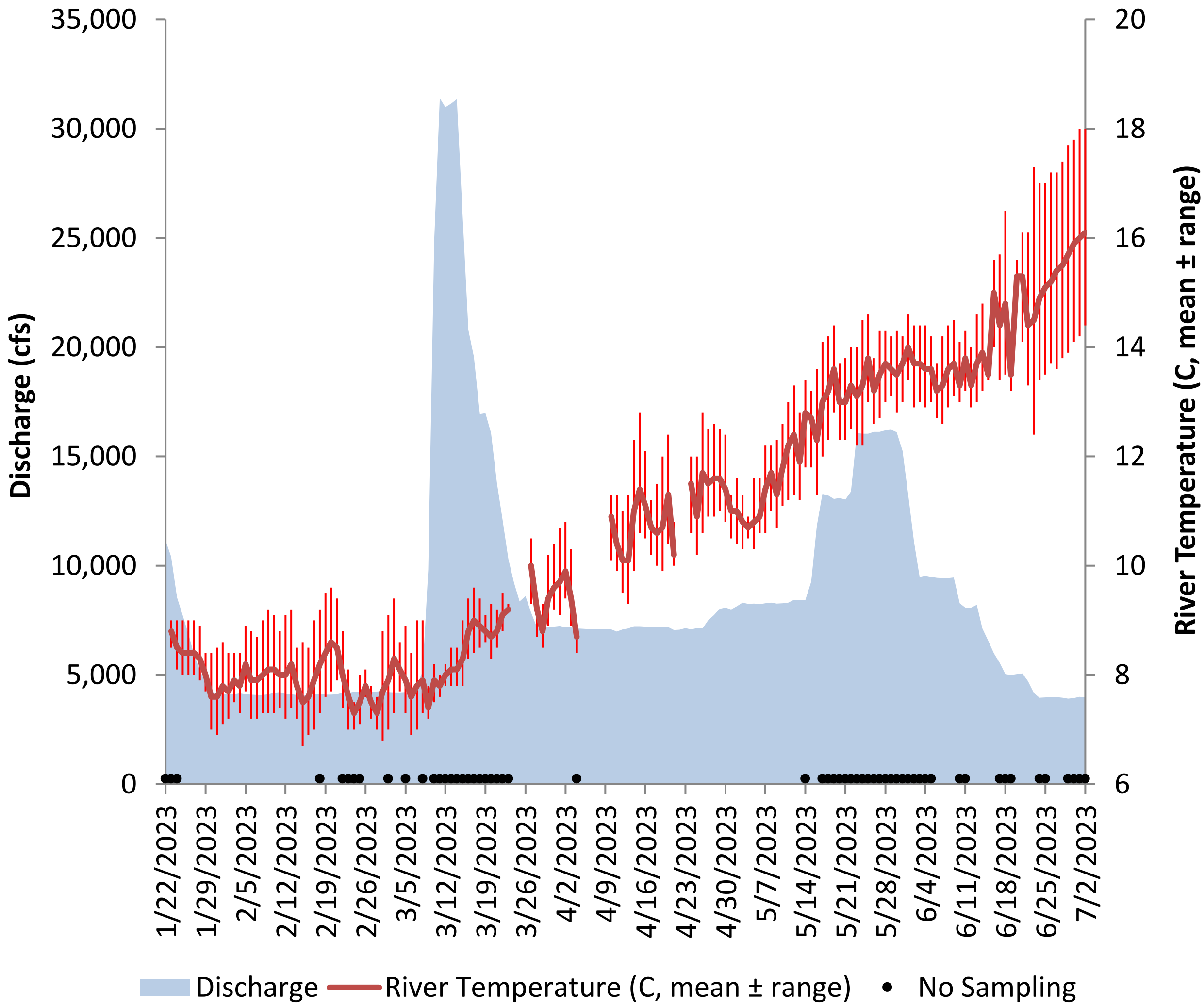

Figure 12: Daily average discharge (cfs) measured at Fair Oaks, and the daily minimum, maximum, and average water temperature (C) measured at Watt Avenue, and dates no sampling occurred during the 2023 lower American River RST sampling season.

Velocity, turbidity, and DO were measured during trap visits throughout the sampling season (Figure 13). Water velocity for Trap 8.1 reached a minimum on March 23, March 24, and March 25 and a maximum on February 25, March 4, and April 10, with a range of 0.40 – 1.40 m/s. Trap 8.2 reached a minimum on March 30 and a maximum on February 5 and March 8 with a range of 0.80 – 1.60 m/s. The mean velocity for Trap 8.1 and Trap 8.2 was similar at 1.03 and 1.23 m/s respectively. The mean velocity for Trap 8.2 is higher than Trap 8.1 likely due to the steeper streambed gradient underneath Trap 8.2. Turbidity for Trap 8.1 reached a minimum on May 3 and a maximum on January 26 with a range of 0.61 – 10.06 NTU. Turbidity for Trap 8.2 reached a minimum on May 7 and a maximum on January 25 with a range of 0.46 – 10.30 NTU. The mean turbidity for Trap 8.1 and Trap 8.2 was similar at 2.94 and 2.77 NTU respectively. The maximum turbidity for Trap 8.1 is slightly higher than Trap 8.2 likely due to Trap 8.1's proximity to an eddy in the northern channel. DO reached a minimum on April 30 and a maximum on February 19 with a range of 8.99 to 13.50 mg/L.

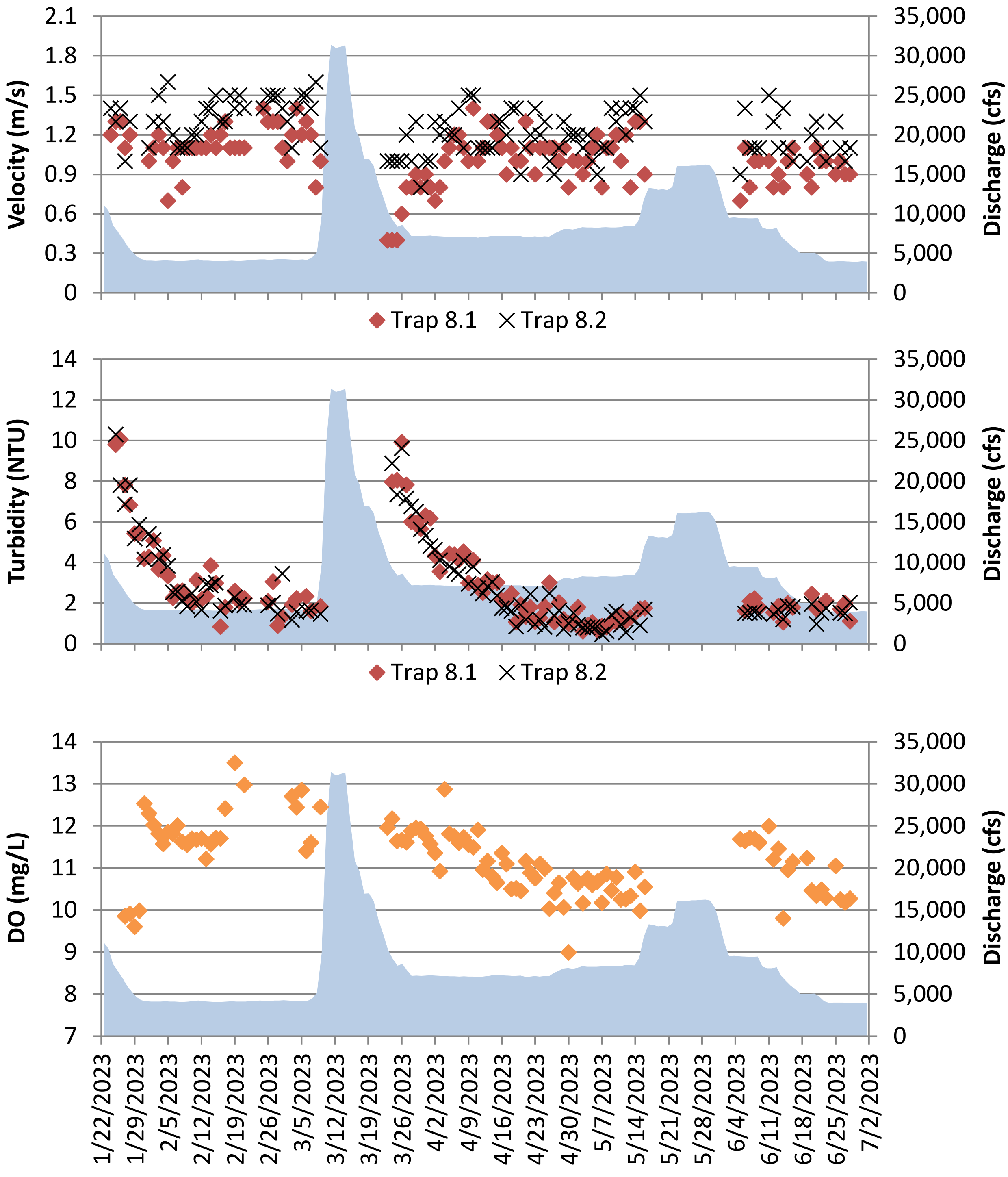

Figure 13: Daily average velocity (m/s) and turbidity (NTU) for both traps, DO (mg/L), and discharge (cfs; measured at Fair Oaks), during the 2023 lower American River RST sampling season.

Catch

The two RSTs deployed during the 2023 sampling season captured 94,401 natural origin fishes, 72 hatchery-produced salmonids, and 125 recaptured Chinook Salmon. The trap furthest from the thalweg, Trap 8.1, captured 55.4% (*n* = 52,346) of these fishes, while Trap 8.2 captured 44.6% (*n* = 42,133). Additionally, 22,122 non-salmonid fishes were captured and identified to at least the genus level (Appendix 3).

Fall-run Chinook Salmon

Natural origin fall-run Chinook Salmon encompassed the most of all natural origin fish captured during the 2023 sampling season with 70,348 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 March 6, when 14.6% (*n* = 10,279) of these fish were captured (Figure 14). Of all fall-run captured during the 2023 sampling season, 58,346 were classified as unmeasured plus-count tallies. Cumulative fall-run catch exceeded 95% on April 6 (Figure 15).

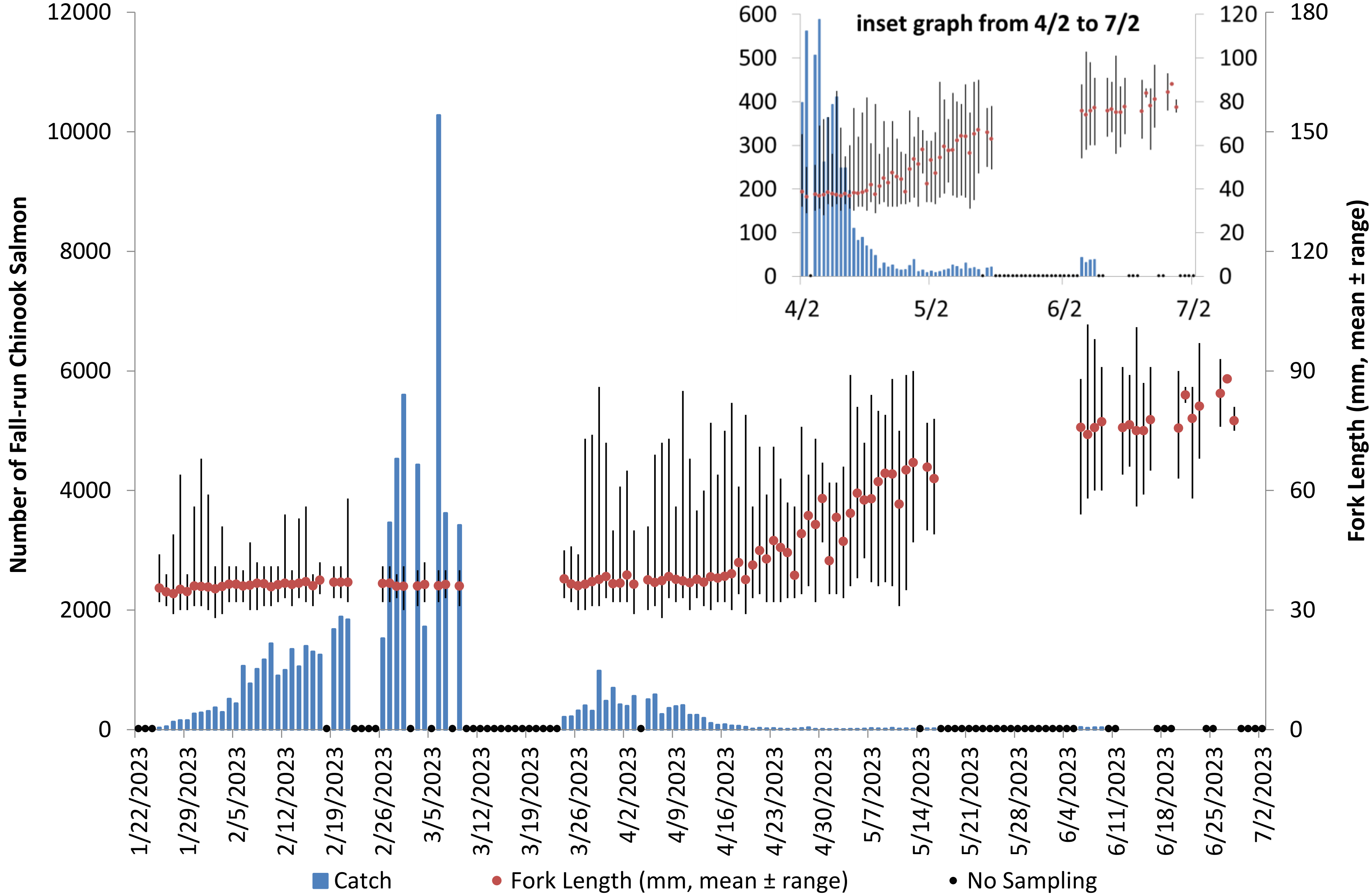

Figure 14: Daily minimum, maximum, and mean fork length (mm) and total catch of natural origin fall-run Chinook Salmon during the 2023 lower American River RST sampling season

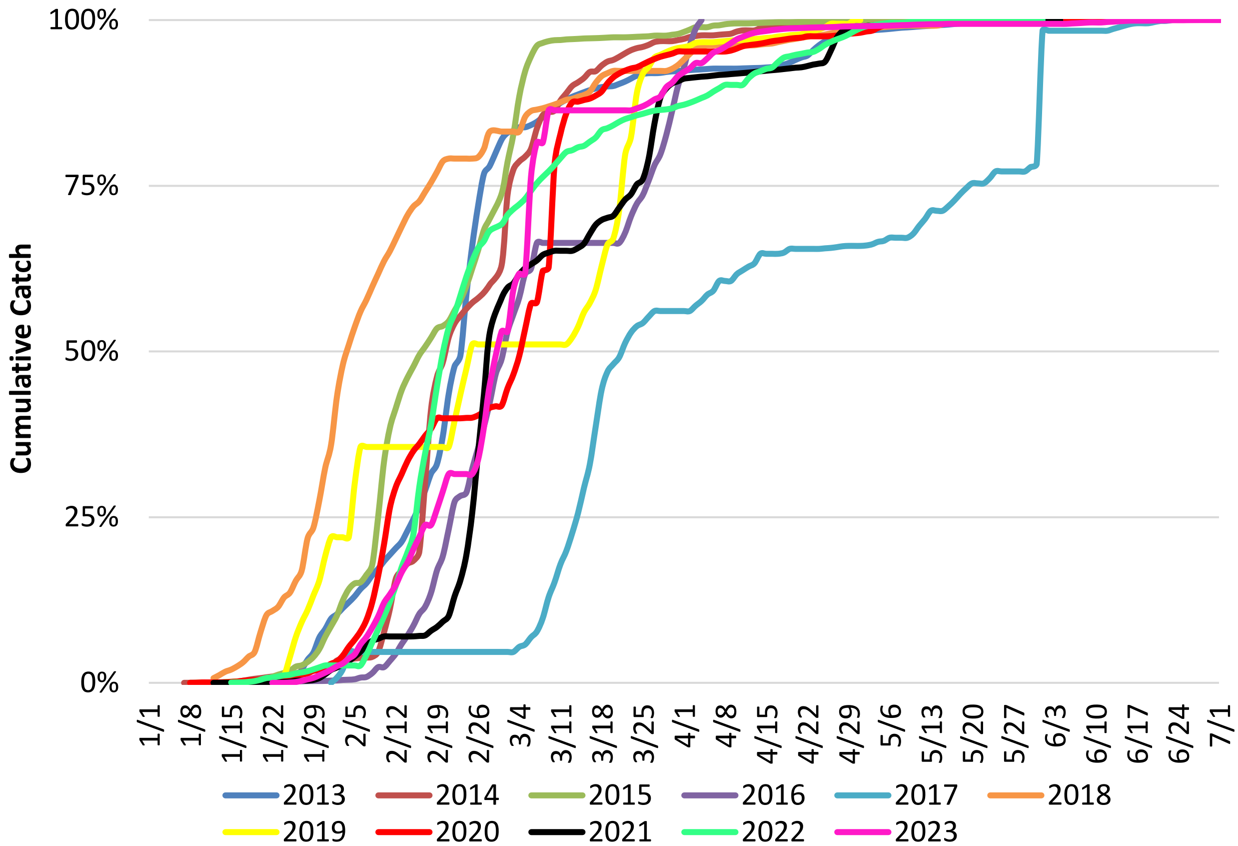

Figure 15: Cumulative catch of natural origin fall-run Chinook Salmon at the lower American River RST from 2013 through 2023.

A total of 12,002 natural origin fall-run were measured for fork length. The weekly minimum, maximum, and average fork lengths throughout the 2023 sampling season are displayed in Table 3. The lowest weekly average fork length of 35 mm was seen during the first week of sampling. The smallest natural origin fall-run was 28 mm and was observed on February 2 and April 7. Fork lengths slowly increased throughout the season with the weekly average reaching a maximum of 83 mm the week of June 25. The largest natural origin fall-run was 103 mm and was observed on June 7.

Table 3: 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 2023 lower American River RST sampling season.

Julian Week	Avg	Range	*n*	St. Dev.
1/22 - 1/28	35	(29 – 64)	373	2.81
1/29 - 2/4	36	(28 – 68)	2,205	2.52
2/5 - 2/11	36	(30 – 47)	6,812	1.66
2/12 - 2/18	37	(31 – 56)	7,359	1.71
2/19 - 2/25	37	(32 – 58)	5,412	1.60
2/26 - 3/4	36	(30 – 42)	21,284	1.55
3/5 - 3/11	36	(31 – 40)	17,323	1.44
3/12 - 3/18	-	-	-	-
3/19 - 3/25	37	(32 – 46)	432	1.95
3/26 - 4/1	37	(30 – 86)	3,623	4.29
4/2 - 4/8	38	(28 – 73)	2,681	3.89
4/9 - 4/15	37	(30 – 85)	1,689	4.58
4/16 - 4/22	40	(29 – 82)	337	8.36
4/23 - 4/29	48	(32 – 76)	145	10.82
4/30 - 5/6	54	(33 – 89)	83	10.95
5/7 - 5/13	62	(31 – 90)	147	12.43
5/14 - 5/20	64	(49 – 78)	40	7.82
5/21 - 5/27	-	-	-	-
5/28 - 6/3	-	-	-	-
6/4 - 6/10	76	(54 – 103)	149	7.90
6/11 - 6/17	76	(56 – 101)	194	6.87
6/18 - 6/24	79	(58 – 97)	46	7.65
6/25 - 7/1	83	(75 – 93)	14	6.25

The subsample of fall-run that were measured for fork length, were also assessed for life stage (Figure 16). The majority of these fish were identified as button-up fry and accounted for 86.4% (*n* = 10,365) of the assessed catch. The remaining life stage catch composition consisted of yolk-sac fry (6.5%, *n* = 782), parr (3.5%, *n* = 418), silvery parr (3.6%, *n* = 436), and smolt (*n* = 1). Fall-run Chinook Salmon identified as yolk-sac fry were captured between January 25 and April 13. Button-up fry were captured between January 25 and May 16. Parr were captured between January 27 and June 26, and silvery parr were caught from January 28 through June 28. Lastly, one fall-run was identified as a smolt and was captured on June 14. Average weekly fork lengths generally increased with life stage progression with yolk-sac fry having the lowest average weekly fork length, and the smolt with the largest weekly fork length. 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, 77 mm for silvery parr, and 101 mm for the smolt (Table 4).

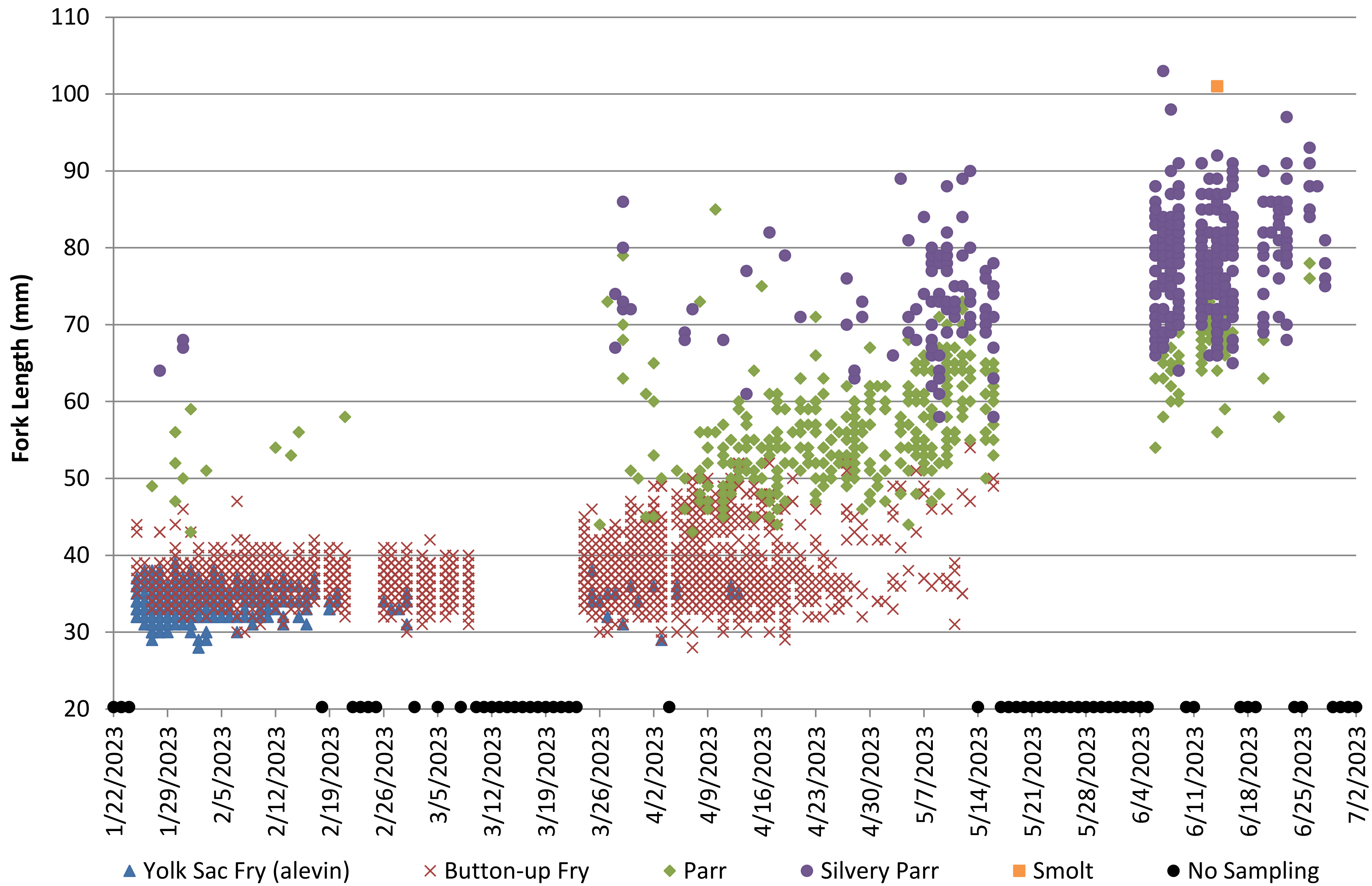

Figure 16: Daily fork length distribution by life stage of natural origin fall-run Chinook Salmon measured and days no sampling occurred during the 2023 lower American River RST sampling season.

Table 4: Weekly average fork length in mm (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 2023 lower American River RST sampling 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*)
1/22 - 1/28	34 (29 - 38, *n* = 252)	36 (33 - 44, *n* = 119)	49 (49, *n* = 1)	64 (64, *n* = 1)	-
1/29 - 2/4	34 (28 - 39, *n* = 352)	36 (32 - 46, *n* = 987)	51 (43 - 59, *n* = 7)	68 (67 - 68, *n* = 2)	-
2/5 - 2/11	34 (30 - 37, *n* = 113)	36 (30 - 47, *n* = 1,287)	-	-	-
2/12 - 2/18	34 (31 - 37, *n* = 33)	37 (31 - 42, *n* = 1,166)	54 (53 - 56, *n* = 3)	-	-
2/19 - 2/25	34 (33 - 35, *n* = 6)	37 (32 - 41, *n* = 594)	58 (58, *n* = 1)	-	-
2/26 - 3/4	33 (31 - 35, *n* = 8)	36 (30 - 42, *n* = 1,192)	-	-	-
3/5 - 3/11	-	36 (31 - 40, *n* = 600)	-	-	-
3/12 - 3/18	-	-	-	-	-
3/19 - 3/25	36 (34 - 38, *n* = 3)	37 (32 - 46, *n* = 387)	-	-	-
3/26 - 4/1	34 (31 - 36, *n* = 7)	37 (30 - 47, *n* = 1,384)	61 (44 - 79, *n* = 11)	75 (67 - 86, *n* = 7)	-
4/2 - 4/8	34 (29 - 36, *n* = 5)	37 (28 - 50, *n* = 1,177)	53 (43 - 73, *n* = 15)	70 (68 - 72, *n* = 3)	-
4/9 - 4/15	35 (35 - 36, *n* = 3)	37 (30 - 52, *n* = 1,098)	52 (45 - 85, *n* = 51)	69 (61 - 77, *n* = 3)	-
4/16 - 4/22	-	37 (29 - 52, *n* = 273)	54 (44 - 75, *n* = 58)	77 (71 - 82, *n* = 3)	-
4/23 - 4/29	-	38 (32 - 52, *n* = 60)	55 (46 - 71, *n* = 63)	69 (63 - 76, *n* = 7)	-
4/30 - 5/6	-	40 (33 - 51, *n* = 19)	57 (44 - 68, *n* = 57)	74 (66 - 89, *n* = 7)	-
5/7 - 5/13	-	40 (31 - 54, *n* = 20)	60 (47 - 73, *n* = 77)	74 (58 - 90, *n* = 49)	-
5/14 - 5/20	-	50 (49 - 50, *n* = 2)	60 (50 - 65, *n* = 20)	71 (58 - 78, *n* = 18)	-
5/21 - 5/27	-	-	-	-	-
5/28 - 6/3	-	-	-	-	-
6/4 - 6/10	-	-	63 (54 - 70, *n* = 18)	78 (64 - 103, *n* = 128)	-
6/11 - 6/17	-	-	67 (56 - 73, *n* = 29)	77 (65 - 92, *n* = 157)	101 (101, *n* = 1)
6/18 - 6/24	-	-	64 (58 - 69, *n* = 4)	80 (68 - 97, *n* = 40)	-
6/25 - 7/1	-	-	77 (76 - 78, *n* = 3)	84 (75 - 93, *n* = 11)	-
Entire Season	**34 (28 - 39, *n* = 782)**	**37 (28 - 54, *n* = 10,365)**	**57 (43 - 85, *n* = 418)**	**77 (58 - 103, *n* = 436)**	**101 (101, *n* = 1)**

Fulton's Condition Factor

Fulton's condition factor (K) for natural origin fall-run Chinook Salmon captured in 2023 is shown in Figure 17. The trend line slopes were positive for button-up fry (0.0021), parr (0.0022), and silvery parr (0.0010) life stages. Yolk-sac fry captured in 2023 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. The smolt trend line was also not included as only one fish was identified as a smolt. Average Fulton's condition factor (K) increased with the life stage progression (Table 5). Since 2013, yearly average K values by life stage have shown a slightly positive trend (Figure 18, Appendix 4).

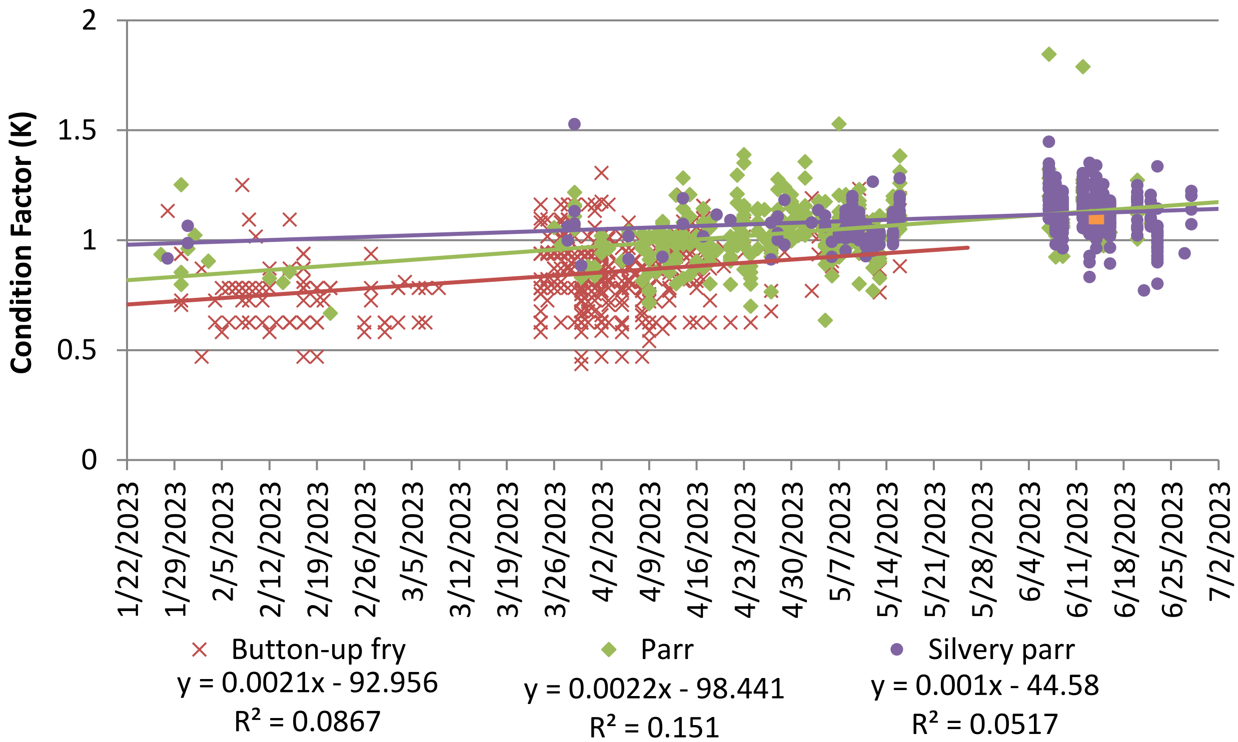

Figure 17: Fulton's condition factor (K) by life stage of fall-run Chinook Salmon during the 2023 lower American River RST sampling season.

Table 5: 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 2023 lower American River RST sampling season.

Life stage	Condition Factor Avg (Range)
Button-up fry	0.84 (0.44 – 1.31)
Parr	1.03 (0.64 – 1.85)
Silvery Parr	1.11 (0.77 – 1.53)
Smolt	1.11 (1.11)

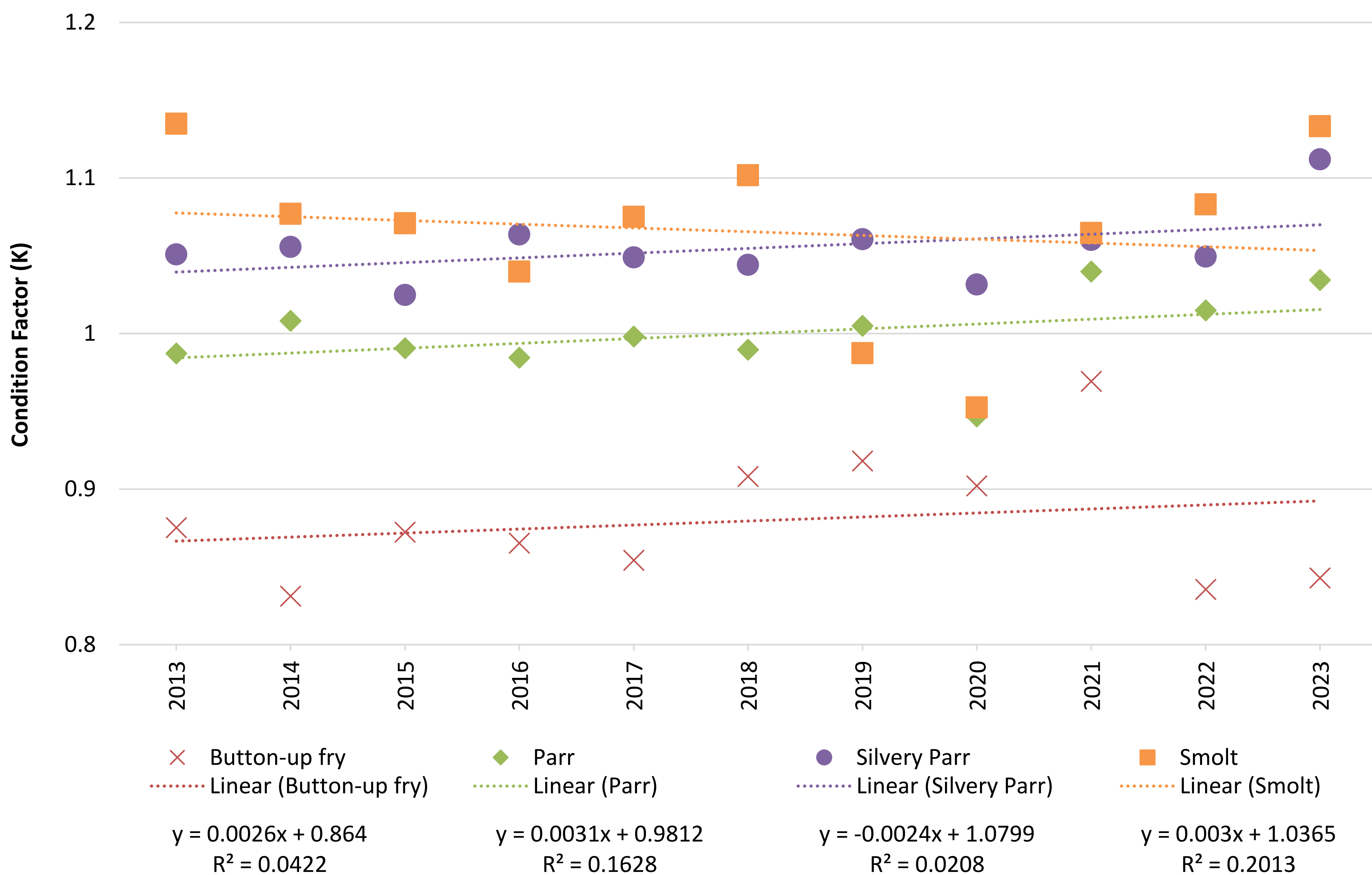

Figure 18: Average Fulton's condition factor by life stage for natural origin fall-run Chinook Salmon from 2013 through 2023.

Trap Efficiency

Six trap efficiency trials were conducted during the 2023 sampling season, five of which were considered successful (Table 6). The trials used a total of 3,460 fall-run Chinook Salmon. Of these fish, 1,513 were natural origin salmon collected from the RSTs and marked with BBY. The remaining 1,947 were acquired from Nimbus Fish Hatchery and marked with VIE. The average trap efficiency across the five trials included for analysis was 3.49% with a total of 88 marked salmon being recaptured within the trial period. The second trial was not included for analysis as both traps were taken offline due to storms and heavy debris loads between February 22 and February 25. Additionally, the average fork length of the recaptured fish was approximately the same size as the average fork length of the released fish.

Table 6: Trap efficiency mark, release, and recapture data during the 2023 lower American River RST sampling season.

Date Marked	Fish Origin	Mark Type	Trial Length (days)	Included for Analysis	Release Date	Release Time	Flow (cfs) at Release	Release Avg FL (mm)	Number of Fish Released	Capture Efficiency	Recapture Avg FL (mm)
2/6/2023	Natural	BBY	12	Yes	2/7/2023	17:30	4,110	36	480	13.54%	37
2/19/2023	Natural	BBY	14	No	2/20/2023	17:00	4,230	37	580	6.03%	37
3/30/2023	Natural	BBY	14	Yes	3/31/2023	18:40	7,470	38	453	1.55%	37
4/19/2023	Hatchery	VIE	14	Yes	4/20/2023	18:29	7,080	56	489	1.02%	58
4/19/2023	Hatchery	VIE	14	Yes	4/20/2023	18:29	7,080	55	486	0.41%	57
5/3/2023	Hatchery	VIE	9	Yes	5/4/2023	18:50	8,240	55	972	0.93%	57

Passage Estimate for Fall-Run Chinook Salmon

Fall-run Chinook Salmon passage estimates are not yet available for 2023. Past passage estimates were calculated using an enhanced efficiency model developed for CAMP by West Inc. However, there is an effort underway to develop a new efficiency model and the USFWS decided to immediately discontinue use of the old model. Future reports will include updated passage estimates for all sampling years for which data are available.

Genetic Analysis

Natural Origin Chinook Salmon

A total of 66 genetic samples were taken from adipose intact Chinook Salmon (25 LAD fall-run, 2 LAD late fall-run, 24 LAD spring-run, and 15 LAD winter-run) and analyzed using SNP genetic markers to determine final run assignments (Appendix 5). Because these salmon had an intact adipose fin, the salmon were presumed to be natural origin. The SNP panel's probabilities of the samples exceeded the 50 percent threshold for all 66 samples and the corresponding run assignments for salmon were assigned based on genetic analysis.

A total of 69,811 natural origin Chinook Salmon captured were classified as fall-run using the LAD criteria. Genetic samples were collected from 25 LAD fall-run throughout the 2023 sampling season. Analyses using SNP genetic markers for these samples indicated that 96% (n = 24) of these individuals were fall-run and 4% (n = 1) was a spring-run, (Table 7). Because the LAD criteria continued to be highly accurate when assigning this run, a final run assessment of fall was applied to the remaining 69,786 LAD fall-run that were not genetically sampled.

A total of 515 natural origin Chinook Salmon captured were classified as late fall-run using the LAD criteria. Genetic samples were collected from 2 LAD late fall-run throughout the 2023 sampling season. Analyses using SNP genetic markers for these samples indicated that 100% (n = 2) of these individuals were fall-run (Table 7). Because the LAD criteria appeared to incorrectly assign this run for most of these individuals, the remaining 513 of the LAD late fall-run that were not genetically sampled were given a final run assignment of fall-run.

A total of 24 natural origin Chinook Salmon captured were classified as spring-run using the LAD criteria. Genetic samples were collected from all 24 of the LAD spring-run throughout the 2023 sampling season. Analyses using SNP genetic markers for these samples indicated that 87.5% (n = 21) of these individuals were fall-run and 12.5% (n = 3) were spring-run (Table 7).

A total of 15 natural origin Chinook Salmon captured were classified as winter-run using the LAD criteria. Genetic samples were collected from all 15 of the LAD winter-run throughout the 2023 sampling season. Analyses using SNP genetic markers for these samples indicated that 86.7% (n = 13) of these individuals were winter-run and 13.3% (n = 2) were fall-run (Table 7).

Table 7: Comparison of natural origin Chinook Salmon run assignments using LAD criteria and SNP genetic markers.

	SNP Confirmed Fall Run	SNP Confirmed Late Fall Run	SNP Confirmed Spring Run	SNP Confirmed Winter Run
LAD Fall	24	0	1	0
LAD Late Fall	2	0	0	0
LAD Spring	21	0	3	0
LAD Winter	2	0	0	13

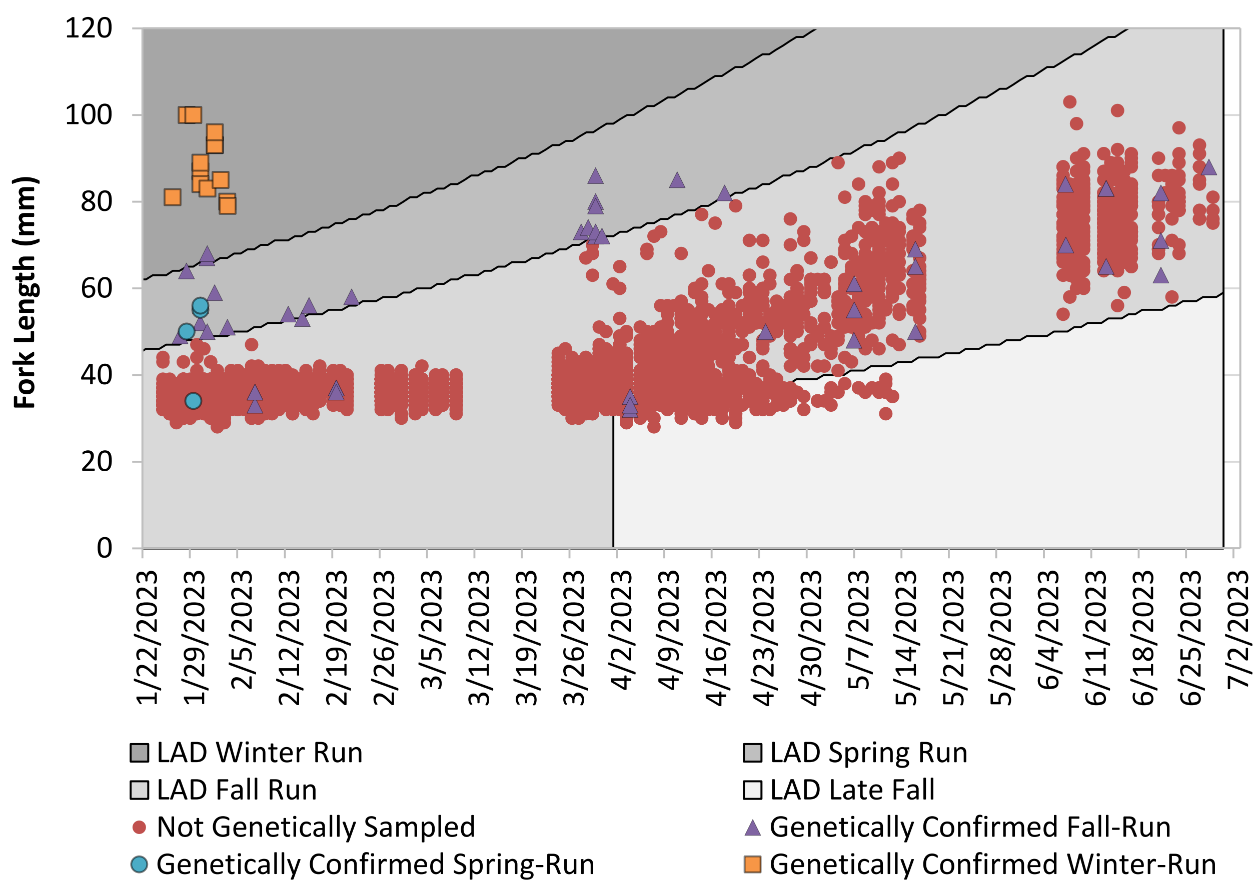

Figure 19: Daily fork length distribution of SNP genetically and not genetically sampled natural origin Chinook Salmon measured during the 2023 lower American River RST sampling season.

Hatchery Origin Chinook Salmon

A total of 14 adipose clipped Chinook Salmon were captured during the 2023 sampling season. Because these salmon had a clipped adipose fin, the salmon were classified as hatchery origin. Genetic samples were collected from 12 of these individuals throughout the 2023 sampling season and analyzed using SNP genetic markers (Appendix 5). Analyses using SNP genetic markers for these samples indicated that all (*n* = 12) of these individuals were fall-run. However, a coded wire tag extracted from one of these individuals indicated that it was a part of the Feather River Hatchery Spring-Run release at Gridley Boat Launch on March 16. Because the average release fork length at Gridley Boat Launch (82 mm) was similar to the average recapture fork length at the RSTs (79 mm) and there were no other hatchery releases that occurred between March 30 and April 19 when these hatchery fish were captured, a final run of spring-run was applied to all 14 adipose clipped Chinook Salmon captured.

Spring-run and Winter-run Chinook Salmon

Genetic analyses suggest that four natural origin spring-run and 13 natural origin winter-run Chinook Salmon were captured during the 2023 sampling season. Genetically confirmed natural origin spring-run were captured between January 28 and January 30 when the LAD spring-run fork length range was between 49 and 66 mm (Figure 19). Of the four genetically confirmed spring-run, one measured outside of the LAD spring-run range and inside the LAD fall-run range. That spring-run was identified as a button-up fry with a fork length of 34 mm with the fish measuring 15 mm shorter than the LAD spring-run minimum for that day. Genetically confirmed winter-run were captured between January 26 and February 3 when the LAD winter-run fork length range was between 65 and 137 mm (Figure 19). The average fork length was 88 mm with a range of 79 to 100 mm. All 13 genetically confirmed winter-run measured within LAD winter-run range.

Steelhead

A total of 260 natural origin steelhead were captured during the 2023 sampling season. Catch peaked on April 15, comprising 7.7% (*n* = 20) of the total natural origin steelhead captured (Figure 20). The majority of captured steelhead were assessed for life stage. The life stage composition consisted of 3 yolk-sac fry, 182 button-up fry, 72 parr, 1 yearling, and 2 that were not assigned a life stage. Fork lengths ranged from 23 – 25 mm for yolk-sac fry, 23 – 53 mm for button-up fry, 44 – 82 mm for parr, and 212 mm for the yearling (Figure 21). Cumulative catch of natural origin steelhead exceeded 95% on June 23 (Figure 22).

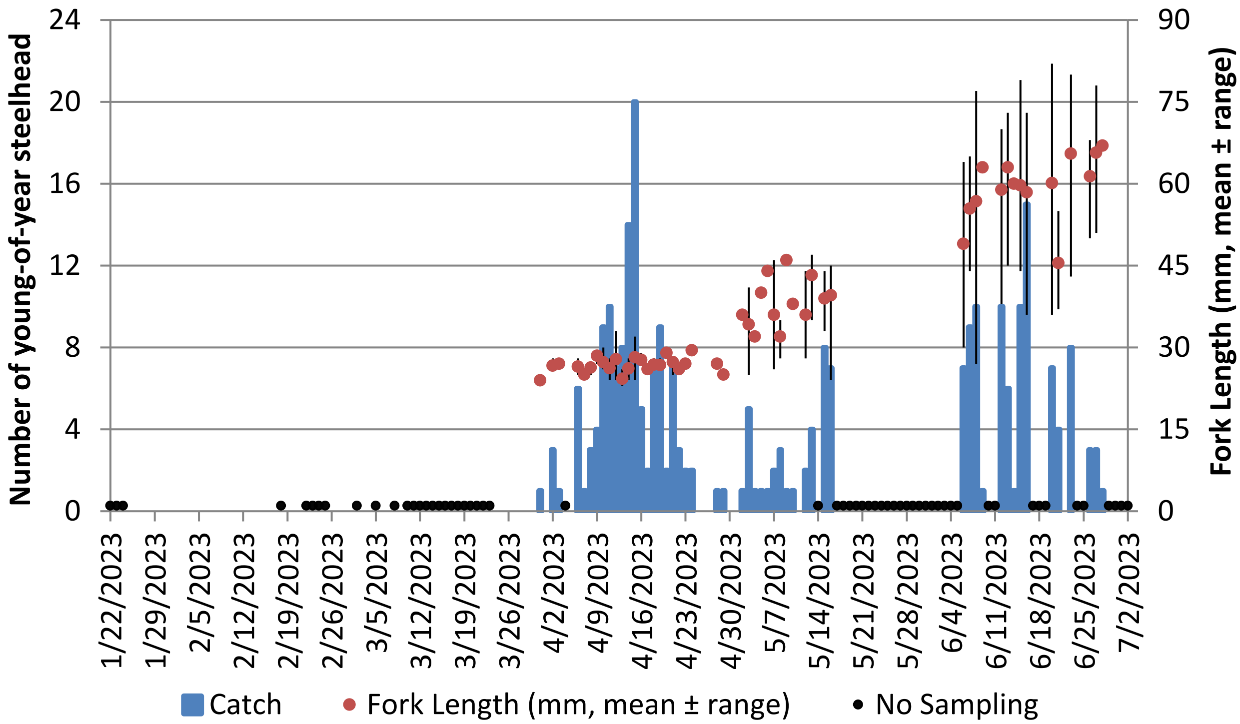

Figure 20: Daily minimum, maximum, and average fork length (mm) and catch distribution of natural origin young-of-year steelhead captured during the 2023 lower American River RST sampling season.

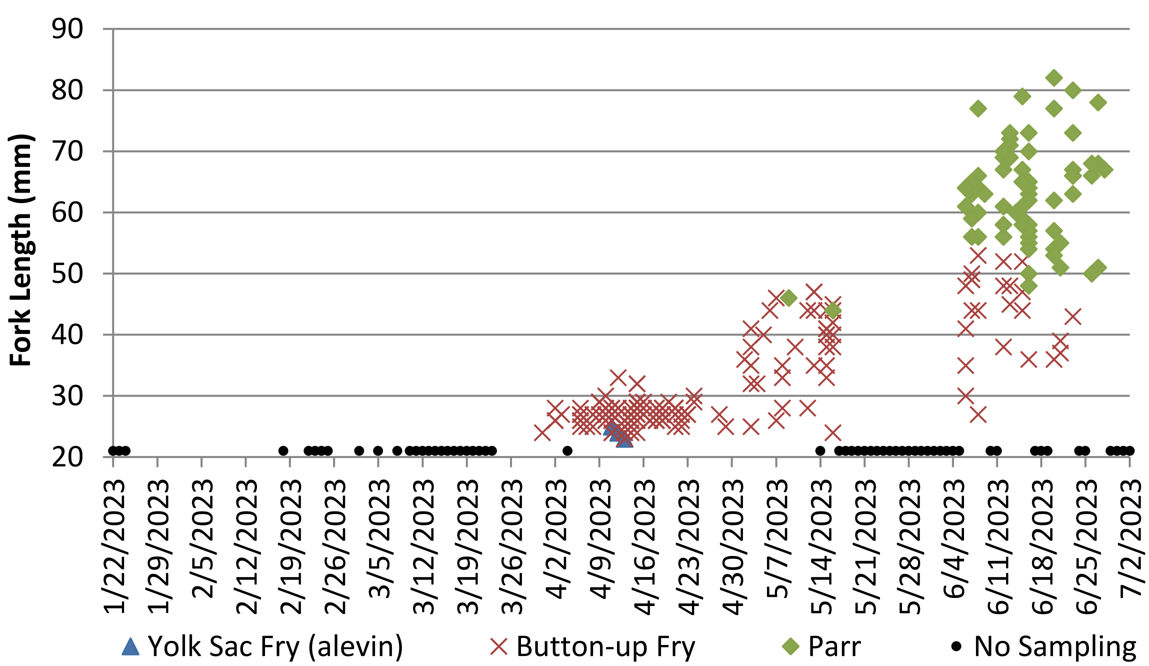

Figure 21: Daily fork length distribution by life stage of natural origin young-of-year steelhead measured and days no sampling occurred during the 2023 lower American River RST sampling season.

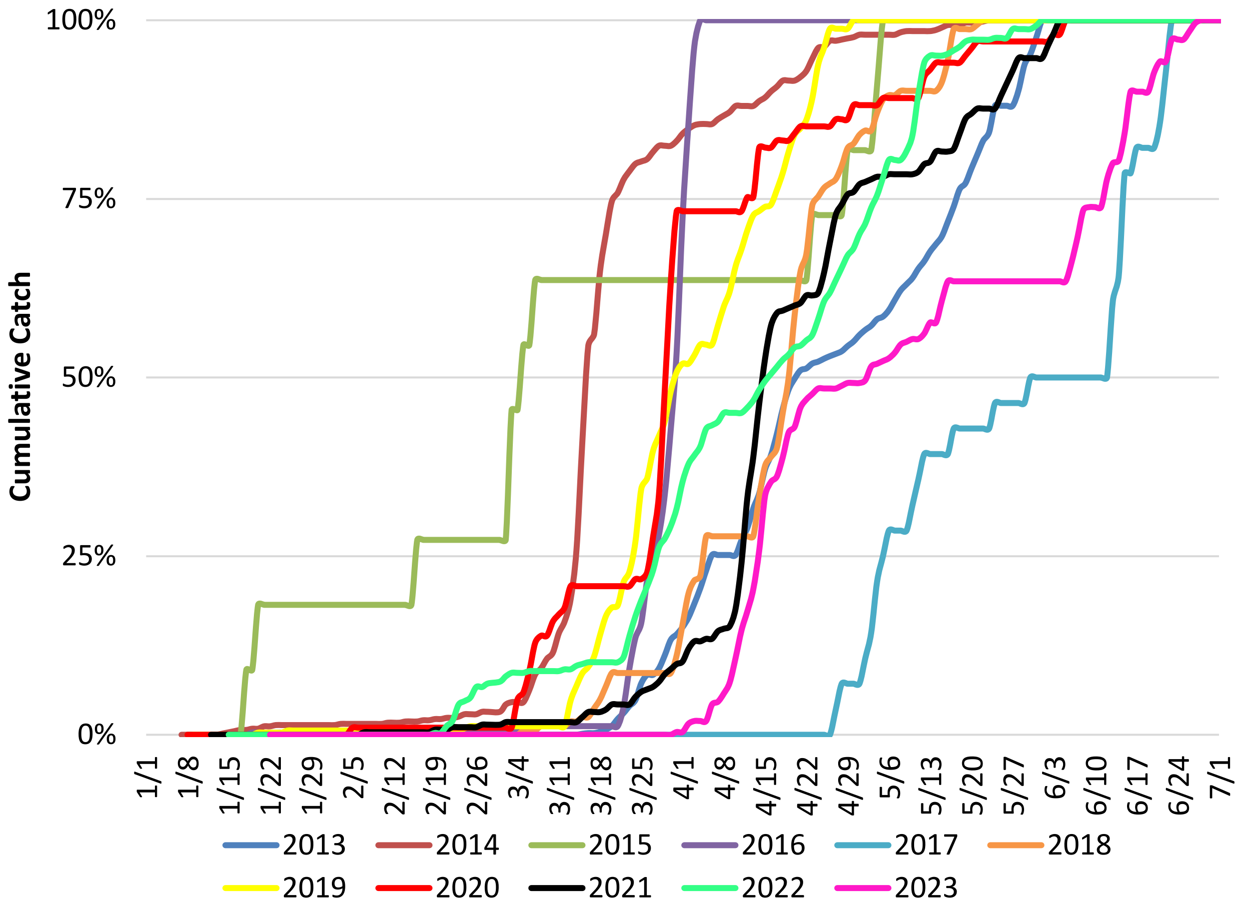

Figure 22: Cumulative catch of natural origin steelhead at the lower American River RST from 2013 through 2023.

In addition to the natural origin steelhead catch, 58 adipose clipped hatchery origin steelhead were also captured. These fish were caught between January 25 and March 28, with an average fork length of 221 mm and range of 109 – 416 mm. Daily catch peaked on January 25 (*n* = 14).

Non-salmonid Species

A total of 23,776 non-salmonid fish were captured during the 2023 sampling season. The majority (*n* = 22,122, 93%) of these fish belonged to 22 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 23). The remaining 7% (*n* = 1,654) were not able to be identified to species level, but belonged to the following families: Centrarchidae (*n* = 5), Cottidae (*n* = 1), Cyprinidae (*n* = 1), Ictaluridae (*n* = 2), and Petromyzontidae (*n* = 1,645). Most non-salmonid fish captured were non-native to the Central Valley watershed (*n* = 21,047, 89%) with the remaining individuals (*n* = 2,729, 11%) being native species. Appendix 7 contains a complete list of non-salmonid species captured by month during the 2023 sampling season.

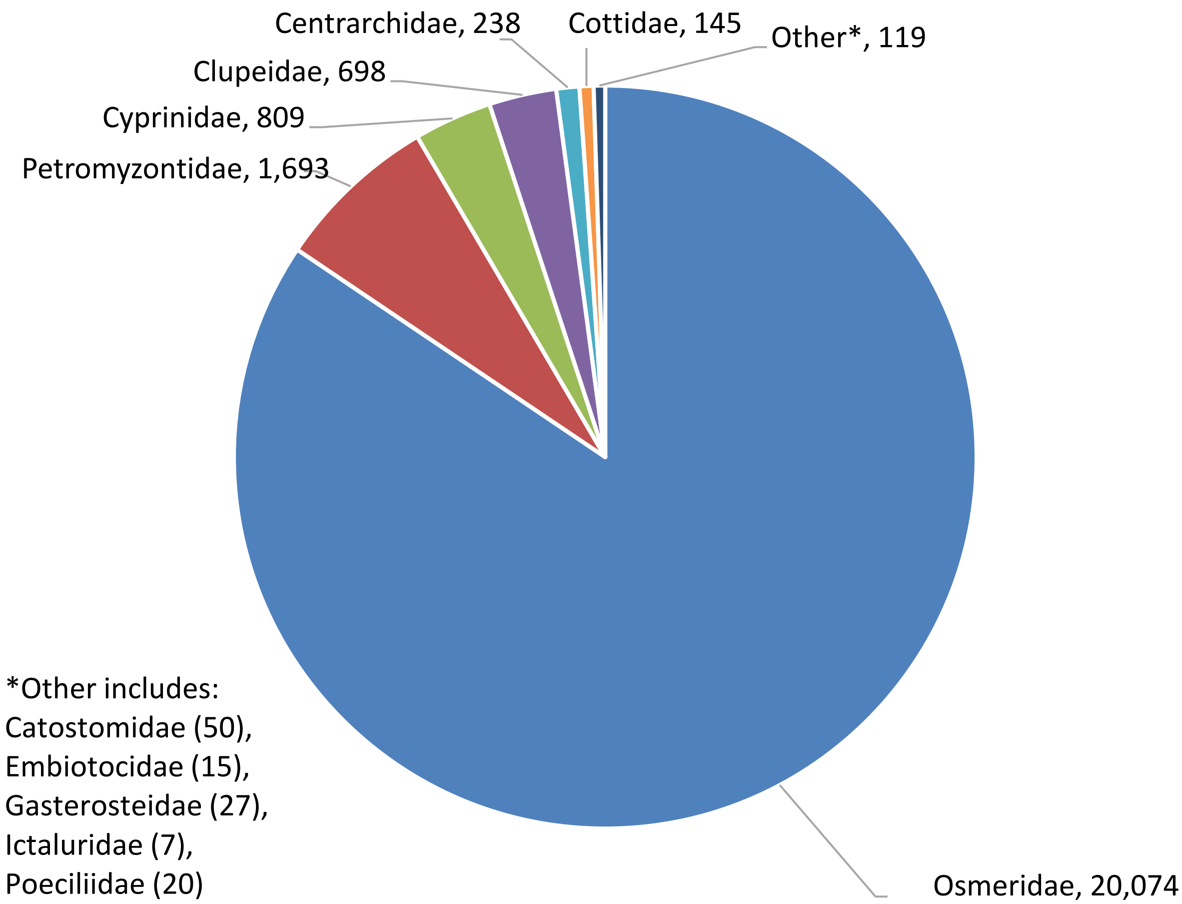

Figure 23: Non-salmonid catch totals for each family of species collected during the 2023 lower American River RST sampling season.

Of the 23,776 non-salmonid fish captured, 1,693 (7.1%) were identified as Petromyzontidae spp. (northern lampreys); 40 (0.2%) of which were identified as Pacific Lamprey, consisting of 12 adults and 28 juveniles; 8 were identified as River Lamprey. The remaining 1,645 (6.9%) captured were identified as Petromyzontidae ammocoetes and were not identified to a species level. Catch of Pacific Lamprey macropthalmia peaked on January 29 and April 17 when 3 (7.5%) of the total Pacific Lamprey were captured. Catch of River Lamprey peaked on April 6 when 2 (25.0%) of the total was captured. Catch of ammocoetes peaked on January 30 when 213 (13.0%) of the total was captured. (Figure 24).

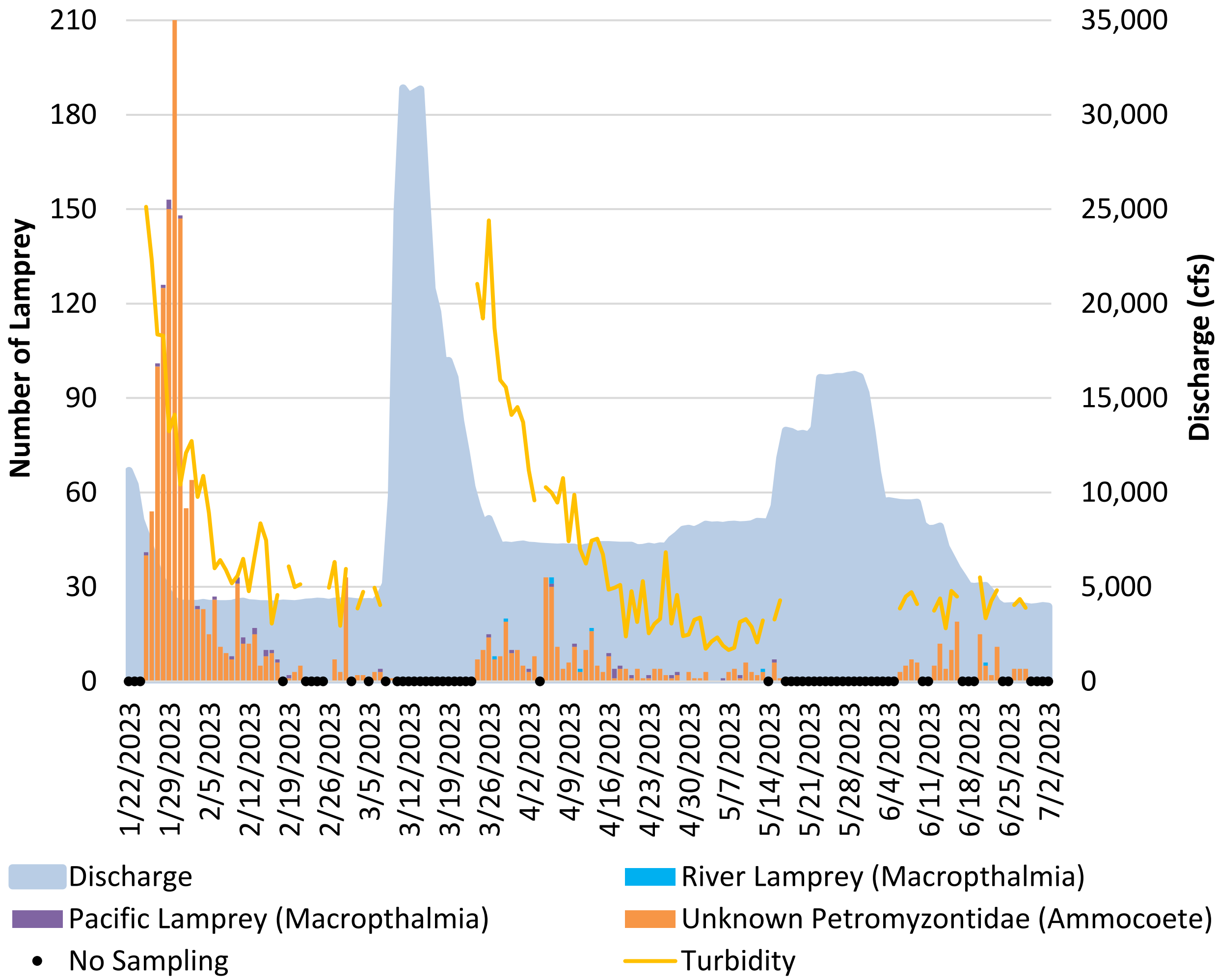

Figure 24: Daily lamprey catch, daily average discharge (cfs) measured at Fair Oaks, and dates no sampling occurred during the 2023 lower American River RST sampling season.

Discussion

Project Scope

The continued operation of the lower American River RSTs during the 2023 sampling season provided valuable biological monitoring data for emigrating juvenile Chinook Salmon and steelhead. Primary objectives of the study were met by collecting data that can be used to estimate passage of fall-run Chinook Salmon and accurately quantifying catch of steelhead, spring-run, and winter-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 RST emigration surveys (2013-2022).

Passage Estimate and Catch

Several factors must be considered when interpreting catch of fall-run, spring-run, and winter-run Chinook Salmon and the quantity of steelhead during the 2023 sampling season. One of the most significant factors was the cold weather and variable river flows experienced throughout the sampling season. In 2023, California experienced a record number of atmospheric rivers that transported large quantities of water vapor from the tropics to California. The atmospheric rivers brought heavy precipitation and high snow levels to the Sierra Nevada, filling many Central Valley reservoirs to near maximum capacity and well above historic averages. Consequently, dam operators increased American River discharges well above 10,000 cfs for flood control and storage management purposes on three separate occasions: January 1 through January 23, March 10 through March 23, and May 16 through June 2 (Figure 12). Evidently, with 10,000 cfs set as the lower American River RST operating threshold, this ultimately limited the amount of data that could be collected during the 2023 sampling season.

The high flows experienced on the lower American River between January 1 and January 23, did not allow for the RSTs to be safely installed until January 24 with the RST sampling season beginning January 25. Through the first seven days of sampling a total of 1,086 fall-run were captured accounting for 1.5% of the total fall-run catch. When interpreting whether the sampling season encompassed the start of the juvenile salmonid emigration period, it is likely that some fall-run were missed due to the high discharge experienced during this time period.

Consistent trap operation was also significantly impacted by two high flow events during the 2023 sampling season. Specifically, between March 10 through March 23, the discharge from Nimbus Dam averaged 21,357 cfs (range: 8,620 – 32,900, Figure 12). This resulted in a cease in trap operations for a total of 14 days (9%) during the 155-day sampling season (Figure 9). With the peak of fall-run catch (n = 10,279) occurring on March 6, a few days prior to the discharge event, fall-run catch totals for the 2023 sampling season bias low (Figure 14). Additionally, during the second discharge event between May 16 through June 2, the discharge from Nimbus Dam average 14,415 cfs (range: 8,900 – 17,100, Figure 12). This resulted in a cease in trap operations for a total of 17 days (11%) during the 155-day season (Figure 9). Contrary to the March discharge event, this cease in trap operations did not occur during peak fall-run catch, as only an average of 20 fall-run per day were captured the previous seven days of sampling leading into this discharge event. However, this cease in trap operations ultimately bias catch totals low.

Due to the colder river temperatures throughout the 2023 sampling season, the RSTs were able to operate until June 28, which is the latest the RSTs have been operated by PSMFC in a sampling season (PSMFC 2013 - 2022). Through the last seven days of sampling, a total of 60 fall-run were captured accounting for 0.1% of the total fall-run catch. When interpreting whether the sampling season encompassed the end of the juvenile salmonid emigration period, it is likely that the end of the salmonid emigration period was sampled.

Fall-run catch totals were also impacted by two in-river hatchery Chinook Salmon releases that occurred during the 2023 sampling season. The first release occurred on February 23 with approximately 1.1 million hatchery fall-run Chinook Salmon released at the Nimbus Fish Hatchery. The released fish average fork length was 36 mm and did not contain any marks to indicate origin (i.e., adipose clip). Because these fish were approximately the same size as the emigrating natural origin fall-run and did not display any marks to indicate origin, it made identifying between natural and hatchery origin fall-run impossible in the field, biasing natural origin fall-run catch totals high. However, 100 fin clips were collected throughout the 2023 sampling season to help distinguish between natural and hatchery origin fall-run catch for this release. The results are currently pending, but will help determine how quickly the released hatchery origin fall-run Chinook Salmon of this size migrate past the lower American River RSTs following release. The second release occurred on May 16 with approximately 855,000 hatchery fall-run Chinook Salmon released at the Sunrise Boat Launch. The released fish average fork length was 85 mm and contained an adipose clip rate of 25%. Contrary to the February hatchery release, this release occurred when the traps were not operating with June 6 as the first day these fish could have been captured. However, no adipose clipped Chinook Salmon were captured once sampling resumed following this release. Additionally, in previous years, released hatchery fish in this size class tend to migrate past the lower American River RSTs more quickly with most fish passing the RSTs in as quickly as four days following release (PSMFC 2020). Evidently, though some hatchery fall-run could have been captured, it does not appear that this release significantly impacted fall-run catch totals.

Salmonid catch is also dependent on the quantity, quality, and recapture efficiencies obtained through trap efficiency trials. Of the six efficiency trials conducted during the 2023 sampling season, five efficiency trials were included for data analysis for future estimation of fall-run passage. The second trial beginning on February 20 was not included for data analysis as the RST operations were ceased between February 22 through February 25 due to windstorms and heavy debris moving downstream when recaptures were expected. The capture efficiencies during the first trial in February was 13.5%, while the last four trials in March through May averaged 1.0% (range: 0.4 – 1.6%). The decrease in capture efficiency between these trials could be explained by the increase in discharge. This is because the north channel carries a smaller proportion of the water volume with an increase in flow, thus causing the RSTs to fish a smaller proportion of the river, ultimately resulting in a lower capture efficiency (Appendix 1, Appendix 6).

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 2023 with velocity averaging 1.1 m/s with a range of 0.4 – 1.6 m/s (USFWS 2008). Additionally, flows remained relatively stable throughout the duration of each trap efficiency trial conducted during the sampling season (Figure 13). Trap operation was also largely successful during all efficiency trials with RST stoppages only occurring on trial 1 and trial 3. During trial 1, Trap 8.1 and Trap 8.2 were stopped on the evening of February 10, three days following the release. During trial 3, Trap 8.2 was stopped on the evening April 1. Additionally, during trial 3, RST operations were suspended the afternoon of April 3 through April 4 due to a permit take exceedance. Though it is possible that the efficiency percentages biased low due to short periods of trap stoppages or when no sampling occurred during these efficiency trials, it is likely that the efficiency percentages are still highly representative of the trap efficiency during the 2023 sampling season.

Biological Observations

Biological data were collected throughout the season to correlate environmental parameters with temporal presence and abundance of salmonids. The data were collected for a subsample of all salmonids to evaluate potential changes in health, growth, and life history strategies. As seen in previous years of biological sampling on the lower American River, most of the fall-run population emigrated as age-0 fry from the American River (PSMFC 2013 – 2022, 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 2023 with 98% (*n* = 69,193) of the season's fall-run catch being captured before April 15. During this period, fork lengths averaged 37 mm with 99% of the subsampled fish identified as yolk-sac fry or button-up fry. After April 15, a steady increase in temperature, average fish length, and the ratio of parr, silvery parr, and smolt life stages were observed (Figure 12, Figure 16).

The lower American River experienced low in-river temperatures throughout the 2023 sampling season, resulting in a higher proportion of fry captured and lower than average fork lengths for fall-run (Appendix 11). This is likely because the optimal growth rate of 15 – 19 C was not observed until later in the sampling season (Myrick and Cech 2001). In 2023, the daily average temperature of 15 C was not observed at the Watt Avenue USGS station until June 17, whereas, in an average year, the daily average temperature of 15 C at the Watt Avenue USGS station is typically observed in early May (Appendix 8). Additionally, because of the lower river temperatures and resulting lower fork lengths, a record number of LAD late fall were captured during the 2023 sampling season (PSMFC 2013 – 2022). These fish were likely smaller fall run because during normal in-river temperature years, there is a significant difference in size between the captured fall run and late fall run Chinook Salmon.

Yearly average condition factor (K) by life stage has slightly increased since PSMFC began operating the American River RSTs in 2013 (Figure 18). The button-up fry life stage continues to be the life stage with the lowest average K value with K generally increasing as salmon progress through the later juvenile life stages. Additionally, the average condition factor values for the 2023 sampling season increased for the parr, silvery parr, and smolt life stages relative to the previous season (2022), however yearly sample sizes for the smolt life stage are significantly smaller than the other life stages. The California Department of Water Resources' Sacramento Valley Water Year Hydrologic Classification Indices indicates that 2021 and 2022 were both critical water type years, while 2023 classifies as a wet water year type (CDWR 2023). Due to the higher flows on the American River in 2023, more rearing habitat for in-river salmonids may have been available during the juvenile emigration period providing access to high quality forage at low metabolic costs (Goertler et al. 2018), thus increasing condition factor in wet water year types. However, more research is needed to determine the significance of various environmental parameters on fish condition on the American River.

Three (12.5%) of the 24 LAD spring-run captured during the 2023 field season were genetically confirmed spring-run. Though the LAD criteria developed by Fischer continued to inaccurately assign this run, there does appear to be a higher likelihood that LAD spring-run captured towards the beginning of the season have a higher likelihood of being a genetically confirmed spring-run. From 2015 through 2023, prior to March 1, 226 LAD natural origin spring-run have been genetically sampled with 30 (13.3%) as genetically confirmed spring run. However, after March 1, the accuracy of the LAD criteria for spring-run diminishes even more as

728 LAD natural origin spring-run that have been genetically sampled produced only 10 (1.4%) genetically confirmed spring run (Appendix 10). The likely explanation for this is the warmer water temperatures experienced in the later months of the season increased the number of LAD spring-run captured. Additionally, at the beginning of the season the size of fall run does not vary much with an average fork length well below the spring run cut off.

In addition, two (13.3%) of the 15 LAD winter run that were classified as genetically confirmed fall-run, were only a few mm larger than the LAD spring run cutoff. Of the other LAD winter run that were classified as genetically confirmed fall run, they averaged 2.7 mm larger than the LAD spring-run cut off with a range of 1 to 6 mm. Otherwise, the SNP analysis continued to accurately assign this run during the 2023 season.

Fourteen adipose clipped Chinook Salmon were captured during the 2023 field season. Because no adipose clipped Chinook Salmon releases occurred on the lower American River before or during their capture period (March 30 through April 19), it is likely that all these fish originated from another watershed. Additionally, 12 (85.7%) of the 14 adipose clipped Chinook Salmon underwent SNP genetic analysis, and all 12 fish were determined to be fall-run, though some traces of spring-run were detected. However, 1 of the 14 adipose clipped Chinook Salmon was extracted for a coded-wire tag and that tag number indicated that the fish was a part of the Feather River Hatchery Spring-Run release at Gridley Boat launch on March 16. Because the average release fork length at Gridley Boat Launch (82 mm) was similar to the average recapture fork length at the RSTs (79 mm) and there were no other hatchery releases that occurred between March 30 and April 19 when these hatchery fish were captured, a final run of spring-run was applied to all 14 adipose clipped Chinook Salmon captured. Adipose clipped Chinook Salmon released from other rivers (i.e., Feather, Coleman, etc..) are not uncommon to capture at the lower American River RSTs and they occur more frequently on high water years (PSMFC 2017). This is likely due to differences in discharges between the Sacramento and American Rivers, occasionally resulting in backflow into the American River.

California Central Valley natural origin steelhead were also assessed for life stage, fork length, and weighed if greater than 40 mm. Between 2013 and 2022, 4,456 steelhead have been captured (annual mean: 446) with 2,206 of these fish being captured in 2013. During the 2023 season, 260 steelhead were captured consisting of 259 age-0 juveniles and one yearling. 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 – 2022). The most redds observed between 2013 and 2022 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 2023 also coincides with what has been previously observed on the American River with most of steelhead captured being recently emerged, age-0 juveniles.

Conclusion

The 2023 RST sampling effort to quantify catch and passage of emigrating juvenile salmonids met all study objectives except estimating passage. At the request of USFWS, passage estimates will not be calculated until the new efficiency model is completed. The data collected during the 2023 sampling season provides valuable insight into salmonid emigration behavior in cold, high-water years. However, we acknowledge several limitations and challenges when interpreting the data collected in 2023 and comparing to previous years due to limitations in sampling, differences in sampling methodologies, and in-river hatchery releases.

Juvenile salmonid emigration monitoring will continue on the lower American River in 2024. To obtain the highest accuracy for catch and passage estimation while maintaining the highest level of safety, adjustments are recommended for future seasons. Firstly, timely coordination with the USBR during significant discharge events will allow ample time to effectively and safely schedule personnel to monitor debris levels and maintain continuous sampling. Secondly, with limited trap efficiency trials conducted during high water years, more trap efficiency trials should be conducted at various flow levels to better understand trap efficiency during different water year types. 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: A view of the American River at Watt Ave under different flow conditions.

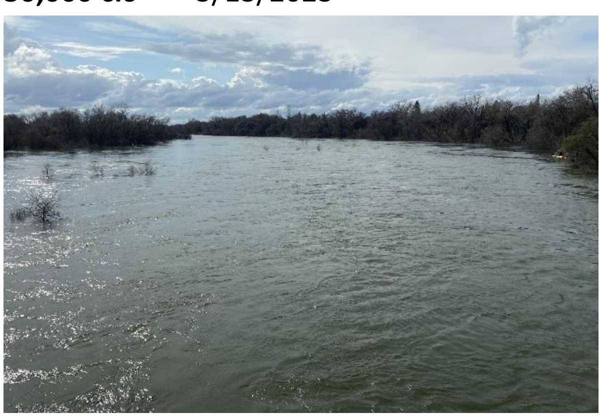
500 cfs 3/20/2014

1,500 cfs 4/24/2014

7,000 cfs 2/23/2016

15,000 cfs 5/31/2023

30,000 cfs 3/13/2023



60,000 cfs 1/11/2017

Appendix 2: Weekly environmental conditions on the lower American River during the 2023 sampling season.

Julian Week	Water Temperature (C°) Avg (range)	Discharge (cfs) Avg (range)	DO (mg/L) Avg (range)	Turbidity (NTU) Avg (range)	Velocity (m/s) Avg (range)
1/22 - 1/28	8.4 (7.9 - 9.0)	7,960 (4,540 - 11,400)	9.88 (9.85 - 9.91)	8.41 (6.82 - 10.30)	1.3 (1.0 - 1.4)
1/29 - 2/4	7.8 (6.9 - 8.6)	4,216 (3,620 - 4,940)	11.40 (9.60 - 12.53)	4.76 (3.66 - 5.86)	1.2 (1.0 - 1.5)
2/5 - 2/11	8.0 (7.2 - 9.2)	4,134 (3,780 - 5,040)	11.74 (11.55 - 12.01)	2.54 (1.84 - 3.82)	1.1 (0.7 - 1.6)
2/12 - 2/18	7.9 (6.7 - 9.2)	4,105 (2,970 - 4,270)	11.71 (11.21 - 12.41)	2.32 (0.83 - 3.84)	1.3 (1.1 - 1.5)
2/19 - 2/25	8.0 (7.0 - 9.6)	4,163 (3,190 - 4,460)	13.23 (12.97 - 13.50)	2.16 (1.88 - 2.59)	1.3 (1.1 - 1.5)
2/26 - 3/4	7.8 (6.8 - 9.4)	4,214 (3,850 - 4,480)	12.57 (12.44 - 12.70)	1.92 (0.89 - 3.45)	1.3 (1.0 - 1.5)
3/5 - 3/11	7.8 (6.9 - 9.0)	11,598 (3,870 - 32,900)	12.07 (11.40 - 12.85)	1.75 (1.47 - 2.34)	1.3 (0.8 - 1.6)
3/12 - 3/18	8.5 (7.8 - 9.6)	25,083 (14,800 - 32,200)	-	-	-
3/19 - 3/25	8.8 (8.3 - 9.5)	12,402 (7,440 - 17,600)	11.92 (11.64 - 12.17)	8.05 (7.33 - 8.87)	0.7 (0.4 - 1.0)
3/26 - 4/1	9.4 (8.5 - 10.7)	7,499 (6,330 - 8,760)	11.77 (11.57 - 11.95)	6.69 (4.81 - 9.91)	0.9 (0.6 - 1.3)
4/2 - 4/8	9.6 (8.4 - 10.8)	7,129 (5,770 - 7,470)	11.72 (10.92 - 12.87)	4.08 (3.43 - 4.62)	1.1 (0.7 - 1.4)
4/9 - 4/15	10.6 (9.3 - 12.8)	7,121 (6,430 - 8,410)	11.36 (10.65 - 12.40)	2.99 (2.37 - 4.11)	1.2 (1.0 - 1.5)
4/16 - 4/22	10.8 (9.9 - 12.4)	7,159 (6,860 - 7,370)	10.85 (10.45 - 11.35)	1.74 (0.84 - 2.48)	1.1 (0.9 - 1.4)
4/23 - 4/29	11.4 (10.2 - 12.8)	7,398 (6,750 - 8,240)	10.57 (10.03 - 11.10)	1.47 (0.72 - 3.00)	1.1 (0.9 - 1.4)
4/30 - 5/6	10.9 (10.3 - 12.4)	8,185 (7,870 - 8,450)	10.37 (8.99 - 10.77)	0.98 (0.61 - 1.78)	1.1 (0.8 - 1.2)
5/7 - 5/13	11.8 (10.6 - 13.3)	8,335 (8,100 - 8,650)	10.44 (10.17 - 10.85)	1.03 (0.46 - 1.59)	1.2 (0.8 - 1.4)
5/14 - 5/20	12.9 (11.3 - 14.4)	11,740 (8,270 - 13,600)	10.48 (9.98 - 10.90)	1.51 (0.90 - 1.74)	1.3 (0.9 - 1.5)
5/21 - 5/27	13.3 (12.2 - 14.6)	15,262 (12,700 - 17,100)	-	-	-
5/28 - 6/3	13.7 (12.8 - 14.6)	13,950 (8,900 - 16,400)	-	-	-
6/4 - 6/10	13.5 (12.6 - 14.5)	9,299 (7,970 - 9,900)	11.67 (11.60 - 11.72)	1.72 (1.49 - 2.22)	1.0 (0.7 - 1.4)
6/11 - 6/17	13.9 (12.9 - 15.7)	7,085 (5,410 - 8,340)	11.09 (9.80 - 11.99)	1.62 (1.06 - 1.98)	1.1 (0.8 - 1.5)
6/18 - 6/24	14.6 (12.4 - 17.3)	4,714 (3,870 - 5,430)	10.56 (10.29 - 11.23)	1.79 (0.97 - 2.45)	1.0 (0.8 - 1.3)
6/25 - 7/1	15.6 (13.5 - 18.0)	3,966 (3,840 - 4,730)	10.44 (10.18 - 11.05)	1.64 (1.10 - 2.01)	1.0 (0.9 - 1.3)

Appendix 3: **List of natural origin fish species caught during the 2023 sampling season on the lower American River.**

Common Name	Family Name	Species Name	Total
Chinook Salmon	Salmonidae	*Oncorhynchus tshawytscha*	70,365
Rainbow Trout / steelhead	Salmonidae	*Oncorhynchus mykiss*	260
American Shad	Clupeidae	*Alosa sapidissima*	4
Bluegill	Centrarchidae	*Lepomis macrochirus*	91
Channel Catfish	Ictaluridae	*Ictalurus punctatus*	4
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*	9
Green Sunfish	Centrarchidae	*Lepomis cyanellus*	6
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	386
Largemouth Bass	Centrarchidae	*Micropterus salmoides*	59
Pacific Lamprey	Petromyzontidae	*Lampetra tridentata*	40
Prickly Sculpin	Cottidae	*Cottus asper*	27
Redear Sunfish	Centrarchidae	*Lepomis microlophus*	43
Riffle Sculpin	Cottidae	*Cottus gulosus*	117
River Lamprey	Petromyzontidae	*Lampetra ayresii*	8
Sacramento Pikeminnow	Cyprinidae	*Ptychocheilus grandis*	413
Sacramento Sucker	Catostomidae	*Catostomus occidentalis*	50
Spotted Bass	Centrarchidae	*Micropterus punctulatus*	31
Threadfin Shad	Clupeidae	*Dorosoma petenense*	694
Threespine Stickleback	Gasterosteidae	*Gasterosteus aculeatus*	27
Tule Perch	Embiotocidae	*Hysterocarpus traskii*	15
Unknown bass	Centrarchidae	*Micropterus sp.*	1
Unknown catfish or bullhead	Ictaluridae		2
Unknown lamprey	Petromyzontidae	*Entosphenus or Lampetra*	1,645
Unknown minnow	Cyprinidae		1
Unknown sculpin	Cottidae	*Cottus spp.*	1
Unknown sunfish	Centrarchidae	*Lepomis spp.*	4
Wakasagi	Osmeridae	*Hypomesus nipponensis*	20,074
Warmouth	Centrarchidae	*Lepomis gulosus*	3
Western Mosquitofish	Poeciliidae	*Gambusia affinis*	20
White Catfish	Ictaluridae	*Ameiurus catus*	1

Appendix 4: Average Fulton's condition factor (Avg) and minimum and maximum condition factor (Range) by life stage for natural origin fall-run Chinook Salmon from 2013 through 2023.

Year	Water Year Type	Button-up fry	Parr	Silvery Parr	Smolt
		Avg (Range)	Avg (Range)	Avg (Range)	Avg (Range)
2013	Dry	0.88 (0.31 - 2.47)	0.99 (0.46 - 2.62)	1.05 (0.65 - 2.79)	1.13 (1.13)
2014	Critical	0.83 (0.47 - 1.41)	1.01 (0.51 - 2.18)	1.06 (0.41 - 1.53)	1.08 (0.45 - 1.55)
2015	Critical	0.87 (0.47 - 2.03)	0.99 (0.51 - 3.40)	1.02 (0.66 - 1.62)	1.07 (0.88 - 2.04)
2016	Below Normal	0.87 (0.36 - 1.31)	0.98 (0.56 - 1.54)	1.06 (0.89 - 1.23)	1.04 (1.04)
2017	Wet	0.85 (0.58 - 1.88)	1.00 (0.56 - 1.61)	1.05 (0.42 - 1.76)	1.08 (0.85 - 1.65)
2018	Below Normal	0.91 (0.47 - 2.76)	0.99 (0.40 - 2.41)	1.04 (0.73 - 1.85)	1.10 (0.93 - 1.33)
2019	Wet	0.92 (0.58 - 1.62)	1.00 (0.21 - 1.59)	1.06 (0.86 - 1.65)	0.99 (0.99)
2020	Dry	0.90 (0.23 - 1.65)	0.95 (0.23 - 3.54)	1.03 (0.32 – 2.00)	0.95 (0.41 - 1.44)
2021	Critical	0.97 (0.47 - 2.03)	1.04 (0.44 - 2.36)	1.06 (0.67 - 1.68)	1.06 (0.89 - 1.47)
2022	Critical	0.84 (0.44 - 1.41)	1.01 (0.64 - 1.46)	1.05 (0.73 - 1.52)	1.08 (0.93 - 1.34)
2023	Wet	0.84 (0.44 - 1.31)	1.03 (0.64 - 1.85)	1.11 (0.77 - 1.52)	1.13 (1.11 - 1.16)

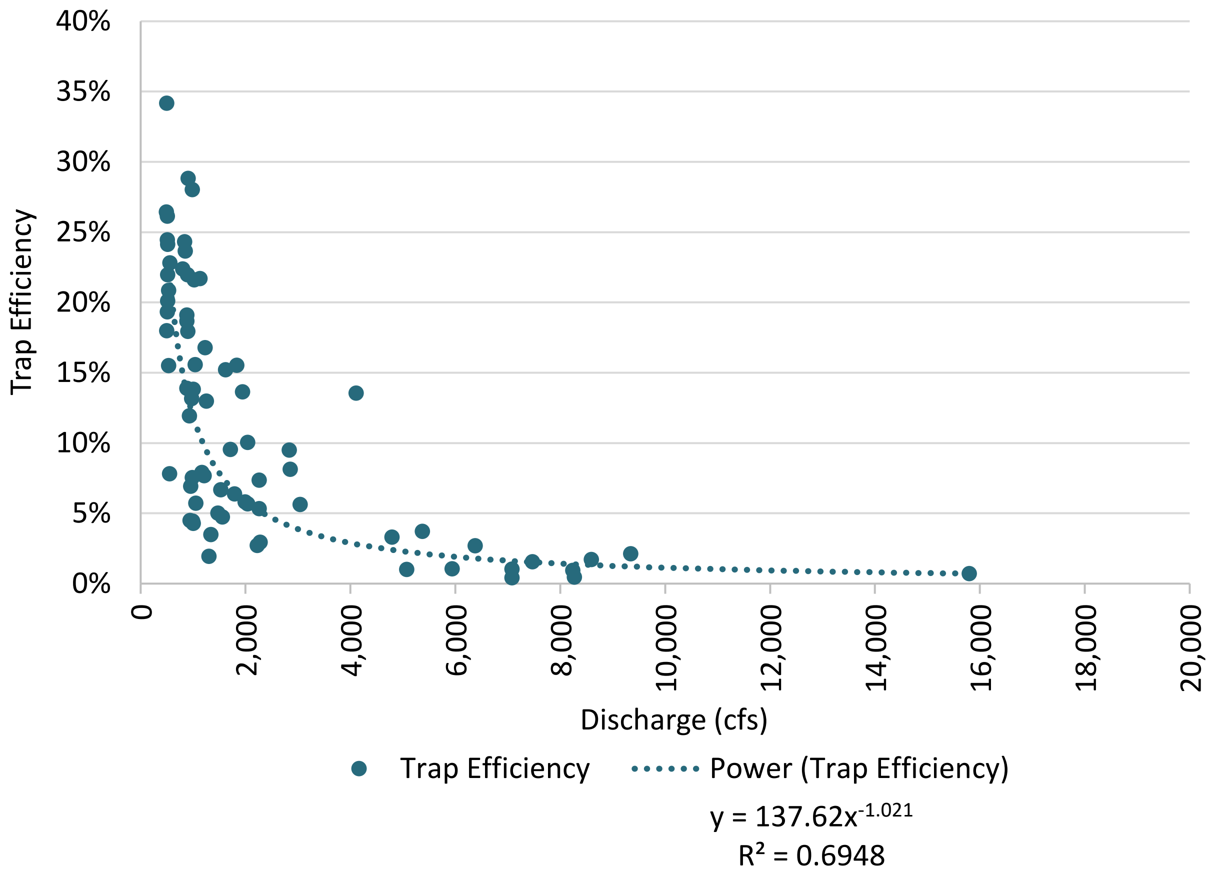
Appendix 5: **Genetic results for fin clip samples from Chinook Salmon caught in the lower American River during the 2023 sampling season.**

Date	Sample #	Adipose Fin Status	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)
1/26/2023	4049-001	Non-clipped	Winter	Winter	1.00	Winter	81	5.8
1/27/2023	4049-002	Non-clipped	Spring	Fall	1.00	Fall	49	1.1
1/28/2023	4049-003	Non-clipped	Winter	Winter	1.00	Winter	100	11.6
1/28/2023	4049-004	Non-clipped	Spring	Fall	1.00	Fall	64	2.4
1/28/2023	4049-005	Non-clipped	Spring	Spring	0.97	Spring	50	1.6
1/29/2023	4049-006	Non-clipped	Winter	Winter	1.00	Winter	100	11.0
1/29/2023	4049-007	Non-clipped	Fall	Spring	0.67	Spring	34	-
1/30/2023	4049-008	Non-clipped	Winter	Winter	1.00	Winter	87	6.8
1/30/2023	4049-009	Non-clipped	Spring	Fall	1.00	Fall	52	1.2
1/30/2023	4049-010	Non-clipped	Winter	Winter	1.00	Winter	84	6.6
1/30/2023	4049-011	Non-clipped	Winter	Winter	1.00	Winter	89	7.5
1/30/2023	4049-012	Non-clipped	Spring	Spring	0.79	Spring	55	1.1
1/30/2023	4049-013	Non-clipped	Spring	Spring	0.99	Spring	56	-
1/30/2023	4049-014	Non-clipped	Spring	Fall	1.00	Fall	56	1.4
1/31/2023	4049-016	Non-clipped	Winter	Fall	1.00	Fall	67	3.2
1/31/2023	4049-015	Non-clipped	Winter	Winter	1.00	Winter	83	-
1/31/2023	4049-017	Non-clipped	Winter	Fall	0.99	Fall	68	3.1
1/31/2023	4049-018	Non-clipped	Spring	Fall	0.97	Fall	50	1.2
2/1/2023	4049-019	Non-clipped	Winter	Winter	1.00	Winter	93	9.3
2/1/2023	4049-020	Non-clipped	Winter	Winter	1.00	Winter	93	9.0
2/1/2023	4049-021	Non-clipped	Winter	Winter	1.00	Winter	96	9.6
2/1/2023	4049-022	Non-clipped	Spring	Fall	0.99	Fall	59	2.1
2/2/2023	4049-023	Non-clipped	Winter	Winter	1.00	Winter	85	6.3
2/3/2023	4049-024	Non-clipped	Spring	Fall	0.99	Fall	51	1.2
2/3/2023	4049-030	Non-clipped	Winter	Winter	0.99	Winter	80	-
2/3/2023	4049-025	Non-clipped	Winter	Winter	1.00	Winter	79	5.3

2/7/2023	4049-026	Non-clipped	Fall	Fall	1.00	Fall	36	-
2/7/2023	4049-027	Non-clipped	Fall	Fall	1.00	Fall	33	-
2/7/2023	4049-028	Non-clipped	Fall	Fall	1.00	Fall	36	-
2/12/2023	4049-029	Non-clipped	Spring	Fall	1.00	Fall	54	1.3
2/14/2023	4049-031	Non-clipped	Fall	Fall	1.00	Fall	53	1.2
2/15/2023	4049-032	Non-clipped	Spring	Fall	1.00	Fall	56	1.5
2/19/2023	4049-033	Non-clipped	Fall	Fall	1.00	Fall	37	-
2/19/2023	4049-034	Non-clipped	Fall	Fall	1.00	Fall	37	-
2/19/2023	4049-035	Non-clipped	Fall	Fall	1.00	Fall	36	-
2/21/2023	4049-036	Non-clipped	Spring	Fall	1.00	Fall	58	1.3
3/27/2023	4049-037	Non-clipped	Spring	Fall	1.00	Fall	73	3.8
3/28/2023	4049-038	Non-clipped	Spring	Fall	0.99	Fall	74	4.3
3/29/2023	4049-039	Non-clipped	Spring	Fall	1.00	Fall	86	6.8
3/29/2023	4049-040	Non-clipped	Spring	Fall	1.00	Fall	80	5.5
3/29/2023	4049-041	Non-clipped	Spring	Fall	1.00	Fall	79	6.0
3/29/2023	4049-042	Non-clipped	Spring	Fall	0.98	Fall	72	5.7
3/29/2023	4049-043	Non-clipped	Spring	Fall	0.96	Fall	72	4.3
3/29/2023	4049-044	Non-clipped	Spring	Fall	1.00	Fall	73	4.4
3/30/2023	4049-047	Adipose Clipped	Spring	Fall	1.00	Spring	84	5.7
3/30/2023	4049-045	Non-clipped	Spring	Fall	1.00	Fall	72	3.3
3/30/2023	4049-046	Adipose Clipped	Spring	Fall	1.00	Spring	73	3.8
3/31/2023	4049-048	Adipose Clipped	Spring	Fall	0.81	Spring	75	4.4
4/1/2023	4049-049	Adipose Clipped	Spring	Fall	1.00	Spring	78	4.9
4/1/2023	4049-050	Adipose Clipped	Spring	Fall	1.00	Spring	84	5.8
4/1/2023	4049-051	Adipose Clipped	Spring	Fall	1.00	Spring	86	7.3
4/2/2023	4049-052	Adipose Clipped	Spring	Fall	0.84	Spring	75	-
4/3/2023	4049-053	Adipose Clipped	Spring	Fall	0.78	Spring	74	4.4
4/3/2023	4049-055	Non-clipped	Fall	Fall	1.00	Fall	35	-
4/3/2023	4049-056	Non-clipped	Late fall	Fall	1.00	Fall	32	-
4/3/2023	4049-057	Non-clipped	Late fall	Fall	0.99	Fall	33	-
4/6/2023	4049-054	Adipose Clipped	Spring	Fall	0.99	Spring	68	-

4/10/2023	4049-058	Non-clipped	Spring	Fall	0.99	Fall	85	6.3
4/17/2023	4049-060	Adipose Clipped	Spring	Fall	0.96	Spring	87	7.0
4/17/2023	4049-061	Non-clipped	Spring	Fall	0.98	Fall	82	5.6
4/18/2023	4049-062	Adipose Clipped	Spring	Fall	1.00	Spring	71	3.3
4/19/2023	4049-063	Adipose Clipped	Spring	Fall	1.00	Spring	97	10.7
4/23/2023	4049-064	Non-clipped	Fall	Fall	1.00	Fall	50	-
5/6/2023	4049-065	Non-clipped	Fall	Fall	1.00	Fall	48	1.0
5/6/2023	4049-066	Non-clipped	Fall	Fall	0.98	Fall	61	1.9
5/6/2023	4049-067	Non-clipped	Fall	Fall	1.00	Fall	55	1.7
5/15/2023	4049-068	Non-clipped	Fall	Fall	1.00	Fall	69	3.4
5/15/2023	4049-069	Non-clipped	Fall	Fall	1.00	Fall	65	2.8
5/15/2023	4049-070	Non-clipped	Fall	Fall	1.00	Fall	50	1.5
6/6/2023	4049-071	Non-clipped	Fall	Fall	0.89	Fall	84	-
6/6/2023	4049-073	Non-clipped	Fall	Fall	0.99	Fall	70	-
6/12/2023	4049-074	Non-clipped	Fall	Fall	1.00	Fall	83	7.1
6/12/2023	4049-075	Non-clipped	Fall	Fall	1.00	Fall	65	3.5
6/12/2023	4049-076	Non-clipped	Fall	Fall	0.98	Fall	83	7.2
6/20/2023	4049-077	Non-clipped	Fall	Fall	1.00	Fall	71	3.9
6/20/2023	4049-078	Non-clipped	Fall	Fall	1.00	Fall	82	6.6
6/20/2023	4049-079	Non-clipped	Fall	Fall	1.00	Fall	63	2.8
6/27/2023	4049-080	Non-clipped	Fall	Fall	1.00	Fall	88	6.4

Appendix 6: **Trap efficiency from 2013 through 2023 as a function of discharge (cfs) at the time of release measured at Fair Oaks.**



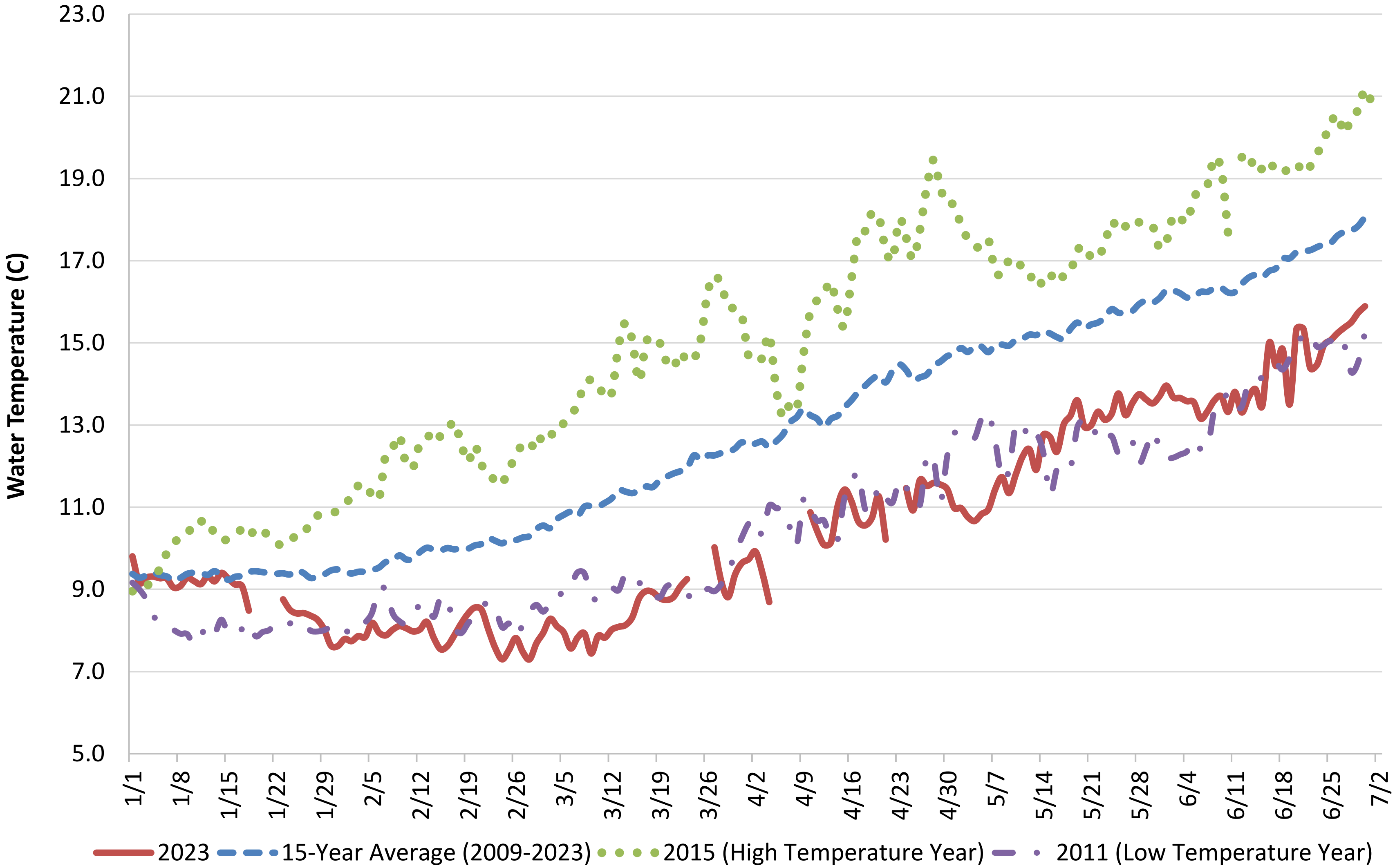
Discharge (cfs)	*n*	Trap Efficiency Avg (range)
< 600	13	21.7% (7.8% - 34.2%)
600 - 999	16	16.7% (4.4% -28.8%)
1,000 - 1,999	21	10.3% (1.9% - 21.7%)
2,000 - 4,999	11	6.7% (2.7% - 13.5%)
>= 5000	12	1.4% (0.4% - 3.7%)

Appendix 7: Monthly average fork length or total length in mm (Avg), minimum and maximum fork lengths or total lengths (Range), and sample size (*n*) for each non-salmonid species captured during the 2023 lower American River RST sampling season.

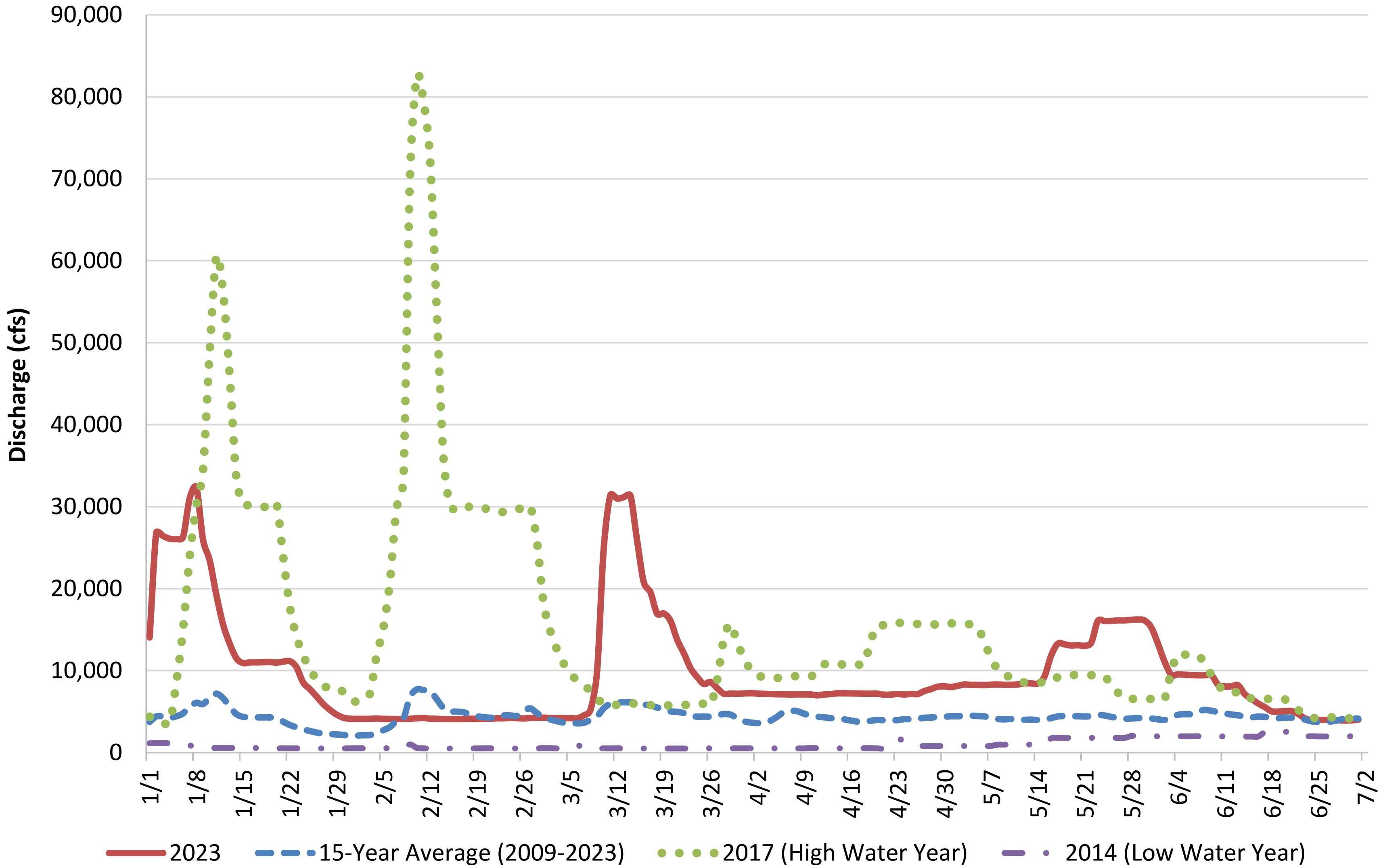
Common Name	January Avg (Range, *n*)	February Avg (Range, *n*)	March Avg (Range, *n*)	April Avg (Range, *n*)	May Avg (Range, *n*)	June Avg (Range, *n*)
American Shad	-	-	-	-	-	319 (290 - 331, *n* = 4)
Bluegill	74 (21 - 200, *n* = 61)	78 (29 - 141, *n* = 12)	44 (30 - 69, *n* = 4)	48 (27 - 122, *n* = 7)	48 (33 - 68, *n* = 3)	59 (30 - 100, *n* = 4)
Channel Catfish	NA (NA, *n* = 1)	-	-	-	62 (59 - 65, *n* = 2)	60 (60, *n* = 1)
Golden Shiner	86 (74 - 109, *n* = 4)	82 (53 - 112, *n* = 4)	-	84 (84, *n* = 1)	-	-
Green Sunfish	72 (72, *n* = 1)	43 (40 - 46, *n* = 2)	89 (89, *n* = 1)	-	-	82 (74 - 90, *n* = 2)
Hardhead	86 (33 - 193, *n* = 69)	68 (32 - 130, *n* = 44)	59 (52 - 68, *n* = 11)	58 (37 - 139, *n* = 70)	54 (38 - 89, *n* = 46)	57 (39 - 176, *n* = 146)
Largemouth Bass	68 (28 - 149, *n* = 44)	73 (47 - 94, *n* = 14)	-	41 (41, *n* = 1)	-	-
Pacific Lamprey	115 (105 - 131, *n* = 8)	123 (113 - 132, *n* = 14)	225 (116 - 439, *n* = 3)	394 (113 - 455, *n* = 12)	138 (113 - 183, *n* = 3)	-
Prickly Sculpin	88 (71 - 102, *n* = 4)	94 (73 - 139, *n* = 8)	-	75 (61 - 104, *n* = 9)	86 (73 - 101, *n* = 3)	94 (83 - 102, *n* = 3)
Redear Sunfish	107 (52 - 185, *n* = 25)	126 (69 - 169, *n* = 17)	52 (52, *n* = 1)	-	-	-
Riffle Sculpin	89 (74 - 123, *n* = 25)	84 (62 - 105, *n* = 26)	79 (63 - 96, *n* = 17)	72 (53 - 118, *n* = 46)	58 (53 - 63, *n* = 2)	85 (85, *n* = 1)
River Lamprey	-	-	199 (193 - 204, *n* = 2)	184 (147 - 197, *n* = 4)	160 (160, *n* = 1)	177 (177, *n* = 1)
Sacramento Pikeminnow	92 (40 - 176, *n* = 140)	76 (38 - 152, *n* = 74)	67 (36 - 178, *n* = 53)	58 (31 - 166, *n* = 80)	62 (35 - 155, *n* = 44)	58 (28 - 126, *n* = 22)

Sacramento Sucker	105 (32 - 205, *n* = 31)	96 (56 - 128, *n* = 9)	88 (77 - 98, *n* = 2)	75 (75, *n* = 1)	-	24 (20 - 32, *n* = 7)
Spotted Bass	82 (56 - 165, *n* = 17)	85 (58 - 188, *n* = 10)	-	46 (41 - 51, *n* = 2)	79 (79, *n* = 1)	34 (34, *n* = 1)
Threadfin Shad	53 (31 - 84, *n* = 363)	58 (31 - 99, *n* = 319)	57 (46 - 89, *n* = 11)	77 (77, *n* = 1)	-	-
Threespine Stickleback	26 (21 - 32, *n* = 3)	44 (31 - 53, *n* = 10)	32 (32, *n* = 1)	47 (42 - 52, *n* = 3)	45 (43 - 47, *n* = 4)	43 (23 - 57, *n* = 6)
Tule Perch	102 (63 - 136, *n* = 5)	116 (66 - 147, *n* = 5)	-	-	-	107 (91 - 118, *n* = 5)
Unknown bass	53 (53, *n* = 1)	-	-	-	-	-
Unknown catfish	-	NA (NA, n = 1)	55 (55, *n* = 1)	-	-	-
Unknown lamprey	117 (67 - 157, *n* = 829)	114 (56 - 142, *n* = 350)	114 (64 - 168, *n* = 128)	113 (59 - 145, *n* = 188)	112 (84 - 133, *n* = 34)	112 (63 - 136, *n* = 116)
Unknown minnow	-	-	-	-	-	28 (28, *n* = 1)
Unknown sculpin	-	-	15 (15, *n* = 1)	-	-	-
Unknown sunfish	26 (25 - 27, *n* = 3)	NA (NA, *n* = 1)	-	-	-	-
Wakasagi	57 (31 - 99, *n* = 3,071)	50 (34 - 104, *n* = 15,927)	51 (36 - 97, *n* = 480)	51 (36 - 72, *n* = 566)	50 (45 - 61, *n* = 20)	69 (55 - 76, *n* = 10)
Warmouth	65 (65, *n* = 1)	65 (63 - 67, *n* = 2)	-	-	-	-
Western Mosquitofish	28 (24 - 35, *n* = 11)	31 (24 - 42, *n* = 5)	29 (29, *n* = 2)	37 (33 - 41, *n* = 2)	-	-
White Catfish	112 (112, *n* = 1)	-	-	-	-	-

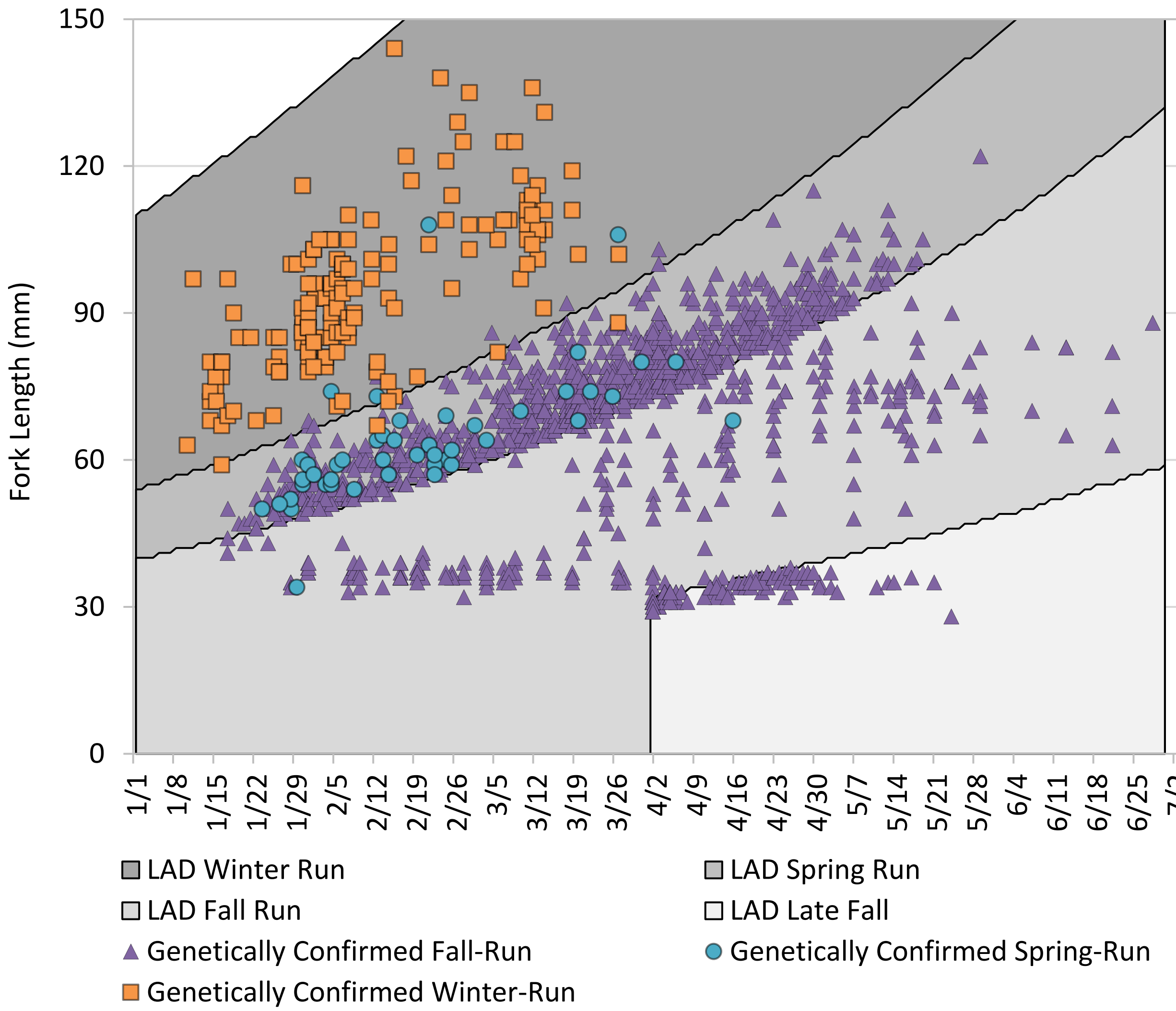
Appendix 8: **Daily average water temperatures (C) in the lower American River at Watt Avenue for the 15 year period 2009 - 2023, the highest temperature year (green round dots), lowest temperature year (purple dash dots), the 15 year average (blue dashes) and the current year (2023, red line). Data from USGS station number 11446980.**



Appendix 9: **Daily average discharge (cfs) on the lower America River at Fair Oaks for the 15-year period 2009 – 2023, the highest water year (green round dots), the lowest water year (purple dash dots), 15 year average (blue dashes) and the current year (2023, red line). Data from USGS station number 11446500.**

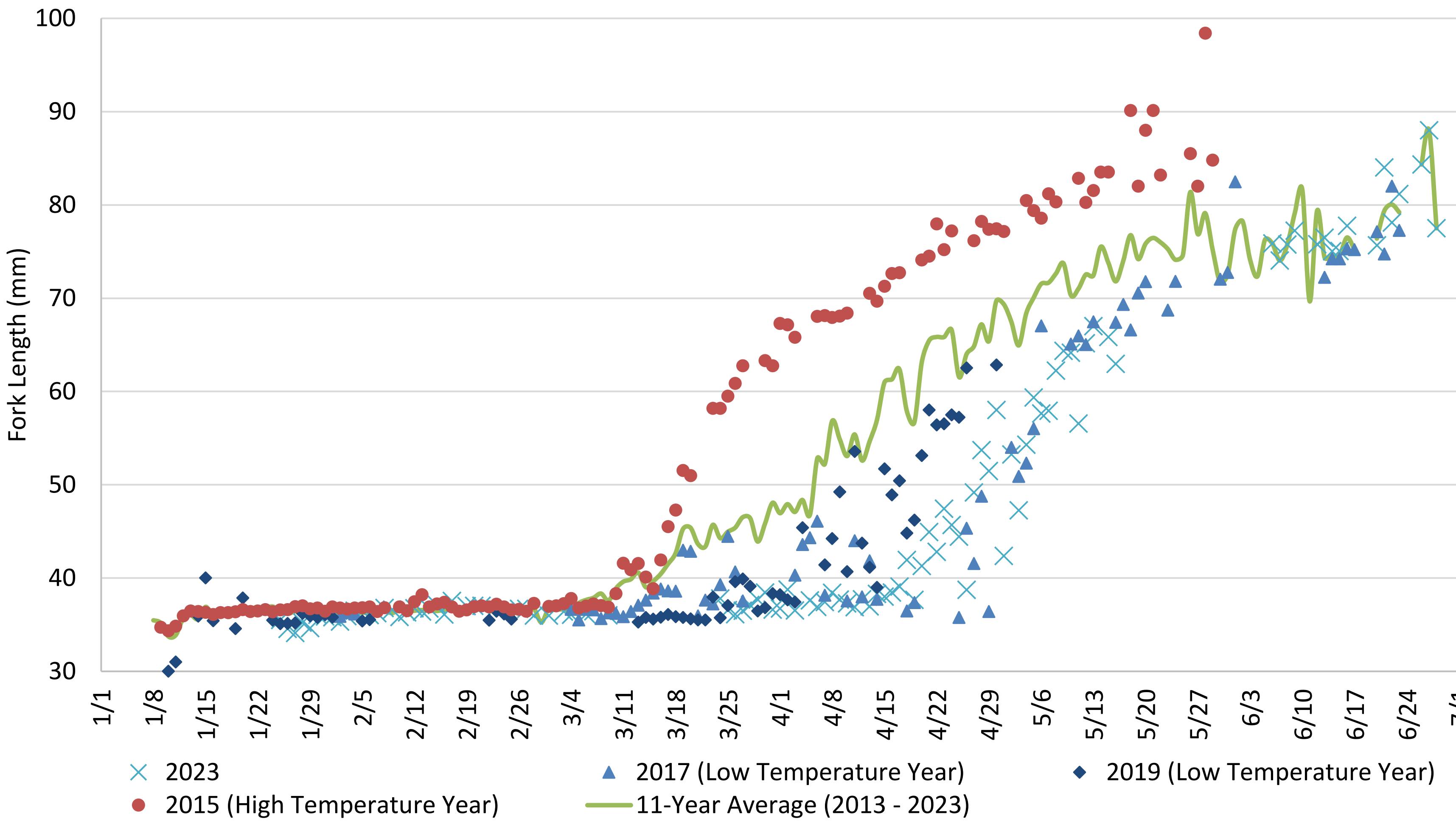


Appendix 10: **Daily fork length distribution of SNP genetically sampled natural origin Chinook Salmon from 2015 through 2023.**



Length-at-Date Run Assignment	SNP Confirmed Fall Run	SNP Confirmed Late Fall Run	SNP Confirmed Spring Run	SNP Confirmed Winter Run
Fall	253	0	2	0
Late Fall	98	0	0	0
Spring	908	0	40	6
Winter	8	0	4	150

Appendix 11: **Daily average fork length (mm) from 2013 – 2023, a high-water temperature year in 2015 (red round dots), a low water temperature year in 2017 (blue triangles), a low water temperature year in 2019 (blue diamonds), the 11 year average (green squares) and the current year (2023, blue X's).**



Appendix 12: **Median discharge (cfs) between January 1 and June 30, total catch of fall-run Chinook Salmon, spring-run Chinook Salmon, winter-run Chinook Salmon, steelhead, and lamprey from 2013 through 2023.**

Year	Discharge (cfs)	Fall-run	Winter-run	Spring-run	steelhead	Lamprey
2013	1,897	262,589	39	14	2,206	1,917
2014	560	379,542	13	5	592	1,525
2015	881	283,153	28	19	11	953
2016	3,776	80,626	1	2	332	1,217
2017	9,459	9,567	0	1	28	269
2018	2,857	90,104	11	0	162	1,093
2019	7,726	15,056	18	9	337	176
2020	1,828	152,378	203	16	101	1,361
2021	1,172	35,433	3	4	283	2,153
2022	1,922	31,581	1	1	404	2,820
2023	7,620	70,348	13	4	260	1,693