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

January – June 2022

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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	Cramer Fish Sciences
cfs	cubic feet per second
CI	Confidence Interval
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DO	dissolved oxygen
ESA	Endangered Species Act
g	gram
L	liter
m	meter
m/s	meters per second
mg/L	milligrams per liter
mm	millimeter
NMFS	National Marine Fisheries Service
NMFS BiOp	NMFS biological and conference opinion
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
OID	Oakdale Irrigation District
PSMFC	Pacific States Marine Fisheries Commission
RPA	Reasonable and Prudent Alternatives
RPM	revolutions per minute
RST	rotary screw trap
SIT	Science Integration Team
SJRRP	San Joaquin River Restoration Program
SNP	single-nucleotide polymorphism
SSJID	South San Joaquin Irrigation District
St. Dev.	standard deviation
SWT	Stanislaus Watershed Team
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
VIE	Visual Implant Elastomer

Abstract

Operation of rotary screw traps on the lower Stanislaus River at Caswell Memorial State Park in 2022 is part of the U.S Fish and Wildlife Service's Anadromous Fish Restoration Program and Comprehensive Assessment and Monitoring Program under the Central Valley Project Improvement Act. 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*. Secondary objectives of the trapping operations focus on collecting fork length and weight data for juvenile salmonids, collecting fin clips from juvenile salmonids to determine genetic run assignment, and gathering environmental data that will be used to develop models that correlate environmental parameters with salmonid size, temporal presence, abundance, and production.

For the 2022 survey season, two 2.4 m (8 foot) rotary screw traps were operated at Caswell Memorial State Park on the lower Stanislaus River in California. Sampling occurred on 143 days of the 154-day season (93%) beginning January 6 and concluding on June 8. Following genetic analysis, it was determined that a total of 989 fall-run Chinook Salmon were captured, as well as zero steelhead. Most of the juvenile salmon captured were identified as button-up fry followed by silvery parr, parr, smolt, and yolk-sac fry life stages. The number of juvenile fall-run Chinook Salmon that were estimated to have emigrated past the Caswell trap site during the 2022 survey season was 113,286 individuals (95% Confidence Interval: 58,650 – 483,200). The passage of juvenile fall-run Chinook Salmon peaked the week of February 5th, when 44% of the total (n = 50,388) was estimated. Passage estimates for steelhead and non-salmonid fish taxa were not assessed due to minimal catch.

This annual report also includes eight appendices to describe different environmental variables and studies related to the trap site or rotary screw trap operations during the 2022 survey 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 *O. 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, introduction of 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 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 and late fall-run Chinook Salmon are a species of special concern, while California Central Valley steelhead are listed as threatened under the ESA.

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 (CVP). 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 rotary screw traps (RSTs) to monitor juvenile salmonids on the Stanislaus River (USBR 2019).

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

The lower Stanislaus River rotary screw traps (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 steelhead 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 cover 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). 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 Dam is equally and jointly owned by the Oakdale Irrigation District (OID) and the South San Joaquin Irrigation District (SSJID). The construction of the 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 rotary screw traps (CFS 2006). Two 8 foot rotary screw traps 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 2: Stanislaus River rotary screw trap site at Caswell Memorial State Park captured by Google Earth on September 2018.). Access to the trapping site was gained through a private road.

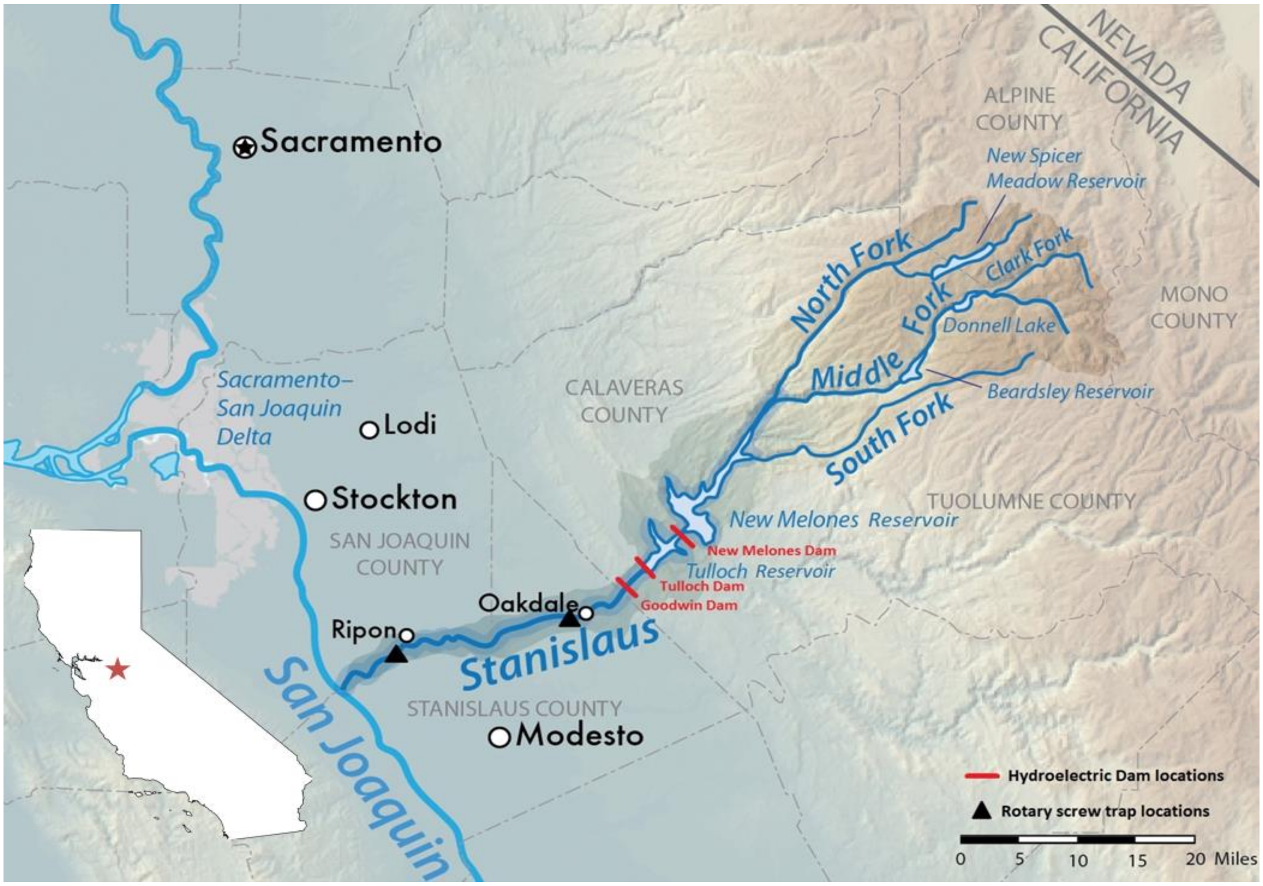

Figure 1: Map of the Stanislaus River and rotary screw trap sites at Caswell Memorial State Park and Oakdale. Inset map illustrates the Stanislaus River in the state of California.

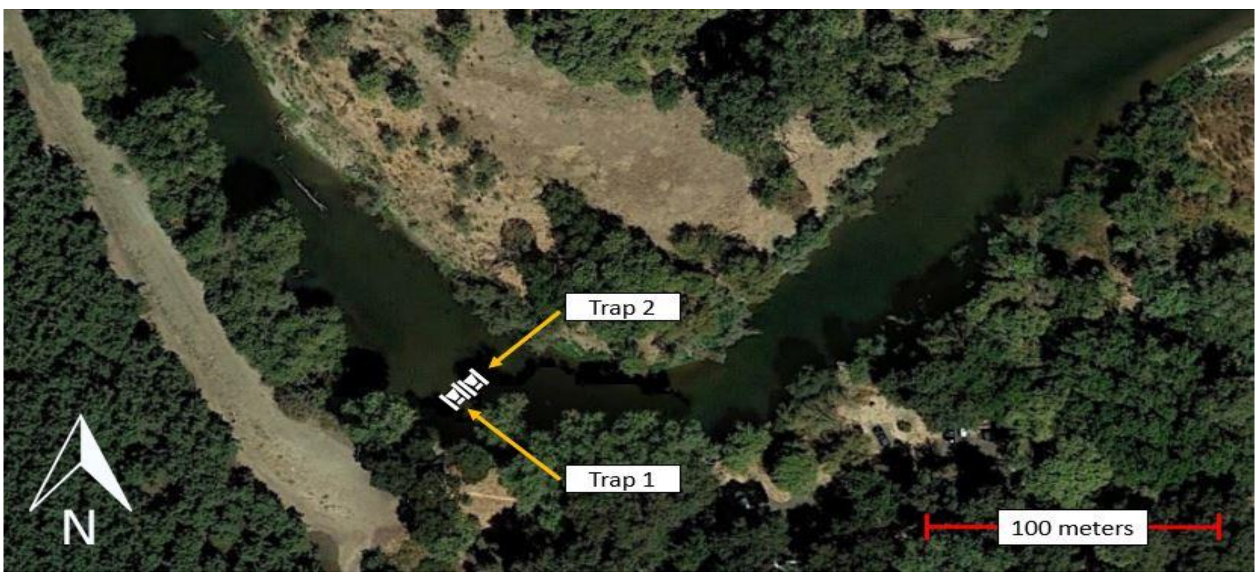

Figure 2: Stanislaus River rotary screw trap site at Caswell Memorial State Park captured by Google Earth on September 2018.

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. Reflective orange buoys were placed on the anchor lines 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 until the following Monday.

Trap Operations

Two 2.4 meter (8 foot) diameter RSTs were deployed in a side-by side configuration and designated as Trap 1 and Trap 2. 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 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 storm events or exceptionally high discharge events, increases in debris size or quantity could hinder trap functionality and potentially increase fish mortality. Therefore, in cases where storms or flow increases caused a significant and unmanageable increase in debris load, traps were taken "out of service" (i.e., cones raised, live well screens removed, and traps removed from the thalweg) until conditions improved.

On daily trap visits, trap function was assessed as "functioning normally," "functioning, but not normally," or "stopped functioning." If the trap was functioning, the revolutions per minute (RPM) was recorded. Subsequently, intakes were checked and recorded as "clear," "partially blocked," "completely blocked," or "backed up into cone." If the trap was not functioning upon arrival, the trap was restored to its normal function without raising the cone. After collecting environmental data and 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 on each trap.

Environmental Parameters

During trap visits, various environmental parameters were recorded at least once per visit. Temperature (C) and dissolved oxygen (DO; mg/l) were measured using a YSI Ecosense DO200A (Yellow Springs Instruments), velocity (m/s) was measured in front of each cone using a Global Water FP111 flow probe, and turbidity (NTU) was collected in front of each cone and measured using a portable turbidity meter (Eutech; Model TN-100). When water depth was less than 3 m, a depth rod was used to record water depth to the nearest centimeter on the port and starboard side pontoons in line with the front of the trap cones. Average daily river discharge (cfs) and average daily river temperature (C) for the Stanislaus River was calculated from instantaneous measurements recorded upstream of the RSTs from the USGS Stanislaus River at Ripon monitoring station (USGS station number 11303000).

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, and tongs. To begin, a rake was used to incrementally remove debris from the live well by placing approximately 2 or 3 scoops (3 - 5 gallons) into the 18 gallon tub. Then, a smaller scoop (approximately 0.25 gallons) of debris was removed from the 18 gallon tub and placed onto the measuring board. Tongs were then used to spread out the debris to carefully scan and ensure any fish trapped in debris were removed and placed into their respective 5 gallon holding bucket.

Fish were separated based on species, race, and marks. Length-at-date (LAD) criteria developed for the Sacramento River was used to assign the run at capture for Chinook Salmon to separate suspected ESA listed 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 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 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, dissolved oxygen and temperature was maintained utilizing 12V aerators, frozen water bottles, and umbrellas for shade to keep holding buckets within 2 degrees Celsius (C) of the river temperature. Overcrowding was also avoided by placing no more than 120 fry, 80 parr, or 50 smolts in a single bucket. Upon reaching capacity, a perforated screw top lid was secured so each holding bucket could be submerged in the river to ensure safe DO and temperature until the fish were ready to be processed.

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

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

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

Fish Processing

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

Data was collected on all species and is detailed by species and run in Table 1. Fork length or total length was recorded to the nearest millimeter (mm). Weight was recorded to the nearest 0.1 gram (g) for up to 25 natural salmonids that were greater than or equal to 40 mm. Salmonid life stages were assigned by following the criteria of the smolt index rating (Table 2). Lamprey life stages were identified as ammocoete (larval), macrophthalmia (juvenile), or adult. All other non-salmonid species were identified as either a juvenile or adult life stage. When applicable, the presence of marks from past trap efficiency trials or the absence of an adipose fin on 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". Additionally, genetic samples were collected for a subsample of LAD spring-run and fall-run Chinook Salmon. After being processed, each fish was placed into an aerated recovery bucket containing 5 ml stress coat before being released downstream of the RSTs.

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

Smolt Index	Life Stage	Morphological Criteria
1	Yolk-sac fry	* Newly emerged with visible yolk-sac
2	Button-up Fry	* Recently emerged with yolk sac absorbed * Seam along mid-ventral line visible * Pigmentation undeveloped
3	Parr	* Seam along mid-ventral line not visible * Scales firmly set * Darkly pigmented with distinct parr marks * Minimal silvery coloration
4	Silvery Parr	* Parr marks visible but faded * Intermediate degree of silvering
5	Smolt	* Parr marks highly faded or absent * Bright silver or nearly white coloration * Scales easily shed (deciduous) * Black trailing edge on caudal fin * Body/head elongating
6	Adult	* ≥ 300mm

Fin Clip Collection

To evaluate the accuracy of the LAD criteria, Chinook Salmon fin clips were collected to accurately determine run assignment through genetic analysis. Fin clips approximately 1 - 2 mm^2 were taken from the upper caudal lobe using disinfected dissection scissors. Clips were stored in 2 ml vials filled with 100% ethanol in a cool location away from direct sunlight. Up to 10 fin clips per week were taken from LAD fall-run and spring-run Chinook Salmon.

The fin clips were split, and the genetic samples were sent to the CDFW Tissue Archive for storage and to U.S. Fish and Wildlife Service's (USFWS) Abernathy Fish Technology Center to assign genetic run using the panel of single-nucleotide polymorphism (SNP) markers described by Clemento et al. (2014). This panel of SNPs was developed by staff from NOAA Fisheries and is now used for several applications by the USFWS and several partner groups (Christian Smith, USFWS, pers. comm.). Detailed methods for DNA extraction, genotyping, and run assignment are described in Abernathy Fish Technology Center Standard Operating Procedure #034.

After receiving genetic results, the SNP panel's probabilities were used to assign final run assignment for all genetically sampled fish. For all LAD fall-run Chinook Salmon that were not genetically sampled, a final run assignment of fall-run was applied as the LAD criteria continued to accurately assign this run. Conversely, for all LAD spring-run Chinook Salmon that were not genetically sampled, a final run assignment of fall-run was applied as the LAD criteria continued to inaccurately assign this run (PSMFC 2017 – 2021).

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

Trap Efficiency

Trap efficiency trials were conducted to quantify the proportion of fall-run Chinook Salmon captured by the RSTs to estimate the total passage of fall-run migrating past the site. Trap efficiency was measured using Bismark Brown Y (BBY) stain as the marking method.

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

At least 300 Chinook Salmon were used to conduct each trap efficiency trial with BBY stain. If less than 300 fish were captured on a given day, fish were held overnight and the fish captured the following day were added to the previous day's catch total to acquire the target number of fish. If daily catch totals continued to be too low, Chinook Salmon were provided by the Oakdale RSTs.

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. Additionally, all releases occurred close to dusk to minimize predation.

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

Retention in Analysis

Under ideal circumstances, the rotary screw traps function normally and continuously between trap visits. However, trap stoppages and abnormal trap functionality can adversely affect catch which ultimately would misrepresent passage estimates. To account for this, if the trap was stopped upon arrival, determined to have been functioning normally for less than 70% of the sampling period, and the West Inc. model imputed a catch greater than the actual catch during the trap visit, the data was excluded from the analysis and the imputed catch is used to calculate passage estimates. This threshold is 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% AND Imputed Catch > Actual Catch

Passage Estimates

Fall-run Chinook Salmon passage estimates were developed using an enhanced efficiency model developed by West Inc. that includes raw catch, trap efficiency, and other parameters. The model description from West Inc. is provided in Appendix 2. Confidence intervals (CI) were computed using parametric bootstrap or Monte Carlo methods as described in McDonald and Banach (2010).

Fulton's Condition Factor

Fall-run Chinook Salmon condition was assessed using the Fulton's condition factor. The first 25 Chinook Salmon greater than or equal to 40 mm were measured for weight and fork length each day. 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 6 and concluded June 8 with 143 days of sampling effort in the 154-day season (93%; Figure 3). Of the 143 days of sampling effort, the traps sampled successfully for approximately 5,806 hours, and sampled unsuccessfully for approximately 1,011 hours (Figure 4). Unsuccessful sampling was a consequence of debris stopping the trap at the entrance of the cone or in the intakes to the live well. Sampling of both traps was suspended for a total of eleven days over the course of the season with no outages being greater than seven days. Weekend shutdowns began May 21 and continued through the duration of the season accounting for seven days without sampling. Trapping was suspended on two other occasions due to staffing shortages, accounting for the remaining four days without sampling.

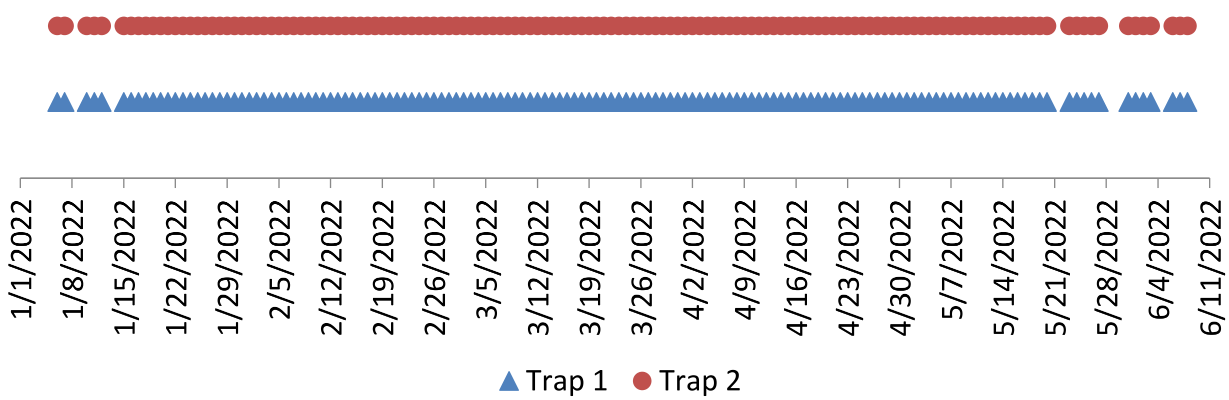

Figure 3: Dates sampling occurred for each trap during the 2022 Stanislaus rotary screw trap survey season.

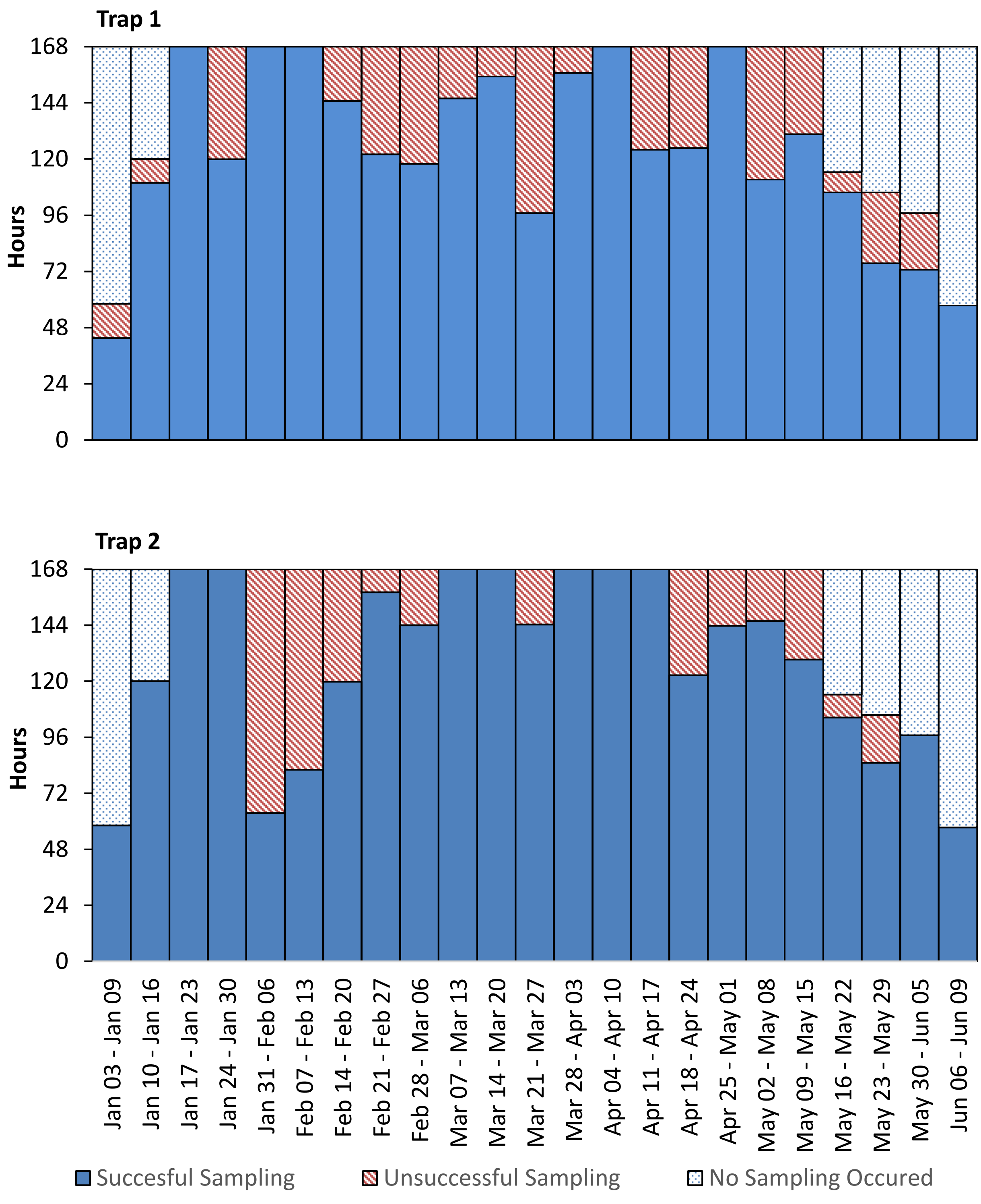

Figure 4: Weighted average hours per Julian week that both traps sampled successfully, sampled unsuccessfully, or did not sample during the 2022 Stanislaus River rotary screw trap survey season.

Environmental Summary

Appendix 3 provides a summary of the environmental conditions averaged by Julian week, starting on January 1, and concluding June 11. 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 February 9 and 11 and a minimum from January 25 through January 29 (range: 208 – 1,510 cfs). Additionally, the daily average discharge reached a maximum on February 11 and a minimum on January 25, 27, and 28 (range: 209 – 1,477 cfs). Instantaneous river temperature, also recorded in 15-minute intervals by USGS at the Ripon gauge station, recorded a maximum temperature on May 25 and minimum on January 3 (range: 8.2 – 19.8 °C).

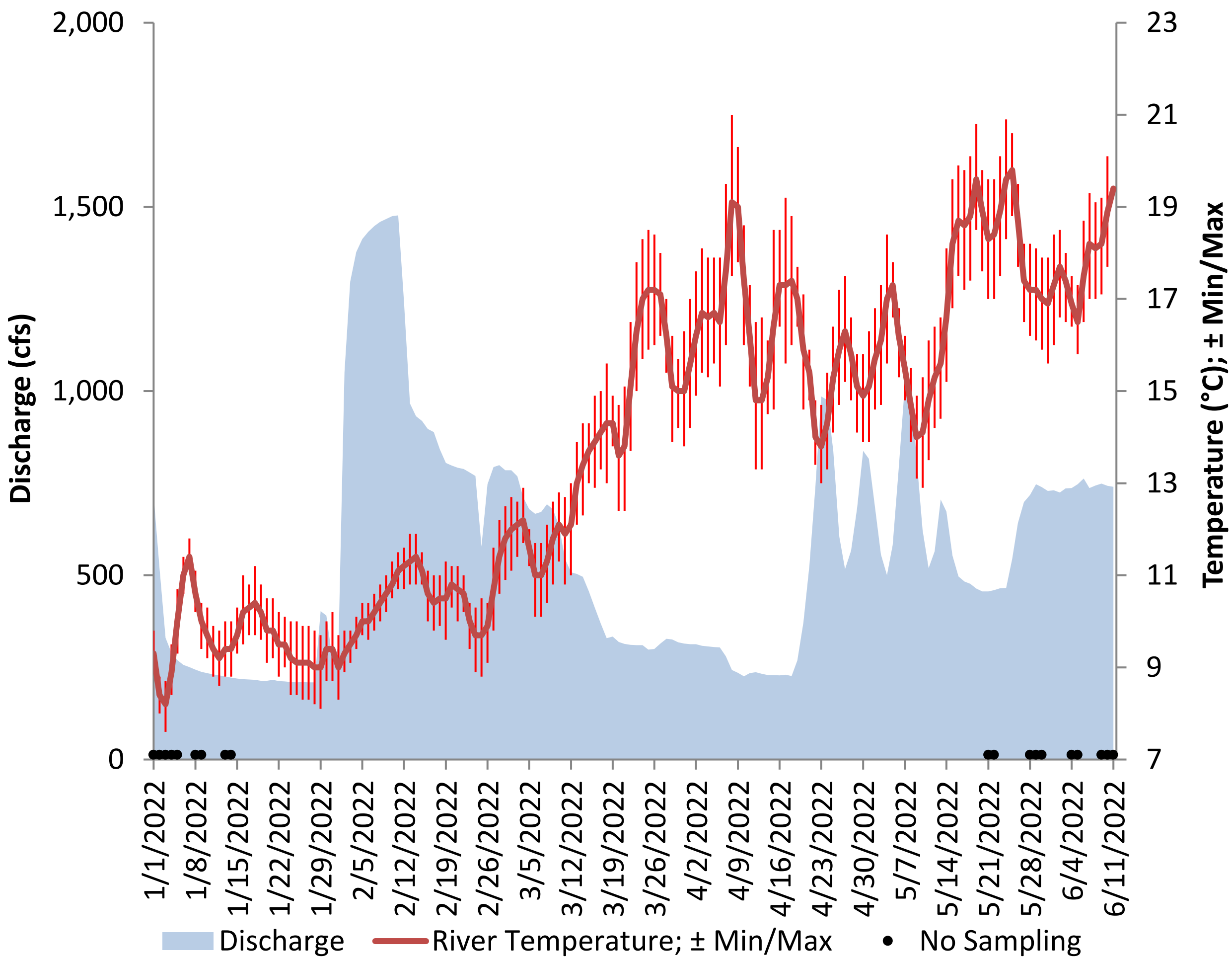

Figure 5: Daily average discharge (cfs) measured at Ripon, and the daily minimum, maximum, and average water temperature (C) measured at Ripon, and dates no sampling occurred during the 2022 Stanislaus River rotary screw trap survey season.

Velocity, turbidity, and dissolved oxygen were measured during trap visits throughout the season (Figure 6). Water velocity for Trap 1 ranged from 0.20 – 0.90 m/s (mean: 0.40 m/s), while Trap 2 also had a range of 0.20 – 0.90 m/s (mean: 0.47 m/s). Mean difference in velocity between Trap 1 and Trap 2 was 0.07 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 January 25 and a maximum on February 2 with a range of 0.86 – 8.35 NTU (mean: 2.46 NTU). Turbidity for Trap 2 reached a minimum on March 11 and a maximum on February 2 with a range of 0.94 – 7.01 NTU (mean: 2.19 NTU). Dissolved oxygen reached a minimum on June 8 and a maximum on January 24 with a range of 7.25 – 12.55 mg/L.

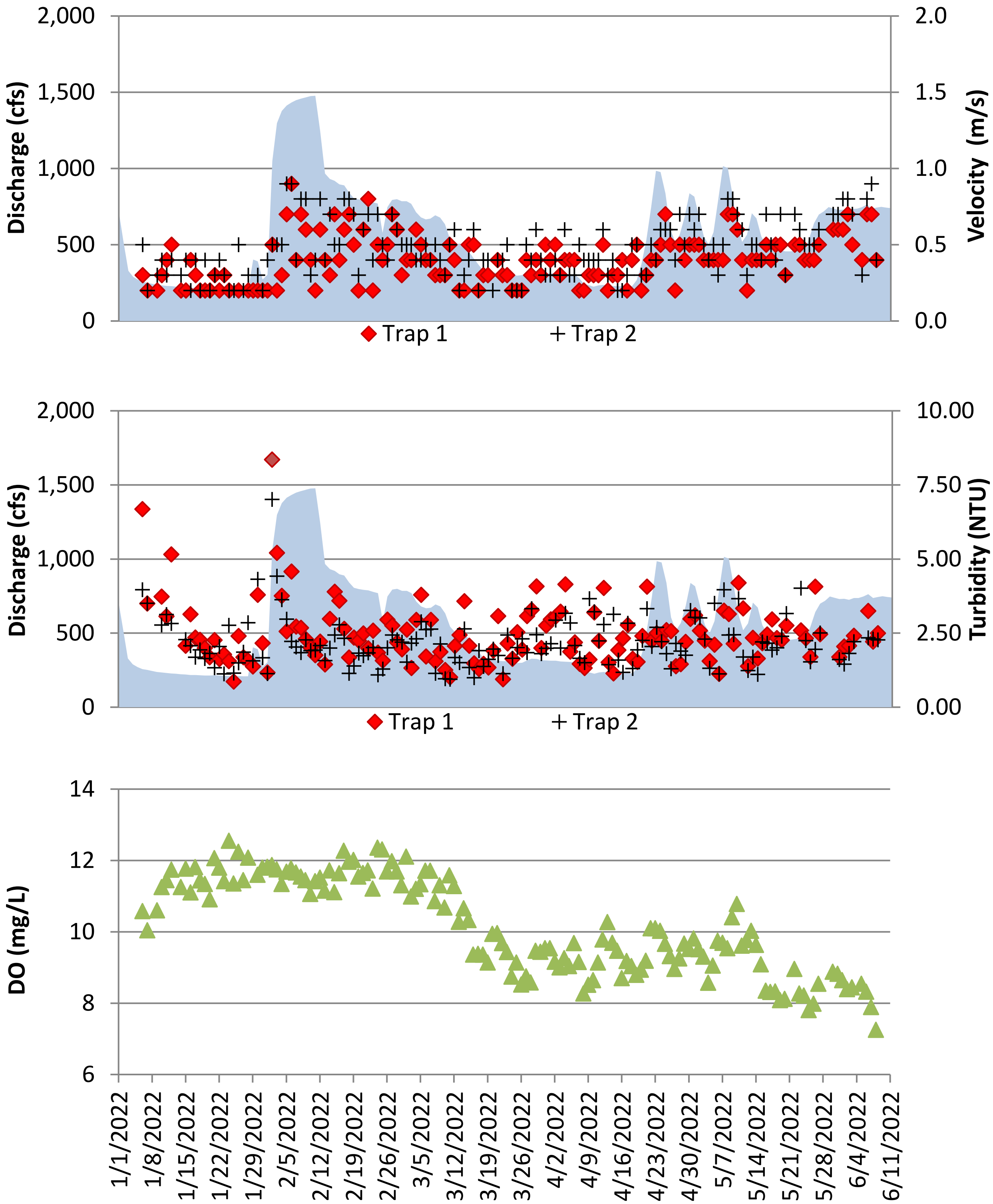

Figure 6: Daily average velocity (m/s), turbidity (NTU), discharge (cfs) measured at Ripon, and dissolved oxygen (mg/L) for both traps during the 2022 Stanislaus River rotary screw trap survey season.

Catch

The two rotary screw traps deployed during the 2022 survey season captured 1,593 natural origin fish and zero hatchery origin fish. The river right trap, Trap 1, captured 45.1% (*n* = 718) of these fish, and the river left trap, Trap 2, captured 54.9% (*n* = 875). Additionally, 17 non-salmonid species were identified as well as 54 non-salmonid individuals that were unable to be identified to the species level (Appendix 4).

Fall-run Chinook Salmon

A total of 989 natural origin fall-run Chinook Salmon were captured during the 2022 survey season. Because these fish did not have an adipose fin clip, they were presumed to be of natural origin. Catch of fall-run first peaked on February 10, when 7.99% (*n* = 79) of these fish were captured (Figure 7). Of all fall-run captured during the 2022 survey season, three were classified as unmeasured plus-count tallies and were classified as fall-run Chinook Salmon. Cumulative fall-run catch exceeded 95% on May 13th (Table 3).

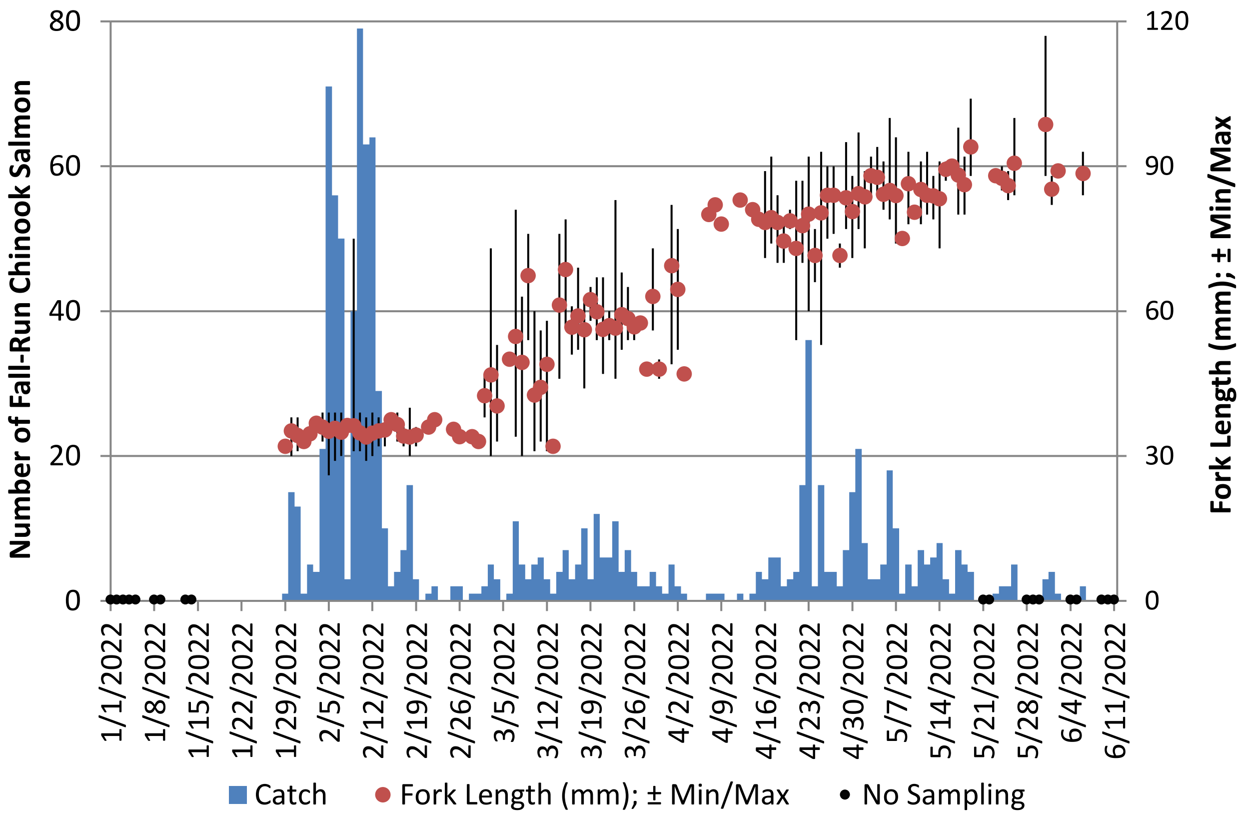

Figure 7: Daily minimum, maximum, and average fork length (mm) and total catch of natural origin fall-run Chinook Salmon during the 2022 Stanislaus River rotary screw trap sampling season.

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

Proportion of Catch	Dates
25%	February 9th
50%	February 13th
75%	April 21st
95%	May 13th

A total of 986 natural origin fall-run were measured for fork length. The weekly minimum, maximum, and average fork lengths throughout the 2022 survey season are displayed in Table 4. The lowest weekly average fork length of 35 mm was observed during the weeks of January 29 and February 5 and 12. Fork lengths slowly increased throughout the season with the weekly average reaching a maximum of 91 mm the week of May 28.

Table 4: 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 2022 Stanislaus River rotary screw trap sampling season.

Julian Week	Avg	Range	*n*	St. Dev.
1/8- 1/15	-	-	-	-
1/15 - 1/21	-	-	-	-
1/22 - 1/28	-	-	-	-
1/29 - 2/4	35	30 - 39	60	2.03
2/5 - 2/11	35	26 - 75	362	3.04
2/12 - 2/18	35	30 - 40	132	2.30
2/19 - 2/25	36	32 - 39	8	2.07
2/26 - 3/4	41	30 - 73	14	14.02
3/5 - 3/11	51	30 - 81	31	14.81
3/12 - 3/18	58	31 - 79	33	10.53
3/19 - 3/25	58	46 - 83	49	6.58
3/26 - 4/1	60	46 - 82	20	10.41
4/2 - 4/8	68	47 - 82	5	16.71
4/9 - 4/15	80	78 - 83	7	1.89
4/16 - 4/22	78	54 - 92	40	6.45
4/23 - 4/29	80	53 - 95	71	7.39
4/30 - 5/6	84	71 - 100	73	5.88
5/7 - 5/13	84	74 - 96	36	5.25
5/14 - 5/20	87	73 - 104	28	6.55
5/21 - 5/27	89	83 - 100	10	5.39
5/28 - 6/3	91	82 - 117	8	10.98
6/4 - 6/10	88	84 - 93	2	6.36

The subsample of fall-run that were measured for fork length, were also assessed for life stage (Figure 8; Table 5). Most of these fish were identified as button-up fry and accounted for 59.3% (*n* = 585) of the assessed catch. The remaining life stage catch composition consisted of yolk-sac fry (0.4%, *n* = 4), parr (10.1%, *n* = 100), silvery parr (29.3%, *n* = 289) and smolts (0.8%, *n* = 8). Fall-run Chinook Salmon identified as yolk-sac fry were captured between January 31 and February 11. Button-up fry were captured between January 29 and April 3. Parr were captured between March 2 and April 24. Silvery parr were caught between February 9 and June 6. Lastly, 8 fall-run were identified as smolts and were captured between March 29 and June 6.

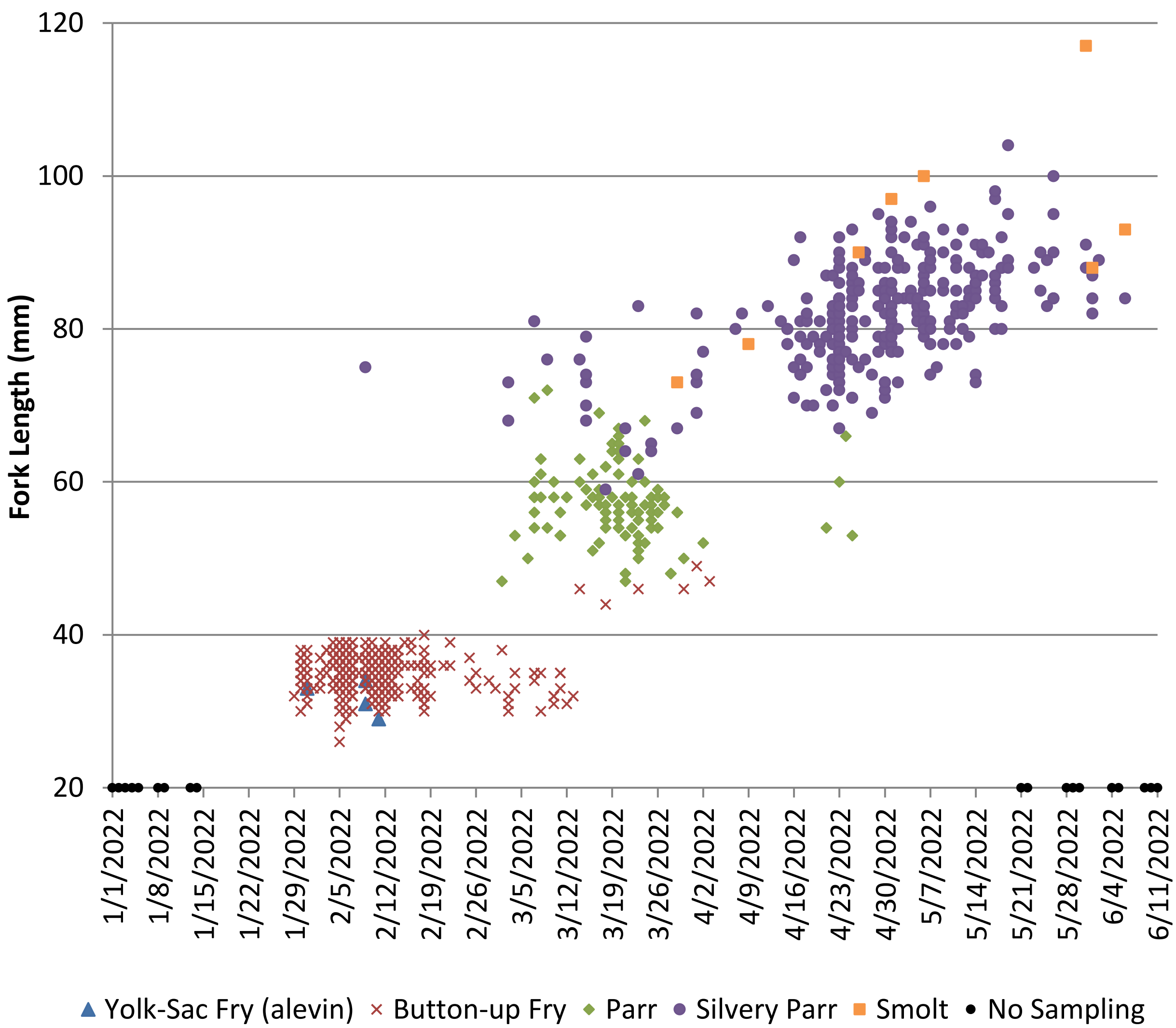

Figure 8: Daily fork length distribution by life stage of natural origin fall-run Chinook Salmon measured during the 2022 Stanislaus River rotary screw trap survey season.

For each identified life stage of measured fall-run Chinook Salmon, fork length distributions varied (Table 5). Fork lengths ranged from 29 – 34 mm for yolk-sac fry, 26 – 49 mm for button-up fry, 47 – 72 mm for parr, 59 – 104 mm for silvery parr, and 73 – 117 mm for smolt life stages.

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 32 mm for yolk-sac fry, 35 mm for button-up fry, 57 mm for parr, 82 mm for silvery parr, and 92 mm for smolts (Table 5).

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

Julian Week	Yolk-Sac Fry Avg (range, *n*)	Button-up Fry Avg (range, *n*)	Parr Avg (range, *n*)	Silvery Parr Avg (range, *n*)	Smolt Avg (range, *n*)
1/1 - 1/7	-	-	-	-	-
1/8 - 1/14	-	-	-	-	-
1/15 - 1/21	-	-	-	-	-
1/22 - 1/28	-	-	-	-	-
1/29 - 2/4	33 (33, *n* = 1)	35 (30 - 39, *n* = 59)	-	-	-
2/5 - 2/11	31 (29 - 34, *n* = 3)	35 (26 - 39, *n* = 357)	-	75 (75, *n* = 1)	-
2/12 - 2/18	-	35 (30 - 40, *n* = 132)	-	-	-
2/19 - 2/25	-	36 (32 - 39, *n* = 8)	-	-	-
2/26 - 3/4	-	33 (30 - 38, *n* = 10)	50 (47 - 53, *n* = 2)	71 (68 - 73, *n* = 2)	-
3/5 - 3/11	-	33 (30 - 35, *n* = 11)	59 (50 - 72, *n* = 18)	79 (76 - 81, *n* = 2)	-
3/12 - 3/18	-	38 (31 - 46, *n* = 4)	58 (51 - 69, *n* = 22)	71 (59 - 79, *n* = 7)	-
3/19 - 3/25	-	46 (46, *n* = 1)	57 (47 - 68, *n* = 42)	67 (61 - 83, *n* = 6)	-
3/26 - 4/1	-	48 (46 - 49, *n* = 2)	55 (48 - 59, *n* = 11)	73 (67 - 82, *n* = 5)	73 (73, *n* = 1)
4/2 - 4/8	-	47 (47, *n* = 1)	52 (52, *n* = 1)	80 (77 - 82, *n* = 3)	-
4/9 - 4/15	-	-	-	80 (78 - 83, *n* = 6)	78 (78, *n* = 1)
4/16 - 4/22	-	-	54 (54, *n* = 1)	78 (70 - 92, *n* = 39)	-
4/23 - 4/29	-	-	60 (53 -66, *n* = 3)	81 (67 - 95, *n* = 66)	90 (90, *n* = 1)
4/30 - 5/6	-	-	-	84 (71 - 94, *n* = 71)	99 (97 - 100, *n* = 2)
5/7 - 5/13	-	-	-	84 (74 - 96, *n* = 36)	-
5/14 - 5/20	-	-	-	87 (73 - 104, *n* = 28)	-
5/21 - 5/27	-	-	-	89 (83 - 100, *n* = 10)	-
5/28 - 6/3	-	-	-	87 (82 - 91, *n* = 6)	102 (88 - 117, *n* = 2)
6/4 - 6/10	-	-	-	84 (84, *n* = 1)	93 (93, *n* = 1)
Entire Season	**32 (29 - 34, *n* = 4)**	**35 (26 - 49, *n* = 585)**	**57 (47 - 72, *n* = 100)**	**82 (59 - 104, *n* = 289)**	**92 (73 - 117, *n* = 8)**

Fulton's Condition Factor

Fulton's condition factor (K) for fall-run natural origin Chinook Salmon captured in 2022 is shown (Figure 9). The trend line slopes were positive for button-up fry (0.0046) and silvery parr (0.0003) and negative slopes for parr (-0.0018) and smolt (-0.0007) life stages. Yolk-sac fry captured in 2022 were unable to be accessed for Fulton's condition factor as every fish identified with this life stage measured less than 40 mm and was therefore not weighed. Average Fulton's condition factor (K) increased with the life stage progression (Table 6).

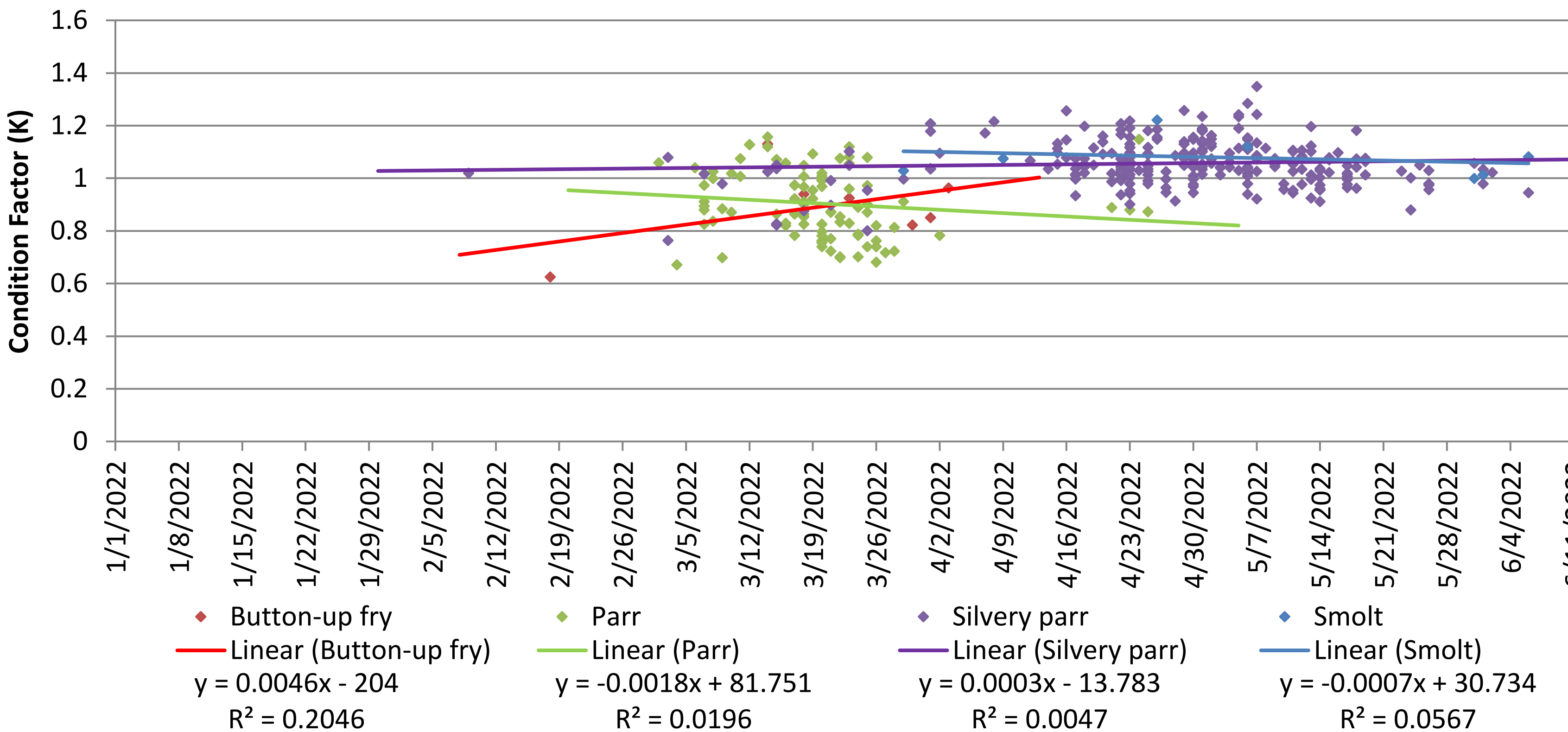

Figure 9: Fulton's condition factor (*K*), by life-stage, of fall-run Chinook Salmon during the 2022 Stanislaus River rotary screw trap survey season.

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

Life stage	Condition Factor Avg (range)
Button-up fry	0.89 (0.63 – 1.13)
Parr	0.90 (0.67 – 1.16)
Silvery Parr	1.06 (0.76 – 1.35)
Smolt	1.08 (1.00 – 1.22)

Trap Efficiency

Two trap efficiency trials were conducted during the 2022 survey season. The two trials used a total of 1,206 fall-run Chinook Salmon acquired from Oakdale RSTs. All Chinook Salmon were of natural origin and marked with BBY stain. The average trap recapture efficiency was 11.89% with a total of 141 marked salmon being recaptured within seven days of the release. Additionally, the average fork length of the recaptured fish was approximately the same size as the average fork length of the released fish.

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

Date Marked	Fish Origin	Included	Date Released	Release Time	Flow (cfs)	Avg release FL (mm)	*n* released	Capture Efficiency	Avg recapture FL (mm)
2/11/22	Natural	Yes	2/11/2022	17:20	1,480	35	858	11.42%	35
3/17/22	Natural	Yes	3/17/2022	18:55	348	41	348	12.36%	41

Fall-run Chinook Salmon were used for all trap efficiency trials.
Included: Indicates if the trial was used in determining passage estimates.
Flow (cfs) = discharge from the USGS gauge 11303000 at time of release.
Natural = Assumed natural production of the Stanislaus River.

Passage Estimate for Fall-run Chinook Salmon

The passage estimate model developed by Flow West Inc. estimated that 113,286 natural origin fall-run Chinook Salmon emigrated past the Caswell rotary screw trap location during the 2022 survey season (95% CI 58,650 to 483,200; Figure 10). The highest weekly passage estimate occurred the week of February 5 with approximately 50,388 fall-run estimated to have emigrated past the rotary screw traps (Table 8). Cumulative passage exceeded 95% on May 18th (Table 9).

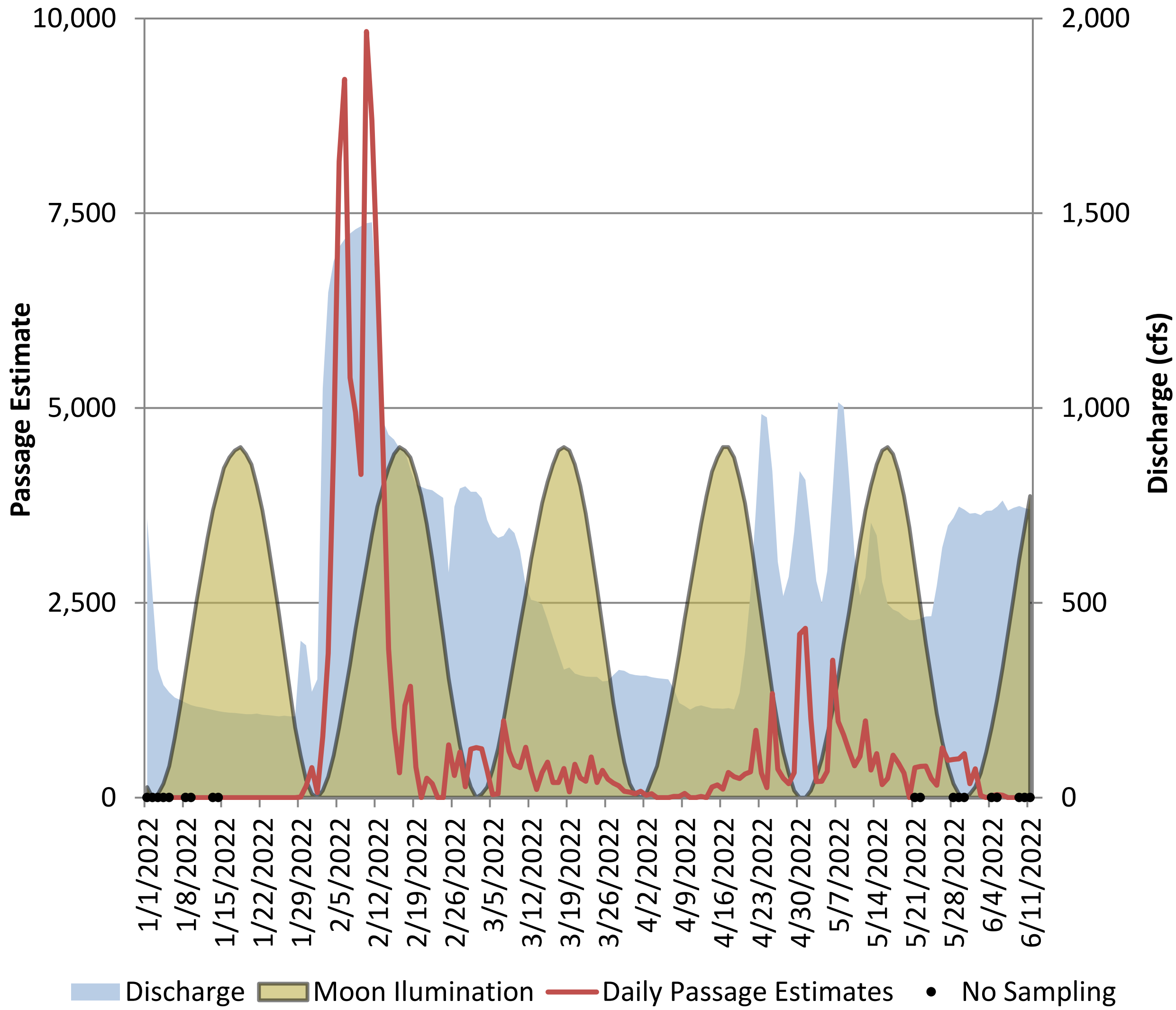

Figure 10: Daily passage estimate of natural origin fall-run Chinook Salmon and daily average discharge at Ripon during the 2022 Stanislaus River rotary screw trap survey season.

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

Julian Week	Discharge	Passage Estimate	CI 95%
1/1 - 1/7	376	0	-
1/8 - 1/14	232	0	-
1/15 - 1/21	216	0	-
1/22 - 1/28	210	0	-
1/29 - 2/4	728	7,772	(4,703 - 22,679)
2/5 - 2/11	1,453	50,388	(40,943 - 405,368)
2/12 - 2/18	956	16,872	(12,695 - 114,511)
2/19 - 2/25	759	1,497	(617 - 6,157)
2/26 - 3/4	770	3,250	(1,149 - 18,981)
3/5 - 3/11	653	3,123	(1,359 - 16,403)
3/12 - 3/18	439	1,984	(901 - 9,144)
3/19 - 3/25	314	2,032	(969 - 9,318)
3/26 - 4/1	317	859	(423 - 3,992)
4/2 - 4/8	294	110	(65 - 348)
4/9 - 4/15	232	367	(161 - 1,922)
4/16 - 4/22	371	2,446	(1,141 - 16,356)
4/23 - 4/29	739	2,889	(1,615 - 17,749)
4/30 - 5/6	681	7,804	(3,164 - 38,939)
5/7 - 5/13	750	4,668	(2,767 - 15,985)
5/14 - 5/20	515	2,280	(1,274 - 6,529)
5/21 - 5/27	533	2,717	(1,105 - 11,853)
5/28 - 6/3	732	2,130	(796 - 11,511)
6/4 - 6/10	746	98	(33 - 293)
Total	**566**	**113,286**	**(58,650 - 483,200)**

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

Proportion of Passage	Dates
25%	February 7th
50%	February 11th
75%	March 20th
95%	May 18th

Genetic Analysis

A total of 121 genetic samples were taken from Chinook Salmon (71 LAD fall-run and 50 LAD spring-run) and analyzed using SNP genetic markers to determine final run assignments (Appendix 5). 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 made based on genetic analysis.

Genetic samples were collected from 71 LAD fall-run throughout the season. Analyses using SNP genetic markers from these samples indicated that 100% *(n* = 71) were correctly identified as fall-run Chinook Salmon (Appendix 5). Because the LAD criteria continued to accurately assign this run, a final run assessment of fall was applied to the remaining 857 LAD fall-run that were not genetically sampled.

A total of 60 natural origin Chinook Salmon classified as spring-run using LAD criteria were captured. Genetic samples were collected from 50 LAD spring-run throughout the 2022 season. Analyses using SNP genetic markers from those samples indicated that 100% *(n* = 50) were identified as fall-run Chinook Salmon (Appendix 5). Because the LAD criteria appeared to incorrectly assign this run, the remaining 10 LAD spring-run that were not genetically sampled were given a final run assignment of fall-run.

Spring, Winter, and Late Fall runs of Chinook Salmon

The results of the genetic analyses suggest that no in-river produced or hatchery origin spring-run, winter-run, or late fall-run Chinook Salmon were detected in the subsample during the 2022 survey season.

Non-salmonid Species

A total of 604 non-salmonid fish were captured during the 2022 survey season. The majority *(n* = 550, 91.1%) of these fish belonged to 17 identified species in the following families: Catostomidae (sucker), Centrarchidae (sunfish/black bass), Clupeidae (shad), Cottidae (sculpin), Cyprinidae (minnow), Ictaluridae (bullhead/catfish), Moronidae (Striped Bass), Petromyzontidae (lamprey), and Poeciliidae (mosquitofish; Figure 11). The remaining 8.9% (*n* = 54) were not able to be identified to species level but belonged to the following families: Centrarchidae (*n* = 38), Petromyzontidae (*n* = 15), and unknown (*n* = 1). Most non-salmonid fish captured were native to the Central Valley watershed (*n* = 331, 54.8%) with the remaining individuals (*n* = 273, 45.2%) being non-native species. Appendix 4 contains a complete list of species captured in the 2022 survey season.

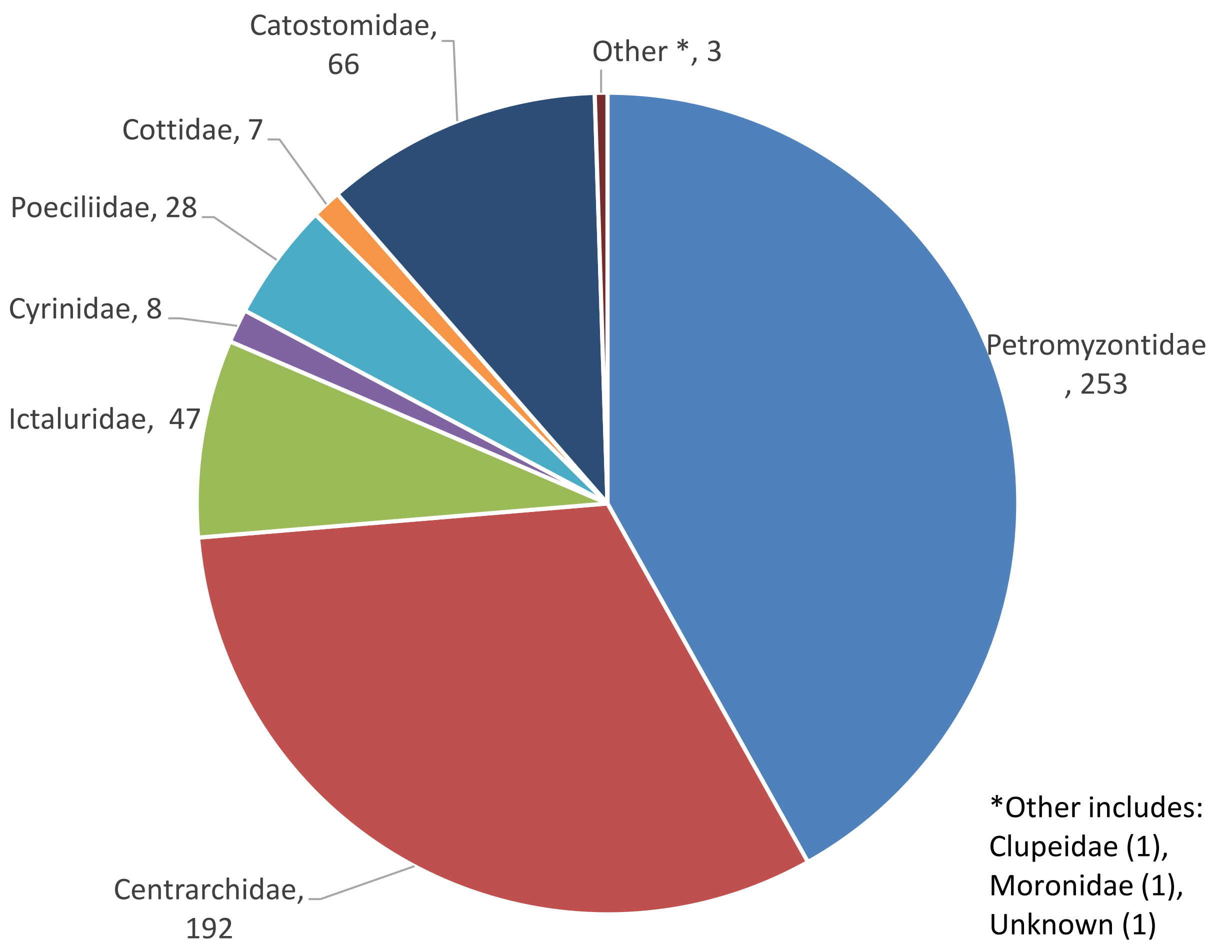

Figure 11: Non-salmonid catch totals for each family of species collected during the 2022 Stanislaus River rotary screw trap survey season.

Of the 604 non-salmonid fish captured, 253 (41.9%) were identified as Petromyzontidae spp. (northern lampreys); 238 (94.1%) of which were identified as Pacific lamprey, consisting of one adult and 237 juveniles. No lamprey that were identified to the species level were identified as River lamprey. The remaining 15 (5.9%) lamprey captured were identified as ammocoetes of Petromyzontidae and could not be identified to a species level. Catch of Pacific Lamprey peaked on March 29 during a precipitation event when 34 (14.3%) of the season's Pacific Lamprey total was captured (Figure 12). Catch of ammocoetes peaked on February 10 and March 29 when two (13.3%) of the season's total were captured.

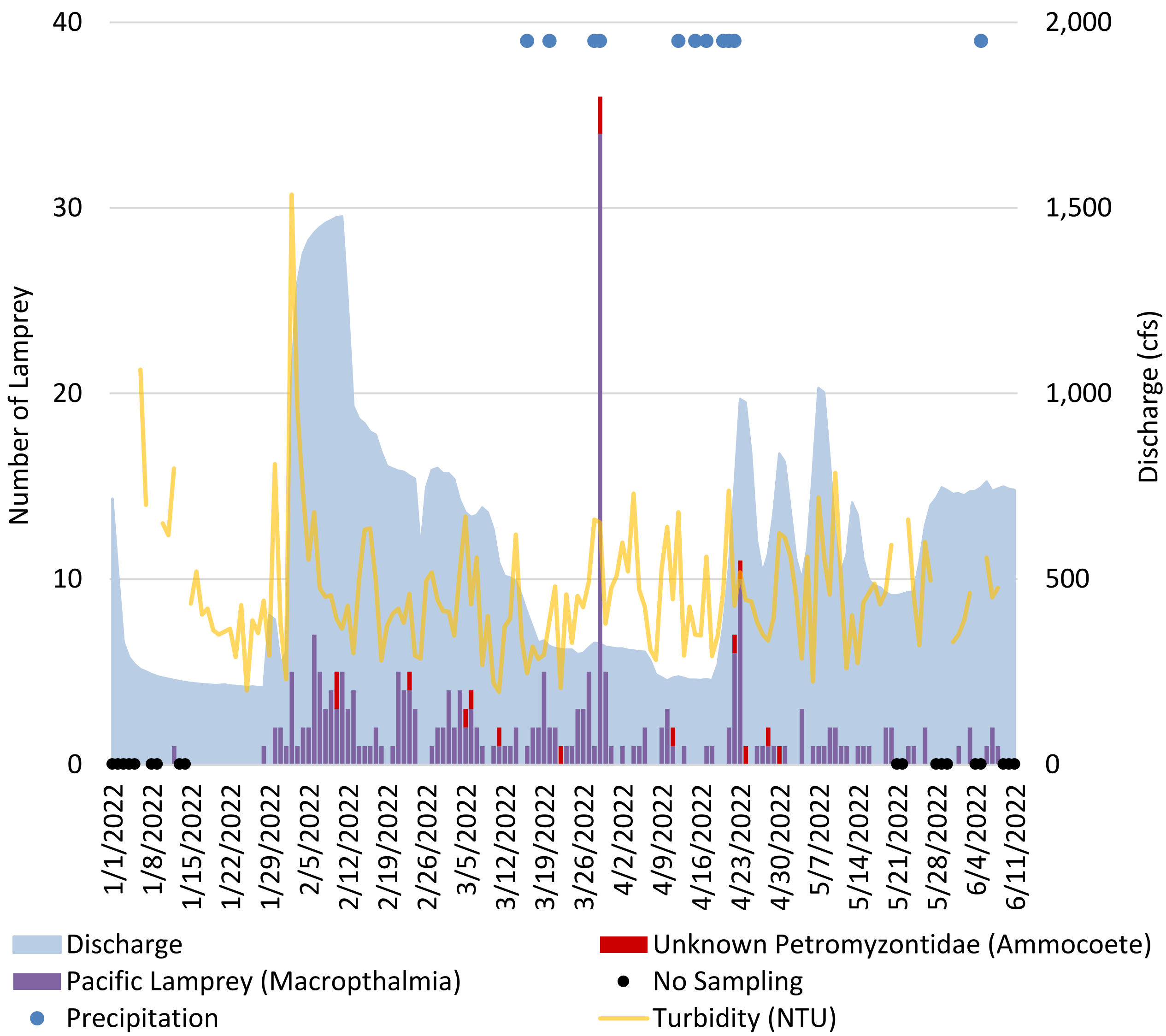

Figure 12: Daily lamprey catch and daily discharge at Ripon during the 2022 Stanislaus River rotary screw trap survey season.

Discussion

Objective

The continued operation of the Stanislaus River rotary screw traps during the 2022 survey season provided valuable biological monitoring data for emigrating salmonids. Primary objectives of the study were met by developing fall-run Chinook Salmon passage estimates and accurately quantifying the catch of all salmonids. 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 rotary screw trap emigration surveys from Cramer Fish Sciences (CFS 2016) and Pacific States Marine Fisheries Commission (PSMFC 2017 – 2021).

Passage Estimate and Catch

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

The first significant factor is whether the sampling season encompassed the entirety of the juvenile salmonid emigration period. Through the first seven days of sampling no fall-run were captured. Furthermore, through the last seven days of sampling a total of 10 fall-run were captured and a passage of 673 fall-run was estimated, accounting for 1.0% of the total fall-run catch and 0.6% of the total fall-run passage estimate. Due to the low catch and passage estimates through the first and last seven days of sampling, it is likely that the sampling season encompassed the majority of the juvenile salmonid emigration period.

Trap operation is another critical factor when interpreting annual catch and passage estimates. Ideally, the RSTs continuously operate to the furthest extent possible through the full length of the salmonid emigration period to accurately enumerate salmonid catch and estimate passage. During the 2022 sampling season, sampling occurred for 93% (143 days) of the 154-day season with an 85% successful sample rate (Figure 3 and 4). Unsuccessful sampling was a consequence of debris stopping the trap at the entrance of the cone or in the intakes to the live well. Additionally, since no fish were captured when the RSTs were not sampling, the CAMP platform imputed an estimate of daily fall-run catch to estimate daily passage during the 11 days no sampling occurred. Since there were no gaps in sampling greater than seven days in duration, the CAMP model was able to estimate passage for the full length of the 2022 sampling season.

Salmonid catch and fall-run passage estimates are also dependent on the quantity, quality, and recapture efficiencies obtained through the trap efficiency trials. 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 an inability to receive hatchery fish led to the completion of only two efficiency trials in 2022 (Table 7).

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 during each trial. 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 around 1.5 m/s (USFWS 2008). Velocities this high are rarely seen on the Stanislaus River at Caswell and were not observed in 2022 with velocity averaging 0.4 m/s with a range of 0.2 – 0.9 m/s. Additionally, the first efficiency trial experienced significant flow alterations and periods of unsuccessful sampling with variable flows ranging from 803 to 1,500 cfs and unsuccessful sampling occurring on February 17 for Trap 1 and February 13 through February 15 for Trap 2 during the trial period. Contrarily, the second efficiency trial observed relatively constant flows ranging from 290 to 332 cfs with unsuccessful sampling occurring on March 21 and March 24 for Trap 1 during the trial period. Despite these factors, between both efficiency trials, 97% of recaptured fish were caught within the first 24 hours after the release. However, it is likely that the efficiency percentage was low due to the short periods of unsuccessful sampling during each efficiency trial.

Biological Observations

Biological data were collected throughout the season to assist development of models that correlate environmental parameters with temporal presence and abundance of salmonids. The data were collected for a subsample of all salmonids to evaluate potential changes in health, growth, and life history strategies. As seen in previous years of biological sampling on the Stanislaus River, most of the fall-run population emigrated as age-0 fry from the Stanislaus River (PSMFC 2017 – 2021, CFS 1996 – 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 fall-run emigration timing coincided with high discharge events in February, April, and May because of a pulse flow intended to cue the outmigration of juvenile salmonids (Figure

5). An increase in catch during these discharge events was observed throughout the season as the majority (81%, n = 802) of the fall-run were captured when discharge was greater than 509 cfs, the sampling season's median discharge. Evidently, discharge was likely the most influential environmental factor in determining emigration timing of fall-run Chinook Salmon during the 2022 survey season. Similar observations were made by Zeug et al (2014) in which historically higher cumulative discharge and flow variability resulted in higher catch and survival of emigrating Chinook Salmon.

Conclusion

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

Juvenile salmonid emigration monitoring will continue on the Stanislaus River at Caswell Memorial State Park in 2023. The following adjustments are recommended for future seasons. 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 season. Expansions to the dates that fish can be acquired from Merced River Hatchery have been pre-approved by CDFW, which would allow for hatchery origin mark recapture trials between January and May if sufficient natural origin fish are not available. Additionally, if Merced River Hatchery is unable to provide hatchery fish, coordinating with the Mokelumne Hatchery and the Oakdale RST project for test fish should be considered. To increase capture efficiency and decrease trap avoidance, hydraulic modifications (e.g., sandbags, wings, or screen panels) to guide more water into the cone and increase velocity and trap RPMs during low flows should be considered in future sampling seasons. These changes could result in increased capture efficiency, increased probability of capturing smolting salmonids, decrease the number of in-season trap adjustments to provide a greater confidence in the passage estimates produced. We believe these efforts will strengthen the future of the Stanislaus River Caswell RST project by continuing to improve our understanding of juvenile salmonids while maintaining focus on safe and effective sampling practices.

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Appendix 1: **Points of interest on the Stanislaus River.**

Point of Interest	Significance	Operator	River Mile (rkm)
New Melones Dam	Constructed 1978; Flood control, power generation, water supply, recreation.	U.S. Bureau of Reclamation	60 (96.6)
Tulloch Dam	Constructed 1957; Flood control, power generation, water supply, recreation.	Tri-Dam Project	55 (88.5)
Goodwin Dam	Constructed 1913; Flood control, water supply.	U.S. Bureau of Reclamation	58.4 (94)
Lover's Leap	Habitat improvement; Gravel augmentation		53.4-51.8 (85.9-83.4)
Lancaster Road	Habitat improvement; side channel restoration project		~41 (65.9)
Oakdale	RST site for monitoring juvenile salmonid abundance and outmigration	FishBio Consulting	40.1(64.5)
Stanislaus River at Ripon (Hwy 99 Bridge)	River discharge and temperature monitoring station	U.S. Geological Survey	15.8 (25.4)
Upper Irrigation Pump at Caswell	Release site for trap efficiency mark-recapture trials		8.9 (14.3)
Caswell Memorial State Park	RST site for monitoring juvenile salmonid abundance and outmigration		8.6 (13.8)
Mouth of Stanislaus River	Stanislaus-San Joaquin Confluence		0

Appendix 2: Enhanced efficiency model description by West Inc.

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

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

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

Methods

Catch Estimation

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

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

Simple Efficiency Estimation

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

Enhanced Efficiency Estimation

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

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

Efficiency-trial Covariates

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

Environmental Covariates

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

CAMP Covariates

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

Percent-Q Covariates

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

Application of Enhanced Efficiency Models

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

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

Stream	Name (Sub-site)	Covariate Model
Stanislaus	*ST004L1 (1002)*	*–1.846 – 0.0007(flow) – 0.009(depth) + 1.096(velocity)*
	ST004L1B (1003)	*–4.447 + 2.523(moon proportion) – 0.017(depth) + 0.038(turbidity) + 1.294(velocity)*

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

Appendix 3: **Weekly environmental conditions on the Stanislaus River during the 2022 survey season.**

Julian Week	Water Temperature (C°) Avg (Range)	Discharge (cfs) Avg (Range)	Dissolved Oxygen (mg/L) Avg (Range)	Turbidity (NTU) Avg (Range)	Velocity (m/s) Avg (Range)
1/1 - 1/7	9.6 (7.6 - 11.8)	376 (247 - 825)	10.31 (10.04 - 10.58)	4.41 (3.49 - 6.68)	0.3 (0.2 - 0.5)
1/8 - 1/14	9.7 (8.6 - 11.1)	232 (221 - 248)	11.26 (10.60 - 11.74)	3.44 (2.77 - 5.15)	0.3 (0.2 - 0.5)
1/15 - 1/21	10.1 (9.1 - 11.2)	216 (212 - 222)	11.49 (10.91 - 12.06)	2.04 (1.33 - 3.13)	0.3 (0.2 - 0.4)
1/22 - 1/28	9.2 (8.2 - 10.2)	210 (208 - 216)	11.84 (11.35 - 12.55)	1.77 (0.86 - 2.85)	0.3 (0.2 - 0.5)
1/29 - 2/4	9.3 (8.1 - 10.2)	728 (298 - 1450)	11.68 (11.34 - 11.87)	3.54 (1.13 - 8.35)	0.3 (0.2 - 0.5)
2/5 - 2/11	10.4 (9.6 - 11.5)	1453 (1380 - 1510)	11.51 (11.06 - 11.78)	2.41 (1.75 - 4.57)	0.6 (0.2 - 0.9)
2/12 - 2/18	10.9 (9.8 - 11.9)	956 (814 - 1480)	11.62 (11.11 - 12.27)	2.34 (1.14 - 3.89)	0.6 (0.3 - 0.8)
2/19 - 2/25	10.3 (8.8 - 11.3)	759 (487 - 817)	11.83 (11.21 - 12.36)	1.87 (1.09 - 2.58)	0.5 (0.2 - 0.8)
2/26 - 3/4	11.4 (9.1 - 12.9)	770 (654 - 827)	11.57 (10.99 - 12.11)	2.26 (1.32 - 2.95)	0.5 (0.3 - 0.7)
3/5 - 3/11	11.5 (10.1- 12.8)	653 (515 - 713)	11.31 (10.68 - 11.71)	1.96 (0.94 - 3.79)	0.4 (0.3 - 0.5)
3/12 - 3/18	13.5 (11.0 - 15.6)	439 (324 - 521)	10.09 (9.36 - 11.28)	1.84 (0.99 - 3.57)	0.4 (0.2 - 0.6)
3/19 - 3/25	15.3 (12.4 - 18.5)	314 (284 - 348)	9.43 (8.74 - 9.96)	1.86 (0.94 - 3.07)	0.3 (0.2 - 0.5)
3/26 - 4/1	15.9 (13.8 - 18.4)	317 (285 - 338)	9.12 (8.52 - 9.54)	2.56 (1.80 - 4.07)	0.4 (0.2 -0.6)
4/2 - 4/8	17.1 (14.9 - 21.0)	294 (238 - 315)	9.08 (8.27 - 9.68)	2.39 (1.32 - 4.14)	0.4 (0.2 - 0.6)
4/9 - 4/15	16.3 (13.3 - 20.3)	232 (223 - 242)	9.36 (8.51 - 10.27)	2.40 (1.14 - 4.02)	0.4 (0.2 - 0.6)
4/16 - 4/22	16.3 (13.4 - 19.2)	371 (225 - 846)	9.13 (8.70 - 10.10)	2.27 (1.17 - 4.06)	0.4 (0.2 - 0.5)
4/23 - 4/29	15.2 (13.0 - 17.5)	739 (499 - 1080)	9.57 (8.96 - 10.10)	2.05 (1.29 - 2.69)	0.5 (0.2 - 0.7)
4/30 - 5/6	16.0 (13.9 - 18.4)	681 (484 - 923)	9.36 (8.57 - 9.81)	2.37 (1.12 - 3.50)	0.5 (0.3 - 0.7)
5/7 - 5/13	14.9 (12.9 - 16.6)	750 (504 -1110)	9.98 (9.54 - 10.78)	2.63 (1.23 - 4.19)	0.5 (0.2 - 0.8)
5/14 - 5/20	18.5 (15.2 - 20.8)	515 (451 - 771)	8.56 (8.08 - 9.63)	2.25 (1.10 - 3.16)	0.5 (0.3 - 0.7)
5/21 - 5/27	18.7 (16.5 - 20.9)	533 (451 - 711)	8.29 (7.80 - 8.96)	2.54 (1.53 - 4.06)	0.5 (0.4 - 0.7)
5/28 - 6/3	17.2 (15.6 - 18.5)	732 (708 - 759)	8.63 (8.39 - 8.88)	1.91 (1.45 - 2.41)	0.7 (0.5 - 0.8)
6/4 - 6/10	17.8 (15.8 - 20.1)	746 (729 - 783)	8.00 (7.25 - 8.54)	2.47 (2.21 - 3.24)	0.6 (0.3 - 0.9)

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

Appendix 4: List of fish species caught during the 2022 Stanislaus River rotary screw trap survey season.

Common Name	Family Name	Species Name	Total
Chinook Salmon	Salmonidae	*Oncorhynchus tshawytscha*	989
Black Crappie	Centrarchidae	*Pomoxis nigromaculatus*	1
Bluegill	Centrarchidae	*Lepomis macrochirus*	28
Brown Bullhead	Ictaluridae	*Ameiurus nebulosus*	1
Golden Shiner	Cyprinidae	*Notemigonus crysoleucas*	3
Green Sunfish	Centrarchidae	*Lepomis cyanellus*	1
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	3
Pacific Lamprey	Petromyzontidae	*Lampetra entosphenus*	238
Prickly Sculpin	Cottidae	*Cottus asper*	6
Riffle Sculpin	Cottidae	*Cottus gulosus*	1
Sacramento Pikeminnow	Cyprinidae	*Ptychocheilus grandis*	2
Sacramento Sucker	Catostomidae	*Catostomus occidentalis*	66
Smallmouth Bass	Centrarchidae	*Micropterus dolomieu*	23
Spotted Bass	Centrarchidae	*Micropterus punctulatus*	101
Striped Bass	Moronidae	*Morone saxatilis*	1
Threadfin Shad	Clupeidae	*Dorosoma petenense*	1
Unknown			1
Unknown Bass	Centrarchidae	*Micropterus sp.*	38
Unknown Lamprey	Petromyzontidae	*Entosphenus* or *Lampetra*	15
Western Mosquitofish	Poeciliidae	*Gambusia affinis*	28
White Catfish	Ictaluridae	*Ameiurus catus*	46

Appendix 5: Genetic results for fin-clip samples from Chinook Salmon caught in the Stanislaus River during the 2022 survey season.

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

Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probability	Final Run Assignment	FL (mm)	Weight (g)
1/30/2022	3881-002	Fall	Fall	1.00	Fall	37	-
1/30/2022	3881-005	Fall	Fall	1.00	Fall	35	-
2/6/2022	3881-006	Fall	Fall	1.00	Fall	34	-
2/6/2022	3881-007	Fall	Fall	1.00	Fall	37	-
2/6/2022	3881-008	Fall	Fall	1.00	Fall	39	-
2/6/2022	3881-009	Fall	Fall	1.00	Fall	36	-
2/6/2022	3881-010	Fall	Fall	1.00	Fall	36	-
2/13/2022	3881-011	Fall	Fall	1.00	Fall	38	-
2/13/2022	3881-012	Fall	Fall	1.00	Fall	33	-
2/13/2022	3881-013	Fall	Fall	1.00	Fall	37	-
2/13/2022	3881-014	Fall	Fall	1.00	Fall	33	-
2/13/2022	3881-015	Fall	Fall	1.00	Fall	38	-
2/26/2022	3881-016	Fall	Fall	1.00	Fall	33	-
2/26/2022	3881-017	Fall	Fall	1.00	Fall	35	-

2/28/2022	3881-018	Fall	Fall	1.00	Fall	34	-
3/1/2022	3881-019	Fall	Fall	1.00	Fall	33	-
3/2/2022	3881-021	Fall	Fall	1.00	Fall	38	-
3/2/2022	3881-020	Fall	Fall	1.00	Fall	47	1.1
3/3/2022	3881-022	Spring	Fall	1.00	Fall	73	4.2
3/3/2022	3881-023	Spring	Fall	1.00	Fall	68	2.4
3/4/2022	3881-028	Fall	Fall	1.00	Fall	53	1.0
3/4/2022	3881-027	Fall	Fall	1.00	Fall	33	-
3/7/2022	3881-029	Fall	Fall	1.00	Fall	58	1.9
3/7/2022	3881-030	Fall	Fall	1.00	Fall	54	1.3
3/7/2022	3881-031	Spring	Fall	1.00	Fall	71	3.2
3/7/2022	3881-032	Fall	Fall	1.00	Fall	35	-
3/7/2022	3881-033	Fall	Fall	1.00	Fall	35	-
3/7/2022	3881-034	Spring	Fall	1.00	Fall	81	5.4
3/7/2022	3881-035	Fall	Fall	1.00	Fall	56	1.6
3/8/2022	3881-036	Spring	Fall	1.00	Fall	63	2.5
3/9/2022	3881-037	Spring	Fall/Spring	0.84/0.16	Fall	72	3.3
3/9/2022	3881-039	Spring	Fall	1.00	Fall	76	4.3
3/13/2022	3881-038	Fall	Fall	1.00	Fall	32	-
3/14/2022	3881-040	Spring	Fall	1.00	Fall	76	4.5
3/14/2022	3881-041	Fall	Fall	1.00	Fall	63	2.8
3/14/2022	3881-042	Fall	Fall	1.00	Fall	60	2.5
3/14/2022	3881-044	Fall	Fall	1.00	Fall	46	1.1
3/15/2022	3881-047	Spring	Fall	1.00	Fall	73	3.2
3/15/2022	3881-048	Spring	Fall	1.00	Fall	68	2.6
3/15/2022	3881-049	Spring	Fall	1.00	Fall	79	-
3/15/2022	3881-043	Fall	Fall	1.00	Fall	57	1.6
3/15/2022	3881-045	Spring	Fall	1.00	Fall	70	3.6
3/15/2022	3881-046	Spring	Fall	1.00	Fall	74	4.2
3/17/2022	3881-050	Spring	Fall	1.00	Fall	69	3.2

3/20/2022	3881-052	Fall	Fall	1.00	Fall	56	1.3
3/20/2022	3881-053	Fall	Fall	1.00	Fall	55	1.3
3/20/2022	3881-054	Fall	Fall	1.00	Fall	65	2.8
3/20/2022	3881-055	Fall	Fall	1.00	Fall	67	3.0
3/23/2022	3881-056	Spring	Fall	0.99	Fall	83	6.0
3/27/2022	3881-057	Fall	Fall	1.00	Fall	58	1.4
3/27/2022	3881-058	Fall	Fall	1.00	Fall	57	-
3/28/2022	3881-059	Fall	Fall	1.00	Fall	48	0.8
3/28/2022	3881-060	Fall	Fall	1.00	Fall	48	0.9
3/29/2022	3881-061	Spring	Fall	1.00	Fall	73	4.0
3/30/2022	3881-062	Fall	Fall	1.00	Fall	46	0.8
3/30/2022	3881-063	Fall	Fall	1.00	Fall	50	-
4/1/2022	3881-064	Spring	Fall	1.00	Fall	82	6.5
4/1/2022	3881-065	Spring	Fall	1.00	Fall	74	4.2
4/2/2022	3881-066	Spring	Fall	1.00	Fall	77	5.0
4/2/2022	3881-067	Fall	Fall	1.00	Fall	52	1.1
4/3/2022	3881-068	Fall	Fall	1.00	Fall	47	1.0
4/7/2022	3881-069	Spring	Fall	1.00	Fall	80	6.0
4/9/2022	3881-070	Spring	Fall	1.00	Fall	78	5.1
4/12/2022	3881-072	Spring	Fall	1.00	Fall	83	6.1
4/14/2022	3881-073	Spring	Fall	1.00	Fall	81	5.5
4/15/2022	3881-074	Fall	Fall	1.00	Fall	78	5.0
4/15/2022	3881-075	Fall	Fall	1.00	Fall	78	5.2
4/15/2022	3881-076	Spring	Fall	1.00	Fall	80	5.8
4/15/2022	3881-077	Spring	Fall	1.00	Fall	80	5.7
4/16/2022	3881-080	Fall	Fall	1.00	Fall	75	5.3
4/16/2022	3881-078	Spring	Fall	1.00	Fall	89	7.6
4/16/2022	3881-079	Fall	Fall	1.00	Fall	71	4.1
4/17/2022	3881-081	Fall	Fall	1.00	Fall	74	4.1
4/17/2022	3881-082	Fall	Fall	1.00	Fall	76	4.1

4/17/2022	3881-083	Fall	Fall	1.00	Fall	81	5.3
4/17/2022	3881-084	Fall	Fall	1.00	Fall	79	5.3
4/17/2022	3881-085	Fall	Fall	1.00	Fall	74	4.2
4/17/2022	3881-086	Spring	Fall	1.00	Fall	92	7.9
4/18/2022	3881-087	Spring	Fall	1.00	Fall	82	5.8
4/18/2022	3881-088	Spring	Fall	1.00	Fall	84	7.1
4/21/2022	3881-089	Spring	Fall	1.00	Fall	87	6.5
4/23/2022	3881-090	Spring	Fall	1.00	Fall	88	8.3
4/23/2022	3881-091	Spring	Fall	1.00	Fall	90	8.0
4/23/2022	3881-092	Spring	Fall	1.00	Fall	89	7.6
4/23/2022	3881-093	Spring	Fall	1.00	Fall	86	7.1
4/24/2022	3881-094	Fall	Fall	1.00	Fall	66	3.3
4/24/2022	3881-095	Fall	Fall	1.00	Fall	77	4.7
4/25/2022	3881-096	Fall	Fall	1.00	Fall	84	7.0
4/25/2022	3881-097	Fall	Fall	1.00	Fall	79	5.2
4/25/2022	3881-098	Fall	Fall	1.00	Fall	85	6.3
4/25/2022	3881-099	Spring	Fall	1.00	Fall	87	6.9
4/25/2022	3881-100	Spring	Fall	1.00	Fall	93	8.8
4/27/2022	3882-086	Spring	Fall	1.00	Fall	89	6.8
4/27/2022	3882-087	Spring	Fall	1.00	Fall	90	6.9
4/29/2022	3881-071	Spring	Fall	1.00	Fall	95	9.4
5/1/2022	3882-098	Spring	Fall	1.00	Fall	92	7.9
5/1/2022	3882-088	Spring	Fall	1.00	Fall	97	-
5/1/2022	3882-089	Spring	Fall	1.00	Fall	93	8.4
5/1/2022	3882-090	Fall	Fall	1.00	Fall	77	5.4
5/1/2022	3882-091	Fall	Fall	1.00	Fall	80	-
5/1/2022	3882-092	Fall	Fall	1.00	Fall	82	-
5/1/2022	3882-093	Fall	Fall	1.00	Fall	79	-
5/1/2022	3882-094	Fall	Fall	1.00	Fall	77	-
5/1/2022	3882-095	Spring	Fall	1.00	Fall	94	-

5/1/2022	3882-096	Spring	Fall	1.00	Fall	94	-
5/1/2022	3882-097	Spring	Fall	1.00	Fall	90	9.0
5/3/2022	3882-099	Spring	Fall	1.00	Fall	92	8.1
5/4/2022	3882-100	Spring	Fall	1.00	Fall	94	9.1
5/6/2022	3881-001	Spring	Fall	1.00	Fall	100	11.2
5/7/2022	3881-003	Spring	Fall	0.95	Fall	96	9.5
5/9/2022	3881-004	Fall	Fall	1.00	Fall	93	8.4
5/9/2022	3881-024	Fall	Fall	1.00	Fall	90	7.8
5/9/2022	3881-025	Fall	Fall	1.00	Fall	85	-
5/10/2022	3881-026	Fall	Fall	0.99	Fall	81	5.2
5/10/2022	3881-051	Fall	Fall	1.00	Fall	80	4.9
5/15/2022	3882-027	Fall	Fall	1.00	Fall	90	7.8
5/15/2022	3882-070	Fall	Fall	1.00	Fall	91	7.7
5/15/2022	3883-030	Fall	Fall	1.00	Fall	87	7.1
5/16/2022	3883-031	Fall	Fall	1.00	Fall	90	8.0
5/17/2022	3883-046	Fall	Fall	1.00	Fall	87	6.9
5/31/2022	3883-087	Spring	Fall	1.00	Fall	117	16.0

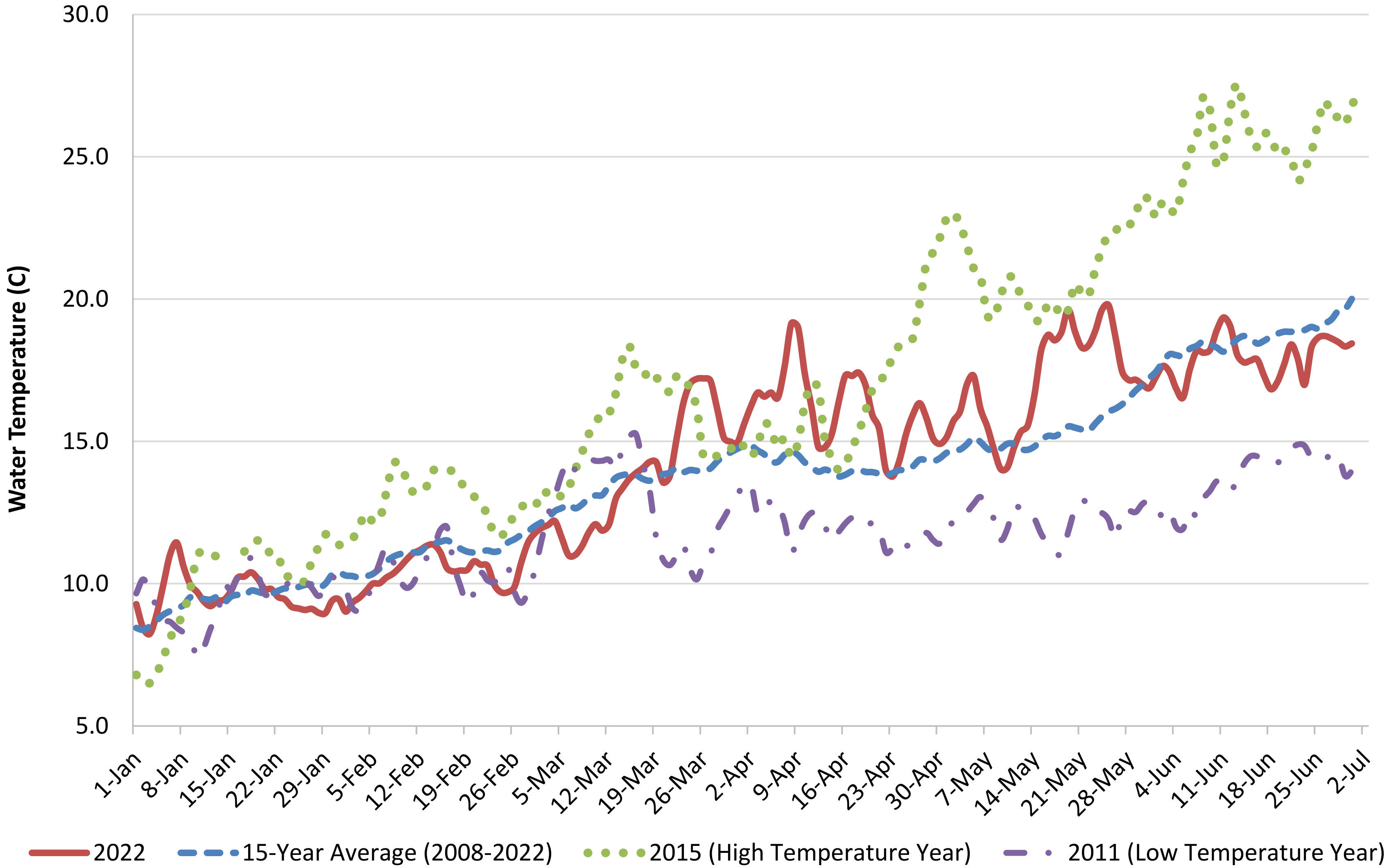
Appendix 6: **Median seasonal discharge (cfs), total catch of fall-run, late fall-run, winter-run, and spring-run Chinook Salmon, steelhead, and lamprey and the associated passage estimate with 95% confidence intervals (CI) for fall-run Chinook Salmon from the 1996 – 2021 Stanislaus River rotary screw trap sampling seasons.**

Year	Discharge	Total Catch						Passage Estimate	
		Fall-run	Late Fall-run	Winter-run	Spring-run	steelhead	Lamprey	Fall-run	95% CI
1996	1,561	2,468	0	0	0	4	857	54,218	[35,733–60,137]
1997	1,701	2,357	0	0	0	11	57	57,586	[44,828–75,666]
1998	2,047	19,525	0	0	0	4	445	1,557,561	[899,587–3,474,805]
1999	1,536	41,234	0	0	0	12	969	1,568,699	[1,334,966–2,413,635]
2000	1,366	73,715	0	0	0	15	4,356	2,338,070	[1,461,824–2,623,188]
2001	532	9,907	0	0	0	34	9,762	93,747	[88,356–N/A]
2002	541	3,835	0	0	0	10	210	45,982	[33,720–50,275]
2003	606	14,059	0	0	0	13	476	136,397	[127,369–179,869]
2004	440	40,087	0	0	0	19	3,589	490,554	[287,261–549,557]
2005	384	25,287	0	0	0	11	5,551	236,279	[187,019–299,694]
2006	3,250	1,589	0	0	0	2	9	375,327	[199,617-836,170]
2007	1,055	2,909	0	0	0	23	502	134,561	[48,417–741,089]
2008	508	230	0	0	0	1	1,010	32,063	[5,535–54,020]
2009	403	767	0	0	0	5	1,074	5,349	[3,156–5,743]
2010	455	1,102	0	0	0	1	5,011	16,994	[8,181–25,129]
2011	1,416	605	0	0	0	2	545	N/A	N/A
2012	637	1,199	0	0	0	3	265	34,235	[20,298–54,952]
2013	498	19,072	0	0	0	4	276	381,702	[161,693–550,092]
2014	353	2,083	0	0	0	3	1,304	23,582	[14,222–46,110]
2015	258	905	0	0	0	2	1,162	10,750	[8,814–N/A]
2016	332	2,207	0	0	0	2	11,839	28,492	[24,662–47,726]
2017	1,940	8,246	0	0	0	0	5	613,144	[217,351–831,859]
2018	1,249	3,515	0	0	1	0	272	222,000	[162,000–293,500]
2019	2,130	6,498	0	0	0	0	686	979,000	[529,400–2,824,000]

2020	872	912	0	0	0	2	1,624	166,720	[70,570–632,500]
2021	450	199	0	0	0	0	3,444	30,264	[21,830 – 151,300]
2022	509	989	0	0	0	0	253	113,286	[58,650 – 483,200]

Discharge: Based on the annual median discharge between January 1 and June 30 from USGS at Ripon, Station #11303000.
Lamprey: Includes adult and all juvenile life stages of Petromyzontidae.
Passage Estimate and CI: Adopted from table 6 of CFS 2016 annual report and from PSMFC 2017 – 2021 annual reports.

Appendix 7: **Daily average water temperature (°C) in the Stanislaus River at Ripon for the 15-year period 2008-2022, the highest temperature year (green round dots), the lowest temperature year (purple dash dots), the 15 year average (blue dashes) and the current year (2022, red line). Data from USGS station number 11303000.**



Appendix 8: **Daily average discharge (cfs) on the Stanislaus River at Ripon for the 15-year period 2008 – 2022, the highest water year (green round dots), the lowest water year (purple dash dots), 15-year average (blue dashes) and the current year (2022, red line). Data from USGS station number 11303000.**