2021 Adult Spring-Run Chinook Salmon Monitoring and Trap and Haul in the San Joaquin River Restoration Area

2021 Draft SJRRP Project Report

2021 Adult Spring-Run Chinook Salmon Monitoring and Trap and Haul in the San Joaquin River Restoration Area

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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 four individuals are qualified to review this work, and that they have peer reviewed this report.

Zachary Sutphin

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PI Signature

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1.0 Introduction

1.1 Background

Historically, California's upper San Joaquin River (SJR) supported stable populations of spring-run Chinook Salmon (*Oncorhynchus tshawytscha;* Yoshiyama et al. 1998). Water management infrastructure erected on the SJR (i.e., Sack Dam, Mendota Dam, and Friant Dam) in support of expanding agricultural production in California's Central Valley blocked migrational pathways and access to suitable over summer holding and spawning habitat, which contributed to the extirpation of adult spring-run Chinook Salmon from the system (Moyle 2002). In response to the current state of Chinook Salmon, and other species in the upper SJR, a lawsuit was filed on the behalf of a coalition of environmental groups challenging the renewal of long-term water contracts. The 18-year lawsuit resulted in a settlement in which two primary goals were established: (1) to restore a naturally reproducing and self-sustaining population of Chinook Salmon as well as other fishes in the system (Restoration Goal), and (2) to reduce impacts on water supply to the contractors (Water Management Goal). The San Joaquin River Restoration Program (SJRRP) was established in an effort to achieve the goals of the settlement (http://www.restoresjr.net/) and is supported by collaborative groups of scientists and managers, from multiple state and federal implementing agencies. The SJRRP Fisheries Management Plan (SJRRP 2010) and Fisheries Framework (SJRRP 2018) define criteria for goals and objectives specific to re-establishing populations of Chinook Salmon in the SJRRP Restoration Area (RA; San Joaquin River from Merced River confluence to Friant Dam).

Strategies to reestablish spring-run Chinook Salmon within the SJRRP Restoration Area (as per SJRRP 2011) have included releases of translocated juvenile salmon sourced from Feather River as well as artificial propagation of spring-run Chinook Salmon produced from the Interim Salmon Conservation and Research Facility (SCARF), as permitted by the National Marine Fisheries Service (NMFS) under the authority of Section 10(a)(l)(A) of the Endangered Species Act of 1973. Releases of translocated juveniles occurred from 2014 through 2016, with the SJRRP relying solely on artificial propagation of spring-run Chinook Salmon as its primary strategy to reestablish juveniles since 2016. These efforts, and subsequent monitoring efforts, have provided evidence of adult spring-run salmon returning to the RA in 2017, 2019, and 2020 (Hutcherson et al. 2020; Sutphin et al. 2019). Until fish passage construction projects are complete, adult salmon returning to the RA will not have access to suitable holding and spawning habitat in the upper reaches of the RA during most water years. Therefore, enumerating, trapping, and truck-transporting adult salmon from the lower reaches to the upper reaches of the RA is necessary to permit evaluation of the majority of biological objectives for naturally returning salmonids established in the SJRRP Fisheries Framework (Table 7 in SJRRP 2018 Fisheries Framework). Trap and haul efforts will continue until in-river fish passage structures are constructed and volitional passage is achieved, and may also be necessary during Critical Years if fish passage structure prove ineffective during such conditions.

1.2 Objectives

The primary objective of this effort was to enumerate adult salmon in the RA, trap and haul the adults around in-river migration impediments and release them into upper reaches of the RA to support additional monitoring efforts (e.g., adult holding and spawning, fry emergence, and juvenile monitoring studies). This effort provides crude estimates of annual adult escapement, as well as immigration timing and factors effecting immigration. Capture, transport and release of naturally returning adult salmon into the upper reaches of the RA supports multiple efforts to quantify criteria specified in the Fisheries Framework, including, but not limited to: pre-spawn adult survival, adult holding and spawning habitat, female fecundity, egg survival to fry emergence, juvenile growth, survival rate, production, and diversity of juveniles exiting the RA (SJRRP 2018). Successful spawning and subsequent production of truck-transported individuals may help increase success of spring-run reintroduction if progeny are able to successfully emigrate and return as adults. In addition, coded wire tag, passive integrated transponder tag, and tissues collected for genetic analyses provide important information pertaining to age class, juvenile release date and release strategy, and familial genetics. Capture of adult spring-run salmon in the RA during their immigration period can expose fish to challenging environmental conditions, including, but not limited to, temperatures commonly exceeding thermal preference. Nonetheless, biologists working for the SJRRP will continue to evaluate salmon survival during these described processes and consider best scientific practices for fish handling and transport to maximize health and survival.

2.0 Materials and Methods

2.1 Study Area and Sampling Duration

Study Area– The SJRRP RA extends upstream approximately 150 river miles (RM) from the Merced River confluence (Stanislaus County) to Friant Dam (Fresno County; Figure 1). The RA is sub-divided into five reaches. Adult salmon monitoring occurred at various locations in the most downstream reach (Reach 5 and 4B), and salmon were truck transported for release in the most upstream reach (Reach 1, Figure 1). Sampling was confined from the first in-river impediments to immigrating fish downstream to the confluence of the San Joaquin and Merced Rivers. In 2021, this was assumed to be the Eastside Bypass Rock Weir (Van Clief) downstream to the Merced River confluence for the duration of monitoring (see Appendix 1A for site-specific pictures). During 2021 adult salmon monitoring, traps were fished upstream of the Merced River confluence at the Hills Ferry Barrier, in Salt Slough, Mud Slough, mainstem SJR at Van Clief, and downstream of the Bear Creek confluence in the Eastside Bypass at the Van Clief location (Figure 1).

Sampling Duration – The first adult spring-run Chinook Salmon was captured and transported on April 5, 2021. Efforts continued daily through June 5, 2021, when sampling was suspended due to a combination of an extensive period without capturing or observing live salmon (5 days – the last transported salmon occurred May 30, 2021 and this fish was identified as in "poor"

condition) and unsuitable river conditions for spring-run Chinook Salmon (i.e., low flows and elevated temperatures).

2.2 Sampling Equipment and Operation

Steel Fyke Trapping – When river conditions provide a narrowed and deep channel, steel fyke traps are the preferred sampling approach for capturing adult immigrating salmon in the RA. These traps can be maintained at elevated flows, provide a large area for captured fish to reside after capture, are less likely to contribute to fish entanglement, and are less prone to damage and holes in the cod end (and loss of samples). To adapt to varying site-specific depths, two different size fyke traps are used: 3.1 m diameter x 6.1 m long and 2.4 m diameter x 5.5 m length. Both styles are constructed primarily of chain link fence (5.1 cm mesh; Figure 2), and have a mouth opening (facing downstream) that constricts to a 0.9 m opening permitting fish to swim into the trap, while making it difficult to escape. Traps were deployed and retrieved from their sampling position in the river by a vehicle-mounted winch connected to a main line (0.64-cm steel cable) wrapped around the trap. This process was aided by additional safety guidelines (1.3-cm rope) wrapped around the front and back of the trap and controlled by individuals on the bank. During fish recovery, traps were rolled to a stable location, maintaining enough depth (> 0.3 m) to provide water for trapped fish. Swinging doors permit entrance into the traps to remove fish using large dip-nets. The fyke traps were generally fished continuously, and were checked, at a minimum, once daily.

Fyke Netting –The nets are constructed of a 1.2 or 1.8 m square entry, followed by a series of three circular compartments, with 2.4 cm square no. 252 knotless nylon mesh. A mesh-constructed partition separates three internal circular compartments that taper to a 25-cm opening, reducing the possibility of fish escaping the net after capture. Wing-walls (1.2 or 1.8 m high) were extended bank to bank in a V-shaped pattern downstream and were used to guide upstream-moving fish into the net (Figure 3). Fyke-nets were anchored with t-posts driven into the substrate. Nets were checked at least once daily for fish, net scour, and damage, were cleaned to prevent debris buildup, were reset and repaired, as necessary.

Marker buoys were placed up- and downstream of all in-river sampling equipment, and flashing amber lights were placed in close proximity to alert boaters of the presence of sampling gear. Water temperature (°C), dissolved oxygen (DO, mg/L) and turbidity (NTU) were measured at each site daily during sampling using a handheld multiparameter instrument. In addition, HOBO TidbiT temperature loggers (Onset; Bourne, MA) were installed at all sampling locations to get a more precise estimate (temperature recorded in 30 min intervals) of site-specific thermal trends.

On occasion during monitoring efforts at the Van Clief location adult salmon were observed swimming downstream of the Eastside Bypass Rock Weir, but upstream of our most upstream fyke net and wingwalls. On these occasions, adult salmon were opportunistically targeted for capture with a combination of seines and dip nets.

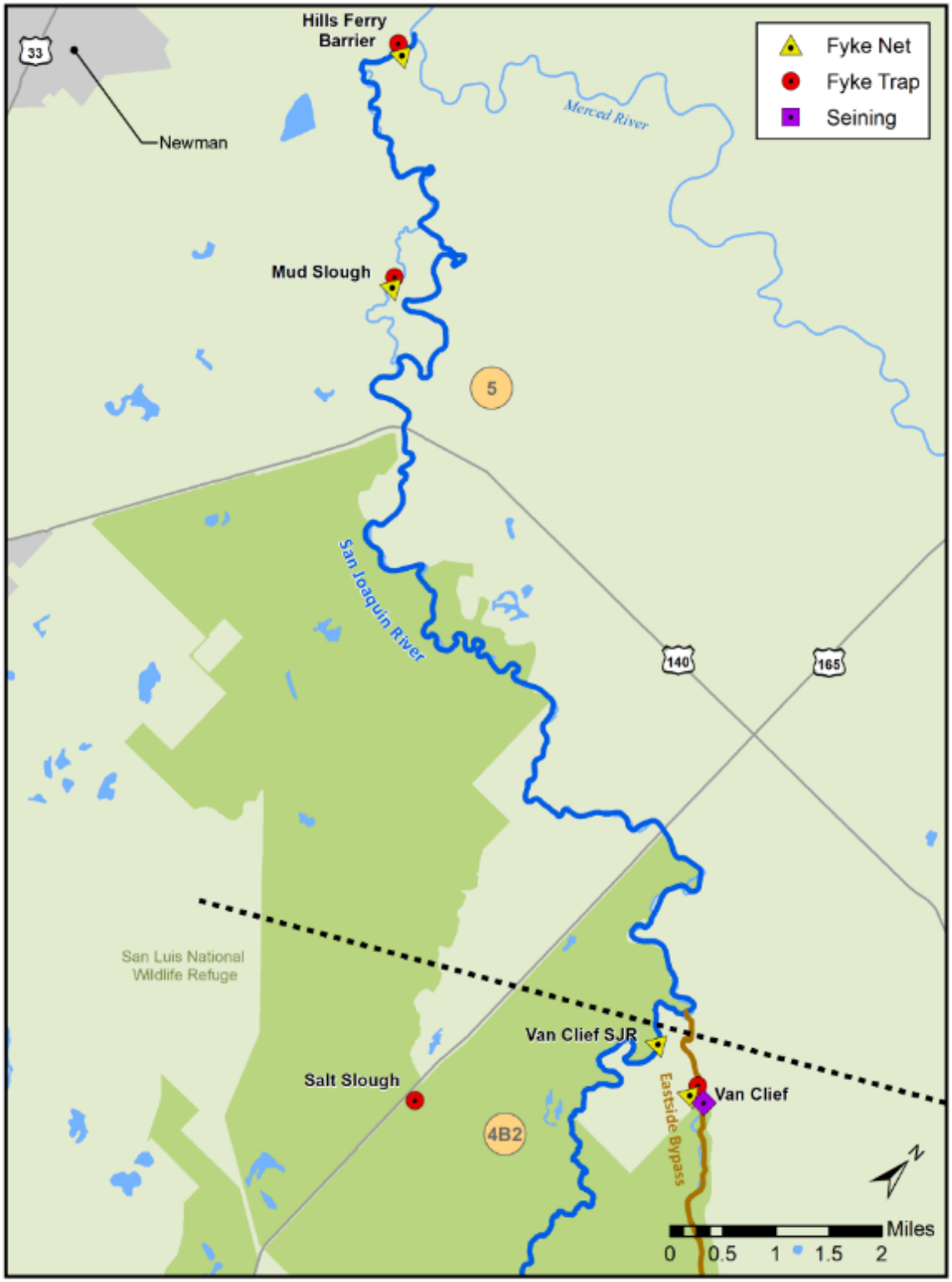

Figure 1.— Map of the San Joaquin River Restoration Program Restoration Area showing adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring locations in Reaches 5 and 4B. Reaches are denoted in orange-yellow circles and defined by black dotted lines. During

the 2021 season, sampling was concentrated downstream of Eastside Bypass Rock Weir (Van Clief).

Figure 2.— Combination of mesh fyke traps and a steel fyke trap used to monitor for adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) in the San Joaquin River Restoration Program Restoration Area (Van Clief location).

Figure 3.— Mesh fyke net used to monitor for adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) at the San Joaquin River Hills Ferry Barrier location in the San Joaquin River Restoration Program Restoration Area.

2.3 Fish Processing, Transport, and Release

Fish Processing – If Chinook Salmon were present in a sample, they were removed prior to any bycatch. Salmon were transferred; one at a time using plastic-coated dip nets, from the trap to a portable insulated Chiller Fish Bag™ (100(L)×40(H)×25(Base) cm) filled at least ½ full of water (river or transport water buffered to within ~4 degrees of on-site temperature). This method allowed fish to remain in water during processing to minimize handling stress. Adult salmon captured were transferred to the fish-haul tank and were processed post-transport at the release site. Salmon processing included collecting a fin-clip from the dorsal or caudal fin for DNA analysis, recording fork (FL) and total length (TL, mm), checking for presence/absence of adipose fin, passive integrated transponder (PIT) tag, and coded wire tag, and making notes on general condition (Figure 4). Identification of fish sex was not attempted because sexually dimorphic characteristics, observed in fall-run Chinook Salmon, were not distinct in captured spring-run Chinook Salmon. Additionally, all salmon released to Reach 1 of the RA were externally marked with a set of uniquely identifiable Dart Tags (Hallprint Fish Tags; Hindmarsh Valley, South Australia) affixed below the dorsal fin (Figure 4). A sub-sample of fish were intragastrically implanted with an acoustic transmitter (V9, 69 kHz transmitter; VEMCO, Bedford, Nova Scotia) and a 23-mm low frequency half-duplex PIT tag (LF HDX+ PIT tag; Oregon RFID, Portland, Oregon). A balling gun, coated in food-grade glycerin was used to place the acoustic transmitter and PIT tag in the salmon, and all tags were verified active prior to insertion (Figure 4). Acoustic and PIT tags were used to track and identify salmon in Reach 1 following their transport and release, supporting adult over-summer holding, survival, and spawning studies. Bycatch (all non-salmonids) were measured (TL, mm) and released upstream of the nets and traps to minimize likelihood of immediate recapture. Recovered salmon mortalities were processed, sexed, and transferred to a freezer and coded wire tags were recovered at a later date by California Department of Fish and Wildlife staff. Additional samples, including eye lenses, egg masses, muscles, scales, and otoliths were recovered and frozen from some individuals for future analyses if deemed important.

Fish Transport - Following capture, spring-run Chinook Salmon were placed in a tank (1.9–3.0 m^3) for transport to Reach 1. Transport water was collected from facilities at Friant Dam and was tempered to ~4-5°C below capture temperature using water from the capture location(s). For example, salmon captured in 21°C SJR water would be immediately transferred and transported in 17°C water. Salt was added to the transport tank at approximately 6–10 ppt to alleviate osmotic imbalance and stress-related effects. Oxygen was supplied via a compressed-gas cylinder and regulator in an effort to maintain dissolved oxygen levels ≥ 8 mg/L.

Multiple in-tank agitators were used to assist with oxygenation and water mixing, but primarily to promote degassing of carbon dioxide which can be harmful to fish at elevated levels (Westers 2001). Water quality (water temperature [°C], salinity [ppt], and dissolved oxygen [mg/L]) was collected with a handheld multiparameter instrument before loading fish and immediately prior to fish release. The tank was checked at least once during transport to ensure the oxygen and agitator systems were operational.

Figure 4.— Above images detail Adult Chinook Salmon (*Oncorhynchus tshawytscha*) post-transport processing. From top left to bottom right image: (1) salmon were removed from the haul tank and measured for fork and total length, (2) transferred to a fish bag filled with transport tank water, (3) checked for presence of adipose fin and PIT tag, (4) checked for presence of coded wire tag, (5) provided gastric implant of acoustic and PIT tags (not pictured) and an external dart tag, (6) provided water-to-water transfer to river in fish bag, and (7/8) removed from fish bag in river and permitted time to adjust to in-river conditions until they were able to swim away under their own volition.

Fish Release – Prior to release, water temperature in the transport tank was tempered to within ~2°C of release site temperature using water from the release location at a rate not exceeding ~2°C/hour. From April 5 – May 5, 2021, adult salmon were truck-transported and released at the Highway 99 or Camp Pashayan location in Reach 1. However, given the thermal parameters for release ($\leq$ 20°C) selected by the SJRRP Fisheries Management Work Group, the release location was moved to Scout Island through May 13, 2021, then to Owl Hollow for the remainder of the season. After tempering, fish were processed (*see Fish Processing*), moved to the river in an insulated Chiller Fish Bag™ filled at least ½ full with transport tank water to minimize stress and atmospheric exposure, and permitted time to recover until they were able to swim away under their own volition (Figure 5).

Adult Spring-Run Straying – Monitoring outside of the RA (downstream of the Merced River and SJR confluence) is not conducted by the SJRRP. However, understanding adult salmon straying rates is mentioned in the SJRRP Fisheries Management Plan. Therefore, with the assistance of the National Marine Fisheries Service, data on adult salmon observed or collected in tributaries was compiled from multiple sources: California Department of Fish and Wildlife (CDFW) carcass surveys (Stanislaus and Tuolumne Rivers; Steve Tsao (CDFW), Personal Communication), Mokelumne River Hatchery (Mokelumne River; Michelle Workman, East Bay Municipal Utility District, Personal Communication), and Cramer Fish Sciences PIT tag array data (Stanislaus River, Steve Zueg) as part of the Bureau of Reclamation's *Oncorhynchus mykiss* life-cycle monitoring and population census study.

3.0 Results and Discussion

Ninety-three adult spring-run Chinook Salmon were captured or recovered during 2021 monitoring efforts, resulting in the third season of successfully trapping and hauling adult spring-run Chinook Salmon in the RA (2019 n=23 and 2020 n=57; Figure 6). The 2021 water year was classified as "dry" with "Critical High" flows, considerably different than the "wet" 2019 year, and with less water than in 2020 ("dry"), indicating adult spring-run salmon successfully immigrated through the SJR and into the RA in less-than-optimal conditions. Based on initial fish capture, the beginning of immigration into the RA during all three ATH seasons (2019, 2020, and 2021) occurred in early April (Figure 6). Unlike 2019, when it was likely adult salmon were still immigrating through the RA when sampling equipment was removed (Sutphin et al. 2019), weekly capture distribution and elevated late-season temperatures suggest the full immigration period was likely encompassed during 2020 and 21 activities. During 2021 monitoring, the most upstream capture location (Van Clief) was a series of nets and traps spanning most the river width in multiple locations (see Figure 2). In addition, upstream fish passage was not available immediately upstream at the Eastside Bypass Rock Weir upstream of this sampling location and carcasses (N = 7) were recovered between most upstream netting locations and downstream of the weir. Therefore, it is assumed the majority of salmon immigrating through Reach 4 of the RA towards the spawning reach were captured or recovered during 2021 monitoring efforts. Nonetheless, current adult escapement estimates are based solely on enumerating captured adults and gear efficiency estimates that would provide measurement error for such estimates are not currently incorporated in the study design.

Figure 5.— Adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) being released into Reach 1 of the San Joaquin River Restoration Program's Restoration Area.

Of the 93 adult salmon captured or recovered, 74 were released into Reach 1 of the RA, of which 61 were tagged prior to release (Table 1). Transport time from capture to release location generally ranges from 1.5 to 2.5 hours. Of the 74 adult salmon released into R1, 40 were released at H99, nine at Camp Pashayan, eight at Scout Island, and 17 were released at Owl Hollow. Twenty-four individuals were provided a combination of both acoustic and PIT tags, 37 were provided only a PIT tag. An individual tagged April 18, 2022 was found as a mortality in a rotary screw trap at Scout Island May 3, 2022. The acoustic tag was removed and redeployed on May 4, 2022. During 2021 efforts, all acoustically tagged fish were released at the most downstream locations (H99 = 23, C.Pashayan = 1). Adult salmon provided acoustic and PIT tags released into Reach 1 supported additional monitoring efforts necessary to track restoration efforts related to salmon population metrics defined in the SJRRP Fisheries Framework (SJRRP 2018). Thirteen salmon were not tagged prior to release. The majority of these individuals were not tagged due to poor condition post transport (N = 9) or because they were deemed too small (N = 1) in an effort to minimize additional stress and promote survival post-release.

In total, 22 mortalities occurred during and immediately following described activities. Eight carcasses were recovered during sampling: six at Van Clief and 2 at HFB. These were individuals found in water or on shore, but not in sample gears. Nine fish were identified as capture location mortalities: one in VC fyke nets, two in HFB fyke nets, and six seining and hand netting efforts in the pool at VC downstream of Eastside Bypass Rock Weir. These were

individuals recovered in sample gear that were either immediately identified as a mortality or deemed to be in conditions that survival to release was not likely (i.e., belly-up, minimal gilling/gulping, little to no swimming response, etc.). One salmon succumbed to mortality during truck-transport. In total, four individuals were recovered as mortalities in rotary screw traps (H99 = 2, Scout Island = 2) deployed to quantify juvenile salmon production, emigration timing and survival. Percent of combined truck-transport induced and capture location mortalities in 2021 (11%) were similar to 2019 (13%) and 2020 (14%). The majority of capture location mortalities in 2021 were post-seining and dip netting (N = 5), and not in-trap mortalities (N = 4). On-site carcass recoveries in 2021 (N = 8, 9%), were higher than 2019 (N = 0) and 2020 (N = 1, 2%). Higher percentages of recovered carcasses in 2021 is likely attributed to our ability to observe and sample the terminus to upstream adult salmon immigration at Eastside Bypass Rock Weir, as six individuals were recovered at that location.

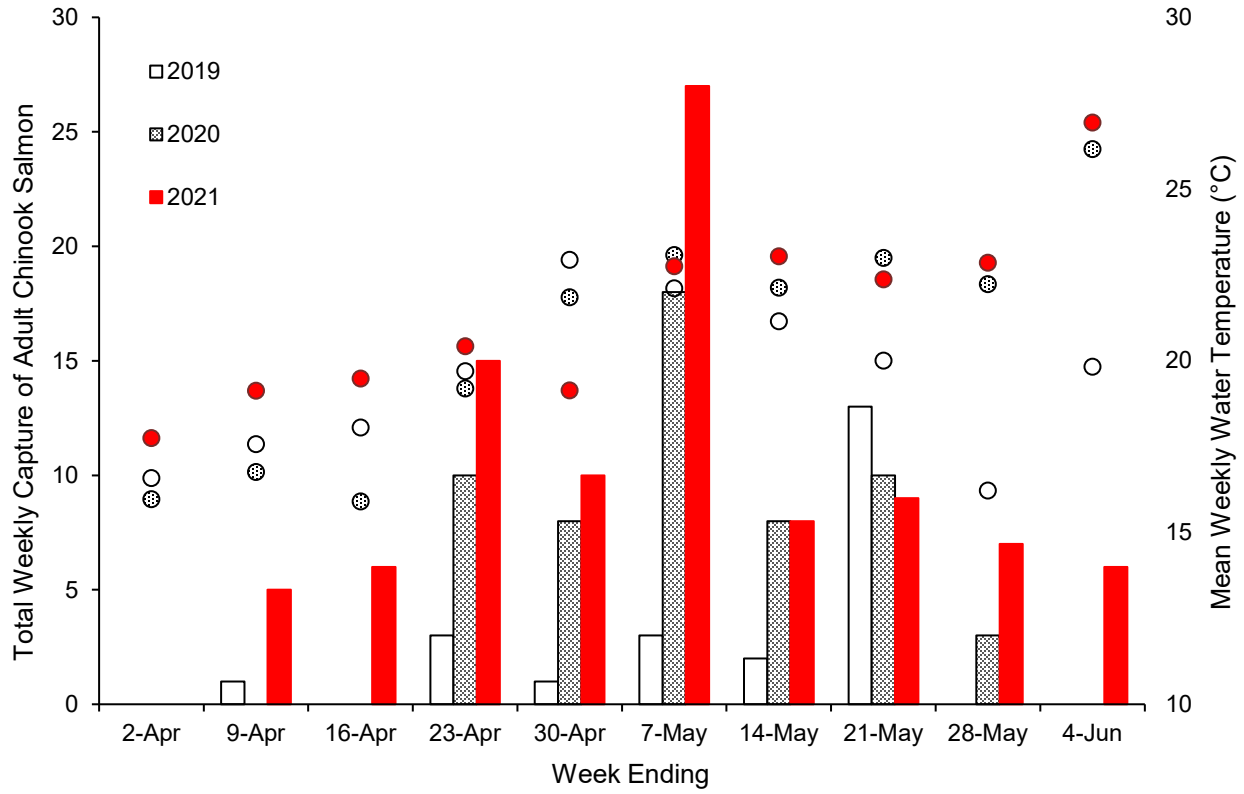

Figure 6.— Weekly capture of adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) during 2019, 2020, and 2021 monitoring efforts in the San Joaquin River Restoration Program's Restoration Area. Mean 2019 (dark grey), 2020 (light grey), and 2021 (red) weekly river temperature at the Stevinson gauging station (SJS, CDEC) is reported on the secondary y-axis.

Of the 87 tissue samples collected during 2021 adult trap and haul efforts and submitted to the NOAA Southwest Fisheries Science Center, genetic analysis classified all individuals as the spring-run phenotype and further classified all samples as Salmon Conservation and Rearing Facility (SCARF) production fish. Through a combination of genetic analysis and field ID 79 individuals were identified to sex (14 unknowns): 42 were identified as female and 37 were

identified as male (1.1:1 female:male ratio). During all three years of adult spring-run Chinook Salmon monitoring and trap and haul sex ratio has been skewed slightly high towards females (2019, 1.6:1, n=18; 2020, 1.1:1, n=40). In general, trends in sex-specific daily capture summed across all years of sampling suggest males and females tend to immigrate into the RA evenly distributed throughout the immigration season (Figure 7).

Size distribution of captured adult salmon across all years of adult spring-run monitoring is reported in Figure 8. The combination of recovered previously CWT tagged fish, PIT tagged fish (n = 2), and genetic analysis indicate 94% of adults (n = 85) returning in 2021 were age-3 (brood year 2018) and 6% (n = 5) were age-4 (brood year 2017). Across all years of adult spring-run monitoring age-3 returners constitute the majority (Figure 9). However, multiple spring-run Chinook Salmon cohorts (multiple age classes) have returned to the RA in each sample season. This is promising for re-establishing a population of spring-run Chinook Salmon in the RA, as one of the key characteristics of a healthy and complex salmon population is the annual return of multiple age classes (CRITFC 1995). Additionally, data recovered from CWT and PIT tags proved multiple juvenile releases strategies can be successful, as recovered adults were initially released on different occasions as both parr/smolts (young-of-year) and larger yearlings.

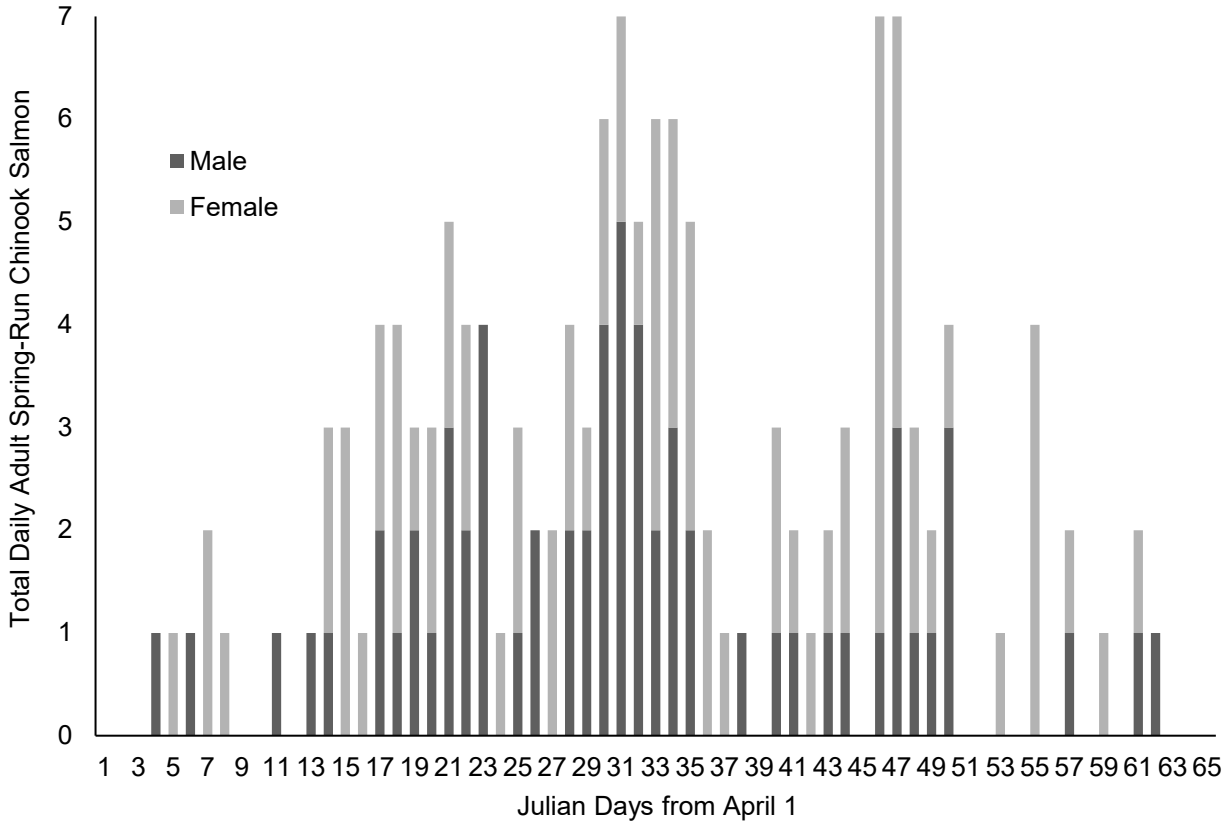

Figure 7.— Total daily capture of adult male (dark grey) and female (light grey) spring-run Chinook Salmon in the San Joaquin River Restoration Area across 2019, 2020, and 2021 monitoring season.

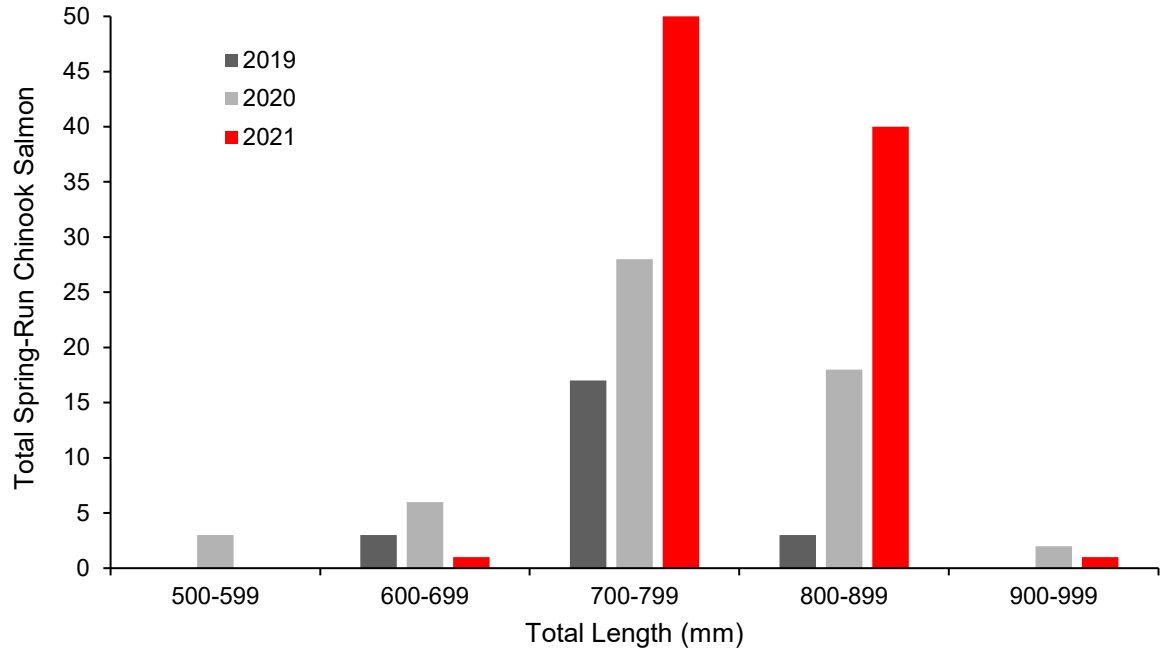

Figure 8.— Size distribution of adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) during 2019, 2020, and 2021 monitoring activities in the San Joaquin River Restoration Program's Restoration Area.

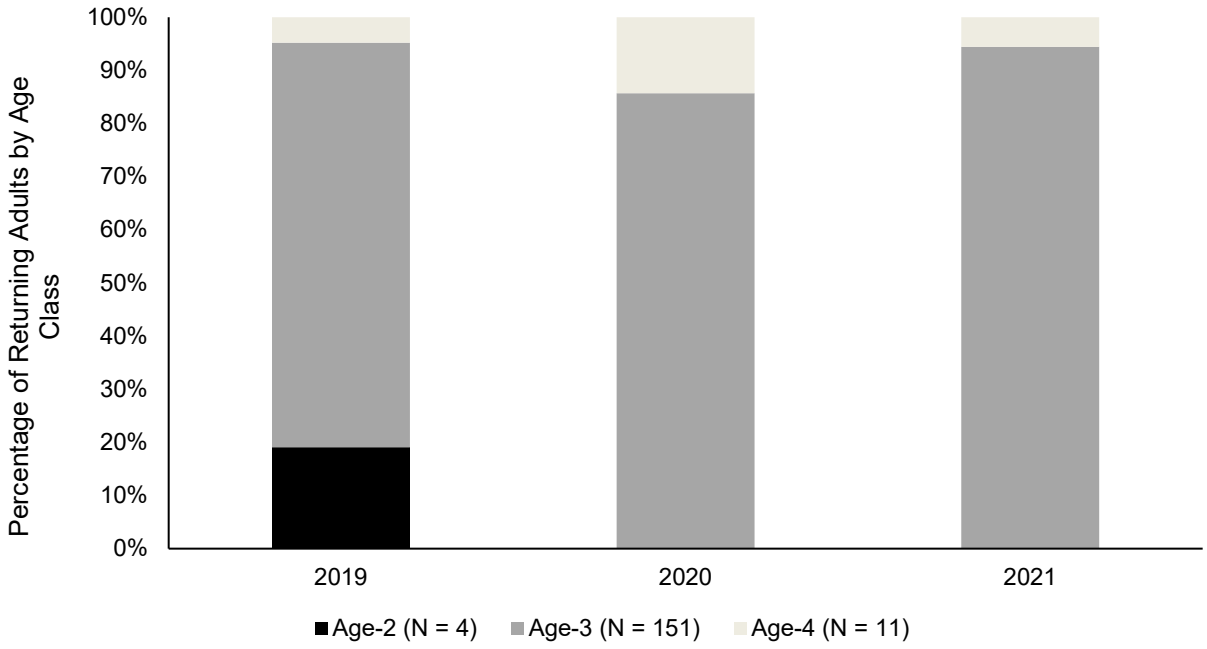

Figure 9.— Age-class distribution of adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) during 2019, 2020, and 2021 monitoring activities in the San Joaquin River Restoration Program's Restoration Area.

Mean monthly water temperatures for the majority of the season and at most capture locations were above the lethal level (>20°C) for adult Chinook Salmon migration (EPA Region 10 2003, SJRRP 2018, Table 2), resulting in the third consecutive year of adult spring-run monitoring and trap and haul efforts (Sutphin et al. 2019; Sutphin and Root 2020) with water temperatures above optimal for the majority of the immigration period. Interestingly, during 2021 efforts the majority (61%) of adult spring-run Chinook Salmon were captured or recovered after April (Figure 6) when in-river water temperatures were consistently above the defined lethal level (Figure 8). Of the adults captured during this period of time (May – June) 77% were transported and released successfully in Reach 1 of the RA. Of those individuals, 80% were identified as being in good condition at the time of capture.

In addition to the SJRRP adult spring-run Chinook Salmon entering the RA, 29 individuals were observed straying into SJR tributaries including 1, 8, 19, and 2 individuals in the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers, respectively (see "Methods" for data sources). The individuals straying had a similar F:M sex ratio (1.3:1.0) as those entering the RA and were comprised of 86% age-3 and 14% age-4 returners. Of the individuals that strayed, eight (28%) were released as yearlings and 21 (72%) were released as young-of-year. Cumulative of adult spring-run Chinook Salmon that returned to the RA or were recovered or observed in SJR tributaries, ten individuals were released as yearlings. Biologists working for the SJRRP are not responsible for or have control over monitoring outside of the RA. Nonetheless, total of adult spring-run Chinook Salmon straying outside of the RA during 2021 was the highest reported since inception of adult spring-run monitoring and trap and haul in 2019. These results support the continued need for Biologists working for the SJRRP to continue to better understand how thermal conditions in the SJR may be impacting adult immigration and straying, as temperatures observed during the current study often exceeded levels that reportedly contribute to cessation of immigration in adult spring-run Chinook Salmon (McCullough et al. 2001).

Across all sampling locations and methods, 489 non-salmonids (bycatch) were captured during adult spring-run monitoring and rescue efforts (Appendix B). Bycatch was dominated by non-native species, including Striped Bass (*Morone saxatilis*, n = 47), Common Carp (*Cyprinus carpio*, n = 328), Channel Catfish (*Ictalurus punctatus*, n = 68), and Black Bass (*Micropterus spp.*, n = 20). Native non-salmonids captured during this effort were limited to the Sacramento Sucker (*Catostomus occidentalis*, n = 2).

Table 1.— Capture date, location and method, as well as other recorded characteristics for all spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured during 2021 adult spring-run Chinook Salmon monitoring and trap and haul. Fish sex is reported as male (M), female (F), or unknown (U).

Sample ID	Date of Capture	Capture Location	Method	FL (mm)	TL (mm)	Sex	Condition	Acoustic Tag ID	Floy Tag	Gastric PIT	Release Location
SJRRP2021ADULT001	4/5/21	Van Clief	Fyke Net	670	720	M	Good	1346	3001/3002	180985027	HWY 99
SJRRP2021ADULT999	4/6/21	Van Clief	Hand Net			F	Mortality				Capture Locaiton
SJRRP2021ADULT002	4/7/21	Van Clief	Fyke Net	620	673	M	Good	1345	3003/3004	180985031	HWY 99
SJRRP2021ADULT003	4/8/21	Van Clief	Fyke Net	710	766	F	Good	1344	3005/3006	180985049	HWY 99
SJRRP2021ADULT004	4/8/21	Van Clief	Fyke Net	735	800	F	Good	1343	3007/3008	180985036	HWY 99
SJRRP2021ADULT005	4/12/21	Van Clief	Fyke Net	765	810	M	Good	1342	3009/3010	180985016	HWY 99
SJRRP2021ADULT006	4/14/21	Van Clief	Fyke Net	733	785	M	Good	1341	3011/3012	180984131	HWY 99
SJRRP2021ADULT007	4/15/21	Van Clief	Fyke Net	747	790	F	Good	1340	3013/3014	180985023	HWY 99
SJRRP2021ADULT008	4/15/21	Van Clief	Fyke Net	770	823	M	Good	1339	3015/3016	180985013	HWY 99
SJRRP2021ADULT009	4/15/21	Van Clief	Fyke Net	700	757	F	Good	1338	3017/3018	180985020	HWY 99
SJRRP2021ADULT010	4/16/21	Van Clief	Fyke Net	820	875	F	Good	1337	3019/3020	180985021	HWY 99
SJRRP2021ADULT011	4/18/21	Van Clief	Fyke Net	767	811	M	Capture Location Mortality				CDFW
SJRRP2021ADULT012	4/18/21	Van Clief	Fyke Net	710	773	F	Good	1336	4001/4002	180985047	HWY 99
SJRRP2021ADULT013	4/19/21	Van Clief	Fyke Net	807	861	U	Good	1335	4003/4004	180985017	HWY 99
SJRRP2021ADULT014	4/19/21	Van Clief	Fyke Net	742	794	U	Good	1334	4005/4006	180985007	HWY 99
SJRRP2021ADULT015	4/19/21	Van Clief	Fyke Trap	734	780	F	Transport Mortality				CDFW
SJRRP2021ADULT016	4/20/21	Van Clief	Fyke Net	757	804	M	Good	1333	4007/4008	180985038	HWY 99
SJRRP2021ADULT017	4/20/21	Van Clief	Fyke Net	736	791	F	Good	1332	4009/4010	180984237	HWY 99
SJRRP2021ADULT018	4/21/21	Van Clief	Fyke Net	678	723	F	Good	1331	4011/4012	180984225	HWY 99
SJRRP2021ADULT999	4/22/21	Van Clief	Hand Net	770	792	U	Carcass				
SJRRP2021ADULT019	4/22/21	Van Clief	Fyke Trap	720	771	M	Fair	1330	4013/4014	180984226	HWY 99
SJRRP2021ADULT020	4/22/21	Van Clief	Fyke Net	670	723	F	Good	1329	4015/4016	180984235	HWY 99
SJRRP2021ADULT021	4/22/21	Van Clief	Fyke Net	820	880	M	Good	1328	4017/4018	180984236	HWY 99
SJRRP2021ADULT022	4/22/21	Van Clief	Fyke Net	740	788	M	Good	1327	4019/4020	180984234	HWY 99
SJRRP2021ADULT023	4/23/21	Van Clief	Fyke Net	820	877	M	Good	1326	5001/5002	180984198	HWY 99
SJRRP2021ADULT024	4/23/21	Van Clief	Fyke Net	740	790	M	Good	1325	5003/5004	180984197	HWY 99
SJRRP2021ADULT025	4/24/21	Van Clief	Seining	770	820	M	Poor		5005/5006		HWY 99
SJRRP2021ADULT026	4/24/21	Van Clief	Seining	696	746	M	Capture Location Mortality				CDFW
SJRRP2021ADULT027	4/26/21	Van Clief	Fyke Net	750	806	F	Good	1324	5007/5008	180984199	HWY 99
SJRRP2021ADULT028	4/26/21	Van Clief	Fyke Net	680	728	F	Good		5009/5010	180984200	HWY 99
SJRRP2021ADULT029	4/28/21	Van Clief	Seining	692	741	F	Poor		5011/5012		HWY 99

Table 1 (Continued).— Capture date, location and method, as well as other recorded characteristics for all spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured during 2020 adult spring-run Chinook Salmon monitoring and trap and haul. Fish sex is reported as male (M), female (F), or unknown (U).

Sample ID	Date of Capture	Capture Location	Method	FL (mm)	TL (mm)	Sex	Condition	Acoustic Tag ID	Floy Tag	Gastric PIT	Release Location
SJRRP2021ADULT030	4/28/21	Van Clief	Seining	793	847	F	Capture Location Mortality				CDFW
SJRRP2021ADULT031	4/29/21	Van Clief	Fyke Net	730	793	M	Poor		5013/5014	180984201	HWY 99
SJRRP2021ADULT032	4/29/21	Van Clief	Fyke Trap	761	810	F	Good		5015/5016	180984202	HWY 99
SJRRP2021ADULT033	4/30/21	Van Clief	Seining	780	831	M	Poor		5017/5018		HWY 99
SJRRP2021ADULT034	4/30/21	Van Clief	Fyke Trap	738	786	F	Good		5019/5020	180984203	HWY 99
SJRRP2021ADULT035	5/1/21	Van Clief	Hand Net	810	850	M	Good		5021/5022	180984204	HWY 99
SJRRP2021ADULT036	5/1/21	Van Clief	Hand Net	742	795	M	Fair		5023/5024	180984206	HWY 99
SJRRP2021ADULT037	5/1/21	Van Clief	Fyke Net	825	880	U	Good		5025/5026	180984205	HWY 99
SJRRP2021ADULT038	5/1/21	Van Clief	Fyke Net	790	848	U	Good		5027/5028	180984207	HWY 99
SJRRP2021ADULT039	5/1/21	Van Clief	Fyke Net	728	779	M	Good		5029/5030	180984209	HWY 99
SJRRP2021ADULT040	5/1/21	Van Clief	Fyke Net	740	780	F	Capture Location Mortality				CDFW
SJRRP2021ADULT041	5/1/21	Van Clief	Seining	680	725	M	Capture Location Mortality				CDFW
SJRRP2021ADULT042	5/2/21	Van Clief	Fyke Net	790	843	M	Good		2001/2002	180984210	HWY 99
SJRRP2021ADULT043	5/2/21	Van Clief	Fyke Net	779	832	F	Good		2003/2004	180984208	HWY 99
SJRRP2021ADULT044	5/2/21	Van Clief	Seining	720	767	F	Capture Location Mortality				CDFW
SJRRP2021ADULT045	5/3/21	Van Clief	Fyke Net	770	825	M	Good		2005/2006	180984211	HWY 99
SJRRP2021ADULT046	5/3/21	Van Clief	Fyke Net	740	775	U	Good		2007/2008	180984212	HWY 99
SJRRP2021ADULT047	5/3/21	Van Clief	Fyke Net	750	806	M	Good		2009/2010	180984213	HWY 99
SJRRP2021ADULT048	5/3/21	Van Clief	Hand Net	760	820	M	Capture Location Mortality				CDFW
SJRRP2021ADULT049	5/4/21	Van Clief	Fyke Net	690	745	U	Good		2011/2012	180984217	Camp Pashayan
SJRRP2021ADULT050	5/4/21	Van Clief	Fyke Net	723	770	U	Good	1336	2013/2014	180984216	Camp Pashayan
SJRRP2021ADULT051	5/4/21	Van Clief	Fyke Net	748	806	M	Good		2015/2016	180984215	Camp Pashayan
SJRRP2021ADULT052	5/4/21	Van Clief	Fyke Net	760	810	F	Good		2017/2018	180984214	Camp Pashayan
SJRRP2021ADULT053	5/5/21	Van Clief	Fyke Net	741	804	U	Good		2019/2020	180984218	Camp Pashayan
SJRRP2021ADULT054	5/5/21	Van Clief	Fyke Net	758	814	M	Good		2021/2022	180984219	Camp Pashayan
SJRRP2021ADULT055	5/5/21	Van Clief	Fyke Net	720	768	M	Good		2023/2024	180985062	Camp Pashayan
SJRRP2021ADULT056	5/5/21	Van Clief	Fyke Net	740	790	F	Good		2025/2026	180985063	Camp Pashayan
SJRRP2021ADULT057	5/5/21	Van Clief	Fyke Net	670	721	F	Good		2027/2028		Camp Pashayan
SJRRP2021ADULT058	5/6/21	Van Clief	Fyke Net	706	760	M	Good		6061/6062	180985064	Scout Island
SJRRP2021ADULT059	5/6/21	Van Clief	Fyke Net	770	832	F	Good		6063/6064	180985065	Scout Island
SJRRP2021ADULT060	5/7/21	Van Clief	Fyke Net	758	816	U	Good		6065/6066	180985066	Scout Island

Table 1 (Continued).— Capture date, location and method, as well as other recorded characteristics for all spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) captured during 2020 adult spring-run Chinook Salmon monitoring and trap and haul. Fish sex is reported as male (M), female (F), or unknown (U).

Sample ID	Date of Capture	Capture Location	Method	FL (mm)	TL (mm)	Sex	Condition	Acoustic Tag ID	Floy Tag	Gastric PIT	Release Location
SJRRP2021ADULT061	5/7/21	Hills Ferry Barrier	Fyke Net	750	809	F	Capture Location Mortality				CDFW
SJRRP2021ADULT062	5/8/21	Van Clief	Fyke Net	720	775	F	Good		6067/6068	180985068	Scout Island
SJRRP2021ADULT063	5/11/21	Van Clief	Fyke Net	735	785	F	Good		6069/6070	180985067	Scout Island
SJRRP2021ADULT064	5/11/21	Van Clief	Fyke Net	685	745	F	Good		6071/6072	180985050	Scout Island
SJRRP2021ADULT065	5/11/21	Hills Ferry Barrier	Fyke Net	780	838	M	Capture Location Mortality				CDFW
SJRRP2021ADULT066	5/12/21	Van Clief	Fyke Trap	790	835	M	Good		6073/6074		Scout Island
SJRRP2021ADULT999	5/13/21	Hills Ferry Barrier	Fyke Net	775	805	U	Carcass				CDFW
SJRRP2021ADULT067	5/13/21	Van Clief	Hand Net	750	800	F	Good		6075/6076		Scout Island
SJRRP2021ADULT068	5/14/21	Van Clief	Fyke Net	720	755	M	Good		6077/6078	180985052	Owl Hollow
SJRRP2021ADULT069	5/15/21	Van Clief	Fyke Net	735	780	F	Good		6079/6080	180985053	Owl Hollow
SJRRP2021ADULT070	5/15/21	Van Clief	Fyke Net	750	805	F	Good		6081/6082	180985054	Owl Hollow
SJRRP2021ADULT071	5/15/21	Van Clief	Fyke Net	740	790	M	Capture Location Mortality				CDFW
SJRRP2021ADULT072	5/17/21	Van Clief	Fyke Trap	780	835	F	Good		6083/6084	180985055	Owl Hollow
SJRRP2021ADULT073	5/18/21	Van Clief	Seining	755	797	F	Poor		6085/6086		Owl Hollow
SJRRP2021ADULT074	5/18/21	Van Clief	Seining	735	770	M	Poor		6087/6088		Owl Hollow
SJRRP2021ADULT075	5/18/21	Van Clief	Fyke Net	690	740	M	Fair		6089/6090		Owl Hollow
SJRRP2021ADULT076	5/18/21	Van Clief	Fyke Net	760	810	F	Good		6091/6092		Owl Hollow
SJRRP2021ADULT077	5/20/21	Van Clief	Fyke Net	850	905	U	Good		2029/6093	180985051	Owl Hollow
SJRRP2021ADULT078	5/24/21	Van Clief	Fyke Net	703	747	F	Good		2030/6094	180985060	Owl Hollow
SJRRP2021ADULT079	5/26/21	Van Clief	Fyke Net	740	795	F	Good		2031/6095	180985056	Owl Hollow
SJRRP2021ADULT080	5/26/21	Van Clief	Seining	741	801	F	Fair		2032/6096	180985057	Owl Hollow
SJRRP2021ADULT081	5/26/21	Van Clief	Seining	675	729	F	Good		2033/6097	180985058	Owl Hollow
SJRRP2021ADULT082	5/26/21	Van Clief	Fyke Net	725	788	F	Fair		2034/6098	180985059	Owl Hollow
SJRRP2021ADULT083	5/28/21	Van Clief	Seining	738	780	F	Fair		2035/6099		Owl Hollow
SJRRP2021ADULT084	5/28/21	Van Clief	Seining	715	768	M	Fair		2036/6100		Owl Hollow
SJRRP2021ADULT085	5/30/21	Van Clief	Seining	726	780	F	Poor		2037/6101		Owl Hollow
SJRRP2021ADULT999	5/30/21	Hills Ferry Barrier	Hand Net	738	770	U	Carcass				CDFW
SJRRP2021ADULT086	6/1/21	Van Clief	Hand Net	670	717	F	Carcass				CDFW
SJRRP2021ADULT087	6/1/21	Van Clief	Hand Net	752	811	M	Carcass				CDFW
SJRRP2021ADULT999	6/2/21	Van Clief	Hand Net	758	809	M	Carcass				CDFW
SJRRP2021ADULT999	6/2/21	Van Clief	Hand Net	799	841	U	Carcass				CDFW

Table 2.— Site-specific water quality (mean ± 1 standard deviation) during April, May, and June 2021 adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul in the San Joaquin River (SJR). Data reported is the mean of point estimates collected at the time of daily site checks.

Location	Month	Temp. (°C):	DO (mg/L):	Cond. (µS/cm):	Turb. (NTU):
Hills Ferry Barrier	April	18.5 ± 1.2	7.8 ± 0.5	2490.3 ± 165.6	40.9 ± 16.7
	May	20.8 ± 1.7	7.6 ± 0.7	2196.8 ± 293.8	38.0 ± 10.1
	June	25.5 ± 0.5	6.9 ± 0.8	1675.2 ± 65.7	50.8 ± 7.3
Mud Slough	April	19.4 ± 4.0	8.5 ± 0.7	3152.0 ± 352.9	64.3 ± 70.0
	May	22.8	8.3	2625	48.1
Van Clief (SJR)	April	18.3 ± 0.9	7.2 ± 1.0	1547.8 ± 40.8	9.9 ± 4.1
	May	21.1 ± 1.4	6.4 ± 0.9	1700.4 ± 50.7	11.8 ± 2.5
	June	25.5 ± 0.1	5.2 ± 0.8	1857.0 ± 20.1	13.6 ± 2.3
Van Clief (ESBP)	April	18.7 ± 0.8	7.6 ± 0.8	1177.8 ± 87.4	78.0 ± 125.6
	May	20.8 ± 1.7	7.9 ± 0.6	865.6 ± 242.4	94.9 ± 131.3
	June	26.2 ± 0.5	7.0 ± 0.8	519.4 ± 276.8	69.8 ± 14.5
Salt Slough	April	18.9 ± 9.5	5.2 ± 2.6	1641.6 ± 219.9	87.9 ± 231.7
	May	21.4 ± 1.6		1420.2 ± 139.6	
	June	26.2 ± 0.4			

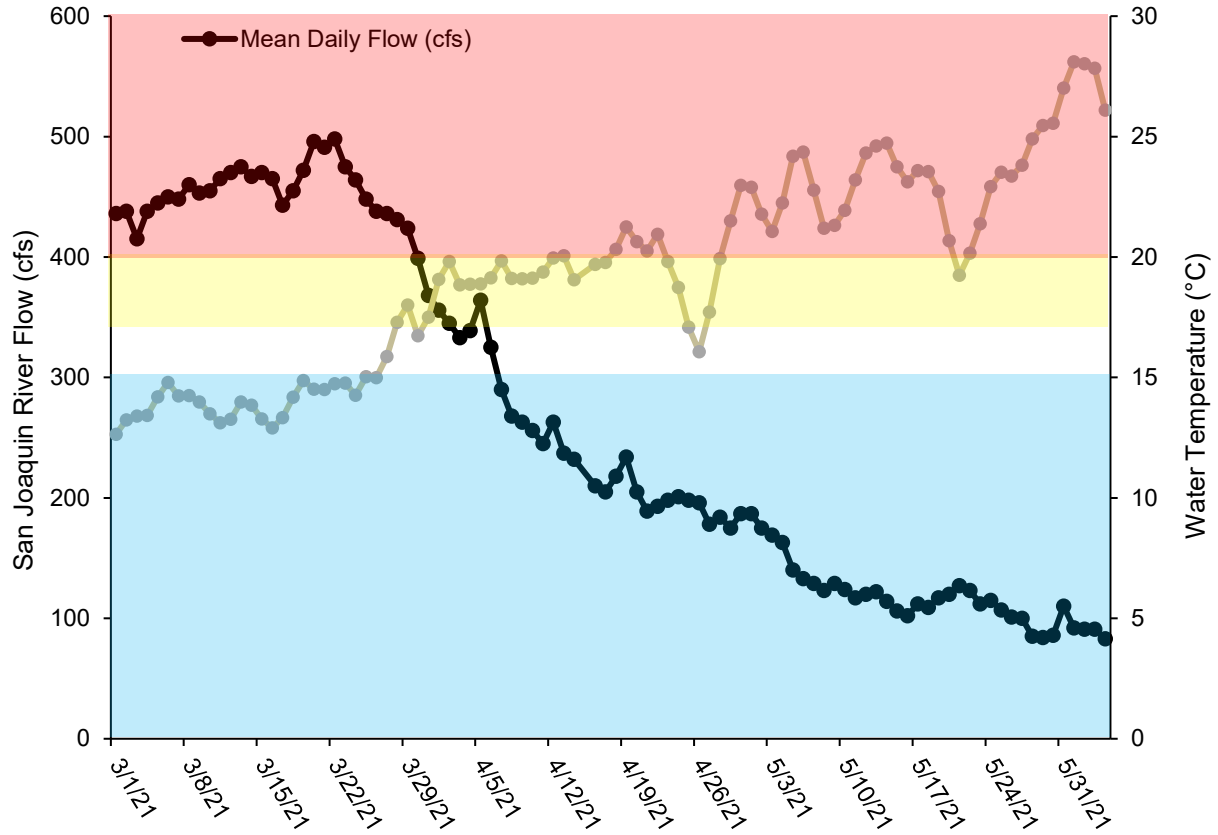

Figure 8.— Water temperature (°C) and flow (cfs) at the most downstream (Hills Ferry Barrier, HFB) sampling location in Reach 5 of the San Joaquin River Restoration Program (SJRRP) Restoration Area during 2021 adult spring-run Chinook Salmon monitoring and trap and haul (SMN California Data Exchange Center Gauging Station Data, cdec.water.gov). Blue, yellow, and red highlighted areas define adult spring-run Chinook Salmon optimal (< 15°C), critical (17-20°C), and lethal (> 20°C) thresholds as defined by the SJRRP.

4.0 References

CRITFC (Columbia River Intertribal Fish Commission). 1995. WY-KAN-USH-MI WY-KISH-WIT Spirit of the Salmon. *The Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs, and Yakama Tribes*. Volume I.Craig, J.K., C.J. Foote, and C.C. Wood. 1996. Evidence for temperature-dependent sex determination in sockeye salmon (Oncorhynchus nerka). Canadian Journal of Fisheries and Aquatic Sciences 53:141–147.

EPA (U.S. Environmental Protection Agency). 2003. *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards*. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Hutcherson, J., Z. Sutphin, P. Ferguson, M. Grill, J. C. Garza, and A. Clemento. 2020. *Juvenile spring-run Chinook Salmon production and emigration in the San Joaquin River Restoration Area. 2017–18 Monitoring and Analysis*. San Joaquin River Restoration Program.

Moyle, P.B. 2002. *Inland Fish of California*, Second edition. University of California Press, Berkeley, California.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5: Summary of technical literature examining the physiological effects of temperature on salmonids. EPA910-D-01-005, U. S. Environmental Protection Agency, Region 10, Seattle, Washington.

SJRRP (San Joaquin River Restoration Program). 2010. *Fisheries management plan: a framework for adaptive management in the San Joaquin River Restoration Program*. November 2010. 164p. https://www.restoresjr.net/?wpfb_dl=866

SJRRP. 2011. Reintroduction Strategy for Spring Run Chinook Salmon. February 2011. 67p. https://www.restoresjr.net/?wpfb_dl=858

SJRRP. 2018. Fisheries Framework: Spring-run and Fall-run Chinook Salmon. http://www.restoresjr.net/?wpfb_dl=1055

Sutphin, Z. S. Durkacz, M. Grill, L. Smith, and P. Ferguson. 2019. *2019 Adult Spring-Run Chinook Salmon Monitoring, Trap and Haul, and Rescue Actions in the San Joaquin River Restoration Area*. San Joaquin River Restoration Program Annual Technical Report ENV-2019-088. Bureau of Reclamation, Denver Technical Service Center, Colorado.

Sutphin, Z. and S. Root. *2020. 2020 Adult Spring-Run Chinook Salmon Monitoring and Trap and Haul in the San Joaquin River Restoration Area.* San Joaquin River Restoration Program Annual Technical Report. Bureau of Reclamation, Denver Technical Service Center, Colorado.

Westers, H. 2001. *Production*. Pages 31–90 in G.A. Wedemeyer, editor. Fish hatchery management, second edition. American Fisheries Society, Bethesda, Maryland.

Yoshiyama, R.M. F.W. Fisher, and P.B. Moyle. 1998. *Historical abundance and decline of Chinook Salmon in the Central Valley Region of California*. North American Journal of Fisheries Management 18:487–521.

5.0 Appendix

5.1 **Appendix A** — 2021 Spring-Run Chinook Salmon Adult Trap and Haul Site-Specific Pictures

Figure A-1.— Image of Eastside Bypass Rock Weir during 2021 spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) adult trap and haul and monitoring efforts. During 2021 monitoring, this location was deemed the first impediment to upstream passage of adult salmonids and no sampling was completed upstream of this location.

Figure A-2.— Sampling equipment (two fyke nets and one fyke trap pictured) immediately downstream of the Eastside Bypass Rock Weir at the Van Clief location (see Figure 1 for map) during 2021 San Joaquin River Restoration Program adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul.

Figure A-3.— Sampling equipment (fyke trap) at the Salt Slough location (Freitas Boat Launch; see Figure 1 for map) during 2021 San Joaquin River Restoration Program adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul.

Figure A-4.— Sampling equipment (two fyke nets pictured) at the Hills Ferry Barrier location (see Figure 1 for map) during 2021 San Joaquin River Restoration Program adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul.

Figure A-5.— Sampling equipment (fyke trap) at the Mud Slough location (see Figure 1 for map) during 2021 San Joaquin River Restoration Program adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul.

5.2 **Appendix B** — Summary of non-salmonids (bycatch)

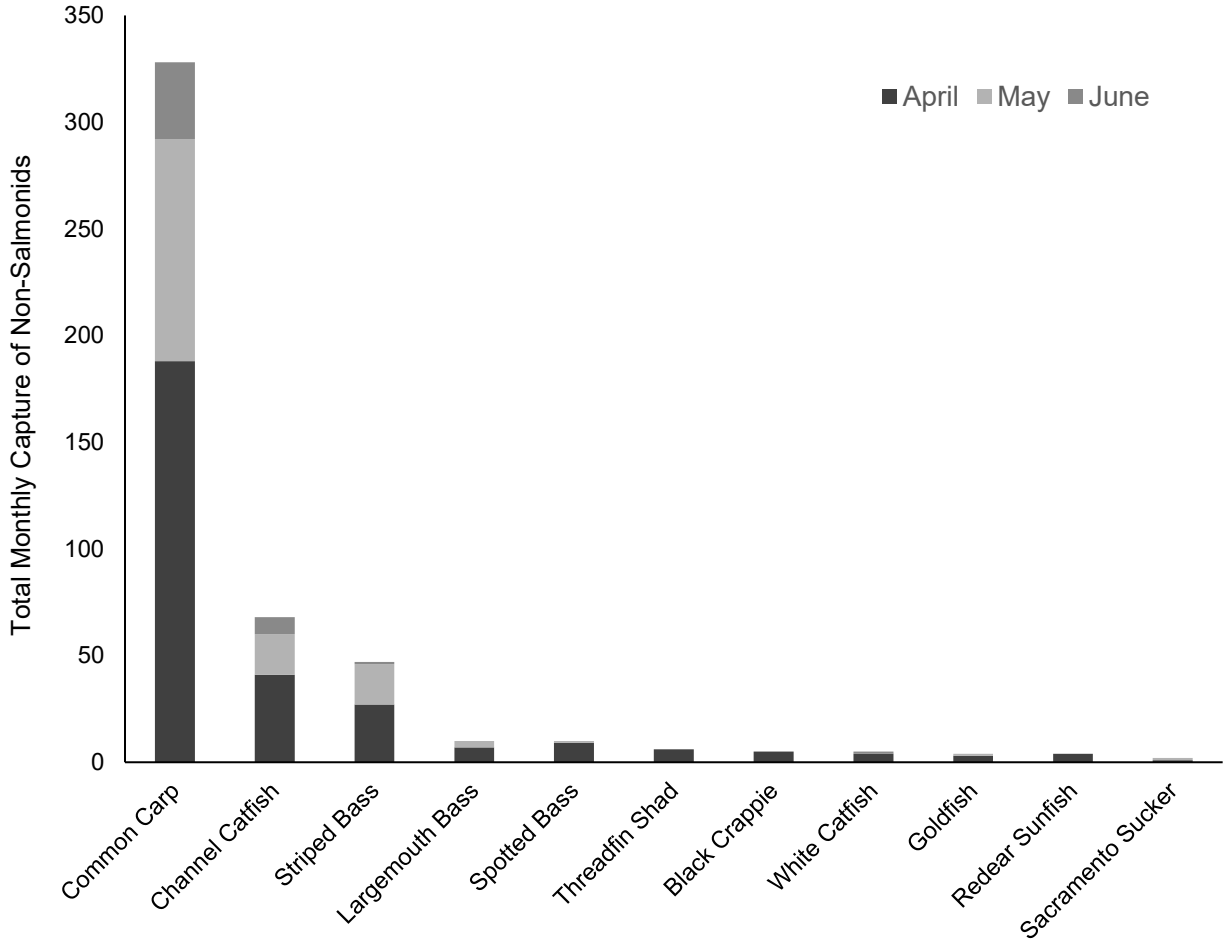

Figure B-1.— Bycatch totals for non-salmonids captured during 2021 adult spring-run Chinook Salmon (*Oncorhynchus tshawytscha*) monitoring and trap and haul.