California Department of Fish and Wildlife
North Central Region

Monitoring for the Development of a Sacramento River Watershed Spring-Run Chinook Salmon Juvenile Production Estimate

Timing, Composition, and Abundance of Juvenile Salmonid Emigration in the Lower Feather River Near Star Bend January 2022 – June 2022[1]

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BY	brood year
BBY	Bismarck Brown Y
CAMP	Comprehensive Assessment & Monitoring Program
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
FRFH	Feather River Fish Hatchery
FSB	Feather River at Boyd's Landing above Star Bend
CPUE	catch per unit effort
CWT	coded wire tag
DWR	California Department of Water Resources
FL	fork length
ft	feet
JPE	juvenile production estimate
LAD	length-at-date
mm	millimeter
NTU	nephelometric turbidity units
RM	river mile
QAQC	quality assurance/quality control
RST	rotary screw trap
SWP	State Water Project
TL	total length
YOY	young-of-year

EXECUTIVE SUMMARY

This report presents the results for the first season of monitoring at a new rotary screw trap (RST) location on the lower Feather River near the Star Bend (River Mile (RM) 17.5) during 2022. The RST project was operated by the California Department of Fish and Wildlife (CDFW) North Central Region Anadromous Fisheries Program to obtain information on the temporal distribution, relative abundance, and race composition of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*), with a focus on spring-run Chinook salmon, emigrating through the lower Feather River. The project collected data using two paired RSTs outfitted with 8-ft diameter cones located approximately one mile downstream of the Star Bend Park and Boat Ramp in Yuba County. The Lower Feather River (Star Bend) RST monitoring site began trapping on January 19, 2022 and concluded June 22, 2022, for a total of 6808.5 hours of sampling.

Environmental data collected during the daily trap checks included river discharge, water temperature, turbidity, and dissolved oxygen levels. The data was averaged over the calendar week (Sunday-Saturday) for reporting purposes. Lower Feather River discharge was recorded from the Department of Water Resources (DWR) California Data Exchange Center (CDEC) Feather River at Boyd's Landing Above Star Bend (FSB) gauge. The mean weekly discharge reached a low in calendar week 18 of 1,599 cubic feet per second (cfs), and a high of 5,817 cfs in week 10. The maximum and minimum mean weekly water temperatures were 22.1 °C in week 25, and 9.3°C in week 5, respectively. Mean weekly turbidity reached its lowest in week 18 at 1.42 nephelometric turbidity units (NTU) and was highest in week 6 with a mean of 6.42 NTU. Dissolved oxygen ranged from 7.1 mg/L to 12.3 mg/L, in weeks 23 and 8, respectively.

The Lower Feather River RST caught totals of 3,470 juvenile Chinook salmon and 496 steelhead during the 2022 monitoring season. Unmarked Chinook salmon catch was 3,077 individuals, with an average catch per unit effort (CPUE) of 0.45 unmarked salmon per hour. Peak catch occurred in week 13, when 403 unmarked juvenile Chinook salmon were captured. The run breakdown of unmarked Chinook salmon catch for the season was 37 (1.2%) spring-run, 24 (0.8%) late fall-run, and 3016 (98%) fall-run. Marked (adipose fin-clipped) juvenile Chinook salmon catch at the lower Feather River RST was 393 fish, which was 11.3% of the total juvenile Chinook salmon catch. All ad-clipped juvenile Chinook salmon caught at this trapping location during the 2022 monitoring season were designated as spring run, as the only hatchery-origin juvenile Chinook salmon released in the Feather River upstream of the trap location during 2022 were spring-run. Of the total steelhead catch, 96.5% were marked (n=479). All marked steelhead were classified as yearlings and unmarked juvenile steelhead (n=17) were classified as young of the year (YOY).

Six trap capture efficiency trials were performed using a mark and recapture methodology for an overall efficiency of 0.79%. The expanded passage estimate was 489,681 (80% Lower/Upper Confidence Intervals: 19,633,729/247,932) total unmarked juvenile Chinook salmon emigrating

past the Lower Feather River trapping site. Passage estimates for each run of juvenile Chinook salmon were: 481,626 fall run, 3,222 late fall-run, and 4,833 spring-run.

INTRODUCTION

CDFW implemented a new RST monitoring site on the lower Feather River in the High Flow Channel at RM 17.5, approximately 1 mile downstream of Star Bend Park and Boat Ramp in Yuba County in January 2022 (**Error! Reference source not found.**). Monitoring at this new location was implemented to support the development of a juvenile production estimate (JPE) for spring-run Chinook salmon in the Sacramento River Watershed as required by Condition of Approval 7.5.2 of Incidental Take Permit (ITP) 2081-2019-066-00 issued by CDFW to DWR for the long-term operation of the State Water Project (SWP). The Star Bend monitoring site augments existing juvenile salmonid monitoring conducted on the lower Feather River by DWR near RM 46 (Herringer Riffle) in the High Flow Channel and RM 60 (Eye Side Channel) in the Low Flow Channel (**Error! Reference source not found.**). The Star Bend site is located downstream of where Honcut Creek (RM 44) and the Yuba River (RM 27.5) enter the lower Feather River and is the lowest juvenile salmonid monitoring site on the lower Feather River prior to the confluence with the Sacramento River (**Error! Reference source not found.**). The additional data collected at the Star Bend site will help to inform a more accurate estimate of the number of juvenile spring-run Chinook salmon (and other juvenile salmonids) emigrating from the Feather River Watershed to the Sacramento River thence the Delta. In addition to contributing data to the spring-run JPE effort, other objectives of this monitoring site include: collecting data on the temporal distribution, abundance, and run composition of other juvenile Chinook salmon, and steelhead trout emigrating through the lower Feather River; comparing the movements of emigrating salmonids in varying environmental conditions; and providing data on juvenile salmonids emigrating to the Delta to inform resource and water agency managers regarding real-time water operations decisions. This report provides a summary of the RST monitoring conducted on the lower Feather River at RM 17.5 in 2022.

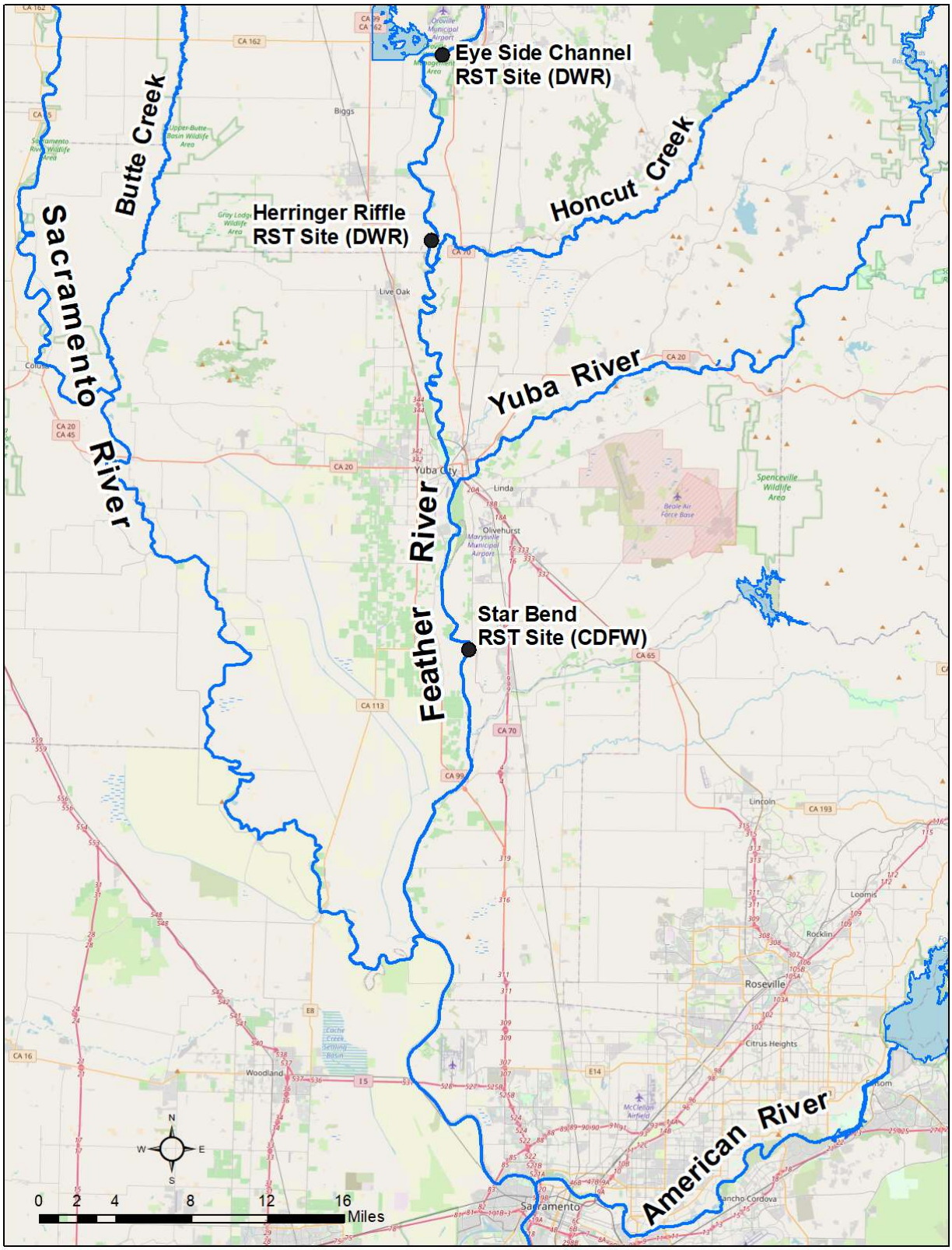

Figure 1. Map of the upper Sacramento River and tributaries depicting locations of the juvenile salmonid RST sampling sites at Eye Side Channel, Herringer Riffle, and Star Bend.

BACKGROUND

The Feather River contains spawning and rearing habitat for Chinook salmon and steelhead. Historically, there was 211 river miles of habitat available for anadromous fish on the Feather River. Much of the existing spawning grounds are now barred by the Oroville Dam and the Fish Barrier at RM 67 (NMFS 2014). The loss of upstream spawning grounds, which geographically separated spring-run spawning from fall-run spawning on the Feather River, has resulted in hybridization between the runs (DWR, 2021). This has made run-identification, run-specific research, and targeted mitigation on the Feather River especially challenging. Anadromous spawning in the Feather River is currently limited to approximately 25 miles of habitat below Oroville Dam (DWR, 2021).

All four runs of Chinook salmon have been observed in the Feather River; however, the predominant runs are fall-run and spring run. Juvenile late fall-run-sized Chinook salmon have been captured in the RSTs on the lower Feather River; however, their population status and use of spawning areas is unknown. Adult winter-run are not known to spawn in the Feather River, however recent otolith analysis found that 44-65% of sampled winter-run adults reared in non-natal habitats as juveniles (Phillis et al. 2018; Maslin et al. 1998). Therefore, it is likely that juvenile winter-run observed in the Feather River are non-natal rearing. Juvenile Chinook salmon emigrate from the Feather River towards the Delta over a wide range of life stages. Juvenile fall-run have a residency of one to seven months and typically migrate March through July. The juvenile spring-run emigration period in the lower Feather River typically begins in mid-November and extends through June. Juvenile spring-run Chinook salmon may emigrate as YOY December through spring, or rear over summer and migrate as yearlings in the fall (DWR, 2021). Juvenile late fall-run Chinook salmon may also migrate as emerged fry, as smolts, or as yearlings and typically migrate during the months of November through May (Fisher 1994; Yoshiyama et al. 1998). Winter-run fry emergence occurs in the upper Sacramento River beginning in June and fish may emigrate as fry or rear for varying periods of time and move downstream from summer through the following April. The lower Feather River RST would likely see non-natal rearing winter-run juveniles during the October to April period, with timing varying with flow.

The Feather River population of *O. mykiss* has a mix of migratory and non-migratory life histories. Adult steelhead generally enter the Delta August through October and migrate upstream to spawn December through April. Adult steelhead are observed returning to the Feather River Fish Hatchery (FRFH) in late October and are spawned there from December through February. Adult steelhead migration and spawning timing may be highly variable depending on river flows and water temperatures during migration periods. Feather River juvenile and adult steelhead begin emigrating between November and July, with a majority

moving downstream between March and May (Kurth 2012). Juvenile steelhead may rear in their natal stream or associated tributary streams for 1-3 years, but generally leave for the ocean at 2 years of age (Hallock, 1989).

The FRFH, located at the Fish Barrier Dam, was constructed in the mid-1960's by DWR as mitigation for the loss of anadromous fish habitat (NMFS 2014). The FRFH produces both fall-run and spring-run Chinook salmon, as well as steelhead trout. Spring-run Chinook salmon and steelhead releases are generally 100% marked by removal of the adipose fin (ad-clipped) and internally tagged with coded wire tags (CWTs), while fall-run releases contain 25% marked/CWT tagged individuals. Historical in-river releases of juvenile fall-run Chinook salmon from FRFH typically included the single release of 1 million fish in late April at Boyd's Pump Boat Launch (RM 22.4) located approximately 5 miles upstream of the Lower Feather River RST. Additional fall-run produced at the FRFH are released annually into San Francisco and San Pablo Bays; however, these fish do not impact catch numbers in the RST and therefore are not considered for RST analyses. Historical in-river releases of spring-run Chinook salmon typically include three paired releases of approximately 336,000 fish at Boyd's Pump Boat Launch and Gridley Boat Launch (RM 49.9; approximately 32.4 miles upstream of the RST site) in early March, late March, and April for a total of 2 million hatchery spring-run Chinook salmon. Historical releases of steelhead typically consist of 450,000 yearling steelhead released into the lower Feather River at Boyd's Pump Boat Launch in February. When available, some steelhead may also be released into Thermalito Afterbay to support the local fishery, but like Bay release, these fish do impact catch number in the RST and are not included in RST analyses. Release strategies for Chinook salmon and steelhead may vary annually based on river conditions (e.g., temperature and flow) and hatchery production (L. McNabb, pers. comm., 2023).

The reduction of available habitat in the Feather River results in increased population density of salmonids, contributing to increased disease and parasite transmission (PFMC, 2019). Higher river temperatures and higher parasite density negatively impact the ability of salmonids to resist disease (Ray et al. 2012). *Ceratonova shasta* is a myxosporean salmonid parasite that causes hemorrhaging and necrosis of the intestine of salmon and trout. Recent studies have documented an up to 83% prevalence of severe *C. shasta* infection in wild juvenile Chinook salmon sampled between RM 59 and RM 22 of the high flow channel of the Feather River. In these studies, most of the infected fish collected were in a diseased state and expected to die from clinical symptoms shortly post-collection. Studies monitoring the infectivity of salmon with *C. shasta* on the Sacramento River show this pathogen to be present and have an infection rate of up to 93% (J. Llamas, pers. comm., 2021). C. *shasta* is likely a significant factor in juvenile Chinook salmon survival, especially for those spawned sections of the watershed with a high parasite load, such as the Feather River (Foott et al. 2023).

Another stressor impacting salmon populations in the Feather River and greater Central Valley is Thiamine Deficiency Complex (TDC). TDC was first recognized in Central Valley hatcheries in early 2020 when juvenile Chinook salmon were observed swimming in corkscrew patterns and dying at unusually high rates. TDC has since been linked to the ocean diet of returning adult

Chinook salmon populations. Specifically, scientists hypothesize that adult female Chinook salmon in the ocean who consume an abundance of anchovies, which are rich in the enzyme thiaminase that breaks down thiamine, return to rivers to spawn with depressed thiamine concentrations in their eggs and produce thiamine deficient offspring (NOAA Fisheries 2021). TDC causes loss of equilibrium, abnormal swimming patterns, lethargy, and early life-stage mortality (Mantua et al. 2021). Emigrating juvenile salmon with TDC have inhibited swimming behavior and are more vulnerable to predation on their journey to the ocean. The FRFH initiated a thiamine treatment protocol for spring-run Chinook salmon in 2021; currently adults, eggs, and fry are given thiamine treatment. While some hatcheries have treated returning adult Chinook salmon with some success, there is currently no effective method to treat TDC for naturally spawning adults or juveniles (Bell, 2022). The effects of TDC on survival of juvenile Chinook salmon in the Sacramento watershed is not well understood, and research is ongoing, including the extent of thiamine deficiency in hatchery versus natural origin fish.

In addition to pathogens and TDC, current water management practices throughout the Delta and its tributaries, including the Sacramento River watershed, can affect survival of emigrating salmonids. Understanding the abundance and timing of emigrating salmonids is crucial in making informed water management decisions. Various operational restrictions have been placed on water diversion projects within the Delta and its tributaries to protect listed salmonids. Real-time data analyses of juvenile salmonid timing, abundance, and emigration improves resource agency and water managers ability to understand the effects of water operations on salmonids and develop protective measures to maximize water project management flexibility while providing protection to migrating salmonids. Data from the lower Feather River RST site is used to adaptively manage water project operations in the Delta. Juvenile salmonid monitoring on the lower Feather River provides valuable real-time data on emigration patterns and abundance to inform the spring-run Chinook salmon JPE and adaptive operations to reduce impacts on Chinook salmon while still facilitating water exportation. It also provides an opportunity to study the life cycle of salmonids and collect information about what influences juvenile survival during emigration through the Feather River watershed.

CDFW issued Incidental Take Permit No. 2081-2019-066-00 (2020 SWP ITP) on March 31, 2020, to DWR for the long-term operation of the State Water Project. Pursuant to section 2081(b) of the Fish and Game Code, the 2020 SWP ITP includes Conditions of Approval (COAs) for the incidental take of Delta smelt, longfin smelt, winter-run Chinook salmon, and spring-run Chinook salmon. This monitoring program was created by the 2020 SWP ITP to provide salmonid data from the lower Feather River to inform several COAs from the ITP, specifically COA 7.5.2 (New and Ongoing Monitoring Required to Develop and Establish a Spring-run Chinook Salmon JPE) and COA 8.1.2 (Salmon Monitoring Team).

- COA 7.5.2 of the 2020 SWP ITP requires the development of a JPE for spring-run Chinook salmon to increase understanding regarding the impacts water operations have on the spring-run Chinook salmon population in the Sacramento River Watershed and inform the development of mitigation measures to reduce take of spring-run Chinook salmon at

Delta fish salvage facilities. Data from the RST monitoring site on the lower Feather River at RM 17.5 will be used along with other datasets from salmonid monitoring programs in the Sacramento River Watershed to inform the development of JPE modeling approaches.

- COA 8.1.2 of the ITP requires a real-time operations monitoring team, called the Salmon Monitoring Team (SaMT), to meet weekly from October through June, to consider and discuss survey data, salvage data, and other pertinent biotic and abiotic factors to provide advice for real-time management of SWP operations to DWR, CDFW, and the Water Operation Management Team (WOMT) to minimize take of winter-run and spring-run Chinook salmon in the Delta. One of the weekly tasks of the SaMT includes estimating the percentage of juvenile winter-run and young-of-year (YOY) spring-run Chinook salmon that are present upstream of the Delta, in the Delta, or have exited the Delta past Chipps Island. The SaMT uses data from the Lower Feather River RST monitoring site, among other datasets, to understand the movement of juvenile salmon in the Sacramento River to estimate the number of winter-run and spring-run Chinook salmon that have entered the Delta.

METHODS

Salmonid monitoring at the Star Bend trapping site on the lower Feather River began on January 19, 2022, and continued through June 22, 2022. During this period there were 144 days of active sampling. The intention is for the RST site to operate from October through June each emigration season; however, the first year of sampling was delayed while CDFW's federal Section 10(a)(1)(A) research permit (number 18181-4R) was amended to add the new RST location. RSTs are the standard fisheries monitoring device used for this and many other juvenile salmonid emigration monitoring programs. RSTs utilize a large aluminum cone enclosed in a perforated screen suspended between two pontoons that rotates with moving water to sample fish moving downstream. The force of moving water (stream flow) on the baffles inside the cone causes it to rotate. Fish enter the upstream end of the rotating cone, become confined inside the cone, and are carried rearward and held in a live box. A detailed description of RST use and operation is available in Kennen et al. (1994) and Volkhardt et al. (2007).

For this project two RSTs were linked together, each with a 2.4 m (8 ft) diameter cone and anchored in place on the east side (river left) of the lower Feather River. The traps were secured with an anchor upstream, and two lines to the bank; one laterally and one diagonally. These connections allowed the trap position to be altered with flow and debris level. During average flow conditions, the RSTs were approximately 20 ft from the left bank and utilized full cone sampling. During periods of high flow traps may have been adjusted to sample closer to the bank to avoid breaking anchor lines, and half-cone sampling may have been used to reduce debris load following the condition-dependent sampling schedule. Half-cone sampling was also used during FRFH releases of steelhead and spring-run Chinook salmon from Boyd's Pump Boat

Launch to reduce catch mortalities and excessive catch of the released fish. Additionally, the RSTs may have suspended operation for more than 24 hours to further reduce catch of hatchery-released fish. These actions were taken to avoid exceedance of permitted take for each species.

The traps were serviced every 24 hours during the sampling season unless fish catch rates during hatchery releases required more frequent checks. During each check, traps were cleaned, fished out, and reset once every 24 hours. During each trap check staff collected data on RST operation including time of servicing, average cone revolutions per minute, total number of cone revolutions since last check, trap conditions (intake debris and live well debris), and water velocity entering each cone. Velocity was measured with the Global Water flow probe (model FP111).

Water quality data, including water temperature, conductivity, and dissolved oxygen was measured daily during each trap check with a YSI water quality meter (model Pro 2030). Additionally, a water sample was collected at the trap and analyzed for turbidity using a LaMotte 2020wi Turbidimeter upon returning to the office. An electronic Onset HOBO temperature logger was set in the river left cone livewell for the duration of the trapping period to record water temperature every hour. River discharge volume was recorded from the CDEC FSB gauge. River flow was important to record because it influences juvenile emigration patterns and may create hazardous working conditions for staff or limit safe boat access during low flow.

All fish captured in the RSTs were identified to species and recorded. Salmonid catch was measured to fork length (FL), and non-salmonid bycatch were measured to total length (TL) to the nearest millimeter (mm). A total of 10 individuals were measured per bycatch species, after which they were plus counted. Juvenile salmonids missing an adipose fin are assumed to be of hatchery origin. Generally, juvenile salmonids with an intact adipose fin are assumed to be of natural origin; however, hatchery releases may not be 100% marked in all years, so these fish may be a mix of hatchery and natural origin. Unmarked juvenile Chinook salmon were assigned a run (i.e., spring-run, fall-run, late fall-run, or winter-run) based on FL using the length-at-date criteria (LAD; Green 1992). For steelhead and Chinook salmon, up to 50 individuals were measured per category: marked Chinook salmon, unmarked Chinook salmon (spring-run, fall-run, late fall-run or winter-run), marked steelhead, and unmarked steelhead. If salmonid catch exceeded 50 individuals in a category, the excess fish were plus counted. Steelhead were categorized into age classes based on FL measurements: Fish < 100 mm were assigned YOY, fish between 100 to 300 mm were assigned yearling, and fish >300 were considered adults. Live Chinook salmon were assigned 1 of 5 developmental life stages (alevin, fry, parr, silvery parr, or smolt) based on visual appearance. No life stages were recorded for mortalities because appearance rapidly changes. No life stages were assigned to tallied individuals.

Data was recorded on waterproof datasheets, then transported to the CDFW Chico field office and reviewed for quality assurance and quality control (QAQC). Data summaries of target

species were updated daily and regularly uploaded to the California Cooperative Anadromous Fish and Habitat Data Program (CalFish; https://www.calfish.org/Home.aspx) to provide public access to real-time catch data. Data was also entered into the Comprehensive Assessment and Monitoring Program (CAMP) database developed for passage analyses and reporting. The database was then verified for QAQC at the end of the trapping season using standard protocols before passage estimates were generated.

Trap efficiency was evaluated using mark recapture methods (Volkhardt 2007). Groups of 500-1300 juvenile Chinook were marked externally using Bismarck Brown Y (BBY) and released 1 river mile upstream from the RST site on the same day as the dye was applied, due to the lack of an overnight holding area. Fish were distributed across the stream when released. Natural origin fish were sourced from the DWR RSTs upstream in the Feather River, and hatchery origin fish were sourced from Feather River Fish Hatchery (FRFH). Passage estimates for juvenile Chinook salmon were generated for each race of Chinook salmon by expanding catch to represent 100 percent effort. To expand catch to reflect 100 percent effort, the mean weekly catch was divided by effort (hours) and adjusted for 336 total hours in a week:

100% effort = mean weekly catch / (trap effort hours/actual hours in a week)

Passage estimates with 80 percent confidence intervals were calculated for all unmarked Chinook salmon races and by dividing the adjusted catch by the mean trap efficiency.

CPUE for each run of Chinook salmon and steelhead was evaluated by dividing the total number of fish captured by the total hours of sampling. In this report, environmental and CPUE data is combined into weekly averages to evaluate trends and help normalized variation in conditions and effort. Sample weeks begin on Sunday and end on Saturday, and each week of the year is assigned a number in accordance with the Julian calendar.

RESULTS

Environmental Conditions

Environmental conditions, including river discharge, water temperature, turbidity, and dissolved oxygen levels, were monitored and recorded daily throughout the sampling season (Table 1). River discharge, as measured at the CDEC FSB gauge, averaged 1,680 cubic feet per second (cfs) at the beginning of the monitoring season in week 3, and averaged 3,785 cfs at the end of the season in week 25. The peak overall discharge during the monitoring season was 6,025 cfs on March 12th 2022 in week 10. The mean weekly discharge reached a low in week 18 of 1,599 cfs, and a high of 5,817 in week 10 (**Error! Reference source not found.**) (DWR, 2022).

Table 1. Weekly data summary of environmental conditions, including mean water temperature (°C), mean river discharge (cfs) (DWR 2022), mean water turbidity (NTU), and mean dissolved oxygen, recorded at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022.

Week	Start of Week	Discharge (CFS)	Temperature (°C)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
3	1/16/2022	1680	9.5	3.94	11.7
4	1/23/2022	1685	10.2	2.85	11.4
5	1/30/2022	3241	9.3	5.27	11.0
6	2/6/2022	3680	10.8	6.42	12.0
7	2/13/2022	3867	11.7	3.80	11.6
8	2/20/2022	4351	11.2	3.07	12.3
9	2/27/2022	5471	12.2	3.09	11.8
10	3/6/2022	5817	11.7	3.61	11.8
11	3/13/2022	3625	12.9	2.58	10.5
12	3/20/2022	3057	14.6	2.10	9.7
13	3/27/2022	3841	15.4	2.08	9.3
14	4/3/2022	2814	16.0	1.83	9.6
15	4/10/2022	1856	14.1	1.48	9.8
16	4/17/2022	1739	15.5	1.67	9.3
17	4/24/2022	1684	17.6	1.90	8.6
18	5/1/2022	1599	17.9	1.42	8.5
19	5/8/2022	2463	16.5	2.15	8.8
20	5/15/2022	2788	18.7	2.33	8.2
21	5/22/2022	2837	19.9	2.09	7.7
22	5/29/2022	3157	19.8	2.30	7.6
23	6/5/2022	3465	20.3	2.84	7.1
24	6/12/2022	3848	20.3	2.12	7.3
25	6/19/2022	3785	20.8	1.98	7.4

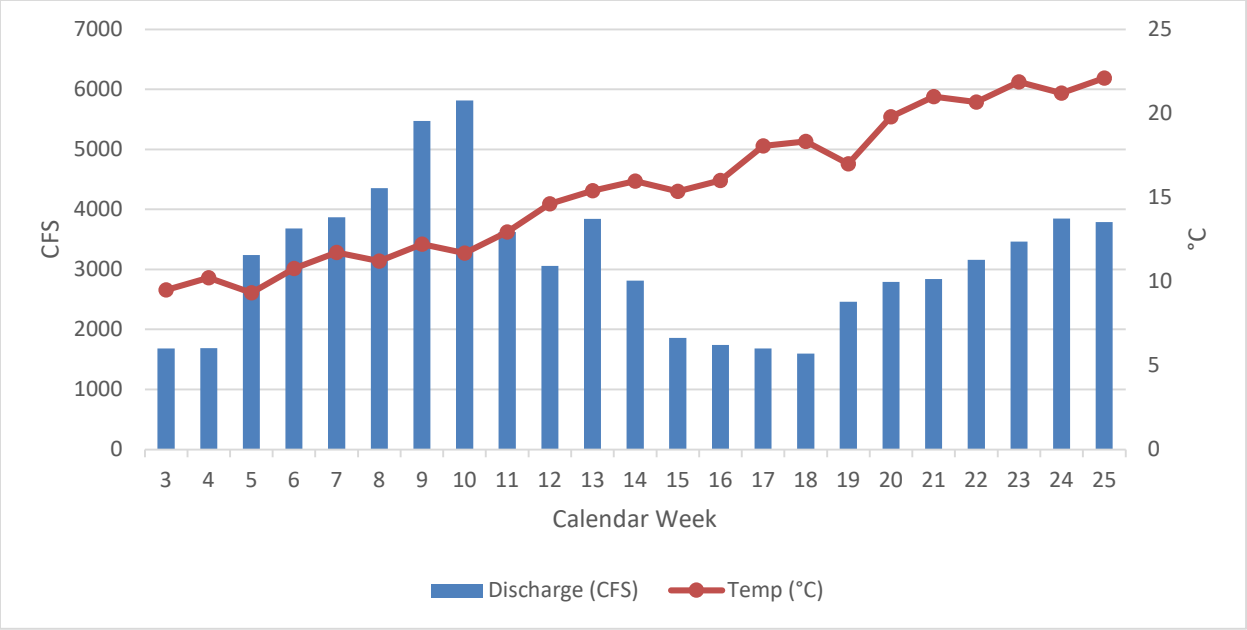

Figure 2. Mean weekly discharge recorded from the California Data Exchange Center Feather River at Boyd's Landing above Star Bend gauge plotted with water temperature recorded with a HOBO temperature logger on the lower Feather River RST near Star Bend from January 19, 2022 (week 3) to June 22, 2022 (week 25).

The maximum and minimum mean weekly water temperatures during the sampling season were 22.1 °C in week 25 and 9.3 in week 5. Fish processing ended on June 21, 2022 during week 25 because temperature exceeded 72°F, the safe handling limit for salmonids (**Error! Reference source not found.**3).

Mean weekly turbidity during the sampling season reached its lowest in week 18 at 1.42 NTU and was highest in week 6 with a weekly mean of 6.42 NTU (Figure 3). Over the monitoring season, turbidity generally mirrored the rise and fall of river flow.

Dissolved oxygen measured at the RST site during the sampling season ranged from 7.1 mg/L in week 23 to 12.3 mg/L in week 8 (Figure 3). Over the monitoring season, dissolved oxygen concentrations generally decreased as temperatures increased, as expected.

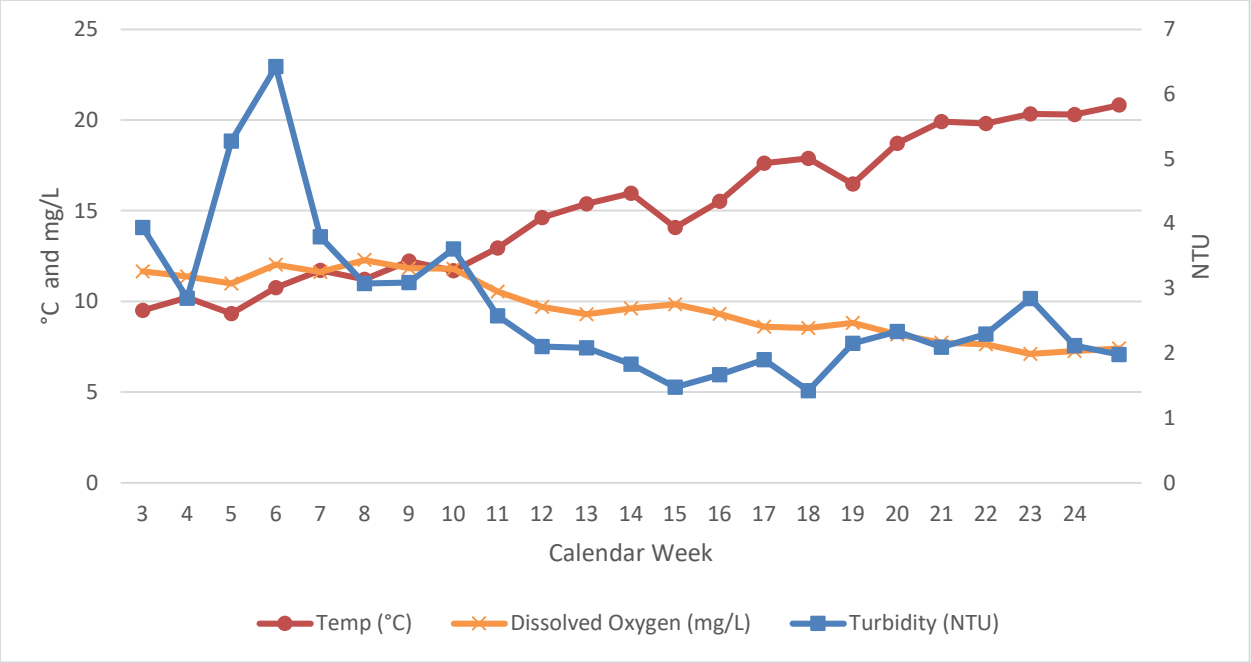

Figure 3. Mean weekly water temperature, dissolved oxygen, and turbidity recorded on the Lower Feather River near Star Bend from January 19, 2022 (week 3) to June 22, 2022 (week 25).

Summary of Juvenile Chinook Salmon Catch

All salmonids captured at the Lower Feather River RSTs are assumed to be produced in the Feather River and its tributaries either naturally in-river or at the FRFH, except juvenile winter-run Chinook salmon, which likely originate in the upper Sacramento River Watershed and use the lower Feather River for non-natal rearing. During the 2021-2022 sampling season, the lower Feather River RST monitoring site only captured juveniles from three of the four Chinook salmon runs present in the Sacramento River and tributaries: spring-run, fall-run, and late fall-run. No juvenile winter-run were observed in catch. Observed juvenile Chinook salmon life stages were limited to fry, parr, and silvery parr. A total of 3,470 juvenile Chinook salmon were captured during the sampling period of January 19 through June 22, 2022. A total of 3,077 individuals were unmarked (intact adipose fin), making up 88.7% of the total catch. Unmarked salmon included natural origin spring-, fall-, and late fall-runs, as well as unmarked hatchery origin spring-run. Marked (clipped adipose fin; “ad-clipped”) Chinook salmon catch was 393 fish, or 11.3% of total catch.

The first juvenile Chinook salmon (n=11) were caught on January 20, the first day of trapping, and were identified as spring-run and fall-run. Peak catch occurred in week 13, where 403 unmarked and 271 ad-clipped salmon were captured with a CPUE of 3.45 fish per hour. This week had 19.4% of the total catch over the 23-week season and took place during a hatchery release of spring-run Chinook salmon from FRFH where 50% of the fish were unmarked (see explanation below). The last juvenile Chinook salmon was caught during week 25, on June 19 and was identified as a late fall-run. Table 2: **Summary of weekly catch of marked and unmarked**

juvenile Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022, with a breakdown of catch by run.

Calendar Week	Start of Week	Total Marked Chinook	Total Unmarked Chinook	Unmarked Fall	Unmarked Spring	Unmarked Late-fall
3	1/16/2022	0	36	34	2	0
4	1/23/2022	0	60	58	2	0
5	1/30/2022	0	219	217	2	0
6	2/6/2022	0	54	54	0	0
7	2/13/2022	0	385	384	1	0
8	2/20/2022	0	355	348	7	0
9	2/27/2022	0	221	215	6	0
10	3/6/2022	0	181	175	6	0
11	3/13/2022	0	238	236	2	0
12	3/20/2022	0	230	228	2	0
13	3/27/2022	271	403	398	5	0
14	4/3/2022	99	123	123	0	0
15	4/10/2022	13	46	46	0	0
16	4/17/2022	4	7	7	0	0
17	4/24/2022	0	28	28	0	0
18	5/1/2022	2	34	32	1	1
19	5/8/2022	3	251	237	1	13
20	5/15/2022	1	171	163	0	8
21	5/22/2022	0	17	17	0	0
22	5/29/2022	0	13	12	0	1
23	6/5/2022	0	3	3	0	0
24	6/12/2022	0	1	1	0	0
25	6/19/2022	0	1	0	0	1
Totals		**393**	**3077**	**3016**	**37**	**24**

provides a more in-depth weekly summary of marked and unmarked catch.

Table 2: **Summary of weekly catch of marked and unmarked juvenile Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022, with a breakdown of catch by run.**

Calendar Week	Start of Week	Total Marked Chinook	Total Unmarked Chinook	Unmarked Fall	Unmarked Spring	Unmarked Late-fall
3	1/16/2022	0	36	34	2	0
4	1/23/2022	0	60	58	2	0
5	1/30/2022	0	219	217	2	0
6	2/6/2022	0	54	54	0	0
7	2/13/2022	0	385	384	1	0

8	2/20/2022	0	355	348	7	0
9	2/27/2022	0	221	215	6	0
10	3/6/2022	0	181	175	6	0
11	3/13/2022	0	238	236	2	0
12	3/20/2022	0	230	228	2	0
13	3/27/2022	271	403	398	5	0
14	4/3/2022	99	123	123	0	0
15	4/10/2022	13	46	46	0	0
16	4/17/2022	4	7	7	0	0
17	4/24/2022	0	28	28	0	0
18	5/1/2022	2	34	32	1	1
19	5/8/2022	3	251	237	1	13
20	5/15/2022	1	171	163	0	8
21	5/22/2022	0	17	17	0	0
22	5/29/2022	0	13	12	0	1
23	6/5/2022	0	3	3	0	0
24	6/12/2022	0	1	1	0	0
25	6/19/2022	0	1	0	0	1
Totals		**393**	**3077**	**3016**	**37**	**24**

In 2022, due to unfavorable flow and habitat conditions in the Feather River caused by the drought, the FRFH only conducted one in-river release of juvenile spring-run Chinook salmon consisting of two groups: 741,256 released at Boyd's Pump Boat Launch and 717,502 at Gridley Boat Launch. Additionally, due to staffing shortages, the in-river released spring-run were marked with adipose fin clips and CWTs at a rate of 50%. Therefore, unmarked juvenile Chinook salmon captured in the RSTs were assumed to be a mix of hatchery and natural origin. The remaining 959,030 spring-run from FRFH were released in San Pablo Bay. All juvenile fall-run Chinook salmon (approximately 1,000,000) from FRFH were released into San Francisco and San Pablos Bays and no in-river releases of fall-run occurred. Fish released in San Pablo and San Francisco Bays have no impact on RST catch and therefore are not included in analyses. All marked juvenile Chinook salmon caught at the RSTs during the 2021-2022 monitoring season were classified as spring-run since no hatchery origin fall-run were released in river.

Unmarked Juvenile Chinook Salmon Catch

Spring-run Chinook Salmon

All unmarked juvenile spring-run Chinook salmon caught in the lower Feather River RSTs after March 30, 2022 (at or beyond week 13) were assumed to be a mixture of natural origin and hatchery origin, due to the partial marking of spring-run released in-river from the FRFH.

A total of 37 unmarked juvenile spring-run Chinook salmon were observed this season, making up 1.2% of the overall unmarked catch. The first unmarked spring-run was caught January 20, 2022 in week 3; the last unmarked spring-run was caught May 10 in week 19 (Figure 2). Peak catch occurred during week 8 when 7 individuals were trapped, representing 18.9% of the total unmarked spring-run captured throughout the sampling season. The CPUE was calculated to be 0.027 during this period. Table 3 provides a summary of unmarked spring-run catch for the 2021-2022 sampling season. All unmarked juvenile spring-run Chinook salmon sampled by the RSTs were assumed to be brood year (BY) 2021 based on size at capture.

Table 3. Summary of weekly catch of unmarked juvenile spring-run Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022. Weeks with zero catch of unmarked juvenile spring-run Chinook salmon are not included in this table.

Week	Start of Week	Total Catch	Effort (Hours)	Catch Per Unit Effort	Average FL (mm)	Min FL (mm)	Max FL (mm)
3	1/16/2022	2	135.9	0.015	57	55	58
4	1/23/2022	2	333.4	0.006	53	53	53
5	1/30/2022	2	328.7	0.006	56	54	57
7	2/13/2022	1	333.0	0.006	58	58	58
8	2/20/2022	7	330.1	0.027	63	58	70
9	2/27/2022	6	209.2	0.0296	65	60	76
10	3/6/2022	6	336.8	0.018	66	63	73
11	3/13/2022	2	402.6	0.005	69	66	72
12	3/20/2022	2	391.2	0.005	74	70	78
13	3/27/2022	5	373.7	0.027	74	73	77
18	5/1/2022	1	301.2	0.003	98	98	98
19	5/8/2022	1	317.7	0.003	97	97	97
	Total Catch	**37**					

Fall-run Chinook Salmon

All unmarked juvenile fall-run Chinook salmon caught in the lower Feather River RST monitoring site after March 30, 2022 (at or beyond week 13) were assumed to be a mixture of natural origin and hatchery origin, due to run misidentification using the LAD criteria combined with the partial marking of spring-run released in-river from the FRFH. The increase in fall-run catch following the hatchery release supports this assumption, as is observed in Figure 4.

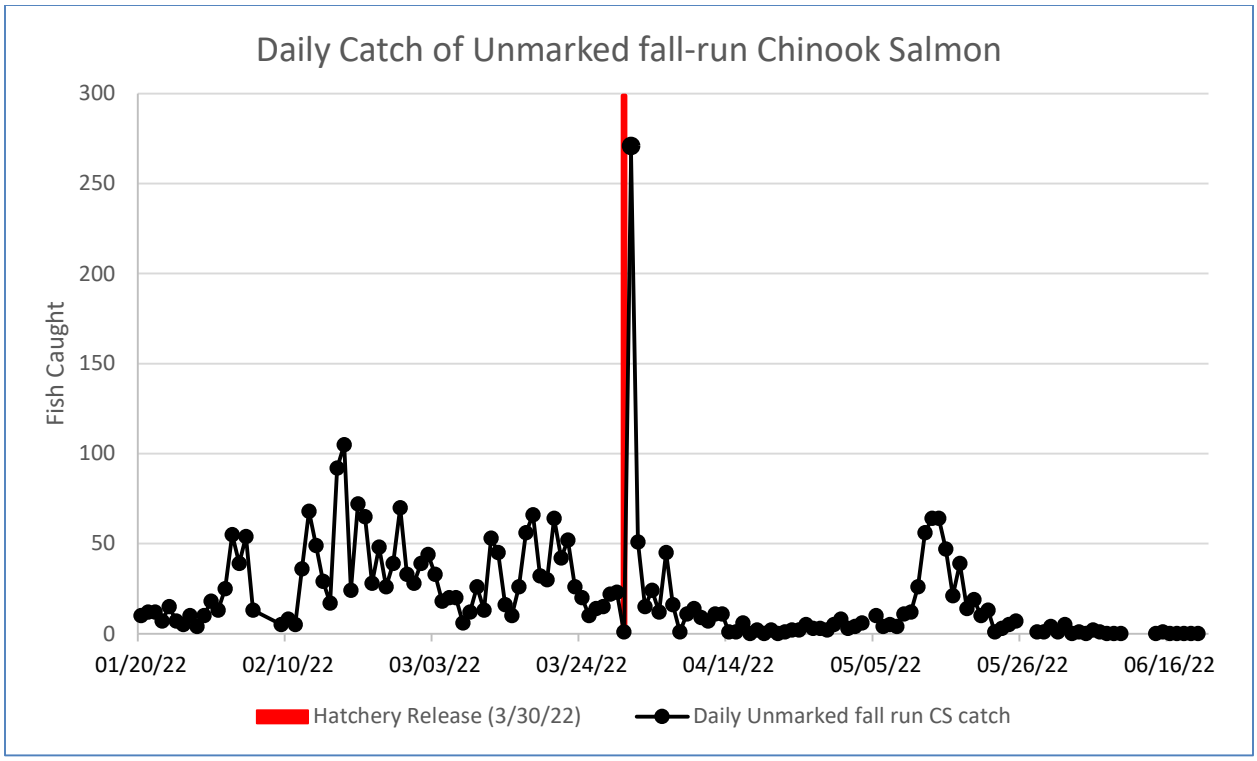

Figure 4: Daily catch of unmarked fall-run Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 to June 22, 2022. The black column indicates the total release of 1,458,758 juvenile spring run Chinook salmon from FRFH.

A total of 3,016 unmarked fall-run juvenile Chinook salmon were captured during the 2021-2022 monitoring season at the lower Feather River RST monitoring site. Fall-run made up the majority of catch, with 98% of the overall unmarked juvenile Chinook salmon catch; however, some of these fish may be spring-run but were misidentified using the LAD criteria. The first fall-run was caught January 20, 2022 in week 3; the last fall-run was caught June 15 in week 24. Peak catch occurred during week 13 when 398 fall-run were trapped, representing 13.2% of the total unmarked fall-run captured throughout the sampling season. The CPUE was calculated to be 2.031 during this period. **Error! Reference source not found.** provides a summary of unmarked fall-run catch for the 2021-2022 sampling season. All unmarked juvenile fall-run Chinook salmon sampled by the RSTs were assumed to be BY 2021 based on size at capture.

Table 4. Summary of weekly catch of unmarked juvenile fall-run Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022. Weeks with zero catch of unmarked juvenile fall-run Chinook salmon are not included in this table.

Week	Start of Week	Total Catch	Effort (Hours)	Catch Per Unit Effort	Average FL (mm)	Min FL (mm)	Max FL (mm)
3	1/16/2022	34	135.9	0.250	38	35	45
4	1/23/2022	58	333.4	0.174	38	34	47

5	1/30/2022	217	328.7	0.660	38	31	49
6	2/6/2022	54	166.6	0.648	38	33	49
7	2/13/2022	384	333.0	2.307	38	29	54
8	2/20/2022	348	330.1	1.469	40	31	337
9	2/27/2022	215	209.2	1.028	43	33	57
10	3/6/2022	175	336.8	0.520	45	33	61
11	3/13/2022	236	402.6	0.586	48	31	66
12	3/20/2022	228	391.2	0.583	49	35	66
13	3/27/2022	398	373.7	2.031	55	31	71
14	4/3/2022	123	371.8	0.395	61	35	75
15	4/10/2022	46	327.7	0.140	61	37	77
16	4/17/2022	7	358.0	0.020	56	37	80
17	4/24/2022	28	246.6	0.114	66	42	87
18	5/1/2022	32	301.2	0.106	61	42	87
19	5/8/2022	237	317.7	0.746	59	43	93
20	5/15/2022	163	351.9	0.463	59	43	99
21	5/22/2022	17	227.8	0.075	64	50	93
22	5/29/2022	12	324.6	0.037	61	50	71
23	6/5/2022	3	232.1	0.013	69	54	79
24	6/12/2022	1	181.2	0.006	61	61	61
	Total Catch	**3,016**					

Late Fall-run Chinook Salmon

A total of 24 unmarked late fall-run Chinook salmon were captured during the 2021-2022 monitoring season at the lower Feather River RST monitoring site, making up 0.8% of the overall unmarked juvenile Chinook salmon catch. The first late fall-run was caught May 2, 2022 in week 18; the last late fall-run was caught June 19 in week 25. Peak catch occurred during week 19 when 13 late fall-run were trapped, representing 18.9% of the total unmarked late fall-run captured throughout the sampling season. The CPUE was calculated to be 0.041 during this period. Table 5 provides a summary of unmarked late fall-run catch for the 2021-2022 sampling season. All juvenile late fall-run Chinook salmon sampled by the RSTs were assumed to be BY 2021 based on size at capture.

Table 5. Summary of weekly catch of unmarked juvenile late fall-run Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022. Weeks with zero catch of unmarked juvenile late fall-run Chinook salmon are not included in this table.

Week	Start of Week	Total	Effort	Catch Per Unit Effort	Average FL	Min FL	Max FL

		Catch	(Hours)		(mm)	(mm)	(mm)
18	5/1/2022	1	301.2	0.003	38	38	38
19	5/8/2022	13	317.7	0.041	39	32	43
20	5/15/2022	8	351.9	0.023	41	36	44
22	5/29/2022	1	324.6	0.003	48	48	48
25	6/19/2022	1	226.9	0.004	50	50	50
	Total Catch	**24**					

Marked Juvenile Chinook Salmon Catch

A total of 393 marked (ad-clipped) juvenile Chinook salmon were observed during the 2021-2022 monitoring season at the lower Feather River RST site. The first marked juvenile Chinook salmon was caught on March 31, 2022 in week 13 and was assigned as spring-run. Catch of this fish occurred the day after FRFH released approximately 1,458,758 juvenile spring-run Chinook salmon into the Feather River at two locations upstream of the RST site (Table 6).

Table 6. Summary of hatchery-produced juvenile Chinook salmon released by the Feather River Fish Hatchery at two locations upstream of the lower Feather River RST monitoring site during the sampling period of January 19, 2022 through June 22, 2022.

Week	Release Date	Species	Race	Hatchery	Release Site	Average FL (mm)	Total Released	% Marked
13	3/30/22	Chinook	Spring	FRFH	Gridley Boat Launch	68	717,502	50%
13	3/30/22	Chinook	Spring	FRFH	Boyd's Pump Boat Launch	68	741,256	50%

Peak catch occurred in week 13, during which 271 marked juvenile Chinook salmon were caught. Trapping efforts were reduced by using half-cone during this week to reduce the potential for RST-related mortalities of hatchery released fish. To calculate CPUE during half-cone sampling, catch was doubled. The estimated CPUE during peak week for juvenile marked Chinook salmon was 1.45. A summary of weekly marked juvenile Chinook Salmon can be found in

Week	Start of Week	Total Catch	Effort (Hours)	Catch Per Unit Effort	Average FL (mm)	Min FL (mm)	Max FL (mm)
13	3/27/2022	271	373.7	1.45	67	45	82
14	4/3/2022	99	371.8	0.30	71	52	86
15	4/10/2022	13	327.7	0.04	73	65	80
16	4/17/2022	4	358.0	0.01	67	39	100
18	5/1/2022	2	301.2	0.01	79	77	81

19	5/8/2022	3	317.7	0.01	72	55	93
20	5/15/2022	1	351.9	0.00	58	58	58
	Total	**393**					

Table 7: Summary of weekly catch of marked juvenile Chinook salmon at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022. Weeks with zero catch of marked juvenile Chinook salmon are not included in this table.

Week	Start of Week	Total Catch	Effort (Hours)	Catch Per Unit Effort	Average FL (mm)	Min FL (mm)	Max FL (mm)
13	3/27/2022	271	373.7	1.45	67	45	82
14	4/3/2022	99	371.8	0.30	71	52	86
15	4/10/2022	13	327.7	0.04	73	65	80
16	4/17/2022	4	358.0	0.01	67	39	100
18	5/1/2022	2	301.2	0.01	79	77	81
19	5/8/2022	3	317.7	0.01	72	55	93
20	5/15/2022	1	351.9	0.00	58	58	58
	Total	**393**					

As mentioned previously, all marked fish captured in the lower Feather River RSTs were assumed to be spring-run released by FRFH, as that was the only hatchery release of juvenile Chinook salmon that occurred upstream of this trapping location during the 2021-2022 monitoring season.

Summary of Steelhead Trout Catch

The lower Feather River RSTs caught 496 steelhead during the 2021-2022 sampling season. Of the total steelhead catch, 96.6% were ad-clipped (n=479). Only 17 of the 496 (3.4%) steelhead captured in the RSTs were unmarked. Any steelhead observed in the RSTs with an intact adipose fin were considered to be natural origin as all hatchery steelhead released by FRFH were marked at 100%. All marked steelhead captured in the RSTs are assumed to originate from the FRFH. Table 8 provides a summary of all juvenile steelhead catch for the 2021-2022 sampling season.

Table 8. Summary of weekly catch of marked and unmarked juvenile steelhead trout, including average fork length (mm), at the lower Feather River RST monitoring site from January 19, 2022 through June 22, 2022. Weeks with zero catch of juvenile steelhead are not included in this table.

Week	Start of Week	Marked Steelhead	Average FL (Marked) (mm)	Unmarked Steelhead	Average FL (Unmarked) (mm)
5	1/30/2022	108	192	0	N/A
6	2/6/2022	137	193	0	N/A
7	2/13/2022	110	197	0	N/A
8	2/20/2022	75	209	0	N/A
9	2/27/2022	20	208	0	N/A
10	3/6/2022	8	222	3	45
11	3/13/2022	2	213	1	205
12	3/20/2022	5	210	1	127
13	3/27/2022	2	207	2	50
14	4/3/2022	1	223	0	N/A
16	4/17/2022	2	266	3	50
17	4/24/2022	0	N/A	1	57
18	5/1/2022	2	238	1	38
19	5/8/2022	0	N/A	1	47
20	5/15/2022	2	287	4	49
21	5/22/2022	1	250	0	N/A
22	5/29/2022	2	246	0	N/A
23	6/5/2022	1	300	0	N/A
24	6/12/2022	1	250	0	N/A
	Total Catch	**496**		**17**	

Unmarked Steelhead Trout Catch

Unmarked juvenile steelhead catch consisted of 17 individuals from week 10 through 20, with minimal increase in catch (greater than two steelhead) in weeks 10, 16, and 20. Of the total catch, 16 fish measured between 31 and 60 mm (less than 100 mm FL) and thus were classified as YOY. One fish measured 205 mm and was classified as a yearling (FL between 100 and 300 mm).

Marked Steelhead Trout Catch

The FRFH released 495,000 steelhead from Boyd's Pump Boat Launch between February 4 and 23, 2022**Error! Reference source not found.**. All steelhead released were tagged with CWTs and marked by removal of the adipose fin. The total catch of 479 ad-clipped juvenile

steelhead occurred at the lower Feather River RSTs after the FRFH steelhead release, starting in week 5 and continuing to week 24. Peak catch of marked juvenile steelhead occurred in week 6, with 137 individuals captured, coinciding with the FRFH release. Week 6 catch comprised 27.6% of the total steelhead catch and had a CPUE of 1.65.

The average FL of juvenile steelhead released from FRFH was 210 mm (classified as yearling). Marked steelhead captured at the lower Feather River RSTs ranged in FL from a minimum of 130 mm to a maximum of 300 mm, with an average of 200 mm. Of the captured marked steelhead, 477 were classified as yearlings and two were classified as adults because their measured FL exceeded the maximum length of the measuring board.

Trap Efficiency Trials and Passage Estimates

A total of six trap efficiency trails were performed during the 2021-2022 trapping season, during weeks 5, 8, 14, 15, 16, and 17 (Table 9). During each trial, fish were stained with BBY and released approximately 1 mile upstream from the RST location. Each release group contained between 500-1,302 marked fall-run Chinook salmon. Trap efficiencies during trials ranged from 0% to 3.15% with an average efficiency of 0.79%. All recaptures occurred within seven days from the date of release.

Table 9: Summary of efficiency trials performed during the 2021-2022 lower Feather River RST trapping season.

Week	Release Date	Origin	run	Mark	Total Released	Total Recaptured	% Efficiency
5	2/1/2022	RST caught	Fall	BBY	1302	18	1.38%
8	2/24/2022	RST caught	Fall	BBY	539	17	3.15%
14	4/6/2022	FRFH	Fall	BBY	530	0	0.00%
15	4/13/2022	FRFH	Fall	BBY	527	0	0.00%
16	4/20/2022	FRFH	Fall	BBY	500	0	0.00%
17	4/27/2022	FRFH	Fall	BBY	500	1	0.20%
						Average	**0.79%**

Passage of unmarked juvenile Chinook salmon emigrating in the lower Feather River near Star Bend was estimated to be 489,681 (80% Lower/Upper CLs:419,633,729/247,932) between January 19 and June 22, 2022. This total estimated passage of unmarked juvenile Chinook salmon includes: 481,626 fall-run, 3,222 late fall-run, and 4,833 spring-run (Table 10). No juvenile winter-run Chinook salmon were observed in catch during 2022, therefore no winter-run passage estimate is available.

Table 10. Estimates of unmarked juvenile Chinook salmon that passed the Lower Feather River RST sampling site from January 19, 2022 through June 22, 2022, including the lower 80% confidence intervals (CI).

Statistic	Fall-run	Late Fall-run	Spring-run	Total Unmarked
Estimated Passage	481,626	3,222	4,833	489,681
Lower 80% CI	19,310,753	129,191	193,786	19,633,729
Upper 80% CI	243,854	1,631	2,447	247,932

Other Fish Captured

A total of 5,145 non-target fish species were trapped in the lower Feather River RSTs during the 2021-2022 sampling season. All fish bycatch were identified to species if possible, or to genera. Some juveniles were too small to be confidently identified and were recorded as unknown minnow or "other". Total length (TL) was measured for up to ten individuals for each bycatch species for each RST and the remaining fish were tallied. A total of 29 different fish species were observed as bycatch (Table 11).

Table 11. Summary of non-salmonid fish species by common and scientific name captured in the lower Feather River RSTs from January 19, 2022 through June 22, 2022 with the total number caught and average, minimum, and maximum total lengths for each species.

Common Name	Species Name	Total Catch	Average TL (mm)	Min TL (mm)	Max TL (mm)
American shad	*Alosa sapidissima*	3	178	106	250
Black bullhead	*Ameiurus melas*	2	94	73	115
Bluegill	*Lepomis macrochirus*	23	32	20	52
Brown bullhead	*Ameiurus nebulosus*	6	80	40	225
California roach	*Hesperoleucus symmetricus*	2	65	62	67
Channel catfish	*Ictalurus punctatus*	19	69	45	156
Common carp	*Cyprinus carpio*	7	157	25	500
Golden shiner	*Notemigonus crysoleucas*	7	91	43	114
Goldfish	*Carassius auratus*	12	53	24	250
Hardhead	*Mylopharodon conocephalus*	85	32	20	73
Hitch	*Lavinia exilicauda*	3	107	90	120
Inland silverside	*Menidia beryllina*	30	55	30	82
Largemouth bass	*Micropterus salmoides*	25	35	27	48
Mosquitofish	*Gambusia*	34	30	20	59
Pacific lamprey	*Lampetra entosphenus*	45	129	96	182
Prickly sculpin	*Cottus asper*	48	36	15	114
Riffle sculpin	*Cottus gulosus*	17	47	20	114
River lamprey	*Lampetra ayresii*	22	145	100	178
Sacramento pikeminnow	*Ptychocheilus grandis*	37	84	22	300
Sacramento sucker	*Catostomus occidentalis*	32	33	22	76
Smallmouth bass	*Micropterus dolomieu*	19	38	22	110
Spotted bass	*Micropterus punctulatus*	106	39	24	250
Striped bass	*Morone saxatilis*	5	31	22	35
Threadfin shad	*Dorosoma petenense*	8	68	53	100
Tule perch	*Hysterocarpus traskii*	25	43	30	92
Unknown bass (Micropterus)	*Micropterus sp.*	61	27	20	45
Unknown Centrarchid	*Centrarchidae*	10	29	21	49
Unknown lamprey	*Petromyzontidae*	23	129	103	145
Unknown minnow		1,276	27	14	45
Wakasagi / Japanese smelt	*Hypomesus nipponensis*	3,116	70	15	9,069
Warmouth	*Lepomis gulosus*	2	39	36	41
White catfish	*Ameiurus catus*	2	87	45	129
White crappie	*Pomoxis annularis*	1	28	28	28
Other	*Unidentified*	31	27	21	35

DISCUSSION

The 2021-2022 juvenile salmonid emigration season was the inaugural season for the lower Feather River RST monitoring site near Star Bend. The trapping location proved successful, with sufficient velocity and flow to operate the RSTs throughout the sampling period. Staff were able to safely access and maintain the RSTs during a variety of environmental conditions and there was limited public interference. The RSTs did not operate over the entire juvenile salmonid emigration period; of the 154 days between initiation of sampling in January and the end of the season in June, the traps were non-operational for only 10 days. Seven of the non-operational days occurred during the last month of trapping when high water temperatures made it unsafe to handle fish. The other three non-operational days followed the release of steelhead from the FRFH, when the cones were raised to reduce excessive take of the released fish. In future seasons, depending on river volume and velocity, the RSTs may be shifted to half-cone sampling in anticipation of hatchery releases to avoid excessive take and mortalities of hatchery fish. This first season of sampling also revealed some issues with field techniques that can be resolved in future sampling efforts. For example, the system used to collect cone revolutions (which is a variable in calculating effort) was inconsistently functioning. In future seasons, a hubodometer will be used as this device will provide a more consistent and accurate measure of revolutions. Additionally, a detachable live well will be developed to hold and acclimate fish obtained from the hatchery prior to conducting efficiency trials to reduce stress and mortality.

Due to research permit delays, sampling at the lower Feather River RST site near Star Bend consisted of a partial sampling season from January 19 through June 22, 2022. The RST monitoring sites operated by DWR upstream from the Star Bend location began fishing two months prior on November 16, 2021 (Eye Side Channel) and November 29, 2021 (Herringer Riffle). In the time before the Star Bend RST began operating, DWR's upstream traps caught only 14% and 18% of their total unmarked Chinook catch for the season respectively, indicating that the peak of juvenile Chinook salmon emigration had not occurred prior to the start of the lower Feather River RST trapping period.

The lower Feather River RST caught a total of 3,077 unmarked juvenile Chinook salmon over 6,808.5 trapping hours. The 2021-2022 season catch of unmarked juvenile Chinook for the closest upstream RST monitoring site at RM 46 (the Herringer RST) was 21,276 individuals over 4,793 trapping hours. The lower catch at the lower Feather River RST could be attributed to operational and environmental variables. Operational variables may include the difference in probability of catch due to variable stream bottom topography and depth. Juvenile Chinook salmon are known to preferentially travel in the channel edges of the rivers (Lowery et al. 2013). The Star Bend RSTs operate approximately 20 feet from the shore and in a 15 ft deep section of the river. Another variable could be the difference in the percent of water column sampled between locations due to different river channel profiles (i.e., the Star Bend RSTs are in a deeper, wider, and higher flow section of the river than the Herringer RSTs). Environmental variables attributing to differences in salmonid catch at the two RST locations may include reduced survival of juveniles due to *C. shasta* infection, TDC, and predation, all of which were

likely exacerbated by poor habitat and migratory conditions (i.e., low flows, high water temperatures, decreased turbidity, and low dissolved oxygen) caused by the drought. Additionally, the estimate of combined spring run and fall run natural adult Chinook salmon escapement on the Feather River for 2021 was 9,652 (Azat, 2023), which was the lowest return since 2009. For comparison, the average (combined) natural spring and fall adult Chinook salmon escapement over the last five years was 37,965. Therefore, a respectively low passage of juveniles through the system this season would be anticipated from the diminished spawning population.

The lower Feather River RSTs captured more fall-run than other runs of unmarked juvenile Chinook salmon with a total of 3,016 fish, comprising 89% of the total unmarked juvenile Chinook salmon catch. Fall-run emigration occurred in multiple peaks associated with periods of increasing flow (**Figure *5***).

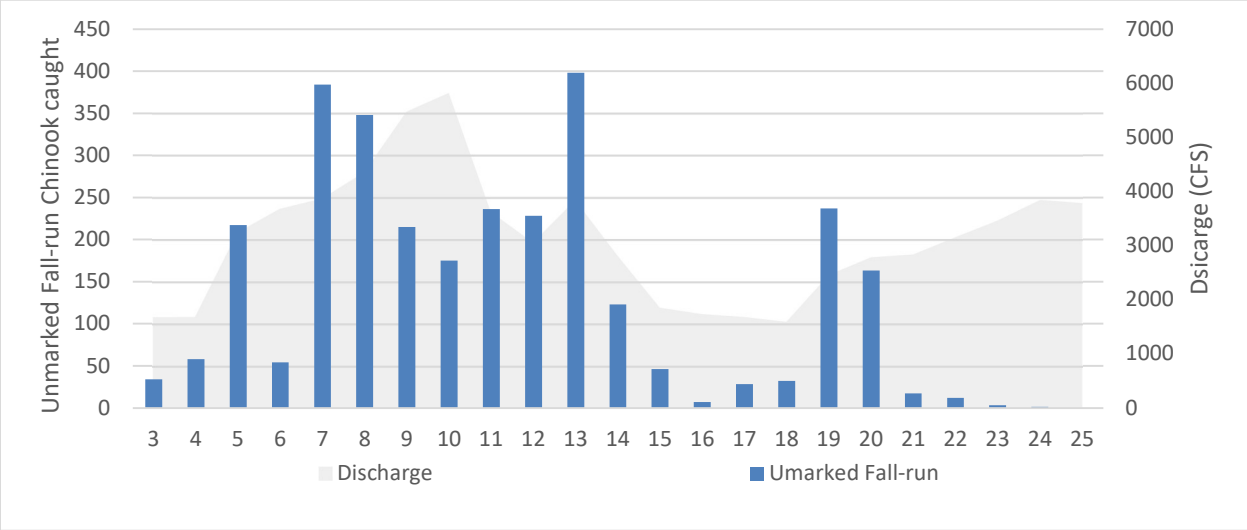

Figure 5: Weekly unmarked fall run Chinook Salmon trapped at the lower Feather River RST monitoring site compared with average weekly discharge recorded from the CDEC FSB gauge from January 19, 2022 to June 22, 2022.

Studies have shown that juvenile salmonid emigration is triggered by increases in flow (see Michel et al. 2013 and Giorgi et al. 1997); however, patterns in unmarked fall run catch at the lower Feather River RST site were visibly biased by the partially marked (50%) spring-run Chinook salmon release from FRFH that took place on March 30, 2022. Specifically, Figure 4 shows the highest daily catch of unmarked fall-run Chinook salmon occurred on March 31, 2022, the day following the release of spring-run Chinook salmon from the FRFH. The proposed plan to shift the RST's to half cone sampling prior to hatchery releases next season should reduce spikes in unmarked catch caused by unmarked hatchery origin fish. The LAD criteria categorized all but one of the 271 unmarked juvenile Chinook salmon captured on March 31, 2022 as fall-run. However, as noted, it is likely that many of the unmarked fall-run were misidentified unmarked hatchery origin spring-run from the previous day's release.

Research by Brandes et al. (2021) has shown extensive overlap in run-specific fork lengths of genetically identified juvenile Chinook salmon, indicating that the traditional LAD criteria (Greene, 1992) is a not an optimal method of run identification. Currently LAD criteria is the best available scientific methodology for determining juvenile Chinook salmon run/race in the Central Valley. The spring-run JPE effort includes a race identification program, with the goal to improve race identification accuracy, simplicity, and speed through development of probabilistic length-at-date (PLAD) models and application of new genetic technology (see Bedwell et al., n.d.) that will provide a more accurate method for assigning Chinook salmon run to juveniles. Genetic sampling was conducted in 2022 (and will continue during subsequent sampling seasons) at the lower Feather River RST monitoring site and several other RST sites within the Sacramento River watershed to gather information for development of the PLAD model.

Steelhead catch at the lower Feather River RST site consisted primarily of hatchery origin yearlings (n=496). Few unmarked individuals were captured (n= 17), and a majority were young of the year. Some of the variation in natural versus hatchery origin steelhead catch could be attributed to higher avoidance of the traps by naturally adapted juveniles as research on hatchery raised versus wild spawned steelhead behavior has shown lower threat avoidance in hatchery fish (Berejikian, 1995). The variation in catch could also be influenced by the difference in local abundance of natural origin fish as well as the behavior of the hatchery fish, who were released in large numbers (n=495,000) into unfamiliar waters with little acclimation to natural threats. The hatchery group was released 4 river miles upstream from the RST on February 4 through 23 and the RSTs captured 72% of the overall hatchery origin steelhead catch in the two weeks following the initial release date. The increased density of fish in the water column during that two-week period would result in a higher probability of capture when compared to natural origin steelhead. Natural origin emigrating steelhead may have passed the trapping location more gradually, so fewer individuals would be passing the trap at a single point, reducing the probability of capture.

Future seasons will illuminate more about the variation between this RST and other trapping locations and allow for a more precise analysis of the data we collect. This season's sampling efforts were valuable to provide salmonid emigration data to water managers and fisheries agencies in real-time to adaptively manage Delta water operations and contribute to the development of JPE models and PLAD development.

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