Juvenile Salmonid Emigration Monitoring in the Lower Stanislaus River at Caswell Memorial State Park, California

January – July 2023

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Acronyms and Abbreviations

Acronym	Definition
BBY	Bismarck Brown Y
C	Celsius
CAMP	Comprehensive Assessment and Monitoring Program
CDFW	California Department of Fish and Wildlife
CFS	Cramer Fish Sciences
cfs	cubic feet per second
CI	Confidence Interval
CVPIA	Central Valley Project Improvement Act
DO	dissolved oxygen
ESA	Endangered Species Act
FL	fork length
g	gram
GVL	UC Davis Genomic Variation Laboratory
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
PSMFC	Pacific States Marine Fisheries Commission
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 Stanislaus River at Caswell Memorial State Park in 2023 is part of a collaborative effort by the United States Fish and Wildlife Service's Anadromous Fish Restoration Program and Comprehensive Assessment and Monitoring Program, the 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 *Oncorhynchus mykiss*. Secondary objectives of trapping operations focus on recording 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 at Caswell Memorial State Park on the lower Stanislaus River in California. Sampling occurred on 153 days of the 179-day season (85%) beginning January 22 and concluding on July 19. Sampling started and ended later than normal due to high flows during the wet 2023 water year. Following genetic analysis, it was determined that a total of 2,293 fall-run Chinook Salmon were captured. Additionally, two natural origin *O. mykiss* were captured, which were the first *O. mykiss* captured by the rotary screw traps since the 2020 sampling season. Most of the juvenile salmon captured were identified as button-up fry followed by parr, silvery parr, smolt, and yolk-sac fry life stages. Five trap efficiency trials were performed during the 2023 sampling season and will be used for future estimation of juvenile fall-run Chinook Salmon passage after development of a more robust efficiency model is completed. Passage estimates for *O. mykiss* and non-salmonid fish taxa were not assessed due to minimal catch.

This annual report also includes eleven appendices to describe different environmental variables and studies related to the trap site or rotary screw trap operations during the 2023 sampling season.

Introduction

The Stanislaus River is a tributary to the San Joaquin River, one of two mainstem rivers of California's Central Valley watershed. This watershed once supported large populations of Chinook Salmon *Oncorhynchus tshawytscha* and steelhead *Oncorhynchus mykiss*, the anadromous form of Rainbow Trout. However, the construction of impassable dams throughout the valley, flat-lining of flows, disconnection of floodplains, hydraulic mining, over-harvesting, introducing predatory species, water diversions and other factors have contributed to the widespread decline of salmonid populations (Lindley et al. 2006; NMFS 2019; Yoshiyama et al. 2001). As a result, spring-run Chinook Salmon (spring-run) and California Central Valley steelhead were listed as threatened under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NMFS) which is a part of the National Oceanic and Atmospheric Administration (NOAA) (NMFS 2014). California Central Valley fall-run Chinook Salmon (fall-run) and late fall-run Chinook Salmon (late fall-run) are a species of special concern.

Congress passed the Central Valley Project Improvement Act (CVPIA) in 1992 to mitigate for the loss of anadromous fish habitat that resulted from the construction and operation of the Central Valley Project (CVPIA 1992). The Fish Resource Area of the CVPIA includes all provisions under section 3406(b) to improve natural production of anadromous fish in Central Valley rivers and streams. The 2019 CVPIA annual work plan describes specific projects, programs or monitoring activities to be conducted, including the operation of rotary screw traps (RSTs) to monitor juvenile salmonids on the Stanislaus River (USBR 2019).

There are two sites where RST monitoring efforts occur on the lower Stanislaus River; Oakdale (river kilometer [rkm] 64.5) and Caswell Memorial State Park (rkm 13.8). These sampling efforts, defined by the CVPIA and NMFS Reasonable and Prudent Actions, monitor juvenile salmonids to provide current data to the CVPIA Science Integration Team and have been conducted since 1993 by California Department of Fish and Wildlife (CDFW), United States Fish and Wildlife Service (USFWS), Cramer Fish Sciences (CFS), FishBio Consultants, or the Pacific States Marine Fisheries Commission (PSMFC). PSMFC has been the sole operator at Caswell Memorial State Park since 2017.

The lower Stanislaus River RSTs at Caswell Memorial State Park monitor juvenile salmonid abundance to help determine if habitat restoration activities and flow management practices are resulting in a positive impact for Chinook Salmon and *O. mykiss* production. Furthermore, this report presents data that describes the size and abundance of other native and non-native fish species in relation to the time of year, river discharge, and environmental conditions.

Study Area

The Stanislaus River headwaters begin on the western slope of the Sierra Nevada mountain range and covers an area of about 1,195 square miles (NOAA 2020). The upper Stanislaus River consists of three forks (North, Middle and South) and tributaries which flow southwest into New Melones Reservoir. The lower Stanislaus River is a major tributary to the San Joaquin River in the southern portion of California's Central Valley watershed and flows north joining the Sacramento River in the Sacramento-San Joaquin Delta. The lower Stanislaus River is 96.6 rkms long from the base of Goodwin Dam to the confluence of the San Joaquin River and provides spawning and rearing habitat for Chinook Salmon and Central Valley steelhead. Suitable spawning habitat exists between Goodwin Dam (rkm 94) and Riverbank (rkm 54.7) while downstream areas are predominately sand substrate (KDH 2008).

The lower Stanislaus River is regulated by three dams; New Melones Dam, Tulloch Dam, and Goodwin Dam (Figure 1, Figure 2). These dams are operated by the United States Bureau of Reclamation (USBR) and the Tri-Dam Project to provide flood control, irrigation for agricultural use, power generation, temperature regulation, and for water quality improvement in the lower San Joaquin River (NMFS 2019). Goodwin and Tulloch Dam are equally and jointly owned by the Oakdale Irrigation District and the South San Joaquin Irrigation District. The construction of Melones Dam in 1926 and New Melones Dam in 1966 was believed to have been a factor in the extirpation of the spring-run Chinook Salmon historically supported by the Stanislaus River (Yoshiyama et al. 2001).

The trapping site at Caswell Memorial State Park (rkm 13.8) was determined in 1993 to be the furthest location from the spawning area that allowed for trap deployment, access, and maintained flows consistent enough to operate RSTs (CFS 2006). Two 8-foot RSTs were positioned in the thalweg of the channel near the furthest northeast corner of the state park. The traps were designated as Trap 1 and Trap 2, with Trap 1 set closer to the southwestern bank of the river and Trap 2 set closer to the northeastern bank of the river (Figure 3). Access to the trapping site was gained through a private road.

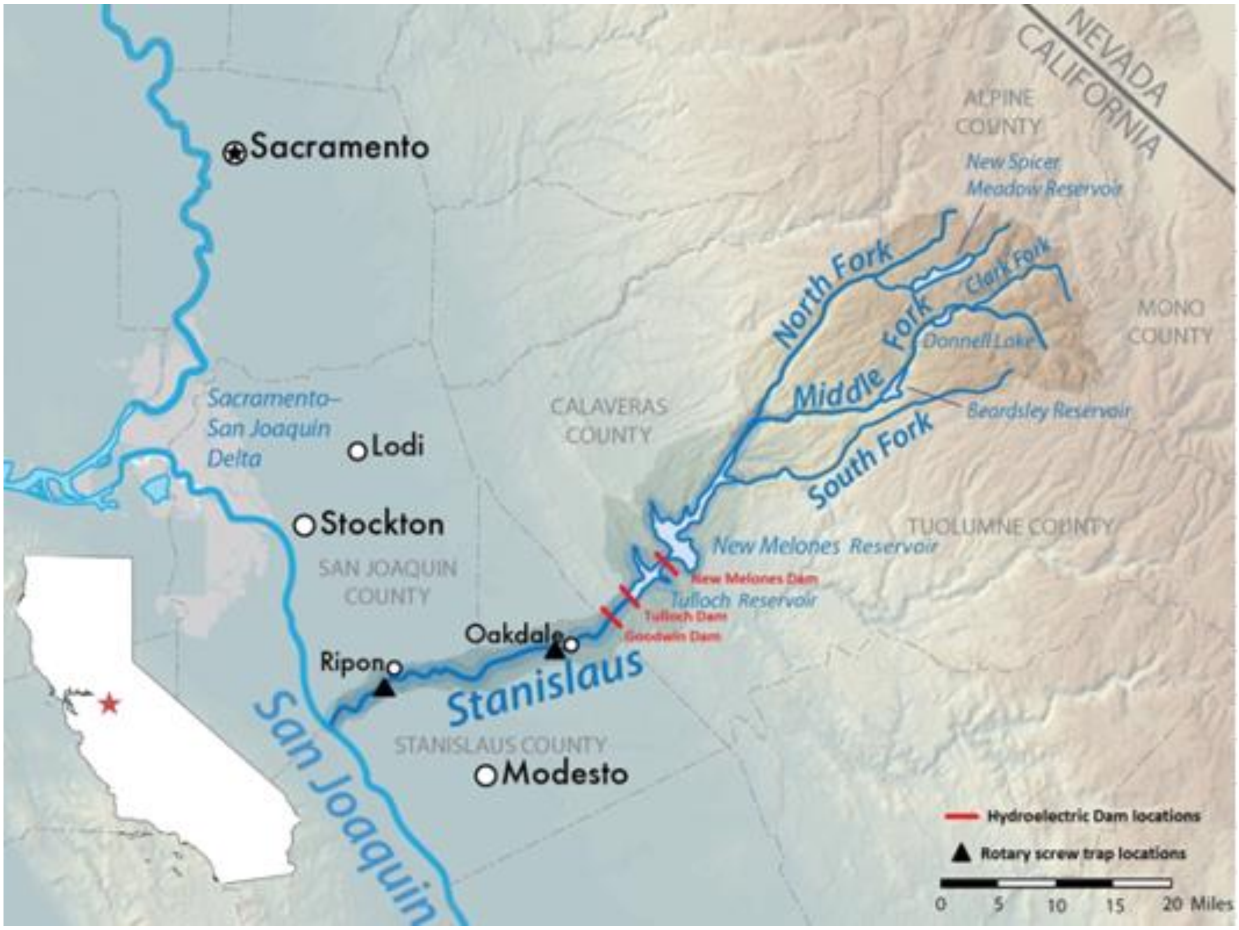

Figure 1: Map of the Stanislaus River and rotary screw trap sites at Caswell Memorial State Park and Oakdale. Inset map illustrates the Stanislaus River in the state of California.

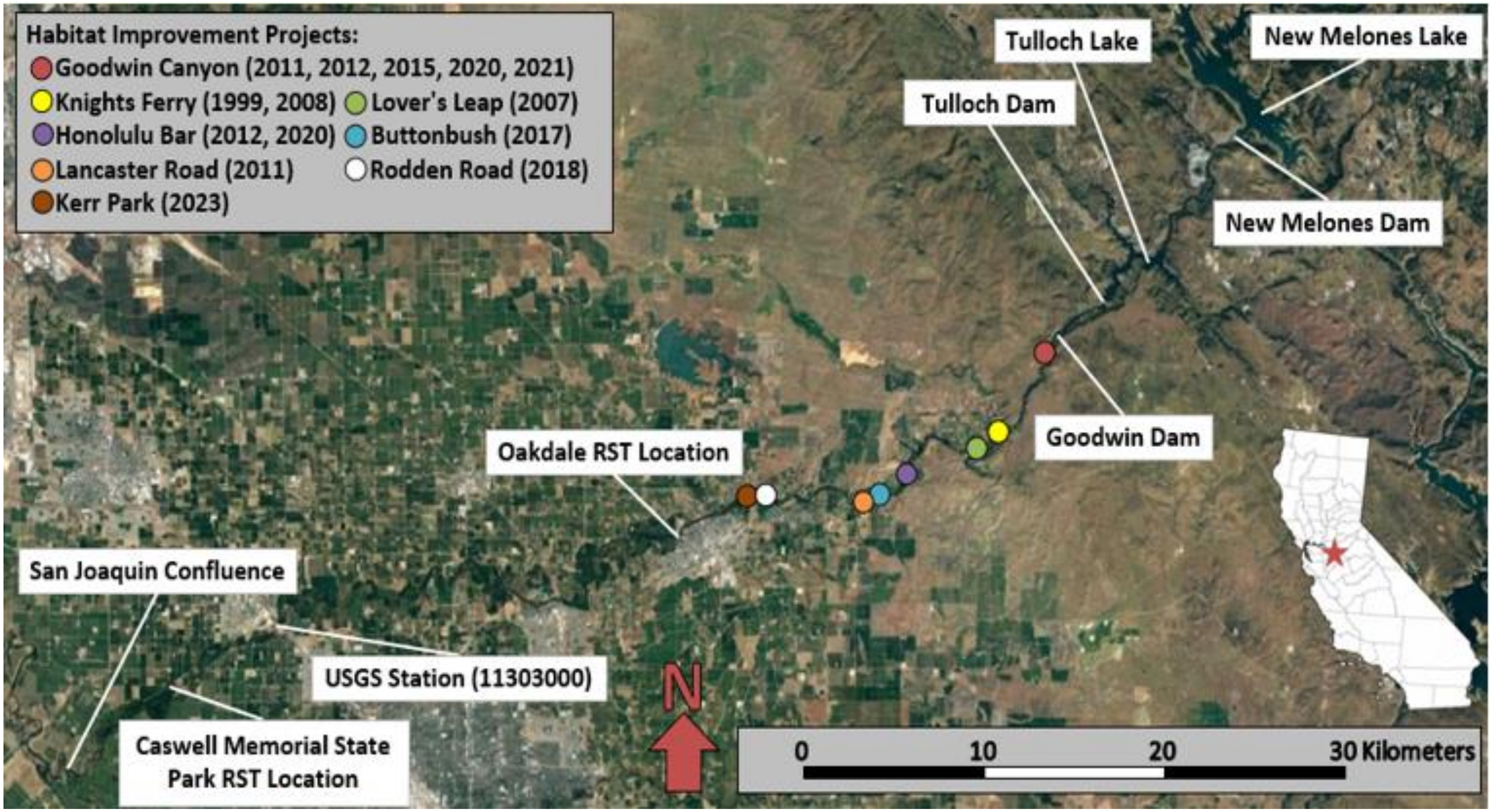

Figure 2: Points of interest on the Stanislaus River.

Methods

Safety Measures

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

For night operations, each crew member was required to attach a strobe light (ACR HemiLight 3) to their personal flotation devices that would turn on automatically if submerged in water.

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 upstream and downstream of the traps. Solar powered amber strobe lights, that automatically turn on in low light conditions, were attached to the outermost railings on 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 late 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 "taken out of service") until the following Sunday evening.

Trap Operations

Two 2.4 m (8 foot) diameter RSTs (EG Solutions) were deployed in a side-by-side configuration and designated as Trap 1 and Trap 2 (Figure 3). The traps were anchored with a 0.95 cm galvanized cable secured to a tree upstream with the cable bridle attached to the outermost pontoon of each trap. An anchor rope was attached to the southwestern bank, allowing for in-channel adjustments and to pull the traps to shore. Once crew members and field sampling gear were on board, the traps were then released back out into the thalweg to continue sampling while the crew collected environmental data and cleared the live wells.

Trap checks were conducted at least once every 24 – 28 hours while traps were actively sampling in the cone-down configuration. During large storms 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.

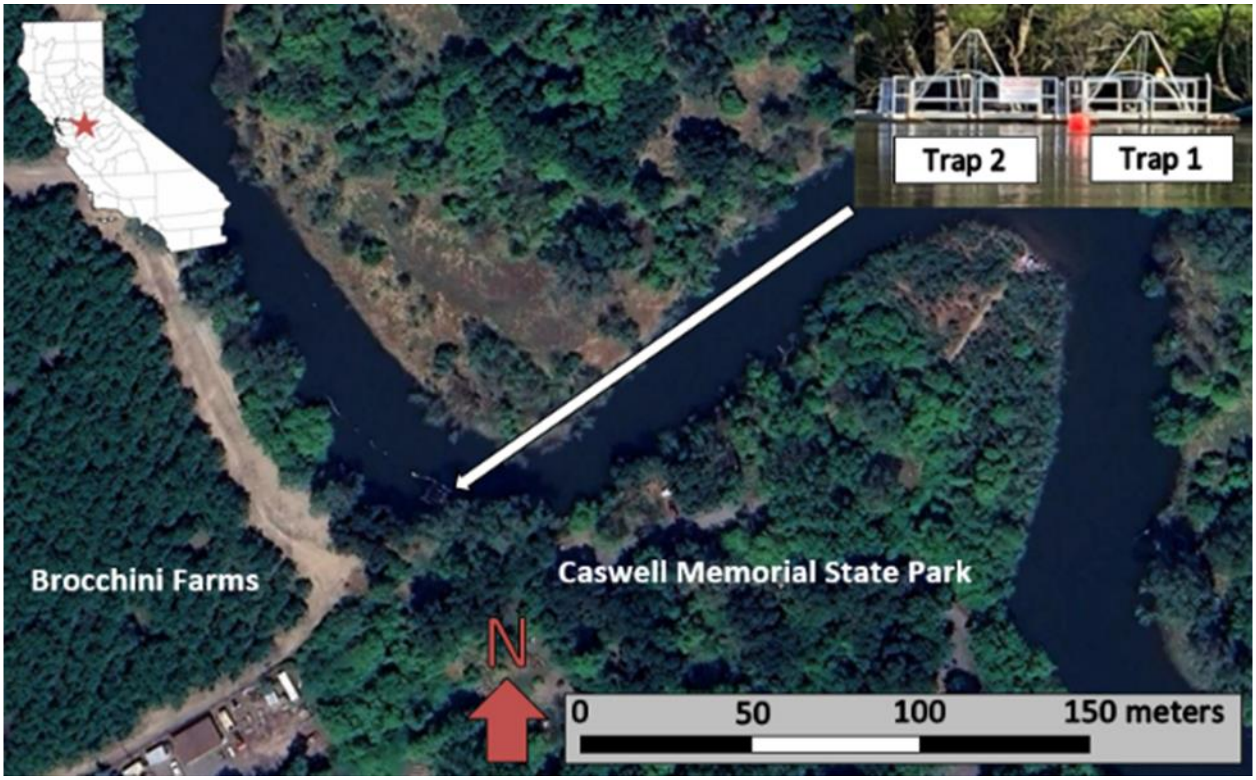

Figure 3: Stanislaus River RST site at Caswell Memorial State Park, captured by Google Earth in May of 2023. Inset image illustrates the side-by-side trap configuration.

On daily trap visits, trap function was assessed as “functioning normally,” “functioning, but not normally,” or “stopped functioning.” If the trap was functioning, the revolutions per minute (RPM) was recorded. Subsequently, intakes were checked and recorded as “clear,” “partially blocked,” “completely blocked,” or “backed up into cone.” If the trap was not functioning upon arrival, the trap was restored to its normal function without raising the cone. After collecting environmental data and clearing the trap, time and total cone rotations were recorded using a mechanical lever actuated counter (Trumeter Company Inc.) attached to the port side pontoon or by an electric hubodometer (Veeder-Root TR 1000-000) mounted to the axel inside of the live well on each trap.

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 Ecosense DO200A 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 units [NTU]) was collected in front of each cone and measured using a portable turbidity meter (Eutech; Model TN-100). When water depth was less than 3 m, a depth rod was used to record water depth to the nearest centimeter on the port and starboard side pontoons in line with the front of the trap cones. Average daily river discharge (cubic feet per second [cfs]) and average daily river temperature (C) were calculated from instantaneous measurements recorded 11.6 rkm upstream of the RSTs from the United States Geological Survey (USGS) Stanislaus River at Ripon monitoring station (USGS station number 11303000, Figure 2).

Catch and Fish Data Collection

Fish Collection

Before clearing the live well of debris and fish, one or two work stations were set up per trap. A work station included an 18-gallon (68.1 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 work station, consisting of an 18-gallon tub, multiple 5-gallon holding buckets, a measuring board, and tongs.

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-run (Greene 1992). Additionally, salmonids were assessed for marks. Ultimately, fish were separated into different buckets for: 1) all spring-run Chinook Salmon, 2) all *O. mykiss*, 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 presumed to be hatchery origin.

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

	Spring Chinook	Fall Chinook	*O. mykiss*	Hatchery Salmonids	Recaptured Chinook	Non-Salmonid Species
Enumerate	All	All	All	All	All	All
Life Stage	50	100	100	50	50	50
Measure	50	100	100	50	50	50
Weigh	25	25	25	0	0	0
Mortality	All	All	All	All	All	All

Fish Processing

Fish were processed on the riverbank adjacent to the traps where there was adequate shade and secluded from the general public. A fish processing station was 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). Species that were identified through the length-at-date criteria as ESA listed (spring-run) and natural origin *O. mykiss* 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 sample size varied by measurement, 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 salmonids greater than or equal to 40 mm. Salmonid life stages were assigned 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 hatchery origin 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 difficult. In those cases, mortalities were considered to be a "mort plus-count". Genetic samples were collected for all LAD spring-run Chinook Salmon. Additionally, genetic samples were collected from a subsample of LAD fall 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 *O. mykiss* adapted from USFWS (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

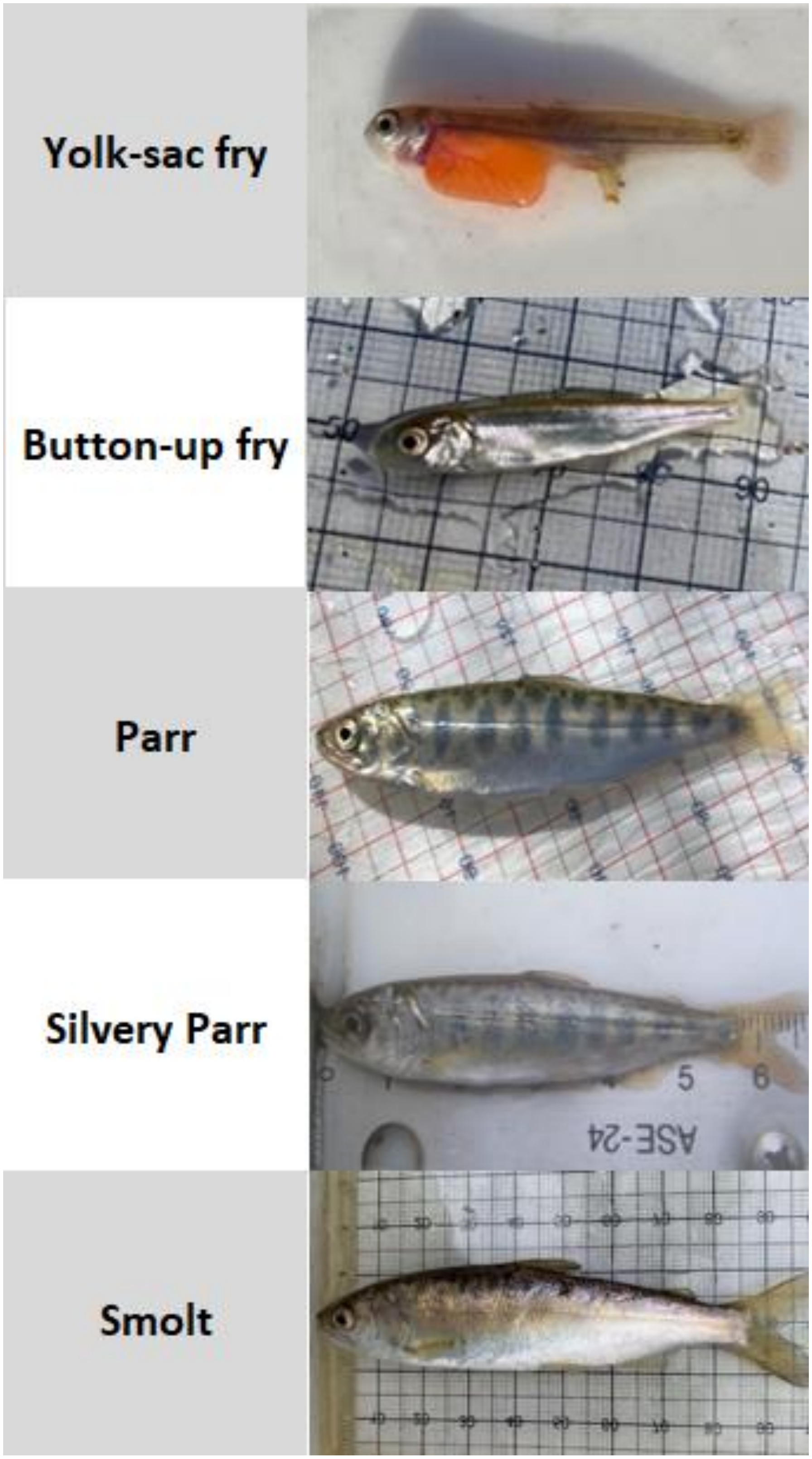

Figure 6: Examples of life stages for Chinook Salmon according to the smolt index rating.

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. Up to 11 fin clips per week were taken from LAD fall-run, late fall-run, and spring-run Chinook Salmon.

Each fin clip sample was split, with half the sample sent to the CDFW Tissue Archive for storage and the other half to the 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 2017 – 2022).

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 Stanislaus River. When possible, efficiency trials were conducted with Chinook Salmon captured in the RSTs. When catches were too low, Chinook Salmon were provided by CDFW.

One method of marking consisted of dyeing the whole body of a Chinook Salmon with Bismarck Brown Y (BBY) stain when the average fork length was less than 60 mm (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 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 the majority of the Chinook Salmon had a fork length greater than 60 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: A Chinook Salmon marked with a pink VIE tag on the snout.

At least 300 Chinook Salmon were used to conduct each trap efficiency trial with BBY stain or VIE tags. When daily catch totals were too low, Chinook Salmon were provided by CDFW's Mokelumne River Hatchery.

The trap efficiency release site was approximately 0.5 rkm upstream of the traps. Marked salmon were released off the bow while rowing an inflatable boat to evenly scatter fish across the width of the river in small groups using dip nets to avoid schooling during release. 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, the majority of released fish were found to migrate past the site within four days. As a result, trial periods were designated as a minimum of four days. During this period, a subsample of 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: $$\text{Hours Fished} \times \text{Revolutions (per hour)} = \text{Estimated Total Revolutions}$$

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

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

Trap 1 and Trap 2 began sampling on January 22 and concluded July 19 with 153 days of sampling effort in the 179-day season (85%; Figure 9). Of the 153 days of sampling effort, Trap 1 sampled successfully for approximately 3,225 hours (91%) and sampled unsuccessfully for approximately 331 hours (9%; Figure 10), while Trap 2 sampled successfully for approximately 2,813 hours (78%) and sampled unsuccessfully for approximately 776 hours (22%; Figure 11). Unsuccessful sampling was a consequence of debris stopping the trap from spinning at the entrance of the cone or intakes to the live well. Sampling of both traps was suspended for a total of 26 days over the course of the season with no outages greater than seven days. This included suspending sampling operations for weekend shutdowns (n = 21 days), heavy winds (2 days), staffing shortages (2 days), and a flow increase (1 day). Additionally, Trap 1 was taken out of service on May 6 due to insufficient river velocities hindering cone rotation.

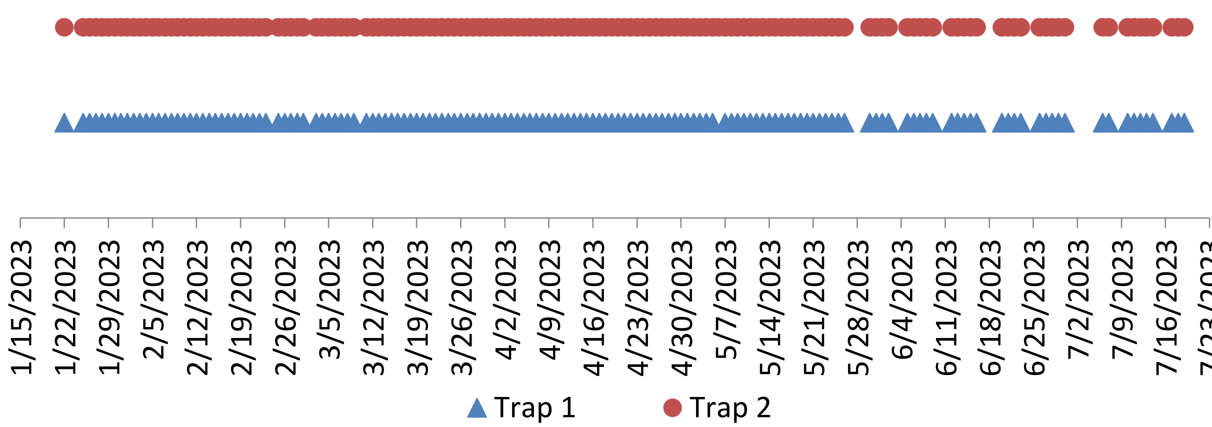

Figure 9: Dates sampling occurred for each trap during the 2023 Stanislaus RST sampling season.

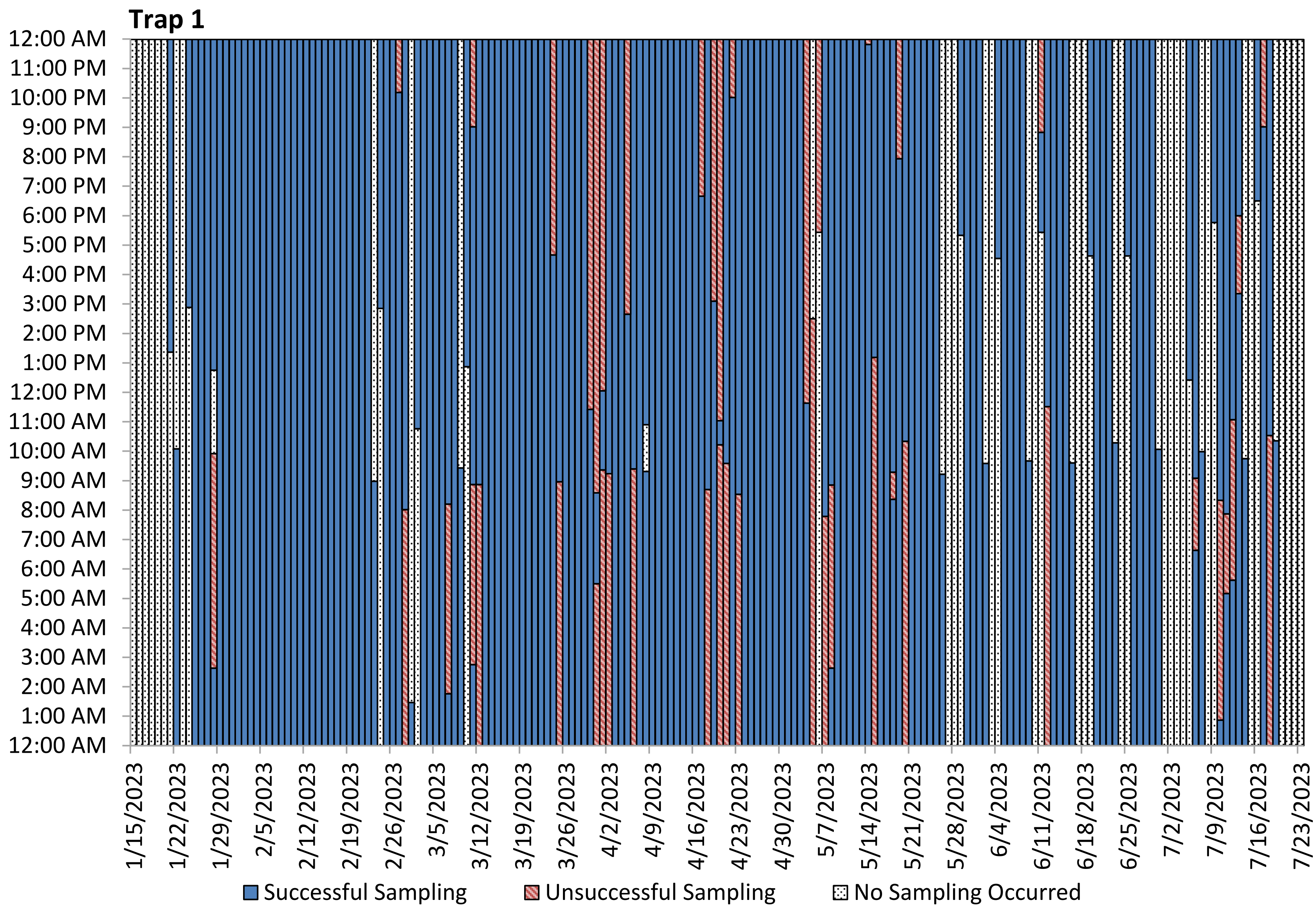

Figure 10: Daily hours Trap 1 sampled successfully, sampled unsuccessfully, or did not sample during the 2023 Stanislaus River RST sampling season.

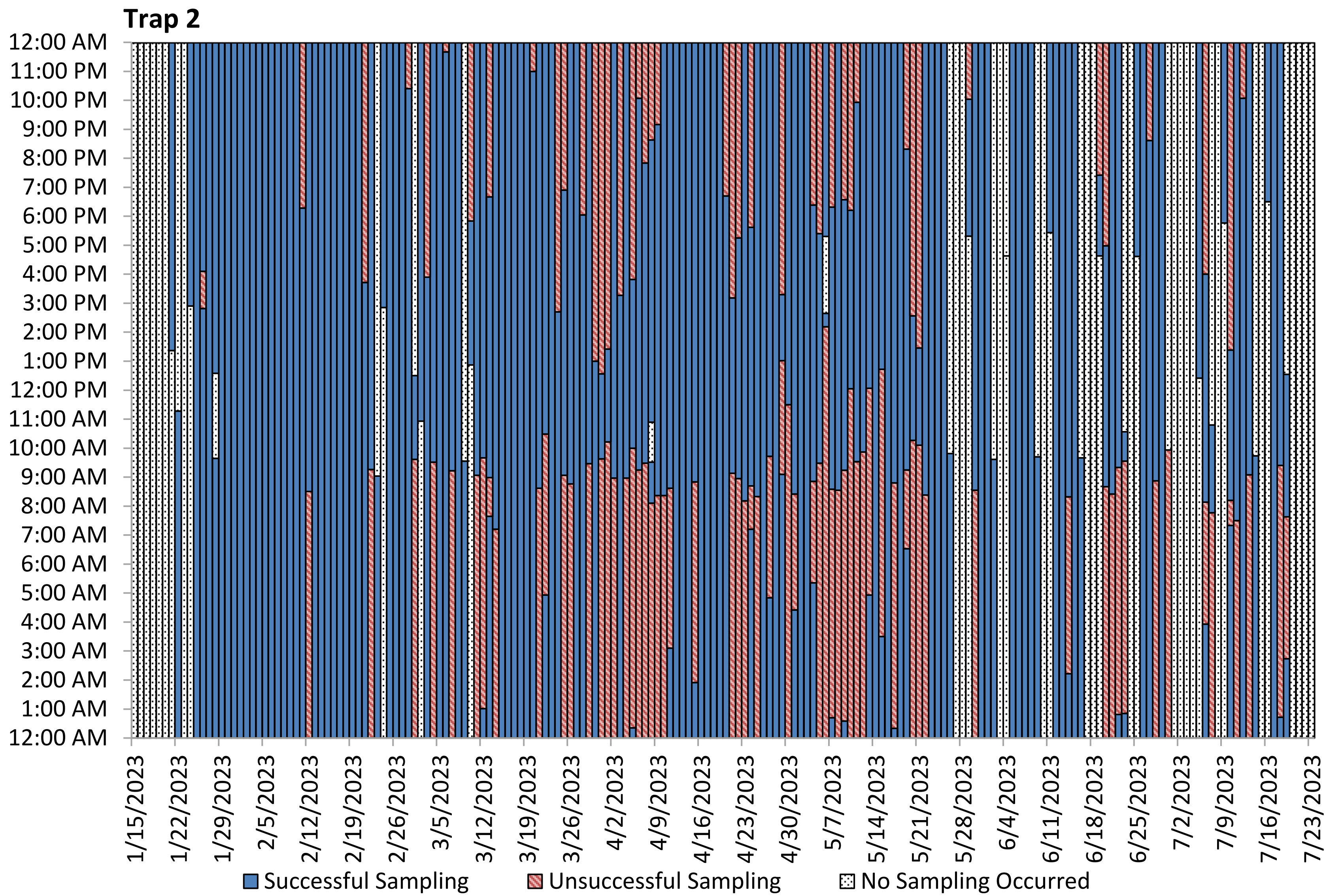

Figure 11: Daily hours Trap 2 sampled successfully, sampled unsuccessfully, or did not sample during the 2023 Stanislaus River RST sampling season.

Environmental Summary

The 2023 sampling season was met with high and variable flows, evidently, resulting in gaps in environmental data collection. However, though this year was wet with occasional high flows, environmental parameters remained relatively ordinary (Appendix 1). 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 maximum on January 17 and a minimum on February 20 (range: 202 – 3,370 cfs; Figure 12). Instantaneous river temperature, also recorded in 15-minute intervals by USGS at the Ripon gauge station, recorded a maximum temperature on July 16 and minimum on February 1 (range: 7.4 – 18.3 °C; Figure 12).

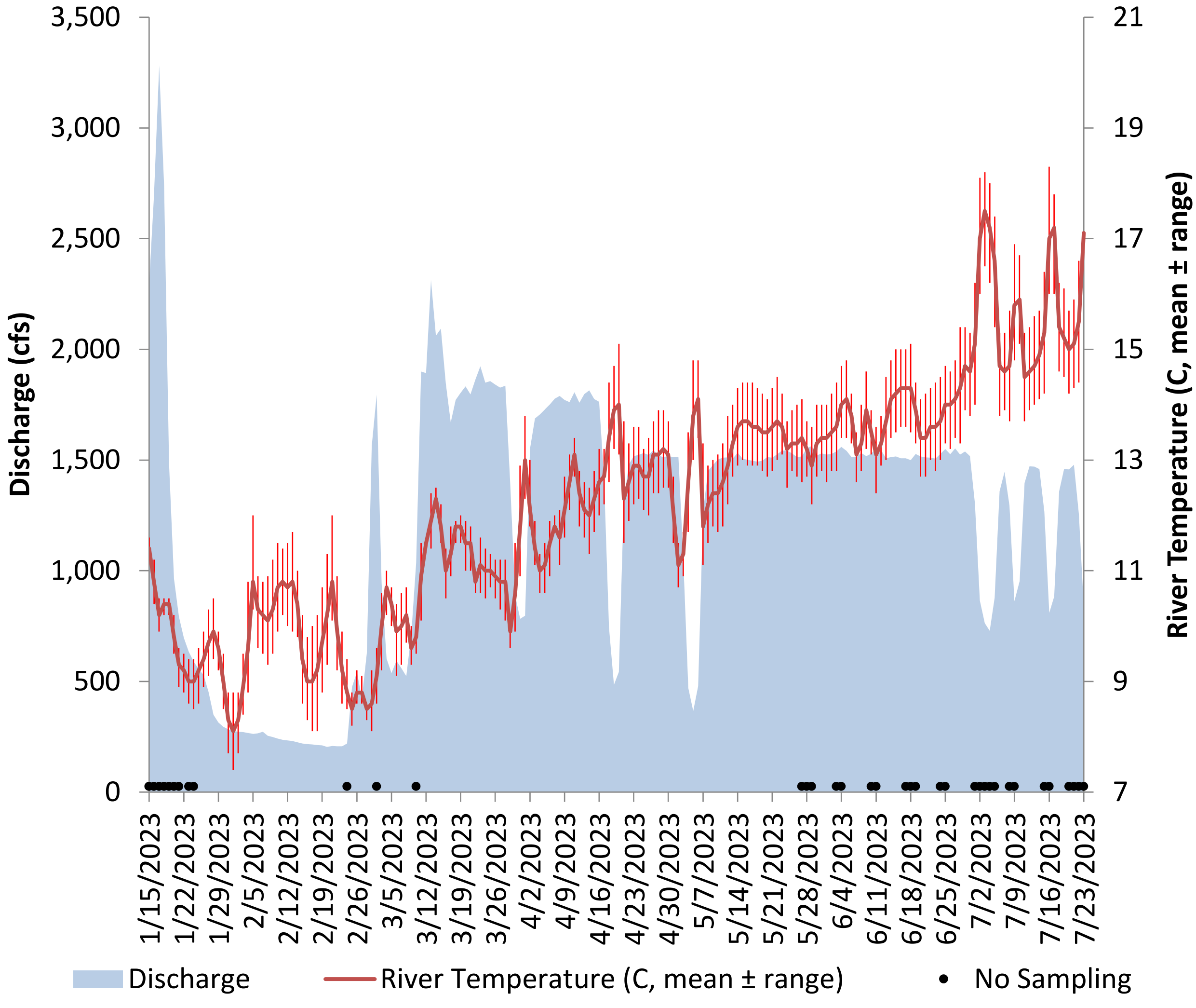

Figure 12: Daily average discharge (cfs) and the daily minimum, maximum, and average water temperature (C) measured at Ripon, and dates no sampling occurred during the 2023 Stanislaus River RST sampling season.

Velocity, turbidity, and DO were measured during trap visits throughout the sampling season (Figure 13). Water velocity for Trap 1 ranged from 0.10 – 0.80 m/s, while Trap 2 had a range of 0.10 – 1.10 m/s. The mean velocity for Trap 1 and Trap 2 was similar at 0.30 and 0.40 m/s, respectively. Mean difference in velocity between Trap 1 and Trap 2 was 0.11 m/s likely due to Trap 2 fishing a closer proximity to the thalweg than Trap 1. Turbidity for Trap 1 reached a minimum on April 29 and a maximum on March 11 with a range of 1.83 – 46.40 NTU. Turbidity for Trap 2 reached a minimum on May 5 and a maximum on March 11 with a range of 1.55 – 46.00 NTU. The mean turbidity for Trap 1 and Trap 2 was similar at 7.10 and 6.74 NTU, respectively. Mean difference in turbidity between Trap 1 and Trap 2 was 0.22 NTU, likely due to Trap 1's closer proximity to an eddy towards the southern bank of the river. DO reached a minimum on May 6 and a maximum on May 12 with a range of 7.93 – 12.80 mg/L.

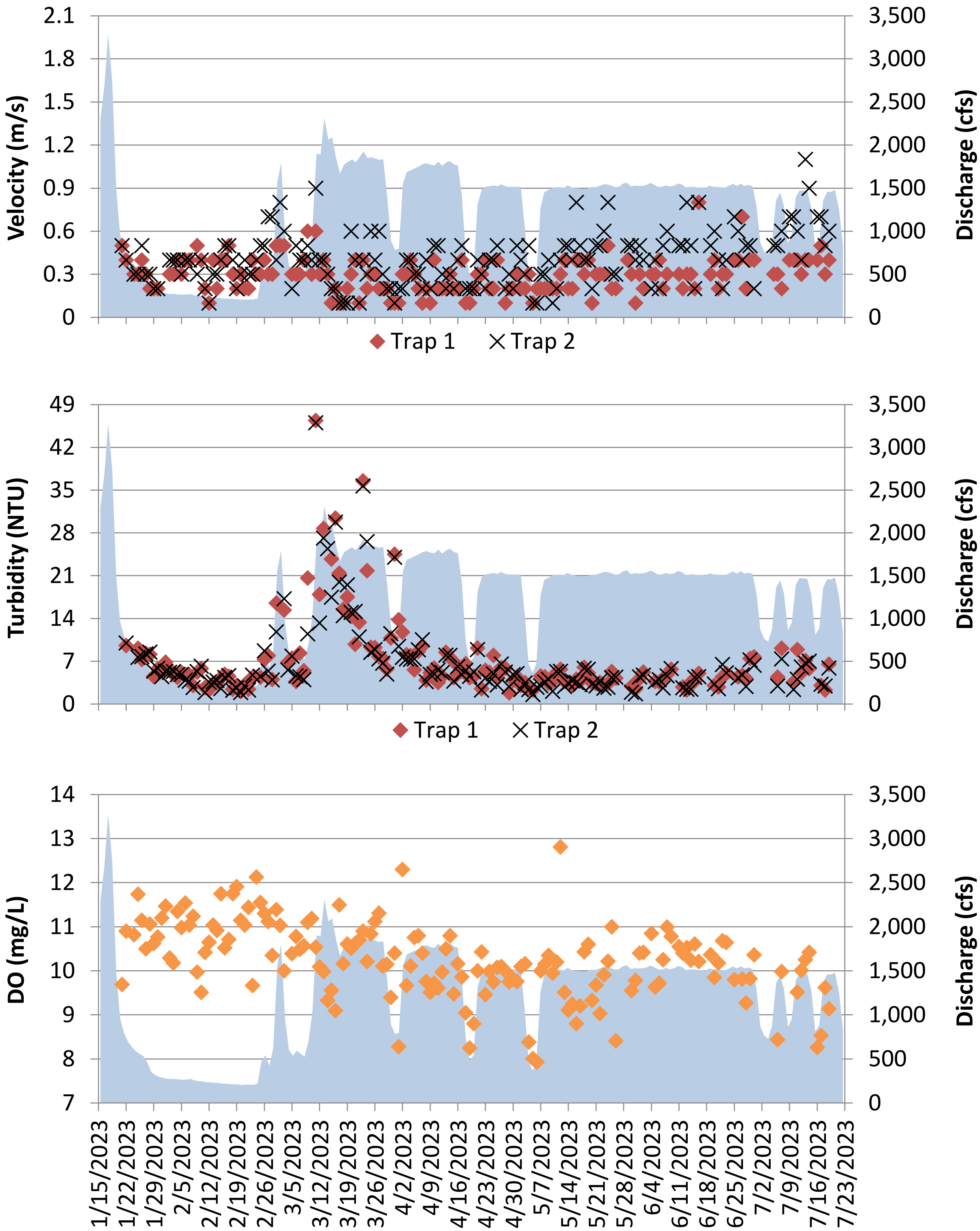

Figure 13: Daily average velocity (m/s) and turbidity (NTU) for both traps, DO (mg/L), and discharge (cfs; measured at Ripon), during the 2023 Stanislaus River RST sampling season.

Catch

The two RSTs deployed during the 2023 sampling season captured 6,755 natural origin fishes and no hatchery produced salmonids. The trap furthest from the thalweg, Trap 1, captured 44.8% (*n* = 3,024) of these fishes, while Trap 2 captured 55.2% (*n* = 3,731). Additionally, 4,460 non-salmonid fishes were captured and identified to at least the genus level (Appendix 2).

Fall-run Chinook Salmon

A total of 2,293 natural origin fall-run Chinook Salmon were captured during the 2023 sampling season. 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 13, when 16.0% (*n* = 366) of these fish were captured (Figure 14). Of all fall-run captured during the 2023 sampling season, 328 were classified as unmeasured plus-count tallies. Cumulative fall-run catch exceeded 95% on May 20, which was later in the calendar year than any other year since 2017 (Figure 15).

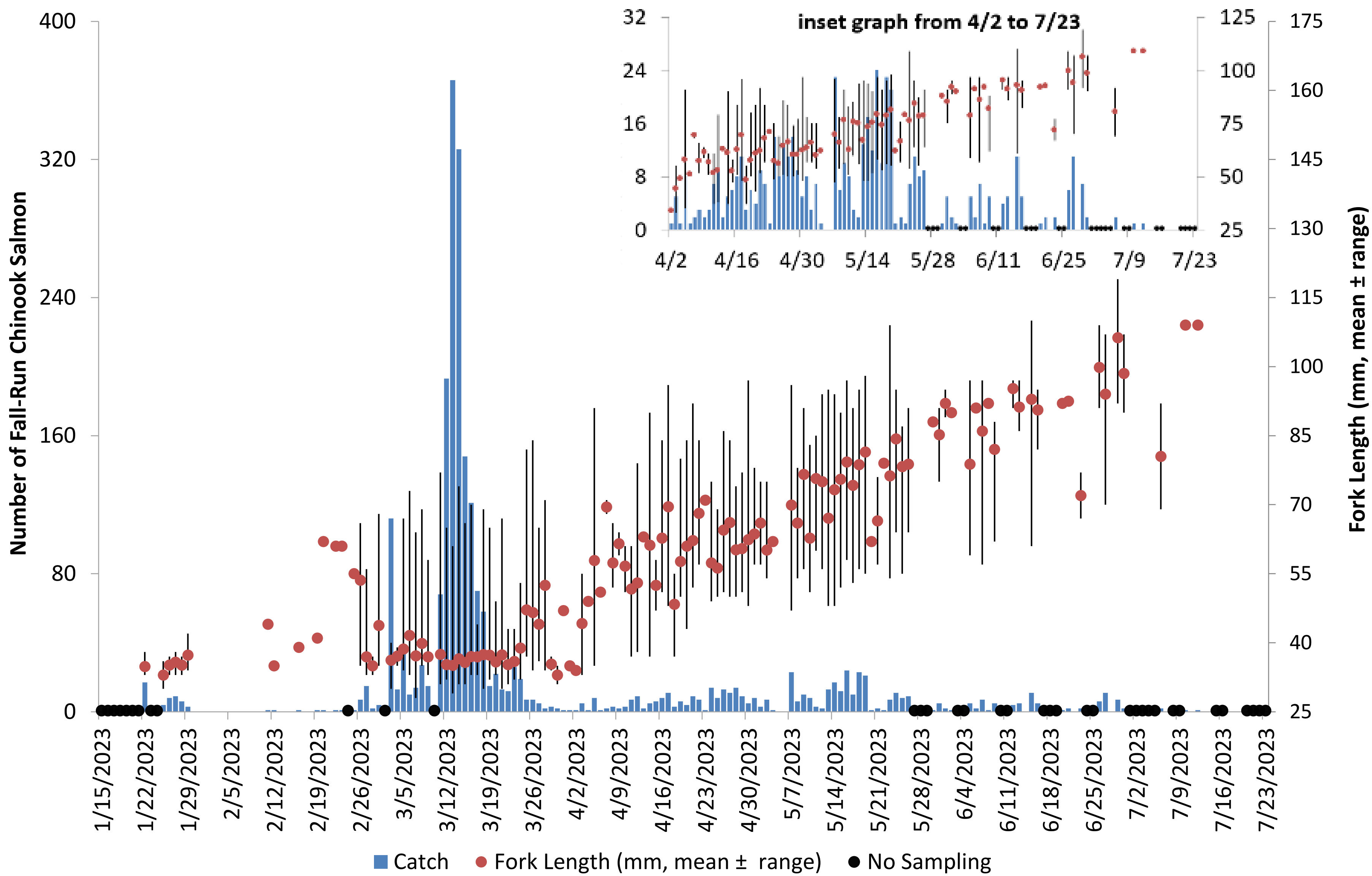

Figure 14: Daily minimum, maximum, and average fork length (mm) and total catch of natural origin fall-run Chinook Salmon during the 2023 Stanislaus River RST sampling season.

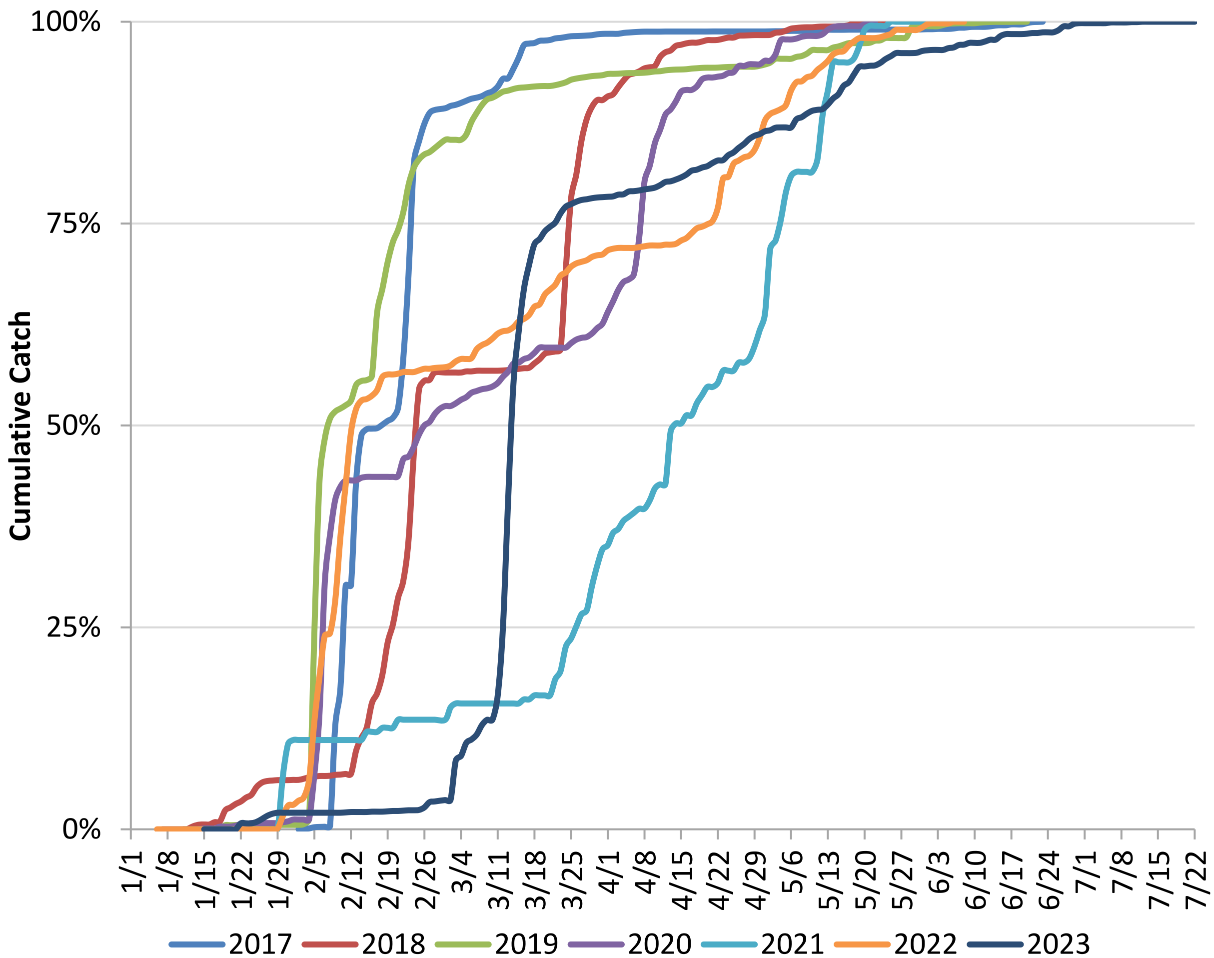

Figure 15: Cumulative catch of natural origin fall-run Chinook Salmon at the Stanislaus River RSTs at Caswell Memorial State Park from 2017 through 2023.

A total of 1,965 natural origin fall-run were measured for fork length (Table 3). The lowest weekly average fork length of 35 mm was observed during the first week of sampling. The smallest natural origin fall-run was 28 mm and was observed on March 7. Fork lengths slowly increased throughout the season with the weekly average reaching a maximum of 109 mm the week of July 9. The largest natural origin fall-run was 119 mm and was observed on June 29.

Table 3: Weekly average (Avg), minimum and maximum (Range), and standard deviation (St. Dev.) of fork lengths (mm) and total weekly catch (n) for natural origin fall-run Chinook Salmon captured during the 2023 Stanislaus River RST sampling season.

Julian Week	Avg	Range	*n*	St. Dev.
1/22 - 1/28	35	(30 - 38)	44	1.67
1/29 - 2/4	37	(34 - 42)	3	4.16
2/5 - 2/11	44	(44)	1	-
2/12 - 2/18	37	(35 - 39)	2	2.83
2/19 - 2/25	56	(41 - 62)	5	8.83
2/26 - 3/4	37	(30 - 68)	153	5.60
3/5 - 3/11	38	(28 - 77)	171	7.22
3/12 - 3/18	36	(29 - 74)	1282	3.91
3/19 - 3/25	37	(30 - 82)	114	6.89
3/26 - 4/1	43	(31 - 84)	21	14.99
4/2 - 4/8	54	(33 - 91)	21	16.78
4/9 - 4/15	55	(37 - 90)	34	10.98
4/16 - 4/22	63	(37 - 96)	48	13.56
4/23 - 4/29	61	(49 - 86)	70	9.26
4/30 - 5/6	63	(48 - 97)	24	10.59
5/7 - 5/13	69	(47 - 96)	65	12.85
5/14 - 5/20	78	(48 - 98)	108	11.17
5/21 - 5/27	79	(54 - 109)	38	13.10
5/28 - 6/3	88	(75 - 95)	9	5.88
6/4 - 6/10	84	(57 - 97)	20	12.96
6/11 - 6/17	92	(61 - 110)	25	8.66
6/18 - 6/24	84	(67 - 93)	5	11.69
6/25 - 7/01	99	(70 - 119)	26	11.11
7/2 - 7/8	81	(69 - 92)	2	16.26
7/9 - 7/15	109	(109)	2	-
7/16 - 7/22	-	-	-	-

The subsample of fall-run that were measured for fork length were also assessed for life stage (Figure 16; Table 4). Most of these fall-run were identified as button-up fry and accounted for 73.5% (*n* = 1,444) of the assessed catch. The remaining life stage catch composition consisted of yolk-sac fry (0.4*%, n* = 8), parr (13.2*%, n* = 260), silvery parr (12.3*%, n* = 242) and smolts (0.6*%, n* = 11). Fall-run Chinook Salmon identified as yolk-sac fry were captured between January 22 and March 15. Button-up fry were captured between January 22 and May 14. Parr were captured between February 20 and June 23. Silvery parr were caught between February 26 and July 6. Lastly, 11 fall-run were identified as smolts and were captured between April 14 and July 12. Average weekly fork lengths increased with life stage progression with yolk-sac fry life stage having the lowest average weekly fork lengths, and smolts having the largest average weekly fork lengths. Fork lengths for the natural origin Chinook Salmon with life stages identified averaged 34 mm for yolk-sac fry, 36 mm for button-up fry, 60 mm for parr, 85 mm for silvery parr, and 102 mm for smolts (Table 4).

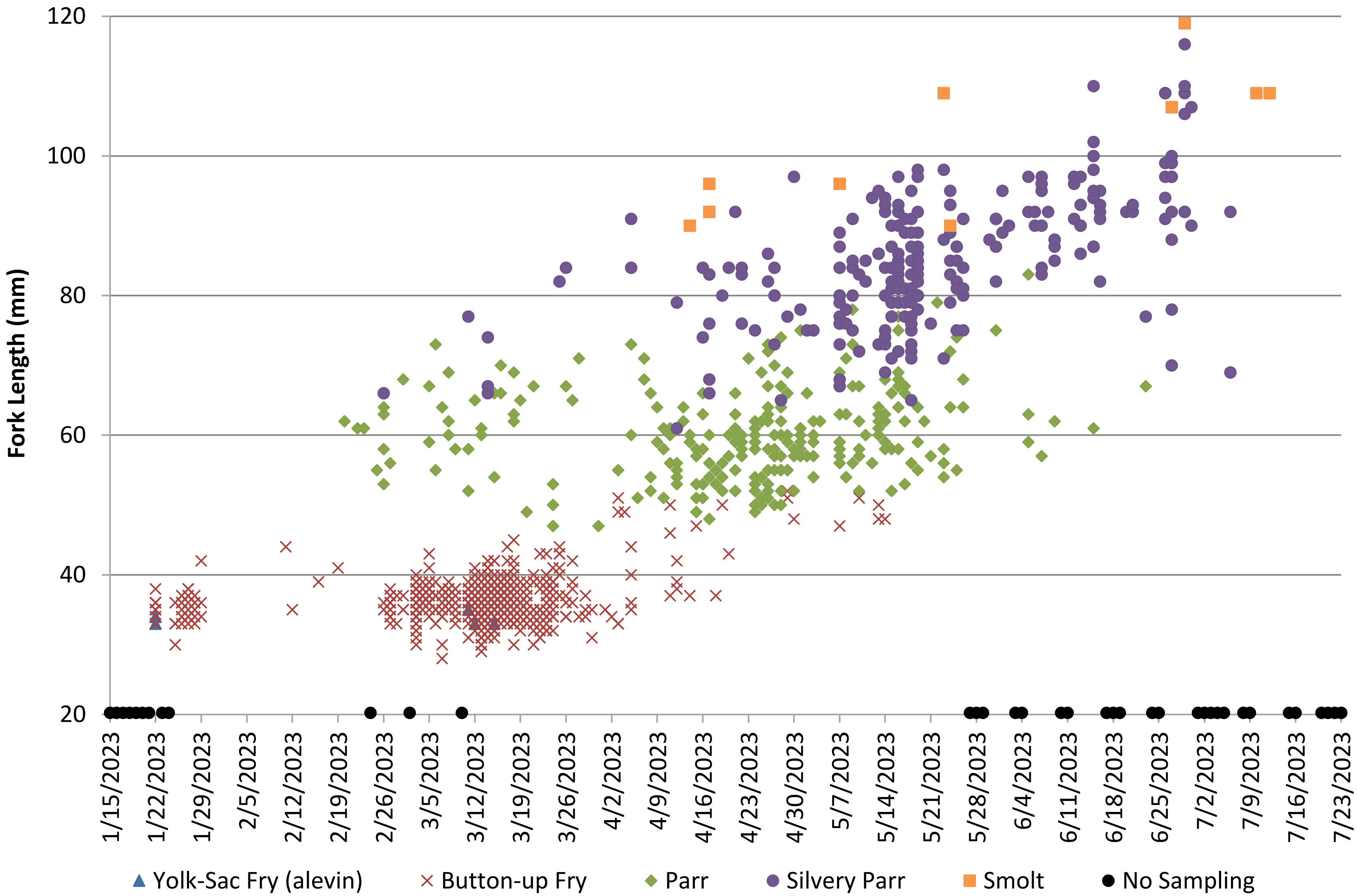

Figure 16: Daily fork length distribution by life stage of natural origin fall-run Chinook Salmon measured during the 2023 Stanislaus River RST sampling season.

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 Stanislaus 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 (33 - 34, *n* = 3)	35 (30 - 38, *n* = 41)	-	-	-
1/29 - 2/4	-	37 (34 - 42, *n* = 3)	-	-	-
2/5 - 2/11	-	44 (44, *n* = 1)	-	-	-
2/12 - 2/18	-	37 (35 - 39, *n* = 2)	-	-	-
2/19 - 2/25	-	41 (41, *n* = 1)	60 (55 - 62, *n* = 4)	-	-
2/26 - 3/4	-	36 (30 - 40, *n* = 146)	60 (53 - 68, *n* = 6)	66 (66, *n* = 1)	-
3/5 - 3/11	35 (35, *n* = 1)	36 (28 - 34, *n* = 158)	62 (52 - 73, *n* = 11)	77 (77, *n* = 1)	-
3/12 - 3/18	33 (33, *n* = 4)	36 (29 - 45, *n* = 940)	64 (54 - 70, *n* = 10)	69 (66 - 74, *n* = 3)	-
3/19 - 3/25	-	36 (30 - 44, *n* = 107)	55 (47 - 67, *n* = 6)	82 (82, *n* = 1)	-
3/26 - 4/1	-	36 (31 - 42, *n* = 16)	63 (47 - 71, *n* = 4)	84 (84, *n* = 1)	-
4/2 - 4/8	-	40 (33 - 51, *n* = 10)	61 (51 - 73, *n* = 9)	88 (84 - 91, *n* = 2)	-
4/9 - 4/15	-	42 (37 - 50, *n* = 8)	57 (49 - 64, *n* = 22)	70 (61 - 79, *n* = 2)	90 (90, *n* = 1)
4/16 - 4/22	-	43 (37 - 50, *n* = 3)	57 (48 - 66, *n* = 31)	79 (66 - 92, *n* = 12)	94 (92 - 96, *n* = 2)
4/23 - 4/29	-	52 (51 - 52, *n* = 2)	59 (49 - 74, *n* = 49)	78 (65 - 86, *n* = 9)	-
4/30 - 5/6	-	48 (48, *n* = 1)	59 (52 - 75, *n* = 19)	81 (75 - 97, *n* = 4)	-
5/7 - 5/13	-	49 (47 - 51, *n* = 4)	61 (52 - 78, *n* = 32)	81 (67 - 95, *n* = 27)	96 (96, *n* = 1)
5/14 - 5/20	-	48 (48, *n* = 1)	63 (52 - 77, *n* = 27)	83 (65 - 98, *n* = 80)	-
5/21 - 5/27	-	-	65 (54 - 79, *n* = 12)	85 (71 - 98, *n* = 23)	100 (90 - 109, *n* = 2)
5/28 - 6/3	-	-	75 (75, *n* = 1)	89 (82 - 95, *n* = 8)	-
6/4 - 6/10	-	-	65 (57 - 83, *n* = 5)	90 (83 - 97, *n* = 15)	-
6/11 - 6/17	-	-	61 (61, *n* = 61)	94 (82 - 110, *n* = 24)	-
6/18 - 6/24	-	-	67 (67, *n* = 67)	89 (77 - 93, *n* = 4)	-
6/25 - 7/01	-	-	-	97 (70 - 116, *n* = 23)	111 (107 - 119, *n* = 3)
7/2 - 7/8	-	-	-	81 (69 - 92, *n* = 2)	-
7/9 - 7/15	-	-	-	-	109 (109, *n* = 2)
Season	34 (33 - 35, *n* = 8)	36 (28 - 52, *n* = 1444)	60 (47 - 83, *n* = 260)	85 (61 - 116, *n* = 242)	102 (90 - 119, *n* = 11)

Fulton's Condition Factor

Fulton's condition factor (K) for fall-run natural origin Chinook Salmon captured in 2023 is shown in (Figure 17). The trend line slopes were positive for button-up fry (0.0018) and silvery parr (0.0008) while parr (-0.0005) and smolt (-0.0007) life stages both had negative trend line slopes. 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. Average Fulton's condition factor (K) increased with life stage progression (Figure 17). Since 2017, yearly average K values per life stage have shown a slightly negative trend (Appendix 3, Figure 18).

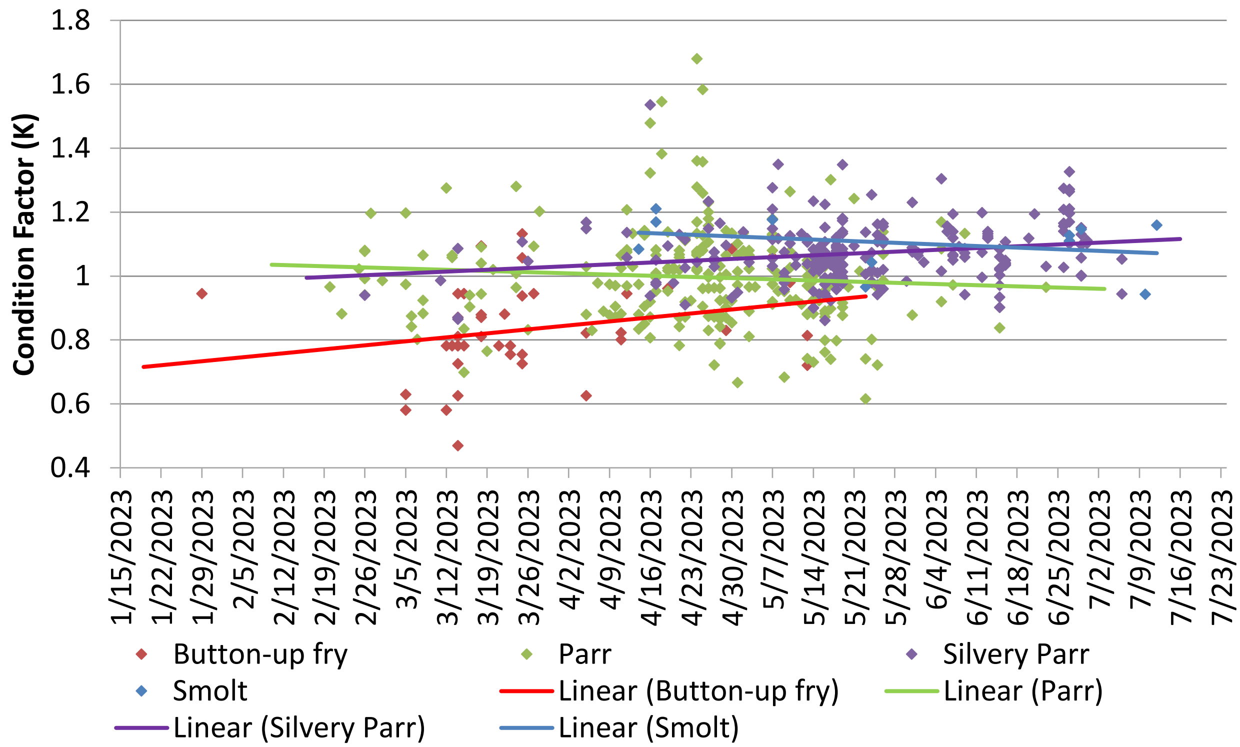

Figure 17: Fulton's condition factor (K), by life-stage, of fall-run Chinook Salmon during the 2023 Stanislaus River RST sampling season.

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 Stanislaus River RST sampling season.

Life stage	Condition Factor Avg (Range)
Button-up fry	0.84 (0.47 – 1.13)
Parr	1.00 (0.62 - 1.68)
Silvery Parr	1.07 (0.86 - 1.54)
Smolt	1.10 (0.94 - 1.21)

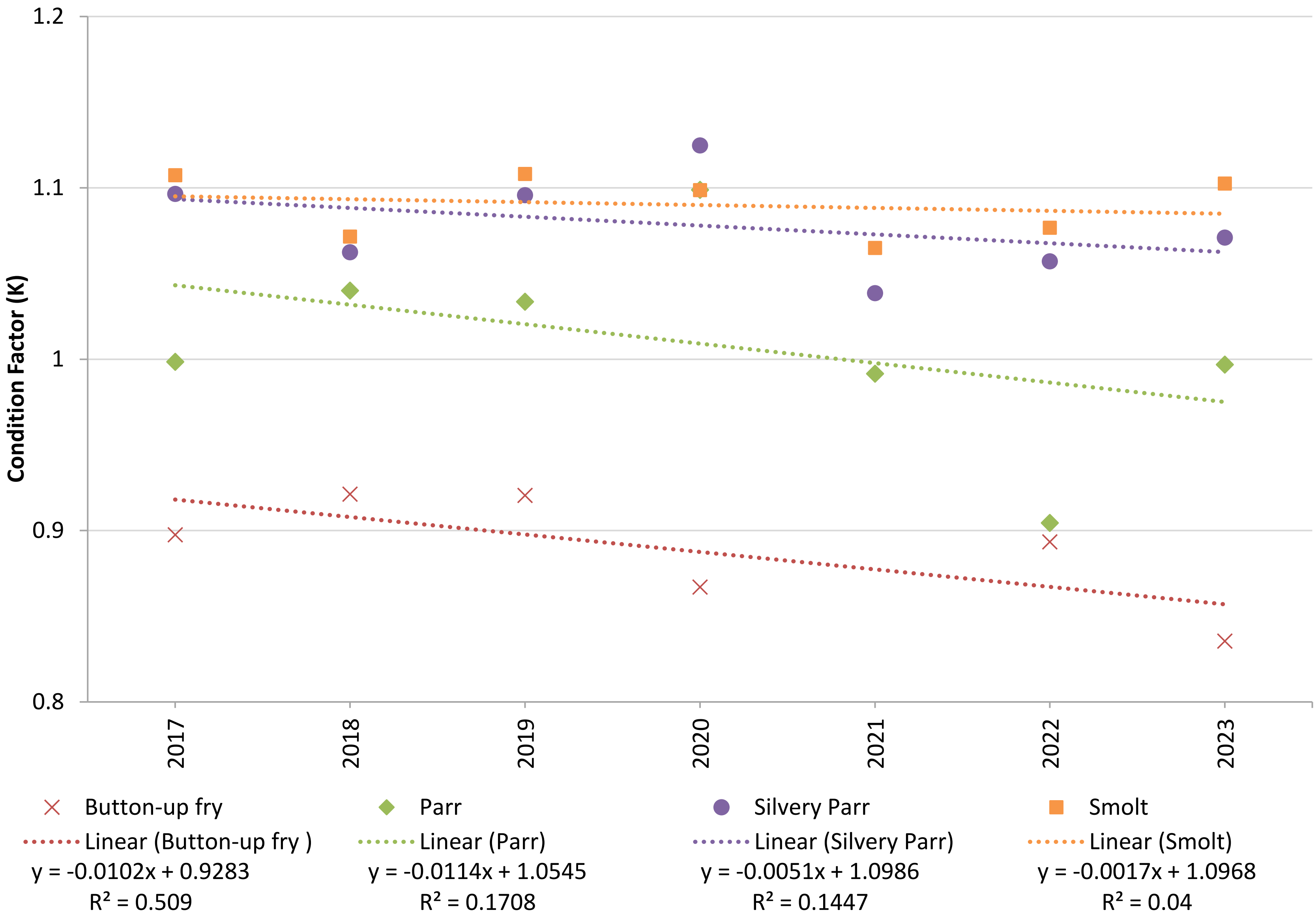

Figure 18: Average Fulton's condition factor by life stage for natural origin fall-run Chinook Salmon from 2017 through 2023.

Trap Efficiency

Five trap efficiency trials were conducted during the 2023 sampling season (Table 6). The five trials used a total of 2,267 fall-run Chinook Salmon. Of these fish, 311 were natural origin salmon collected from the RSTs and marked with BBY. The remaining 1,956 were acquired from Mokelumne River Hatchery and marked with BBY or VIE. 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 acquired during the 2023 Stanislaus River RST sampling season.

Date Marked	Fish Origin	Mark Type (Color)	Included	Date Released	Release Time	Flow (cfs)	Avg release FL (mm)	*n* released	Capture Efficiency	Avg recapture FL (mm)
2/15/2023	Hatchery	BBY	Yes	2/16/2023	17:20	217	44	537	4.47%	46
3/14/2023	Natural	BBY	Yes	3/15/2023	16:55	2,130	36	311	6.43%	37
3/22/2023	Hatchery	VIE (Orange)	Yes	3/23/2023	18:38	1,900	62	347	0.29%	62
3/22/2023	Hatchery	VIE (Pink)	Yes	3/23/2023	18:38	1,900	62	347	0.00%	-
5/10/2023	Hatchery	VIE (Red)	Yes	5/11/2023	18:46	1,510	77	725	0.00%	-

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

A total of 91 genetic samples were taken from Chinook Salmon (54 LAD fall-run, 1 LAD late fall-run, and 36 LAD spring-run) and analyzed using SNP genetic markers to determine final run assignments (Appendix 4). All salmon sampled for genetics did not have a clipped adipose fin and were presumed to be of natural origin. The SNP panel's probabilities for the samples exceeded the 50 percent threshold for all 121 samples and the corresponding run assignments for salmon were assigned based on genetic analysis.

A total of 2,255 natural origin Chinook Salmon captured were classified as fall-run using the LAD criteria. Genetic samples were collected from 54 LAD fall-run throughout the 2023 sampling season. Analyses using SNP genetic markers from these samples indicated that 100% (n = 54) of these individuals were fall-run (Appendix 4). Because the LAD criteria continued to be highly accurate when assigning this run, a final run assessment of fall was applied to the remaining 2,201 LAD fall-run that were not genetically sampled (Figure 19).

A total of 36 natural origin Chinook Salmon captured were classified as spring-run using the LAD criteria. Genetic samples were collected from all 36 LAD spring-run throughout the 2023 sampling season. Analyses using SNP genetic markers from those samples indicated that 100% (n = 36) were fall-run (Figure 19; Appendix 4).

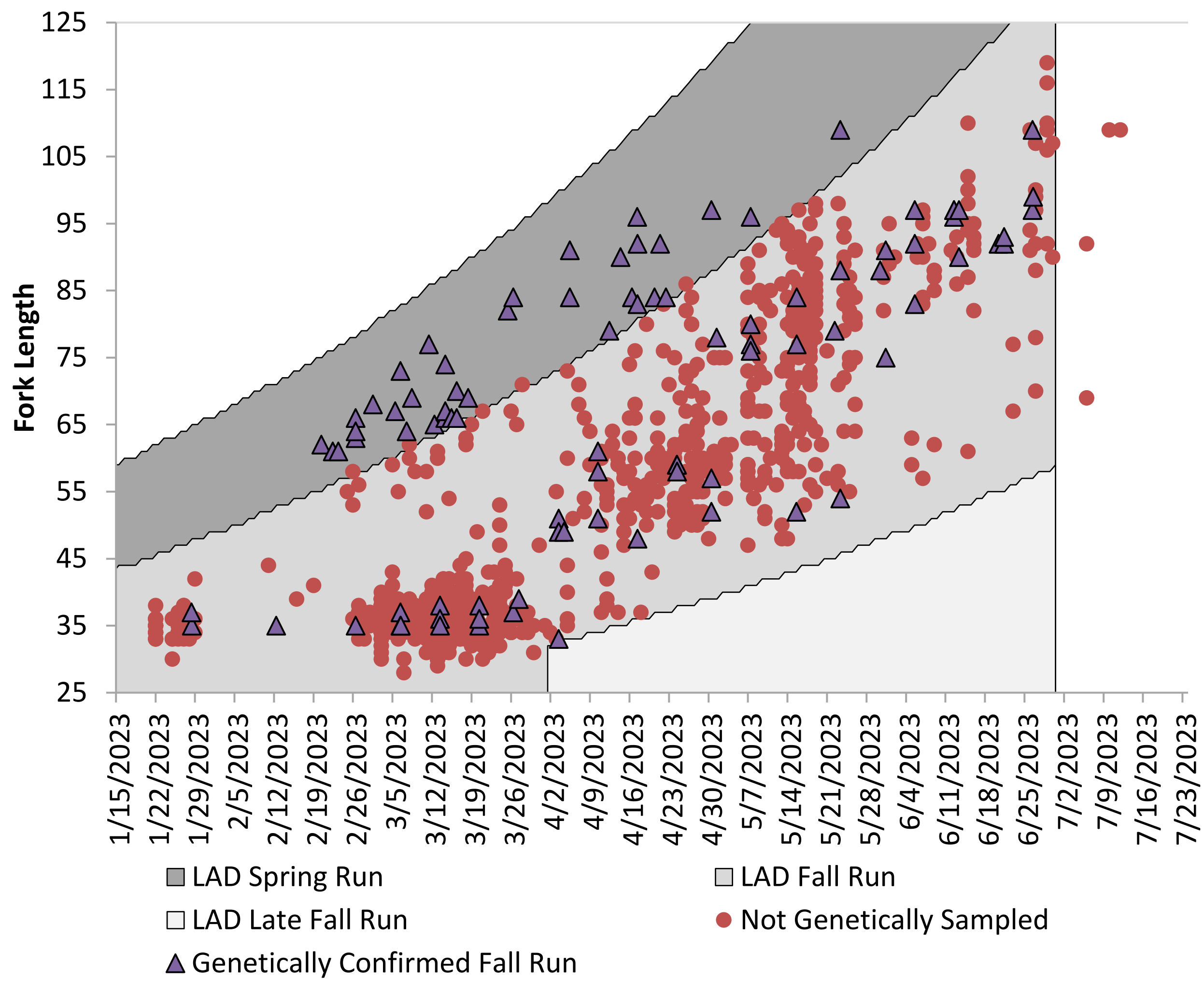

Figure 19: Daily fork length distribution of SNP genetically and not genetically sampled natural origin Chinook Salmon measured during the 2023 Stanislaus River RST sampling season.

O. mykiss

Two natural origin *O. mykiss* were captured during the 2023 sampling season. Both were identified as smolts. The first was captured on February 28 with a fork length of 246 mm. The second was captured on June 26 with a fork length of 225 mm.

Non-salmonid Species

A total of 4,460 non-salmonid fish were captured during the 2023 sampling season. The majority (*n* = 4,418, 99%) of these fish belonged to 25 identified species in the following families: Atherinopsidae (silverside), Catostomidae (sucker), Centrarchidae (sunfish/black bass), Clupeidae (shad), Cottidae (sculpin), Cyprinidae (minnow), Embiotocidae (surfperch), Ictaluridae (bullhead/catfish), Petromyzontidae (lamprey), and Poeciliidae (mosquitofish; Figure 20). The remaining 1% (*n* = 42) were not able to be identified to species level but belonged to the following families: Centrarchidae (*n* = 8), Cottidae (*n* = 3), Cyprinidae (*n* = 8), Ictaluridae (*n* = 3), Petromyzontidae (*n* = 19), and unknown (*n* = 1). The majority of non-salmonid fish captured were not native to the Central Valley watershed (*n* = 3,960, 89%) with the remaining individuals (*n* = 500, 11%) being native species. Non-salmonid catch varied throughout the 2023 sampling season (Appendix 5).

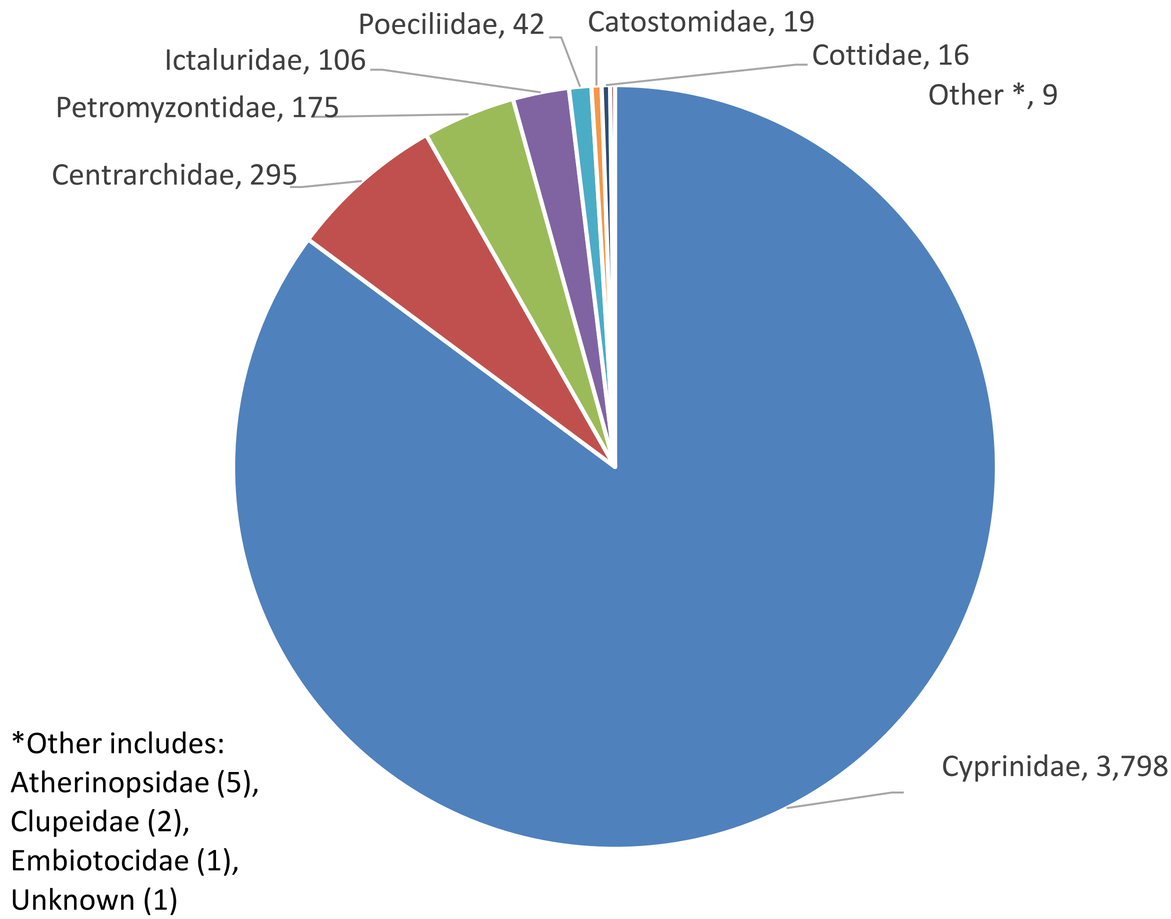

Figure 20: Non-salmonid catch totals for each family of species collected during the 2023 Stanislaus River RST sampling season.

Of the 4,460 non-salmonid fish captured, 175 (3.9%) were identified as Petromyzontidae spp. (northern lampreys); 156 (89.1%) of which were identified as Pacific lamprey, consisting of one adult and 155 juveniles. The remaining 19 (10.9%) lamprey captured were identified as Petromyzontidae ammocoetes and were not identified to a species level. Catch of Pacific Lamprey peaked on February 26 when 63 (40.4%) of the total was captured (Figure 21). Catch of ammocoetes peaked on March 14 when 3 (15.8%) of the total was captured.

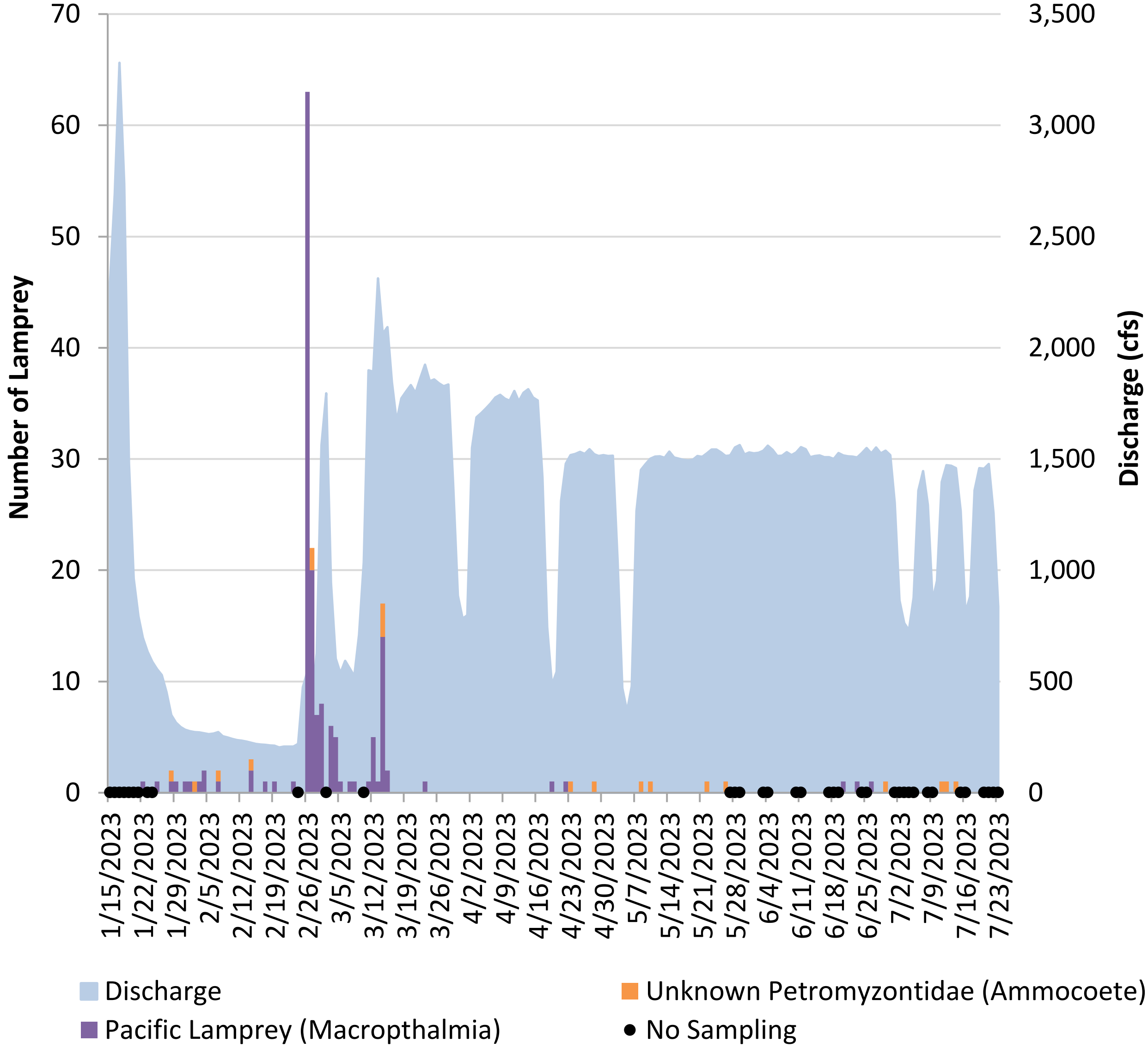

Figure 21: Daily lamprey catch and daily average discharge at Ripon during the 2023 Stanislaus River RST sampling season.

Discussion

Project Scope

The continued operation of the Stanislaus River RSTs during the 2023 sampling season provided valuable biological monitoring data for emigrating juvenile salmonids. 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 *O. mykiss*. 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 Stanislaus River salmonids by expanding on previous RST emigration surveys from CFS (CFS 2016) and PSMFC (PSMFC 2017 – 2022).

Passage Estimate and Catch

Several factors must be considered when interpreting catch of fall-run Chinook Salmon and *O. mykiss* during the 2023 sampling season. One of the most significant factors was the cold weather and variable river flows experienced throughout the sampling season. Between December 2022 and April 2023, numerous atmospheric river storms made landfall in California, ending California's driest consecutive 3 year period on record (CDWR, 2023). Due to the storms between December 27, 2022 and January 17, 2023, the New Melones Dam weather station measured 20.7 inches of accumulated rainfall (USBR NML gage, retrieved from California Data Exchange Center). Consequently, on December 31, 2022 increased side flows into Lake Tulloch prompted releases of up to 3,600 cfs into the lower Stanislaus River. Due to safety concerns of swift moving water and large mobilized debris within the water column, the RSTs at Caswell could not be safely installed until discharge levels at the USGS Ripon gauge reduced and stabilized below 1,000 cfs on January 20, 2023.

Because the RSTs could not be safely installed until January 20 due to the high and variable river discharges when salmonids on the Stanislaus River tend to migrate (Zeug et al 2014), it is likely that the beginning of the juvenile salmonid emigration period was missed. Through the first seven days of sampling during the 2023 season, 47 fall-run were captured, accounting for 2.1% of the total fall-run catch. Contrarily, due to the colder than average water temperatures experienced on the Stanislaus River throughout the 2023 sampling season, the RSTs at Caswell were able to sample until July 19, marking the latest the RSTs have sampled since 1996 (CFS 2016, PSMFC 2017-2022). Through the last seven days of sampling a total of one fall-run was captured, accounting for 0.4% of the total fall run catch. Due to the low catch that occurred the last seven days of sampling, it is likely that the sampling season encompassed the end of the juvenile salmonid emigration period.

Trap operation is another critical factor to consider when interpreting annual catch. Ideally, the RSTs continuously operate to the furthest extent possible through the full length of the juvenile salmonid emigration period to accurately quantify salmonid catch. During the 2023 sampling season, sampling occurred for 85% (153 days) of the 179-day season with an 84% successful sample rate (Figure 9, Figure 10, and Figure 11). Heightened and variable flows, high winds, and precipitation events during the 2023 sampling season brought large and heavy debris downstream. As a result, the RSTs were occasionally stopped by debris at the entrance of the cone or intakes to the live well resulting in unsuccessful periods of RST operation. To mitigate the potential for trap stoppages when increased debris loads were observed, sampling crews conducted multiple trap checks per day to ensure the RSTs continuously operated to the furthest extent possible. Additionally, when debris loads were considered too high and unmanageable, the RSTs were taken out of service until conditions improved. Since fewer fish were likely captured when the RSTs were sampling unsuccessfully, it is likely that the juvenile salmonid catch totals bias low during these periods of unsuccessful or no sampling.

The RSTs experienced lower than normal RPMs on three separate occasions, March 30 to April 1, April 19 to April 20, and May 4 to May 6, when flows ranged from 366 to 887 cfs at Ripon. Typically, these lower RPMs are only experienced when flows at Ripon are at approximately 200 cfs, whereas discharges between 300 and 900 cfs typically display a higher Trap RPM rate. A possible explanation for the lower RPMs during these periods is likely related to the high discharge on the mainstem San Joaquin River, which is located approximately 13.8 rkms downstream of the RSTs. Specifically, flows on the San Joaquin River at Vernalis (USGS station number 11303500), which is located 4.3 rkms downstream from the San Joaquin and Stanislaus River confluence, ranged between 25,315 and 32,336 cfs during the abovementioned periods. During these periods, discharge at Ripon was closer to seasonal lows, while the discharge at Vernalis was at seasonal highs. Evidently, it is possible that due to the variation in discharges between the Stanislaus River and mainstem San Joaquin River, that water from the San Joaquin River back flooded into the Stanislaus River, resulting in lower than ideal RPMs for sampling (Appendix 6).

Salmonid catch and fall-run passage estimates are also dependent on the quantity, quality, and recapture efficiencies obtained through the trap efficiency trials. An attempt is made each sampling season to complete at least ten efficiency trials to produce estimates of the highest confidence. However, insufficient catch of natural origin fall-run Chinook Salmon and only being allotted 2,500 fall-run Chinook Salmon from the Mokelumne River Hatchery led to the completion of only five efficiency trials in 2023 (Table 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). However, several environmental factors had detrimental effects on the quality of the efficiency trials including insufficient velocity, flow alterations, and periods of unsuccessful sampling. Insufficient velocity can be one of the most challenging factors to control without making significant alterations to the RSTs or sampling site. The ideal velocity for 8-foot RSTs is approximately 1.5 m/s (USFWS 2008). Velocities this high are rarely seen on the Stanislaus River at Caswell and were not observed in 2023 with velocity averaging 0.4 m/s with a range of 0.1 – 1.1 m/s.

The first efficiency trial experienced constant flows ranging from 204 to 217 cfs with unsuccessful sampling occurring for Trap 2 on February 21, however, 96% of recaptures were caught on the first two days of the trial (February 17 and 18). Similarly for trial two, 100% of the recaptures occurred on the first two days of the trial (March 16 and March 17) with trap stoppages occurring on March 20 and March 22. This trial also experienced relatively steady discharge (range: 1,669 – 2,093 cfs). Trials three and four were performed at the same time and experienced stable discharge (range: 1,827 – 1,857 cfs) for the first five days until flows dropped to 783 cfs on March 31. Beginning March 30, both RSTs experienced abnormally low RPMs due to suspected backflow from the mainstem San Joaquin River. Additionally, trial three had one total recapture that occurred on day four of the trial, while a single recapture from trial four was recaptured 21 days after the release. The fifth trial experienced steady discharge (range: 1,493 – 1,533) with stoppages on May 11, May 13, and May 15 following the release. Due to periods of unsuccessful sampling during each trial and suspected backflow during trials three and four, it is likely that the efficiency percentage bias low.

The two *O. mykiss* smolts captured during the 2023 sampling season were the first natural origin *O. mykiss* captured since 2020. Catch of natural origin *O. mykiss* has been historically minimal (annual range: 0 – 34) at the Caswell RST site since consistent sampling began in 1996 (CFS 2016, Appendix 7). Factors that likely contribute to the low annual catch of natural origin *O. mykiss* include larger salmonids having the swimming ability to avoid the RSTs, insufficient water velocity for optimal RST operation, and the heightened probability of unsuccessful sampling during discharge events when *O. mykiss* are expected to migrate (Eschenroeder et al. 2022, Johnson et al. 2007, USFWS 2008). Additionally, of the 185 *O. mykiss* captured since 1996, 169 (91%) had fork lengths greater than 150 mm. Eschenroeder et al. (2022) suggests that most *O. mykiss* in the Stanislaus River follow a resident life-history strategy and smolt emigration is less frequent.

Biological Observations

Biological data were collected throughout the season to assist with the development of models that 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, most of the fall-run population emigrated as age-0 fry from the Stanislaus River (PSMFC 2017 – 2022, CFS 1996 and 2016). In the Central Valley, this emigration timing is most representative of an ocean-type life history where recently emerged fry and parr 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 81% (n = 1,851) of the season's fall-run catch being captured before April 15. During this period, fork lengths averaged 37 mm with 95% 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 16).

The peak in natural origin fall-run Chinook Salmon catch was seen the week of March 12, coinciding with the increased releases into the lower Stanislaus River beginning March 10. Daily average flows increased from 710 cfs on March 9 to 2,312 cfs on March 13 (Figure 14). Consequently, an increase in catch during this discharge event was observed as the majority (56%, *n* = 1,292) of the fall-run Chinook Salmon total were captured between March 11 and March 17 (Figure 14). Evidently, discharge was likely the most influential environmental factor in determining emigration timing of fall-run Chinook Salmon during the 2023 sampling season. Similar observations were previously made on the Stanislaus River by Zeug et al (2014), wherein higher cumulative discharge and flow variability were found to have the highest correlation with successful passage of juvenile Chinook Salmon.

Yearly average condition factor (K) by life stage has slightly decreased since PSMFC began operating the Caswell RSTs in 2017 (Figure 18, Appendix 3). 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, as seen in previous years. Additionally, the average condition factor values for the 2023 sampling season increased for the parr, silvery parr, and smolt life stages relative to the two previous seasons (2021 and 2022), however yearly sample sizes for the smolt and button-up fry life stages are significantly smaller than the other life stages. The California Department of Water Resources' San Joaquin Valley Water Year Hydrologic Classification Indices indicates that 2021 and 2022 were both critical water year types, while 2023 classifies as a wet water year type (CDWR 2023; Appendix 3). Due to the higher flows on the Stanislaus 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 Stanislaus River.

The Stanislaus River experienced higher than average discharge and 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 8, Appendix 9, Appendix 10). 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 Ripon USGS station until July 1, whereas, in an average year, the daily average temperature of 15 C at the Ripon USGS station is typically observed in early May (Appendix 9).

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 the 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, variable water year types. However, we acknowledge several limitations and challenges when interpreting the data collected in 2023 and comparing to previous years due to limitations in sampling and differences in sampling methodologies.

Juvenile salmonid emigration monitoring will continue on the Stanislaus River at Caswell Memorial State Park in 2024. In order to obtain the highest accuracy for catch and passage estimation while maintaining the highest level of safety, adjustments are recommended for future seasons. Firstly, to achieve an increased level of accuracy in the passage estimates, additional focus should be applied to the quantity of efficiency trials completed throughout the sampling season. Expansions to the dates and an increase in total of fish that can be acquired from Merced River Hatchery or Mokelumne River Hatchery have been pre-approved by CDFW, which would allow for more hatchery origin mark recapture trials between January and May if sufficient natural origin fish are not available. Secondly, constructing a debris barrier in front of the RSTs will lessen debris quantity and reduce trap stoppages to allow for higher accuracy in catch and passage estimation. We believe these efforts will strengthen the future of the Stanislaus River Caswell RST project and continue 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: **Weekly environmental conditions on the Stanislaus River during the 2023 sampling season.**

Julian Week	Water Temperature (C°) Avg (Min - Max)	Discharge (cfs) Avg (Min - Max)	DO (mg/L) Avg (Min - Max)	Turbidity (NTU) Avg (Min - Max)	Velocity (m/s) Avg (Min - Max)
1/15 - 1/21	10.3 (8.9 - 11.6)	2,033 (738 - 3,370)	9.69 (9.69)	-	0.5 (0.5)
1/22 - 1/28	9.3 (8.5 - 10.5)	543 (330 - 735)	11.03 (10.50 - 11.74)	8.44 (7.29 - 9.99)	0.3 (0.2 - 0.5)
1/29 - 2/4	8.8 (7.4 - 10.8)	283 (263 - 330)	10.84 (10.18 - 11.47)	5.25 (4.35 - 6.84)	0.3 (0.2 - 0.4)
2/5 - 2/11	10.5 (9.3 - 12.0)	255 (234 - 281)	10.67 (9.51 - 11.54)	4.27 (1.86 - 6.18)	0.4 (0.2 - 0.5)
2/12 - 2/18	9.8 (8.1 - 11.7)	222 (211 - 237)	11.05 (10.52 - 11.75)	3.56 (2.25 - 4.86)	0.3 (0.1 - 0.5)
2/19 - 2/25	9.6 (8.2 - 12.0)	247 (202 - 615)	11.27 (9.67 - 12.13)	3.19 (1.87 - 4.70)	0.3 (0.2 - 0.5)
2/26 - 3/4	9.2 (8.1 - 11.0)	928 (397 - 2,100)	10.87 (10.00 - 11.39)	9.20 (3.93 - 17.20)	0.5 (0.3 - 0.8)
3/5 - 3/11	10.1 (9.1 - 11.5)	837 (513 - 2,010)	10.72 (10.39 - 11.19)	14.19 (3.68 - 46.40)	0.4 (0.2 - 0.9)
3/12 - 3/18	11.6 (10.5 - 12.5)	1,950 (1,630 - 2,440)	9.96 (9.10 - 11.50)	21.92 (13.23 - 30.40)	0.2 (0.1 - 0.4)
3/19 - 3/25	11.2 (10.5- 12.0)	1,847 (1,740 - 1,970)	10.63 (10.21 - 10.90)	18.13 (8.46 - 36.50)	0.3 (0.1 - 0.6)
3/26 - 4/1	11.1 (9.6 - 13.8)	1,337 (645 - 1,860)	10.11 (8.28 - 11.31)	10.86 (4.89 - 24.50)	0.2 (0.1 - 0.6)
4/2 - 4/8	11.5 (10.6 - 13.0)	1,713 (1,280 - 1,790)	10.52 (9.67 - 12.30)	7.71 (3.63 - 11.73)	0.3 (0.1 - 0.4)
4/9 - 4/15	12.4 (11.3 - 13.4)	1,784 (1,740 - 1,850)	9.94 (9.48 - 10.80)	5.68 (3.51 - 8.45)	0.3 (0.1 -0.5)
4/16 - 4/22	13.1 (11.5 - 15.1)	1,106 (391 - 1,770)	9.51 (8.25 - 10.43)	5.43 (2.29 - 9.13)	0.3 (0.1 - 0.5)
4/23 - 4/29	12.9 (12.0 - 13.9)	1,525 (1,500 - 1,580)	9.88 (9.46 - 10.10)	4.79 (1.83 - 7.93)	0.3 (0.1 - 0.5)
4/30 - 5/6	12.6 (10.7 - 14.8)	986 (329 - 1,530)	9.12 (7.93 - 10.16)	3.20 (1.55 - 4.95)	0.3 (0.1 - 0.5)
5/7 - 5/13	12.5 (11.1 - 14.0)	1,461 (988 - 1,530)	10.42 (9.51 - 12.81)	4.06 (2.07 - 5.68)	0.3 (0.1 - 0.5)
5/14 - 5/20	13.6 (12.7 - 14.4)	1,506 (1,480 - 1,560)	9.53 (8.80 - 10.60)	4.10 (3.06 - 6.01)	0.4 (0.1 - 0.8)
5/21 - 5/27	13.4 (12.5 - 14.5)	1,526 (1,500 -1,560)	9.71 (8.41 - 11.00)	3.62 (2.55 - 5.31)	0.4 (0.2 - 0.8)
5/28 - 6/3	13.3 (12.2 - 14.4)	1,537 (1,500 - 1,580)	10.04 (9.55 - 10.42)	3.42 (1.65 - 5.21)	0.4 (0.1 - 0.5)
6/4 - 6/10	13.7 (12.6 - 14.8)	1,530 (1,500 - 1,580)	10.37 (9.63 - 10.99)	4.26 (2.60 - 5.80)	0.3 (0.2 - 0.6)
6/11 - 6/17	13.9 (12.4 - 15.0)	1,522 (1,500 - 1,570)	10.42 (10.21 - 10.61)	3.36 (2.29 - 4.99)	0.5 (0.2 - 0.8)
6/18 - 6/24	13.7 (12.7 - 15.1)	1,514 (1,490 - 1,550)	10.34 (9.85 - 10.68)	4.06 (2.49 - 6.47)	0.4 (0.2 - 0.6)
6/25 - 7/1	14.4 (13.2 - 16.2)	1,502 (991 - 1,580)	9.81 (9.27 - 10.36)	5.38 (2.87 - 7.69)	0.5 (0.2 - 0.7)
7/2 - 7/8	16.0 (13.7 - 18.2)	1,048 (719 - 1,460)	9.21 (8.44 - 9.98)	5.95 (2.95 - 9.12)	0.4 (0.2 - 0.6)
7/9 - 7/15	15.1 (13.7 - 16.9)	1,268 (784 - 1,490)	10.05 (9.52 - 10.42)	5.66 (2.34 - 8.90)	0.6 (0.3 - 1.1)
7/16 - 7/22	15.8 (14.2 - 18.3)	1,239 (728 - 1,510)	8.89 (8.26 - 9.62)	3.97 (2.27 - 6.49)	0.5 (0.3 - 0.7)

Appendix 2: List of fish species caught during the 2023 Stanislaus River RST sampling season.

Common Name	Family Name	Species Name	Total
Chinook Salmon	Salmonidae	*Oncorhynchus tshawytscha*	2,293
Rainbow Trout / steelhead	Salmonidae	*Oncorhynchus mykiss*	2
Black Crappie	Centrarchidae	*Pomoxis nigromaculatus*	4
Bluegill	Centrarchidae	*Lepomis macrochirus*	124
Brown Bullhead	Ictaluridae	*Ameiurus nebulosus*	2
Channel Catfish	Ictaluridae	*Ictalurus punctatus*	1
Common Carp	Cyprinidae	*Cyprinus carpio*	3,452
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*	30
Goldfish	Cyprinidae	*Carassius auratus*	12
Green Sunfish	Centrarchidae	*Lepomis cyanellus*	1
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	119
Hitch	Cyprinidae	*Lavinia exilicauda*	5
Inland Silverside	Atherinopsidae	*Menidia beryllina*	5
Largemouth Bass	Centrarchidae	*Micropterus salmoides*	40
Pacific Lamprey	Petromyzontidae	*Lampetra entosphenus*	156
Prickly Sculpin	Cottidae	*Cottus asper*	13
Red Shiner	Cyprinidae	*Cyprinella lutrensis*	7
Redear Sunfish	Centrarchidae	*Lepomis microlophus*	10
Sacramento Pikeminnow	Cyprinidae	*Ptychocheilus grandis*	161
Sacramento Sucker	Catostomidae	*Catostomus occidentalis*	19
Smallmouth Bass	Centrarchidae	*Micropterus dolomieu*	31
Splittail	Cyprinidae	*Pogonichthys macrolepidotus*	4
Spotted Bass	Centrarchidae	*Micropterus punctulatus*	77
Threadfin Shad	Clupeidae	*Dorosoma petenense*	2
Tule Perch	Embiotocidae	*Hysterocarpus traskii*	1
Unknown			1
Unknown Bass	Centrarchidae	*Micropterus sp.*	7
Unknown Catfish or Bullhead	Ictaluridae		3
Unknown Lamprey	Petromyzontidae		19
Unknown Minnow	Cyprinidae		8
Unknown Sculpin	Cottidae	*Cottus sp.*	3
Unknown Sunfish	Centrarchidae	*Lepomis sp.*	1
Western Mosquitofish	Poeciliidae	*Gambusia affinis*	42
White Catfish	Ictaluridae	*Ameiurus catus*	100

Appendix 3: Average Fulton's condition factor (Avg) and sample size (n) by life stage for natural origin fall-run Chinook Salmon from 2017 through 2023.

Year	Water Year Type	Button-up fry Avg (Range)	Parr Avg (Range)	Silvery parr Avg (Range)	Smolt Avg (Range)
2017	Wet	0.90 (0.44 - 1.31)	1.00 (0.53 - 2.35)	1.10 (0.64 - 1.81)	1.11 (0.84 - 1.28)
2018	Below Normal	0.92 (0.38 - 1.21)	1.04 (0.51 - 1.62)	1.06 (0.80 - 1.69)	1.07 (1.01 - 1.12)
2019	Wet	0.92 (0.47 - 1.44)	1.03 (0.74 - 1.79)	1.10 (0.82 - 1.34)	1.11 (1.01 - 1.18)
2020	Dry	0.87 (0.87)	1.10 (0.48 - 2.72)	1.12 (0.56 - 1.93)	1.10 (0.99 - 1.19)
2021	Critical	-	0.99 (0.83 - 1.21)	1.04 (0.68 - 1.26)	1.07 (0.77 - 1.39)
2022	Critical	0.90 (0.63 - 1.13)	0.90 (0.67 - 1.16)	1.06 (0.76 - 1.35)	1.08 (1.00 - 1.22)
2023	Wet	0.84 (0.47 - 1.13)	1.00 (0.62 - 1.68)	1.07 (0.86 - 1.54)	1.10 (0.94 - 1.21)

Appendix 4: **Genetic results for fin-clip samples from Chinook Salmon caught in the Stanislaus River during the 2023 sampling season.**

Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	W (g)
1/28/2023	4050-001	Fall	Fall	1.00	Fall	37	-
1/28/2023	4050-002	Fall	Fall	1.00	Fall	35	-
2/12/2023	4050-003	Fall	Fall	1.00	Fall	35	-
2/20/2023	4050-004	Spring	Fall	1.00	Fall	62	2.3
2/22/2023	4050-005	Spring	Fall	1.00	Fall	61	2.0
2/23/2023	4051-051	Spring	Fall	0.97	Fall	61	-
2/26/2023	4050-007	Spring	Fall	1.00	Fall	64	2.6
2/26/2023	4050-010	Fall	Fall	1.00	Fall	35	-
2/26/2023	4050-008	Spring	Fall	1.00	Fall	66	2.7
2/26/2023	4050-009	Spring	Fall	1.00	Fall	63	2.7
3/1/2023	4050-012	Spring	Fall	0.99	Fall	68	3.1
3/5/2023	4050-013	Spring	Fall	1.00	Fall	67	3.6
3/6/2023	4050-016	Fall	Fall	1.00	Fall	35	-
3/6/2023	4050-014	Spring	Fall	1.00	Fall	73	3.4
3/6/2023	4050-015	Fall	Fall	1.00	Fall	37	-
3/6/2023	4050-017	Fall	Fall	1.00	Fall	35	-
3/7/2023	4050-018	Spring	Fall	1.00	Fall	64	2.1
3/8/2023	4050-019	Spring	Fall	1.00	Fall	69	2.9
3/11/2023	4050-021	Spring	Fall	1.00	Fall	77	4.5
3/12/2023	4050-020	Spring	Fall	0.95	Fall	65	3.5
3/13/2023	4050-024	Fall	Fall	0.99	Fall	35	-
3/13/2023	4050-023	Fall	Fall	1.00	Fall	36	-
3/13/2023	4050-022	Fall	Fall	1.00	Fall	38	-

3/14/2023	4050-026	Spring	Fall	1.00	Fall	67	2.6
3/14/2023	4050-027	Spring	Fall	1.00	Fall	74	4.4
3/14/2023	4050-025	Spring	Fall	1.00	Fall	66	2.5
3/15/2023	4050-028	Spring	Fall	1.00	Fall	66	2.4
3/16/2023	4051-053	Spring	Fall	1.00	Fall	70	3.1
3/16/2023	4051-052	Spring	Fall	1.00	Fall	66	2.7
3/18/2023	4050-029	Spring	Fall	1.00	Fall	69	3.1
3/20/2023	4050-030	Fall	Fall	1.00	Fall	36	-
3/20/2023	4050-031	Fall	Fall	1.00	Fall	38	-
3/20/2023	4050-032	Fall	Fall	1.00	Fall	35	-
3/25/2023	4050-033	Spring	Fall	1.00	Fall	82	6.1
3/26/2023	4050-036	Fall	Fall	0.92	Fall	37	-
3/26/2023	4050-034	Spring	Fall	1.00	Fall	84	6.2
3/27/2023	4050-037	Fall	Fall	1.00	Fall	39	-
4/3/2023	4050-038	Fall	Fall	1.00	Fall	51	-
4/3/2023	4050-039	Late fall	Fall	1.00	Fall	33	-
4/3/2023	4050-040	Fall	Fall	1.00	Fall	49	-
4/4/2023	4050-041	Fall	Fall	0.86	Fall	49	-
4/5/2023	4050-042	Spring	Fall	1.00	Fall	91	8.8
4/5/2023	4050-043	Spring	Fall	1.00	Fall	84	6.8
4/10/2023	4050-046	Fall	Fall	1.00	Fall	51	1.2
4/10/2023	4050-045	Fall	Fall	1.00	Fall	61	2.2
4/10/2023	4050-044	Fall	Fall	1.00	Fall	58	1.7
4/12/2023	4050-047	Spring	Fall	1.00	Fall	79	5.6
4/14/2023	4051-054	Spring	Fall	1.00	Fall	90	7.9
4/16/2023	4050-048	Spring	Fall	1.00	Fall	84	9.1
4/17/2023	4050-049	Spring	Fall	0.97	Fall	96	10.7
4/17/2023	4050-053	Fall	Fall	1.00	Fall	48	1.1

4/17/2023	4050-050	Spring	Fall	1.00	Fall	92	9.1
4/17/2023	4050-051	Spring	Fall	1.00	Fall	83	6.0
4/20/2023	4051-055	Spring	Fall	1.00	Fall	84	5.8
4/21/2023	4051-056	Spring	Fall	1.00	Fall	92	8.8
4/22/2023	4050-055	Spring	Fall	1.00	Fall	84	6.6
4/24/2023	4050-056	Fall	Fall	1.00	Fall	59	2.4
4/24/2023	4050-058	Fall	Fall	0.99	Fall	58	2.1
4/24/2023	4050-057	Fall	Fall	1.00	Fall	59	2.2
4/30/2023	4050-061	Fall	Fall	1.00	Fall	52	1.2
4/30/2023	4050-060	Fall	Fall	1.00	Fall	57	2.1
4/30/2023	4050-059	Spring	Fall	1.00	Fall	97	8.5
5/1/2023	4050-062	Fall	Fall	1.00	Fall	78	4.5
5/7/2023	4050-063	Fall	Fall	0.71	Fall	80	-
5/7/2023	4050-064	Fall	Fall	1.00	Fall	77	-
5/7/2023	4050-065	Fall	Fall	0.83	Fall	76	-
5/7/2023	4050-066	Spring	Fall	1.00	Fall	96	10.4
5/15/2023	4050-067	Fall	Fall	1.00	Fall	52	-
5/15/2023	4050-069	Fall	Fall	1.00	Fall	84	6.2
5/15/2023	4050-068	Fall	Fall	1.00	Fall	77	4.9
5/22/2023	4050-070	Fall	Fall	1.00	Fall	79	5.0
5/23/2023	4050-072	Fall	Fall	1.00	Fall	54	-
5/23/2023	4050-073	Fall	Fall	1.00	Fall	88	7.2
5/23/2023	4050-071	Spring	Fall	1.00	Fall	109	12.5
5/30/2023	4050-074	Fall	Fall	1.00	Fall	88	6.7
5/31/2023	4050-075	Fall	Fall	1.00	Fall	91	8.2
5/31/2023	4050-076	Fall	Fall	1.00	Fall	75	3.7
6/5/2023	4050-077	Fall	Fall	1.00	Fall	97	11.9
6/5/2023	4050-079	Fall	Fall	1.00	Fall	83	6.2

6/5/2023	4050-078	Fall	Fall	1.00	Fall	92	7.9
6/12/2023	4050-081	Fall	Fall	0.96	Fall	97	9.8
6/12/2023	4050-082	Fall	Fall	1.00	Fall	97	-
6/12/2023	4050-080	Fall	Fall	1.00	Fall	96	10.6
6/13/2023	4050-083	Fall	Fall	1.00	Fall	90	8.3
6/13/2023	4050-084	Fall	Fall	1.00	Fall	97	10.2
6/20/2023	4050-085	Fall	Fall	1.00	Fall	92	8.7
6/21/2023	4050-086	Fall	Fall	1.00	Fall	92	-
6/21/2023	4050-087	Fall	Fall	1.00	Fall	93	9.6
6/26/2023	4050-088	Fall	Fall	1.00	Fall	97	10.4
6/26/2023	4050-089	Fall	Fall	1.00	Fall	109	13.3
6/26/2023	4050-090	Fall	Fall	1.00	Fall	99	11.3

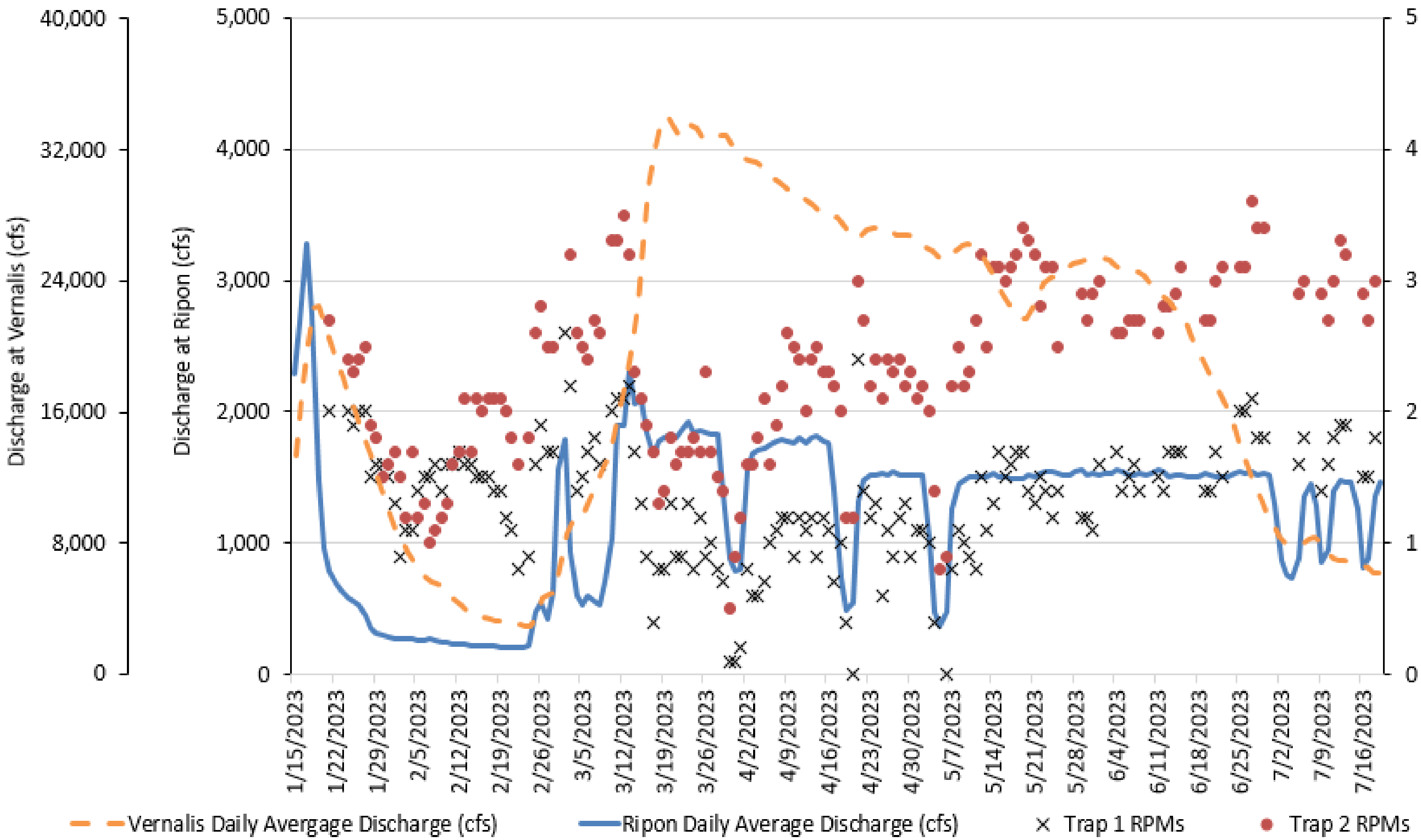
Appendix 5: **Monthly average fork length or total length in mm (Avg), minimum and maximum fork lengths or total lengths (Range), and sample size (*n*) for each non-salmonid species captured during the 2023 Stanislaus River RST sampling season.**

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)	July Avg (Range, n)
Black Crappie	89 (79 - 103, *n* = 3)	-	-	-	-	-	58 (58, *n* = 1)
Bluegill	38 (25 - 120, *n* = 82)	36 (27 -50, *n* = 17)	41 (24 - 84, *n* = 15)	37 (37, *n* = 2)	31 (28 - 34, *n* = 2)	49 (24 - 130, *n* = 5)	134 (134, *n* = 1)
Brown Bullhead	144 (144, *n* = 1)	199 (199, *n* = 1)	-	-	-	-	-
Channel Catfish	-	-	-	-	-	-	92 (92, *n* = 1)
Common Carp	-	-	NA (NA, *n* = 1)	-	-	61 (23 - 114, *n* = 1,173)	65 (37 - 121, *n* = 2,278)
Golden Shiner	66 (55 - 76, *n* = 2)	77 (73 - 81, *n* = 2)	65 (48 - 77, *n* = 9)	-	-	47 (39 - 54, *n* = 2)	52 (42 - 75, *n* = 15)
Goldfish	-	-	-	-	-	49 (49, *n* = 1)	68 (50 - 83, *n* = 11)
Green Sunfish	-	-	-	-	-	130 (130, *n* = 1)	-
Hardhead	46 (26 - 59, *n* = 5)	57 (52 - 59, *n* = 4)	55 (34 - 74, *n* = 63)	52 (38 - 131, *n* = 26)	50 (45 - 57, *n* = 13)	59 (55 - 67, *n* = 3)	54 (44 - 63, *n* = 5)
Hitch	-	32 (32, *n* = 1)	57 (43 - 71, *n* = 2)	45 (45, *n* = 1)	-	48 (48, *n* = 1)	-
Inland Silverside	-	-	-	50 (50, *n* = 1)	-	78 (68 - 87, *n* = 3)	80 (80, *n* = 1)
Largemouth Bass	-	44 (44, *n* = 1)	72 (65 - 82, *n* = 3)	67 (67, *n* = 1)	-	-	58 (42 - 78, *n* = 35)
Pacific Lamprey	130 (116 - 146, *n* = 5)	135 (98 - 175, *n* = 100)	130 (111 - 163, *n* = 46)	317 (152 - 481, *n* = 2)	-	117 (112 - 120, *n* = 3)	-

Prickly Sculpin	-	76 (70 - 82, *n* = 2)	130 (130, *n* = 1)	-	-	48 (37 - 59, *n* = 6)	51 (43 - 62, *n* = 4)
Red Shiner	-	-	-	-	-	49 (45 - 54, *n* = 3)	64 (42 - 93, *n* = 4)
Redear Sunfish	43 (39 - 55, *n* = 5)	86 (33 - 190, *n* = 3)	124 (124, *n* = 1)	-	87 (87, *n* = 1)	-	-
Sacramento Pikeminnow	263 (263, *n* = 1)	-	49 (31 - 83, *n* = 54)	44 (31 - 65, *n* = 35)	46 (37 - 67, *n* = 20)	50 (28 - 86, *n* = 40)	50 (25 - 90, *n* = 11)
Sacramento Sucker	47 (33 - 60, *n* = 2)	-	56 (39 - 75, *n* = 5)	50 (43 - 56, *n* = 2)	390 (390, *n* = 1)	26 (20 - 30, *n* = 8)	NA (NA, *n* = 1)
Smallmouth Bass	-	-	86 (62 - 109, *n* = 2)	154 (111 - 196, *n* = 2)	156 (74 - 232, *n* = 5)	191 (84 - 264, *n* = 7)	73 (52 - 210, *n* = 15)
Sacramento Splittail	-	-	-	-	-	53 (50 - 57, *n* = 3)	62 (62, *n* = 1)
Spotted Bass	64 (48 - 83, *n*= 4)	121 (58 - 184, *n* = 2)	296 (296, *n* = 1)	126 (61 - 191, *n* = 2)	153 (57 - 263, *n* = 12)	205 (54 - 300, *n* = 12)	66 (47 - 218, *n* = 44)
Threadfin Shad	-	-	-	-	-	117 (117, *n* = 1)	113 (113, *n* = 1)
Tule Perch	-	100 (100, *n*= 1)	-	-	-	-	-
Unknown	-	-	-	-	NA (NA, *n* = 1)	-	-
Unknown Bass	-	-	-	-	22 (22, *n* = 1)	46 (17 - 167, *n* = 6)	-
Unknown Catfish or Bullhead	-	NA (NA, *n* = 1)	53 (53, *n* = 2)	-	-	-	-
Unknown Lamprey	97 (97, *n* = 1)	118 (86 - 141, *n* = 5)	144 (135 - 156, *n* = 3)	113 (98 - 127, *n* = 2)	122 (93 - 150, *n* = 4)	108 (108, *n* = 1)	126 (110 - 136, *n* = 3)
Unknown Minnow	33 (33, *n* =1)	-	-	35 (35, *n* = 1)	-	21 (20 - 22, *n* = 2)	82 (82, *n* = 1)

Unknown Sculpin	-	-	-	-	31 (31, *n* = 1)	NA (NA, *n* = 1)	30 (30, *n* = 1)
Unknown Sunfish	-	-	-	-	38 (38, *n* = 1)	-	-
Western Mosquitofish	24 (21 - 26, *n* = 3)	34 (25 - 54, *n* = 4)	35 (28 - 47, *n* = 6)	30 (26 - 38, *n* = 18)	33 (28 - 38, *n* = 5)	24 (24, *n* = 1)	37 (31 - 41, *n* = 5)
White Catfish	55 (46 - 71, *n* = 5)	61 (40 - 180, *n* = 37)	55 (39 - 68, *n* = 27)	58 (49 - 65, *n* = 5)	61 (47 - 115, *n* = 15)	55 (47 - 59, *n* = 5)	84 (60 - 98, *n* = 6)

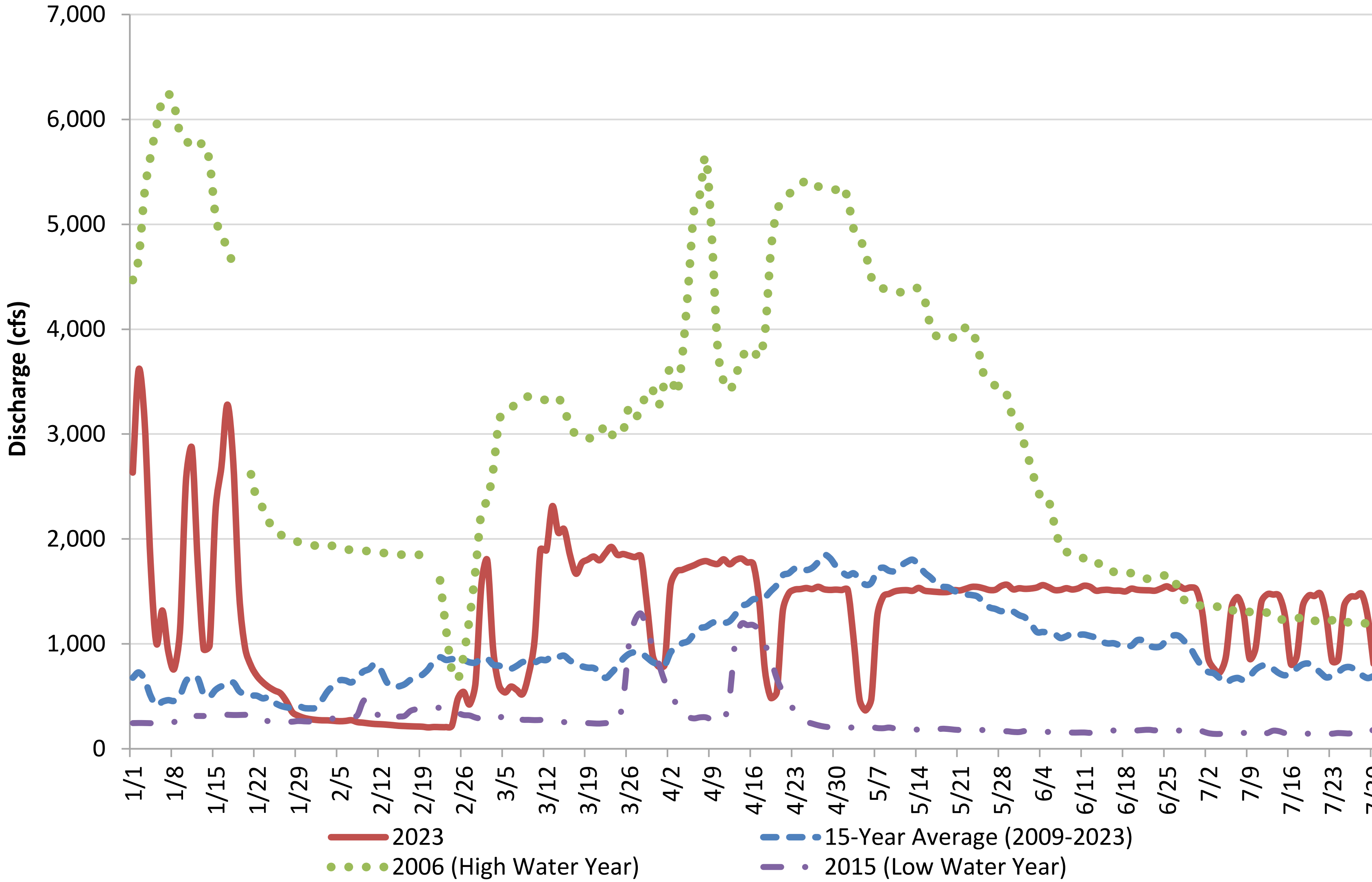
Appendix 6: **Daily average discharge (cfs) on the mainstem San Joaquin River at Vernalis (orange dashes; USGS Station number 11303500), daily average discharge (cfs) on the Stanislaus River at Ripon (blue line; USGS Station number 11303000), Trap 1 RPMs (black X's) and Trap 2 RPMs (red round dots).**



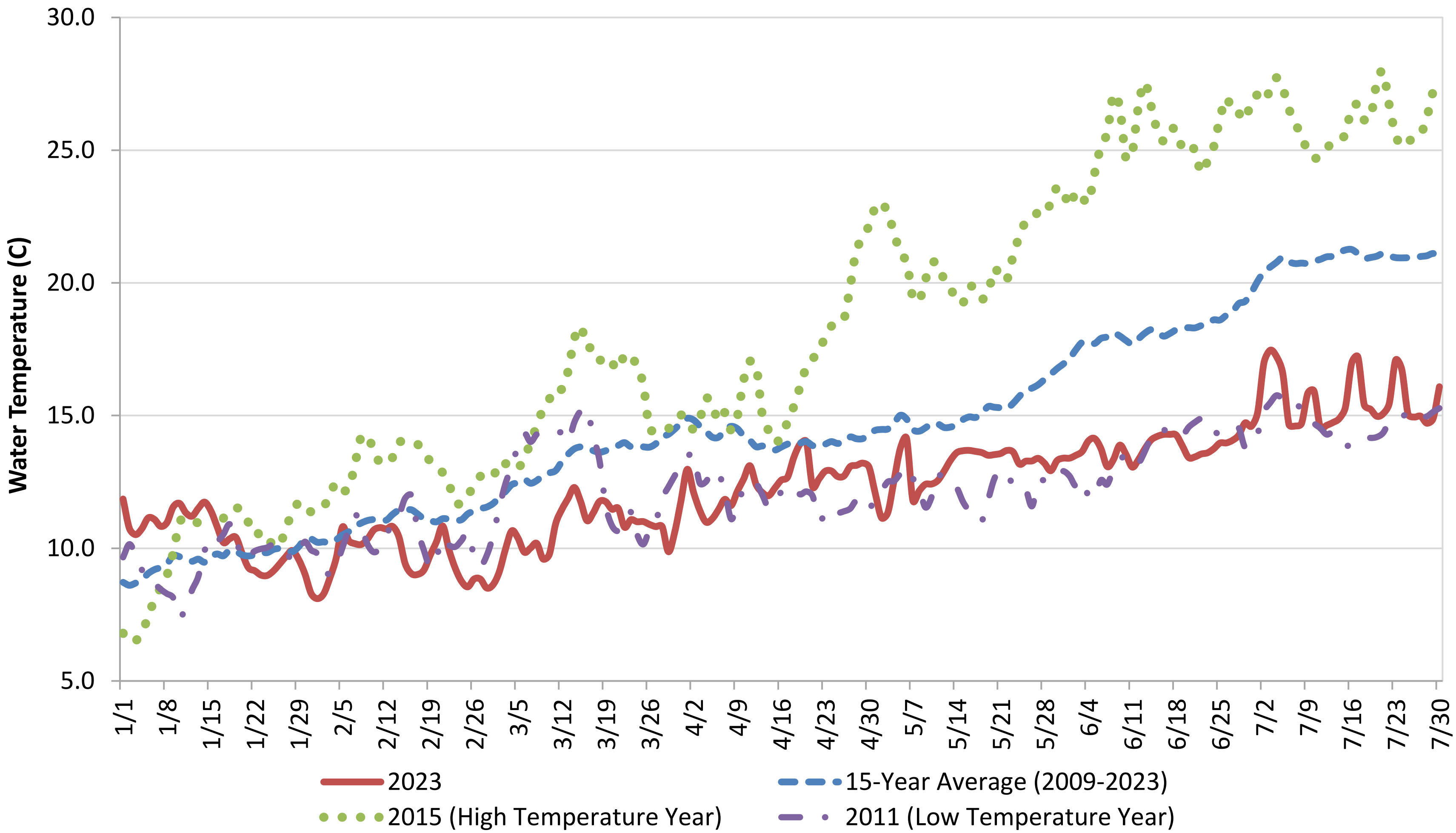
Appendix 7: **Median discharge (cfs) between January 1 and July 30, total catch of fall-run, late fall-run, and spring-run Chinook Salmon, *O. mykiss*, and lamprey from the 1996 – 2021 Stanislaus River RST sampling seasons (CFS 2016, PSMFC 2017-2022).**

Year	Discharge (cfs)	Fall-run	Late Fall-run	Spring-run	*O. mykiss*	Lamprey
1996	1,190	2,468	0	0	4	857
1997	1,670	2,357	0	0	11	57
1998	2,030	19,525	0	0	4	445
1999	1,510	41,234	0	0	12	969
2000	1,000	73,715	0	0	15	4,356
2001	530	9,907	0	0	34	9,762
2002	534	3,835	0	0	10	210
2003	587	14,059	0	0	13	476
2004	470	40,087	0	0	19	3,589
2005	348	25,287	0	0	11	5,551
2006	2,980	1,589	0	0	2	9
2007	858	2,909	0	0	23	502
2008	462	230	0	0	1	1,010
2009	376	767	0	0	5	1,074
2010	345	1,102	0	0	1	5,011
2011	1,670	605	0	0	2	545
2012	601	1,199	0	0	3	265
2013	451	19,072	0	0	4	276
2014	347	2,083	0	0	3	1,304
2015	245	905	0	0	2	1,162
2016	299	2,207	0	0	2	11,839
2017	1,530	8,246	0	0	0	5
2018	984	3,515	0	1	0	272
2019	1,990	6,498	0	0	0	686
2020	809	912	0	0	2	1,624
2021	554	199	0	0	0	3,444
2022	472	989	0	0	0	253
2023	1,500	975	0	0	2	2,293

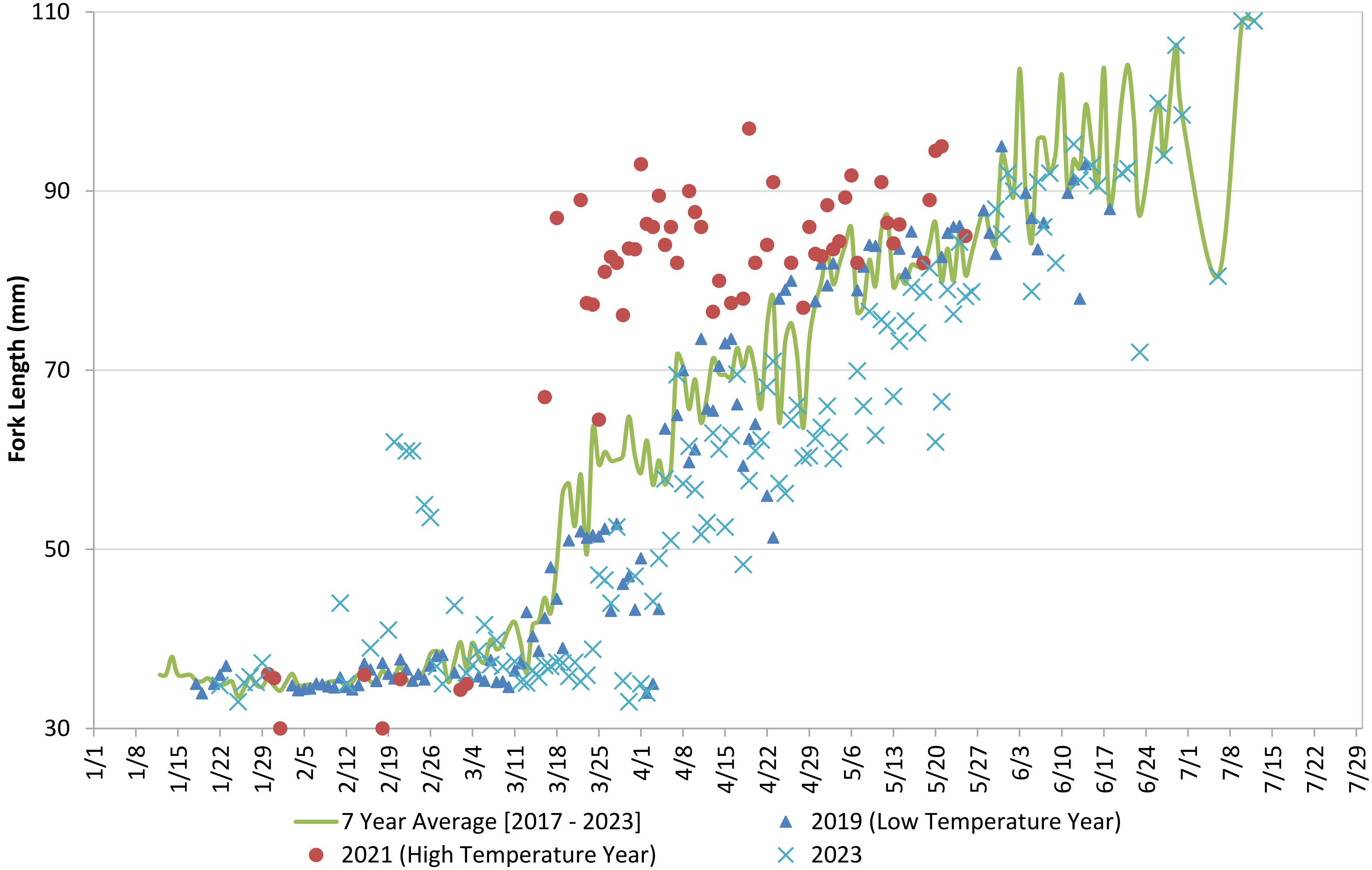
Appendix 8: **Daily average discharge (cfs) on the Stanislaus River at Ripon for the 15-year period 2009 – 2023, a high water year in 2006 (green round dots), a low water year in 2015 (purple dash dots), the 15-year average (blue dashes) and the current year (2023, red line). Data from USGS station number 11303000.**



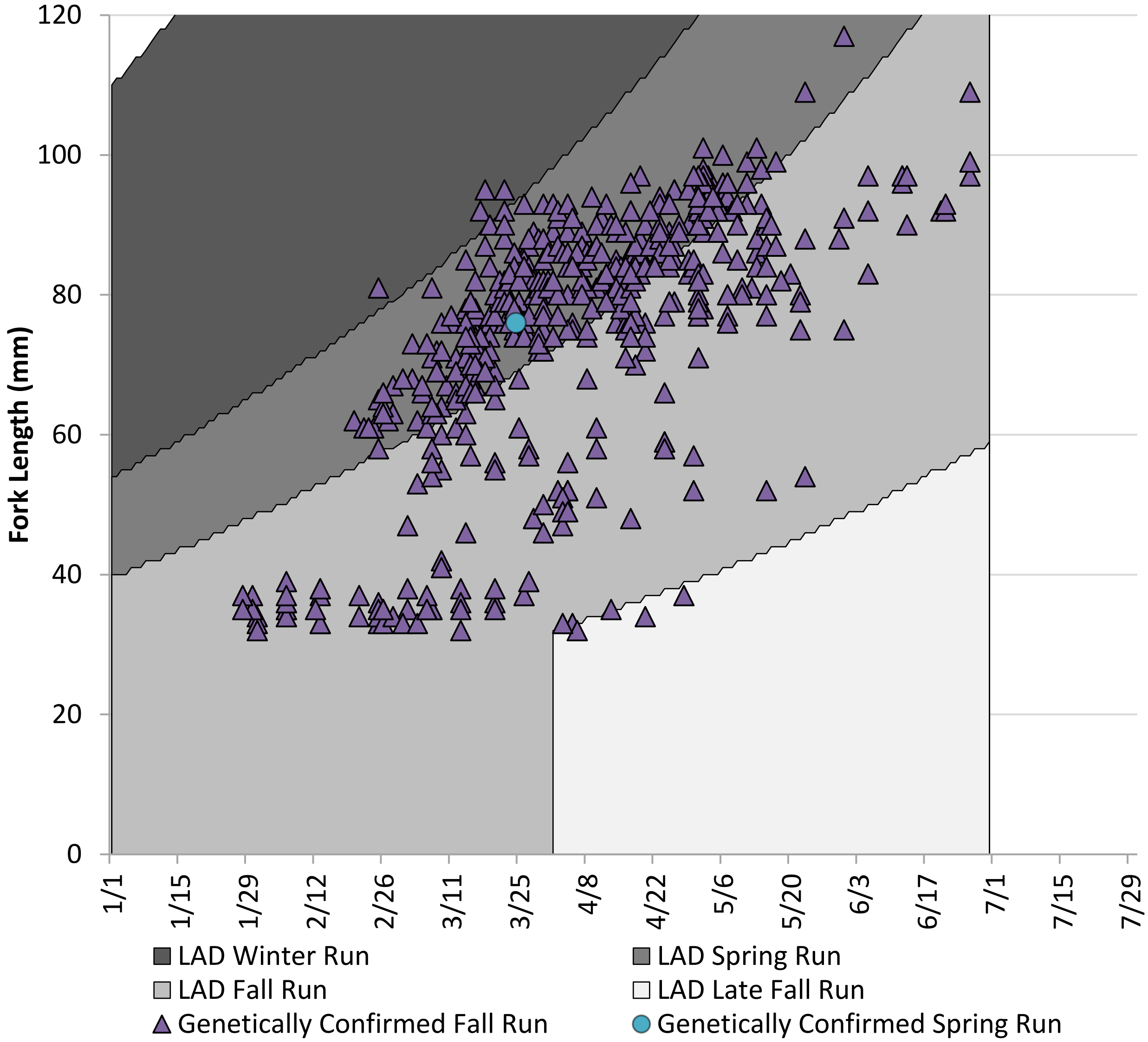
Appendix 9: **Daily average water temperature (°C) in the Stanislaus River at Ripon for the 15-year period 2009-2023, a high temperature year in 2015 (green round dots), a low temperature year in 2011 (purple dash dots), the 15 year average (blue dashes) and the current year (2023, red line). Data from USGS station number 11303000.**



Appendix 10: **Daily average fork length (mm) from 2017 – 2023, a high water temperature year in 2021 (red round dots), a low water temperature year in 2019 (blue triangles), the 7 year average (green line) and the current year (2023, blue X's).**



Appendix 11: **Daily fork length distribution of SNP genetically sampled natural origin Chinook Salmon from 2017 through 2023.**



LAD Run Assignment	SNP Confirmed Fall Run	SNP Confirmed Spring Run
LAD Fall	237	0
LAD Late Fall	6	0
LAD Spring	246	1
LAD Winter	4	0