Juvenile Spring-Run Chinook Salmon Production and Emigration in the San Joaquin River Restoration Area

2018–19 Monitoring and Analysis

SAN JOAQUIN RIVER
RESTORATION PROGRAM

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Self-Certification of Peer Review

This report has been peer reviewed by the following two individuals, at least one of whom is from outside my work group:

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I certify that, to my best knowledge, these two individuals are qualified to review this work, and that they have peer reviewed this report.

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PI Signature

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1.0 Introduction

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit challenging the renewal of long-term water service contracts between the United States and the Central Valley Project Friant Division Long-Term Contractors. After more than 18 years of litigation of this lawsuit, known as NRDC et al. vs. Rodgers et al., 2006, a stipulation of the settlement (Settlement) was reached. The Settlement establishes two primary goals: (1) Restoration—to restore and maintain fish populations in "good condition" in the mainstem San Joaquin River (SJR) below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish and (2) Water Management—to reduce or avoid adverse water supply impacts on all of the Friant Division long-term contractors that may result from the Interim and Restoration Flows provided for in the Settlement.

The Settlement, though, does not define the process for restoring and maintaining fish populations. The Fisheries Framework was developed to provide a criterion for goals and objectives relating to this process (SJRRP 2018). Within the Framework, stressors are identified, and a plan is provided for reducing these stressors to produce self-sustaining populations of fall-run and spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) in the Restoration Area. Rotary screw trap (RST) monitoring of juvenile salmon permits evaluation of these criteria.

Juvenile migration success has been posited as one limiting factor for sustaining spring-run and fall-run Chinook Salmon in the Restoration Area (SJRRP 2018). Since salmon have been extirpated from the area following the construction of Friant Dam in the 1940s, limited data are available regarding juvenile Chinook Salmon emigration, timing, and survival prior to recent reintroduction efforts (e.g., adult trap and haul, juvenile releases, and broodstock releases). The 2017–18 season was the first full year of study efforts to evaluate movements of juvenile spring-run Chinook Salmon. Prior to that, juvenile tracking and monitoring efforts were limited to fall-run Chinook Salmon (Hueth et al. 2017; Sutphin et al. 2018). During summer 2018, 179 (120 males and 59 females) spring-run adult broodstock were released into Reach 1 following rearing efforts at the Interim Salmon Conservation and Research Facility (hereafter, referred to as SCARF) located in Friant, California (Durkacz et al. 2019). Following adult spawning in fall 2018, downstream juvenile presence, distribution, and abundance were monitored late 2018–late spring/early summer 2019.

Data collected through these activities provides information regarding juvenile spring-run Chinook Salmon production, temporal distribution, and survival, and will assist management in comparing current conditions against criteria in the Fisheries Framework. In turn, this will help to determine whether future restoration efforts are appropriate or need to be adjusted to meet the conditions of the Settlement.

1.1 Objectives

The following objectives are intended to provide data regarding the juvenile life stage of spring-run Chinook Salmon following redd emergence. Specifically, they should provide data to help evaluate criteria identified in the Fisheries Framework for spring-run Chinook Salmon at the juvenile life-stage—including fry-to-smolt survival rates, juvenile production, and annual spawners contributing to production (SJRRP 2018). Efforts herein will help to gauge how current river conditions support juvenile spring-run Chinook Salmon in the Restoration Area. Information from the following objectives will assist SJRRP management with decisions regarding continued restoration activities. The objectives are:

1) Estimate production of juvenile spring-run Chinook Salmon from the spawning grounds in Reach 1.

2) Evaluate survival of juvenile spring-run Chinook Salmon through the Restoration Area.

3) Determine timing of juvenile salmon emigration through Reach 1 of the Restoration Area.

4) Identify factors that may influence Objectives 1–3 (e.g., flow, temperature, fish size).

5) Quantify spawning adult salmon contributing to progeny in the Restoration Area via genetic analyses.

2.0 Materials and Methods

2.1 Study Sites and Schedule

Rotary screw traps are frequently used to monitor juvenile salmon movements and estimate production (Thedinga et al. 1994; Volkhardt et al. 2007; Pilger et al. 2019). Rotary screw traps (2.4-m diameter) were placed at four locations in Reach 1 (Figure 1) and 2 of the Restoration Area: Owl Hollow (RM 259), Sycamore Island (RM 252), Highway 99 (Hwy 99; RM 243), and San Mateo crossing (RM 212). Trap placement was contingent upon site accessibility and suitability as well as redd locations in the river. Proper trap operation requires adequate water depth to allow unimpeded rotation of the RST cone and enough flow to physically rotate the cone. Traps were placed in the thalweg to maximize the volume of water sampled. For production estimates, ideal placement of RSTs is at the downstream extent of the spawning area (Volkhardt et al. 2007); screw traps interspersed between redds allow for estimates of survival and site-specific production rates within the spawning area. During fall 2018 survey efforts, 42 spring-run Chinook Salmon redds were detected (Durkacz et al. 2019). The Hwy 99 RST was placed downstream of all observed redds. The RST at San Mateo Crossing was selected because this location provided the greatest distance from Hwy 99 to allow survival estimates while being upstream of significant impediments to fish movement (e.g., Mendota Dam and Sack Dam).

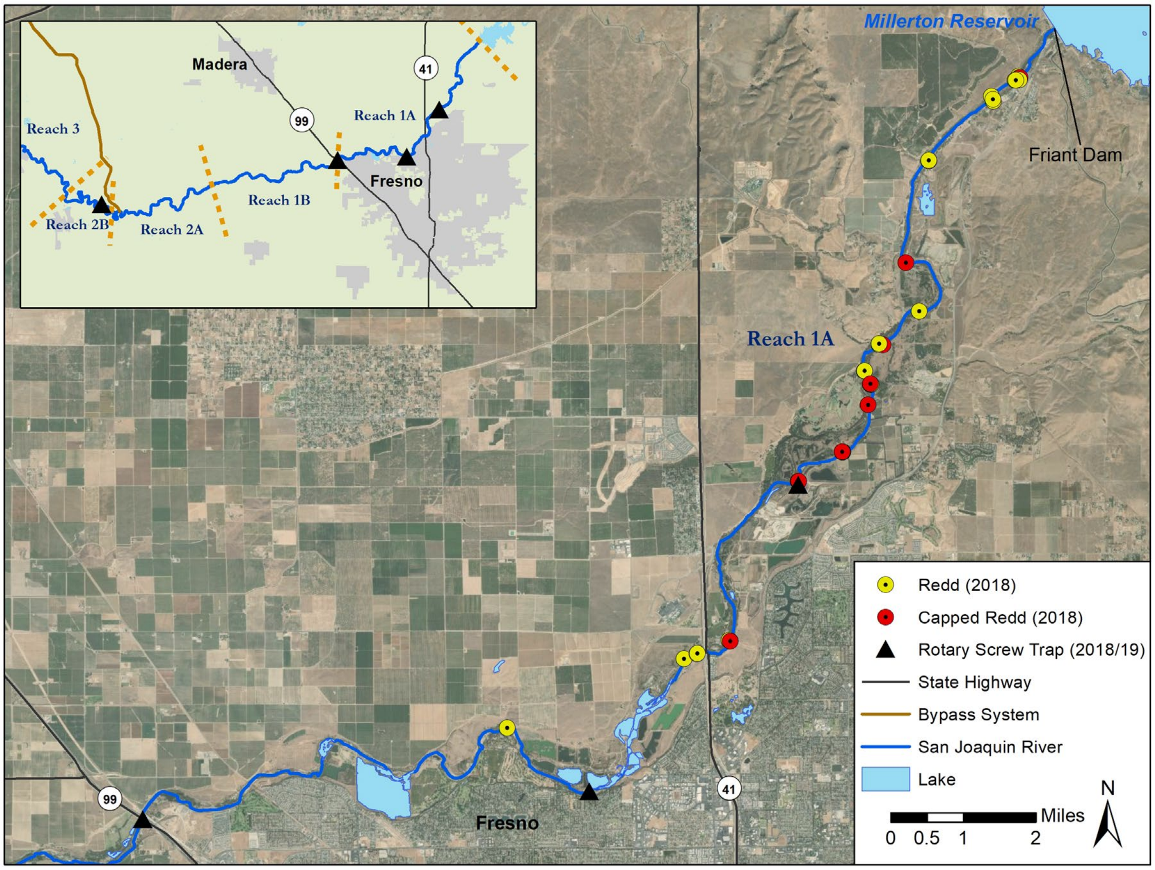

Figure 1.—Recorded salmon redds and rotary screw trap locations (San Mateo rotary screw trap in Reach 2 indicated in inset map). Map provided by Andrew Minks, Bureau of Reclamation, Sacramento, California.

Periods of trap operation are listed in Table 1. At the RST locations in Reach 1, traps were operated beginning mid-November. The San Mateo RST was placed in the fishing position mid-December, prior to commencing efficiency releases—the first salmon was captured at Hwy 99 on February 6, also suggesting fishing the San Mateo RST prior to this was not necessary (i.e., since no fish were captured at Hwy 99, this suggests salmon were not yet moving out of Reach 1). The Owl Hollow and Sycamore Island RSTs were removed mid-March due to safety concerns pertaining to high flows (Figure 2). The San Mateo RST was removed following an extended period without wild salmon capture. The Hwy 99 RST was removed prior to an extended period of higher flow releases beginning late-May 2019 (Figure 2).

Table 1.—Sampling dates for rotary screw trap (RST) locations during 2018–19 sampling season.

RST Site:	Start:	Stop:
Owl Hollow	11/16/2018	3/16/2019
Sycamore Island	11/16/2018	3/15/2019
Hwy 99	11/16/2018	5/21/2019
San Mateo	12/13/2018	4/30/2019

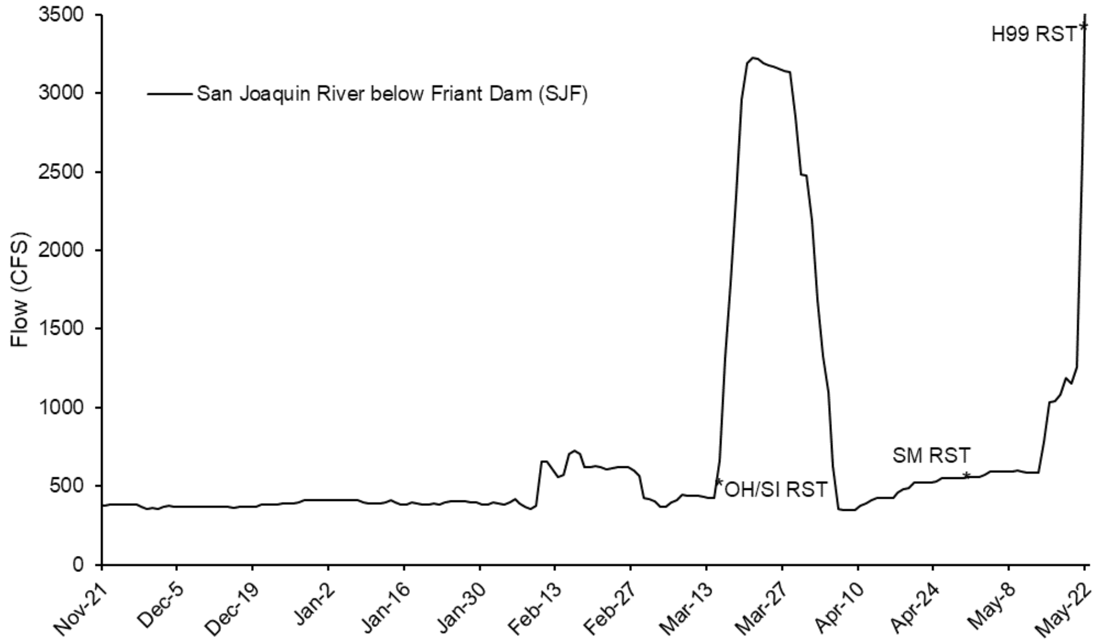

Figure 2.—Flows in the San Joaquin River (San Joaquin River Below Friant Dam station [SJF]) during the 2018–19 sampling season. Asterisks indicate removal of indicated rotary screw traps: OH=Owl Hollow, SI=Sycamore Island, SM=San Mateo, H99=Highway 99.

2.2 Trap Placement and Operation

At all but the San Mateo location, each RST was secured with a 13-mm (1/2-in.) wire rope affixed high enough above the water surface to allow for recreational river usage (e.g., kayakers, fishermen). Affixed to the highline was a snatch block that permitted lateral positioning of the RST for optimal operation. The RST was attached to the snatch block with two 10-mm (3/8-in.) wire ropes—one connected to the front of each RST pontoon. Two additional 10 mm (3/8 in.) wire ropes connected to the snatch block were secured on either side to the high line using wire rope clips that prevented lateral movement after the RST was suitably located. These also allowed for repositioning the screw trap from the shoreline after loosening the clamps from each side. Buoys and lights placed up and downstream of each RST alerted recreationalists to its presence. Figure 3 illustrates the installed Owl Hollow RST in operation. Site conditions at the San Mateo RST location were such that the trap could be located adjacent to the river margin, allowing the wire ropes to be situated at water level on only one side of the river (no high line needed).

Figure 3.—Owl Hollow rotary screw trap attached to high line wire rope via snatch block (not visible) and smaller diameter wire ropes (made apparent to recreationalists using pink flagging). Lateral rope, connected to shoreline, on downstream side of trap prevents excessive swaying.

Following installation, traps were lowered into the fishing position. They were checked daily for proper operation and to remove captured fish. Site conditions were recorded, including trap operation (i.e., rotating or not), temperature, dissolved oxygen, and turbidity. Debris loads were categorically annotated (low, medium, high) based on the proportion of the live well filled with debris (no debris to one-third full, one- to two-thirds full, and more than two-thirds full, respectively) and subsequently cleared. Traps were scrubbed as necessary to remove accumulated algae/debris. Captured fish were enumerated and processed (see *Fish Processing* below) and released downstream of the RST. When any of the RSTs could not be checked in a 24-hour period (e.g., flood releases exceeding safe operation), personnel raised and secured the cone in the non-fishing position until safe operation could resume.

2.3 Fish Processing

Fish were removed daily during RST checks. All captured fish were typically identified to species and recorded—bycatch were enumerated and measured to total length (TL; nearest mm). In cases where large numbers of any one species were captured, a subsample of 20 fish were measured for length, and the remaining fish counted. In some cases, small fish (e.g., young-of-year *Micropterus* and cyprinid spp.) were identified to family or genus. Bycatch are not discussed within the body of this report, but data are available in Appendix A.

Salmon were anesthetized in a solution of 40–60 mg/L MS-222 (tricaine methanesulfonate) before processing. Wild fish were differentiated from efficiency fish (see *Efficiency Tests* section below) by the presence of an adipose fin and lack of identifying marks. They were measured for fork (FL;mm) and total length (TL; mm), weighed (nearest 0.1 g), and a tissue sample was collected from the caudal fin for genetic analysis. Salmon were classified as yolk-sac fry, fry, parr, smolt, or yearling based on criteria in Volkhardt et al. (2005); Cramer Fish Sciences (CFS 2014) provides a Smolt Index Protocol that further elaborates on this differentiation and the RST protocol (USFWS 2008) includes a visual representation of fish within each age class. Anesthetized fish were allowed recovery time in a bucket of fresh water prior to release. After processing, bycatch and salmon were released downstream of the RST. Salmon were carried in the recovery bucket approximately 30 meters downstream of traps before release, with the aim of ensuring such fish were not recaptured at the same location. However, *post hoc* genetic analysis permits the opportunity to reveal potential recaptures at RST locations (see *Genetic Analyses* under the *Analyses* section below).

2.4 Efficiency Tests

Efficiency tests were completed multiple times, at varying intervals, for each RST during the 2018–19 sampling season. Catch rates of wild salmon were anticipated to be insufficient to conduct efficiency tests following the CAMP protocol (USFWS 2008), because of the limited number of spawning broodstock. For that reason, hatchery fish (spring-run Chinook Salmon, reared at the SCARF) were used to conduct efficiency tests. All hatchery fish in the Restoration Area are required to be coded wire tagged before being released, and fish were required to be a minimum of 55 mm FL for coded wire tagging. Resultantly, efficiency tests could not commence until late January during the 2018–19 season when hatchery fish were sufficient size for tagging.

Efficiency tests were typically conducted at each RST location every 1–2 weeks. For each trap, 11–16 groups of 600 fish (nominal) were released through May 2019. Calibration protocols for estimating production of salmon in the Central Valley indicate that enough fish be used so trap efficiency estimates not be altered by more than five percent for each additional salmon captured (USFWS 2008). Though group sizes of 600 fish exceed this metric (each recaptured fish would represent one-sixth of 1 percent), these larger group sizes also help estimate survival to downstream RSTs. Limiting fish to smaller release group-sizes could preclude the ability to evaluate this metric as the total fish captured at downstream traps is limited by trap efficiency, and loss over time (i.e., mortality). The intent of these staged releases was to evaluate trap efficiency at each RST with increasing fish size and varying environmental conditions during the sampling season (Carlson et al. 1998; Volkhardt et al. 2007). While the Owl Hollow and Sycamore Island RSTs were removed mid-March due to high flow conditions, marked fish were still released at these locations to estimate downstream movement and survival.

Groups of fish for each release were marked using a needle-free, CO_2-powered injector (NEWWEST Technologies, LLC., Santa Rosa, CA). Replicate groups were uniquely colored and marked (Figure 4). Tag color was provided by using tattoo ink, strained to remove sediment, and diluted 12-to-1 with distilled water. By varying the color and fin combinations across RSTs and release date, staff could ascribe recaptured fish to specific releases. A subsample of 100 fish/release site replicate were measured (FL/TL [mm];

weight [g]) to describe morphometrics of each group. Fish were size-graded prior to marking, and the size variation was limited to no more than 10–15 mm for each release group. Fish were typically given a 72-h recovery period prior to release.

Figure 4.—Example of hatchery-reared, marked spring-run Chinook Salmon *(Oncorhynchus tshawytscha*) used for rotary screw trap efficiency tests.

Fish were released upstream of the RSTs, with the intent to allow fish to distribute across the river as they typically would, but near enough where other factors (e.g., predation) would not affect the number making it to the location of the RST—generally, this is recommended as 400–800 m upstream of the RST (USFWS 2008). Additionally, fish were subdivided into groups and released over an hour's duration at varying locations across a single transect perpendicular to the flow, to reduce schooling of the entire batch. Published protocols suggest that releases be staged across the diel period to incorporate any temporal bias of typical migration times (Volkhardt et al. 2005; USFWS 2008). However, Tattam et al. (2013) found a significant difference in the estimate of efficiency between fish released during daylight hours and naturally migrating fish, but not between fish released during civil twilight and naturally migrating fish. Therefore, fish releases were started an hour before sunset with the intent to have all fish in the water by that time.

Rotary screw traps were checked two hours following each release to limit overcrowding in the live well overnight. For salmon with an observable mark, staff recorded the location/color of the mark. In the event of the colored mark fading beyond recognition, a missing (clipped) adipose fin was used to indicate hatchery origin. This information was recorded but these fish were not included in overall efficiency estimates since they could not be attributed to specific releases. Following initial efficiency testing, all salmon subsequently captured the remainder of the field season were checked for the presence of a colored mark. The remainder of the processing and release procedures were like those for wild salmon and are outlined in the *Fish Processing* section above (though no tissue samples were collected from efficiency release fish).

2.5 Analyses

Genetic Analyses—The Southwest Fisheries Science Center Santa Cruz Laboratory received 450 tissue samples from juvenile Chinook Salmon captured in RSTs from the San Joaquin River. Using standard laboratory protocols, DNA was extracted, and individuals genotyped with the set of 96 single-nucleotide polymorphism (SNP) markers that has been employed throughout the project to date. Importantly, this set of loci has been used to genotype all SCARF broodstock individuals, their progenitors at the Feather River Hatchery, and a comprehensive baseline of Central Valley and other Chinook Salmon populations. This allows both parentage-based analyses as well as stock identification and traditional population genetic analyses.

Analysis of these samples proceeded incrementally. Duplicate genotypes, analogous to recaptures in a mark-recapture framework, were first identified. Data were analyzed to evaluate potential growth rates of these recaptured fish. With respect to all tissue samples collected, it was determined that some of the captured salmon were not offspring of the spring-run broodstock released into the system. An attempt was made to assign these juvenile fish to multiple pools of adults, both those known in the system, and others potentially contributing offspring to juvenile production—potential parents included SCARF captive broodstock adults and broodstock from the Feather River Hatchery (the source of SCARF broodstock and their siblings). For juveniles sampled in the RSTs that were not assigned to two parents, an alternative analysis technique was employed (COLONY software; Jones and Wang 2010) that allows for identification of single parents, when only one has been sampled, and the *de novo* assembly of full-sibling groups by inferring the genotypes of unsampled parents.

Rotary Screw Trap Efficiency and Production—Trap efficiency is based on the ratio of captured, marked fish, to the total number of released, marked fish. These ratios, combined with the capture of wild fish, can be used to determine the total number of naturally produced fish moving past each RST. Under the constraints of RST efficiency evaluations, several assumptions were made (Volkhardt et al. 2007; USFWS 2008):

- hatchery fish are representative of wild fish, both in size and behavior
- all fish have equal probability of capture
- marked fish remain readily identifiable within each efficiency interval
- all released fish move downstream and have an equal opportunity to encounter downstream RSTs
- rotary screw trap efficiency is constant within each efficiency interval
- the population is closed

Production over time was estimated using the daily catch and RST efficiency at each trap location. Production was calculated specifically for spring-run Chinook Salmon encountered during RST operations. Any other captured salmonids (e.g., fall-run Chinook Salmon, other *Oncorhynchus spp.*), genetically identified, were excluded from these analyses. Hatchery fish (SCARF fish not related to the adult broodstock releases) were also excluded from production analyses.

The following stratified mark-recovery approach for the use of a single partial capture trap, from Carlson et al. (1998), and further outlined in Volkhardt et al. (2007) and the CAMP protocol (USFWS 2008), was used to estimate production and associated variance for each efficiency interval:

$$\hat{n}_i = \frac{u_i(M_i + 1)}{m_i + 1}$$

$$v(\hat{n}_i) = \frac{(M_i + 1)(u_i + m_i + 1)(M_i - m_i)u_i}{(m_i + 1)^2(m_i + 2)}$$

where $\hat{n}_i$ is the estimated production in interval *i*, u_i is the unmarked fish in interval *i*, M_i is the number of marked fish released in interval *i*, and m_i is the number of marked fish recaptured in the corresponding RST during interval *i*. Interval *i* constitutes the period between one efficiency release group and the next. Prior to the first release, and following the last, the nearest efficiency estimate was used to estimate fish production during such periods. For example, the first efficiency release at Hwy 99 was January 29, 2018. Trap efficiency calculated at this interval was used to estimate production of wild fish from trap installation until the next efficiency release on February 5, 2018.

At each RST, total production and the associated variance over the sampling season is the sum across all efficiency release periods:

$$\hat{N} = \sum_{i=1}^{n} \hat{n}_i$$

$$V(\hat{N}) = \sum_{i=1}^{n} v(\hat{n}_i)$$

Traps were occasionally placed in the non-fishing position (e.g., over holidays, during periods of high flows when trap access was considered unsafe). Furthermore, trap operation was sometimes inhibited as a result of debris preventing RST rotation. To account for fish that would have otherwise been captured during these periods, which would affect production estimates, estimates of salmon that would have otherwise been captured during these periods were calculated. Since daily variation in salmon capture was quite variable, these estimates were based on 3-day running average of salmon captured before and after any non-fishing periods. A 3-day running average was used because this was the median value between peak capture across days throughout the sampling season.

In most instances, survival estimates of fish released at the Owl Hollow RST exceeded 100 percent at Sycamore Island, and most survival estimates of fish released at Sycamore Island exceeded 100 percent at Hwy 99—in an extreme instance, by a factor of 60 (see following section for description of survival analyses). This suggested Sycamore Island and Hwy 99 RST efficiency estimates were unreliable and biased low (i.e., trap efficiency at Sycamore Island and Hwy 99 was likely higher than estimated through efficiency tests). It is likely the release locations selected for marked efficiency fish violated the assumptions of efficiency testing—most likely that fish did not distribute in a manner consistent with fish from upstream locations, limiting the likelihood of encountering the RST and reducing the probability of capture.

Some logical reasoning led us to re-evaluate the method for determining RST efficiency at Sycamore Island and Hwy 99. One could assume that increasing the distance of the release location to the RST would expose efficiency fish to a higher potential for predation or other obstacles that could limit fish from reaching the target location. Resultantly, one would expect to see lower survival rates (and lower efficiency rates) from efficiency fish released further away than a comparable group released synchronously and nearer to any specific RST. Therefore, any contradiction to this (which was observed at the Sycamore Island and Hwy 99 RSTs via survival estimates) would suggest a biased-low efficiency estimate. Higher efficiency estimates, then, for efficiency fish released at farther upstream locations (i.e., a greater distance from the RST) as compared to those released at a more proximate location, but having a lower trap efficiency estimate, would be more accurate. Following this reasoning, and to provide a more accurate assessment of RST efficiency at Sycamore Island and Hwy 99, fish released at the Owl Hollow and Sycamore Island RST locations were used to estimate trap efficiency at the next downstream RST locations, respectively. This resulted in an increase in trap efficiency estimates from original location releases.

Survival—Survival during the previous sampling season (2017–18) was estimated using the recapture of marked fish between RSTs (Hutcherson et al. 2020). The reliability of these estimates is dependent upon the assumption that hatchery and wild fish behave in the same manner. The total number of marked fish from each efficiency test, released at upstream RSTs, and surviving to the Hwy 99 RST, is estimated as the sum product, $\Sigma(1/e_i)\, m_{ij}$, using the following matrices:

$$\begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_i \end{bmatrix} \begin{bmatrix} m_{11} & m_{12} & \cdots & m_{1j} \\ m_{21} & m_{22} & \cdots & m_{2j} \\ \vdots & \ddots & \ddots & \vdots \\ m_{i1} & m_{i2} & \cdots & m_{ij} \end{bmatrix},$$

,

where e_i is the efficiency of the Hwy 99 RST during interval i, m_{ij} is the number of marked fish from the upstream efficiency group j (from either upstream RST releases), captured in the i^{th} interval. Survival for each marked release is then estimated using:

$$\frac{[\Sigma(1/e_i)\, m_{ij}]}{M_j}$$

where M_j is the total number of marked fish, M, released in group j. Though the objectives of this study were to calculate survival and factors influencing juvenile salmon emigration, wet conditions in spring 2019, resulting in multiple high flow events, precluded estimating survival with an acceptable level of confidence—during these periods, RSTs were either placed in the non-fishing position due to safety concerns, or recapture of released efficiency fish was too low (or nonexistent) to calculate trap efficiency during these periods. Nonetheless, the calculations above are included since they were used to identify shortcomings in efficiency fish release locations, leading to changes in efficiency calculations indicated in the previous section (*Rotary Screw Trap Efficiency and Production*).

Post hoc analyses using wild salmon genetics provided an alternative method for evaluating survival across RST locations. Genetic analyses by the Southwest Fisheries Science Center Santa Cruz Laboratory, Santa Cruz, permitted maternal genotyping of wild salmon captured in rotary screw traps. Using maternal genotype, captured progeny were organized to each respective maternal line. Family group size was extrapolated to account for RST efficiency at the time of capture. The following assumptions were used when determining family group size at each RST:

- Each fish from a specific family groups had equal chance of survival.
- Downstream movement of offspring from a specific family group was proportional to fish captured in any RST from that maternal line.
- Capture probability was equal for all fish encountering RSTs.

Evaluating the reduction in family-specific group sizes from upstream to downstream RST locations permits survival estimates in the Restoration Area where RSTs operate. While the limitations of the current season (e.g., reduced sampling duration for Owl Hollow and Sycamore Island RSTs, and low efficiency during periods of high flows) still preclude accurate survival estimates, the methods and results are discussed herein to provide the groundwork during future sampling efforts.

3.0 Results

As a result of high flows during the 2018–19 sampling season, the Owl Hollow and Sycamore Island RSTs were removed mid-March. Likewise, the Hwy 99 RST was removed late-May prior to another high-flow event (Figure 2). These truncated efforts should be considered when interpreting results from the efforts described herein. A total of 453 salmon were captured across the four RSTs during the 2018–19 field season (Table 2). Based on genetic analyses, 419 of these were Chinook Salmon—of these, 409 were genetically identified as spring-run Chinook Salmon, while the remaining 10 were fall-run. Genetic analyses identified most of the non-Chinook species as *O. nerka*—these were assumed to be Kokanee (land-locked Sockeye Salmon) escapees from the California Department of Fish and Wildlife (CDFW) San Joaquin Hatchery near Friant Dam. Among the spring- and fall-run Chinook Salmon were five yearlings; four of these were fall-run while the other was a spring-run Chinook Salmon. Of the 409 spring-run Chinook salmon, 377 were determined to be broodstock progeny. Three fish with unavailable tissue samples (fish inadvertently released before tissue samples collected or tissue samples lost after collection) were also grouped into the broodstock progeny category—based on the date of capture, the proportion of total broodstock progeny captured to other salmon, and the fact that the remaining fish captured the days those three fish were concurrently captured were all determined to be spring-run broodstock progeny, those three fish were also classified accordingly. Of the progeny captured, 29 maternal broodstock genotypes were positively identified.

Thirty-one of the remaining juvenile salmon captured were determined to be non-target SCARF fish (either SCARF escapees or efficiency-release fish mistakenly identified as wild salmon), and one fish was determined to be a Feather-River Hatchery fish, likely also an escapee. The majority of these fish were likely SCARF escapees—all but seven were captured at the fry life stage, prior to efficiency fish releases. Those salmon captured at the fry stage likely escaped the hatchery prior to receiving coded wire tags and being adipose-clipped. Conversely, fish captured later in the season may have been SCARF escapees or efficiency-release fish; efficiency-release fish could have been mistakenly identified as wild fish if colored marks faded from initial tagging and clipped adipose fins were overlooked. Multiple yearlings were identified as precocious males—sexually mature yearlings, maturing without seaward migration (Larsen 2004). The remaining fall-run salmon were likely from fish released into Reach 1 as part of an educational outreach program, the Classroom Aquarium Education Program (https://wildlife.ca.gov/CAEP), where classrooms hatch fry from eggs at the eyed-stage and subsequently release these fish following yolk-sac absorption. Since the fall-run Chinook Salmon, the non-broodstock juveniles, and the single spring-run yearling were not related to the production of spring-run Chinook Salmon during the 2018–19 sampling season, they were not included in production estimates.

Table 2.—Total Chinook Salmon (*Oncorhynchus tshawytscha*) captured during 2018–19 rotary screw trap operation in the San Joaquin River Restoration Area. Italicized numbers indicate total fish, by subgrouping, captured within respective groups (in bold).

	Owl Hollow	**Sycamore Island**	**Hwy 99**	**San Mateo**	**Totals:**
Spring-run	308	25	79	0	412
Broodstock	*284*	*25*	*71*	*0*	*380*
SCARF	*24*	*0*	*7*	*0*	*31*
Feather River Escapee	*0*	*0*	*1*	*0*	*1*
Fall-run	0	2	8	0	10
Yearling	*0*	*1*	*3*	*0*	*4*
Classroom Fish	*0*	*1*	*5*	*0*	*6*
Other Salmon	15	6	7	3	31

Figure 5 identifies captured fish by size and time of capture. A logarithmic regression and 95 percent prediction bands help distinguish between spring-run Chinook Salmon and the other cohorts captured. Fish were classified to life stage by physical characteristics observed in the field. However, to account for potential discrepancies in individual observers, outliers were determined using Tukey's Method (observations outside one-and-a-half times the inner quartile range). Captured fry were typically less than 35 mm. Smolts were determined to be fish greater than 66 mm and yearlings were over 170 mm. Few parr were captured but can be assumed to be between fry and smolt size ranges. Early in the sampling season, fry were predominately captured at upstream locations (Owl Hollow and Sycamore Island; Figure 5–6). Fry capture was greatest upon initiation of trap operation at the upstream RSTs; capture rates increased through early-December and subsequently decreased through mid-January. Thereafter, most wild spring-run salmon captured were identified as smolts The Owl Hollow and Sycamore Island RSTs were removed mid-March, so no additional data are available at those locations after that time. However, capture rates at Hwy 99 continued to increase, peaking late-April, early-May. No wild Chinook Salmon were captured at the San Mateo RST during the 2018–19 sampling season.

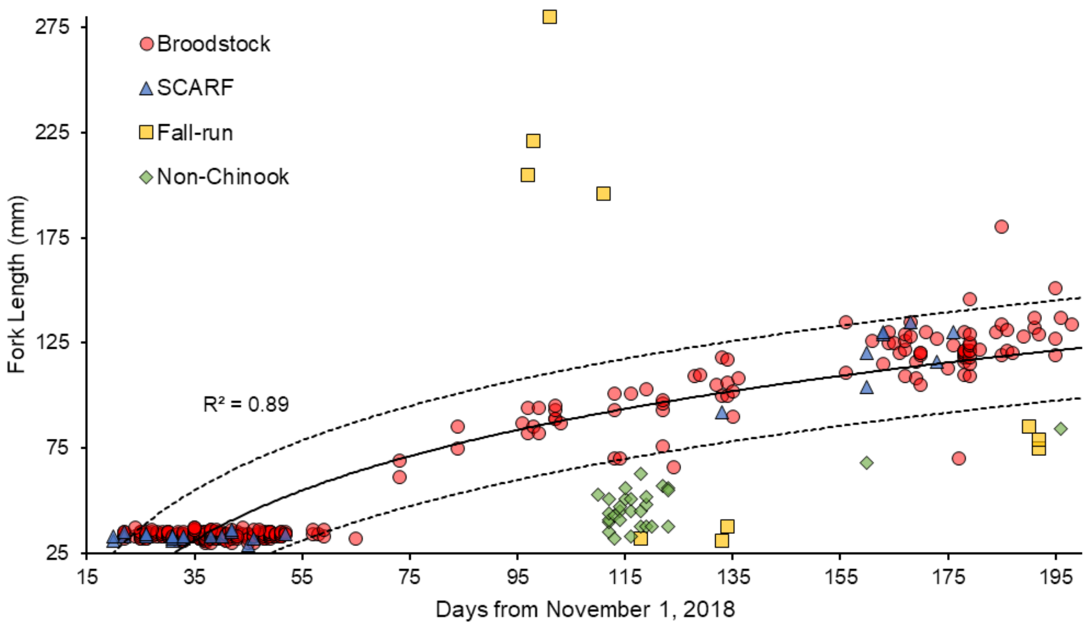

Figure 5.—Logarithmic trendline (solid line) and 95 percent prediction interval (dashed lines) based on size and date of capture for spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured during the 2018–19 sampling season. Note how the non-Chinook and fall-run Chinook Salmon, but not SCARF fish, fall outside the prediction bands for spring-run broodstock progeny.

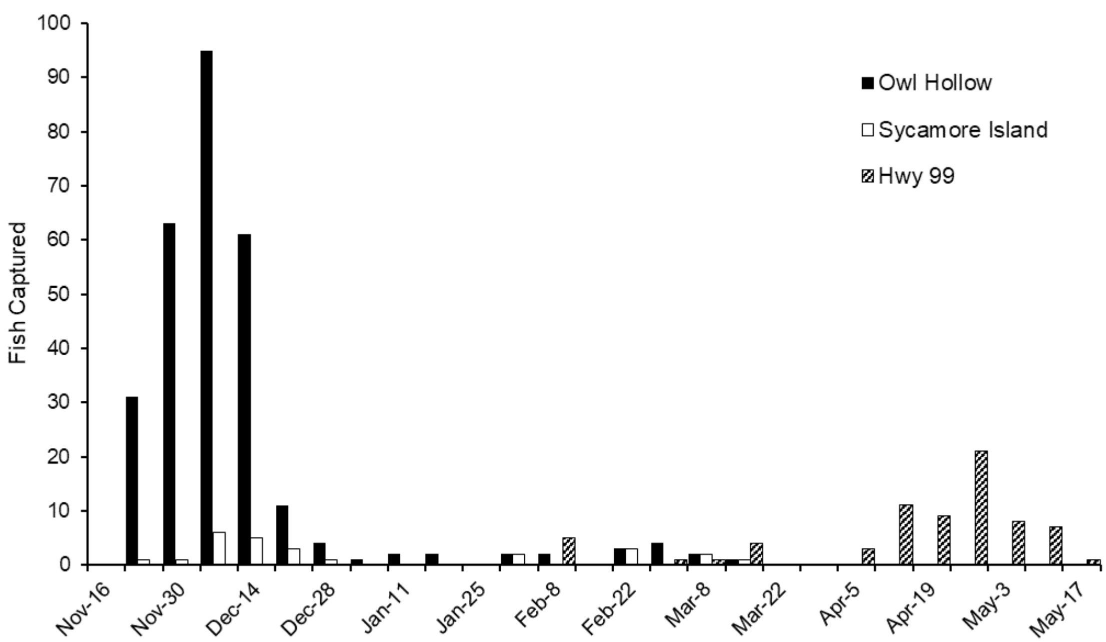

Figure 6.—Wild salmon captured (7-day blocks from date shown) at rotary screw traps (RSTs) installed in Reach 1 of the San Joaquin River Restoration Area during the 2018–19 sampling season. The Owl Hollow and Sycamore Island RSTs were removed mid-March preceding a flood pulse; no spring-run Chinook Salmon were captured at the San Mateo RST.

Rotary Screw Trap Efficiency and Production—Averaged across efficiency release groups, RST efficiency at Owl Hollow was 11.1 ± 7.2 percent (mean ± SD). Trap efficiency for Sycamore Island was 7.2 ± 7.3 percent. However, after adjusting efficiency using Owl Hollow-released fish (see *Materials and Methods: Analyses*), trap efficiency increased to 8.0 ± 4.6 percent. Hwy 99 efficiency was 7.2 ± 6.0 percent, and after using Sycamore Island-released fish to estimate trap efficiency, this estimate increased to 8.8 ± 6.7 percent. San Mateo RST efficiency was 0.9 ± 0.7 percent.

Since upstream RSTs (Owl Hollow and Sycamore Island) were removed mid-March, a final production estimate is only provided for Hwy 99. At the time of removal, the production estimate at Hwy 99 was 1,400 ± 433 (± 95 percent CI). Cumulative production estimates during operation at Sycamore Island and Hwy 99 are indicated in Figure 7. Because of the low and variable efficiency estimates at the Owl Hollow and San Mateo RSTs, production and survival could not be reliably estimated at these locations. We suspect the Owl Hollow RST location suffered from similar issues as the release locations of Sycamore Island and Hwy 99. However, without marked fish releases further upstream with which to compare, such a determination was not possible. With regards to the San Mateo RST—unlike using Sycamore Island-released fish to estimate the efficiency of the Hwy 99 RST, insufficient Hwy 99-released efficiency fish were captured at San Mateo to either attribute the trap as having low efficiency, or otherwise suggest a problem existed with the release location. Resultantly, no estimates of production or survival were calculated at these locations; only quantitative data with respect to timing and total captured fish are further discussed. Efficiency estimates for each interval at the four RST locations are presented in Appendix B.

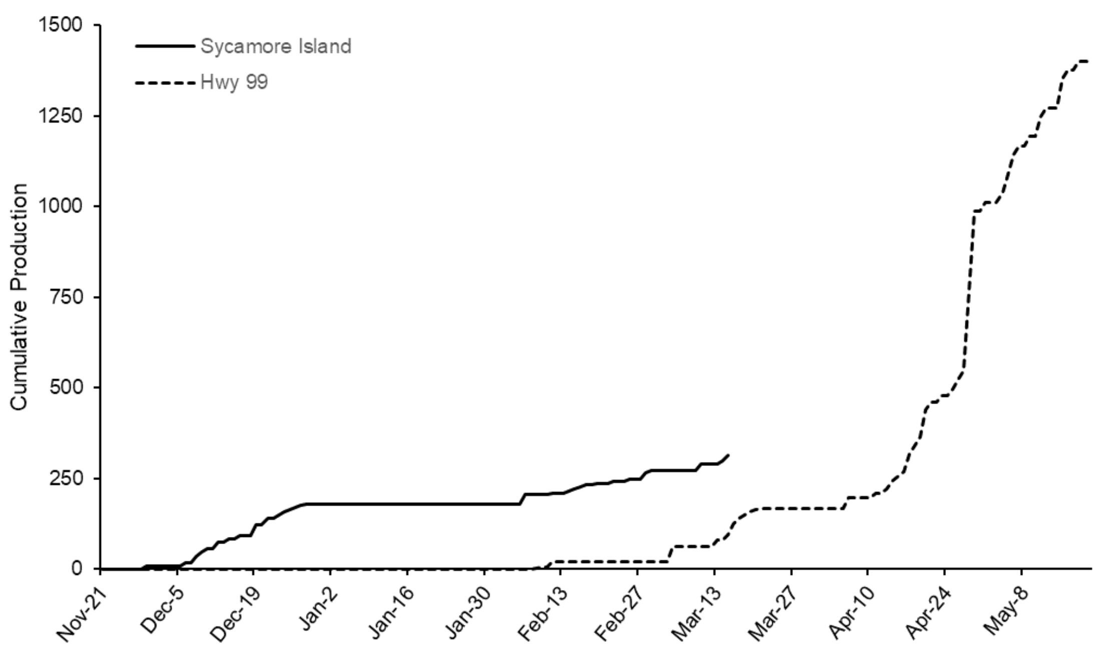

Figure 7.—Cumulative production of wild Chinook Salmon (*Oncorhynchus tshawytscha*) at rotary screw traps in Reach 1 of the San Joaquin River Restoration Area during the 2018–19 sampling season.

Survival—The approach for estimating survival in the 2017–18 sampling season relied on the recapture of marked fish at downstream RSTs, standardized to RST efficiency at the time of recapture. Since trap efficiency calculations were adjusted to use marked efficiency groups released from upstream locations, survival could not be reliably estimated during the 2018–19 sampling season; however, estimated family group sizes, using maternal genotypes, are presented here to illustrate the method for evaluating survival of wild fish during future sampling efforts.

Two groups of fry were released under similar RST operating conditions during December and January 2019–20. Since RST trap efficiency estimates at Owl Hollow during the 2018–19 sampling season were questionable (see *Rotary Screw Trap Efficiency and Production*), and because efficiency testing did not begin until late-January, the average efficiency of fry release groups from 2019–20 was used as a surrogate to trap efficiency estimates during the 2018–19 sampling season when fry were predominately captured. Similar metrics were used to evaluate family group sizes at Sycamore Island. Since no fry were captured at Hwy 99, efficiency estimates, previously described in this report, were used to extrapolate family group sizes at this location. The results of extrapolated family group sizes are illustrated in Figure 8. Note, though, that estimates are likely biased low from the early removal of the Owl Hollow and Sycamore Island RSTs, as well as reduced trap efficiency during high flow periods.

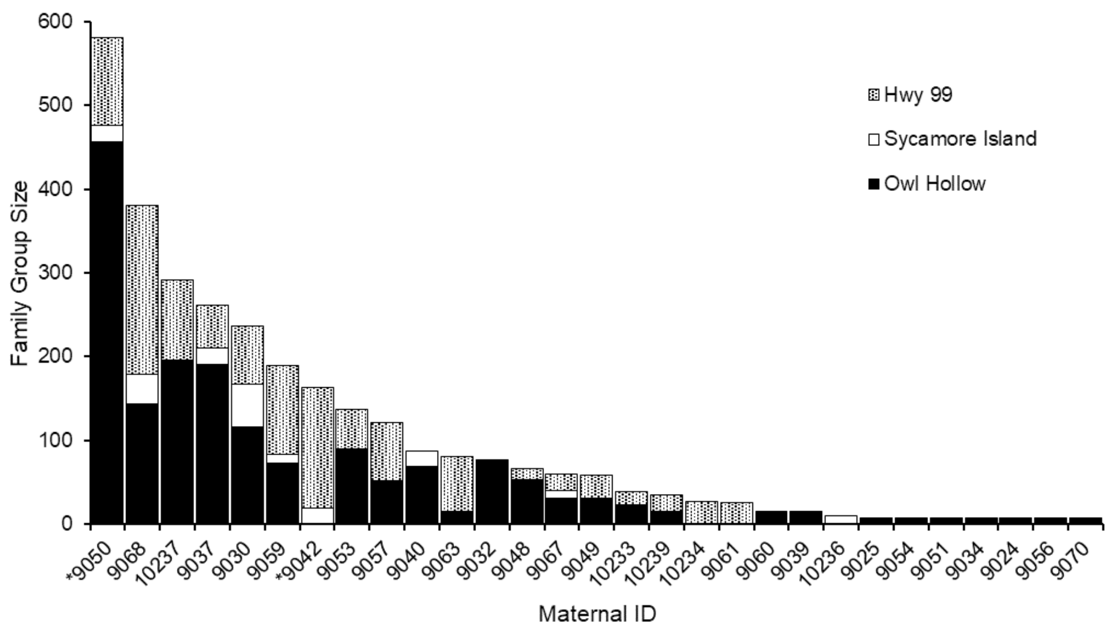

Figure 8.—Extrapolated family groups passing rotary screw traps, identified by contributing maternal broodstock (identified by acoustic tag numbers). Those numbers marked with asterisks denote capped redds for evaluating fry emergence.

Emigration Timing—Production at Hwy 99 and flow are depicted in Figure 9. Flow data were collected from the California Data Exchange Center (https://cdec.water.ca.gov/) using gaging stations located in Reach 1 of the Restoration Area. Of note is the large flow pulse on March 17, declining early-April, and a substantial increase again beginning mid-May. The first wild salmon captured at Hwy 99 was on February 6. After February 11, there was a notable lag in catch until late February. Capture of wild salmon during March was sporadic. However, capture rates were relatively consistent during April, peaking late-April. Thereafter, capture rates were relatively steady until the completion of RST sampling May 21.

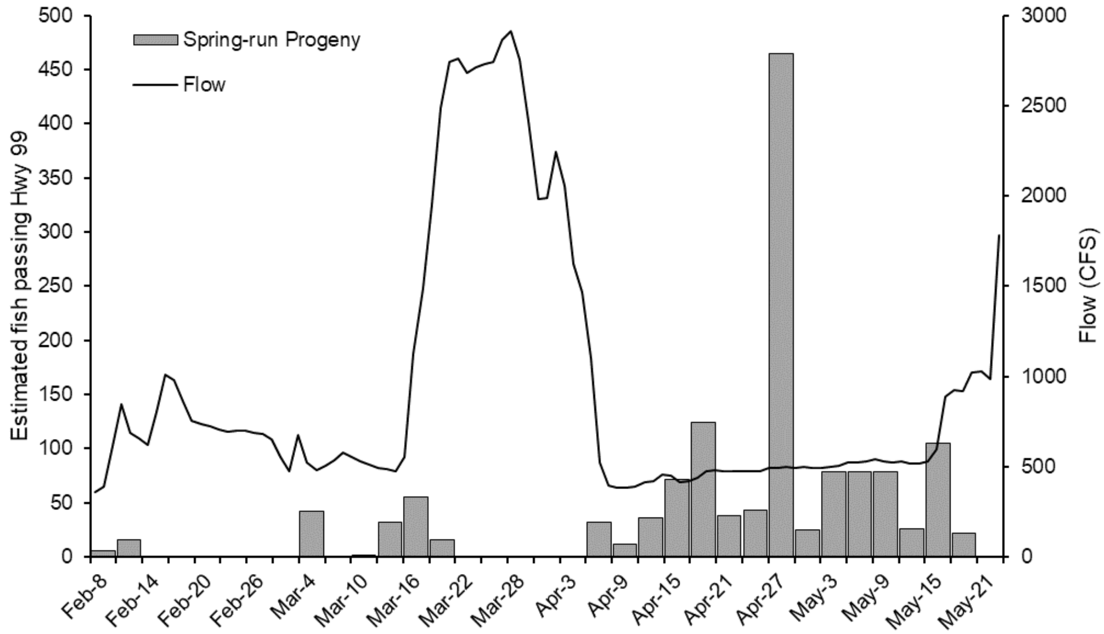

Figure 9.—Downstream movement (via production estimates) of spring-run Chinook Salmon (*Oncorhynchus tshawytscha*; left vertical axis; 3-day intervals following the listed date) during 2018–19 field season at Highway 99, with respect to average daily flow (CFS, measured at Highway 41; right vertical axis).

4.0 Discussion

Early in the season, fry were predominately captured at upstream RSTs—no spring-run fry were captured at the Hwy 99 RST. As the sampling season progressed, fewer fish were captured at upstream RSTs and smolts comprised nearly all of the spring-run Chinook Salmon captured at the Hwy 99 RST. However, this could be biased since the Owl Hollow and Sycamore Island RSTs were removed mid-March. The notable lack of salmon capture mid-March at Hwy 99 was likely a result of trap inefficiency. Typically, the SJR changes from a relatively slow-moving glide with higher amounts of aquatic vegetation to a more constrained, higher-velocity cobble channel as it flows underneath the Hwy 99 overpass. The main channel has a sharp bend under typical flow conditions. However, during the high flow conditions mid-March, the river expanded dramatically, with quite a large proportion overtopping the normal riverbank at this bend. While site-specific flow evaluations were not conducted, the majority of flow appeared to overtop the bank, spreading across the area beneath the Hwy 99 overpass, and no longer predominately through the constricted channel where the RST was placed. Relatively few efficiency fish were captured during this period. As an example of trap inefficiency during this time: a group of 1,200 marked efficiency fish, twice the amount of the typical release group, was released upstream of the Hwy 99 RST. Of the 1,200 fish released, only a single fish was recaptured. Likewise, no wild fish were captured during this period. While it is possible the river expanded creating margin habitat for wild fish to disperse and hold, the fact that only a single efficiency fish was captured from the group of 1,200 released suggests that RST efficiency at this location was so low during this period to essentially be ineffective in capturing downstream-moving fish. Furthermore, the cumulative production curves in Figure 7 suggest that capture may not yet have plateaued when RSTs were removed. Considering these events, production estimates presented in this report are undoubtedly underestimated.

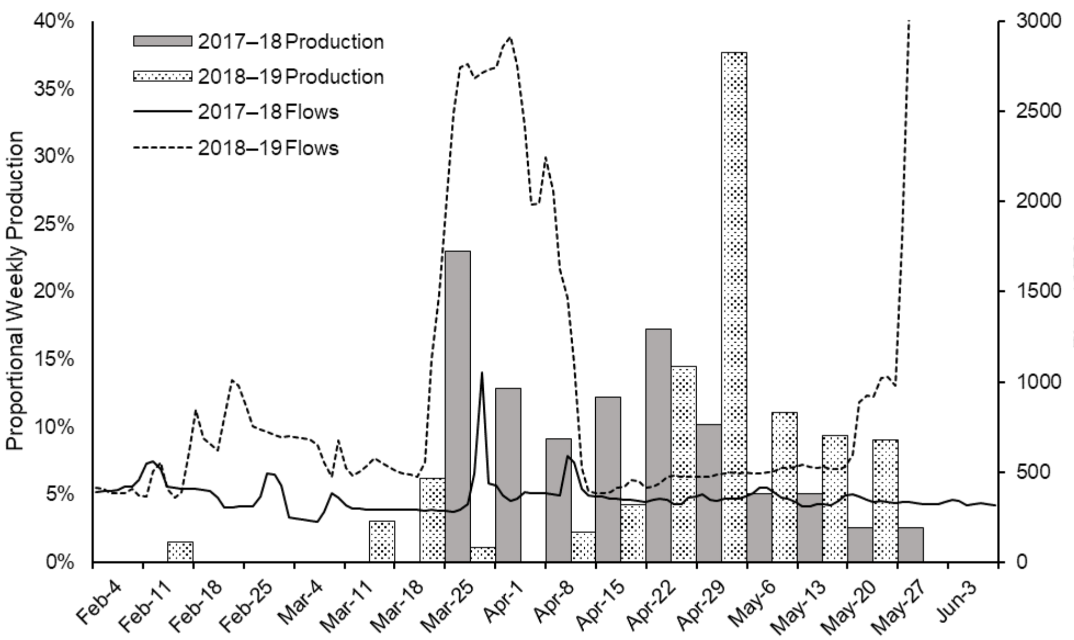

Figure 10.—Weekly proportional estimated production of spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) at the Highway 99 rotary screw trap (RST) for the 2017–18 and 2018–19 sampling seasons. Of note, the RST was placed in the non-fishing position March 16–19, due to high flows, and subsequently removed May 22, 2019 during the 2018–19 sampling season. Flows during the 2018–19 sampling season, following trap removal, exceed the scale on the secondary y-axis.

While all of the spring-run production at Hwy 99 occurred within a two-month period from mid-March to mid-May, during the 2017–18 sampling season, spring-run Chinook Salmon were captured early-February to late-May during the 2018–19 sampling season (Figure 10). Most of the fish captured at Owl Hollow, particularly earlier in the sampling season, were fry. Relatively few fish were captured at the Sycamore Island RST before its removal mid-March. However, nearly all spring-run salmon captured at Hwy 99 were smolts—few parr were captured at any RST location. This could indicate fry move downstream shortly after emergence but are holding between Owl Hollow and Sycamore Island prior to smoltification and emigration. Smoltification is the physiological processes that prepare salmon for seaward migration (Baggerman 1960) and is a complex interaction of the individual and environmental parameters, often correlated to photoperiod (Komourdjian et al. 1976) and temperature (Roper and Scarnecchia 1999). Achord et al. (2007) suggest that growth and development influence emigration, finding that larger fish emigrate earlier than smaller fish; reaching sufficient body size is necessary for smoltification (Dickhoff et al. 1997). In addition to the physiological processes that influence smoltification and subsequent migration, it has been suggested that increased springtime flows may promote seaward migration by juvenile salmon (Scheuerell et al. 2009). The ability to keep RSTs in operation during high flow conditions will be necessary to evaluate these movements and the factors contributing to emigration in the Restoration Area.

Similar to evaluating factors contributing to emigration timing, the lack of continuous operation of upstream RSTs during this sampling season precluded the ability to accurately estimate downstream survival of juvenile salmon. During the 2017–18 sampling season, survival was estimated using marked efficiency fish group size differences from upstream RSTs to Hwy 99. However, since the Owl Hollow and Sycamore Island RST were removed mid-March and concerns exist regarding trap efficiencies at Hwy 99 during high flow periods, these comparisons could not be made. While survival of family groups could be inferred through genetic analyses of captured fish (Figure 8), such estimates are likely biased low for the aforementioned reasons.

Considerations and Conclusion—Foremost, the ability to safely operate RST under a variety of flow condition needs to be addressed to permit continuous operation throughout the sampling season. Previous juvenile salmon monitoring efforts have been in years with lower flows than the 2018–19 sampling season (Hueth et al. 2017; Sutphin et al. 2018; Hutcherson et al. 2020). Flows encountered during the sampling season described herein revealed some shortcomings under such conditions, but provides an opportunity to explore methods to improve trap access and safety (e.g., dynamic cabling systems for relocating traps, kayak/boat access, overhead safety lines for traversing river to RSTs) during future monitoring efforts. Some/all of these will be employed during future efforts to permit continuous RST operation to the extent safely possible. Beyond safety concerns, installation of multiple RSTs may be considered at Hwy 99 to offset the increasing river width at this location during high flow conditions. Since regular efficiency fish releases occur, changes in operating efficiency with multiple RSTs in place can still be estimated.

Release locations for efficiency fish and RST installation spots will be addressed during future sampling efforts. It was evident the Sycamore Island and Hwy 99 release locations violated the assumptions for efficiency evaluations since fish released at the upstream locations provided better estimates of trap efficiency than fish released at those specific RSTs. During future RST efficiency tests, release locations will be moved further upstream to allow fish a better opportunity to distribute in the river more naturally.

The San Mateo RST location as well as the location for efficiency fish releases was of concern after the 2017–18 sampling season—relatively few marked fish and wild fish were captured here. Efficiency fish were released further upstream during the 2018–19 sampling season to allow for improved dispersal. However, this trap once again suffered from low efficiency estimates and low salmon capture. Understanding juvenile salmon movements downstream of the Hwy 99 location are necessary in determining migration patterns and survival in the remainder of the Restoration Area where conditions are generally considered less suitable for salmon. For future sampling years, a more suitable location should be selected to improve trap operation and efficiency.

While efficiency testing will continue to be evaluated using hatchery-reared salmon, until there are successive years of returning wild salmon that can produce sufficient progeny for efficiency tests, there is some concern hatchery salmon may not adequately represent the behavior and trends observed in wild fish (Wedemeyer et al. 1980; Volkhardt et al. 2007): Melnychuk et al. (2010) found that, on average, wild fish moved faster than hatchery fish during downstream migrations. They suggest stress after release or conditions varying from the hatchery environment as potential contributing factors for this difference. Fish size and growth rates have often been attributed to earlier migration rates (Ewing et al. 1984; Beckman et al. 1998). Marked fish in this study were concurrently smaller than wild fish (Figure 11). Ensuring hatchery fish are as near to size as wild fish captured could limit some of the concerns about using hatchery fish as a surrogate to wild salmon.

However, if continuous RST operation can safely be accomplished in future sampling years, the ability to use genetic parentage inference to identify family groups and assess downstream movements of broodstock progeny may preclude the necessity to use efficiency fish to evaluate survival and timing, as proposed in the 2017–18 sampling season (Hutcherson et al. 2020). Since individual progeny in the Restoration Area can be ascribed to specific broodstock (Figure 8), determining the difference in production estimates of individual family groups at specific RST locations may help understand survival and timing across RST locations. Additionally, using the maternal genotypes, we can assess the total females contributing to the offspring captured in RSTs throughout the season. This may help researchers better understand redd success with respect to location in the Restoration Area. Using these methods requires several assumptions: maternal genotypes are identifiable through tissue samples collected and at least one progeny is captured in the rotary screw traps to ascribe to each successful redd in Reach 1. This method will be evaluated during future sampling efforts to determine whether this is a viable alternative to using efficiency fish to describe survival and emigration timing.

Hatchery fish are required to be large enough for coded-wire tagging (typically 55 mm FL, using full-size coded wire tags). Resultantly, efficiency tests were not conducted until hatchery fish reached adequate size—efficiency test did not commence until late January. This meant that it was necessary to extrapolate initial efficiency test results to smaller size classes of salmon captured before this time. If movement and behavior patterns of marked fish are not commensurate with wild fish due to size discrepancies, results of trap efficiencies and production may be skewed. During future efforts, half-size coded wire tags will be used to tag a subset of fry/parr for evaluating trap efficiencies sooner in the season. While these fish will likely be too small to use the needle-free injector to apply a colored fin mark, fin clips may be used to provide a means to identify these fish to efficiency-release groups. This should allow trap efficiency to be evaluated at upstream RST locations, earlier in the season when fry are predominately captured. Ideally, this should provide more accurate estimates for fish in these life stages.

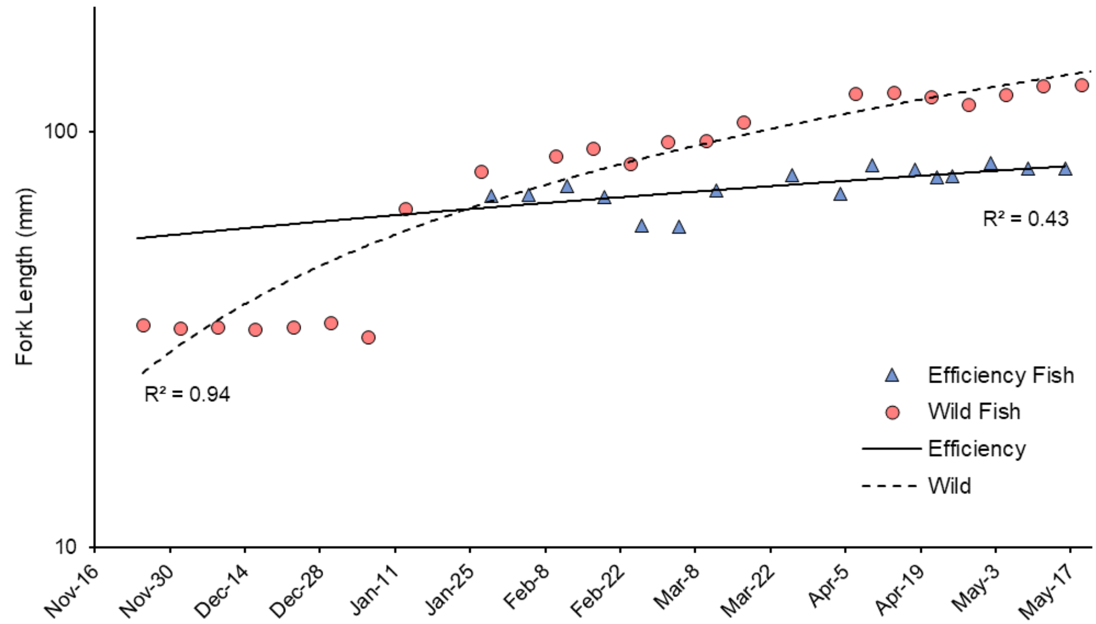

Figure 11.—Fork lengths (weekly average) of wild spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) and recaptured efficiency fish (by release) during 2018–19 sampling season. Note the trendline and y-axis are log-scale.

Continued monitoring of spring-run Chinook Salmon will provide metrics of survival and production in the Restoration Area. As methods are refined, the study design can be improved to provide more precise estimates of these values. Additionally, collecting baseline data through initial monitoring may help develop standards for future efforts. For example, coordinating length-at-capture data (Figure 5), which is often used to distinguish salmon runs in other California river systems (Johnson et al. 1992), across multiple sampling years and in conjunction with genetics may help distinguish unique cohorts of salmon present in the Restoration Area. This could help in future years when volitional passage is available for both spring- and fall-run salmon, when genetically testing all fish is not logistically or financially feasible.

Future restoration activities involve the construction of bypass structures at Sack Dam and Mendota Dam and will provide access to returning adult salmon to spawning grounds in Reach 1. Interim efforts may also present the opportunity to transport captured adult spring-run salmon to Reach 1, providing increased opportunities for spawning and production. In turn, biologists may be able to take advantage of using wild fish in lieu of hatchery fish to evaluate patterns of movement, seasonal growth rate, and survival. This, in turn, provides the opportunity to collect data pertaining to criteria established in the Fisheries Framework (SJRRP 2018). Evaluating salmon movement and numbers beyond the spawning areas in Reach 1 may provide estimates of survival and identify areas where unacceptable loss rates occur. Such information can be used to guide management decisions regarding future efforts in the Restoration Area.

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6.0 Appendix A: Bycatch

During the 2018–19 field season, 5,250 non-target fish, comprising 26 species were captured in the four rotary screw traps (Table A-1). Threadfin Shad (*Dorosoma petenense*) comprised 33.5 percent of the bycatch and were the most numerous individual species captured. Centrarchid species were the next most numerous bycatch, comprising 47.2 percent of the total bycatch throughout the season—the bulk of the centrarchid species captured were Black Crappie (*Pomoxis nigromaculatus*), followed by juvenile Bluegill (*Lepomis macrochirus*). Of the 26 species captured, eight were native: Kern Brook Lamprey (*Lampetra hubbsi*), Pacific Lamprey (*Entosphenus tridentatus*), Sacramento Pikeminnow (*Ptychocheilus grandis*), Sacramento Sucker (*Catostomus occidentalis*), Prickly Sculpin (*Cottus asper*), Riffle Sculpin (*C. gulosus*), Threespine Stickleback (*Gasterosteus aculeatus*), and Rainbow Trout *(O. mykiss*). Native species made up 19.9 percent of the bycatch.

Table A-1.—Total season bycatch in all rotary screw traps during 2018–19 sampling season. Asterisk denotes native species to the San Joaquin River.

Family:	Species:	Common Name:		Season Totals:
Petromyzontidae	*Lampetra hubbsi*	Kern Brook Lamprey	*	17
	Entosphenus tridentatus	Pacific Lamprey	*	569
	Petromyzontidae spp.	Unidentified spp.	*	142
Centrarchidae	*Pomoxis nigromaculatus*	Black Crappie		881
	Micropterus spp.	Black Bass spp.		75
	Micropterus salmoides	Largemouth Bass		2
	Micropterus punctulatus	Spotted Bass		31
	Lepomis macrochirus	Bluegill		512
	Lepomis cyanellus	Green Sunfish		82
	Lepomis microlophus	Redear Sunfish		153
	Lepomis gulosus	Warmouth		1
Cyprinidae	*Cyprinus carpio*	Common Carp		46
	Notemigonus crysoleucas	Golden Shiner		318
	Carassius auratus	Goldfish		6
	Ptychocheilus grandis	Sacramento Pikeminnow	*	25
Ictaluridae	*Ameiurus spp.*	Bullhead spp.		3
	Ictalurus punctatus	Channel Catfish		30
	Ameiurus catus	White Catfish		13
Catostomidae	*Catostomus occidentalis*	Sacramento Sucker	*	28
Cottidae	*Cottus asper*	Prickly Sculpin	*	234
	Cottus gulosus	Riffle Sculpin	*	1
	Cottus spp.	Unidentified spp.	*	10
Gasterosteiade	*Gasterosteus aculeatus*	Threespine Stickleback	*	14
Salmonidae	*Oncorhynchus mykiss*	Rainbow Trout	*	4
Moronidae	*Morone saxatilis*	Striped Bass		2
Clupeidae	*Alosa sapidissima*	American Shad		4
	Dorosoma petenense	Threadfin Shad		1,760
Percidae	*Percina macrolepida*	Bigscale Logperch		39
Poeciliidae	*Gambusia affinis*	Mosquitofish		248

7.0 Appendix B: Rotary Screw Trap Efficiency

Table B-1.—Marked efficiency release data for individual release groups during the 2018–19 sampling season at the Owl Hollow and Sycamore Island rotary screw traps. Data includes release group (i), location, size (M_i), release date, and total marked fish recaptured (m_i) within efficiency interval. Also included are the total wild spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured($\hat{u}_i$) during concurrent period.

Release Interval (i):	Release Date:	Location:	# Released (M_i):	Recaptured before next period (m_i):	Wild salmon during interval ($\hat{u}_i$):
1	1/29/19	Owl Hollow	600	6	280
2	2/5/19	Owl Hollow	600	115	3
3	2/12/19	Owl Hollow	580	90	1
4	2/19/19	Owl Hollow	599	72	3
5	2/26/19	Owl Hollow	592	117	4
6	3/5/19	Owl Hollow	590	20	1
7	3/12/19	Owl Hollow	588	42	2
1	1/29/19	Sycamore Island	599	0	19
2	2/5/19	Sycamore Island	600	50	2
3	2/12/19	Sycamore Island	573	21	1
4	2/19/19	Sycamore Island	595	29	3
5	2/26/19	Sycamore Island	587	46	1
6	3/5/19	Sycamore Island	593	19	1
7	3/12/19	Sycamore Island	589	133	2

Table B-1 (continued).—Marked efficiency release data for individual release groups during the 2018–19 sampling season at the Highway 99 (Hwy 99) and San Mateo rotary screw traps. Data includes release group (i), location, size (M_i), release date, and total marked fish recaptured (m_i) within efficiency interval. Also included are the total wild spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured ($\hat{u}_i$) during concurrent period.

Release Interval (i):	Release Date:	Location:	# Released (M_i):	Recaptured before next period (m_i):	Wild salmon during interval ($\hat{u}_i$):
1	1/30/19	Hwy 99	600	84	0
2	2/6/19	Hwy 99	599	131	6
3	2/13/19	Hwy 99	594	57	0
4	2/20/19	Hwy 99	601	19	0
5	2/27/19	Hwy 99	596	50	1
6	3/6/19	Hwy 99	594	36	0
7	3/13/19	Hwy 99	596	40	7
8	3/26/19	Hwy 99	1200	1	0
9	4/4/19	Hwy 99	1249	120	2
10	4/11/19	Hwy 99	593	26	10
11	4/18/19	Hwy 99	600	69	9
12	4/22/19	Hwy 99	600	64	23
13	5/2/19	Hwy 99	600	0	6
14	5/9/19	Hwy 99	600	12	7
15	5/16/19	Hwy 99	600	0	2
1	1/30/19	San Mateo	600	13	0
2	2/6/19	San Mateo	593	2	0
3	2/13/19	San Mateo	536	4	0
4	2/20/19	San Mateo	557	8	0
5	2/27/19	San Mateo	581	1	0
6	3/6/19	San Mateo	591	8	0
7	3/13/19	San Mateo	590	1	0
8	4/4/19	San Mateo	1000	1	0
9	4/12/19	San Mateo	208	3	0
10	4/18/19	San Mateo	600	6	0
11	4/23/19	San Mateo	599	6	0

Table B-2.—Marked efficiency release groups (Chinook Salmon, *Oncorhynchus tshawytscha*) for evaluating production at Sycamore Island and Highway 99 (Hwy 99) rotary screw trap (RST) locations. Due to the low precision of original marked releases at Sycamore Island and Hwy 99, Owl Hollow RST and Sycamore Island RST-released groups were used to estimate trap efficiency and production at Sycamore Island and Hwy 99, respectively.

Release Interval (i):	Release Date:	Location:	# Released (M_i):	Recaptured before next period (m_i):	Total Wild Fish Captured ($\hat{u}_i$):
1	1/29/19	Sycamore Island	586	62	19
2	2/5/19	Sycamore Island	600	44	2
3	2/12/19	Sycamore Island	563	23	1
4	2/19/19	Sycamore Island	561	97	3
5	2/26/19	Sycamore Island	592	32	1
6	3/5/19	Sycamore Island	590	30	1
7	3/12/19	Sycamore Island	588	35	2
1	1/30/19	Hwy 99	540	73	0
2	2/6/19	Hwy 99	528	138	6
3	2/13/19	Hwy 99	503	74	0
4	2/20/19	Hwy 99	583	64	0
5	2/27/19	Hwy 99	498	11	1
6	3/6/19	Hwy 99	426	31	0
7	3/13/19	Hwy 99	550	34	9
8	4/11/19	Hwy 99	237	19	14
9	4/20/19	Hwy 99	573	29	7
10	4/26/19	Hwy 99	464	18	21
11	5/3/19	Hwy 99	600	22	14
12	5/18/19	Hwy 99	600	26	1