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

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Acronyms and Abbreviations

Acronym	Definition
ESA	Endangered Species Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic Atmospheric Administration
CVPIA	Central Valley Project Improvement Act
SIT	Science Integration Team
DSM	Decision support model
SJRRP	San Juan River Restoration Program
NMFS BiOp	NMFS biological and conference opinion
USBR	United States Bureau of Reclamation
CVP	Central Valley Project
SWP	State Water Project
RPA	Reasonable and Prudent Alternatives
SOG	Stanislaus Operations Group
VAMP	Vernalis Adaptive Management Plan
AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFW	California Department of Fish and Wildlife
USFWS	United States Fish and Wildlife Service
Cramer	Cramer Fish Sciences
PSMFC	Pacific States Marine Fisheries Commission
RST	rotary screw traps
OID	Oakdale Irrigation District
SSJID	South San Joaquin Irrigation District
SEWID	Stockton East Water Irrigation District
RPM	revolutions per minute
USGS	United States Geological Survey

Acronym	Definition
L	liter
mm	millimeter
g	gram
SNP	single-nucleotide polymorphism
BBY	Bismarck Brown Y
VIE	Visual Implant Elastomer
CFS	cubic feet per second
GAM	generalized additive model
C	Celsius
NTU	Nephelometric Turbidity Units
m/s	meters per second
DO	Dissolved oxygen
mg/l	milligrams per liter

Abstract

Operation of the rotary screw traps on the lower Stanislaus River at Caswell Memorial State Park in 2019 is part of the U.S Fish and Wildlife Service's AFRP and CAMP under the NMFS RPA actions and CVPIA. The primary objective of the trapping operations is to collect data that can be used to estimate the production of juvenile fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and quantify the raw catch of steelhead/rainbow trout (*Oncorhynchus mykiss*). Secondary objectives of the trapping operations focus on collecting fork length and weight data for juvenile salmonids and gathering environmental data that will eventually be used to develop models that correlate environmental parameters with salmonid size, temporal presence, abundance, and production.

For the 2019 survey season, two 2.4 meter (8 foot) rotary screw traps (RSTs) were operated at Caswell Memorial State Park on the lower Stanislaus River in California. Sampling occurred on 99 of the 130 days between 11 January 2019 and 20 June 2019. A total of 6,498 fall-run juvenile Chinook salmon was captured. The passage of juvenile fall-run Chinook salmon peaked during the week of 5 February, when 51.25 percent (n = 3,330) was captured. The majority of the captured juvenile Chinook salmon belonged to the button-up fry life stage; fewer numbers of the yolk sac fry, parr, silvery parr, and smolt life stages were also collected. Four trap efficiency trials were used to estimate the production of juvenile fall-run Chinook salmon. Trap efficiencies during those four trials ranged from 0.00 to 1.52 percent, with an average efficiency of 0.66 percent. The number of in-river produced juvenile fall-run Chinook salmon that were estimated to have emigrated past the Caswell trap site on the Stanislaus River during the 2019 survey season was 979,000 individuals (95 percent confidence intervals = 529,400 to 2,824,000). Finally, 4,479 individuals belonging to 21 different identifiable non-salmonid species were caught and 132 non-salmonid individuals were caught that were identified to family but were unable to be identified to species.

This annual report also includes seven appendices. Four of those appendices describe different environmental variables and studies related to the trap site or rotary screw trap operations during the 2019 survey season.

Introduction

The Stanislaus River is a tributary to the San Joaquin River, one of two main stem 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, over the past decade, these populations have undergone a widespread decline. The construction of impassable dams throughout the valley has reduced habitat availability for these fish populations by disrupting the natural gravel supply and distribution downstream. Additionally, hydraulic mining, over-harvesting, hydropower implementation, introduction of species, water diversions and other factors have contributed to the decline of these fish populations (Yoshiyama et al 2000, Lindley et al 2006, NMFS 2009). As a result, Chinook salmon and 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 2016).

In order to help protect, restore, mitigate and improve the natural production of juvenile Chinook salmon and steelhead in the Central Valley, the Central Valley Project Improvement Act (CVPIA) was established in 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 CVPIA Science Integration Team (SIT) was developed to use current data in decision support models (DSMs) and recommend Fish Resource Area priorities. Additionally, the CVPIA funded the San Joaquin River Restoration Program (SJRRP) to reintroduce spring-run Chinook salmon into the San Joaquin River. The success of this reintroduction as well as the continued improvement of natural production of anadromous fish is reliant upon continued monitoring throughout the watershed. Accordingly, the 2019 CVPIA annual work plan describes specific required projects, programs or monitoring activities, based on SIT recommended priorities, to be conducted which include the rotary screw trap monitoring program, Migratory Corridor Rehabilitation and Salmonid Spawning and Rearing Habitat Restoration on the Stanislaus River (CVPIA 1992, USBR 2019).

In 2009 NMFS completed their biological and conference opinion (NMFS BiOp) based on the U.S. Bureau of Reclamation's (USBR) proposed long-term operations of the Central Valley Project (CVP) and State Water Project (SWP), leading to Reasonable and Prudent Alternatives (RPA) intended to reduce the threat on ESA-listed species and negative impacts on crucial habitat. The RPA actions from the NMFS BiOp established requirements related to Stanislaus River operations which involve flow management and temperature control, restoration of freshwater migratory habitat, and adult escapement and juvenile monitoring for the Central Valley steelhead.

To meet flow management and temperature control requirements, as put forth in NMFS BiOp Appendix 2-E, the Stanislaus Operations Group (SOG) and USBR maintain a flow schedule that includes Vernalis Adaptive Management Plan (VAMP) fall and spring pulse flows. The fall pulse flows are meant to provide suitable temperatures to migrating and holding adult steelhead in October and November. After 1 March, spring pulse flows are initiated to protect incubating eggs, cue out-migrating juveniles, and signal incoming adult, potentially spring-run, Chinook salmon (NMFS 2009).

Recommended Central Valley stream restoration actions, outlined in the NMFS RPA and supported by the CVPIA's Anadromous Fish Restoration Program (AFRP), have resulted in multiple gravel restoration efforts to restore and create spawning and rearing habitat in the Stanislaus River. For example, in 2007 the Lover's Leap Restoration Project was completed where approximately 25,000 tons of gravel and cobble was placed within the 25.5 mile salmonid spawning reach (KDH 2008). Restoration also occurred at Lancaster Road where over 2 acres of floodplain and nearly 640 feet of side-channel habitat were restored (Cramer 2012). Restoration Projects still in progress include the Two Mile Bar Salmonid Habitat, creating a spawning side channel through a high floodplain, as well as other proposed projects.

Despite all efforts that have already been completed, continuous restoration, management and monitoring activities are needed to further aid the recovery of Chinook salmon and steelhead populations. To this end, NOAA Fisheries adopted a new ESA recovery plan in 2014 for Central Valley steelhead as well as Central Valley spring-run Chinook salmon and Sacramento River winter-run Chinook salmon. In 2016 a 5-year status review was completed by NMFS, determining that Chinook salmon and steelhead would remain threatened under the ESA (NMFS 2016), requiring the continuation of restoration and management activities. As the Stanislaus River is a top priority for steelhead reintroduction and a candidate for reintroduction of spring-run Chinook salmon, continued effort by the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP) is important in determining how restoration activities and flow management affect the current salmonid populations.

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 RPA actions, monitor juvenile salmonids to provide current and relevant data to the 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 (Cramer) or Pacific States Marine Fisheries Commission (PSMFC). This report describes efforts to determine the timing and abundance of emigrating juvenile salmonids using rotary screw traps (RSTs) on the lower Stanislaus River at Caswell Memorial State Park in 2019 as part of a larger effort to determine if habitat restoration activities and flow management regulations are improving Chinook salmon production. Furthermore, this report presents data that describe the size and abundance of other native and non-native fish species in relation to the time of year, river discharge, and environmental conditions.

The primary objective of the lower Stanislaus River trapping operations is to collect data that can be used to estimate the production of juvenile fall-run Chinook salmon and observe abundance of steelhead. Secondary objectives of the trapping operations focus on collecting fork length and weight data for juvenile salmonids and gathering environmental data that will eventually be used to develop models that correlate environmental parameters with salmonid size, temporal presence, and abundance/production. An ancillary objective of the trapping operations is to collect non-salmonid fish species data that can be used to characterize the fish community in the Stanislaus River in the vicinity of the RSTs.

Study Area

The Stanislaus River headwaters begin on the western slope of the Sierra Nevada mountain range and cover an area of about 980 square miles (USBR 2017). 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, located in Tuolumne, Calaveras and Stanislaus counties, is a major tributary to the San Joaquin River, which is the southern portion of California's Central Valley watershed. The San Joaquin River flows north and joins the Sacramento River in the Sacramento-San Joaquin Delta. The lower Stanislaus River is approximately 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 fall-run Chinook salmon and Central Valley steelhead. The primary spawning habitat is relegated between Goodwin Dam (rkm 94) and Riverbank (rkm 54.7) (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 USBR and the Tri-Dam Project to provide flood control, irrigation and agricultural use, power generation, and temperature regulation, and are also used to meet flow management requirements. Goodwin Dam is equally and jointly owned by the Oakdale (OID), South San Joaquin (SSJID), and the Stockton East Water irrigation districts (SEWID). 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.

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 and access, and maintained flows consistent enough to operate rotary screw traps (Cramer 2006). Two 8 foot rotary screw traps were positioned in the thalweg of the channel near the Northern most corner of the State Park (Figure 2). 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.

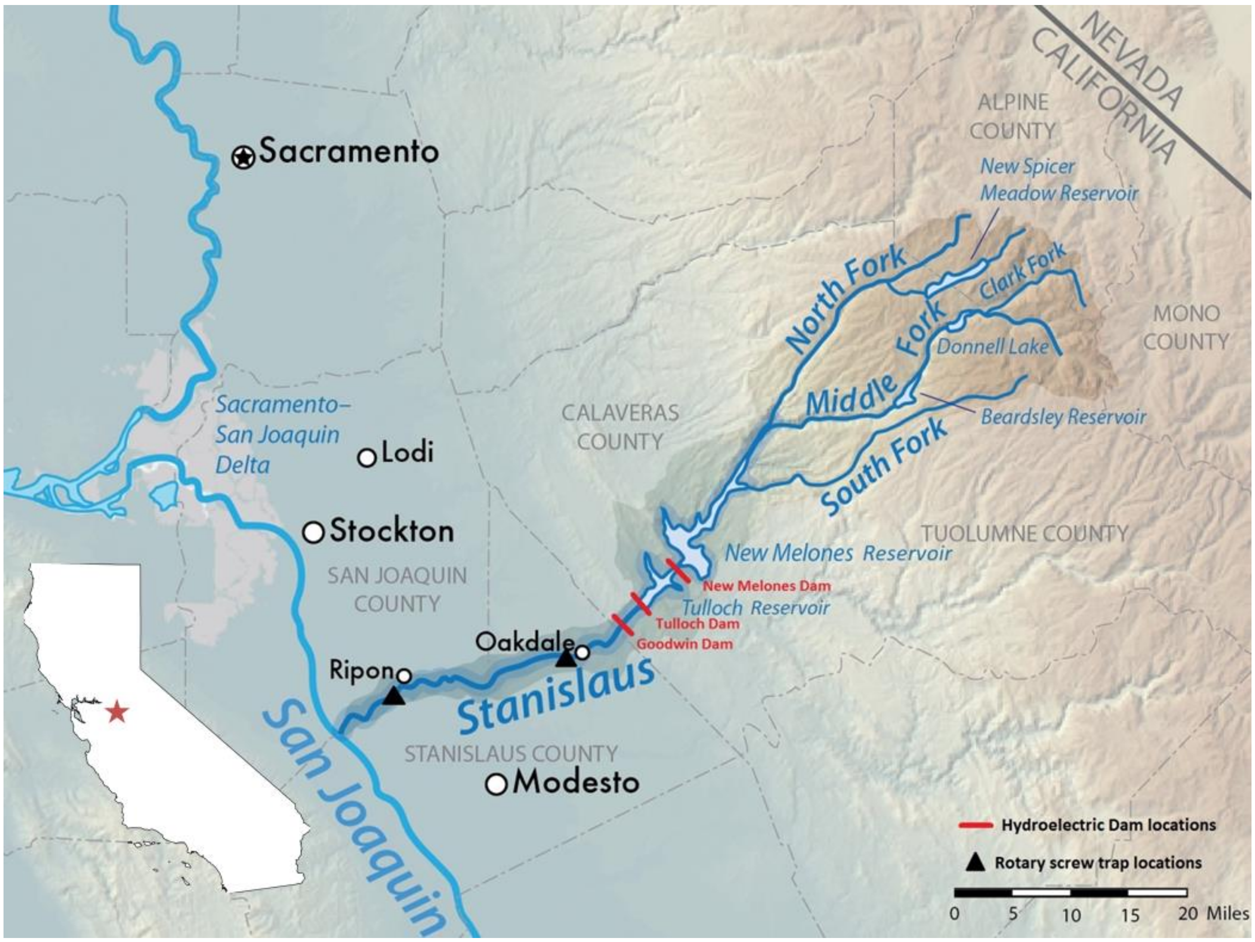
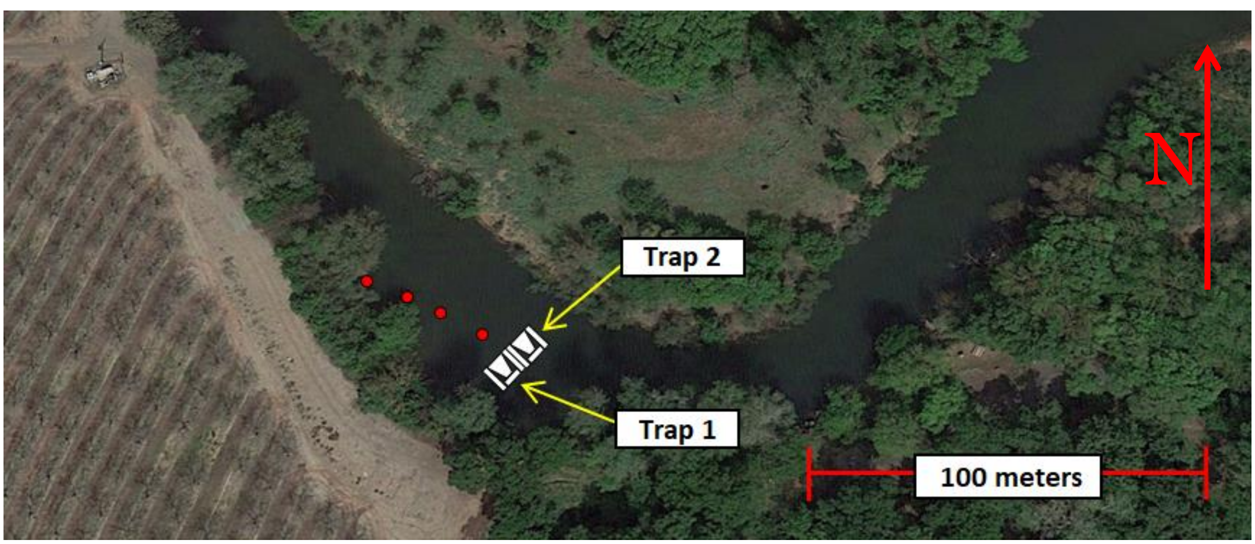


Figure 2: Operations map for the Stanislaus River Rotary Screw Trap Project.

Figure 3: Stanislaus River rotary screw trap site at Caswell Memorial State Park.



Methods

Trapping Operations

Sampling for the 2019 survey season started on 10 January and ended on 20 June. The two 2.4 meter (8 feet) diameter RSTs were fished in a side-by side configuration anchored in two separate locations. A ¼ inch galvanized cable, affixed with orange buoys, was secured to a tree upstream with a cable bridle attached to the outermost pontoon of each trap. An additional anchor rope was attached to the southwestern bank, allowing for in-channel adjustments. In order for the crew to board the traps, this auxiliary anchor rope was also used 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 trapping while environmental data were collected and live wells were cleared.

Trap checks were conducted at least once every 24 hours when traps were fishing in a cone-down configuration. During large storm events or measurable river flow increases, trap functionality could be hindered by larger sized or higher quantities of debris, creating a high potential for fish mortality. Therefore, to help prevent fish mortality, additional day-time trap checks or supplementary night-time checks were conducted during peak emigration weeks, or when field conditions suggested the potential for high debris loads. Night checks were primarily used to clear debris and to keep the traps functioning properly; typically fish were not processed during these checks. In cases where a storm or flow increase was deemed severe enough, traps were taken out of service for an indefinite amount of time until the conditions improved. When traps were out of service, trap cones were raised, live well screens were pulled, and sampling was temporarily suspended.

The number of cone rotations between trap visits was monitored using a mechanical lever actuated counter (Trumeter Company Inc.) attached to the port side pontoon on each trap; this data was used to determine how well traps functioned between trap visits. The effect of debris buildup on trap cone rotation rates was quantified by counting the number of revolutions per minute (RPM) before and after each cone was cleaned each day. Cleaning of the cones relied on the use of a scrub brush to clear off algae and other vegetation, or stopping a trap cone to remove larger debris. For each trap visit, the extent of cone intake obstruction caused by debris was assigned a category of “none”, “partially blocked”, “completely blocked”, or “backed up into cone.”

Safety Measures

All crew members were trained on RST safety and personal flotation devices were worn at all times when members were on the RSTs. For night operations, crew members were required to affix a strobe light to their personal flotation devices that turned on automatically when submerged in water. Two 12-volt, 1260 lumens, LED flood lights were affixed to each trap.

A variety of devices were installed to keep the public safe and away from the traps. “Keep Away” signs in English and Spanish were installed on the traps. A flashing amber construction light was attached to the outermost railings on the traps to alert the public at night that there was a potential navigation hazard. Orange or reflective buoys were placed on the anchor cable and bridal. Signs were installed upstream and downstream of the traps, warning river users of the proximity to the trap location.

Environmental Parameters

During every trap visit when fish were processed, environmental data were recorded. Temperature and dissolved oxygen were measured using a YSI dissolved oxygen meter (YSI EcoSense DO200A), velocity in front of each cone was recorded using a Global Water flow probe, and turbidity was measured using a Eutech portable turbidity meter (Eutech; Model TN-100). When river depth was 300 cm or less, a depth rod was used to measure water depth underneath the trap to the nearest centimeter on the port and starboard sides of the 2-trap array, in line with the front of the trap cones. Average daily river discharge and average daily temperature for the Stanislaus River was determined using data from the U.S. Geological Survey’s (USGS) Stanislaus River at Ripon monitoring station (USGS station number 11303000).

Catch and Fish Data Collection

After environmental data was collected, the process of clearing out each RST’s live well and fish work-up began. First, debris was removed from the live well and placed into 68.14 liter (L) tubs which crew members sifted through, setting aside or enumerating any fish, alive or dead, and enumerating debris volume by gallon. After all debris was removed, an assessment of debris type and volume was recorded. Next, the crew netted any remaining fish from the live well and placed them in 18.93 L buckets with lids, segregating salmonids from non-salmonids or potential predators. During periods of hot weather, fish were placed in buckets with aerators to provide them with oxygen and an ice pack to keep the water temperature at a safe level. If fish were held in buckets for a prolonged amount of time, oxygen depleted water was regularly exchanged with fresh river water.

On days when less than 100 Chinook salmon were caught in a trap, the fork length of each salmon from each trap was measured to the nearest one millimeter (mm), their life stage was assessed using the smolt index rating (Table 1), the presence of marks used during trap efficiency trials or absence of adipose fin clips were noted, and their mortality status (live vs. dead) was assessed. If Chinook salmon were ≥ 40 mm in fork length, the first 25 were weighed to the nearest 0.1 gram (g).

When more than 100 Chinook salmon were caught in a trap, a random sample of 100 live salmon from each trap was collected. The fork length, life stage, mark status, and fin clip status for each of the 100 salmon was assessed. If the individuals were ≥ 40 mm in fork length, the first 25 were weighed to the nearest 0.1 g after they were measured and assessed for life stage. Because dead salmon are difficult to accurately measure and identify to life stage due to varying stages of decomposition that alter body size, weight, and color, live salmon were preferentially used for the random sample of 100, when possible. In those cases, mortalities were considered "mort plus-count;" an unassigned life stage category.

The random sample was achieved by placing a net full of Chinook salmon from the live well into a 68.14 L tub. Debris was removed from the tub with salad tongs/probes, leaving only the subsampled salmon in the tub. After removing the debris from the tub, a random net full of salmon was taken from the 68.14 L tub and placed in an 18.93 L bucket designated for Chinook salmon subsampling. From the subsampled bucket, 100 Chinook salmon were randomly selected for analysis. Additional fall-run Chinook salmon in excess of the 100 that were present in the tub or trap live well were not measured and weighed, but each of these salmon were checked for marks, enumerated, and recorded on data sheets as a "live plus-count tally," or "mort plus-count tally." A "plus-count tally" was defined as the total number of fish that were caught in a trap on a given day, and that were not measured, weighed, or assigned a life stage.

If steelhead were captured, each individual was counted, fork lengths were measured to the nearest 1 mm, life stage was assessed using the smolt index rating in Table 1, and mortality status was assessed. In addition, each steelhead was checked for the presence or absence of a mark (i.e., adipose fin clipped) and the weights of each individual ≥ 40 mm in fork length were recorded.

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

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

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

Prior to collecting fish fork lengths and weights, individuals were anesthetized with sodium bicarbonate tablets (Alka-Seltzer Gold) to reduce stress as they were processed. One Alka-Seltzer tablet was added to one liter of water. Approximately eight to 10 fish, depending on size and crew manageability, were placed in a solution of river water and Alka-Seltzer, then measured and weighed. The crew routinely observed the gill activity of fish immersed in the solution; reduced gill activity was an indication fish were ready to be processed. After fish were measured and weighed, they were placed in an 18.93 L bucket with a mixture of fresh river water and stress coat additive (Poly-Aqua) to help replenish their slime coat as the fish recovered from the anesthetic. As soon as it was determined that the fish had fully recovered from anesthesia, all fish were released well downstream of the traps to prevent recapture.

Chinook salmon were assigned a salmon run at the time of capture using length-at-date (LAD) criteria that were developed for the Sacramento River by Greene (1992). When Chinook salmon appeared to be late fall-, winter- or spring-run salmon using the LAD criteria, 1 to 2 mm samples were commonly taken from the upper caudal fin. These samples were then sent to the staff at the USFWS's Abernathy Fish Technology Center to perform genetic run assignments using the panel of single-nucleotide polymorphism (SNP) markers described by Clemento et al. (2014). This panel of SNPs was developed by NOAA Fisheries, and is now used for several applications by the 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.

Trap Efficiency

Trap efficiency trials were conducted to quantify the proportion of the emigrating fall-run Chinook salmon that were passing through the river and were collected by the RSTs; these data were then used to estimate the total number of fall-run Chinook salmon migrating past the RSTs. Trap efficiencies were assessed using two different marking methods.

On method of marking consisted of dying the whole body of a fall-run Chinook salmon with Bismarck Brown Y (BBY) stain when a majority of the juvenile salmon had a fork length <50 mm. At least 500 salmon were needed to conduct trials with BBY stain. When < 500 Chinook salmon were caught on a given day, they were held overnight and salmon caught the next day were added to achieve the minimum number of Chinook salmon required for a trap efficiency trial. If the minimum number of salmon needed to conduct a trap efficiency trial were not captured within a 48-hour period, they were not used for an efficiency trial and were released downstream of the traps. When daily catch totals of in-river produced salmon were deemed too low to provide sufficient numbers of fish for accurate trap efficiency tests, hatchery fall-run Chinook salmon from Merced River Hatchery were used to supplement in-river produced salmon.

Once enough Chinook salmon were attained to conduct a trap efficiency trial, either in-river or hatchery produced, they were placed in a 141.95 L insulated ice chest and stained using a solution of 0.6 g of BBY for every 20 L of river water. The actual amount of stain used varied depending on water turbidity and the number of salmon being stained. Salmon were stained for approximately two hours, and their condition was monitored during the staining process as well was water temperature and dissolved oxygen levels. After staining, salmon were rinsed with fresh river water and placed in a 75.71 L live car and held until twilight when they were released using the technique described below.

The other method of marking used was a Visual Implant Elastomer (VIE) tag which consisted of inserting a syringe loaded with elastomer and hardener at a ratio of 10 parts elastomer to one part hardener into the snout of an anesthetized fall-run Chinook salmon and injecting a small amount of the liquid fluorescent elastomer just under the skin. The elastomer then hardens and a tag retention test was done after each tagging session. This marking method is performed on fish with a fork length >50 mm. Tagging supplies, mixing procedures and protocols for VIE tags were provided by Northwest Marine Technology, Inc.

To evaluate the potential for a difference in size distribution between salmon released during a trap efficiency trial and associated recaptured salmon, 100 fork lengths from the released salmon were used to produce an average release length and compared with the average length of the recaptured salmon.

The release site was approximately 0.5 rkm upstream of the traps, located at the upper of two irrigation pumps. Two methods were used depending on river flows at the time of the release. At river flows of less than approximately 2,000 cubic feet per second (CFS), fish were taken up to the release site from the RSTs using a small motorized boat. To avoid schooling when Chinook salmon were released, they were scattered across the width of the river channel by small dip nets. When river flows were greater than approximately 2,000 CFS, safety precautions were taken and tagged fish were transported up to the release site via truck in aerated 68.14 L tubs and then released into the thalweg using a 10 foot tube. The tube allowed enabled the crew to work safely from shore and still deposit the fish into the thalweg. Net-fulls of fish were collected from the tubs and placed into a 2.5 gallon bucket with fresh river water. This bucket was then poured carefully into one end of the tube which rested at a 30 degree downward angle to the river until empty and then an additional bucket of fresh river water was poured into it to ensure all fish had passed through the tube. This process continued until all fish had been released into the river. Every release of marked Chinook salmon occurred close to twilight to mimic natural migration patterns and avoid predation.

In visits following each trap efficiency release, the RST live-wells were carefully observed for any marked fish. A random sample of 100 recaptured Chinook salmon from each trap efficiency trial 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”.

After each efficiency trial, a determination was made whether to include or exclude that trial from analysis. Factors that influenced this decision included success of fishing based on trap functionality, or other factors that might have adversely affected catch and therefore biased the resultant efficiency. If excluded from analysis, the trial was not used in the development of the generalized additive model (GAM) and did not influence overall trap efficiency. The calculation of the GAM is described below.

Passage Estimates

Fall-run Chinook salmon passage estimates were developed using an enhanced efficiency model developed by West Inc. Passage estimates were not developed for the other Chinook salmon runs because these runs are not known to spawn in the Stanislaus River. Passage estimates were also not developed for steelhead because Central Valley steelhead fry are believed to rear in-river for one to three years before they immigrate to the ocean as smolts (Moyle et al. 2008), at which point they become more difficult to capture, as their larger size increases their ability to avoid the traps. The following model description was excerpted from a West Inc. document sent to those who implement the model.

> *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 (Table 1) 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 2). 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 2: 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.

Retention in Analysis

For every sampling period, a determination was made whether to include or exclude that period from analysis. Factors that influenced this decision included success of fishing based on trap functionality, or other factors that might have adversely affected catch.

If fishing was unsuccessful, a calculation was conducted using the clicker total and after cleaning RPMs to determine the amount of time the trap had been functioning normally. If this calculation indicated the trap had been functioning normally for at least 70 percent of the sampling period, the sampling period was kept in analysis. If the trap was determined to have been functioning normally for less than 70 percent of the sampling period, the period was excluded from analysis. Sampling periods excluded from analysis were treated by the CAMP platform like periods not fished and a catch estimate was produced based on Method #2, as described above. This estimated catch was then compared to the actual catch encompassing that sampling period. Under the assumption that abnormal trap function adversely affects catch, the higher of the two was considered to more accurately represent what would have been caught under normal trap function. Therefore any period with abnormal trap function was only excluded from analysis if the catch estimate produced was higher than what had actually been caught. Furthermore, if an unsuccessful trapping period was the first or last of the season, or if there were seven or more consecutive days of unsuccessful trapping the CAMP platform was unable to impute catch. Therefore, the actual catch was assumed to be more accurate and the period was included in analysis.

Confidence Intervals

Confidence intervals were computed using parametric bootstrap or Monte Carlo methods as described in the "Feasibility of Unified Analysis Methods for Rotary Screw Trap Data in the California Central Valley," by McDonald and Banach (2010).

Fulton's Condition Factor

Fall-run Chinook salmon condition was assessed using the Fulton's condition factor. The first 25 Chinook salmon larger than 40 mm captured each day were measured for weight and fork lengths. The ratio of the two was used to calculate their condition factor:

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

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

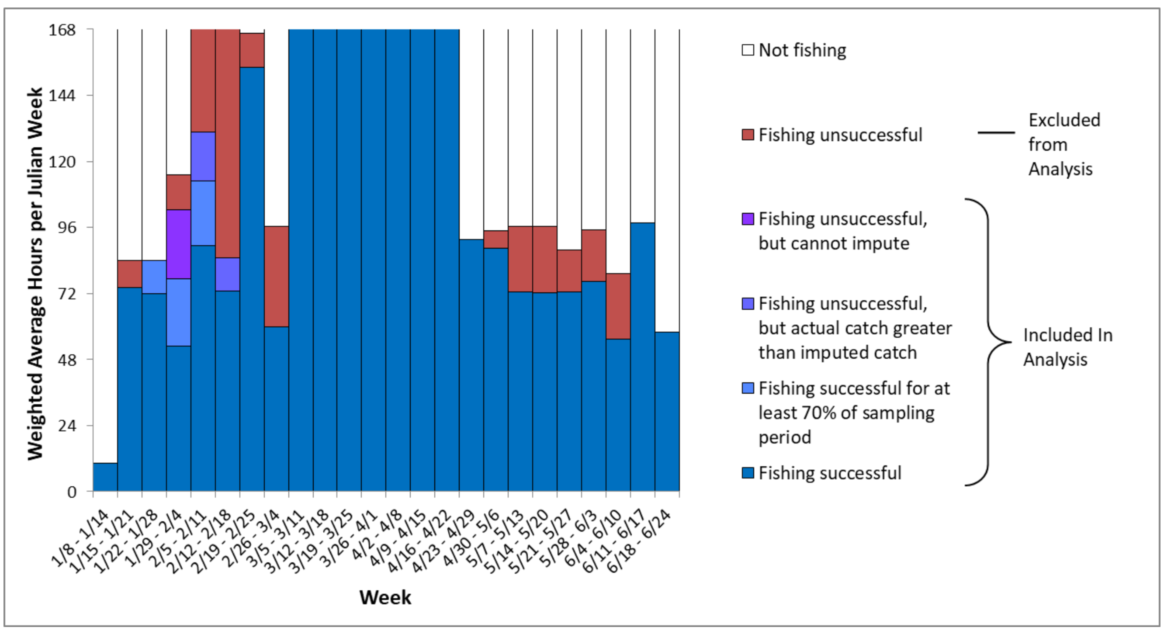
Results

Trap Operations

For the 2019 survey season, two 8ft RSTs were deployed in the Stanislaus River at the Caswell Memorial State Park and began sampling on 10 January 2019 at river flows of approximately 230 CFS. These low flows hindered the capability of the RSTs to function so sampling was suspended until 16 January when trap adjustments were made and flows increased from a storm event. Continuous sampling occurred until 1 March when trapping was temporarily suspended to limit fish mortality due to a scheduled flow increase. Sampling resumed on 4 March, fished continually until 26 April when cones were raised for the weekend. From this point, trapping occurred four days a week due to limited staff and lowered catch totals. This schedule continued until 20 June when trap operations for the 2019 survey season concluded. As a result, sampling took place on 99 of the 130 days between 10 January and 20

June. During this time, the traps fished unsuccessfully (defined as a period of time during which the trap was fishing, but catch was determined to be adversely affected by abnormal trap function) for approximately 358 hours. Traps fished successfully for approximately 2,507 hours and did not fish for approximately 999 hours (Figure 4). Of the 358 hours of unsuccessful fishing, 55 were included in analysis despite abnormal trap function, following the process described in the Methods section of this report. As a result, a total of 2,562 hours of fishing were included in analysis and used to develop the passage estimate, and 303 hours of fishing were not included in analysis (Figure 4).

Figure 4: Weighted average hours per Julian week that both traps fished successfully, fished unsuccessfully, or did not fish during the 2019 Stanislaus River rotary screw trap survey season.

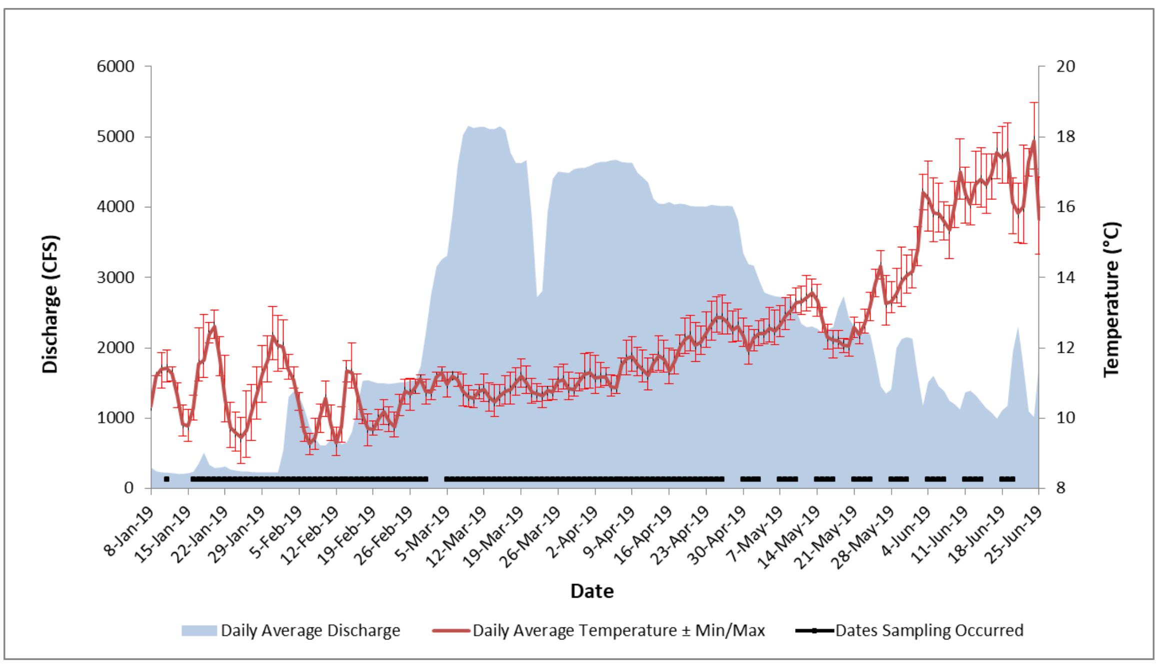


Environmental Summary

Appendix 2 provides a summary of the overall environmental conditions during the 2019 survey season, averaged by Julian week.

River discharge and temperature data, recorded in 15 minute increments, were acquired from the USGS station 11303000 on the Stanislaus River at Ripon, 12.5 rkm upstream of the RSTs. River discharge during the survey season ranged from a low of 206 CFS on 14 January to a high of 5,180 CFS on 9 March (Figure 5). River temperature during the survey season ranged from a low of 8.6° Celsius (C) on 25 January, to a high of 18.4° C on 17 June (Figure 5).

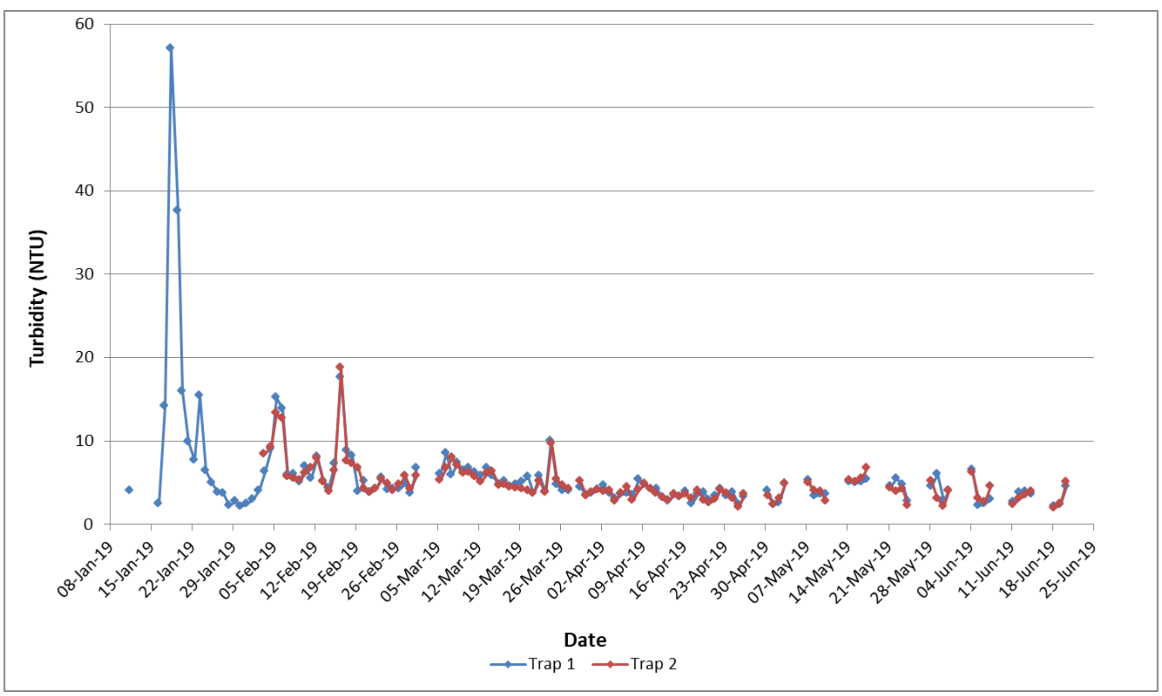
Figure 5: Average daily discharge (CFS) and average daily water temperature (°C), measured at Ripon, during the 2019 Stanislaus River rotary screw trap survey season.



Note: Discharge and water temperature data for the 8 January to 25 June time period were acquired from the USGS website at **http://waterdata.usgs.gov/ca/nwis/uv**

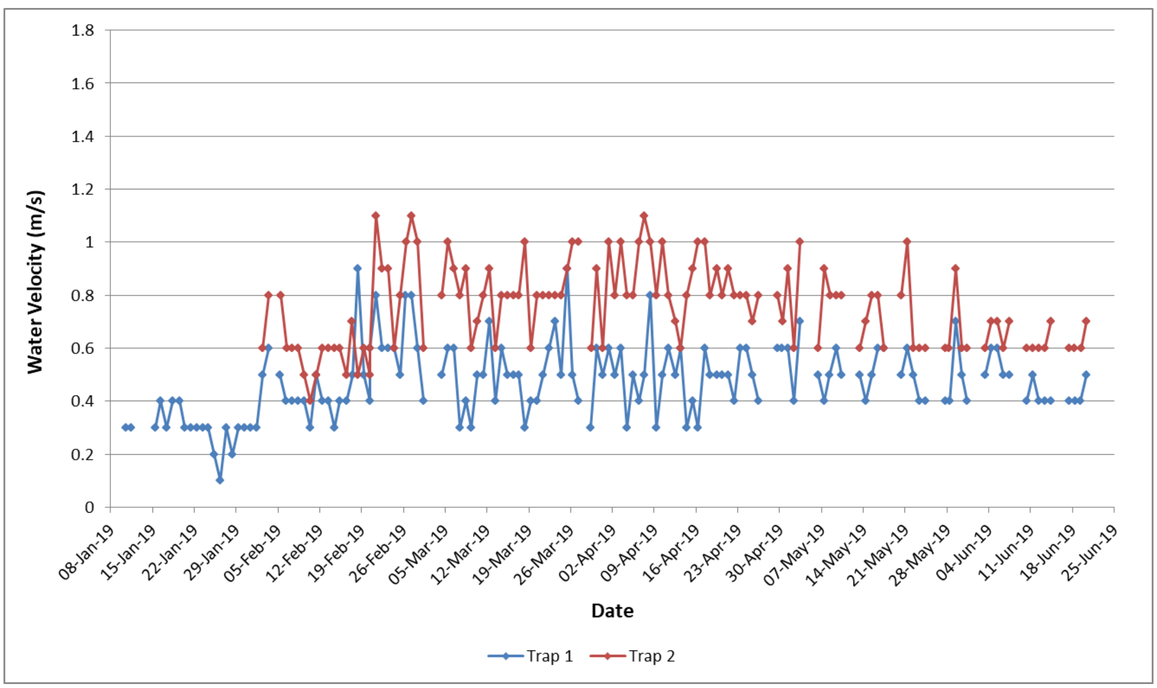
River turbidity was measured in the field, from water samples taken daily from each trap. Turbidity did not vary considerably between traps (Figure 6), but on average was slightly higher for Trap 1 (southwest side) than for Trap 2 (northeast side). Turbidity for Trap 1 reached a season maximum on 18 January, with 57.00 Nephelometric Turbidity Units (NTU) and Trap 2 reached a season maximum on 16 February with 18.70 NTU. Turbidity for Trap 1 reached a season low on 30 January, with 2.07 NTU. The season low for Trap 2 came on 18 June with 1.94 NTU. Weekly average turbidity across both traps, averaged by Julian week, is shown in Appendix 2. Weekly average turbidity reached a high of 22.82 NTU during the week of 15 January and had a weekly average low of 3.07 NTU during the week of 18 June.

Figure 6: Comparison of daily turbidity measured in the field during the 2019 Stanislaus River rotary screw trap survey season.



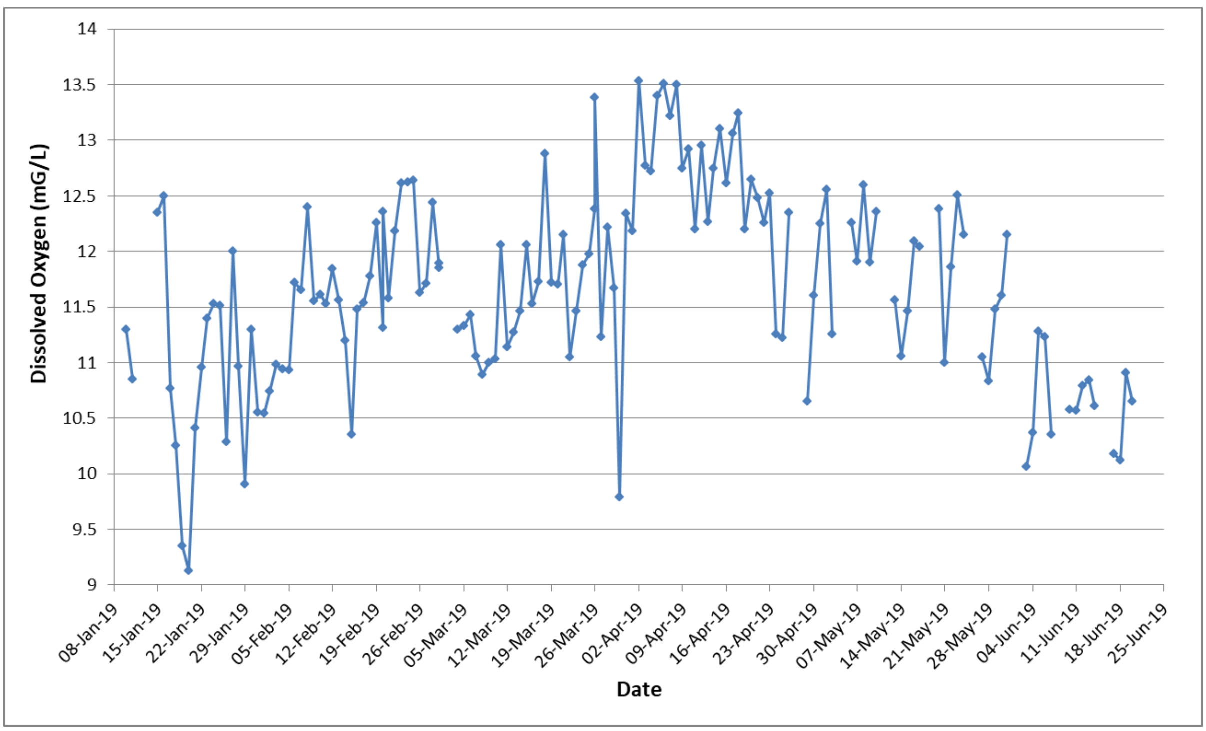
Water velocities (Figure 7) were also measured for each trap on a daily basis, and were taken from in front of each cone. Water velocities in front of Trap 2 (northeast side) were on average higher than for Trap 1 (southwest side). Water velocities in front of Trap 2 reached a low of 0.4 meters per sec (m/s) on 10 February, and reached a high of 1.1 m/s on 21 February. Water velocities in front of Trap 1 ranged from a low of 0.1 m/s on 26 January to a high of 0.9 m/s on 18 February. Weekly water velocity averaged across both traps by Julian week, is shown in Appendix 2. Weekly average water velocity ranged from a low of 0.24 m/s for the week of 22 January to a high of 0.76 m/s for the week of 26 February.

Figure 7: Comparison of water velocities measured daily in the field in front of each trap during the 2019 Stanislaus River rotary screw trap survey season.



Dissolved oxygen (DO) in the river water (Figure 8), taken in the field as a single daily measurement, ranged from a low of 9.13 milligrams per liter (mg/l) on 20 January to a high of 13.53 mg/l on 2 April. Weekly average DO (Appendix 2) for the 2019 survey season, averaged by Julian week, ranged from a low of 10.56 mg/l for the week of 18 June to a high of 13.24 mg/L for the week of 2 April.

Figure 8: Daily dissolved oxygen content measured in the field during the 2019 Stanislaus River rotary screw trap survey season.



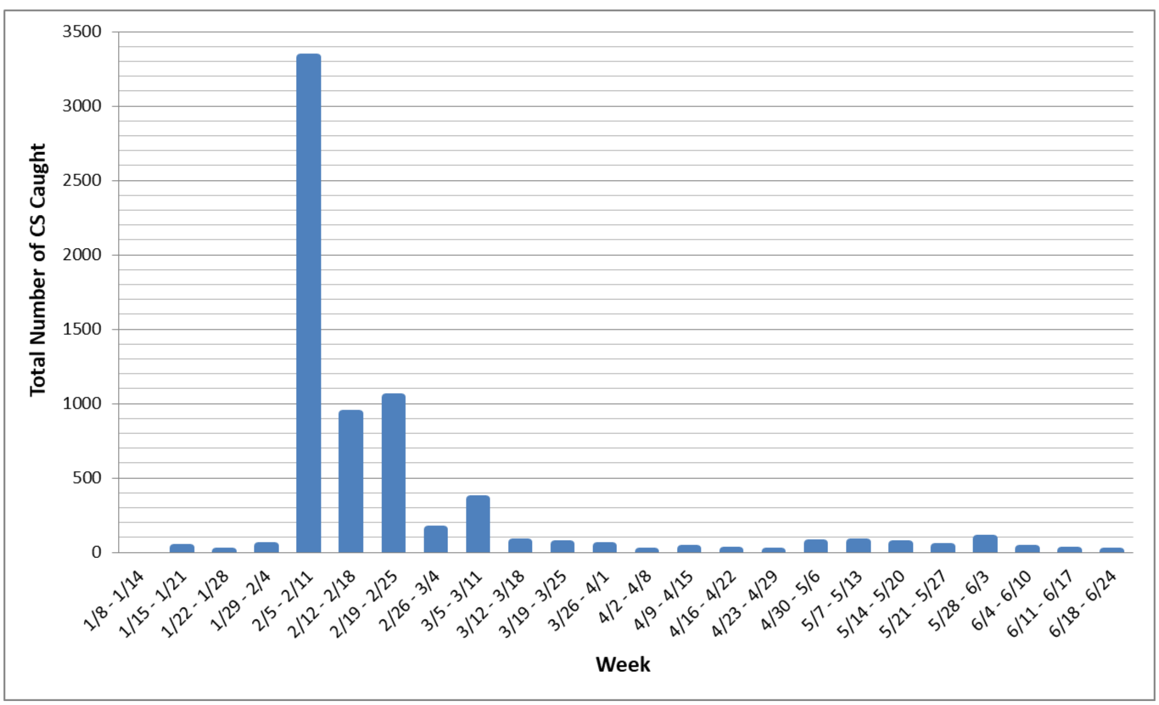
Catch

The two rotary screw traps deployed during the 2019 survey season captured a total of 11,109 fish. Trap 1 (south western side) captured 46.51 percent (n = 5,167) of these fish, and Trap 2 (north eastern side) captured 53.49 percent (n = 5,942). Chinook salmon were the only salmonid species captured. Twenty-one identified non-salmonid species were also captured as well as 132 individual non-salmonids that were unable to be identified to species (Appendix 3).

Fall-run Chinook salmon

Of the 11,109 fish captured during the 2019 survey season, a total of 6,498 of these were in-river produced, unmarked fall-run Chinook salmon (Figure 9). Catch of in-river produced, unmarked fall-run Chinook salmon peaked during the week of 5 February, when 51.25 percent (n = 3,330) was captured. The single day with the highest catch of fall-run Chinook salmon was on 5 February, when 1,473 were captured.

Figure 9: Weekly catch distribution of in-river produced, unmarked fall-run Chinook salmon during the 2019 Stanislaus River rotary screw trap survey season.



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

A total of 3,326 of the 6,498 in-river produced, unmarked fall-run Chinook salmon captured were measured for fork length. The weekly average fork length (Figure 10 and Table 2) began at a low of 34.00 mm during the first week of sampling, and increased to a season high of 88.36 mm the week of 11 June. During the week of 18 June when trapping was terminated for the season, the weekly average fork length was 88.00 mm.

Figure 10: Average weekly fork length for fall-run Chinook salmon during the 2019 Stanislaus River rotary screw trap survey season.

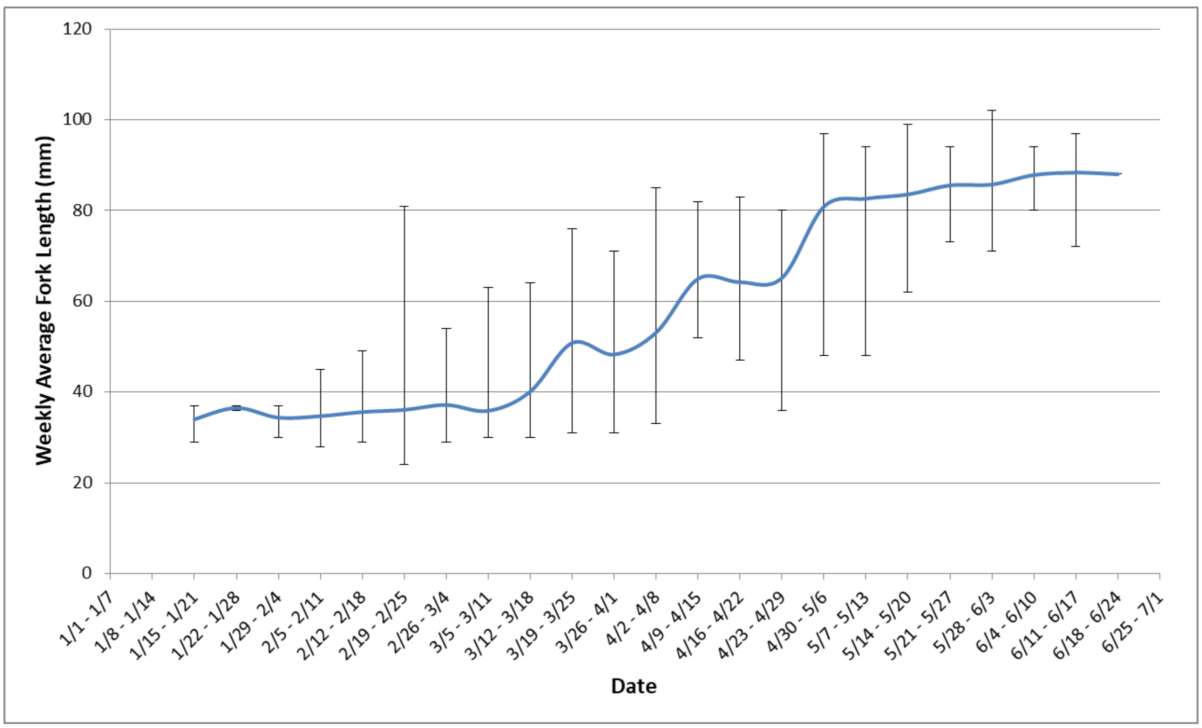
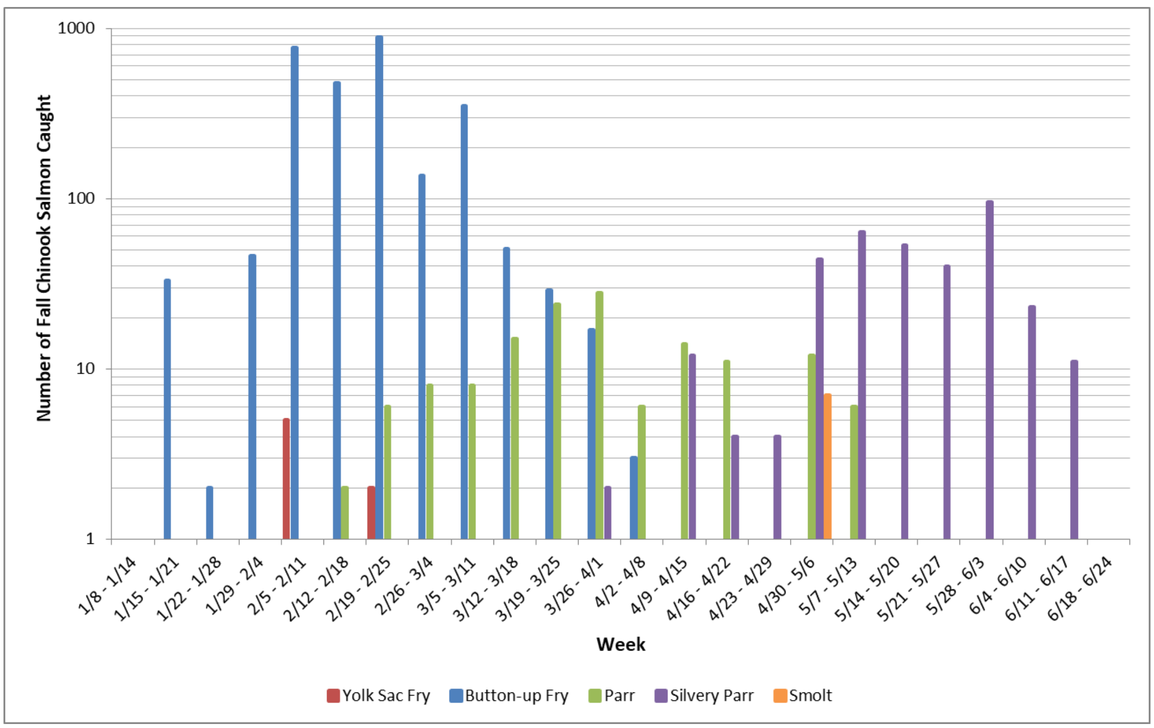


Table 2: Average, minimum, maximum and standard deviations of fork lengths (mm) per week for fall-run Chinook salmon during the 2019 Stanislaus River rotary screw trap survey season.

Julian Week	Fork Length			
	Average	Min	Max	St. Dev.
1/8 - 1/14	-	-	-	-
1/15 - 1/21	34	29	37	2.37
1/22 - 1/28	37	36	37	0.71
1/29 - 2/4	34	30	37	1.42
2/5 - 2/11	35	28	45	2.41
2/12 - 2/18	36	29	49	3.19
2/19 - 2/25	36	24	81	3.74
2/26 - 3/4	37	29	54	5.47
3/5 - 3/11	36	30	63	3.87
3/12 - 3/18	40	30	64	9.72
3/19 - 3/25	51	31	76	12.15
3/26 - 4/1	48	31	71	11.20
4/2 - 4/8	53	33	85	16.73
4/9 - 4/15	65	52	82	8.87
4/16 - 4/22	64	47	83	9.50
4/23 - 4/29	65	36	80	29.33
4/30 - 5/6	81	48	97	14.48
5/7 - 5/13	83	48	94	7.44
5/14 - 5/20	84	62	99	13.21
5/21 - 5/27	86	73	94	14.35
5/28 - 6/3	86	71	102	5.76
6/4 - 6/10	88	80	94	3.97
6/11 - 6/17	88	72	97	6.99
6/18 - 6/24	88	88	88	-

Of the in-river produced, unmarked fall-run Chinook salmon measured for fork length, a total of 3,326 were also assessed for life stage (Figure 11 and Table 3). The majority of this total was salmon identified as button-up fry life stage, which accounted for 84.49 percent (n = 2,810) of the assessed catch. Salmon identified as yolk sac fry life stage comprised 0.30 percent (n = 10), parr life stage comprised 4.27 percent (n = 142), silvery parr comprised 10.67 percent (n = 355), and smolt life stage comprised 0.27 percent (n = 9) of the individuals assessed for life stage.

Figure 11: In-river produced, unmarked fall-run Chinook salmon catch by life stage during the 2019 Stanislaus River rotary screw trap survey season.



Note: Since the *y*-axis scale is logarithmic, weeks where one Chinook salmon of a given life stage was captured do not appear in the graph. See table 3 for weeks with a catch of one. Plus-counted fall-run Chinook salmon are not included in the graph.

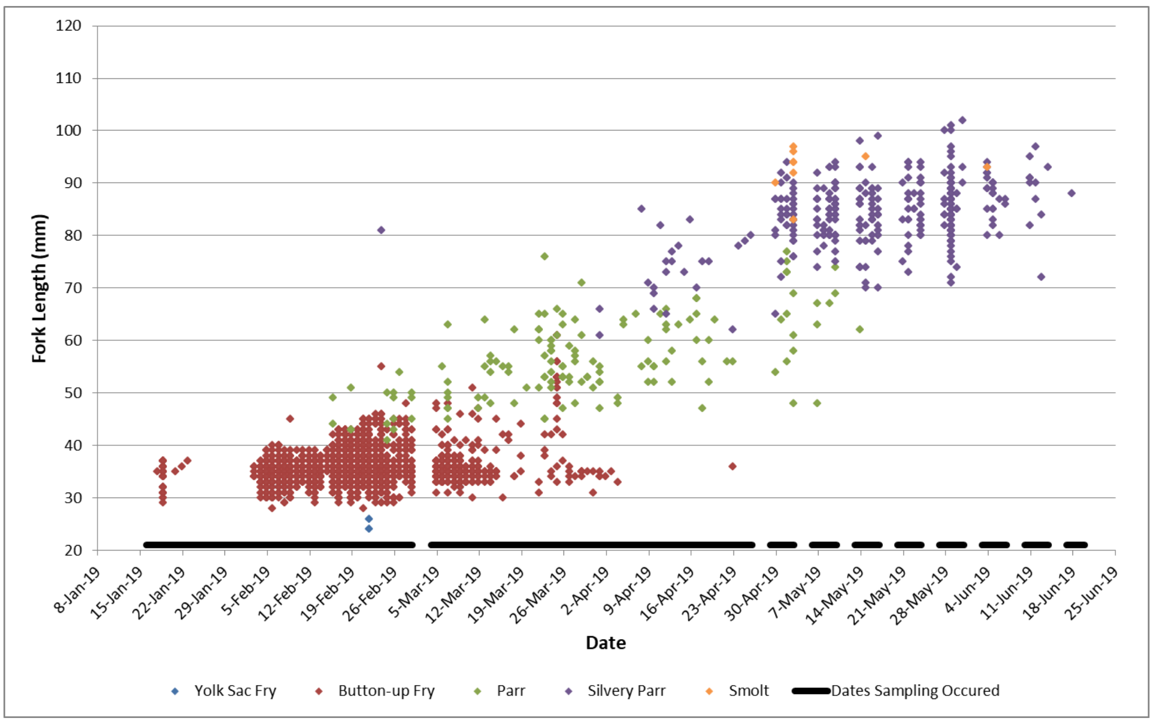
Table 3: Total of in-river produced, unmarked fall-run Chinook salmon by life stage or unassigned life stage during the 2019 Stanislaus River rotary screw trap survey season.

Julian Week	Yolk Sac Fry	Button-up Fry	Parr	Silvery Parr	Smolt	Unassigned Life Stage	Total
1/8 - 1/14	0	0	0	0	0	0	0
1/15 - 1/21	1	33	0	0	0	0	34
1/22 - 1/28	0	2	0	0	0	0	2
1/29 - 2/4	0	46	0	0	0	0	46
2/5 - 2/11	5	771	0	0	0	2,554	3,330
2/12 - 2/18	1	479	2	0	0	454	936
2/19 - 2/25	2	889	6	1	0	145	1,043
2/26 - 3/4	0	137	8	0	0	12	157
3/5 - 3/11	1	352	8	0	0	1	362
3/12 - 3/18	0	51	15	0	0	1	67
3/19 - 3/25	0	29	24	0	0	1	54
3/26 - 4/1	0	17	28	2	0	0	47
4/2 - 4/8	0	3	6	1	0	0	10
4/9 - 4/15	0	0	14	12	0	0	26
4/16 - 4/22	0	0	11	4	0	0	15
4/23 - 4/29	0	1	1	4	0	1	7
4/30 - 5/6	0	0	12	44	7	1	64
5/7 - 5/13	0	0	6	64	0	0	70
5/14 - 5/20	0	0	1	53	1	1	56
5/21 - 5/27	0	0	0	40	0	1	41
5/28 - 6/3	0	0	0	95	0	0	95
6/4 - 6/10	0	0	0	23	1	0	24
6/11 - 6/17	0	0	0	11	0	0	11
6/18 - 6/24	0	0	0	1	0	0	1
Total	10	2,810	142	355	9	3,172	6,498

Note: Unassigned life stage includes plus-counts.

As shown in Figure 12, Chinook salmon identified as yolk sac fry life stage were captured between 19 January and 9 March, salmon identified as button-up fry were captured between 18 January and 23 April, and salmon identified as parr life stage were caught between 16 February and 14 May. Chinook salmon identified as silvery parr life stage were captured starting 24 February to the last week of the survey season on 18 June, and salmon identified as smolt life stage were caught between 30 April and 4 June.

Figure 12: Daily fall-run Chinook salmon fork lengths during the 2019 Stanislaus River rotary screw trap survey season.



For each identified life stage of measured fall-run Chinook salmon, fork length distributions varied (Table 4). Salmon identified as yolk sac fry life stage ranged from 24 mm to 33 mm. Button-up fry ranged from 28 mm to 61 mm, parr life stage ranged from 41 mm to 77 mm, and silvery parr ranged between 62 mm and 102 mm. Smolt life stage ranged from 83 mm to 97 mm.

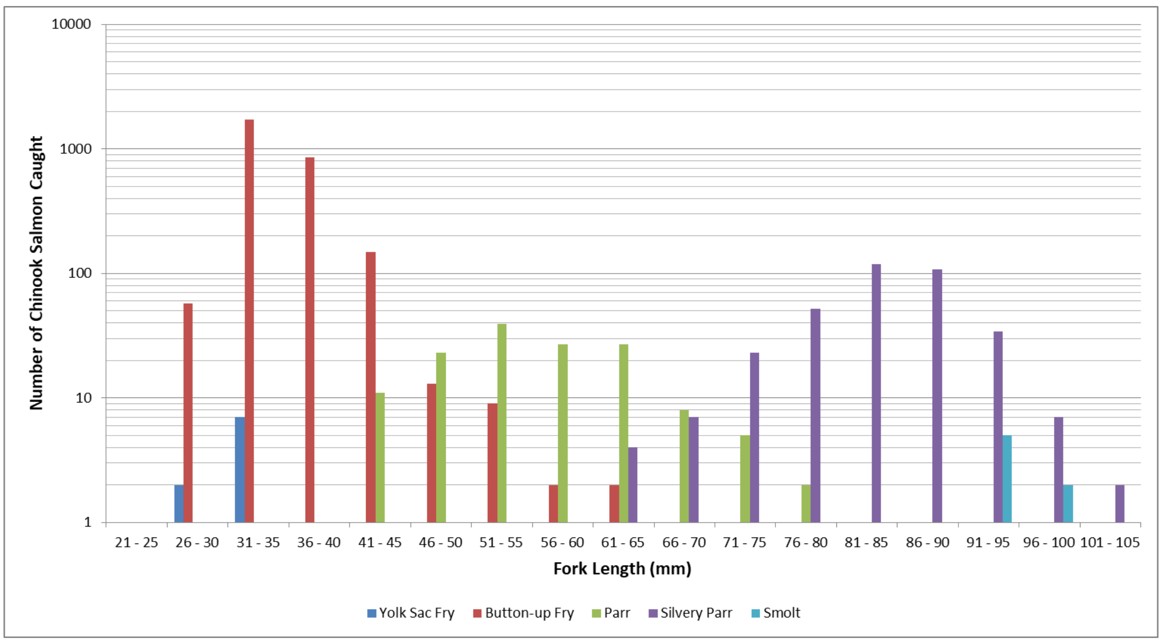
Weekly average fork lengths increased by life stage progression with yolk sac fry life stage having the lowest weekly average fork lengths, and smolt life stage having the largest weekly average fork lengths (Figure 13). Overall average fork length for each life stage also increased according to life stage progression. Salmon identified as yolk sac fry life stage had an average folk length of 31 mm. Salmon identified as button-up fry had an average of 36 mm, parr had an average of 56 mm, silvery parr had an average of 81 mm and smolt had an average of 93 mm.

Table 4: Average, minimum and maximum fork lengths (mm) per week for each stage of fall-run Chinook salmon during the 2019 Stanislaus River rotary screw trap survey season.

Julian Week	Yolk-Sac Fry			Button-up Fry			Parr			Silvery Parr			Smolt		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
1/8 - 1/14															
1/15 - 1/21	32	32	32	34	29	37									
1/22 - 1/28				37	36	37									
1/29 - 2/4				34	30	37									
2/5 - 2/11	32	30	33	35	28	45									
2/12 - 2/18	33	33	33	36	29	43	47	44	49						
2/19 - 2/25	25	24	26	36	28	55	45	41	51	81	81	81			
2/26 - 3/4				37	29	48	48	43	54						
3/5 - 3/11	32	32	32	36	30	51	51	45	63						
3/12 - 3/18				36	30	47	54	47	64						
3/19 - 3/25				45	31	61	58	45	76						
3/26 - 4/1				35	31	42	55	47	71	64	61	66			
4/2 - 4/8				34	33	35	57	48	65	85	85	85			
4/9 - 4/15							58	52	66	73	65	82			
4/16 - 4/22							60	47	68	76	70	83			
4/23 - 4/29				36	36	36	56	56	56	75	62	80			
4/30 - 5/6							64	48	77	84	65	94	92	83	97
5/7 - 5/13							65	48	74	84	74	94			
5/14 - 5/20							62	62	62	84	70	99	95	95	95
5/21 - 5/27										86	73	94			
5/28-6/3										86	71	102			
6/4 - 6/10										88	80	94	93	93	93
6/11 - 6/17										88	72	97			
6/18 - 6/24										88	88	88			

Catch totals distributed by 5 mm fork length size classes are shown in Figure 13 and Table 5. Chinook salmon measured to be between 31 mm and 40 mm were captured most frequently. The size class between 31 mm and 35 mm, consisting of yolk sac fry and button-up fry life stages, comprised 51.92 percent (n = 1,727), and the size class between 36 mm and 40 mm, consisting of only button-up fry life stage, comprised 25.80 percent (n = 858) of the 2019 survey season's total unmarked fall-run catch measured for fork length.

Figure 13: Distribution of fall-run Chinook salmon life stage by fork length during the 2019 Stanislaus River rotary screw trap survey season.



Note: Plus-counted fall-run Chinook salmon are not included in the graph. Since the *y*-axis scale is logarithmic, fork length categories containing only one salmon are not shown in the graph. See table 5 for categories represented by only one individual.

Table 5: Distribution of fall-run Chinook salmon life stage by fork length size class during the 2019 Stanislaus River rotary screw trap survey season.

Fork Length Size Class (mm)	Yolk Sac Fry	Button-up Fry	Parr	Silvery Parr	Smolt	Total
21 - 25	1	0	0	0	0	1
26 - 30	2	57	0	0	0	59
31 - 35	7	1,720	0	0	0	1,727
36 - 40	0	858	0	0	0	858
41 - 45	0	149	11	0	0	160
46 - 50	0	13	23	0	0	36
51 - 55	0	9	39	0	0	48
56 - 60	0	2	27	0	0	29
61 - 65	0	2	27	4	0	33
66 - 70	0	0	8	7	0	15
71 - 75	0	0	5	23	0	28
76 - 80	0	0	2	52	0	54
81 - 85	0	0	0	119	1	120
86 - 90	0	0	0	107	1	108
91 - 95	0	0	0	34	5	39
96 - 100	0	0	0	7	2	9
101 - 105	0	0	0	2	0	2

Fulton's Condition Factor

Fulton's condition factor (K) for in-river produced, unmarked fall-run Chinook salmon captured in 2019 displayed a slightly increasing trend in condition throughout the survey season (Appendix 5). The overall trend line exhibited a positive slope of 0.0019. The trend line slopes were positive for button-up fry (0.0024), and parr (0.0035) life stages; however the silvery parr and smolt life stages had slightly negative slopes of -0.0007 and -0.0004 respectively. Yolk-sac fry captured in 2019 were unable to be assessed for Fulton's condition factor as every fish identified with this life stage was measured below 40 mm and was therefore not weighed.

Trap Efficiency

Four mark-recapture trap efficiency trials were conducted throughout the 2019 survey season, all of which were included in analysis and used by the CAMP platform to determine passage estimates (Table 6). These trials used a total of 1,890 hatchery produced fall-run Chinook salmon from Merced Fish Hatchery and 659 in-river produced salmon. A total of 17 released salmon was recaptured. For the three trials in which fish were recaptured, the average fork length of recaptured fish was approximately the same as the average fork length of released fish, and per trial ranged from a difference of approximately 0 mm to 3 mm smaller. The average trap efficiency of the four trials kept in analysis and used to determine passage estimates was 0.66 percent.

Table 6: Trap efficiency data for mark and recapture trials during the 2019 Stanislaus River rotary screw trap survey season.

Date	Fish Origin	Mark Color	Release ID Code	Included in Analysis	Date	Time	Average Fl (mm)	Total Released	Trial Day 1	2	3	4	5	6	7	Total Recaptured	Average Fl (mm)	Trap Efficiency	Flow (CFS) Time of Release
BBY Staining					Release				Recaptures for all Traps Combined							Recapture Summary			
2/6/2019	In-river	Brown	315	Yes	2/6/2019	13:45	34	659	10	0	0	0	0	0	0	10	34	1.52%	1120
3/26/2019	Hatchery	Brown	316	Yes	3/26/2019	17:55	52	637	4	0	0	0	0	0	0	4	52	0.63%	4520
Visual Implant Elastomer					Release				Recaptures for all Traps Combined							Recapture Summary			
4/16/2019	Hatchery	Green	317	Yes	4/16/2019	19:07	67	638	2	0	1	0	0	0	0	3	64	0.47%	4080
4/23/2019	Hatchery	Pink	318	Yes	4/23/2019	18:54	72	615	0	0	0	-	-	-	-	0	-	0.00%	4030

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

Hatchery = Merced Fish Hatchery.

BBY = Bismark brown Y whole body stain.

Release ID Code: This code is associated with the CAMP RST platform used to store RST data.

Included in Analysis: indicates if the trial was used by the CAMP RST platform to determine passage estimates.

Flow (CFS) is the discharge acquired from the USGS station 11303000 on the Stanislaus River at Ripon, 12.5 rkm upstream of the RSTs at the day and time of the trap efficiency release.

Passage Estimate for Fall-run Chinook salmon

According to the CAMP platform "run_passage" report, a total of 979,000 in-river produced fall-run Chinook salmon were estimated to have emigrated past the Caswell Memorial State Park rotary screw trap location on the Stanislaus River during the 2019 survey season. The 95 percent confidence interval for this estimate was from 529,400 to 2,824,000 individuals. The CAMP platform "lifestage_passage" report, which subdivides a passage estimate by life stage, estimated a total of 868,900 fry (including both yolk sac fry and button-up fry life stages), 120,400 parr (including both parr and silvery parr life stages), and 3,075 smolts emigrated past the trap location during the 2019 survey season.

A comparison of weekly passage estimates to weekly discharge at the USGS monitoring station at Ripon is displayed in Figure 14 and Table 7.

Figure 14: Daily passage estimate of fall-run Chinook salmon and daily discharge at Ripon during the 2019 Stanislaus River rotary screw trap survey season.

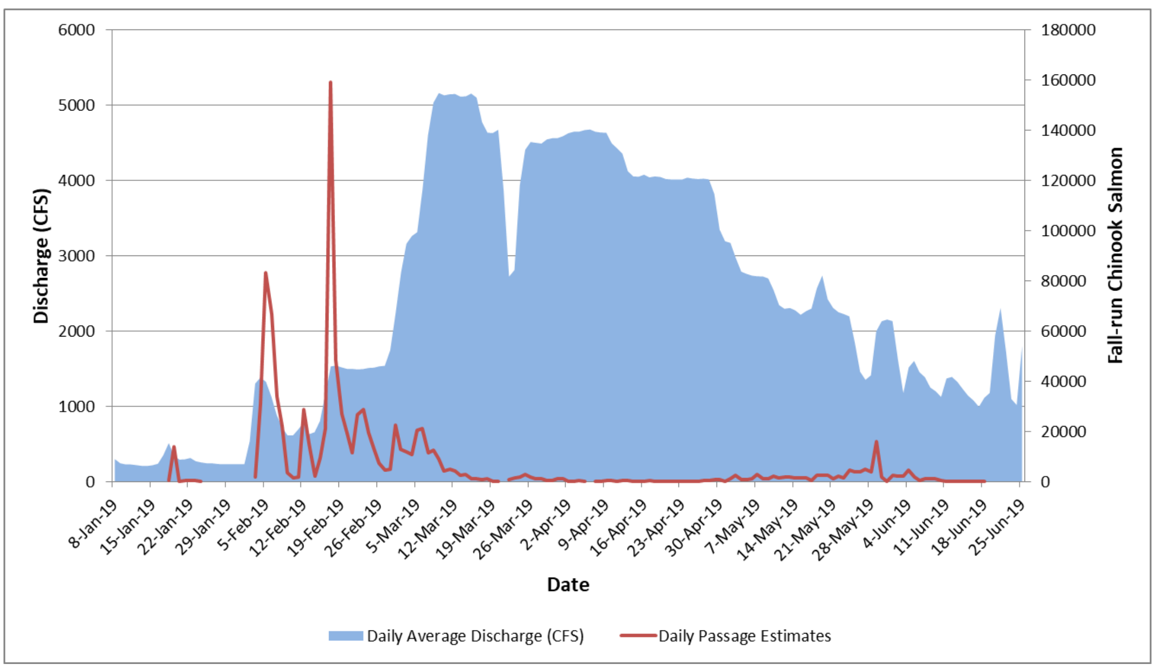


Table 7: Weekly passage estimate of fall-run Chinook salmon and weekly discharge at Ripon during the 2019 Stanislaus River rotary screw trap survey season.

Date	Discharge (CFS)	Passage Estimate
1/8 - 1/14	234	0
1/15 - 1/21	321	14,817
1/22 - 1/28	256	872
1/29 - 2/4	593	32,887
2/5 - 2/11	854	212,913
2/12 - 2/18	1,016	284,641
2/19 - 2/25	1,502	146,280
2/26 - 3/4	2,319	74,595
3/5 - 3/11	4,606	84,070
3/12 - 3/18	5,002	13,841
3/19 - 3/25	3,860	7,371
3/26 - 4/1	4,533	7,504
4/2 - 4/8	4,647	472
4/9 - 4/15	4,302	2,034
4/16 - 4/22	4,035	898
4/23 - 4/29	3,990	1,984
4/30 - 5/6	2,992	7,235
5/7 - 5/13	2,518	12,245
5/14 - 5/20	2,395	12,428
5/21 - 5/27	1,947	21,467
5/28 - 6/3	1,802	28,928
6/4 - 6/10	1,361	10,709
6/11 -6/17	1,218	782
6/18 - 6/24	1,483	13

Genetic Analysis

During the 2019 survey season genetic analysis using SNP genetic markers was conducted on a total of 18 samples taken from in-river produced juvenile Chinook salmon captured in the RSTs. The SNP panel's probabilities for each of the 18 samples exceeded a 50 percent threshold; the final salmon run assignments for those salmon were therefore made based on genetic data. A complete accounting of the final salmon run assignments made using genetic markers is provided in Appendix 4.

A total of 17 in-river produced Chinook salmon captured in 2019 were classified as spring-run Chinook salmon using LAD criteria. Genetic samples taken from each of these salmon were analyzed to determine run assignments. The analyses indicated 100.00 percent (n = 17) of those individuals were fall-run Chinook salmon (Table 8).

One Chinook salmon classified as winter-run Chinook salmon using LAD criteria was captured during the 2019 survey season. Genetic samples taken from this fish determined a final run assignment of fall-run (Table 8).

A total of two Chinook salmon classified as late fall-run Chinook salmon using LAD criteria were also captured in 2019. Genetic samples were not taken from these fish however the genetics between late-fall-run and fall-run are considered indistinguishable therefore these fish were assigned a final run of fall-run.

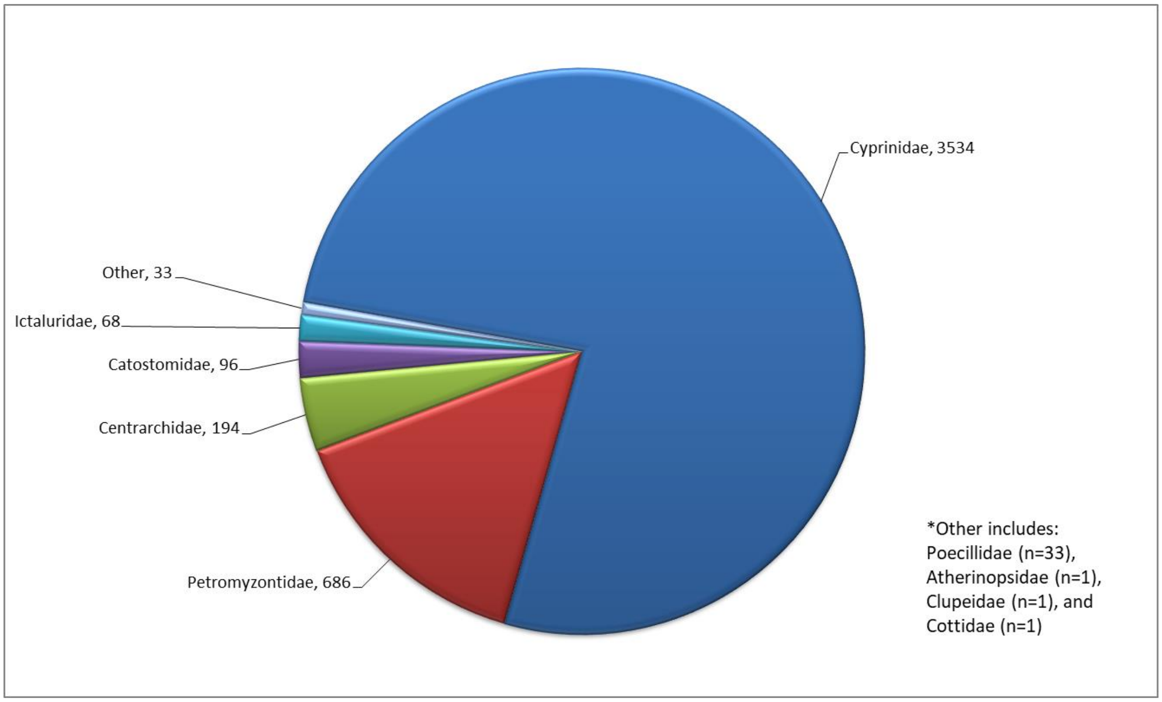
Spring- , Winter- and Late Fall-run Chinook salmon

The results of the genetic analyses suggest that no in-river produced spring-run or winter-run Chinook salmon were captured during the 2019 survey season. Historical results of genetically sampled LAD late-fall-run Chinook salmon suggest no late-fall-run Chinook salmon were captured.

Non-salmonid Species

In addition to the salmonids, 4,611 non-salmonid fish were captured during the 2019 survey season. The majority (n = 4,479, or 97.14 percent) of these fish belonged to 21 identified species in the following families: *Atherinopsidae* (silversides), *Catostomidae* (sucker), *Centrarchidae* (sunfish/black bass), *Clupeidae* (shad), *Cottidae* (sculpin), *Cyprinidae* (minnow), *Ictaluridae* (bullhead/catfish), *Petromyzontidae* (lamprey), and *Poeciliidae* (mosquitofish) (Figure 15). A total of 132 (2.86 percent) were not able to be identified to species level, but belonged to the following families: *Centrarchidae, Cyprinidae*, *Ictaluridae* and *Petromyzontidae*. Of the non-salmonid fish captured in 2019, a total of 1689 (37.67 percent) are of species native to Central Valley watersheds, and a total of 2795 (62.33 percent) are of non-native species. A complete list of non-salmonid species captured in the 2019 survey season is presented in Appendix 3.

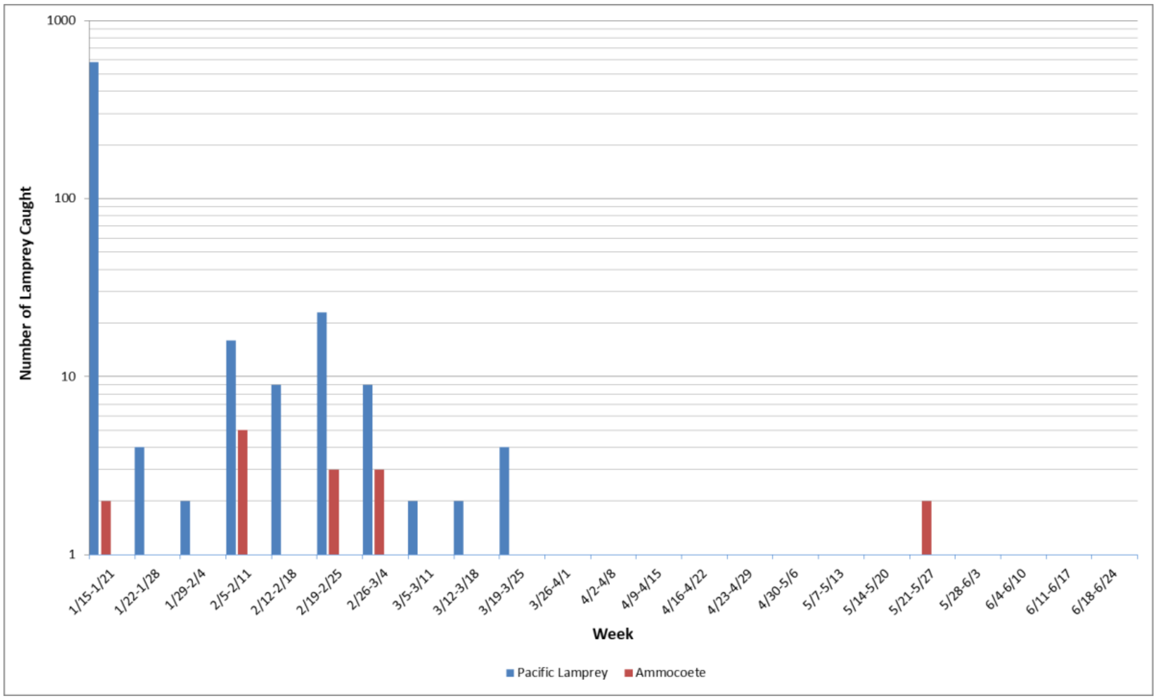
Figure 15: Non-salmonid catch totals for families of fish species collected during the 2019 Stanislaus River rotary screw trap survey season.



Of the 4,611 non-salmonid fish captured in 2019, 686 (14.88 percent) were lamprey species. Of the lamprey capture, individuals identified as Pacific lamprey totaled 661 (96.35 percent) and were all identified as juvenile life stage. Lamprey identified as ammocoetes totaled 24 (3.49 percent) and were unidentifiable to the species level. One (0.14 percent) lamprey identified as juvenile life stage was unable to be identified to species level. No lampreys captured in 2019 were identified as River lamprey.

The majority (n=656, 99.24 percent) of Pacific lamprey was captured between 17 January and 25 March. Pacific lamprey catch peaked the week of 15 January with 88.50 percent (n=585) of the season’s total. Ammocoetes were captured throughout the season with the peak weekly catch (n=5, 20.83 percent) occurring on the week of 5 February.

Figure 16: Total weekly lamprey catch during the 2019 Stanislaus River rotary screw trap survey season.



Note: Since the *y*-axis scale is logarithmic, weeks with a catch of one lamprey are not shown in the graph. Catch totals of one for Pacific lamprey occurred the weeks of 2 April, 9 April, 16 April and 28 May. Catch totals of one for Ammocoetes occurred the weeks of 29 January, 12 February, 19 March, 26 March, 9 April and 28 May. One unidentified lamprey was captured the week of 26 February.

Discussion

When interpreting the data collected during the 2019 survey season and the juvenile Chinook salmon passage estimate produced from that data, several influential factors must be considered. One of the most significant of these may have been environmental factors, especially fluctuating river flow levels. During the 2019 survey season, both high and low flows were experienced, both of which may have hindered the ability to collect consistent and high quality data by reducing the successful operation of the traps, or by limiting the number of trap efficiency tests that could be performed.

Increased flows, like those seen during the 2019 survey season, increase the amount of debris in the water column, which can affect the successful operation of the rotary screw traps by stopping the rotation of the cone or can increase the potential for damage to traps and sampling equipment. Increased debris associated with high flows can also cause fish mortality by crushing fish within the debris or by causing fish trapped within a stopped cone to become pummeled by incoming water. When debris loads were judged too high to be managed even by performing night checks in addition to day checks, or if weather conditions are deemed too dangerous to perform daily routine checks, the RST cones were raised and pulled out of the thalweg until the debris load was reduced to a manageable level. This occurred once during the 2019 survey season where cones were raised on 1 March and lowered on 4 March once high debris levels subsided and safety concerns associated with weather conditions decreased. As data cannot be collected when the cones are raised, the CAMP platform was used to estimate potential catch during gaps in sampling less than seven days in duration, as described in the Methods section of this report. With the understanding that the smaller the gap in sampling, the more confidence can be had in the accuracy of the estimated catch, and when it was necessary to cease sampling entirely, an effort was made to lower the RST cones and resume trapping as soon as possible.

Lower flows were also experienced during the 2019 survey season for the first three weeks of sampling when Stanislaus River flows averaged approximately 271 CFS, resulting in a lowered river velocity that also hindered the ability of the rotary screw traps to rotate normally.

Furthermore, river flow effects trap efficiency trials. Since trap efficiencies are inversely related to river discharge, trap efficiency trials rely heavily on a consistent river discharge throughout the entire trial period in order to accurately determine efficiencies. However, efforts to maintain successful trap operation during trial periods proved difficult due to fluctuating discharge throughout the survey season. As a result, at least one trap was stopped or not functioning normally at some point during two of the four trials. Because this was consistent with day to day operation of the traps, the trials were deemed to be an accurate representation of the daily catch numbers and thus all five trials were included for analysis.

Given that two of the four trials used in analysis contained periods of unsuccessful trap operation, the trap efficiencies for the 2019 survey season were likely an underestimate of what the traps would have recaptured under normal function, and the 2019 trap efficiencies were therefore likely biased low. Since trap efficiencies are used to develop passage estimates for the in-river produced fall-run Chinook salmon, a low bias in the trap efficiencies may have resulted in a high bias for the passage estimate.

The total number of in-river produced fall-run Chinook salmon estimated to have emigrated past the rotary screw trap location on the Stanislaus River at Caswell Memorial State Park was 979,000 individuals, with 95 percent confidence intervals ranging from 529,400 to 2,824,000 individuals. This relatively large confidence interval width is likely due to the higher distribution of daily catch totals throughout the 2019 survey season.

It is important to note that this passage estimate was not calculated entirely from actual catch. The 2019 passage estimate includes multiple days of estimated catch which may reduce the accuracy of the passage estimate. Days for which catch was estimated include gaps in sampling that were less than seven days and days that were excluded from analysis due to unsuccessful fishing, as described in the Methods section of this report. It is also important to note that this passage estimate only includes the salmon estimated to have emigrated past the rotary screw trap location between 10 January and 20 June. The 2019 survey season likely encompassed the majority of the juvenile fall-run Chinook salmon emigration period. Out of the 6,498 fall-run Chinook salmon captured in the 2019 survey season, only 34 were captured during the first seven days of sampling, comprising only 0.97 percent of the total season catch of Chinook salmon, and comprising 0.93 percent (n = 2,060) of the total passage estimate. During the last seven days of sampling, 19 salmon were captured, consisting of 0.54 percent of the total catch and 0.52 percent (n = 1146) of the total passage estimate.

A unimodal peak was observed in unmarked juvenile fall-run Chinook salmon catch during the 2019 survey season. The peak was seen during the fourth week of sampling and ended the sixth week of sampling. The timing of this peak may have been influenced by the fluctuating river flows seen in the 2019 survey season. The lower Stanislaus River flows, which had remained low, were increased to meet Vernalis Flow Objectives, and scheduled outflow changes from Goodwin Dam beginning on 1 February increased river flows from approximately 229 CFS to 1,470 CFS on 4 February. This flow increase precipitated the week with the largest catch seen between 5 February and 11 February where 3,330 salmon were captured (51.25 percent of the total captured) and 212,913 Chinook salmon were estimated to have out-migrated past the rotary screw trap location (21.75 percent of the total passage estimate).

Weeks five and six of sampling had catch totals of 936 (14.40 percent) and 1,043 (16.05 percent) respectively. Passage estimates for weeks five and six totaled 284,641 (29.08 percent) for week five and 146,280 (14.94 percent) for week six.

In 2019, no spring or winter-run Chinook salmon was genetically proven to have been captured at the Caswell RST location on the Stanislaus River. Despite releases of spring-run into the upper San Joaquin River which began in 2014 as an experimental study to support reintroduction by the SJRRP (NOAA 2014), no spring-run juveniles were believed to have been captured at the Caswell RST site. A total of 18 genetic samples were taken from captured Chinook salmon with fork lengths above the length-at-date fork length thresholds for spring- and winter-runs, but genetic analysis of the samples taken indicated that 18 sampled fish were fall-run Chinook salmon. However, further genetic analyses should be conducted on both juvenile and adult Chinook salmon to determine if spring-run Chinook salmon currently utilize the Stanislaus River for spawning or rearing habitat.

Furthermore, no steelhead were captured during the 2019 survey season at Caswell Memorial State Park, unlike in previous survey seasons, during which small numbers of steelhead smolt were caught at the Caswell and Oakdale rotary screw trap locations (NMFS 2017). The relatively low steelhead population numbers in combination with the reduced trap efficiencies seen during 2019 survey season are likely factors contributing to the absence of steelhead in the 2019 Caswell RSTs catch.

Management Implications

In order to determine if efforts made by AFRP and others to increase the abundance of Chinook salmon and steelhead on the lower Stanislaus River have been successful, additional monitoring of juvenile salmonid emigration is required. There should also be continued management of river flows and water temperature to maintain favorable river conditions for the anadromous fish populations in the Stanislaus River. The 2019 data is of particular interest as it can be used to further understand the impact of the recent five year drought on anadromous species. Additionally, it is a required monitoring program as stated in the NMFS BiOp and can be used to help determine the success of habitat rehabilitation and species reintroduction. This data can then also be used to guide water management modifications including timing of pulse flows which may influence juvenile Chinook salmon emigration.

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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: Weekly environmental conditions during the 2019 Stanislaus River rotary screw trap survey season.

Julian Week	Water Temperature (C°)			Discharge			Dissolved Oxygen (mg/L)			Turbidity (NTU)			Velocity (m/s)		
	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max
1/8-1/14	10.87	9.5	11.8	234	206	326	11.08	10.85	11.30	3.96	3.96	3.96	0.30	0.30	0.30
1/15-1/21	11.42	9.3	13.9	321	209	613	10.68	9.13	12.50	22.82	2.40	57.00	0.34	0.30	0.40
1/22-1/28	9.98	8.6	11.4	256	229	336	11.24	10.29	12.00	6.30	2.19	15.42	0.24	0.10	0.30
1/29-2/4	11.69	10.6	13.1	593	229	1510	10.71	9.91	11.30	4.39	2.07	9.17	0.41	0.30	0.70
2/5-2/11	9.89	8.8	11.0	854	594	1370	11.63	10.93	12.40	8.10	5.18	14.23	0.49	0.35	0.65
2/12-2/18	10.31	9.0	11.9	1016	609	1550	11.39	10.35	11.84	8.30	4.10	18.15	0.53	0.45	0.70
2/19-2/25	10.09	9.3	11.0	1502	1480	1540	12.20	11.31	12.64	4.57	3.77	5.46	0.68	0.53	0.95
2/26-3/4	10.95	10.5	11.5	2319	1500	3310	11.80	11.30	12.44	5.01	3.95	6.28	0.76	0.50	0.95
3/5-3/11	10.85	10.2	11.7	4608	3180	5190	11.26	10.89	12.06	6.57	5.58	7.63	0.64	0.45	0.80
3/12-3/18	10.73	10.1	11.5	5010	4610	5180	11.72	11.14	12.88	5.20	4.48	6.36	0.66	0.50	0.80
3/19-3/25	10.83	10.4	11.6	3864	2540	4700	11.71	11.05	12.15	5.34	3.67	9.80	0.68	0.50	0.90
3/26-4/1	11.05	10.4	11.9	4545	4480	4610	11.90	9.79	13.38	4.09	3.44	4.78	0.67	0.45	0.80
4/2-4/8	11.21	10.4	12.2	4663	4600	4710	13.24	12.72	13.53	3.81	2.94	4.75	0.72	0.55	0.90
4/9-4/15	11.55	10.8	12.4	4321	4050	4670	12.71	12.20	13.10	3.68	2.84	4.80	0.63	0.55	0.75
4/16-4/22	11.98	11.1	12.9	4055	4010	4120	12.64	12.20	13.24	3.38	2.72	4.13	0.68	0.60	0.80
4/23-4/29	12.66	12.0	13.4	4013	3540	4070	11.60	10.65	12.52	3.14	2.15	3.56	0.66	0.60	0.70
4/30-5/6	12.35	11.6	13.1	3004	2720	3530	11.99	11.26	12.56	3.41	2.29	4.84	0.66	0.50	0.85
5/7-5/13	13.18	12.4	14.0	2518	2250	2760	12.07	11.56	12.60	3.91	2.70	5.25	0.64	0.55	0.70
5/14-5/20	12.42	11.8	13.7	2394	2190	2880	11.81	11.06	12.38	5.37	4.92	6.73	0.63	0.55	0.70
5/21-5/27	13.17	12.0	14.9	1933	1270	2350	11.71	11.00	12.51	4.03	2.22	5.47	0.57	0.50	0.80
5/28-6/3	14.32	12.6	17.4	1782	1080	2150	11.22	10.06	12.15	3.96	2.14	6.02	0.58	0.50	0.80
6/4-6/10	15.99	14.6	17.6	1329	1020	1630	10.76	10.35	11.28	3.82	2.27	6.54	0.59	0.50	0.65
6/11-6/17	16.71	15.3	18.4	1182	907	1380	10.60	10.18	10.84	3.33	2.31	3.90	0.52	0.50	0.55
6/18-6/24	16.87	15.1	18.5	1455	925	2360	10.56	10.12	10.91	3.07	1.94	5.06	0.53	0.50	0.60

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 3: List of fish species caught during the 2019 Stanislaus River rotary screw trap survey season.

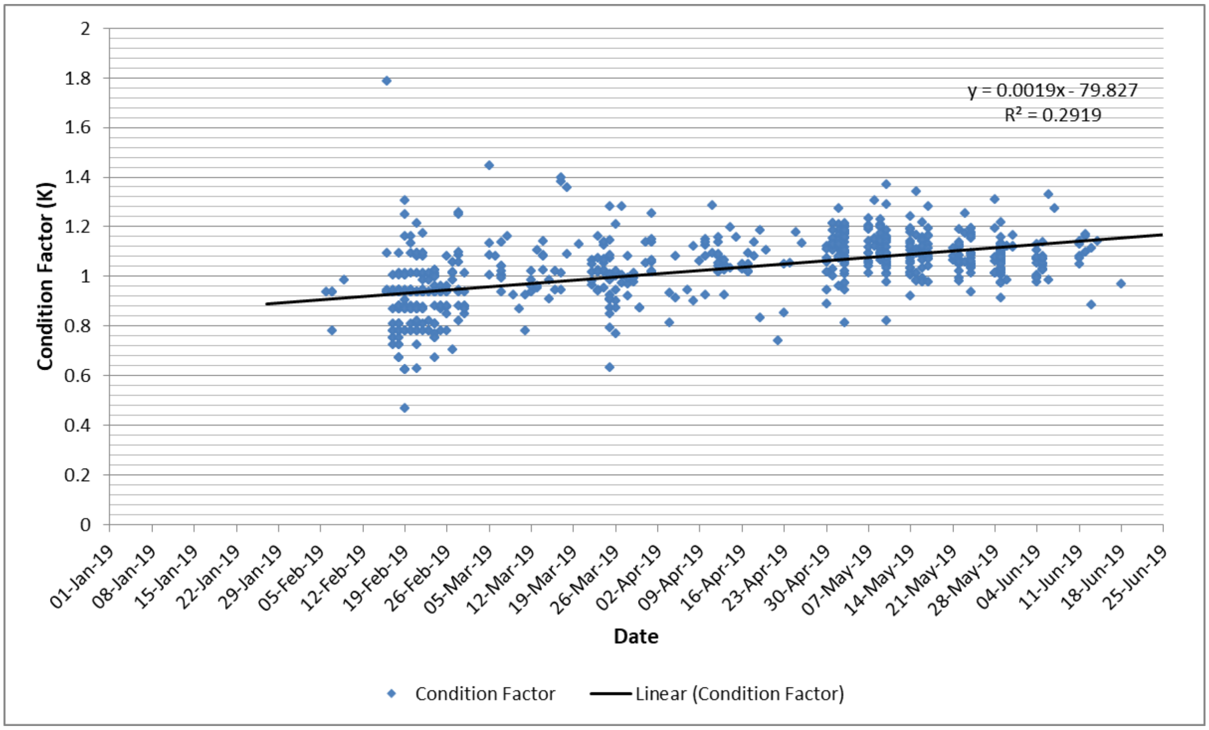
Common Name	Family Name	Species Name	Total Number Caught
Chinook salmon	Salmonidae	*Oncorhynchus tshawytscha*	6498
Black crappie	Centrarchidae	*Pomoxis nigromaculatus*	2
Bluegill	Centrarchidae	*Lepomis macrochirus*	35
Channel catfish	Ictaluridae	*Ictalurus punctatus*	4
Fathead minnow	Cyprinidae	*Pimephales promelas*	1
Golden shiner	Cyprinidae	*Notemigonus crysoleucas*	33
Goldfish	Cyprinidae	*Carassius auratus*	2561
Green sunfish	Centrarchidae	*Lepomis cyanellus*	3
Hardhead	Cyprinidae	*Mylopharodon conocephalus*	353
Inland silverside	Atherinopsidae	*Menidia beryllina*	1
Pacific lamprey	Petromyzontidae	*Lampetra entosphenus*	661
Prickly sculpin	Cottidae	*Cottus asper*	1
Redear sunfish	Centrarchidae	*Lepomis microlophus*	1
Sacramento pikeminnow	Cyprinidae	*Ptychocheilus grandis*	575
Sacramento sucker	Catostomidae	*Catostomus occidentalis*	96
Smallmouth bass	Centrarchidae	*Micropterus dolomieu*	4
Speckled dace	Cyprinidae	*Rhinichthys osculus*	3
Spotted bass	Centrarchidae	*Micropterus punctulatus*	52
Threadfin shad	Clupeidae	*Dorosoma petenense*	1
Western mosquitofish	Poeciliidae	*Gambusia affinis*	30
White catfish	Ictaluridae	*Ameiurus catus*	61
White crappie	Centrarchidae	*Pomoxis annularis*	1
Unknown bass (Micropterus)	Centrarchidae	*Micropterus sp.*	5
Unknown catfish or bullhead	Ictaluridae		3
Unknown lamprey	Petromyzontidae		25
Unknown minnow	Cyprinidae		8
Unknown sunfish (Lepomis)	Centrarchidae	*Lepomis sp.*	91
		Total	**11,109**

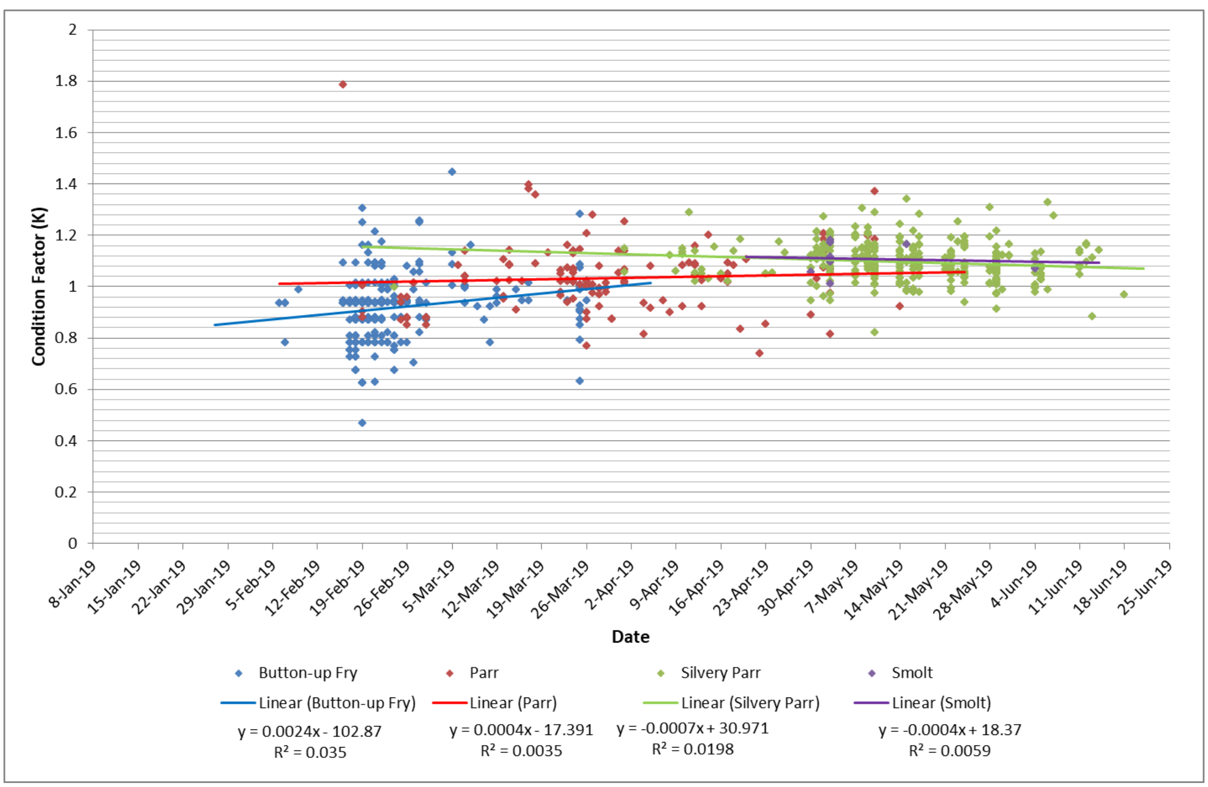
Appendix 4: Genetic results for fin-clip samples from Chinook salmon caught during the 2019 Stanislaus River rotary screw trap survey season.

Sample #: refer to a unique number assigned by field staff, and that allowed the tracking of individual fish samples.
LAD run assignment: Chinook salmon run assignment based on the length-at-date run assignment methodology developed by Greene (1992).
SNP Run Assignment: Chinook salmon run assignment using "Genetic Call to 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.
W: weight in grams.

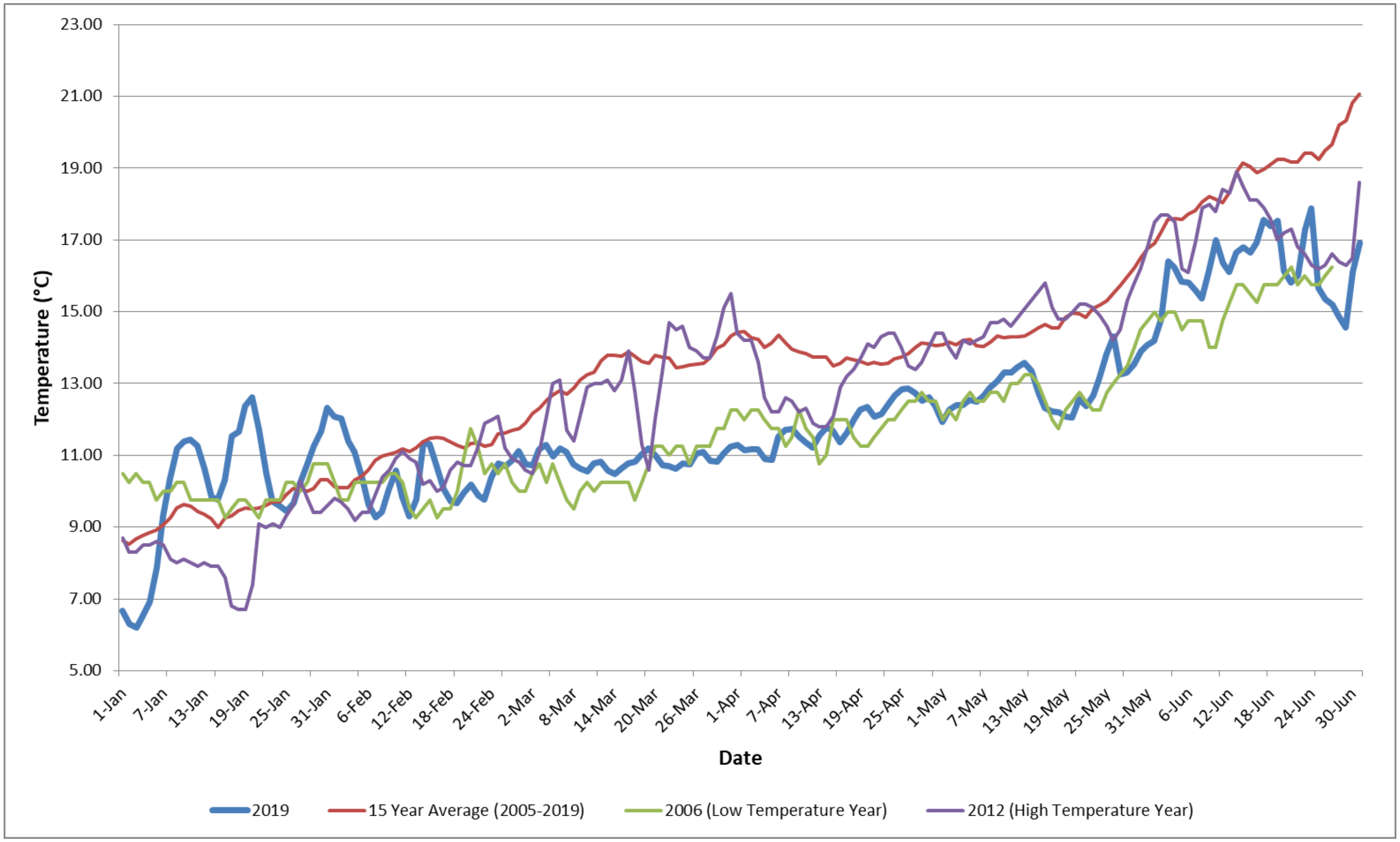
Date	Sample #	LAD Run Assignment	SNP Run Assignment	SNP Probablity	Final Run Assignment	FL (mm)	W (g)
24-Feb-19	3528-001	Winter	Fall	0.990	Fall	81	5.3
7-Mar-19	3528-002	Spring	Fall	0.994	Fall	63	2.6
23-Mar-19	3528-003	Spring	Fall	0.984	Fall	76	5.1
8-Apr-19	3528-004	Spring	Fall	1.000	Fall	85	6.9
11-Apr-19	3528-005	Spring	Fall	0.999	Fall	82	71
16-Apr-19	3528-006	Spring	Fall	1.000	Fall	83	6
30-Apr-19	3528-007	Spring	Fall	1.000	Fall	90	7.7
1-May-19	3528-008	Spring	Fall	1.000	Fall	90	8.2
1-May-19	3528-009	Spring	Fall	0.993	Fall	92	8.8
2-May-19	3528-010	Spring	Fall	0.977	Fall	91	9.6
2-May-19	3528-011	Spring	Fall	0.999	Fall	94	8
3-May-19	3528-012	Spring	Fall	1.000	Fall	97	10.2
3-May-19	3528-013	Spring	Fall	1.000	Fall	96	9.7
3-May-19	3528-014	Spring	Fall	0.994	Fall	92	8.6
3-May-19	3528-015	Spring	Fall	1.000	Fall	94	8.4
3-May-19	3528-016	Spring	Fall	1.000	Fall	94	9.8
14-May-19	3528-017	Spring	Fall	1.000	Fall	98	11.2
17-May-19	3528-018	Spring	Fall	0.999	Fall	99	11.6

Appendix 5: Fulton's condition factor (*K*), overall, and by life-stage, of fall-run Chinook salmon during the 2019 survey season.





Appendix 6: Daily average water temperature (°C) in the Stanislaus River at Ripon for the 15 year period 2005-2019, the highest temperature year, the lowest temperature year, the 15 year average and the current year (2019).Data from USGS station number 11303000.



Appendix 7: Daily average discharge (CFS) on the Stanislaus River at Ripon for the 15-year period 2005 – 2019, the highest water year, the lowest water year, 15 year average and the current year (2019). Data from USGS station number 11303000.