

**Interim Monitoring Plan
for the
Spring-Run Chinook Salmon
Juvenile Production Estimate
Science Program**

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Prepared by

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in collaboration with

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for

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INTRODUCTION

This document serves as the interim plan describing the initial monitoring that will be undertaken to inform the development of multiple alternative approaches for calculating a Spring-Run Chinook Salmon Juvenile Production Estimate (JPE). The plan is a tool to help coordinate sampling across programs and to identify potential data gaps. This plan is expected to change, especially as new information is developed and lessons are learned as a result of initial implementation.

On March 31, 2020, the California Department of Fish and Wildlife (CDFW) issued Incidental Take Permit No. 2081-2019-066-00 (2020 SWP ITP) to the California Department of Water Resources (DWR) for the long-term operation of the State Water Project (SWP) (Project) in the Sacramento-San Joaquin Delta (Delta). The 2020 SWP ITP provides take authorization for Project activities as described therein for the following species: longfin smelt (*Spirinchus thaleichthys*), Delta smelt (*Hypomesus transpacificus*), spring-run Chinook salmon (spring-run; *Oncorhynchus tshawytscha*), and winter-run Chinook salmon (winter-run; *Oncorhynchus tshawytscha*) (collectively known as “Covered Species”). The 2020 SWP ITP includes several Conditions of Approval intended to avoid, minimize, and/or mitigate the impacts of the Project on the Covered Species. Condition of Approval 7.5.2 — New and Ongoing Monitoring Required to Develop and Establish a Spring-Run Chinook salmon JPE (COA 7.5.2) — requires DWR to develop a juvenile production estimate (JPE) for spring-run Chinook salmon (Spring-Run JPE). Specifically, COA 7.5.2 of the 2020 SWP ITP requires DWR to convene a team to develop a plan to continue existing monitoring and conduct new monitoring and other studies to obtain the data necessary to inform the development of a Spring-Run JPE in the Sacramento River watershed. This document is the interim monitoring plan developed by this team.

Monitoring will be conducted in spring-run Chinook salmon natal tributaries and include adult passage, spawning, and escapement surveys, juvenile emigration monitoring using screw traps coupled with trap capture efficiency studies, juvenile survival studies using appropriate tagging methodologies, and genetic sampling of adult and juvenile Chinook salmon sampled during monitoring. Data collected from monitoring and any relevant historical data

will be used to develop inputs and refine models under consideration for a Spring-Run JPE.

While the primary purpose of this initial monitoring is to inform development of a Spring-Run JPE, the information collected will also provide valuable insight with respect to population trends of spring-run Chinook salmon in the Sacramento River watershed, and more specifically, the number of spring-run produced in each tributary, their life history strategies, and survival from their natal streams to the lower Sacramento and Feather rivers and then to the point of Delta entry. This information, along with other relevant data from the tributaries and Delta, will increase our understanding of the impacts the SWP has on spring-run populations in the Sacramento River watershed and inform CDFW and DWR when developing new minimization measures to reduce take of spring-run associated with SWP activities.

BACKGROUND

CDFW and DWR have worked collaboratively since the 2020 SWP ITP was issued in March 2020 to organize and lead the effort to develop a Spring-Run JPE. To kick off the effort, DWR and CDFW, with the help of the Delta Stewardship Council Delta Science Program (DSP), organized a public Scoping Workshop to solicit information on the current understanding of spring-run Chinook salmon science in the context of the development of a Spring-Run JPE for the Sacramento River watershed. The DSP developed the Scoping Workshop in collaboration with a multi-agency steering committee, which included the National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries, also known as the National Marine Fisheries Service, or NMFS), United States Bureau of Reclamation (Reclamation), United States Fish and Wildlife Service (USFWS), California State Water Contractors (State Water Contractors), and Metropolitan Water District of Southern California (MWD), in addition to DWR and CDFW. The Scoping Workshop was held in September 2020 and was attended by approximately 300 participants representing over 50 different organizations, including State, federal, local, and Tribal governments, public water agencies, universities, non-governmental organizations (NGOs), and consulting firms.

Following the Scoping Workshop, DWR established a JPE Core Team (as required by the 2020 SWP ITP COA 7.5.2), which includes representatives from DWR, CDFW, NOAA Fisheries, Reclamation, USFWS, State Water Contractors, and MWD. The purpose of the team is to advise on and help

coordinate all aspects of the implementation of the Spring-Run JPE effort, including species monitoring and special studies, funding, contract management, data management, modeling and model selection, reporting, and outreach. To develop an approach for implementation of the Spring-Run JPE effort and to fulfill the requirement of COA 7.5.2, the JPE Core Team developed the Spring-Run JPE Science Plan (Science Plan) (see California Department of Water Resources et al. 2020) in December 2020. The Science Plan outlines the science activities that will be implemented to meet the goal of developing a Spring-Run JPE ready for implementation no later than March 31, 2025. The Science Plan describes the elements necessary to move forward quickly and efficiently to develop potential approaches to the JPE (as identified during the Scoping Workshop and later refined by the JPE Core Team). These elements include:

- Additions to Existing Programs and/or New Monitoring Programs: Existing spring-run Chinook salmon life stage monitoring programs will be augmented (as necessary), and new life stage monitoring programs will be implemented in representative streams (selected by the JPE Core Team) to test the efficacy of the potential JPE approaches.
- Special Studies: In addition to life stage monitoring and the use of available historical data, targeted research will be necessary for the development and implementation of the JPE. Specifically, research will include the development of genetic approaches to successfully distinguish spring-run Chinook salmon from other runs of Chinook salmon in the Sacramento River drainage. Other targeted research includes studies to determine sampling efficacy, life history diversity, and reach-specific survival of juveniles.
- Historical Data: Available historical information on spring-run Chinook salmon will be utilized to develop initial quantitative JPE models and estimates while additional data are collected from existing and new monitoring programs and during species studies. Historical data will be utilized to inform subsequent steps in the JPE process as applicable.
- Long-Term Monitoring: The scope of a long-term monitoring program to support an annual Spring-Run JPE will be determined once the above elements of the research and monitoring phase are implemented and initial approaches to a JPE are developed.
- Structured Decision-Making: A Spring-Run JPE approach and long-term monitoring program will be selected at the end of the research and

development phase using a formal structured decision-making (SDM) process to ensure the process and outcomes are transparent and objective and based on shared, clearly articulated, fundamental objectives. The JPE Core Team will also use the SDM process to help guide other planning efforts and implementation decisions described in the Science Plan.

This Spring-Run JPE Monitoring Plan describes the monitoring and special studies elements outlined in the JPE Science Plan that will be implemented in representative streams to inform the development of JPE approaches. As described in the JPE Science Plan, the first priority for the JPE Core Team was the selection of representative streams to ensure life stage monitoring and targeted studies are identified, planned, and implemented in those streams as soon as possible to provide data to inform the different potential JPE approaches. The JPE Core Team met during late January and February 2021 to select representative streams using SDM principles. Specific criteria considered to select representative streams included:

- Current Abundance: The number of spring-run Chinook salmon produced by the tributaries and the relative contribution of juveniles from each tributary to the population of spring-run entering the Delta.
- Diversity of Representation: (1) Regional Diversity — geographic location of tributary (upper, middle, or lower Sacramento River Watershed); (2) NMFS Watershed Classification — Core 1, 2, or 3 population as described in the *Recovery Plan for the Evolutionary Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run and the Distinct Population Segment of California Central Valley Steelhead* (National Marine Fisheries Service 2014); and (3) Fill Data Gaps — the tributary provides unique information about spring-run, for example, varying life history diversity strategies (young-of-year [YOY] versus yearling).
- Feasibility/Difficulty: Factors contributing to monitoring delays or preclusion of monitoring in certain areas, including, but not limited to, land ownership and/or other access issues, environmental constraints, lack of appropriate research permits, low population numbers or otherwise sensitive populations, and presence of other sensitive species.
- Current Monitoring Effort: Presence of established ongoing spring-run monitoring and the level of effort required to increase monitoring as

necessary to include collection of data for all life stages necessary for the development of a JPE.

- External Learning Opportunity — Spring-Run: Opportunities for monitoring and research programs that will contribute to the development of the JPE while concurrently informing or enhancing non-JPE oriented spring-run management actions, research, and monitoring.
- Extent of Historical Data: Availability of historical datasets for the purpose of initial modeling of different JPE approaches.
- External Learning Opportunity — Other Species: Opportunities for monitoring and research programs that will contribute to the development of the JPE while concurrently informing or enhancing non-JPE oriented management actions, research, and monitoring focused on other sensitive species such as steelhead (*Oncorhynchus mykiss*) or winter-run Chinook salmon.

The JPE Core Team selected seven streams to represent the Sacramento River spring-run Chinook salmon population for the initial development of the JPE. These streams include **Clear Creek, Battle Creek, Mill Creek, Deer Creek, Butte Creek, Yuba River, and Feather River** (Figure 1). Spring-run will also be monitored in the mainstem Sacramento River by existing programs and by a new monitoring station in the lower Sacramento River downstream of the confluence with the Feather River to represent juvenile spring-run “**Delta Entry**.” Monitoring juvenile spring-run at the point of Delta Entry will serve both as calibration and confirmation of JPE model forecasts produced using tributary monitoring of earlier life stages. Due to low or no spring-run abundance in recent years and therefore minimal contribution to the overall population in the Sacramento River, Big Chico Creek, Antelope Creek, and Beegum Creek were considered, but not selected as representative streams. The upper Sacramento River mainstem (above Red Bluff Diversion Dam) was not selected as a representative stream due to the level of effort that would be required to implement meaningful and comprehensive life stage monitoring in such a large geographic area. The decision to not select certain tributaries or the upper Sacramento River as representative streams for the initial JPE development does not preclude them from being included in JPE development at a later stage in the process.

Following the selection of representative streams, the JPE Core Team created a Monitoring Coordination subteam as well as subteams for each representative stream and for Delta Entry. Subteams were also concurrently formed to guide and implement other elements of the JPE Science Plan: Race Identification, Data Management, Quantitative Modeling, and SDM. Subteam members include a subset of the JPE Core Team augmented by additional subject matter experts from representatives of the same entities that comprise the JPE Core Team. The Monitoring Coordination subteam is responsible for coordinating the monitoring programs and special studies across representative streams and Delta Entry that will be implemented to inform initial JPE approaches, except for research related to run identification, which will be handled by the Race ID subteam. The representative stream and Delta Entry subteams are responsible for identifying gaps in current monitoring and recommending additional monitoring and special studies to collect the data necessary for testing and evaluating JPE approaches. The Race Identification subteam is tasked with developing a more robust juvenile spring-run Chinook salmon run identification methodology using a Bayesian probabilistic length-at-date (PLAD) approach based on genetic identification. The Data Management subteam is tasked with the establishment and coordination of a database to serve as a central repository and data portal for historical and newly generated data on spring-run. The Quantitative Modeling subteam is tasked with using the Spring-Run JPE database to build and parameterize initial quantitative JPE models, updating those models with new information, and using the models to identify and quantify sources of uncertainty. The SDM subteam, which consists of all members of the JPE Core Team, is responsible for the ultimate task of working through the formal SDM process to select the most appropriate JPE approach and long-term monitoring program to inform an ongoing annual JPE.

Each representative stream subteam met individually in March 2021 and took an inventory of all current spring-run Chinook salmon life stage monitoring. The subteams reviewed current monitoring for their respective streams and determined which of these monitoring programs could be implemented as is and which needed augmenting or new monitoring to provide the data necessary to inform initial JPE approaches. Monitoring that will be implemented for each stream during the initial JPE development phase (currently underway and continuing through March 2024) is described in this document under the monitoring section for each representative

stream. This document also includes proposed studies to measure juvenile survival from tributary rotary screw trap (RST) stations to the confluence with the mainstem Sacramento River, and from the confluence to the point of Delta Entry. The representative stream subteams' review of current monitoring highlighted a considerable need for genetic identification of both spring-run adults and juveniles across all tributaries. This plan notes genetic sampling at monitoring stations, however specific research related to run identification is described in detail in a separate plan produced by the Race ID subteam.

REPRESENTATIVE STREAM MONITORING

Clear Creek

Background

Clear Creek is the first major tributary to the Sacramento River downstream of Shasta Dam. Clear Creek originates in the mountains east of Trinity Reservoir and flows approximately 35 miles to where it converges with the Sacramento River near Redding, California (River Mile [RM] 289).

Historically, Clear Creek provided 25 miles of habitat for Chinook salmon (National Marine Fisheries Service 2014). Whiskeytown Dam (RM 18.3) is a complete barrier to fish passage and the limit of anadromy in the Clear Creek watershed (Bottaro and Chamberlain 2019).

Numerous habitat and flow restoration actions undertaken since 1995 through joint agency partnerships, such as the Central Valley Project Improvement Act (CVPIA) and the CALFED Bay-Delta Program, have helped to reestablish spring-run Chinook salmon (and steelhead) in the Clear Creek watershed. These actions have included increased minimum flows, water temperature control through flow management, large-scale stream and floodplain restoration, and gravel augmentation (Bottaro and Chamberlain 2019). Also included in CVPIA efforts was the removal of McCormick-Saeltzer Dam in 2000, which provided spring-run access to 12 additional miles of prime spawning habitat (National Marine Fisheries Service 2014).

Additionally, the NMFS 2009 Biological Opinion for the Continued Operation of the Central Valley Project and State Water Project (National Marine Fisheries Service 2009) required specific flow and restoration actions benefitting spring-run in Clear Creek, including spring attraction flows to encourage upstream migration of adults, enhancement of spawning habitat

through channel maintenance flows and gravel augmentation, thermal stress reduction through improved temperature management of flow releases from Whiskeytown Dam, and adaptive management of instream flows to maintain suitable habitat.

Clear Creek is classified as a NMFS Core 1 population for spring-run Chinook salmon recovery, meaning the watershed has the known ability or potential to support a viable population and meets the criteria for low extinction risk for spring-run. Core 1 populations form the foundation of the NMFS recovery strategy and are the first focus of recovery efforts. Clear Creek is the only Core 1 population to represent the northwestern California diversity group, which is composed of streams that enter the Sacramento River from the northwest (National Marine Fisheries Service 2014). Although Clear Creek did not historically support a large spring-run population, the population has increased since the early 1990s due to continuing habitat and flow restoration efforts in the watershed. Average spawner escapement from 2015 to 2019 ranged from 25 (2017) to 62 (2019) and increased to 172 in 2020 (Azat 2021). The Clear Creek spring-run population is considered persistent; however, it is classified as a dependent population as it relies on inputs of migrants from spring-run populations in other tributaries such as Deer, Mill, and Butte creeks (National Marine Fisheries Service 2014).

Spring-Run Chinook Salmon Timing

Adult spring-run Chinook salmon enter Clear Creek in April, hold during the summer, and spawning begins in late August or early September. Since 2003, a separation weir has been installed in Clear Creek from late August until early November to keep spring-run upstream and separated from fall-run Chinook salmon (fall-run; *Oncorhynchus tshawytscha*) downstream. The annual placement of the segregation weir at either Reading Bar (RM 8.2) or Shooting Gallery (RM 7.5) is based on the holding distribution of adult spring-run during that particular year. Juvenile spring-run emigrate from Clear Creek to the Sacramento River from mid-November through June (Schraml et al. 2020).

Life Stage Monitoring

USFWS currently implements the following life stage monitoring programs on Clear Creek from Whiskeytown Dam to the Sacramento River to develop population indices for both adult and juvenile spring-run:

- Adult passage monitoring using video systems and Adaptive Resolution Imaging Sonar (ARIS).
- Adult holding monitoring using snorkel surveys.
- Adult spawner surveys consisting of redd counts and carcass biosampling.
- RST monitoring to develop juvenile YOY passage estimates.

These current monitoring programs will be sufficient to provide data on adult and juvenile spring-run in Battle Creek to inform initial JPE approaches. These monitoring programs are described in more detail below and in the following pages.

A map depicting the locations of existing and proposed monitoring programs in Clear Creek is provided in Figure 2.

Adult passage monitoring: Since 2012, a video weir monitoring station has been operated year-round on Clear Creek (RM 0.2) at the confluence with the Sacramento River to develop quantitative estimates of adult salmonids entering Clear Creek from the Sacramento River. Monitoring equipment consists of a floating resistance board weir with over-head and under-water video camera systems, and an ARIS sonar imaging unit for use during turbid water conditions. Data are collected continuously on all fish passing upstream and downstream and stored on external hard drives for post processing. Data recorded on salmonids include counts, adipose fin presence/absence, sex, grilse status (Fork Length [FL] < 61 centimeters), spawning condition, and exact time of passage. Chinook salmon are assigned a run based on their physical condition and the date of passage. Data obtained from this monitoring program are used to estimate adult upstream passage for each adult return year. Passage estimates for spring-run are developed using video data from March 1 through August 15 (Bottaro and Chamberlain 2019).

Adult holding surveys: Since 1999, snorkel surveys have been conducted throughout the entire length of Clear Creek (from Whiskeytown Dam to the

confluence with the Sacramento River) in April, May, June, and July to count holding adult spring-run and provide an indication of the population size and holding distribution in the early part of the season. These snorkel surveys are also used to measure the success of pulse flows from Whiskeytown Dam in attracting more salmon into the creek and encouraging their movement upstream. The snorkel surveys conducted in August are used to generate the Clear Creek spring-run annual population index or August Index (AI), which dictates when the segregation weir is installed. This monitoring program has been conducted since 1999 (Bottaro and Chamberlain 2019).

Adult spawner/redd surveys: Since 1999, snorkel surveys have been conducted throughout the entire length of Clear Creek (from Whiskeytown Dam to the confluence with the Sacramento River) from September through November to document adult spawning through observation of redds and carcasses. During surveys, all redds are mapped with GPS, classified by age, marked, and given an identification number to differentiate between old and new redds. Physical data on redds are also collected, including substrate size and source type, redd dimensions, and flow immediately upstream of the redd. Time of spawning is estimated using the date and age data for each redd. Estimated spawning timing and temperature data are then used to estimate emergence timing for each redd (Bottaro and Chamberlain 2019).

When carcasses are encountered during surveys, biological data are recorded and samples are collected. Biological data recorded include fork length, sex, egg retention, adipose fin presence/absence, carcass condition, presence of tags, and spawning status. Samples taken include scales, fin or flesh for future genetic analyses, and heads from adipose-clipped fish, from which coded wire tags (CWTs) and otoliths are later extracted for analyses. This monitoring program has been conducted since 1999 (Bottaro and Chamberlain 2019).

Juvenile production monitoring: RSTs are used as the primary method to evaluate trends in juvenile salmon abundance in Clear Creek. Single 5-foot diameter RSTs are operated annually in Clear Creek at RM 8.4 (upper RST) and at RM 1.77 (lower RST). The lower RST has been in operation since 1998 and is used to estimate passage of juvenile spring-run, fall-run, and late fall-run (late-fall) Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead. The lower RST was found to greatly underestimate spring-run passage as it is difficult to differentiate between spring-run and fall-run at

this location, so the upper RST began operation in 2003 and is used specifically to index passage of spring-run (Schraml et al. 2020). Yearling spring-run juveniles are not detected in RST catches, so RST monitoring provides data for passage estimates for YOY spring-run only. However, some yearling spring-run have been observed during adult holding snorkel surveys in the summer (Charles Chamberlain, personal communication, March 2021).

The three primary objectives of the RST Program include (1) calculating annual juvenile passage indices for Chinook salmon and steelhead for inter-year comparisons and analyses of the effectiveness of stream restoration activities; (2) obtaining juvenile salmonid life history information, including size, emergence timing, emigration timing, and potential factors limiting survival at various life stages; and (3) collecting otolith and tissue samples for juvenile salmonids or analyses and development of baseline genetic markers for Clear Creek salmonid populations (Schraml et al. 2020).

The start of the trapping season is determined by estimating emergence timing using redd construction timing and water temperature data. Generally trapping occurs from November through June. Standardized RST sampling techniques are used at both monitoring locations. Traps are checked daily, and data are collected on fish caught (e.g., taxa, dead or alive, count, and length measurements), RST operations (dates/times, water depth, cone rotations, and amount/type of debris), and environmental conditions (basic weather conditions, water temperature, current velocity, and turbidity). When less than 250 Chinook salmon are collected in the RST, all are counted, measured to fork length, assigned a life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt), and assigned a run designation using length-at-date (LAD) tables from Greene (1992). Subsampling is conducted when more than 250 Chinook salmon are collected in the RST. Tissue samples are taken from LAD winter-run and late fall-run Chinook salmon as well as any Chinook salmon with a fork length over 100 millimeters at both RST locations for the purpose of run identification (Schraml et al. 2020). Additionally, samples (tissue or opercule) will now be taken consistently from select LAD spring-run to confirm run using genetic analyses as part of the new Spring-Run JPE effort (see Race ID Plan).

Mark-recapture trials are conducted for both RST locations to determine the efficiency of the RSTs in catching juvenile salmonids moving downstream in

a given time period. Fish are either marked with Bismark Brown Y (BBY) stain or marked with both BBY and a caudal fin clip. Marked fish are released 0.4 or 0.2 river miles upstream of the lower and upper RSTs, respectively. The number of fish released and recaptured from mark-recapture trials are used to calculate weekly trap efficiencies. All species and life stage passage estimates at the lower RST are calculated using mark-recapture trials from fall-run Chinook salmon due to the low catch rates of other salmonids at that location. Spring-run mark-recapture trials are used to estimate capture efficiency at the upper RST. Juvenile passage indices at each trap location are calculated by dividing the weekly catch totals by either the weekly trial or season average trap efficiency. Juvenile spring-run passage indices are adjusted for redds (if present) identified above the weir (RM 7.5), but below the upper Clear Creek RST. In addition to passage estimates, juveniles-per-redd estimates are also calculated using the number of observed redds and the annual juvenile production index (JPI) (Schraml et al. 2020).

Battle Creek

Background

Battle Creek is a major tributary to the upper Sacramento River located in Shasta and Tehama counties, California. The Battle Creek watershed drains approximately 369 square miles and has the highest base flow of any tributary to the Sacramento River between the Feather River and Keswick Dam (Ward and Kier 1999). Battle Creek is comprised of two primary forks: the North Fork (30.2 river miles long) and the South Fork (30.5 river miles long; Schraml and Earley 2020). The forks drain into the mainstem of Battle Creek, which flows approximately 16.2 miles west before reaching the Sacramento River (RM 272) east of Cottonwood, California. Historically there were 52.44 river miles of habitat available for anadromous fish; however, anadromy is currently limited by the Eagle Canyon Dam on the North Fork (5.23 river miles north of the fork) and the Coleman Diversion Dam on the South Fork (2.54 river miles north of the fork; Schraml and Earley 2020).

Battle Creek outflow is regulated by Pacific Gas and Electric Company's (PG&E's) Battle Creek Hydroelectric Project, which was constructed in the early 1900s and consists of several diversion dams and reservoirs on the North Fork and South Fork that support five high-head, low-volume powerplants. The Coleman National Fish Hatchery (CNFH) is located downstream of the hydroelectric project on the mainstem 6 river miles

upstream of the confluence with the Sacramento River. The hatchery was constructed in the 1940s by Reclamation to mitigate for the loss of salmon spawning habitat caused by the construction of the Shasta Dam on the upper Sacramento River. CNFH supports the production of fall-run, late fall-run, and Jumpstart winter-run Chinook salmon as well as steelhead. In 2008, construction of an improved barrier weir and fish ladder was completed at the CNFH. The new ladder design consists of the barrier weir (blocking upstream fish passage), the middle fish ladder (where video monitoring occurs), an auxiliary ladder (which controls flow in the middle ladder), a hatchery ladder (which leads to holding ponds and the spawning building), and a river ladder leading to Battle Creek upstream of the weir (Stanley et al. 2020).

As a part of efforts to increase Central Valley salmonid populations in Battle Creek, the CVPIA Anadromous Fisheries Restoration Program outlined actions to increase flows past PG&E's power diversions and to provide adequate holding, spawning, and rearing habitat for anadromous salmonids (United States Fish and Wildlife Service 2001). In 1999, PG&E, CDFW, USFWS, Reclamation, and NMFS signed an agreement for the Battle Creek Salmon and Steelhead Restoration Project to improve fish passage and habitat conditions within Battle Creek (National Marine Fisheries Service et al. 1999). The goal of the project is to restore approximately 42 miles of habitat in Battle Creek and an additional 6 miles of habitat in tributaries to Battle Creek. Specifically, the project includes removal of five diversion dams, placement of new screens and ladders on three remaining dams, and increased streamflow in the North and South Forks. Following the removal of Wildcat Dam (RM 0.9) in 2010 and increased streamflows, fish passage improved on the North Fork as demonstrated by the increased number of redds found above the former dam site the following year (Bottaro and Brown 2012). Additional restoration construction activities have been completed on the North and South Forks to improve fish passage, including fish ladders and screens, but are not operational due to the need for additional work and testing. The Battle Creek spring-run population is considered persistent; however, the completion of restoration efforts could increase habitat availability for spawning adults, thus increasing the population.

Battle Creek is classified as a Core 1 watershed for spring-run Chinook salmon recovery, meaning the watershed has the known ability or potential

to support a viable population and meets the criteria for low extinction risk for spring-run. Battle Creek is the only Core 1 population to represent the basalt and porous lava diversity group, composed of streams from the northernmost part of the Sacramento River watershed. Battle Creek is specifically classified as a Core 1 watershed because the watershed can withstand warming air temperatures due to coldwater spring inputs. Although the population is relatively small, the spring-run population in Battle Creek is persisting in accessible reaches of the mainstem, and the North and South Forks as adults continue to repopulate the watershed (NMFS 2014). Average spawner escapement from 2015 to 2019 ranged from 30 (2017) to 181 (2015) and remained low at 47 in 2020 (Azat 2021). As of recently, Battle Creek is considered by NMFS to be an independent population, supporting one of four remaining self-sustaining Central Valley spring-run populations (Cordoleani 2020).

Spring-Run Chinook Salmon Timing

Adult spring-run Chinook salmon enter Battle Creek starting in February, hold during the summer, and spawn from September through November. A barrier weir and hatchery ladder at CNFH is installed and operated annually from August through early March to collect broodstock for hatchery propagation of fall-run, late fall-run, and Jumpstart winter-run Chinook salmon as well as steelhead. Beginning in 2019, USFWS started keeping the barrier in place through mid-July to help collect adult Jumpstart winter-run Chinook salmon. While the barrier is in place, USFWS handles and transports spring-run upstream of the hatchery. Once the barrier weir is removed, fish can move volitionally through the middle fish ladder (river ladder) at the hatchery into upper Battle Creek. The spring-run juvenile emigration season usually begins in mid-November and extends through June.

Life Stage Monitoring

USFWS currently implements the following life stage monitoring programs on Battle Creek from the limit of anadromy on the North and South Forks downstream to the CNFH, to develop population indices for both adult and juvenile spring-run:

- Adult passage monitoring using adult trapping at the CNFH weir and video systems.
- Adult holding monitoring using snorkel surveys.

- Adult spawner surveys consisting of redd counts and carcass biosampling.
- RST monitoring to develop juvenile YOY passage estimates.

These current monitoring programs will be sufficient to provide data on adult and juvenile spring-run in Battle Creek to inform initial JPE approaches. These monitoring programs are described in more detail below and in the following pages.

A map depicting the locations of existing and proposed monitoring programs in Battle Creek is provided in Figure 3.

Adult passage monitoring: Since the mid-2000s, annual adult salmonid passage monitoring on Battle Creek is performed by sampling fish at the CNFH barrier weir (RM 6) and video surveillance. Beginning in March, all fish moving upstream in Battle Creek pass through the hatchery fish ladder and enter ponds outside of the CNFH spawning facilities where they are identified by species and enumerated, and data is collected. All spring-run are released upstream into Battle Creek. Salmonids are measured to fork length, identified to sex when possible, inspected for scars, tissue damage, the presence of an adipose fin, external tags, and tissue samples are also taken from all unclipped salmonids for future genetic analyses. Historically, sampling occurred until March 31, however, beginning 2019, USFWS started keeping the ladder in place through mid-July to help collect adult Jumpstart winter-run Chinook salmon. After mid-July, the hatchery ladder is closed, the river ladder is opened, and all fish species passing through the fish ladder are monitored and enumerated using a video system installed in the middle fish ladder. The video system consists of a digital color video camera and digital video recorder with both continuous and motion detection recording. Data are transferred daily to an external hard drive for later analyses. Salmonid passage is monitored using the video system until August, at which time the main ladder entrance and the river ladder are closed in anticipation of fall-run upstream migration. All Chinook salmon that pass through the video system are assigned run classifications based on timing and phenotypic characteristics. Data obtained from this monitoring program are used to estimate adult upstream passage for each adult return year (Stanley et al. 2020).

Adult holding surveys: Historically, this monitoring program consisted of snorkel surveys from May through late September in portions of the North and South Forks (downstream of barriers to anadromy) and mainstem Battle Creek down to the CNFH barrier weir to document adult Chinook salmon holding prior to spawning (Newton et al. 2008). Surveys were discontinued in 2009 due to lack of funding, but USFWS expects to restore the surveys as part of the Battle Creek winter-run Chinook salmon reintroduction program in 2021. Adult holding surveys via snorkel surveys are anticipated for July and August 2021.

Adult spawner/redd surveys: Since the 1990s, snorkel surveys have been conducted annually in Battle Creek from August through November to obtain a count of all spring-run redds and document their spatial distribution. Surveys are conducted in portions of the North and South Forks (downstream of barriers to anadromy) and the mainstem down to the CNFH barrier weir. During surveys, all redds are mapped with GPS, classified by age, marked, and given an identification number to differentiate between old and new redds. Physical data on redds are also collected, including substrate size and source type, redd dimensions, and flow immediately upstream of the redd. Time of spawning is estimated using the date and age data for each redd. Estimated spawning timing is then used to estimate emergence timing for each redd (Stanley et al. 2020).

When carcasses are encountered during surveys, biological data are recorded and samples are collected. Biological data recorded include fork length, sex, egg retention, adipose fin presence/absence, carcass condition, presence of tags, and spawning status. Samples taken include scales, tissue for future genetic analyses, and heads from adipose-clipped fish, from which CWTs and otoliths are later extracted for analyses (Stanley et al. 2020).

Juvenile production monitoring: RSTs have been used to monitor downstream passage of juvenile salmonids on Battle Creek since 1998. Historically, this monitoring program consisted of two RST stations located on the mainstem of Battle Creek. The lower RST (RM 2.8) was used to target fall-run Chinook salmon passage and is no longer in operation as of 2006. The upper RST (RM 6.2), located upstream of the CNFH barrier weir, is currently used to estimate passage of spring-run Chinook salmon and steelhead. The upper RST station utilizes one 5-foot diameter cone.

The RST monitoring program has three primary objectives: (1) determining an annual juvenile passage index for Chinook salmon and steelhead for inter-year comparisons; (2) obtaining juvenile salmonid life history information, including size, condition, emergence timing, emigration timing, and potential factors limiting survival at various life stages; and (3) collecting tissue samples for genetic analyses (Schraml and Earley 2020).

The seasonal timing of operation of the upper Battle Creek RST is based on juvenile spring-run emigration, which is typically from mid-November through the end of June. The start of RST monitoring is determined by estimating emergence timing using redd timing and water temperature data. The trap is operated continuously and checked daily unless conditions (e.g., high flows, high debris loads, and reduced staffing) limit trap operations or require multiple trap checks to avoid mortality of captured fish or damage to equipment. During trap checks, data are collected on fish caught (e.g., taxa, dead or alive, count, and length measurements), RST operations (dates/times, creek and cone fishing depth, cone rotations, and amount/type of debris), and environmental conditions (basic weather conditions, water temperature, creek velocity, and turbidity). All Chinook salmon are counted, measured to fork length, assigned a life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt), and assigned a run designation using LAD tables from Greene (1992). All juvenile Chinook salmon identified as fall-run based on LAD are considered to be spring-run because the CNFH barrier weir closure in August prevents upstream passage of adult fall-run. Tissue samples are taken from LAD winter-run and late fall-run Chinook salmon as well as any Chinook salmon with a fork length over 100 mm for the purpose of run identification (Schraml and Earley 2020). Additionally, samples (tissue or opercule) will now be taken consistently from select LAD spring-run to confirm run using genetic analyses as part of the new Spring-Run JPE effort (see Race ID Plan).

Mark-recapture trials are conducted to determine the efficiency of the RST in catching all juvenile salmonids moving downstream in a given time period. Catch rates for steelhead, spring-run, and late fall-run are too low to conduct separate mark-recapture trials, thus all species and life stage passage estimates are calculated using hatchery-origin fall-run Chinook salmon fry obtained from CNFH. Fish are marked with BBY stain. Marked fish are released 1 mile upstream of the upper RST location. The number of fish released and recaptured from mark-recapture trials are pooled to estimate

values for weekly trial totals and calculate weekly trap efficiencies. Weekly juvenile passage indices for Chinook salmon and steelhead are calculated by dividing the weekly catch totals by either the weekly trap efficiency or season average trap efficiency. RST monitoring does not detect many yearling spring-run; the most abundant life stage caught in the RST are typically fry (Schraml and Earley 2020). Thus, passage estimates are only used for generating a spring-run juvenile production estimate for YOY juveniles. In addition to passage estimates, juveniles-per-redd estimates are also calculated using the number of observed redds and the annual JPI (Schraml and Earley 2020).

Mill Creek

Background

Mill Creek is an east side tributary to the Sacramento River located in Tehama County, California. Mill Creek originates near Lassen Volcanic National Park at an elevation of approximately 8,200 feet and flows approximately 60 miles to where it meets the Sacramento River (RM 230) at an elevation of approximately 200 feet near the town of Los Molinos (National Marine Fisheries Service 2014). Mill Creek has two water diversion facilities on its lower reaches, Upper Dam (RM 5.4) and Ward Dam (RM 2.8), both owned by Los Molinos Mutual Water Company. Historically a third diversion facility, Clough Dam, was located on lower Mill Creek (RM 5.8), but it washed out during a flood in 1997 (Johnson and Merrick 2012). Both Upper Dam and Ward Dam have fish ladders, but fish passage is impaired due to design deficiencies. The ladder at Upper Dam does not meet CDFW and NMFS criteria for the full range of fish passage flows for upstream passage of adult salmonids. Additionally, fish screening and return of juveniles to Mill Creek is deficient in facilitating downstream passage of juvenile salmonids due to the long distance between the diversion and fish screens (National Wildlife Health Center 2015). Plans to correct diversion facility deficiencies and improve fish passage with a new, enlarged fish ladder at Upper Dam were completed; however, the project has not been implemented due to concern from CDFW and NMFS that constructing a new ladder would result in prohibitive levels of increased maintenance. In 2015, a new fish ladder, diversion intake, and fish screen bay were constructed at Ward Dam to correct fish passage deficiencies. However, since its construction, deposition of cobbles in the cells of the fish ladder and a large cobble bar has unexpectedly and repeatedly formed upstream of the fish

ladder during large storm events, reducing pool depths and increasing velocities in the fish ladder, obstructing flow into the fish ladder, and negatively impacting diversion capacity. Discussions and plans are currently in progress to address the substrate accumulation issue, but a project has not been finalized or implemented (Wardman 2017).

NMFS (2014) classified Mill Creek a NMFS Core 1 population for spring-run Chinook salmon recovery, meaning the watershed has the known ability or potential to support a viable population and meets the criteria for low extinction risk for spring-run. Mill Creek is part of the northern Sierra Nevada diversity group, composed of streams that are tributary to the Sacramento River from the east from Antelope Creek to the Mokelumne River. Mill Creek is recognized as an independent population (National Marine Fisheries Service 2014), supporting one of four remaining self-sustaining Central Valley spring-run populations. Despite impaired streamflows and fish passage conditions in the lower reaches of Mill Creek below water diversions, there are no major dams along the creek that prohibit passage, thus allowing salmonids access to high-quality headwater habitat in the upper portion of Mill Creek (Armentrout et al. 1998; National Marine Fisheries Service 2014). Spawning and holding habitat located at high elevations in Mill Creek is of high quality and considered some of the best remaining salmonid habitat in the Central Valley. This high elevation habitat also helps to isolate fall-run from spring-run to prevent geographic cooccurrence and maintain genetic and phenotypic diversity of the population. Mill Creek is considered a conservation stronghold for Central Valley spring-run populations (National Marine Fisheries Service 2014). The spring-run population on Mill Creek is small and variable and has declined in recent years with an average spawner escapement of 160 from 2015 to 2019, decreasing to 80 fish in 2020. Mill Creek is now at a high level of extinction risk based on population viability criteria identified by NMFS (National Marine Fisheries Service 2014). Implementation of fish passage improvements, such as those planned at Upper Dam and Ward Dam, will provide increased availability of spawning habitat in Mill Creek and may help to increase adult abundance.

Spring-Run Chinook Salmon Timing

Adult spring-run migrate into Mill Creek between late February and mid-July, with peak migration occurring in April and May. Spring-run hold during the summer and then spawn late August through October. Adult spring-run

spawn over a range of elevations within Mill Creek, which has a significant effect on egg incubation and timing of fry emergence in the watershed. Thus, depending on the elevation at which the female spawned, spring-run fry emerge over a six-month period, from November through May (Johnson and Merrick 2012). Otolith analyses conducted by Cordoleani et al. (2018), highlighted multiple juvenile rearing strategies contributing to adult Mill Creek spring-run populations, with the contribution of different strategies being different among years. Data from the historical Mill Creek RST program showed spring-run juveniles from a single brood year could be captured in the RST over a 17-month period as fry or yearlings. Yearling migration occurs from October through June, with peak emigration from October through December. YOY spring-run emigration occurs from November through June, with peak emigration in February and March. Due to the extended emergence timing and extended emigration period of spring-run juveniles in Mill Creek, LAD tables (Greene 1992) often incorrectly assign yearling spring-run as late fall-run and winter-run, and YOY spring-run as fall-run and late fall-run (Johnson and Merrick 2012).

Life Stage Monitoring

Varying methodologies combined with incomplete sampling efforts to count spring-run populations in Mill Creek over the years have made data comparisons between years challenging. For example, adult surveys conducted prior to the 1980s used incomplete spawning ground surveys, carcass surveys with unknown expansion factors, and partial ladder and fish counts. Since the early 1990s, adult abundance surveys have been conducted using redd counts, which has enabled comparison of data among more recent years (Killam 2020). Adult counts via snorkel surveys are not conducted on Mill Creek due to the natural turbidity of the creek. Juvenile spring-run emigration monitoring on Mill Creek was historically conducted on Mill Creek from 1996 through 2010 using a RST station located immediately downstream of Upper Dam, but survey methods did not allow for calculation of absolute abundance estimates due to lack of trap efficiency tests. Emigration monitoring is currently conducted for juvenile steelhead on Mill Creek (RM 5), and although juvenile spring-run are incidentally collected, the seasonal operation and location of the RST does not produce adequate data to calculate juvenile spring-run passage estimates.

CDFW currently implements the following life stage monitoring programs on Mill Creek to develop population indices for adult spring-run:

- Adult passage monitoring using video monitoring at Ward Dam.
- Adult redd counts.

To fill data gaps for developing population indices for juvenile salmon, the Mill Creek subteam recommends implementation of the following monitoring program during the initial JPE development phase:

- RST monitoring to develop egg-to-fry survival and juvenile YOY passage estimates.

These monitoring programs will provide important data on adult and juvenile spring-run in Mill Creek to inform initial JPE approaches. These monitoring programs are described in more detail below and in the following pages.

A map depicting the locations of existing and proposed monitoring programs in Mill Creek is provided in Figure 4.

Adult passage monitoring: Since 2012, passage of adult spring-run (and fall-run) into Mill Creek from the Sacramento River has been monitored year-round using a video station located at the fish ladder exit on Ward Dam. The video stations consist of overhead and underwater cameras and a Dual-Frequency Identification Sonar (DIDSON) imaging unit (Killam 2020). Data are collected continuously on all fish passing upstream and downstream and stored on external hard drives for post processing. Data recorded on salmonids include counts, adipose fin presence/absence, sex, grilse status (FL < 61 centimeter), spawning condition, exact time of passage, and run identification. Data obtained from this monitoring program are used to estimate adult upstream passage for each adult return year. Passage estimates for adult spring-run are developed using video data from late-February to mid-July.

Adult spawner/redd surveys: Redd surveys have been conducted on Mill Creek annually since the mid-1990s to count redds, document spawning locations, and collect biological information and samples from carcasses. Walking surveys are conducted in Mill Creek beginning in late September and concluding in the month of October when all survey sections have been completed. A total of 30.1 miles of spring-run spawning habitat is walked,

beginning at the Highway 36 Bridge crossing (RM 51.4) near Mineral, California, and ending 9.4 miles downstream of Black Rock (RM 16). Data from the survey are used to develop an adult population estimate and calculate egg-to-fry survival estimates. Pre-spawn mortalities are recorded when encountered; however, an estimate of pre-spawn mortalities is not calculated.

During surveys, redds are mapped with GPS and classified by age, marked, and given an identification number to differentiate between old and new redds. Time of spawning is estimated using the date and age data for each redd. Estimated spawning timing and temperature data are then used to estimate emergence timing for each redd. When carcasses are encountered during surveys, biological data are recorded and samples are collected. Biological data recorded include fork length, sex, egg retention, adipose fin presence/absence, carcass condition, presence of tags, and spawning status. Samples taken include otoliths, scales, fin or flesh for future genetic analyses, and heads from adipose-clipped fish, from which CWTs will be extracted for analyses.

Juvenile production monitoring: Juvenile spring-run production monitoring is not currently conducted on Mill Creek. Historically, CDFW conducted rotary screw trapping on Mill Creek (1996–2010). This monitoring program provided life history information for juvenile spring-run and steelhead, including overall trends in abundance and the emigration timing. Trap efficiency trials were not conducted under this monitoring program; therefore, historical spring-run egg-to-fry survival estimates and juvenile production indices are not available for Mill Creek (Johnson and Merrick 2012).

Juvenile spring-run emigration monitoring on Mill Creek is proposed for implementation during the initial JPE development phase to allow for the calculation of egg-to-fry survival estimates and juvenile production indices. Although yearling spring-run are well documented and currently observed in Mill Creek, historic RST efforts on Mill Creek show that sampling yearlings using RSTs is challenging due to the tendency of these larger juveniles to avoid the trap and their emigration primarily occurring during freshets. However, the JPE research and development phase will include operation of the RST from October through June to capture both yearling and YOY emigration to estimate abundance for both life history strategies. If RST

sampling on Mill Creek during the JPE research and development phase does not produce adequate data to estimate yearling production, the JPE Core Team will explore additional survey methodologies for developing yearling abundance estimates. Obtaining a yearling production estimate on Mill Creek will be important to ensure inclusion of multiple spring-run life history strategies when investigating initial JPE approaches.

A single 5-foot diameter RST will be operated on Mill Creek, immediately upstream of Ward Dam (RM 2.9), to monitor juvenile spring-run emigration. The monitoring program will be operated continuously from October through June with trap checks occurring daily. However, traps will not be fished during high flow events, low water conditions in which velocities are insufficient to turn the cone or cause water temperatures to elevate to unsafe levels for fish handling, and periods when staff are not available to conduct trap checks, to minimize risk of injury to staff, prevent damage to equipment, and minimize stress and mortality to fish. Data collected during trap checks will include trap operational information, environmental conditions, and fish data. Trap operational information will include length of time the trap is sampled, trap condition, and cone revolutions. Environmental conditions will include air temperature, water temperature, turbidity, weather conditions, and stream velocity. All fish captured will be counted and identified to species. A subsample of Chinook salmon and steelhead will be weighed and measured to the nearest fork length and assigned a life-stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt) (Johnson and Merrick 2012). All Chinook salmon will be assigned a run designation using LAD tables from Greene (1992). However, due to the discrepancies in using LAD tables to assign run classification to juveniles Chinook salmon in Mill Creek (as described above), tissue or opercula samples will be taken from a subsample of fish to confirm their run using genetic analyses (see Race ID Plan).

Trap capture efficiency trials will be conducted over a wide range of hydrological conditions to evaluate fish passage and estimate juvenile abundance. Marking methodologies for trap efficiency studies will include Visible Elastomer (VIE) tags and BBY stain. Marked fish are released approximately 1 mile upstream of the sampling site and the number of fish recaptured will be used to estimate capture efficiency. Efficiency studies will be conducted using trap captured natural origin fall-run, spring-run, and late fall-run Chinook salmon. In recent years adult returns of all runs of Chinook

salmon in Mill Creek have declined, resulting in reduced juvenile production. To obtain sufficient sample sizes for mark recapture trials it may be necessary to use fall-run and late fall-run from CNFH. The number of fish released and recaptured from mark-recapture trials will be used to calculate weekly trap efficiencies. Juvenile passage indices at each trap location will be calculated by dividing the weekly catch totals by either the weekly trial or season average trap efficiency.

Deer Creek

Background

Deer Creek is an east side tributary to the Sacramento River located in Tehama County, California. Deer Creek originates at Butt Mountain at an elevation around 7,320 feet and flows approximately 60 miles to where it meets the Sacramento River (RM 220) at an elevation of 180 feet near the town of Vina (National Marine Fisheries Service 2014). Although water diversion facilities are present on the lower reaches of Deer Creek, there are no major dams along the creek that prohibit passage, thus allowing salmonids access to high-quality headwater habitat in the upper portion of Deer Creek (Armentrout et al. 1998).

Deer Creek has two waterfalls in the upper part of the watershed that are natural barriers to fish, Lower Deer Creek Falls (RM 43), and Upper Deer Creek Falls (RM 48). A fish ladder was constructed on Lower Deer Creek Falls in the early 1940s, providing salmonids access to an additional 5 miles of habitat, which is now considered important for holding and spawning spring-run Chinook salmon (National Marine Fisheries Service 2014). Over time, the ladder deteriorated and did not meet current CDFW and NMFS criteria for fishways, thus a new fish ladder was installed in 2017. A ladder was also constructed on Upper Deer Creek Falls in the early 1950s; however, the ladder was never effective in passing spring-run, nor is the habitat above the falls considered suitable for spring-run, thus the ladder remains closed during their migration period (Armentrout et al. 1998).

Deer Creek has two water diversion facilities on its lower reaches owned by Deer Creek Irrigation District (DCID; RM 12) and Stanford Vina Ranch Irrigation Company (SVRIC; RM 5). The dam at the DCID diversion facility was removed in 2019 and replaced with a roughened rock ramp to provide improved fish passage. The SVRIC diversion dam is equipped with fish

ladders on both sides; however, pool depths, lengths, jump heights, and velocities in both ladders do not meet current CDFW and NMFS criteria for fishways, and plans are currently underway to develop a new fish passage screening project at the SVRIC Dam. Low flows in Deer Creek downstream of the SVRIC Dam, resulting from upstream diversions, can also lead to impaired or blocked passage of adult and juvenile spring-run, especially in below-normal water years.

NMFS (2014) classified Deer Creek an NMFS Core 1 population for spring-run Chinook salmon recovery, meaning the watershed has the known ability or potential to support a viable population and meets the criteria for low extinction risk. Deer Creek is part of the northern Sierra Nevada diversity group, composed of streams tributary to the Sacramento River from the east from Antelope Creek to the Mokelumne River. Deer Creek is recognized as an independent population (National Marine Fisheries Service 2014), supporting one of four remaining self-sustaining Central Valley spring-run populations. Spawning and holding habitat located at high elevations in Deer Creek is of high quality and considered some of the best remaining salmonid habitat in the Central Valley. This high-elevation habitat also helps to isolate fall-run from spring-run to prevent geographic cooccurrence and maintain genetic and phenotypic diversity of the population. Deer Creek is considered a conservation stronghold for Central Valley spring-run populations (National Marine Fisheries Service 2014). The spring-run population on Deer Creek is small and variable and has declined in recent years with an average spawner escapement of 213 from 2015 to 2019, decreasing to 40 fish in 2020. Due to recent declines in adult abundance, Deer Creek is now at a high level of extinction risk based on population viability criteria identified in (National Marine Fisheries Service) 2014. Additional fish passage improvements, such as those planned at the SVRIC diversion facility, will provide better access to holding and spawning habitat in upper Deer Creek and may help to increase adult abundance.

Spring-Run Chinook Salmon Timing

Adult spring-run migrate into Deer Creek between late February and early July, with peak migration occurring in April and May. Spring-run hold over summer until spawning commences in late August through October. Adult spring-run spawn over a range of elevations within Deer Creek, which has a significant effect on egg incubation and timing of fry emergence in the watershed. Thus, depending on the elevation at which the female spawned,

spring-run fry emerge over a six-month period, from November through May (Johnson and Merrick 2012). Otolith analyses conducted by Cordoleani et al. (2018) highlighted multiple juvenile rearing strategies contributing to adult Deer Creek spring-run populations, with the contribution of different strategies being different among years. Data from the historical Deer Creek RST program showed spring-run juveniles from a single brood year could be captured in the RST over a 17-month period as fry or yearlings. Yearling migration occurs from October through June, with peak emigration from October through December. YOY spring-run emigration occurs from November through June, with peak emigration in February and March. Due to the extended emergence timing and extended emigration period of spring-run juveniles in Deer Creek, LAD tables (Greene 1992) often incorrectly assign yearling spring-run as late fall-run and winter-run, and YOY spring-run as fall-run and late fall-run (Johnson and Merrick 2012).

Life Stage Monitoring

Varying methodologies combined with incomplete sampling efforts to count spring-run populations in Deer Creek over the years have made data comparisons between years challenging. For example, adult surveys conducted prior to the 1980s used incomplete spawning ground surveys, carcass surveys with unknown expansion factors, and partial ladder and fish counts. Since the early 1990s, adult abundance surveys have been conducted using standardized snorkel counts, which has enabled comparison of data between more recent years (Killam 2020; National Marine Fisheries Service 2014). Juvenile spring-run emigration monitoring was historically conducted on Deer Creek from 1994 through 2010 using a RST station located about a mile downstream of the former DCID diversion dam; however, survey methods did not allow for calculation of absolute abundance estimates due to lack of trap efficiency tests. Emigration monitoring is currently conducted for juvenile steelhead on Deer Creek at RM 8.5, and although juvenile spring-run are incidentally collected, the seasonal operation and location of the RST does not produce adequate data to calculate juvenile spring-run passage estimates.

CDFW currently implements the following life stage monitoring programs on Deer Creek to develop population indices for adult spring-run:

- Adult passage monitoring using video monitoring at the SVRIC diversion dam and Lower Deer Creek Falls.

- Adult holding monitoring using snorkel surveys.

To fill data gaps for developing population indices for juvenile salmon, the Deer Creek subteam recommends implementation of the following monitoring program during the initial JPE development phase:

- Adult spawner snorkel surveys consisting of redd counts and carcass biosampling.
- RST monitoring to develop egg-to-fry survival and juvenile YOY passage estimates.

These monitoring programs will provide important data on adult and juvenile spring-run on Deer Creek to inform initial JPE approaches. These monitoring programs are described in more detail below and in the following pages.

A map depicting the locations of existing and proposed monitoring programs in Deer Creek is provided in Figure 5.

Adult passage monitoring: Since 2014, passage of adult spring-run (and fall-run) into Deer Creek from the Sacramento River has been monitored year-round using two video stations located in the north and south fish ladders of the SVRIC diversion dam. The video stations consist of overhead and underwater cameras and a VAKI Riverwatcher system (Killam 2020). Data are collected continuously on all fish passing upstream and downstream and stored on external hard drives for post processing. Data recorded on salmonids include counts, adipose fin presence/absence, sex, grilse status (FL < 61 centimeter), spawning condition, exact time of passage, and run identification. Data obtained from this monitoring program are used to estimate adult upstream passage for each adult return year. Passage estimates for adult spring-run are developed using video data from late-February to mid-July.

Since 2019, an experimental video station has been operated in the new fish ladder at Lower Deer Creek Falls to monitor adult passage above the falls.

Adult holding surveys: Snorkel surveys have been conducted annually since 1980 on Deer Creek during August to count holding adult spring-run. Currently, a total of 22.4 miles of Deer Creek is snorkeled, beginning at Upper Deer Creek Falls (RM 48) and ending approximately 3 miles below the Ponderosa Bridge crossing (RM 24). In years when fish are observed near

RM 24, the survey is extended downstream an additional 3 miles. The survey is split into eight sections with multiple snorkelers recording fish counts for later comparison and consensus of total fish observed. Data from the survey are used to calculate an adult spring-run population estimate and document the elevations and water temperatures associated with adult holding locations. Pre-spawn mortalities are recorded when encountered; however, an estimate of pre-spawn mortalities is not calculated.

Adult spawner/redd surveys: Adult spring-run spawner/redd surveys are not currently conducted on Deer Creek. Historically, these surveys were conducted by the United States Forest Service Lassen National Forest but were discontinued around 2014.

Adult spring-run spawner/redd surveys on Deer Creek are proposed for implementation during the initial JPE development phase to contribute to the development of an adult population estimate and calculate egg-to-fry survival estimates. Snorkel surveys will be conducted in Deer Creek from Upper Deer Creek Falls (RM 48) to RM 38.7 from August through November to count completed redds, document spawning locations, and collect biological information and samples from carcasses. During surveys all redds will be mapped with GPS and classified by age. Time of spawning will be estimated using the date and age data for each redd. Estimated spawning timing and temperature data are then used to estimate emergence timing for each redd. When carcasses are encountered during surveys, biological data will be recorded and samples will be collected. Biological data will include fork length, sex, egg retention, adipose fin presence/absence, carcass condition, presence of tags, and spawning status. Samples taken will include otoliths, scales, fin or flesh for future genetic analyses, and heads from adipose-clipped fish, from which CWTs will be later extracted for analyses.

Juvenile production monitoring: Juvenile spring-run production monitoring is not currently conducted on Deer Creek. Historically, CDFW conducted rotary screw trapping on Deer Creek (1994–2010). This monitoring program provided life history information for juvenile spring-run and steelhead, including overall trends in abundance and the emigration timing. Trap efficiency trials were not conducted under this monitoring program; therefore, historical spring-run egg-to-fry survival estimates and

juvenile production indices are not available for Deer Creek (Johnson and Merrick 2012).

Juvenile spring-run emigration monitoring on Deer Creek is proposed for implementation during the initial JPE development phase to allow for the calculation of egg-to-fry survival estimates and juvenile production indices. Although yearling spring-run are well documented and currently observed in Deer Creek, historic RST efforts on Deer Creek show that sampling yearlings using RSTs is challenging due to the tendency of these larger juveniles to avoid the trap and their emigration primarily occurring during freshets. However, the JPE research and development phase will include operation of an RST from October through June to capture both yearling and YOY emigration to estimate abundance for both life history strategies. If RST sampling on Deer Creek during the JPE research and development phase does not produce adequate data to estimate yearling production, the JPE Core Team will explore additional survey methodologies for developing yearling abundance estimates. Obtaining a yearling production estimate on Deer Creek will be important to ensure inclusion of multiple spring-run life history strategies when investigating initial JPE approaches.

A single 5-foot diameter RST will be operated on Deer Creek immediately below the Stanford Vina Ranch Irrigation Company (SVRIC) Diversion Dam (RM 4.9) to monitor juvenile spring-run emigration. The monitoring program will be operated continuously from October through June with trap checks occurring daily. However, traps will not be fished during high flow events, low water conditions in which velocities are insufficient to turn the cone or cause water temperatures to elevate to unsafe levels for fish handling, and periods when staff are not available to conduct trap checks, to minimize risk of injury to staff, prevent damage to equipment, and minimize stress and mortality to fish. Data collected during trap checks will include trap operational information, environmental conditions, and fish data. Trap operational information will include length of time the trap is sampled, trap condition, and cone revolutions. Environmental conditions will include air temperature, water temperature, turbidity, weather conditions, and stream discharge. All fish captured will be counted and identified to species. A subsample of Chinook salmon and steelhead will be weighed and measured to the nearest fork length and assigned a life-stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt) (Johnson and Merrick 2012). All Chinook salmon will be assigned a run designation using LAD tables from Greene

(1992). However, due to the discrepancies in using LAD tables to assign run classification to juveniles Chinook salmon in Deer Creek (as described above), tissue or opercule samples will be taken from a subsample of fish to confirm run using genetic analyses (see Race ID Plan).

Trap capture efficiency trials will be conducted over a wide range of hydrological conditions to evaluate fish passage and estimate juvenile abundance. Marking methodologies for trap efficiency studies will include VIE tags and BBY stain. Marked fish will be released approximately 1 mile upstream of the sampling site, and the number of fish recaptured will be used to estimate capture efficiency. Efficiency studies will be conducted using trap-captured natural-origin fall-run, spring-run, and late fall-run Chinook salmon. In recent years, adult returns of all runs of Chinook salmon in Deer Creek have been depressed, resulting in reduced juvenile production. To obtain sufficient sample sizes for mark-recapture trials, it may be necessary to use fall-run and late fall-run salmon from CNFH. The number of fish released and recaptured from mark-recapture trials will be used to calculate weekly trap efficiencies. Juvenile passage indices at each trap location will be calculated by dividing the weekly catch totals by either the weekly trial or season average trap efficiency.

Butte Creek

Background

Butte Creek is a tributary to the Sacramento River located primarily in Butte County with smaller portions in Tehama, Glenn, Colusa, and Sutter counties, California. The Butte Creek watershed drains approximately 811 square miles and enters the Sacramento River at two locations: the Butte Slough Outfall gates (located at the historic outlet of Butte Creek, RM 138.3) and the downstream end of the Sutter Bypass near the confluence of the Feather River with the Sacramento River (RM 80; McReynolds et al. 2005).

The Butte Slough Outflow gates are a flow control structure operated and maintained by DWR to allow high Butte Creek flows to enter the Sacramento River. The Sutter Bypass begins downstream of the Butte Slough Outfall gates and serves as a 40-mile-long flood relief system for the Sacramento River (Butte Creek Watershed Project 1998). When Sacramento River flows exceed the crest elevation of Tisdale Weir (44.45 feet; RM 119), flows enter the Sutter Bypass (California Department of Water Resources 2010). Under

normal Butte Creek flow conditions, Butte Creek enters the Sutter Bypass and splits into two channels, known as the East and West borrow canals, that run along either side of the bypass before draining into the Sacramento River.

The watershed includes a series of dams, diversions, and canals located in the upper, middle, and lower portions of Butte Creek. In the upper watershed, Butte Creek receives water from the West Branch of the Feather River through the PG&E operated DeSabra-Centerville Hydroelectric Project (Federal Energy Regulatory Commission [FERC] Project No. 803; BCWP 1998). The hydroelectric project was built in the late 1800s and early 1900s and consists of two small storage reservoirs, three major diversions (Hendricks Diversion Dam, Butte Head Dam, and Centerville Dam), several small diversions and feeder dams, 20 miles of water conveyance, penstocks, and three powerhouses (Toadtown, DeSabra, and Centerville; PG&E 2008). Between the Butte Head Dam and the Centerville Dam, Energy Growth Partnership owns and operates the Forks of Butte Hydroelectric Project, which was built in the 1980s (Butte Creek Watershed Project 1998).

Quartz Bowl Pool (RM 58.5), a 15-foot-tall waterfall, is located roughly 1 mile upstream of the Centerville Dam (RM 57) and currently limits most upstream fish passage beyond this point (Butte Creek Watershed Project 1998; Garman 2016b). River miles identified in Butte Creek are approximate river miles determined by surveying reaches within the creek. Historically, Chinook salmon and steelhead spawning occurred upstream of Quartz Bowl Pool into the Butte Creek canyon during higher flows; however, diversions and reduced flows have limited access above the natural barrier and further restricted access at Centerville Dam (Butte Creek Watershed Project 1998; National Marine Fisheries Service 2014). Currently, spawning and holding habitat for adult Chinook salmon is largely limited to the 11 miles downstream of the Quartz Bowl Pool to the Centerville Covered Bridge (RM 47.4) where flows are controlled by PG&E for power generation (McReynolds and Garman 2009). Downstream of this reach, there are four dams and additional diversions, including the Parrot-Phelan (RM 44), Durham Mutual, Adams, and Gorrill Ranch dams that were retrofitted with fish ladders and fish screens in the 1990s (California Department of Fish and Wildlife 2005).

As a side note, PG&E filed for a FERC license renewal for the DeSabra-Centerville Hydroelectric Project (FERC 803) in 2007 and later withdrew its

application for a new FERC license in 2017 and announced its intentions to sell the project (National Oceanic and Atmospheric Administration 2021). The original license, through amendments, includes minimum flow and temperature requirements for Chinook salmon and steelhead (California Department of Fish and Wildlife 2014; National Marine Fisheries Service 2014). If negotiations do not result in the sale of the hydroelectric project, FERC will initiate an orphaned project and require the decommissioning.

Additional restoration actions have occurred downstream of these dams, including the removal of the Western Canal Dams (and replacement with a siphon) and Point Four, McGowan, and McPherin diversions (California Department of Fish and Wildlife 2005). There have also been water control structure and fish passage improvements throughout the Sutter Bypass at Willow Slough Weir, Weirs 2, 3, and 5, and an ongoing project at Weir 1 (California Department of Fish and Wildlife 2005; Reclamation 2020). Work to improve the Butte Slough Outfall gates is also ongoing with DWR committed to funding replacement of the flap gates and electrical components to improve operations and reduce fish stranding (California Department of Water Resources 2020).

Butte Creek is classified as a Core 1 watershed for spring-run Chinook salmon, meaning the watershed has the known ability or potential to support a viable population and meets the criteria for low extinction risk for spring-run (National Marine Fisheries Service 2014). Butte Creek is part of the northern Sierra Nevada diversity group, composed of streams tributary to the Sacramento River from the east from Antelope Creek to the Mokelumne River. The naturally spawning independent population of spring-run on Butte Creek has been considered a stronghold for the species and has been the most abundant population of spring-run since flow and passage improvements were completed in the 1990s (National Marine Fisheries Service 2014; California Department of Fish and Wildlife 2021). Despite current population abundance, water temperatures continue to pose threats to holding adult spring-run. Butte Creek holding and spawning areas are lower in elevation (below 931 feet) than Deer and Mill creeks, which can expose spring-run to warmer temperatures, a situation likely to be exacerbated in the future by climate change (National Marine Fisheries Service 2014).

Historical spring-run escapement estimates for Butte Creek are available from 1960 until present (National Marine Fisheries Service 2014; Azat 2020). Grandtab reports both snorkel survey data (1960 to present) and carcass survey data (2001 to present). Adult escapement has been variable with noted increases in recent years due to restoration efforts within the watershed. The average spawner escapement for snorkel and carcass surveys between 2015 and 2019 were 2,977 and 4,808, respectively (Azat 2020). In 2020, spawner escapement declined below the four-year average to 1,559 (snorkel survey) and 1,281 adult fish (carcass survey) (Jessica Nichols, personal communication, June 29, 2021).

Spring-run Chinook Salmon Timing

Adult spring-run Chinook salmon enter Butte Creek starting in February, hold during the summer, and spawn from September through October (California Department of Fish and Wildlife 2021). Peak spawning occurs in the last week of September or the first week of October, depending on water temperatures. Annually, in early October, CDFW installs exclusion barriers in the fish ladder at Parrot-Phelan Diversion Dam to block upstream migration of fall-run to prevent introgression and redd superimposition. The exclusion barriers allow the continued flow of water through the ladder. In some years, fall-run can ascend the ladder with the barriers in place. Water temperatures affect egg incubation in Butte Creek, leading to earlier juvenile emergence in November compared to other tributaries like Mill and Deer creeks where juveniles emerge from January through March (McReynolds et al. 2005; Johnson and Merrick 2012). The spring-run juvenile emigration season in Butte Creek usually begins in December and extends through February, which is also earlier than the emigration season in Mill and Deer creeks (National Marine Fisheries Service 2014). Yearling spring-run are known to rear in Butte Creek and emigrate later in the spring (National Marine Fisheries Service 2014).

Life Stage Monitoring

CDFW currently implements the following existing life stage monitoring programs on Butte Creek between the Quartz Bowl Pool and Durham Mutual fish ladder to develop population indices for adult spring-run and assess relative abundance of juvenile spring-run:

- Adult passage monitoring at Durham Mutual fish ladder.
- Adult holding monitoring using snorkel surveys.

- Adult spawner surveys consisting of carcass biosampling.
- RST and off-stream diversion fish screen (DST) monitoring.

To enhance adult and juvenile spring-run monitoring on Butte Creek, the Butte Creek subteam recommends implementation of the following life stage monitoring programs during the initial JPE development phase:

- Adult spawner surveys consisting of redd counts.
- RST monitoring to assess relative juvenile abundance at Maddock Road.

Existing monitoring programs, coupled with proposed new monitoring, will provide important data on adult and juvenile spring-run in Butte Creek to inform initial JPE approaches. These monitoring programs are described in more detail in the following pages.

A map depicting the locations of existing and proposed monitoring programs in Butte Creek is provided in Figure 6.

Adult passage monitoring: Since 2014, a VAKI Riverwatcher system located in the Durham Mutual fish ladder (RM 42) has been operated year-round to measure relative abundance, temporal distribution, age structure from length frequency distributions, and hatchery contributions of spring-run and fall-run Chinook salmon and steelhead (Garman 2019). Data are collected continuously on all fish passing upstream and downstream and stored on external hard drives for post processing. Data recorded on salmonid passage include the time of passage, counts, species or run identification, adipose presence/absence, upstream or downstream direction of passage, speed of fish movement, and body depth (which is later converted to length). Spring-run passage estimates are developed using video data collected from February through June. Data from the monitoring station are used in conjunction with snorkel (adult holding) and carcass surveys to estimate annual spring-run adult escapement. In previous years, hundreds of Chinook salmon were observed jumping onto and ascending the Durham Mutual Dam rather than passing through the fish ladder. Therefore, the escapement estimate derived from the VAKI Riverwatcher should not be considered an accurate upstream passage count of migrating spring-run (Garman 2019).

Adult holding surveys: Adult holding surveys are conducted to provide an estimate of adult spring-run escapement prior to spawning, to determine holding distribution of adults, and to assess pre-spawn mortality events in coordination with water operations in Butte Creek. Snorkel escapement surveys are conducted within four reaches between Quartz Bowl Pool (RM 58.5) and Parrot-Phelan Diversion Dam (RM 44; 14.5 RM in length) for four consecutive days in July. This survey was standardized in 2001 to provide a total annual escapement estimate by summing the average observed count for each pool. However, snorkel survey methodology likely underestimates adult escapement when there are large populations (Garman 2016a). Pre-spawning mortality surveys (also a snorkel survey) are conducted within six reaches between Quartz Bowl Pool and Parrot-Phelan Diversion Dam. Surveys are conducted weekly within each reach between June and September to provide an estimate of pre-spawn mortality to better explain differences between escapement estimates during summer holding and fall spawning. When carcasses are encountered, biological data are recorded for each carcass, including carcass condition, spawning status, fork length, adipose fin presence/absence, and presence of tags. Samples taken from a subset of carcasses include scales, tissue for future genetic analyses, and heads, from which otoliths are later extracted for analyses. Pre-spawned carcasses are tagged with a unique number disc attached to the maxilla and returned to the water to later estimate the total number of pre-spawn mortalities. Within each reach, a HOBO temperature data logger is maintained, and water temperatures are recorded each week during surveys. Escapement surveys have been conducted since 1954 with various survey methods used with varying precision. Standard snorkel survey methodology was used beginning in 1989, with pre-spawn snorkel surveys beginning in 2001 (Garman 2016a).

Adult spawner/redd surveys (existing and proposed): Post-spawn carcass surveys are conducted weekly beginning the third week of September and extending through October (approximately seven weeks) by walking/snorkeling six reaches between the Quartz Bowl Pool (RM 58.5) and Parrot-Phelan Diversion Dam (RM 44). Adult escapement estimates are calculated using the Cormack-Jolly-Seber mark-recapture model for open populations. When fresh carcasses are encountered, biological data are recorded for each carcass, including the carcass condition, spawning status and sex, fork length, adipose fin presence/absence, and presence of tags. Samples taken from a subset of fresh carcasses include scales, fin or flesh

for future genetic analyses, and heads from adipose-clipped fish, from which CWTs and otoliths are later extracted for analyses. Fresh carcasses are tagged with a unique number disc attached to the maxilla and returned to the water for the mark-recapture study. All other carcasses (at various stages of decomposition) are examined for the presence/absence of an adipose fin and then chopped in half and returned to the river. Carcass surveys have been conducted annually since 2001 (Garman 2019).

To augment existing adult surveys and refine escapement estimates, CDFW proposes conducting weekly redd surveys beginning when the first redd is identified during adult holding surveys and continuing through October. Redd surveys will be conducted between Quartz Bowl Pool (RM 58.5) and Parrot-Phelan Diversion Dam (RM 44) using a systematic sampling design to evaluate spatial and temporal distribution of redds and redd superimposition during the spawning season. During surveys, crews will map redds using GPS to identify the number of successful spawning events and collect the following data: total dimensional area (if mass aggregate spawning is assumed), habitat type (pool, riffle, run, or glide), substrate composition, number of fish observed on the redd, reach and sub-reach, and any comments regarding observed redd superimposition. A fiberglass extendable rod will also be used to measure physical dimensions of the redd, including pot length and width and tail spill length and width. To prevent double counting of redds, a spray painted rock, or other identifying mechanism, will be placed near each mapped redd.

Juvenile (YOY and yearling) passage monitoring (existing and proposed): An RST and off-stream DST fitted with a trap box located at Parrot-Phelan Diversion Dam (RM 44) are used to evaluate trends in juvenile spring-run and steelhead emigration timing and abundance from Butte Creek (Garman 2016b). The 8-foot diameter RST and the 4 foot-by-3 foot-by-7 foot trap box are operated between November and June, targeting the YOY emigration timeframe for spring-run Chinook salmon. However, CDFW proposes operating the traps beginning in September to better capture the yearling size class. It is unclear if operating the RST and DST program in the early fall will capture additional yearling spring-run juveniles because yearlings are known to actively avoid capture (Garman 2016b). This trap is located above the typical fall-run Chinook salmon spawning area, and, in most years, most of the smolts are spring-run outmigrants (United States Fish and Wildlife Service 2010). Genetic testing of juvenile outmigrants will

be used to better understand the extent of adult fall-run passage and inter-spawning with spring-run upstream of Parrot-Phelan Diversion Dam fish ladder in areas occupied by spring-run (Garman 2016b). RST and DST monitoring have been conducted since 1995, except for 2009 through 2011 (United States Fish and Wildlife Service 2010; Garman 2016b).

Trap checks occur once per day but can occur up to twice a day during periods of high flow or high debris (United States Fish and Wildlife Service 2010). If fewer than 2,000 fish are captured, all fish are counted and identified to species, otherwise volumetric sampling is performed to count fish. Fork length and weight are measured for all steelhead and up to 50 individuals of juvenile salmon. Fork length is measured for up to 10 of each non-salmonid species. For all salmonids measured, life stage (YOY or yearling) is assigned based on length frequency distributions, and the presence or absence of an adipose fin is recorded. As part of the new Spring-Run JPE effort, samples (tissue or opercule) will be taken from select fish to confirm run using genetic analyses (see Race ID Plan). Data are also recorded on environmental conditions (water temperature, velocity) and RST operations (sample period, cone revolutions, and trap condition; Garman 2016b).

Historically, trap efficiency studies have not been conducted for the Parrot-Phelan Diversion Dam RST. Thus, data collected by the existing RST/DST program provide information on the temporal distribution, relative abundance, and size at emigration for spring-run Chinook salmon (and steelhead) emigrating from Butte Creek, but do not provide a passage estimate. All data are still recorded in the USFWS Comprehensive Assessment Monitoring Program (CAMP, [The Comprehensive Assessment & Monitoring Program | U.S. Fish & Wildlife Service](#)) (Garman 2016b). During the 2020/2021 juvenile emigration season, CDFW implemented a pilot trap efficiency study to evaluate fish passage and estimate juvenile abundance. The data from the study are currently being analyzed with the goal of continuing the effort during future monitoring seasons and will be used to inform the new Spring-Run JPE effort. Methodologies will be consistent with the pilot year study. Efficiency studies will continue to use trap-captured natural origin spring-run. Marking methodologies will include VIE tags and BBY stain. Marked fish will be released 1 mile upstream of the Parrot-Phelan Diversion Dam RST sampling site, and the number of fish recaptured will be used to estimate capture efficiency. The number of fish released and

recaptured from mark-recapture trials will be used to calculate weekly trap efficiencies. Juvenile passage indices at each trap location will be calculated by dividing the weekly catch totals by either the weekly trial or season average trap efficiency.

To augment the existing RST and DSR program, the Butte Creek Subteam proposes adding an additional RST program at Maddock Road (RM 7, within the Sutter Bypass). A historical program led by CDFW at this location operated between 2001 and 2004 to evaluate trends in juvenile Chinook salmon timing and abundance (United States Fish and Wildlife Service 2010). This trapping program ended due to the inability to discriminate between different runs of Chinook salmon; however, some studies were conducted to evaluate survival between fish captured and tagged at the Parrot-Phelan RST (RM 44) and fish recaptured at the Maddock Road RST (RM 7). CDFW proposes conducting similar survival studies between sites by operating the Maddock Road RST consistent with operations at the Parrot-Phelan RST site (see the Juvenile Survival Monitoring section on page 63).

Yuba River

Background

The Yuba River watershed spans portions of Sierra, Placer, Yuba, and Nevada counties and is comprised of the North, Middle, and South Forks of the Yuba River. The North Yuba River flows into Bullards Bar Reservoir and is joined by the Middle Yuba River approximately 5 miles downstream of New Bullards Bar Dam. The South Yuba River originates high in the Sierra Nevada and flows 64 miles before joining the North and Middle forks at the U.S. Army Corps of Engineers (USACE) Englebright Reservoir (RM 24) (NMFS 2014). Englebright Dam is a complete fish passage barrier and is the limit of anadromy for salmonids on the Yuba River. The "lower Yuba River" is used to refer to the 24-mile section of the Yuba River from Englebright Dam downstream to the confluence with the Feather River. Another smaller USACE-owned debris dam, Daguerre Point Dam (DPD), is located on the lower Yuba River at RM 11.5. DPD is equipped with fish ladders on the north and south sides of the dam to allow passage of salmonids and other fishes.

Lower Yuba River instream flow requirements are specified in the Lower Yuba River Accord (Yuba Accord) Fisheries Agreement, which was developed and signed by Yuba Water Agency (YWA; formerly Yuba County Water

Agency), NMFS, USFWS, CDFW, and a group of non-governmental organizations (California Trout, South Yuba River Citizens League, and The Bay Institute). The Yuba Accord Fisheries Agreement requires YWA to maintain instream flows in the lower Yuba River to benefit native Chinook salmon, steelhead, and other fish and aquatic resources (Yuba County Water Agency [YCWA] 2014). Flows are released into the river from Englebright Dam via coordinated operations of two powerhouses on the lower Yuba River. YWA's Narrows 2 Powerhouse (FERC No. 2466) is located on the north side of the lower Yuba River just below Englebright Dam. PG&E's Narrows 1 Powerhouse is located on the south side of the lower Yuba River less than 0.5 mile downstream of YWA's Narrows 2 Powerhouse (FERC No. 1403). The Yuba Accord Fisheries Agreement also includes a funding source (River Management Fund) to monitor and evaluate the flow schedules, condition of fish resources, and the viability of salmonids in the lower Yuba River. The Yuba Accord River Management Team (RMT) oversees the management and implementation of River Management Fund expenditures to implement fisheries monitoring, studies, and habitat enhancement on the lower Yuba River (Yuba Accord River Management Team 2013).

NMFS (2014) classified the Yuba River as a NMFS Core 2 population for spring-run Chinook salmon recovery, meaning the population meets, or has the potential to meet, the biological recovery standard for moderate risk of extinction. Core 2 populations have lower potential to support viable populations than Core 1 populations due to lower abundance, or the amount and quality of habitat. The Yuba River is part of the northern Sierra Nevada diversity group, composed of streams tributary to the Sacramento River from the east from Antelope Creek to the Mokelumne River. The Yuba River is recognized as a dependent population, as it relies on inputs of migrants from spring-run populations in other tributaries. The lower Yuba River is among the last Central Valley floor tributaries supporting populations of naturally spawning spring-run, although straying of Feather River Fish Hatchery (FRFH) spring-run (and fall-run) regularly occurs. In addition to hatchery influence, naturally spawning spring-run in the lower Yuba River have been impacted or potentially impacted by the lack of access to habitat above Englebright Dam, impaired adult passage at DPD, degraded spawning and rearing habitat and natural river function and morphology, and impaired juvenile passage downstream of DPD.

Limited historic records indicate the spring-run salmon population in the Yuba River was relatively large prior to impacts associated with gold mining, dam construction, and water diversions (National Marine Fisheries Service 2014). Recent data based on VAKI Riverwatcher counts of adult Chinook salmon passing upstream of DPD suggest the spring-run population size on the lower Yuba River ranges from a few hundred to a few thousand; however, the population likely has a high extinction risk due to hatchery influence (National Marine Fisheries Service 2016a). Restoration actions, including implementation of habitat enhancement in the lower Yuba River downstream of Englebright Dam, and reintroduction of spring-run into their historic habitat in the North Yuba River upstream of New Bullards Bar Dam are key for recovery of naturally spawning spring-run in the Yuba River watershed (National Marine Fisheries Service 2016a).

Spring-Run Chinook Salmon Timing

Adult spring-run immigration and holding in the lower Yuba River occurs from March through September. Spring-run are known to hold over summer in deep pools and cool water downstream of the Narrows 1 and Narrows 2 Powerhouses as well as further downstream in the Narrows Reach (the “Narrows” reach of the lower Yuba River refers to a 1.2-mile section of the river consisting of an inaccessible and narrow bedrock canyon). However, recent studies have shown spring-run holding over a broader area, including areas as far downstream as Simpson Lane Bridge (RM 1.5) and as far upstream as just below Englebright Dam (RM 24). Spring-run spawning occurs in the lower Yuba River from September through mid-October. Nearly all spring-run spawning is believed to occur upstream of DPD. Spring-run fry rear in the lower Yuba River from mid-November through mid-February, with some juveniles rearing year-round. The YOY emigration period occurs from mid-November through June, with peak emigration occurring from January through March. Historic RST data suggests Chinook salmon primarily emigrate from the lower Yuba River as fry; however, some juvenile salmon exhibiting a yearling life history strategy were observed during RST monitoring. Yearlings (smolts) emigrate from the lower Yuba River from October through mid-May (Yuba Accord River Management Team 2013).

Life Stage Monitoring

The following existing life stage monitoring programs are currently conducted on the Yuba River for adult spring-run:

- Adult passage monitoring using video monitoring at DPD.
- Adult spawner surveys consisting of redd counts in the Englebright Dam Reach, carcass mark-recapture surveys downstream of DPD, and carcass biosampling upstream of DPD.

To fill data gaps for developing population indices for adult and juvenile salmon, the Yuba River subteam recommends implementation of the following monitoring programs during the initial JPE research and development phase:

- Enhanced redd surveys to include the entire length of the Yuba River where spawning may occur.
- RST monitoring to develop juvenile production estimates and evaluate temporal emigration, distribution of juvenile size, and size-class composition through time.

Existing monitoring programs, coupled with proposed new monitoring, will provide important data on adult and juvenile spring-run in the Yuba River to inform initial JPE approaches. These monitoring programs are described in more detail below and in the following pages.

A map depicting the locations of existing and proposed monitoring programs in the Yuba River is provided in Figure 7.

Adult passage monitoring: Since 2003, year-round passage monitoring of adult Chinook salmon and steelhead in the lower Yuba River has been conducted using two VAKI Riverwatcher systems and digital cameras located in the north and south fish ladders at DPD. Data collected for each fish passage event include date/time, direction of passage (upstream versus downstream), speed of fish moving through the system, and fish body depth (which is later converted to fork length). Water temperature is also recorded every hour. All data are downloaded weekly and stored on external hard drives. Data are reviewed by personnel to identify fish species, check adipose fin presence/absence, and identify non-passage events. Data collected by the VAKI Riverwatcher systems are used to characterize the annual abundance of Chinook salmon (and steelhead) from Englebright Dam

downstream to DPD. Temporal demarcation dates are selected annually and applied to the data series to separate spring-run from fall-run, which allows for an estimation of spring-run abundance above DPD (Yuba County Water Agency 2016).

Adult holding surveys: Currently, adult holding surveys are not conducted on the lower Yuba River. Surveys may be useful in the future to distinguish spring-run from fall-run to further refine an abundance for adult spring-run. Passage monitoring, carcass surveys, and enhanced redd surveys will be the focus of adult monitoring in the Yuba River during the research and development phase of the JPE; however, data collected from these surveys will be evaluated to determine if additional monitoring, such as adult holding surveys, would be beneficial to developing a JPE. If implemented, adult holding surveys would consist of visual fish counts above and below DPD from July to August via snorkel surveys or walking crews.

Adult spawner/redd surveys: Currently, both redd and carcass surveys are completed annually on the Yuba River, although redd surveys are limited. Existing redd surveys are conducted by Pacific States Marine Fisheries Commission through a contract with USACE to assess the temporal and spatial distribution of Chinook salmon and steelhead spawning within a 1-mile section of the lower Yuba River from YWA's Narrows 2 Powerhouse to approximately 0.25 miles downstream of the confluence with Deer Creek. Surveys are conducted via snorkel surveys from mid-September to mid-March. These surveys are conducted to evaluate adult Chinook salmon and steelhead use of restored spawning habitat associated with the long-term gravel augmentation program downstream of Englebright Dam, which was included in the NMFS Biological Opinion issued to USACE for the ongoing operation and maintenance of Englebright Dam and Reservoir. Data collected during surveys include date, streamflows, Secchi disk depth, redd location, time of redd observation, redd species identification, number of fish observed on each redd, any notes regarding redd superimpositions, and redd measurements. Redd data are used to enumerate Chinook salmon redds and identify spatial distribution of spawning Chinook salmon in the study area (Stearman et al. 2017).

Expanding redd surveys to encompass the entire potential spawning area within the lower Yuba River may help to refine abundance estimates of adult spring-run and further understanding of the spatial and temporal distribution

of spring-run spawning in the system. Additionally, data from redd surveys coupled with juvenile abundance estimates obtained from proposed RST monitoring (see Juvenile Production Monitoring section on page 45) could be used to estimate egg-to-fry survival. Redd surveys will be expanded to include most of the Yuba River from Englebright Dam to the confluence with the Feather River. Specifically, four reaches will be surveyed: Englebright Dam to just below Deer Creek (RM 24 to RM 23.1; Reach 1), below the Narrows Pool to the State Route 20 Bridge (RM 21.5 to 17.5; Reach 2), from State Route 20 Bridge to DPD (RM 17.5 to RM 11.5; Reach 3), and DPD to Simpson Lane Bridge (RM 11.5 to RM 1.5; Reach 4). Redd surveys will exclude the 0.7-mile section of the lower Yuba River from immediately below the first set of riffles on Deer Creek to the top of the Narrows Pool (Narrows Reach) due to safety concerns. Additionally, the approximately 2-mile section of the lower Yuba River from Simpson Lane Bridge to the confluence with the Feather River will not be surveyed due to lack of suitable spawning substrate and lack of historical observation of redds. Redd surveys will be conducted using kayaks and by foot beginning the first or second week of September and extending through December. Each redd encountered will be numbered, measured, and distinguished as Chinook salmon or steelhead. Additional data collected for each redd will include habitat type, substrate measurements, number of fish observed on the redd, location of redd in the river (side channel or main channel), and any observable redd superimposition.

A biometric sampling survey of Chinook salmon carcasses is conducted upstream of DPD to collect biological data (e.g., sex, fork length, scales, genetic samples, otoliths, and female spawning status), recover CWTs, and other information (e.g., date/time, location, weather, Secchi depth, streamflow, etc.). The survey is conducted annually from September through December/January from Narrows Pool downstream to just above DPD (approximately 10 miles). The biometric survey upstream of DPD excludes the Narrows Reach as well as the area immediately upstream of DPD. A formal carcass survey is not conducted upstream of DPD (no mark-recapture survey) as the VAKI Riverwatcher is principally used to estimate annual Chinook salmon escapement upstream of DPD. A mark-recapture carcass survey is conducted downstream of DPD (RM 11.5) to the Simpson Lane Bridge (RM 1.5) annually from September through December/January. The same biometric sampling data are collected on carcasses below DPD as for carcasses above DPD; however, carcasses downstream of DPD are tagged

and used for mark-recapture experiments to generate an escapement estimate using a superpopulation modification of the Cormack-Jolly-Seber model (Bergman et al. 2012).

Juvenile production monitoring: Juvenile spring-run production monitoring is not currently conducted on the Yuba River. Historically, annual rotary screw trapping was conducted on the lower Yuba River at Hallwood Boulevard (RM 7.5) from 1999 to June 2009. Monitoring efforts were conducted by CDFW from 1999 to 2006, which consisted of sampling generally from October/November through the winter, and either into June or through the summer (September). The RMT took over operation of the RST monitoring station from the fall of 2006 through August 2009. Trap efficiency tests were conducted during the 2007 to 2009 monitoring periods, which allowed for the generation of juvenile Chinook salmon abundance estimates during these time periods. For years in which efficiency tests were not conducted, observed catch has been used in lieu of abundance estimates to compare annual data sets (Yuba Accord River Management Team 2013).

Juvenile spring-run emigration monitoring on the lower Yuba River is proposed for implementation during the initial JPE research and development phase to allow for the calculation of egg-to-fry survival estimates and juvenile production indices. The RST monitoring station will be located at the historic site at Hallwood Boulevard, or another location if this site is no longer viable. Two RSTs with 8-foot diameter cones will be operated year-round (October 1 through September 30), pending interruptions of sampling effort within a particular survey period due to excessive debris or high streamflows. An examination of historical catch data from summer months may suggest year-round RST sampling is not necessary, in which case operation dates may be modified. Both RSTs will be serviced, and fish data collected at least once per day; however, during periods of excessive algal growth (June through October), high debris loads, or high flow events, the RSTs will be serviced at least twice per day to ensure continued operation and to reduce fish mortality. Data collected during trap checks will include trap operations, environmental information, and fish data. Trap operational data will include trap status (e.g., operational, blocked, etc.), cone rotation speed, length of sampling period, and debris volume. Environmental data will include water temperature, velocity, and turbidity. All fish will be identified to species. Juvenile Chinook salmon will be assigned a run based on LAD tables (Greene 1992), and samples (tissue or opercule) will be taken

from a subsample of fish to confirm run using genetic analyses (see Race ID Plan). A random subsample of Chinook salmon from each run will be measured to fork length and weighed and assigned a life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt). Fork length will be measured for an additional random subsample of 100 juvenile Chinook salmon, or 10% of the total salmon catch, whichever is greater. For the remaining juvenile Chinook salmon, “plus counts” for each run will be conducted by taking the product of the fraction of each run observed and the number of remaining fish that were counted. If the remaining number of fish is greater than 10,000, volumetric estimation will be used to enumerate fish.

Trap efficiency trials using mark-recapture methods (e.g., BBY stain) will be performed weekly throughout the year when catch of juvenile Chinook salmon is sufficient. Mark-recapture study groups will consist of a minimum of 300 fish and up to 1,000 fish. Fish will be released approximately 0.5 miles upstream from the RSTs. Trap efficiency will be estimated using the number of fish recaptured during the seven days following release of a test group. Juvenile passage indices at each trap location will be calculated by dividing the weekly catch totals by the weekly trap efficiency trial. Annual abundance estimates can be calculated by dividing the total estimated annual catch by the mean of the weekly trap efficiencies.

Feather River

Background

The Feather River is a principal tributary to the Sacramento River. Beginning at Oroville Dam, the mainstem (also known as the lower Feather River) flows approximately 67 miles through Butte, Yuba, and Sutter counties, to where it empties into the Sacramento River near Verona (RM 80) (California Department of Water Resources 2021). Upstream of the reservoir, four main tributaries converge into Lake Oroville: the South Fork, Middle Fork, North Fork, and the West Branch. Honcut Creek (RM 44), Yuba River (RM 27.5), and Bear River (RM 12.5) empty into the lower Feather River and together with the upper tributaries comprise a watershed that drains approximately 6,200 square miles (Bilski and Kindopp 2009).

Historically, there were 211 river miles of habitat available for anadromous fish on the Feather River; however, anadromy is currently limited by the Fish Barrier Dam (RM 67), which is located immediately upstream of the FRFH

(National Marine Fisheries Service 2014). The Fish Barrier Dam directs fish away from the mainstem and into a fish ladder that leads into the FRFH. The FRFH was constructed in the late 1960s by DWR to mitigate for the loss of salmon and steelhead spawning and rearing habitat caused by the construction of the Oroville Dam. The FRFH supports the production of fall-run and spring-run Chinook salmon as well as steelhead. Anadromous fish spawning in the Feather River is now largely limited to approximately 25 miles of habitat, with most of the spawning occurring in the Low Flow Channel (RM 67-59), beginning immediately downstream of the Fish Barrier Dam, and additional spawning occurring in the upper section of the High Flow Channel, which refers to portion of the lower Feather River immediately downstream of the Low Flow Channel to the confluence with the Sacramento River (RM 59-0). Spring-run Chinook salmon spawning occurs exclusively in the Low Flow Channel. DWR has provided improved conditions in the uppermost reach of the Low Flow Channel through gravel augmentations in 2014 (as required under the FERC License Settlement Agreement) and again in 2017 (California Department of Water Resources 2018).

During high flow releases, the lower Feather River outflow is highly regulated by Oroville Dam, which is operated under a coordinated agreement between DWR and Reclamation. Water releases are made from Oroville Dam into the Thermalito Diversion Pool, which is impounded by the Thermalito Diversion Dam. The main features of the Oroville-Thermalito Complex include the Oroville Dam, Lake Oroville, Hyatt Powerplant, and the Thermalito Facilities, which together provide water for local diversion and SWP diversions as well as hydropower generation. Non-flood control operations of the lower Feather River are controlled by a CDFW 1983 Agreement, which includes minimum flows and ramping criteria, and a FERC license (FERC Project No. 2100), which includes conditions to operate the hydropower project (National Marine Fisheries Service 2019).

In 2016, NMFS issued a Biological Opinion to FERC regarding the effects of relicensing the Feather River Division of the SWP for 50 years. This Biological Opinion requires several Reasonable and Prudent Measures and Terms and Conditions, including creating a segregation weir to separate fall-run and spring-run adults, increasing spawning and rearing habitat for steelhead, improving water temperatures and modeling, improving current monitoring of Endangered Species Act-listed species, improving management of the FRFH (including developing a Hatchery Genetics Management Plan), and

implementing a monitoring program for Green Sturgeon (National Marine Fisheries Service 2016b). The issuance of a new FERC license, and thus the requirements of the Biological Opinion, are currently pending. Additional restoration projects proposed for the Feather River include gravel augmentation (RM 63–67), removal of the Sunset Pumps (RM 38), and floodplain restoration at Nelson Slough (RM 8; Reclamation 2020). These three projects received CVPIA funding for Fiscal Year 2020. The gravel augmentation project is led by CDFW and DWR and builds off previous augmentation projects implemented in 2014 and 2017 in the Low Flow Channel. The removal of the Sunset Pumps is led by DWR, USFWS, and Sutter Extension Water District and has been in the planning stages since 2014. The project will improve upstream passage of adult steelhead, Chinook salmon, and sturgeon into the 28 river miles of habitat above Sunset Pumps and will minimize predation of juveniles moving downstream. The Nelson Slough restoration project is led by CDFW and USFWS and would increase floodplain habitat available to Feather River salmonids by lowering and widening the slough to provide better floodplain connection with the Sutter Bypass.

The lower Feather River is classified as a Core 2 watershed for spring-run Chinook salmon (as well as steelhead), meaning the watershed meets or has the potential to meet the biological recovery standard for a moderate risk of extinction (National Marine Fisheries Service 2014). The naturally spawning dependent population of spring-run, supported by hatchery production, currently has a high risk of extinction due to limited spawning areas and reduced quality of habitat (California Department of Fish and Wildlife 2021; National Marine Fisheries Service 2014). Substantial introgression between hatchery fall-run and spring-run populations has occurred due to overlap in migration timing, limited availability of in-river spawning habitat, and hatchery practices. Improved hatchery practices have reduced introgression in the hatchery by separating the runs, but continued introgression in natural spawners remains an issue due to temporal and spatial overlap in spawning areas (National Marine Fisheries Service 2014). Thus, comprehensive in-river escapement data is not available. Historical spring-run escapement estimates for the FRFH are available from 1963 until present; however, hatchery escapement does not reflect true spring-run abundance. Beginning in 2003, DWR and CDFW implemented a methodology to distinguish spring-run from fall-run entering the hatchery. Specifically, fish arriving at the hatchery between April 1 and July 1 are tagged as spring-

run and returned to the river; FRFH spring-run escapement is the number of these tagged fish that subsequently return to the hatchery during the spring-run spawning period (September). From 2005 to 2020, the number of tagged spring-run returning to the hatchery ranged from 532 (2017) to 4,294 (2013), with 1,525 spring-run returning most recently in 2020 (Azat 2020; Jason Julienne, personal communication, June 2021).

Spring-Run Chinook Salmon Timing

Historically, adult spring-run Chinook salmon migrated to the higher streams and headwaters of the Feather River watershed, while fall-run spawned mainly in the lower Feather River (Yoshiyama 2001). However, the construction of the Oroville Dam in the 1960s has since blocked upstream migration and eliminated the spatial segregation between the two spawning runs. As indicated earlier, this overlap in spawning habitat and timing has led to redd superimposition and hybridization between the two runs on the Feather River. Adult spring-run that reach the FRFH from April through June are tagged as spring-run at the hatchery and returned to the river where they hold during the summer. Tagged spring-run adults that enter the hatchery again in the fall are spawned during the month of September (California Department of Fish and Wildlife 2019). The following spring, approximately 2 million spring-run juveniles are released in-river from the FRFH (California Department of Fish and Wildlife 2020). Quantities of hatchery releases are based on hatchery planning protocols and can deviate annually based on production conditions and in-river conditions. In-river adult spring-run spawning occurs September through the first two weeks in October. The juvenile spring-run emigration season in the Feather River usually begins in mid-November and extends through June. Data suggest that there are two likely emigration strategies employed by juvenile spring-run. One cohort appears to emigrate early after emergence, as YOY, in December and January. Another cohort appears to rear for a period and emigrate throughout the spring, as large parr or smolts. Yearling spring-run are known to rear in the lower Feather River over summer prior to emigration (California Department of Water Resources 2021).

Life Stage Monitoring

DWR currently implements the following life stage monitoring programs for spring-run Chinook salmon on the Feather River from near the FRFH through the High Flow Channel:

- Adult broodstock selection and enumeration at the FRFH.
- Adult movement and holding using acoustic tagging.
- Reconnaissance level pre-spawn mortality survey.
- Adult spawner surveys consisting of redd counts and carcass biosampling (estimates currently not reported for spring-run exclusively).
- RST monitoring to develop egg-to-fry survival and juvenile YOY passage estimates in the Low Flow Channel and upper High Flow Channel (estimates currently not reported for spring-run exclusively).
- Juvenile rearing monitoring using beach seine and snorkel surveys.

The Feather River subteam recommends implementing the following additional monitoring programs during the initial JPE development phase to fill data gaps for developing population indices for adult and juvenile salmon:

- Adult passage monitoring using video monitoring in the Low Flow Channel.
- RST monitoring to develop refined YOY passage estimates in the lower Feather River.

Existing monitoring programs, coupled with proposed new monitoring, will provide important data on adult and juvenile spring-run in the Feather River to inform initial JPE approaches. These monitoring programs are described in more detail in the following pages.

A map depicting the locations of existing and proposed monitoring programs in the Feather River is provided in Figure 8.

Adult broodstock selection and enumeration (existing): Currently, there is no comprehensive monitoring program to quantify adult spring-run escapement in the Feather River. Existing operations at the FRFH provide an estimate of adult escapement of early-arriving Chinook salmon, but do not account for all adult spring-run in the lower Feather River. The hatchery

traps adult Chinook salmon ascending the hatchery fish ladder annually from April through June and tags each fish with two external Hallprint tags before immediately releasing them downstream of the hatchery. In some years, many adult Chinook salmon enter the ladder, but do not migrate up to the spawning building to receive a tag (California Department of Water Resources 2021). These fish are returned to the river unmarked and are not included in the hatchery spring-run escapement estimate. In September, the FRFH opens the fish ladder again to collect broodstock spring-run. Hallprint-tagged fish are collected and spawned as spring-run broodstock. Tissue samples are also taken from spawned fish for genetic analyses. Hatchery trap count records have been kept since 1963.

Adult passage monitoring (proposed): To augment data collected during adult broodstock selection and enumeration, DWR proposes to install and operate a resistance board weir at RM 61 with four passage chutes mounted to boxes containing underwater video cameras to provide images of fish passing upstream and downstream through the weir. A small trap will be installed on the upstream side of the passage chutes to collect fish when turbidity levels are too high to record clear images of passing fish. Video of passing fish will be recorded and stored on external hard drives. Personnel will review the video and record data on salmonids, including counts, fork length, adipose fin presence/absence, time of passage, and potentially other data. The video monitoring will greatly improve the quantitative estimate of adult spring-run Chinook salmon entering the Low Flow Channel. This monitoring station will be operated year-round, but specifically from March through June to quantify adult spring-run in-river abundance. Data obtained from this monitoring program will be used to estimate spring-run upstream passage for each adult return year. DWR is currently in the planning and permitting stages for the installation of the monitoring station, with anticipated installation completed in late 2021.

Adult prespawn mortality surveys (existing): Boat surveys are conducted between the East Gridley Bridge (RM 51) and the Fish Barrier Dam (RM 67) in June through August (in most years) to find adult spring-run that have died prior to spawning. These surveys help determine pre-spawn mortality in spring-run Chinook salmon. Though sampling has varied over the years, in general when carcasses are encountered, biological data are recorded for each carcass, including the carcass condition, spawning status, adipose fin presence/absence, and presence of tags. Samples taken include

scales, otoliths, tissues for genetic analyses, and heads from adipose-clipped fish, from which CWTs are later extracted for analyses. This monitoring program has been conducted with varying levels of data collection since approximately 2005.

Adult spawner/redd surveys (existing): Spatial and temporally intensive redd surveys are conducted between Gateway Riffle (RM 59.7) and Table Mountain Riffle (RM 66.9) in the Low Flow Channel from September through December (September through October specific to spring-run). Redd surveys are also conducted in the High Flow Channel from Vance Riffle (RM 58.7) to Developing Riffle (RM 51.7). During surveys, crews map redds using a GPS to identify the number of successful spawning events. If a redd is mapped by foot, physical data (redd size, water depth, velocity, and substrate) are collected on every fifth or tenth redd based on time constraints (California Department of Water Resources 2018; California Department of Water Resources 2021). Physical data are not collected for redds observed by boat. Depths are measured at the head and pot of the redd. Velocity is measured at the head of the redd. Sediment size is estimated visually and categorized into five size groups (California Department of Water Resources 2018). Redd surveys have been conducted annually in the lower Feather River since 2008. DWR is planning to shift to drone aerial surveys in the future but will continue ground surveys until the new technology provides to be accurate and consistent.

Carcass surveys are conducted weekly by boat between the East Gridley Bridge (RM 51) and the Fish Barrier Dam (RM 67) between September and December. When carcasses are encountered with Hallprint tags (known as early running Chinook salmon, assumed to be spring-run), biological data are recorded for each carcass, including the carcass condition, spawning status, adipose fin presence/absence, and presence of tags. Samples taken include scales, tissue for future genetic analyses, and heads from adipose-clipped fish, from which CWT and otoliths are later extracted for analyses. Carcass surveys have been conducted annually since 2000, and data are used in annual egg-to-fry calculations.

Beginning in water year 2021, DWR is required by the 2020 SWP ITP to monitor redds in the High Flow Channel from September through November if thresholds 1 or 2 in the Water Transfer Monitoring Plan are met (California Department of Water Resources 2021). Threshold 1 is met if the Feather

River Water Operations Team deems monitoring is warranted. Threshold 2 is met if a Hallprint-tagged spawned female carcass is found in the High Flow Channel. DWR will collect fin clips of all fresh carcasses during the first six to eight weeks of the escapement survey for future genetic analysis to better understand spring-run and fall-run overlap in the High Flow Channel. Redd mapping will include redd size, water depth, velocity, and a characterization of the substrate (California Department of Water Resources 2021). Given the timing of when spawning occurs for spring-run in the Low Flow Channel (September-early October) and the near absence of spawning in the High Flow Channel at that time in most years, it is currently assumed that all spring-run spawn in the Low Flow Channel. However, some carcasses do drift into the high flow channel so efforts will be made (as described above) to monitor for spawning in the High Flow Channel.

Juvenile YOY production monitoring (existing): RSTs are used to evaluate trends in juvenile salmonid emigration timing and abundance in the lower Feather River. Currently, two RST monitoring stations are operated; one in the Low Flow Channel (RM 60.2, Eye Side Channel) and one in the High Flow Channel (RM 45.7, Herringer Riffle; Cook and Kindopp 2019). Both locations use RSTs with 8-foot diameter cones, with one trap operated at the Low Flow Channel station and two traps operated in tandem at the High Flow Channel station. The monitoring programs for both the Low Flow Channel and High Flow Channel have been conducted since 1998, with some changes in the actual trap location over the years (United States Fish and Wildlife Service 2010). For the Low Flow Channel, trapping has occurred at both the Eye Side Channel (RM 60.2) and Steep Riffle (RM 61). For the High Flow Channel, trapping has occurred at Herringer Riffle (RM 45.7), Live Oak (RM 42), and Sunset Pumps (RM 38). Multiple trap locations are needed because water operations created different flow regimes in the High Flow Channel and Low Flow Channel. DWR operates the Low Flow Channel for temperature management, and generally holds flows between 600 and 800 cubic feet per second, while the High Flow Channel may have flow fluctuations from 800 to 40,000 cubic feet per second or more (California Department of Water Resources 2019). The Low Flow Channel contains all the suitable spawning habitat for salmonids and has colder water temperatures than the High Flow Channel. Water in the High Flow Channel is warmed in Thermalito Afterbay and has higher rates of disease and pathogens when flows are insufficient to flush the system. Therefore, emigration cues, temperature, disease, survival, and species composition may differ between the two reaches.

Data collected by the existing RST program provide information on the temporal distribution, relative abundance, and run composition of YOY Chinook salmon and steelhead emigrating to the lower Feather River. The primary goals and objectives of the existing program are to (1) estimate egg-to-fry survival for Chinook salmon and calculate annual juvenile passage indices for Chinook salmon and steelhead, and (2) monitor, record, and compare movements of emigrating Chinook salmon and steelhead during specific environmental conditions (California Department of Water Resources 2019). Although the monitoring data exists to develop annual juvenile passage estimates for spring-run Chinook salmon, DWR does not currently report that data.

Sampling is conducted between December and June annually but may begin as early as November. Trap checks typically occur once per day but may occur multiple times a day to reduce the potential for fish mortality and to ensure traps are functioning properly. If numbers permit, all fish are counted and identified to species. When juvenile salmonids are highly abundant, a simple volume displacement method is used to count fish in increments of 1,000. Each day fork length is measured for up to 50 individuals of each salmonid species and up to 20 of each non-salmonid species. A subsample of natural origin fall-run-sized Chinook salmon is sacrificed (for a few months each season) for future analysis of *Ceratonova shasta* by USFWS. All measured Chinook salmon are assigned a run designation using the LAD tables from Greene (1992). For all salmonids measured, life stage is assigned (yolk-sac fry, fry, parr, silvery parr, or smolt) and the presence/absence of an adipose fin is recorded. Data are also recorded on environmental conditions (turbidity, water temperature, flow) and RST operations (sample period, cone revolutions, and trap condition) (California Department of Water Resources 2019).

Mark-recapture trials are conducted for both trapping locations to determine the efficiency of the RSTs in catching juvenile salmonids moving downstream in a given time period. Fall-run Chinook salmon are collected from each of the RST locations and are marked with a unique VIE tag corresponding to the release date and location and, in some cases, are stained with BBY stain to help with identification in the RSTs. Marked fish are released approximately 0.5 river miles upstream of the corresponding RST locations, with equal proportions released along each side of the river. Mark-recapture studies are generally conducted twice a week or more, depending on fish

availability, between December and May to calculate trap efficiencies. Trap efficiency data and raw catch data collected in RSTs are analyzed using models from the USFWS CAMP to develop passage estimates. Passage estimates are then used to develop egg-to-fry survival estimates based on the relationship of the number of spawned carcasses counted during adult surveys and the number of juveniles captured in the Low Flow Channel RST (California Department of Water Resources 2019).

Adult holding surveys (proposed): Adult holding surveys to count over-summering spring-run would likely use methods such as DIDSON. Visual observation such as snorkel surveys will not be effective in the areas where spring-run hold in the Feather River.

Juvenile YOY production monitoring (proposed): To augment the existing RST program and refine juvenile passage estimates further downstream in the lower Feather River, a new RST station is proposed at RM 17. This RST location was selected after conducting a site reconnaissance survey in May 2021 beginning at Feather River's confluence with the Sacramento River and extending to RM 17. RM 17 is located just below Star Bend boat launch, which is owned by Yuba County and provides access for deploying RSTs as well as boats. This location offers appropriate water depth and velocity and has low public access and use. Trap locations were also considered at RM 6 and RM 7. Both sites have suitable access through either Verona or Star Bend boat launches; however, RM 17 offered improved conditions for deployment and reduced public access to the RST.

Data collected by the proposed lower RST program will provide refined information on the temporal distribution, relative abundance, and run composition of juvenile Chinook salmon and steelhead, with a focus on spring-run, emigrating from the lower Feather River. This monitoring location can serve as a fixed point of comparison for lower Feather River catch and an estimate of spring-run entering the Sacramento River from both the Feather and Yuba rivers, and will provide a backup sampling location in case of a catastrophic event at the upper RST locations. The primary goals and objectives of the additional trap location are to (1) monitor, record, and compare movements of emigrating spring-run during specific environmental conditions, and (2) estimate emigrating spring-run numbers entering the Sacramento River from the lower Feather River. Data collected at this monitoring station may also be useful in providing early

warning of emigrating spring-run moving toward the Delta for real-time water operations of the SWP.

The proposed lower Feather River RST program will use paired RSTs with 8-foot diameter cones and will be operated similar to the Knights Landing and Tisdale monitoring programs. Sampling will be conducted with a condition-dependent approach to ensure quantitative and contiguous sampling across a large range of potential operational conditions (e.g., large fluctuations in flows, temperature, catch, and debris). The frequency of trap checks (daily, twice daily, or continuous) will be dictated by flow conditions and debris load. In some situations, environmental conditions or take concerns may necessitate half cone sampling, which uses modified RST cones to reduce sampling effort by 50%. Other sampling modifications due to large or unstable flows and/or debris loads may include implementing random subsampling time periods, fishing one cone instead of two, or sampling closer to the shore (California Department of Fish and Wildlife 2018).

Sampling will begin in late September or early October and continue through early June; however, sampling may begin slightly earlier if water temperatures are suitable for handling juvenile salmon. Prior to removal of debris and sampling of fish, the following environmental data will be collected: water temperature (continuous and instantaneous), velocity, turbidity, discharge, and water clarity. All fish sampled will be enumerated and identified to species. For salmonids, the following data will be recorded: presence/absence of an adipose fin, fork length, weight, life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt), and mortalities. All Chinook salmon will be identified to run based on LAD tables (Greene 1992). Tissue or opercule samples will also be taken from a subsample of Chinook salmon for later genetic analyses for the purpose of verifying run designation (California Department of Fish and Wildlife 2018).

Mark and recapture methods will be used to estimate capture efficiency to evaluate fish passage and develop estimates of abundance. Marking methodologies for trap efficiency studies will include VIE tags and BBY stain. Marked fish will be released approximately 1 mile upstream of the sampling site and the number of fish recaptured will be used to estimate capture efficiency. Efficiency studies will be conducted using trap-captured fall-run and late fall-run, as well as hatchery-raised fall-run and spring-run Chinook

salmon from the FRFH. Trap efficiency data will be applied to catch totals to produce run-specific passage estimates. Passage estimates will be generated for Chinook salmon using models developed by the USFWS CAMP, which calculates daily passage by dividing daily catch by a daily estimate of efficiency derived from efficiency trials conducted during the season (Julienne et al. 2020).

Juvenile rearing monitoring: Beach seine and snorkel monitoring is conducted annually to evaluate the size and distribution of naturally produced spring-run throughout the lower Feather River. Beach seining is conducted from January through September, depending on temperature, between the Fish Barrier Dam (RM 67) and Star Bend Boat Launch (RM 18). Snorkel surveys are conducted from February through September between the Fish Barrier Dam (RM 67) and Honcut Creek (RM 44) in the High Flow Channel. During beach seining, up to 50 individuals of each salmonid species and 20 of each non-salmonid species are measured to fork length. All salmonids greater than 40 mm are weighed. A subsample of natural origin and hatchery origin Chinook salmon are sacrificed for future analysis of *Ceratonova shasta* by USFWS. Data are also recorded on environmental conditions (substrate, cover type, mesohabitat, water temperature, weather) and seining conditions (time of haul, location, seine area). During snorkel surveys, biological data (estimated number of juveniles, estimated fork length, species) as well as environmental data (substrate, cover type, mesohabitat, depth of observation, water temperature, weather) are collected. This monitoring program has been conducted in all but four years since 1999.

Beginning in water year 2021, DWR is required by the 2020 SWP ITP to monitor juvenile stranding in the High Flow Channel from July through November if the Feather River Water Operations Team deems monitoring warranted as indicated in the Water Transfer Monitoring Plan (California Department of Water Resources 2021). If monitoring is warranted, stranding surveys will be conducted in ponds that are disconnected primarily in the upper 8 miles of the High Flow Channel. If existing RST monitoring or beach seining indicates spring-run presence further downstream, stranding surveys will extend to the confluence with the Yuba River (RM 27.5). If there are abrupt flow fluctuations in the Low Flow Channel, stranding surveys will be conducted in the entire length of the channel. Stranded ponds will be mapped with GPS and sampled to determine the length, width, and average

depth of the area. Visual observations will be conducted to determine the appropriate fish sampling method (beach seining, electrofishing, snorkeling). If temperatures are suitable and fish are in healthy condition, up to 50 salmonids will be measured, and all Chinook salmon will be identified to run based on LAD tables (Greene 1992), before being returned to the river (if authorized by CDFW and NMFS). If run designation of Chinook salmon is questionable, a tissue swab will be taken for future genetic analyses.

Mainstem Sacramento River and Delta Entry

Background/Spring-Run Chinook Salmon Timing

Juvenile spring-run can emigrate from their natal tributaries to the ocean as fry, parr, or smolts in the spring following emerging as YOY, or oversummer in their natal tributary or other suitable cold-water habitat in the Sacramento River network, and emigrate the following fall, winter, or spring as yearlings (California Department of Fish and Game 1998). Thus, the juvenile spring-run emigration period can extend from October through June, depending on the life history strategy of individual fish. YOY spring-run in the Sacramento River watershed typically emigrate soon after emergence as fry and rear for a few months in downstream habitats, such as the mainstem Sacramento River, accessible floodplains (e.g., Sutter or Yolo bypasses), or the Delta. YOY spring-run may also rear in their natal habitat and out-migrate as parr or smolts. Juvenile spring-run mark-recapture studies on Butte Creek suggest that rearing versus migratory behavior can be highly variable between individuals within the same brood year and across water years and that emigration cues can be both flow and temperature related. Specifically, mark-recapture studies in Butte Creek observed YOY spring-run residence times ranging from 67 to 113 days before fish entered the Sacramento River near the confluence with the Feather River (Hill and Webber 1999). Yearling spring-run may spend up to 17 months in freshwater habitat before emigrating to the ocean. Large numbers of yearling spring-run enter the Sacramento River from Mill and Deer creeks in October and November (Johnson and Merrick 2012). This diversity in juvenile life history expression and emigration timing in natal tributaries results in highly variable timing of juvenile spring-run entry into the Delta.

Existing RST monitoring programs at Knights Landing and Tisdale Weir on the lower Sacramento River (described below) in conjunction with the new RST proposed on the lower Feather River at RM 17 (see Feather River

section on page 47) will provide estimates of spring-run juveniles emigrating toward the Delta from the upper Sacramento River tributaries and the Feather and Yuba rivers, respectively. As part of the new Spring-Run JPE effort, an additional RST station will be installed on the lower Sacramento River downstream of all spring-run tributaries and just upstream of the legal boundary of the Delta to develop a direct estimate of juvenile spring-run entering the Delta from the lower Sacramento River.

Knights Landing and Tisdale Weir RSTs

CDFW's existing RST monitoring programs at Knights Landing and Tisdale Weir provide information on the temporal distribution, relative abundance, and run composition of juvenile Chinook salmon, and the temporal distribution and relative abundance of steelhead emigrating from the upper Sacramento River to the Delta. The primary goals and objectives of the juvenile salmonid monitoring program are to (1) provide early warning of emigrating listed salmonids moving toward the Delta so the Central Valley Project and SWP can modify water operations; (2) monitor, record, and compare movements of emigrating salmonids during specific environmental conditions; and (3) estimate emigrating salmonid numbers in the lower Sacramento River above the Delta (California Department of Fish and Wildlife 2018). Current (or proposed) RST monitoring in the upper Sacramento River tributaries (see Clear Creek, Battle Creek, Mill Creek, Deer Creek, and Butte Creek sections above) provide passage estimates of juvenile spring-run from those tributaries at the time of entry into the Sacramento River. Data from the Knights Landing and Tisdale Weir monitoring programs will provide additional information about those emigrating juvenile spring-run as they move downstream through the Sacramento River toward the Delta.

Since 1996, CDFW has operated RSTs near the town of Knights Landing (RM 88.5) to monitor juvenile salmonid emigration (Figure 9). Currently, this is the most downstream juvenile salmonid monitoring location in the mainstem Sacramento River, upstream of the Feather and American rivers. With its long-term dataset, the Knights Landing sampling location provides a fixed point of comparison for evaluating changes in emigration over time. In July 2010, juvenile salmonid emigrant monitoring was initiated at Tisdale Weir (RM 120) approximately 15 miles south of the town of Colusa in Sutter County and 31.5 river miles upstream of the Knights Landing RST (Figure 9). The Tisdale Weir monitoring location utilizes similar techniques to those

developed for the Knights Landing monitoring program. In conjunction with Knights Landing, catch data collected at Tisdale Weir helps to refine distributional and timing information and is useful in evaluating influences of Sacramento River flood control structures on salmonids. Additionally, the Tisdale Weir monitoring location serves as a fixed point of comparison for lower Sacramento River catch and provides a backup sampling location in case of a catastrophic event at Knights Landing (California Department of Fish and Wildlife 2018).

Both the Knights Landing and Tisdale monitoring programs use paired RSTs with 8-foot diameter cones. Sampling is conducted with a condition-dependent approach to ensure quantitative and contiguous sampling across a large range of potential operational conditions (e.g., large fluctuations in flows, temperature, catch, and debris). The frequency of trap checks (daily, twice daily, or continuous) are dictated by flow conditions and debris load. In some situations, environmental conditions or take concerns may necessitate half cone sampling, which utilizes modified RST cones to reduce sampling effort by 50%. Other sampling modifications due to large or unstable flows and/or debris loads include implementing random subsampling time periods, fishing one cone instead of two, or sampling closer to the shore (California Department of Fish and Wildlife 2018).

Generally, sampling begins in late September or early October and continues through early June. However, as has occurred in more recent years, sampling may begin in late August or earlier in September if water temperatures are suitable for handling juvenile salmonids (California Department of Fish and Wildlife 2018). Prior to removal of debris and sampling of fish, the following environmental data are collected: water temperature (continuous and instantaneous), velocity, turbidity, discharge, and water clarity. All fish sampled are enumerated and identified to species. For salmonids, the following data will be recorded: presence/absence of an adipose fin, fork length, weight, life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt), and mortalities. All Chinook salmon will be identified to run based on LAD tables (Greene 1992). Tissue or opercule samples will also be taken from a subsample of Chinook salmon for later genetic analyses for the purpose of verifying run designation (California Department of Fish and Wildlife 2018). A subsample of CWT Chinook salmon caught in the traps are euthanized for later CWT extraction and reading to determine hatchery origin (California Department of Fish and Wildlife 2018).

Mark and recapture methods are utilized at both sampling locations to estimate capture efficiency to evaluate fish passage and develop estimates of abundance. Marking methodologies for trap efficiency studies include VIE tags and BBY stain. Marked fish are released 1 mile upstream of the sampling site and the number of fish recaptured are used to estimate capture efficiency. Efficiency studies are conducted using trap captured fall-run or hatchery raised fall-run and late fall-run from CNFH (preferred). Trap efficiency data are applied to catch totals to produce run-specific passage estimates. Passage estimates are generated for Chinook salmon using models developed by the USFWS CAMP, which calculates daily passage by dividing daily catch by a daily estimate of efficiency derived from efficiency trials conducted during the season (Julienne et al. 2020).

Delta Entry RST

As described in the Science Plan, the Spring-Run JPE Core team proposes to operate a new RST monitoring program in the lower Sacramento River to develop a direct estimate of juvenile spring-run entering the Delta from natal tributaries of the Sacramento River. This estimate will be useful for calibrating JPE models and providing an estimate of YOY versus yearling production. Additionally, this monitoring station will be equipped with Juvenile Salmon Acoustic Telemetry System (JSATS) receivers to track acoustically tagged fish from survival studies (see the Juvenile Survival Monitoring section on page 63).

To provide an accurate estimate of juvenile spring-run production from the Sacramento River watershed, the location of the RST monitoring station must be located downstream of the confluence of the Sacramento and Feather rivers, and upstream of the Sacramento River confluence with the American River. Boat reconnaissance surveys were conducted on the Sacramento River between Verona Marina (RM 78.5) and approximately 1 mile downstream of the Interstate 5 Bridge (RM 69.5) to select a location for the new Delta Entry RST monitoring station in May 2021. The selected preferred location for the RST monitoring station is located at RM 75 on river left behind a wing dam (Figure 9). This location is relatively close to the Verona Marina and can be used to deploy traps and launch boats for trap checks, offers good shelter and accessibility for servicing the monitoring station, and provides appropriate water depth and velocity for trap operation. Although this location has moderate public access, the positioning of the wing dam reduces the amount of river anchor needed to secure the

RST to the shoreline, thus reducing potential navigational safety concerns. Other locations reviewed and considered (and documented as potential backup locations) include RM 78, which had similar features as RM 75 but required the river anchor to be set toward the middle of the channel, and the Interstate 5 Bridge, which would also require anchoring further into the active channel of the Sacramento River and may require attachment to the bridge. Additional locations were investigated in the survey area; however, they were eliminated due to safety concerns or lack of appropriate operational flow and/or depth.

The Delta Entry RST Monitoring Station will be operated similar to CDFW's existing RST monitoring programs at Knights Landing and Tisdale Weir. The monitoring station will consist of paired RSTs with 8-foot diameter cones. Originally, up to four RSTs were considered for the Delta Entry monitoring station; however, during the reconnaissance surveys, it was determined that none of the potential locations will accommodate functional operation of more than two traps (equivalent to the paired design used at Knights Landing and Tisdale). Trap sampling and the frequency of trap checks will be conducted using a condition-dependent approach to ensure quantitative and contiguous sampling across a large range of potential operational conditions (California Department of Fish and Wildlife 2018).

Sampling will be conducted annually, beginning in late September or early October, but potentially earlier (late August or early September) if water temperature is suitable for handling juvenile salmonids. All fish sampled will be enumerated and identified to species. For salmonids, the following data will be recorded: presence/absence of an adipose fin, fork length, weight, life stage classification (yolk-sac fry, fry, parr, silvery parr, or smolt), and mortalities. All Chinook salmon will be identified to run based on LAD tables (Greene 1992). Tissue or opercule samples will also be taken from a subsample of Chinook salmon for later genetic analyses for the purpose of verifying run designation (California Department of Fish and Wildlife 2018). A subsample of CWT Chinook salmon caught in the traps are euthanized for later CWT extraction and reading to determine hatchery origin (California Department of Fish and Wildlife 2018).

Mark and recapture methods will be used at the Delta Entry RST station to estimate capture efficiency to evaluate fish passage and develop estimates of abundance. Marking methodologies for trap efficiency studies will include

VIE tags and BBY stain. Marked fish will be released approximately 1 mile upstream of the sampling site and the number of fish recaptured will be used to estimate capture efficiency. Efficiency studies will be conducted using trap captured fall-run or hatchery raised fall-run and late fall-run Chinook salmon from CNFH (preferred). Trap efficiency data will be applied to catch totals to produce run-specific passage estimates. Passage estimates will be generated for Chinook salmon using models developed by the USFWS CAMP, which calculates daily passage by dividing daily catch by a daily estimate of efficiency derived from efficiency trials conducted during the season (Julienne et al. 2020). Analyses for the Delta Entry RST will be commensurate with those provided for Knights Landing and Tisdale for comparison purposes.

JUVENILE SURVIVAL MONITORING

In addition to life stage monitoring to inform initial JPE approaches, studies are needed to estimate survival of juveniles within tributaries prior to emigration as well as survival of emigrants through the Sacramento River to the point of Delta entry. Survival studies will consist of tag and release studies utilizing electronic tracking technology (e.g., passive integrated transponder [PIT] tags or acoustic telemetry) to monitor fish movement and migration (and potentially habitat use). Currently, ongoing survival studies using acoustic tags and receivers are conducted on Butte Creek and the Feather River. Additionally, an acoustic tag telemetry study was recently conducted on the Yuba River during spring 2021. These studies are summarized below and in the following pages, as well as new survival studies proposed during the research and development phase of the JPE.

Existing/Ongoing Juvenile Survival Studies

Butte Creek

CDFW in collaboration with NOAA, DWR, and Reclamation currently conduct ongoing pilot projects through Butte Creek and the Sutter Bypass evaluating the movement and survival of juvenile Chinook salmon to the Golden Gate Bridge (Cordoleani et al. 2019). This pilot project began in 2015 and utilizes a RST at Weir 2 (see Figure 6) to trap up to 200 emigrating smolts (fall-run and spring-run greater than 80 mm) between March and May. The RST at Weir 2 is used solely to collect juvenile Chinook salmon smolts for the ongoing acoustic telemetry study and is not used for juvenile Chinook salmon emigration monitoring. Juveniles are implanted with a JSATS

acoustic tag and released into the Sutter Bypass downstream of Weir 2. In addition to this study, CDFW currently implements acoustic tagging of smolts at Parrot-Phelan Diversion Dam RST and DST from May through June; however, sample sizes are relatively small (approximately 20–30) due to minimum fish size requirements for acoustic tagging. CDFW currently does not implement YOY or yearling specific survival studies but proposes adding studies using JSATS tags implanted in juvenile Chinook salmon (mid-September through June) at both the Parrot-Phelan Diversion Dam RST and DST (RM 44) and the proposed RST site at Maddock Road (RM 7).

Yuba River

During spring 2021, the RMT conducted a YOY survival study using JSATS tags and receivers in the lower Yuba River to (1) assess the efficacy of JSATS tagging methods as a means of conducting mark-recapture based survivorship studies on the lower Yuba River, (2) identify rates of survival as juvenile Chinook salmon traverse various reaches within the lower Yuba River, (3) analyze movement patterns of JSATS tagged fish released within the lower Yuba River, (4) identify presence of JSATS tagged fish in the lower Yuba River that were not initially tagged and released in the lower Yuba River, and (5) model these responses as a function of relevant predictor covariates (e.g., temperature, flow, etc.). The study area included 24 miles of lower Yuba River from just below Englebright Dam to the confluence with the Feather River, with a total of 16 receivers deployed throughout the study reach (eight upstream and eight downstream of DPD). Additional receivers were also installed in the north and south fish ladders at DPD and in the Hallwood/Cordua Diversion. Juvenile fall-run Chinook salmon from the FRFH were used as study fish and outfitted with JSATS tags. Tagged salmon were split into two groups of 200 and released on May 21, 2021, at two locations, approximately 11.4 miles upstream of DPD and immediately downstream of DPD. Ongoing data analyses for this study included estimating survival from both the upstream and downstream release locations using a single release mark-recapture model, assessing (dis)similarities in survival rates of tagged fish relative to predictor covariates, and evaluating movements patterns of juvenile salmon as they moved through the river.

Feather River

Currently, NMFS conducts survival studies on acoustically tagged hatchery spring-run (>85 mm FL) released from FRFH as well as hatchery spring-run captured in the RSTs (at Eye Side Channel and Herringer Riffle) and during

beach seine surveys. There are currently 12 receivers in the lower Feather River with additional receivers throughout the Sacramento River and Delta (Figure 10). To augment existing monitoring, DWR proposes to conduct survival studies for multiple life stages (YOY, smolt, and yearling) of spring-run using acoustically tagged natural origin and/or hatchery spring-run or fall-run (of similar size of spring-run) juveniles. These studies, coupled with trap efficiency studies at existing and proposed RSTs, could help identify areas of high mortality along the lower Feather River under different release conditions (e.g., fish size, location of release, time of day, flow, turbidity, etc.). There are currently five years of historical survival data (2008–2012) collected for YOY juveniles within the lower Feather River, multiple years of survival data for hatchery smolts (including proposed studies required in the draft FRFH's Hatchery Genetic Management Plan), and no historical survival data available for yearling spring-run.

Proposed Survival Studies

Clear, Battle, Mill, Deer, and Butte Creeks

Tributary survival monitoring: For Clear, Battle, Mill, Deer, and Butte creeks, primarily PIT tag technology will be utilized to evaluate tributary survival of spring-run prior to emigration. Juvenile survival studies using acoustic tagging technology are currently conducted on Butte Creek and the Yuba River as described in the Existing/Ongoing Juvenile Survival Studies section on page 64. Data from these studies may be useful for developing initial JPE approaches; however, these studies are/were conducted independent of the JPE process.

PIT tag technology is preferred for these studies because the size and quantity of emigrating spring-run available in these tributaries will not consistently provide an appropriate sample size for acoustic tagging studies. Generally, a minimum size of >80 mm FL is recommended when acoustically tagging salmonids. An acoustic study sample size will range from 200–400 fish depending on the tributary. During years in which the size and quantity of juvenile salmon is sufficient, an acoustic tagging study may be considered in lieu of a PIT tag study. Channel spanning PIT tag antenna arrays will be installed in each tributary near the confluence of the Sacramento River prior to tagging any fish. The antenna arrays will consist of paired antennas to determine the directional movement of fish in each tributary. Antennas will be calibrated monthly at minimum. Study fish (>60 mm) will be collected at

RST monitoring stations and PIT tagged using standard techniques. Study fish may include a mix of natural origin Chinook salmon runs (spring-run, fall-run, and late fall-run), as any run of natural origin juvenile Chinook salmon will be presumed to represent spring-run juvenile survival in lower reaches. In each tributary, approximately 100–300 fish will be tagged, the number depending on the tributary. If adequate numbers cannot be obtained, the use of supplementary fall-run or late fall-run from CNFH may be considered in some tributaries to provide an appropriate sample size for the studies. Fish will be tagged and released during the spring-run emigration period from October through June, with release timing targeted to mimic tributary-specific emigration timing. When fish pass through the arrays, the unique PIT tag number, antenna ID, and date and time of passage will be recorded on a data logger. Data recorded from the antenna system will be analyzed to determine the number of fish that passed through the antenna system (assumed emigration) and timing of emigration. This information can be used with juvenile passage estimates from the RST monitoring stations to estimate the number of fish that survived from the RST monitoring station to the confluence with the Sacramento River. Expected PIT tagging locations, antenna locations, the number of study fish, the run of study fish, and release periods for the PIT tag survival studies for each tributary are provided in Table 1.

Table 1 Expected PIT tagging location, antenna location(s), total number of study fish, run of study fish, and release period for the PIT tag survival studies in Clear, Battle, Mill, Deer, and Butte creeks.

Representative Stream	PIT Tagging location	Proposed Antenna Location	Total Number of Study Fish (approximate)	Race of Study Fish	Release Period
Clear Creek	Upper RST (RM 8.4)	RM 0.2 (passage monitoring video station)	100	spring, fall, late fall	November through June
Battle Creek	Upper RST (RM 6.2)	Near the confluence with the Sacramento River	100	spring, fall, late fall, CNFH fall and late fall	November through June
Mill Creek	RST (RM 2.9)	Near the confluence with the Sacramento River	100	spring, fall, late fall	October through June
Deer Creek	RST (RM 4.9)	Near the confluence with the Sacramento River	100	spring, fall, late fall	October through June
Butte Creek	Parrot-Phelan Diversion Dam RST/DST (RM 44)	2 arrays; 1 upstream and 1 downstream of the East and West borrow canals	300	spring-run, fall	September through June

Note: The run of fish used for the study will vary depending on the number and run of fish collected in each tributary. Existing PIT antennas are located in Clear Creek at RM 3.17, Battle Creek at RM 3.8, Mill Creek at RM 1.47, and Deer Creek at RM 5; however, installing antennas in each tributary at the confluence with the Sacramento River will provide more accurate data regarding the number of juveniles that survive to emigrate from the tributaries into the Sacramento River.

Survival to Delta entry: A new acoustic tagging study is proposed to evaluate survival of spring-run YOY parr and smolts emigrating from Clear, Battle, Mill, Deer, and Butte creeks through the Sacramento River to the Delta. Due to the limited availability of appropriately sized Chinook salmon within these tributaries for acoustic tagging and to minimize the impact on naturally produced populations, fall-run Chinook salmon produced at CNFH will be obtained for use in this study to represent emigrating spring-run. Fish will be acoustically tagged and released during the peak of the spring-run migration period for the respective tributaries, which, based on current and historic RST monitoring, is March through May. Fish will be released in quantities of approximately 100 in weekly intervals over a 12-week period. Quantities of fish may vary annual based on availability of appropriately sized fish for tagging. Release locations will be as close to each tributary confluence as possible. The timing of tributary-specific releases will reflect observed emigration timing of spring-run parr and smolts in each tributary.

This study will rely on existing acoustic receivers as well as newly installed receivers within the Sacramento River (Figure 10) downstream to the Delta to track fish movement and migration. New receivers will be installed strategically to augment the existing receiver array. For example, a new receiver will be installed at the new RST monitoring station on the lower Sacramento River at Delta Entry (RM 75). Data recorded from the acoustic array will be analyzed to determine the timing and number of fish that passed through the various receiver arrays. This information can be compared with release data to estimate the number of fish that survived from the release locations through the Sacramento River to Delta Entry. The acoustic survival data obtained from this study can be used to calculate overall annual in-river parr and smolt emigration survival to the Delta, as well as tributary specific emigration survival to the Delta.

NEXT STEPS

The JPE Core Team will continue to meet at least quarterly (usually monthly or more frequently) during the research and development phase to:

- Implement the steps of the SDM process that will be used to develop initial approaches to a Spring-Run JPE.
- Discuss progress of the subteams (Monitoring Coordination, Race Identification, Data Management, and Quantitative Modeling) to ensure that work on each subject area is coordinated.

- Review data obtained from new and ongoing monitoring programs.
- Review methods used to implement monitoring and recommend adjustments as appropriate.
- Request additional monitoring deemed necessary to complete a Spring-Run JPE.
- Recommend approaches to using the Spring-Run JPE and monitoring results as operational criteria to minimize take of spring-run as a result of Project operations.
- Evaluate the need to revise and update the monitoring plan to incorporate genetic testing of spring-run when it becomes available.

DWR, in collaboration with the JPE Core Team and the subteams, will review data collected from new and ongoing monitoring programs and special studies during the research and development phase and prepare a draft plan that describes the approach to calculating a Spring-Run JPE and the long-term monitoring needed to collect the data to calculate a Spring-Run JPE annually. The plan will be reviewed and finalized by DWR and the JPE Core Team and approved by CDFW prior to annual calculation of the Spring-Run JPE is initiated.

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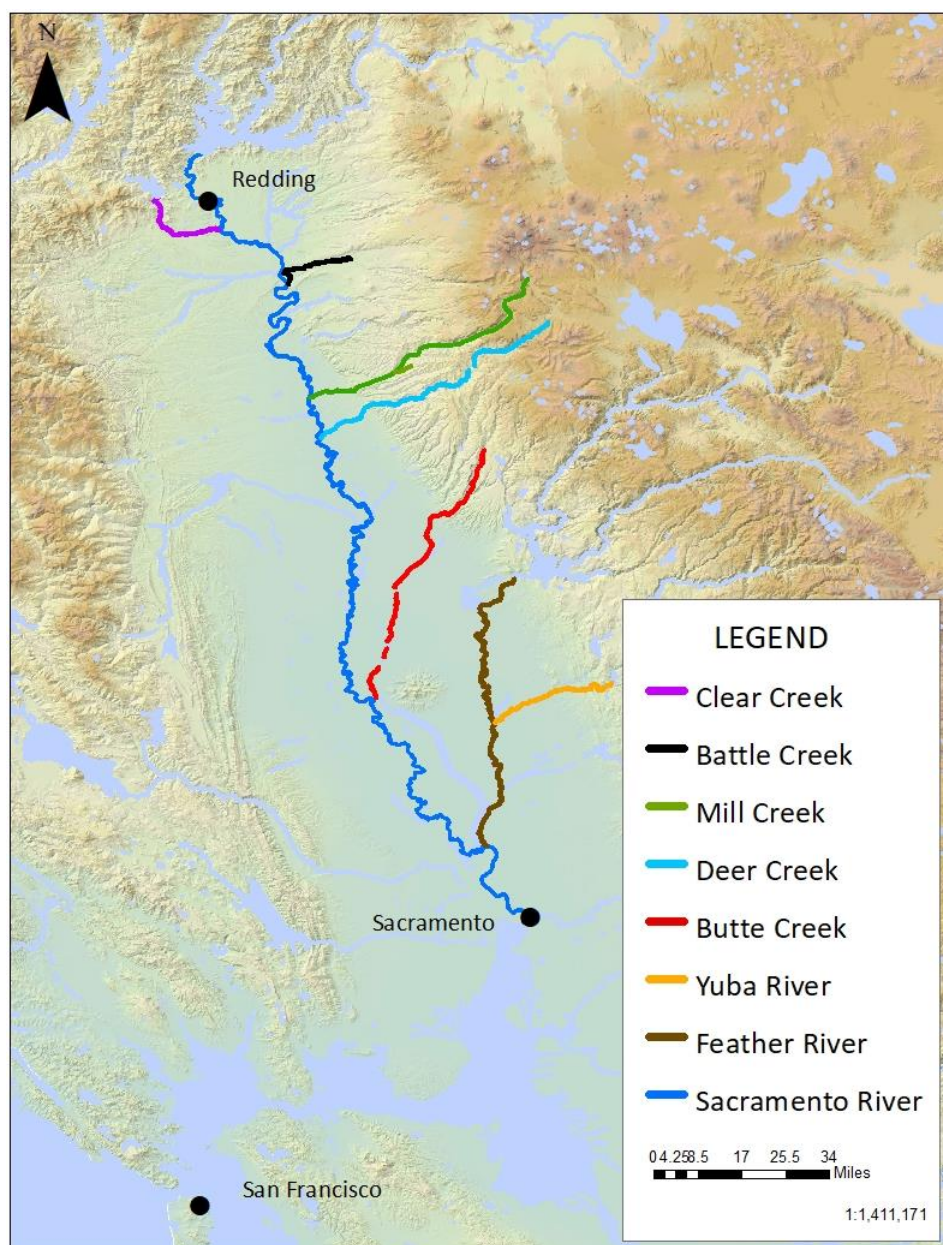
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FIGURES

Figure 1 Map of the Sacramento River and tributaries selected as representative streams for the development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate



Note: Representative streams include Clear Creek, Battle Creek, Mill Creek, Deer Creek, Butte Creek, the Yuba River, the Feather River, and the lower Sacramento River. Additionally, the lower Sacramento River downstream of the confluence with the Feather River was selected as the portion of the watershed to represent entry of juvenile spring-run Chinook salmon in the Delta.

Figure 2 Map of existing and adult and juvenile spring-run Chinook salmon monitoring locations on Clear Creek, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

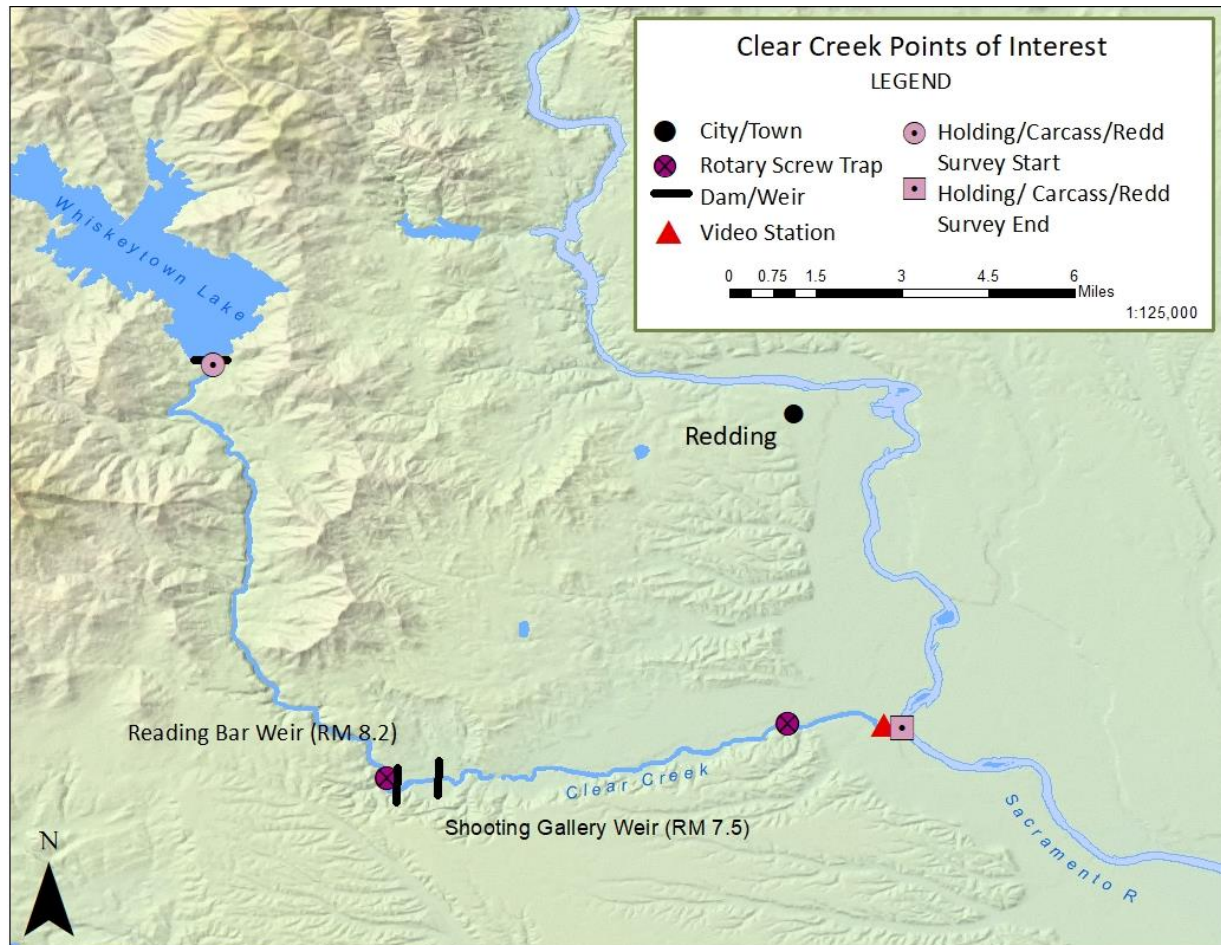


Figure 3 Map of existing and adult and juvenile spring-run Chinook salmon monitoring locations on Battle Creek, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

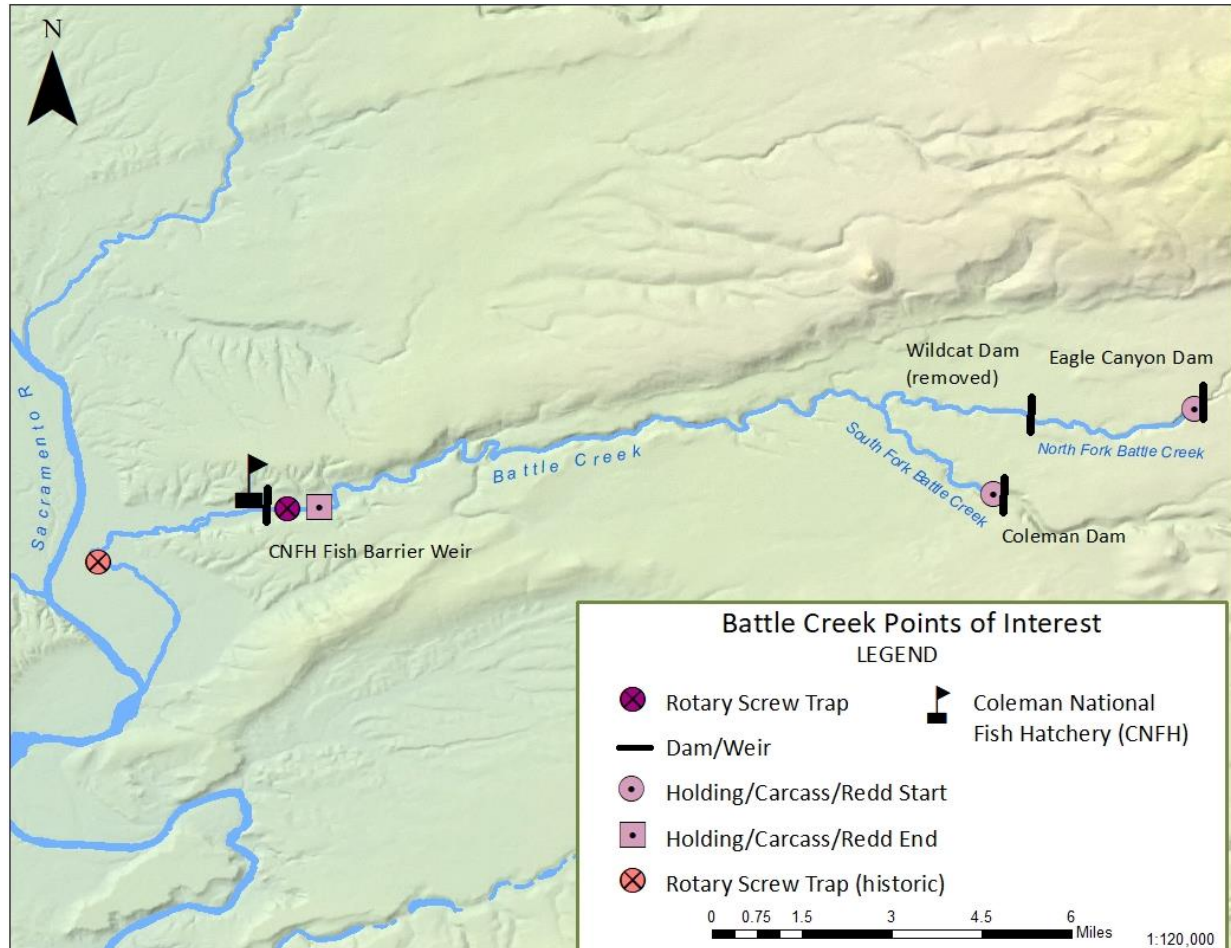


Figure 4 Map of existing and proposed adult and juvenile spring-run Chinook salmon monitoring locations on Mill Creek, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

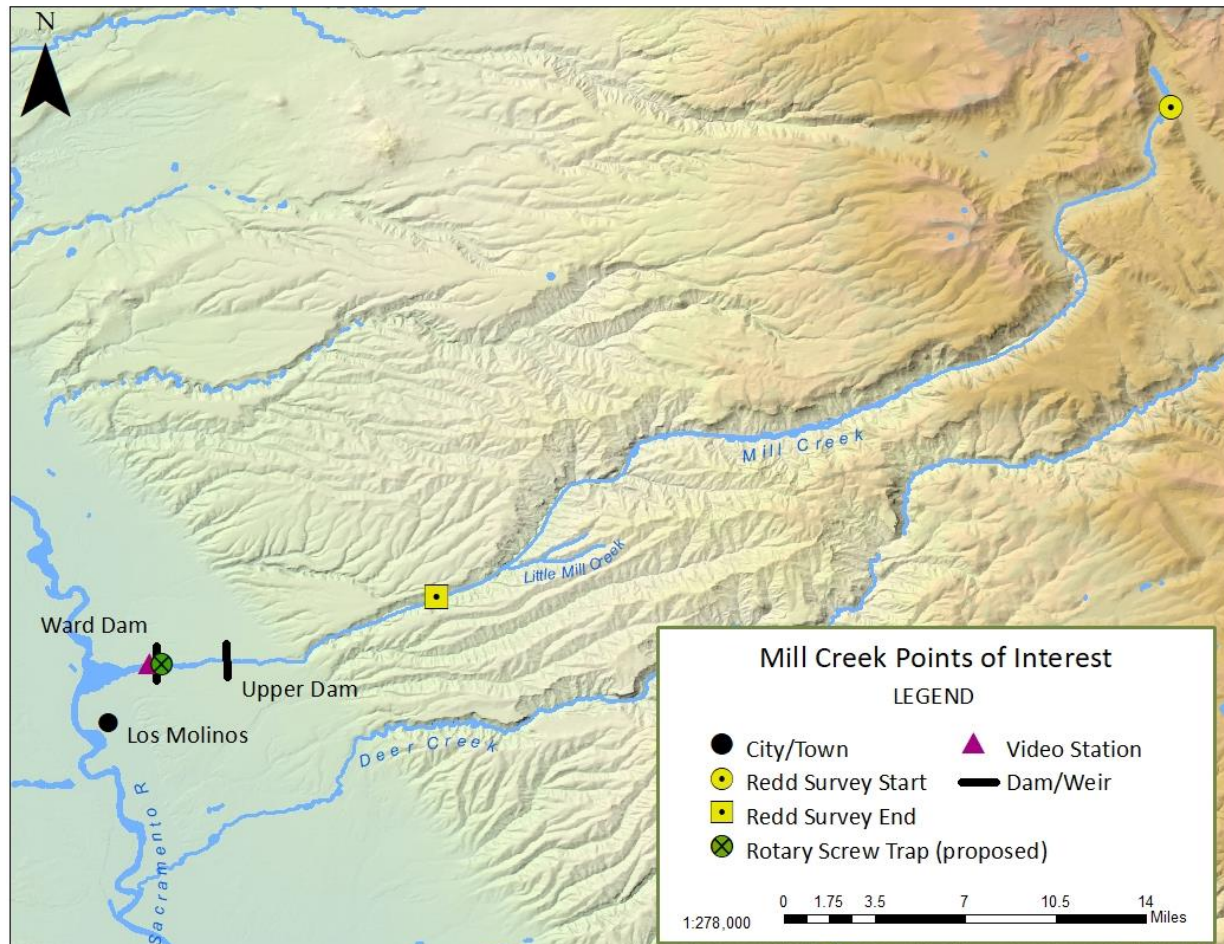


Figure 5 Map of existing and proposed adult and juvenile spring-run Chinook salmon monitoring locations on Deer Creek, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

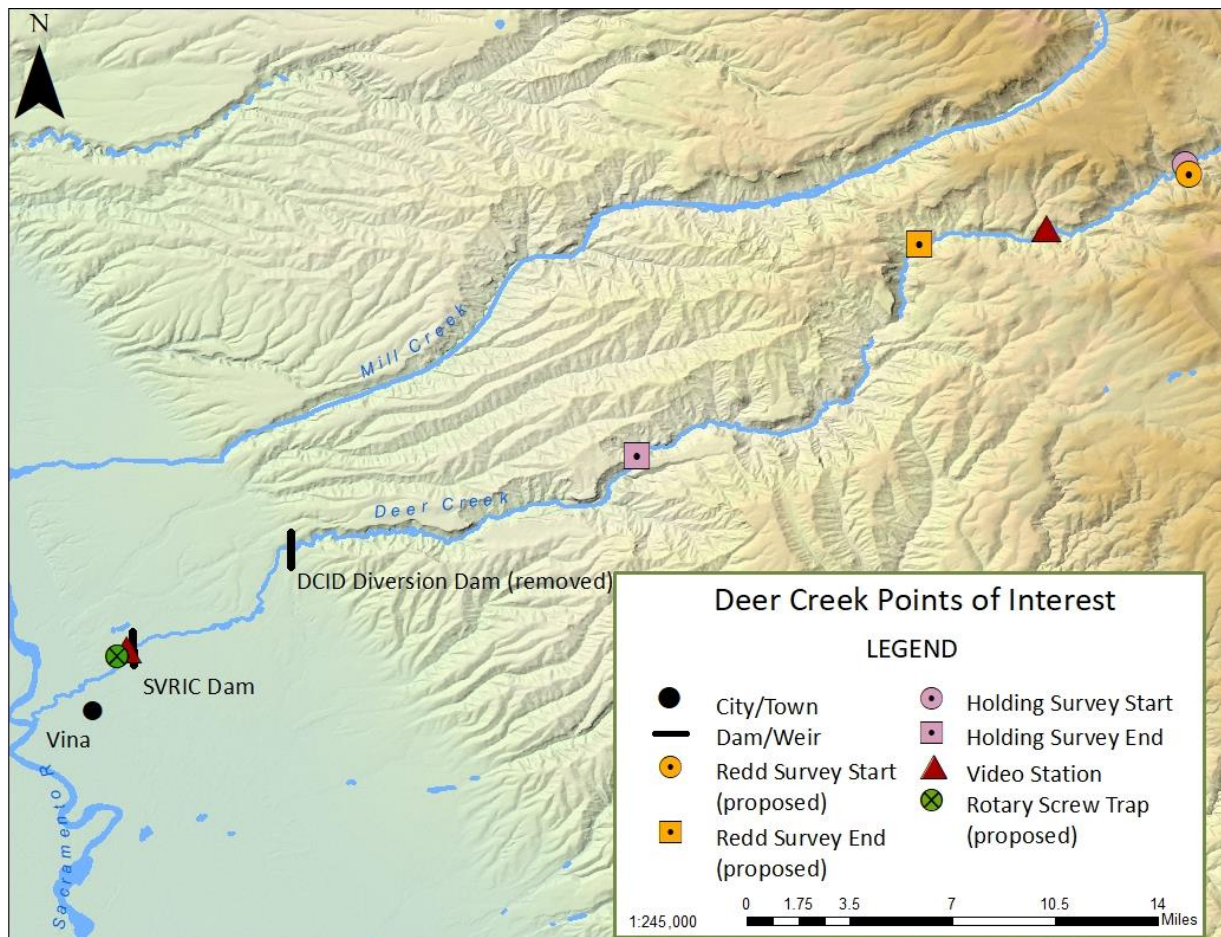


Figure 6 Map of existing and proposed adult and juvenile spring-run Chinook salmon monitoring locations on Butte Creek, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

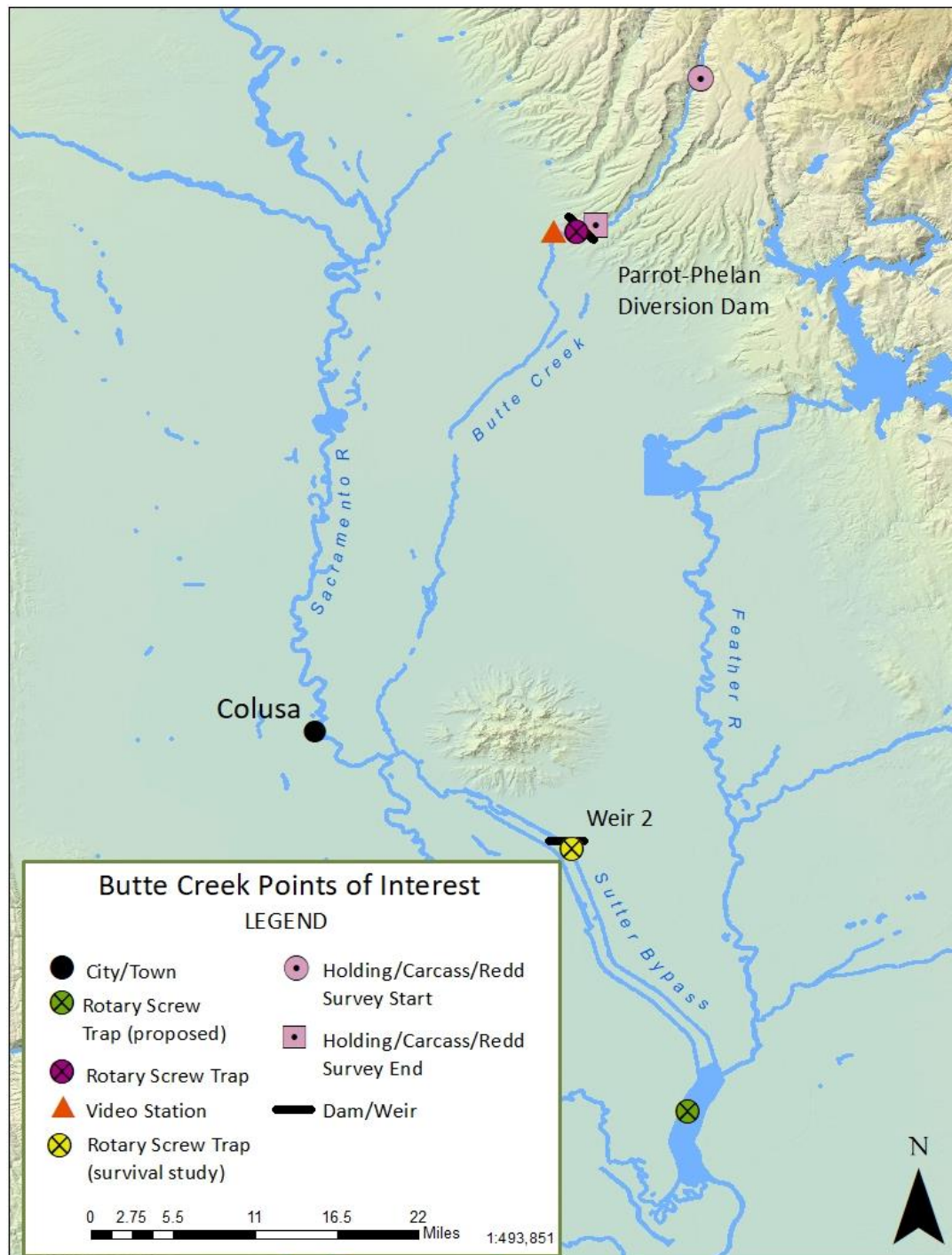


Figure 7 Map of existing and proposed adult and juvenile spring-run Chinook salmon monitoring locations on the Yuba River, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

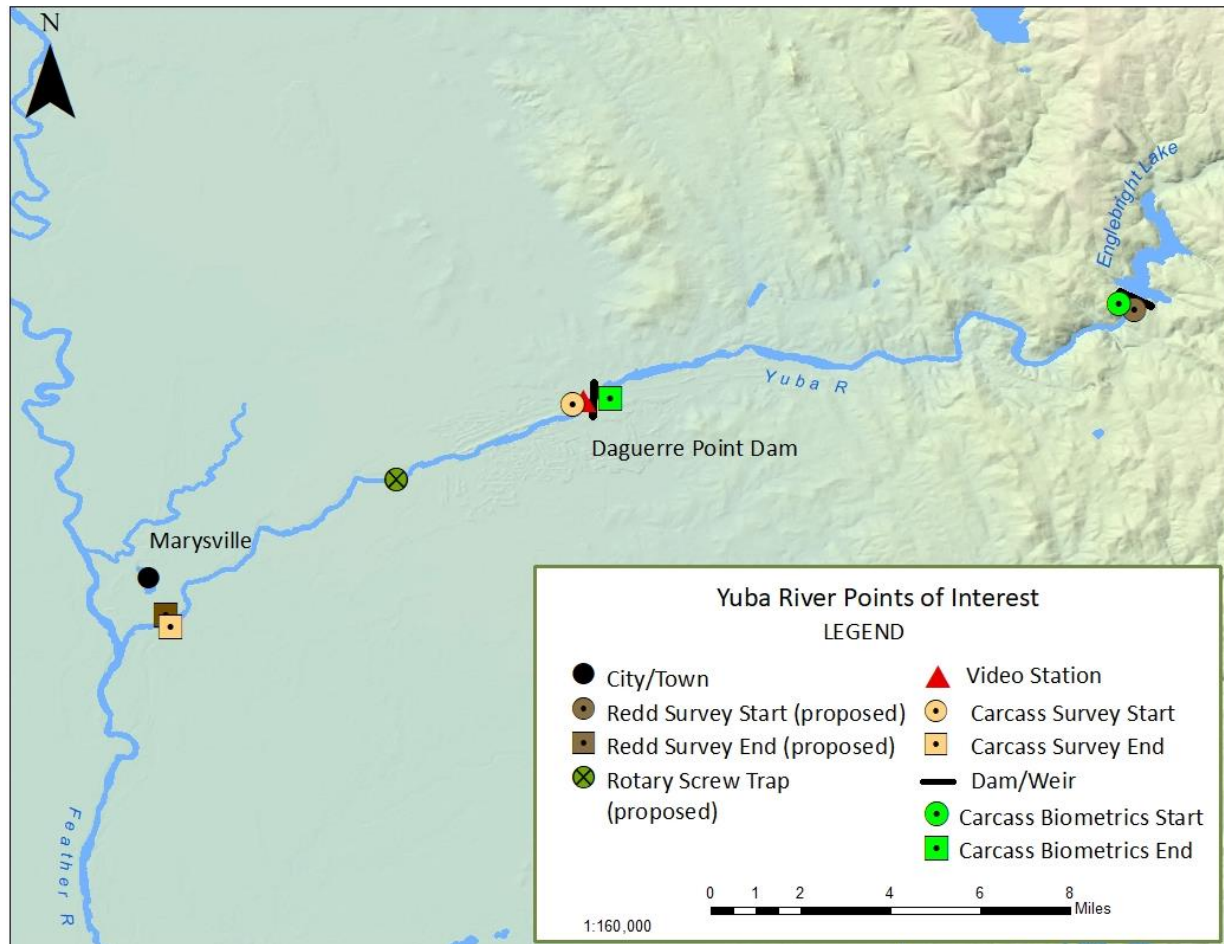


Figure 8 Map of existing and proposed adult and juvenile spring-run Chinook salmon monitoring locations on the Feather River, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

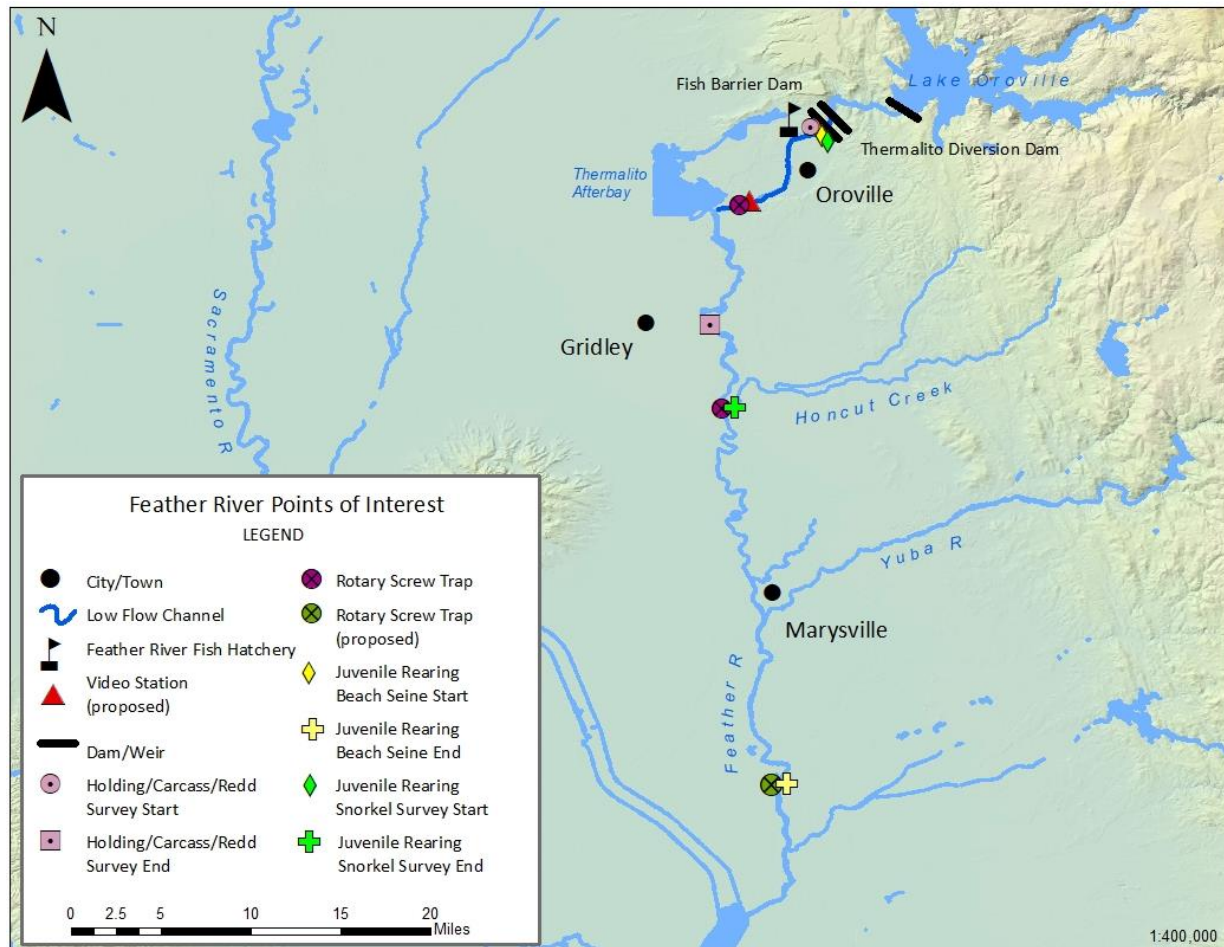


Figure 9 Map of existing and proposed juvenile spring-run Chinook salmon monitoring locations on the Sacramento River, including the lower Sacramento River and Delta Entry, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook Salmon Juvenile Production Estimate

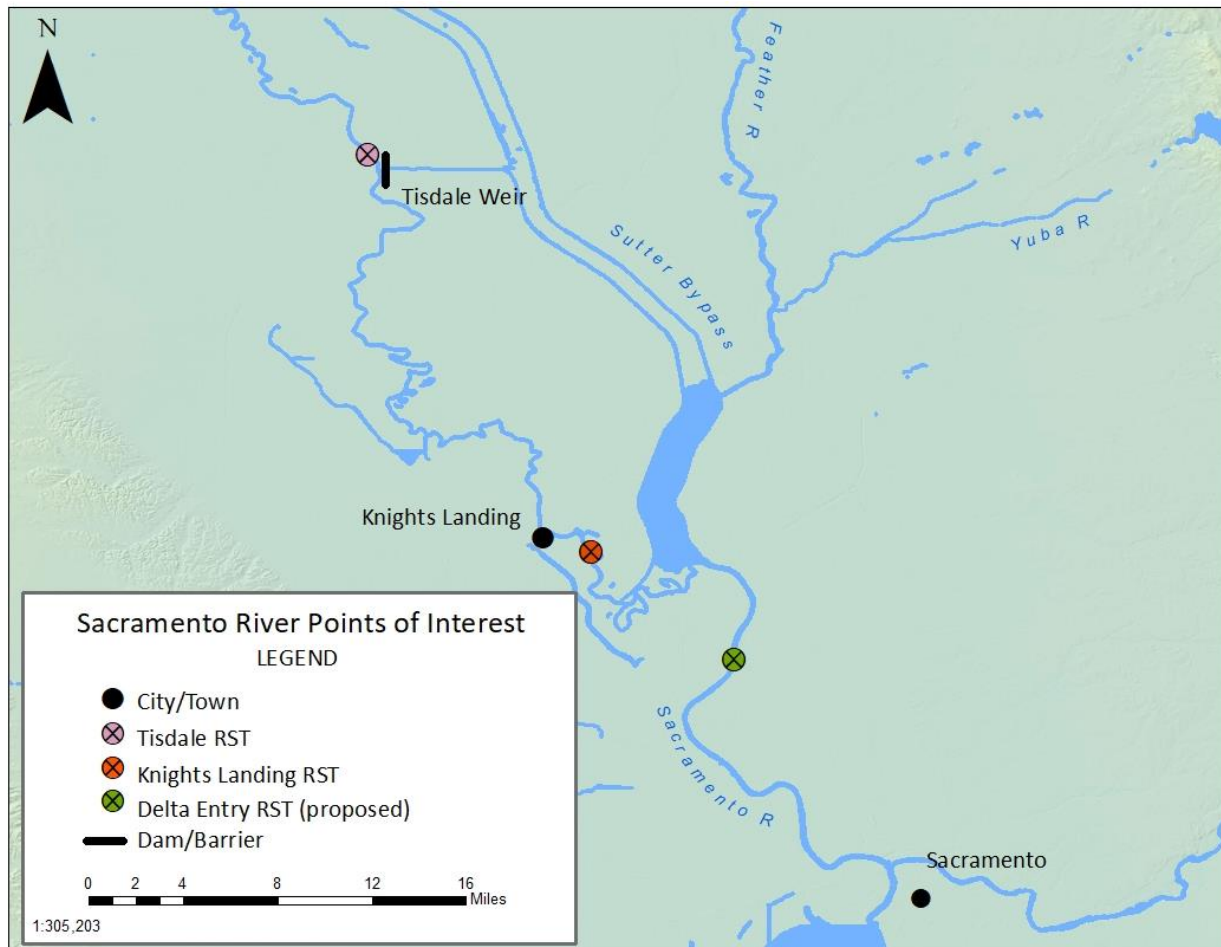
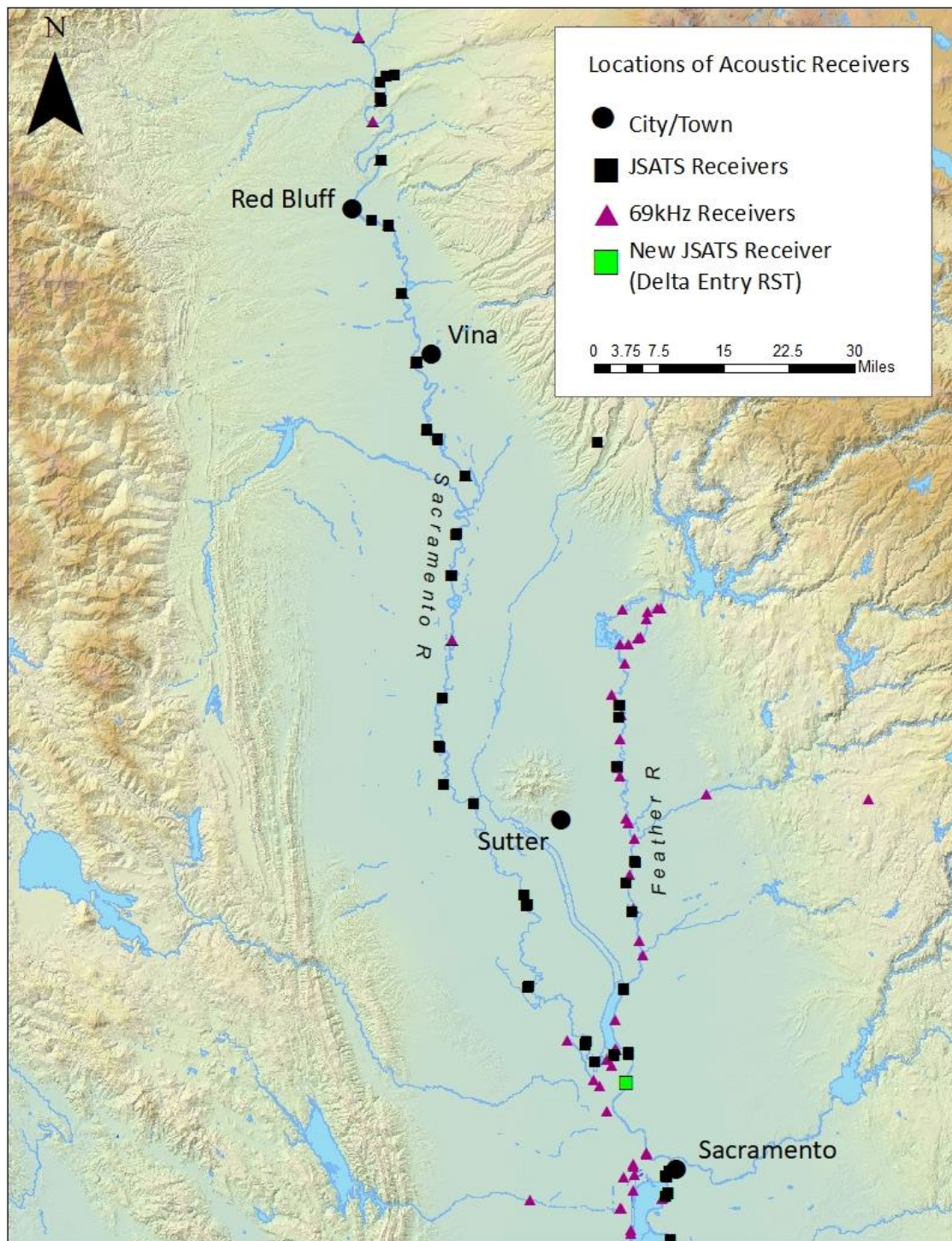


Figure 10 Map of existing and proposed locations of acoustic receivers in the Sacramento River watershed from the upper Sacramento River into the Delta



Note: These receivers will be used to track juvenile salmonids during existing and proposed survival studies, from which data will be used for development of initial approaches to a Sacramento River watershed spring-run Chinook salmon Juvenile Production Estimate.