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Review of the San Joaquin River Restoration Program's Reintroduction of Native Anadromous Fish: Technical Paper for the Report to Congress

December 2024

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
West Coast Region

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List of Acronyms

CDFW	California Department of Fish and Wildlife
CCV	California Central Valley
CV	Central Valley
cfs	Cubic feet per second
CVO	Central Valley Office
CVP	Central Valley Project
CWT	Coded Wire Tag
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FMP	Fishery Management Plan
FR	Federal Register
FRFH	Feather River Fish Hatchery
HGMP	Hatchery Genetics Management Plan
HMRD	Henry Miller Reclamation District
MSA	Magnuson–Stevens Fishery Conservation & Management Act
NEP	Nonessential Experimental Population
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PFMC	Pacific Fisheries Management Council
RA	Restoration Administrator
RMPC	Regional Mark Processing Center
RST	Rotary Screw Trap
(i)SCARF	(interim) Salmon Conservation and Research Facility
sDPS	Southern Distinct Population Segment
SJRRP	San Joaquin River Restoration Program
SRKW	Southern Resident Killer Whale
SWFSC	Southwest Fisheries Science Center
TAC	Technical Advisory Committee
USBR/Reclamation	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
YOY	Young-of-Year

1 Background

The San Joaquin River originates in the southern Sierra Nevada mountains and flows southwest onto the San Joaquin Valley floor before turning northwest to its confluence with the Sacramento River in the Sacramento-San Joaquin River Delta (Delta). Water from the Delta then flows through San Francisco Bay and out to the Pacific Ocean. The San Joaquin River watershed has been extensively modified through the construction of large dams for agriculture, municipalities, flood control, and hydroelectric generation. These dams have blocked salmon from accessing vital high quality and high elevation upstream habitats, and have significantly reduced and altered river flows for salmon, aquatic wildlife, and people who live adjacent to the river or use it for cultural or recreational purposes.

In the 1940s, Friant Dam was completed and diversions began, which disconnected and dewatered the San Joaquin River for approximately 60 miles. Shortly thereafter, Central Valley (CV) spring-run Chinook salmon were extirpated from the San Joaquin River. In 2006, after 18 years of litigation over the dewatering of the river (*NRDC et al., v Kirk Roger, et al.*), a Settlement was reached between a coalition of environmental non-governmental organization (the plaintiffs) and Friant Water Users Authority, and the U.S. Departments of the Interior and Commerce (the defendants). The Settlement established the Restoration and Water Management Goals, and required a set of actions to accomplish these Goals over a set time period. To achieve the Restoration Goal, the Settlement calls for: modifying barriers in the river channel to provide fish passage; establishing water allocations to reconnect the San Joaquin River down to the confluence of the Merced River; and reintroduction of Chinook salmon.

In 2009, the San Joaquin River Restoration Settlement Act [Public Law 111-11] was passed to implement the Settlement, and created the implementing agencies: Bureau of Reclamation (Reclamation), U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS), in coordination with the California Department of Water Resources (DWR) and California Department of Fish and Wildlife (CDFW). Reclamation is the federal lead agency but works in conjunction with the other implementing agencies to implement the Settlement and Settlement Act. The Settlement Act also stipulates that no later than December 31, 2024, the Secretary of Commerce shall report to Congress on the progress of the SJRRP. The report shall include:

> *"(A) an assessment of the major challenges, if any, to successful reintroduction;*
> *(B) an evaluation of the effect, if any, of the reintroduction on the existing population of California Central Valley Spring Run Chinook salmon existing on the Sacramento River or its tributaries; and*
> *(C) an assessment regarding the future of the reintroduction."*

To support the information provided in the Report to Congress, this technical paper includes a more detailed evaluation of the San Joaquin River Restoration Program's (SJRRP; Figure 1) reintroduction efforts, challenges, and assessment of the future. The Settlement Act had anticipated this report to be completed after full implementation of the Settlement had been achieved and associated data on reintroduction collected. Full implementation of the Settlement has not been achieved for various reasons; however, the report and this technical paper aim to address the three Congressional questions in the Settlement Act to the best extent possible. This technical paper describes reintroduction efforts, successes, and some challenges thus far, and provides a preview of what success could look like after full implementation of the Settlement.

A priority of the SJRRP is the reintroduction of CV spring-run Chinook salmon (*Oncorhynchus tshawytscha*). Full implementation of the Settlement is anticipated to benefit all native fish species, including other anadromous fish and their habitats managed by NMFS.[1] The other anadromous fish managed by NMFS's California Central Valley Office (CVO) in the San Joaquin River are: California Central Valley (CCV) steelhead (*O. mykiss*); the southern Distinct Population Segment (sDPS) of North American green sturgeon (*Acipenser medirostris*); and CV fall-run Chinook salmon (*O. tshawytscha*).

To support the information described in the Report to Congress, this technical paper provides:

1. An overview of the life cycle and ecology of anadromous fish species specific to the SJRRP Restoration Area (hereafter referred to as the Restoration Area) and San Joaquin River basin.
2. A summary of annual fisheries monitoring completed by the SJRRP to assess the status of the reintroduced population of CV spring-run Chinook salmon.
3. An evaluation of the reintroduction on the populations of CV spring-run Chinook salmon in the Sacramento and San Joaquin River basins.
4. An assessment of challenges to reintroduction.
5. An overview of additional beneficial effects of the SJRRP.
6. Recommendations and opportunities for partners working with the SJRRP.

Additionally, section 9 provides a glossary of scientific or policy terms and phrases that are used within, or relevant to, this technical paper.

[1] NMFS is responsible for the stewardship of the nation's ocean resources and their habitat. The California Central Valley Office has responsibility for salmon, steelhead trout, and green sturgeon conservation and recovery in the geographic region from the San Francisco Bay east including waters of the Sacramento-San Joaquin Delta and its tributaries to their headwaters in the Sierras. We work in these river basins to protect species listed under the Endangered Species Act by evaluating the impact of proposed federal actions, developing recovery plans, seeking conservation partnerships with local governments and landowners, and ensuring safe fish passage past federal, and some private, dams.

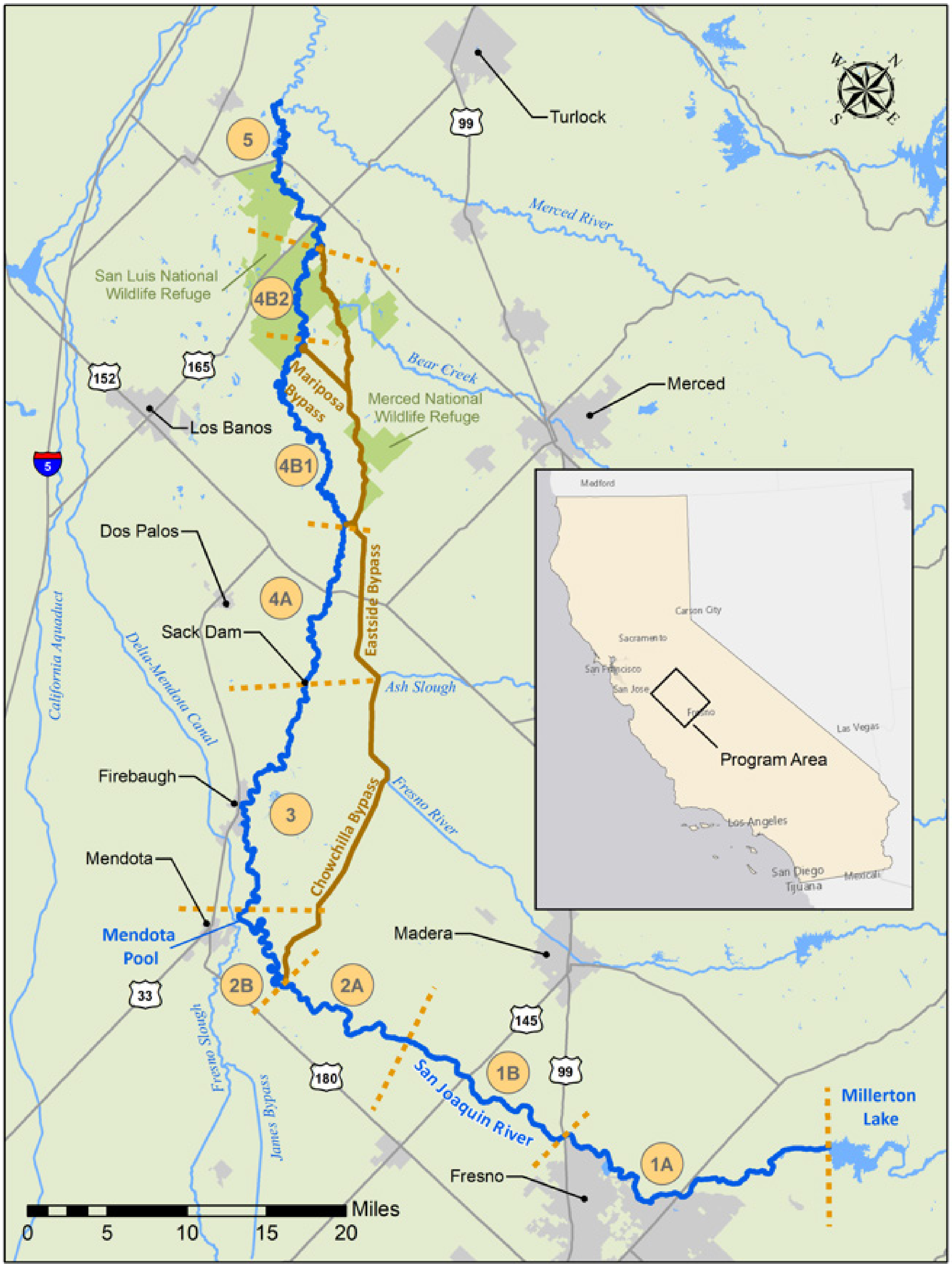

Figure 1. Map of the San Joaquin River Restoration Program (SJRRP) Area and location within California. Restoration Flows are routed through the San Joaquin River from Friant Dam (Millerton Lake) through Reach 4A. Restoration Flows are then routed into the Eastside Bypass at the downstream end of Reach 4A, and routed back into the San Joaquin River at the upstream end of Reach 5. Restoration Flows are not routed through Reach 4B1 or 4B2. Legend: Thick dark blue line is the natural San Joaquin River channel; Dark yellow lines are major canals or flood bypasses; Light blue lines are other water bodies; Green areas are federal wildlife refuges; Light gray are urban areas; Gray lines are roads; Orange dotted lines indicate Reach boundaries; Orange bubbles identify Reach numbers. Map credit: U.S. Bureau of Reclamation.

2 Anadromous Fish in the Restoration Area and San Joaquin River Basin

The Settlement establishes two primary goals:

1. **Restoration Goal –** To restore and maintain fish populations in “good condition” in the main stem San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing/self-sustaining populations of salmon and other fish.
2. **Water Management Goal –** 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.

Paragraph 14 of the Settlement indicates that both spring-run and fall-run Chinook salmon shall be reintroduced into the San Joaquin River between Friant Dam and the confluence with the Merced by December 31, 2012. Section (a) goes on to say:

> *“In the event that competition, inadequate spatial or temporal segregation or other factors determined to be beyond the control of the Parties make achieving the Restoration Goal for both spring-run and fall-run Chinook salmon infeasible, then priority shall be given to restoring self-sustaining populations of wild spring-run Chinook salmon (paragraph 14 section (a)).”*

As mentioned earlier, full implementation of the SJRRP has not yet been achieved, due to various unforeseen circumstances, so neither the Restoration Goal nor the Water Management Goal has been fully realized. Currently reintroduction of CV spring-run Chinook salmon is being prioritized. Despite the improvements outlined in Paragraph 11 being incomplete and Exhibit B flows not yet fully realized, CV spring-run Chinook salmon have been reintroduced to the Restoration Area since 2014, and have returned from the ocean to naturally spawn and complete their life cycle consecutively since 2019 (although there is genetic evidence this has occurred since 2017). NMFS believes this has clearly demonstrated that it is possible for Chinook salmon to reestablish in the San Joaquin River.

Section 2 provides an overview of the life cycle of anadromous salmonid and sturgeon species that occur in the Restoration Area and greater San Joaquin River Basin, as well as an overview of NMFS’ management authorities for those species. The life history information provided is to illuminate important environmental factors that are influential in their survival, and helps explains why certain monitoring methods are used to understand the condition of the populations. This information is also provided to help explain the beneficial impacts of the SJRRP on other native anadromous fish, beyond CV spring-run Chinook salmon.

2.1 Central Valley Spring-run Chinook Salmon

2.1.1 NMFS Regulatory Authority

CV spring-run Chinook salmon are listed as threatened under the federal Endangered Species Act (ESA) (70 FR 37160; June 28, 2005). Critical habitat for CV spring-run Chinook salmon has been designated within the Sacramento River Basin (70 FR 52488; September 2, 2005). The Evolutionarily Significant Unit[2] (ESU) for CV spring-run Chinook salmon was designated on June 28, 2005 (70 FR 37160). To facilitate the reintroduction of CV spring-run Chinook salmon into the Restoration Area, NMFS addressed the issue of incidental take under ESA section 10(j), and issued a rule that designated the reintroduced population of salmon as a "nonessential experimental population"[3] (NEP) (78 FR 79622; December 31, 2023). The NEP designation provides protections and certainty for landowners, water users, and others within the Restoration Area.

2.1.2 Life Cycle

The life cycle of CV spring-run Chinook salmon is illustrated in Figure 2. Generally, adult fish migrate from the Pacific Ocean in a reproductively immature state and swim upstream into the San Joaquin River basin in the spring months (approximately March through June) using olfactory, or smell, senses to locate their birth waters (Moyle 2002). Upon arriving in their natal stream and rivers, the adult fish hold over summer months (approximately June through September), then spawn and lay eggs in gravel nests (redds) in cold freshwater (<55 degrees Fahrenheit or 13 degrees Celsius) in the early fall months (approximately September through November) (Moyle 2002). Larval fish, also known as 'alevins', hatch from eggs and emerge from their gravel nests throughout the fall and early winter months (approximately October through December). Juvenile fish then rear and feed in freshwater from late fall through spring (approximately October through June); or may choose to rear for a full year (i.e., October to subsequent October to December), and become 'yearling' juveniles when conditions are suitable.

As juvenile fish rear, they migrate downstream and eventually reach the Sacramento-San Joaquin River Delta, and then the San Francisco Bay estuary. Once juvenile fish have completed the physiological changes necessary to enter saltwater (called smoltification), they enter the Pacific Ocean and rear to adulthood for approximately three to four years, which is typical for Chinook salmon. Adult fish then migrate back upstream to freshwater to start the life cycle over again and create the next generation.

Chinook salmon are "semelparous" fish, meaning they reproduce once in their lifetime and then die shortly after spawning. Scientific literature has shown that the decomposing carcasses of ocean-returned salmon provide marine derived nutrients that act like fertilizer to the vegetation on the riverbanks and riparian areas (Gende et al. 2002, Naiman et al 2002, Janetski et al. 2009). Salmon carcasses support important macroinvertebrate (such as insects)

[2] Refer to the glossary in Section 9 for a definition of an ESU.
[3] Refer to the glossary in Section 9 for a definition of NEP.

communities that are unique to river systems with salmon and provide essential food to juvenile salmon and aquatic river animals (Gende et al. 2002, Keirnan et al. 2010). Healthy and flourishing riparian vegetation provides food, shade, cover, and water temperature refugia for juvenile salmon, and helps improve the survival of the next generation of salmon (NMFS 2014).

In general, wetter water years result in higher survival of juveniles out-migrating during the spring of the same water year they were born. The juvenile cohort that experienced wetter outmigration conditions is more likely to experience higher outmigration survival (Michel et al. 2015, Michel 2019, Notch et al. 2020), which can result in a higher abundance of adults returning to freshwater to spawn three years later. Drier water years generally result in low survival during spring outmigration and can encourage a subset (roughly 10%) of the juveniles to express the yearling life history strategy (Cordoleani et al 2021). This results in a lower number of juveniles out-migrating to the ocean much later in the year. When the dry-condition-cohort return as adults, there could be fewer adults because there was lower survival during the juvenile spring outmigration. Therefore, the number of adult spawners is likely to be lower from a juvenile cohort that experienced drought conditions in freshwater during their out-migration, in comparison to a juvenile cohort that experienced high river flows during a wet water year while out-migrating.

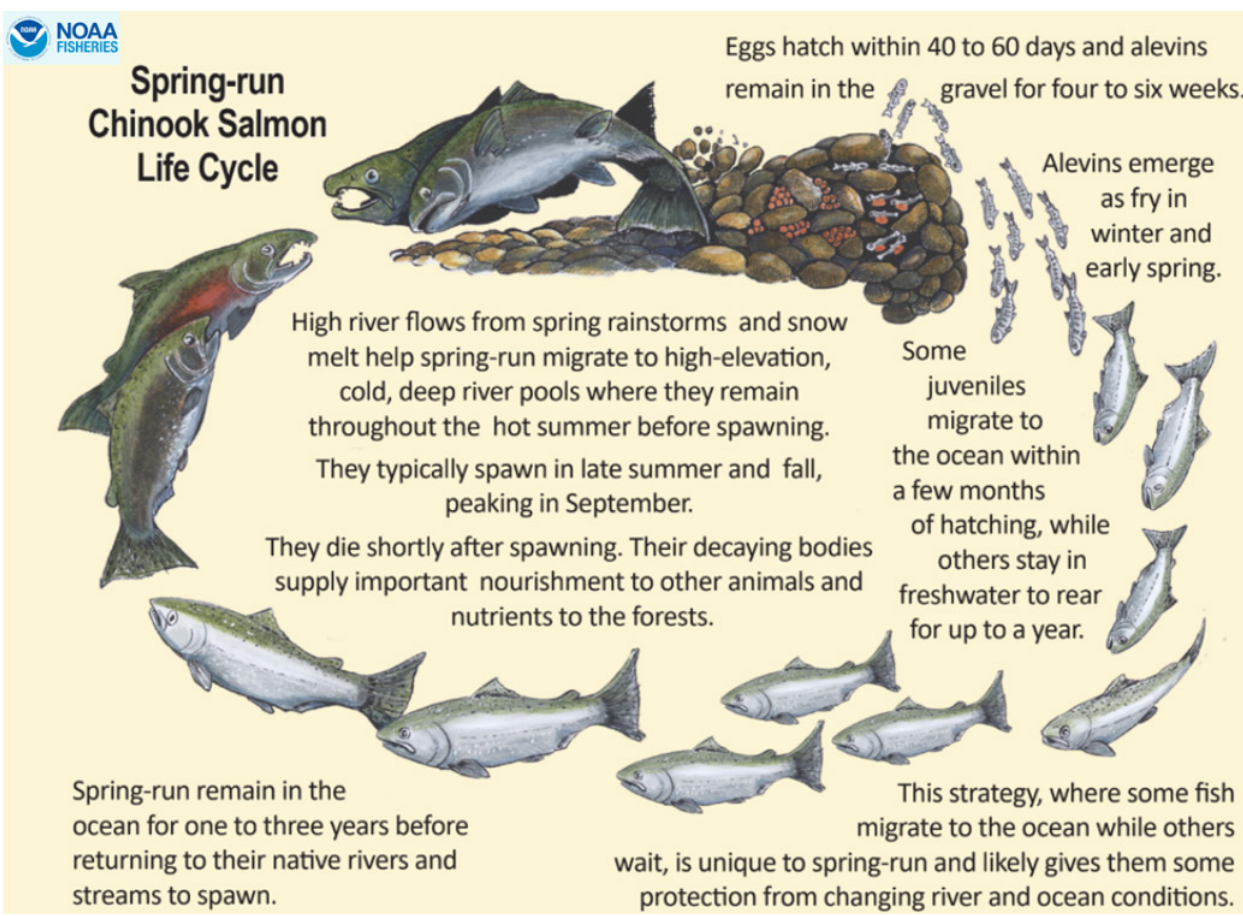

Figure 2. Life cycle of Pacific Coast Chinook salmon (*Oncorhynchus tshawytscha*). Illustration by NOAA Fisheries.

2.2 Central Valley Fall-run Chinook Salmon

2.2.1 NMFS Regulatory Authority

Essential Fish Habitat (EFH) for Pacific Coast Chinook salmon is managed by NMFS under the Magnuson–Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.). For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the associated physical, chemical, and biological properties that are used by fish (50 CFR 600.10). EFH for Chinook salmon (both fall-run and spring-run) has been designated within the Restoration Area by the Pacific Fishery Management Council (PFMC) for the Pacific Coast Salmon Federal Fishery Management Plan (FMP) (PFMC 2016). Since there is no critical habitat designated under the ESA for any Chinook salmon species within the Restoration Area, NMFS manages Chinook salmon habitat under the MSA. Under the MSA, NMFS must consider any non-ESA listed salmon stocks and life history differences, for example between fall and spring-run Chinook salmon, when consulting on EFH.

2.2.2 Life Cycle

The life cycle of CV fall-run Chinook salmon is similar to that described for CV spring-run Chinook salmon above (refer to Figure 2). The primary difference is a genetically influenced behavior for when adults return to freshwater to spawn. CV fall-run Chinook salmon adults typically return to freshwater from the Pacific Ocean in a sexually mature state and migrate upstream into the San Joaquin River in the fall months (approximately October through December). Unlike CV spring-run Chinook salmon, CV fall-run Chinook salmon do not hold prior to spawning, and will spawn shortly after reaching their spawning ground. The larval fish, or alevins, hatch from eggs and emerge from their gravel nests throughout the fall and winter months (approximately November through January). Juvenile fish then rear in freshwater from late fall through spring (approximately November through June); or may choose to rear for a full year (i.e., November to subsequent November) (Moyle 2002). Similar to CV spring-run Chinook salmon, juvenile fish rear as they migrate downstream and eventually reach the Sacramento-San Joaquin River Delta and the San Francisco Bay estuary, and then enter the Pacific Ocean to rear to adulthood for three to four years.

2.3 California Central Valley Steelhead

2.3.1 NMFS Regulatory Authority

CCV steelhead are listed as threatened under the federal ESA (63 FR 13347; March 19, 1998). Critical habitat for CCV steelhead has been designated within the Sacramento River and the San Joaquin River Basins (70 FR 52488; September 9, 2005). The ESU for CCV steelhead was designated on July 10, 2000 (65 FR 42422) and updated to a Distinct Population Segment (DPS) on January 5, 2006 (71 FR 834). CCV steelhead are able to access the Restoration Area under adequate flow conditions, and thus would benefit from full implementation of the Settlement.

2.3.2 Life Cycle

The life cycle of CCV steelhead has some notable differences compared to Chinook salmon (Figure 3). Generally, CCV steelhead adults enter the San Joaquin River basin from the Pacific Ocean in the winter months during high freshwater flows, and return to their natal streams to build gravel nests and spawn in the late winter and early spring months. Unlike Chinook salmon, adult steelhead are iteroparous, and may survive after several spawning seasons, return back to the ocean to feed, and then return to freshwater to spawn again in following years (Moyle 2002, NMFS 2014). Juvenile steelhead can rear in freshwater for upwards of a year or more before migrating out to the Pacific Ocean to grow to adulthood (Moyle 2002, NMFS 2014). The life cycle of CCV steelhead is highly flexible, including some fish completing their entire life cycle in freshwater, which are also known as resident rainbow trout.[4] Scientific studies continue to research and hypothesize which genetic and environmental factors contribute to a fish's decision to stay in freshwater its whole life or to migrate out to the ocean (Kendall et al. 2015, Pearse and Garza 2015).

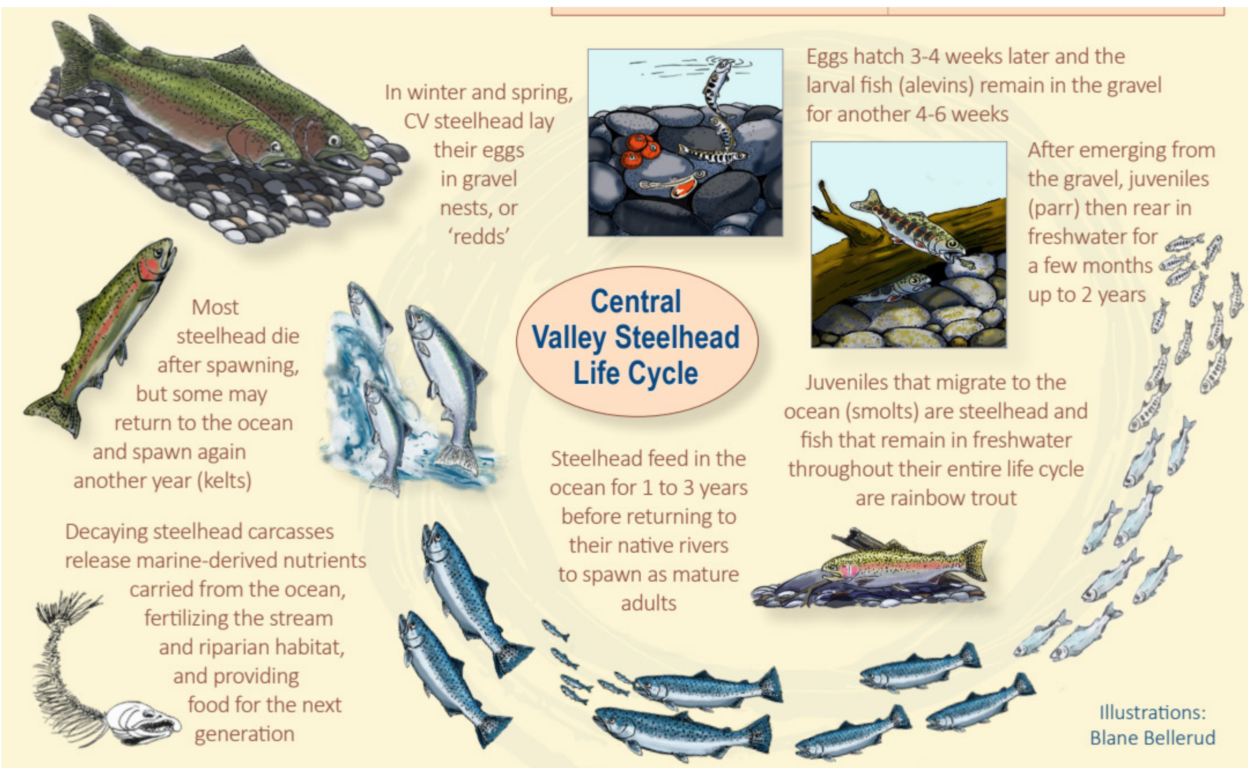

Figure 3. Life cycle of California Central Valley steelhead (*Oncorhynchus mykiss*). Illustration by NOAA Fisheries.

[4] Resident rainbow trout are not listed under the ESA.

2.4 Southern Distinct Population Segment of North American Green Sturgeon

2.4.1 NMFS Regulatory Authority

The sDPS of North American green sturgeon (hereafter referred to as green sturgeon) are listed as threatened under the ESA (71 FR 17757; April 7, 2006). Critical habitat for green sturgeon is designated in the Sacramento River basin (74 FR 52300; October 9, 2009). Green sturgeon have been documented in the Restoration Area, and can access the Restoration Area under adequate flow conditions and would benefit from full implementation of the Settlement.

2.4.2 Life Cycle

The life cycle of green sturgeon is quite different from salmon and steelhead and is illustrated and described in Figure 4. Green sturgeon are anadromous fish that are native to the Central Valley, including the San Joaquin River basin. In the San Joaquin River, sub-adult and adult green sturgeon may choose to swim into the river to feed in various locations at multiple times throughout their long lives. Since green sturgeon spawn and primarily rear in the Sacramento River basin, directed green sturgeon monitoring in the San Joaquin River basin is non-existent and available data are therefore limited. Recent observations of green sturgeon in the San Joaquin River basin have been documented by Anderson et al. (2018) and Root et al. (2020).

The topography of the mainstem San Joaquin River is generally a low gradient, sinuous river channel, where the predominant gravel size is fine sediment or sands (McBain and Trush 2002). Sub-adult and adult green sturgeon are benthic, or bottom- feeders, and prefer riverine areas with slower velocities and deeper pools (NMFS 2018). The San Joaquin River likely contains feeding grounds for green sturgeon sub-adults and adults, if there are adequate flows and water temperatures available to create necessary holding and feeding habitat.

Full implementation of the Settlement will benefit green sturgeon and may play a role in the conservation and recovery of this species. Additional information on the distribution, threats, and recovery recommendations of green sturgeon is described in the NMFS Green Sturgeon Recovery Plan (2018).

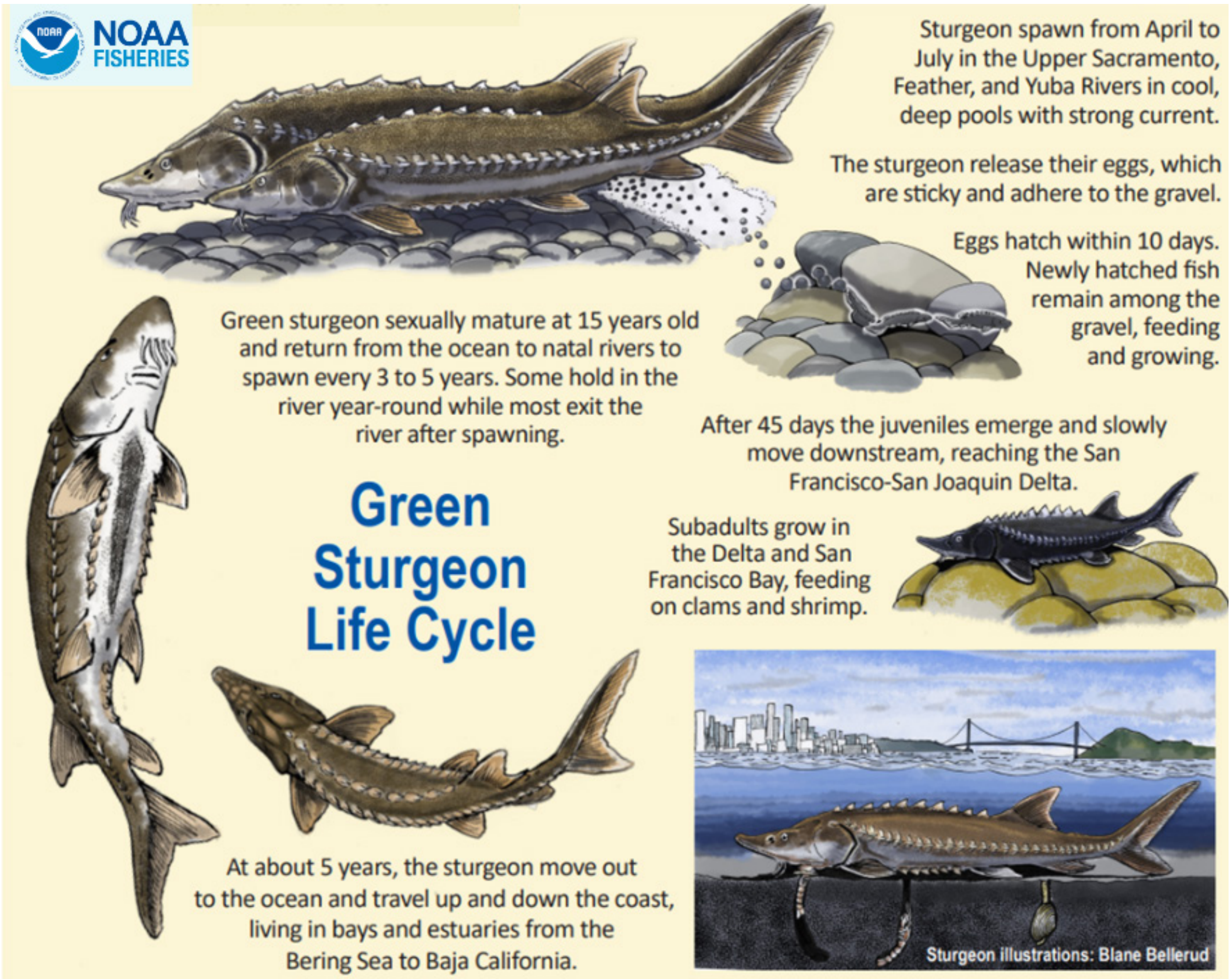

Figure 4. Life cycle of the southern Distinct Population Segment (sDPS) of North American green sturgeon (*Acipenser medirostris*). Illustration created by NOAA Fisheries.

3 Evaluation of Reintroduction of Central Valley Spring-Run Chinook Salmon

3.1 Background

To effectively evaluate the complex life cycle of anadromous salmon, monitoring methods need to target life stages within the habitats where they naturally occur. Fisheries monitoring and the data collected by the SJRRP should be evaluated and interpreted with the understanding that fisheries monitoring was not a specific condition of the 2006 Settlement or 2009 Settlement Act. Over the years, SJRRP biologists have adapted and shifted the monitoring priorities based on funding constraints.

The SJRRP has produced several fisheries management documents to guide and prioritize reintroduction activities and fisheries monitoring, and to determine success. Reintroduction and associated monitoring of CV spring-run Chinook salmon within the Restoration Area (refer to Figure 1) has included:

- Release of hatchery produced juvenile fish and ancillary (supplemental) adult broodstock fish.
- Monitoring in Reaches 4 and 5, and the Eastside Bypass for adult fish returning from the ocean to the Restoration Area to spawn.
- Trap and haul (hereafter referred to as "assisted migration") of adult fish captured in Reaches 4 and 5, and the Eastside Bypass, and transported upstream of impassible barriers to the spawning areas in Reach 1.
- Monitoring of spawning success of both ocean-run and hatchery-raised broodstock adults released in the Reach 1, using redd and carcass counts.
- Monitoring of naturally-spawned juvenile fish in Reach 1 and 2.

Over the years, various special studies and other monitoring actions have helped guide reintroduction activities and provided information on the status of the population and habitat.

3.2 Salmon Conservation and Research Facility

The creation, operation, staffing, and maintenance of a salmon conservation hatchery was not originally envisioned within the 2006 Settlement or 2009 Settlement Act. However, reintroduction efforts of CV spring-run Chinook salmon are critically dependent on the Salmon Conservation and Research Facility (SCARF) and the continued efforts of the California Department of Fish and Wildlife (CDFW) staff operating it. The salmon hatchery began as a temporary facility located near the base of Friant Dam. CDFW has maintained and operated the Interim SCARF (iSCARF) since 2012, where they served as initial facilities to receive donor stock from the Feather River Fish Hatchery, and raise fish to maturity in a captive broodstock program. As part of the ESA section 10(a)(1)(A) permit for reintroduction activities, CDFW has developed and implemented a Hatchery and Genetics Management Plan (HMGP) in 2016 and updated in 2023 (CDFW 2016, 2023).

The HGMP describes the overall hatchery donor stock and broodstock strategies, while the annual Donor Stock Collection Plan describes the planned and proposed annual broodstock activities (USFWS 2014 through 2024).

The iSCARF maintains the first captive broodstock of CV spring-run Chinook salmon in the State of California. The ability of the iSCARF to produce juvenile salmon and adult broodstock has been essential in the success of reintroduction by the SJRRP. All adult and juvenile CV spring-run Chinook salmon released to the river from the iSCARF are marked with an adipose-fin clip and a coded wire tag (NMFS 2023).

The juvenile production fish that the iSCARF has raised and released into the Restoration Area is a crucial component in the ongoing reintroduction program. Table 1 summarizes the annual iSCARF juvenile releases by year, origin, and lifestage. Yearling fish are typically released in Reach 5 in November or December each year. Young-of-year (YOY) juveniles are typically, but not exclusively, released in Reach 4 or 5 from the end of January to early April, depending on environmental conditions, logistical constraints, and considerations for any special studies occurring at the time.

Construction of the new SCARF began in 2018, and will be completed in 2024 (Figure 5). The delay in completion of the SCARF was due to logistics and contractual issues that arose during construction. Despite the delay, CDFW hatchery staff continued to develop and implement pioneering studies in the science of hatchery aquaculture to improve the quality of broodstock fish and of fish raised and released to the river (Grill 2019, McGrath-Castro 2019, Rosenthal 2019, Winsor et al. 2021).

Table 1. Summary table of production releases of juvenile CV spring-run Chinook salmon by the iSCARF by year, origin, and life stage. All releases in the Table occurred in Reach 5 in the late fall or early winter months, except where noted otherwise. Note: This Table does not include fish released as special studies or monitoring in the Restoration Area, including those released for rotary screw trap efficiency tests in Reach 1.

Year Released	Young-of-Year: FRFH[a]	Young-of-Year: iSCARF	Yearlings: iSCARF
2014	60,114	0	0
2015	54,924	0	0
2016	57,320	47,560	544
2017	38,106	51,044	1,450
2018	0	167,848	5,200
2019	0	171,028	9,641
2020	0	203,059	5,094
2021	0	175,031	3,712
2022	0	166,288	4,577
2023	0	190,716	5,943[b]
2024	0	196,310	Not Available

[a] From 2014-2017 juveniles from Feather River Fish Hatchery (FRFH) were collected and moved to the San Joaquin River. They were then held near the base of Friant Dam for approximately three days to “imprint” on the San Joaquin River water chemistry. After imprinting, these fish were transported to Reach 5 and released for the reintroduction. The SJRRP called this strategy “translocation” and it was only used to supplement production releases until the iSCARF was able to produce a sufficient number of juveniles.
[b] Approximately 2,406 fish were released into Reach 1 in summer 2023 due to logistical constraints at the iSCARF.

Figure 5. The new Salmon Conservation and Research Facility (SCARF) near Friant Dam. Shown in the picture are circular tanks (20 and 30 feet in diameter) that will house: adult broodstock raised and used for spawning (tanks within covered structure in background of photo), and juvenile salmon produced for release into the SJRRP Area (net-covered tanks in forefront of the picture). Photo Credit: NOAA Fisheries.

3.3 Monitoring of Adult CV Spring-run Chinook Salmon

In 2012, the SJRRP began investigating the feasibility of assisted migration by conducting pilot studies using adult CV fall-run Chinook salmon captured in Reach 5 and transported to Reach 1 (SJRRP 2017). These initial assisted migration feasibility studies were conducted from 2012 through 2016 using CV fall-run Chinook salmon adults that originated from the Mokelumne River hatchery, with smaller proportions from the Feather River, American River, Merced River, and Coleman salmon hatcheries (SJRRP 2017, SJRRP 2018). Across all years, the survival of transported fish was high (ranged from low to high 90th percentiles; SJRRP 2017). The primary conclusion of these feasibility studies was that assisted migration is a viable method to transfer Chinook salmon to Reach 1, pending completion of Paragraph 11 Settlement projects.

The first documented capture of an adult CV spring-run Chinook salmon returning to Reach 5 occurred in 2019[5] (Figure 6). Table 2 summarizes the number of adult CV spring-run Chinook salmon transported from Reach 5 to the spawning reaches in Reach 1. Full details of the assisted migration monitoring objectives, methods, and results, are described in annual reports produced by the SJRRP (Barkstedt et al. 2017, Sutphin et al. 2019, Sutphin et al. 2021, Sutphin et al. 2022). Generally, assisted migration activities are conducted

[5] There is genetic evidence that some fish returned during high flows in 2017 and 2018; however, 2019 was the first year that a returning adult was captured in-hand.

from mid-March through early June in Reach 4 and 5. The number of adult salmon that return each year from the Pacific Ocean is significantly influenced by their survival rate as juveniles; which in turn depends on the environmental conditions they experienced while rearing and migrating downstream through the San Joaquin River and Delta.

Figure 6. Picture of the first returning adult CV Spring-run Chinook salmon captured during assisted migration operations in spring 2019. Photo credit: U.S. Bureau of Reclamation.

Table 2. Number of adult CV spring-run Chinook salmon captured in Reach 5 and transferred to Reach 1, and broodstock adults from the iSCARF released into Reach 1, per year.

Year (Spring Months)	Adults Captured, Reach 5	Adults transported to Reach 1	Adult Broodstock released in Reach 1
2016	0	0	25
2017	0	0	115
2018	0	0	179
2019[a]	23	19	114
2020	57	48	285
2021	93	74	200
2022	11	10	74
2023[b]	No monitoring	No monitoring	270
2024	9	9	204

[a] Assisted migration activities were halted once river flows prevented monitoring equipment to be safely deployed and checked by staff. Volitional fish passage was created by high flows in late spring 2019.
[b] Assisted migration activities did not occur in spring 2023 due to high flows that prevented monitoring equipment to be safely deployed and checked by staff. Volitional fish passage was created by high flows through spring 2023.

The number of ocean-run adult CV spring-run Chinook salmon that returned to the Restoration Area also varies on an annual basis, depending on river flows and water temperatures in the San Joaquin River as they migrate upstream. Special studies have been completed over several years to determine how water temperature influences the over-summer holding lifestage of adult fish (reports in prep). These studies included tagging of adult fish during assisted migration activities before they are released to Reach 1 or 2. Observations were made on how tagged fish then distribute and hold in the river during the hot Central Valley summer. Preliminary results indicate that the majority of adults, both ocean-run and released broodstock, hold over summer in the first 10 miles downstream of Friant Dam (CDFW pers. comm. 2024). However, in some years, ocean-run adults may hold over summer up to 15 to 20 miles downstream, if flows allow for "patches" of water that are cooler than what is observed in stationary water temperature monitoring stations. Millerton Reservoir is a smaller reservoir compared to many other storage reservoirs in the Central Valley, and has a limited cold-water pool[6] which constrains cold water management options. The size of the reservoir, combined with limited cold water for fish during the summer, results in adult CV spring-run Chinook migrating as far upstream as possible during the summer to hold in some years.

In addition to the adults that were assisted in their migration, Table 2 includes the number of ancillary, or supplemental, adult broodstock released to Reach 1, from 2016 to present. Ancillary broodstock are mature adult fish raised in the iSCARF that were in excess of the annual number to be spawned. Instead of culling mature adult broodstock fish that were not needed for hatchery spawning, these fish were instead released into the Reach 1 spawning areas to contribute to the in-river spawning population.

3.4 Monitoring of Chinook Salmon Redds and Spawning

To measure the success of in-river spawning by CV spring-run Chinook salmon, redd and carcass monitoring methods are implemented each year from approximately August through November (Figure 7). These methods generally include visual counts of redds and carcasses of salmon after they spawn. Several environmental factors can influence where female salmon build their redds, including overall river flows, water temperature, gravel size, gravel quality (i.e., not a lot of fine sediment that would suffocate eggs), and site-specific hydraulics of water flowing over and in between the gravel.

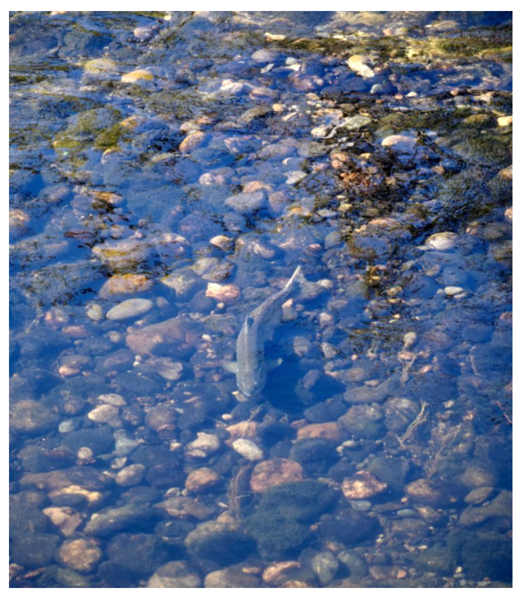

Figure 7. Picture of a CV spring-run Chinook salmon (middle of the picture) over a gravel nest, or redd, in the Restoration Area in 2019. Photo credit: U.S. Bureau of Reclamation.

Currently, the majority of suitable CV spring-run Chinook salmon spawning habitat (i.e., the combination of gravel, flows, and water temperatures) is limited to the first 5 to 7 miles downstream of Friant Dam (SJRRP 2018). Despite the limited spawning habitat, salmon have been observed successfully spawning within the Restoration Area. Table 3 shows the number of redds and carcasses observed in Reach 1.

[6] Refer to the glossary for a description of "cold-water pool".

Table 3. Number of Chinook salmon redds and carcasses observed per year.

Year (Fall Months)	Redds Observed	Carcasses Observed	Notes
2016	3	1	
2017	13	18	
2018	42	23	
2019	209	168	149 carcasses of fish that volitionally returned
2020	73	48	
2021	32	41	
2022	5	8	
2023	6	17	
2024	13	8	

3.5 Egg Incubation Monitoring

Salmon eggs are buried by female salmon within nests made up of river gravel, which means the egg incubation habitat is significantly influenced by river flows and water temperatures (Quinn 2007, Jensen et al. 2009). River flows must be adequate to create intra-gravel habitat that is well-oxygenated and not overwhelmed by fine sediment that could suffocate the eggs and alevins (Roni et al. 2016). Similarly, water temperatures must be cold enough to ensure the survival of eggs and alevins (Bergendorf et al. 2002).

Special studies and monitoring on salmon egg incubation and survival have been conducted in various years. Overall, results of the studies indicate survival from eggs to alevin to juvenile fish are significantly influenced by the habitat quality of the specific location of each individual redd (Castle et al. 2016a, Castle et al. 2016b, Perez et al. 2017, Durkacz et al. 2019, Demarest et al. 2021, Demarest et al. 2022). This is in alignment with scientific literature concluding that egg incubation habitat quality depends on river flows and water temperatures at individual redd locations (Bergendorf et al. 2002, Quinn 2007, Jensen et al. 2009). Preliminary results from the egg incubation and survival studies also seem to indicate that survival from egg to alevin to juvenile is lower than the 50% objective outlined in the Fisheries Framework (SJRRP 2018). With improved river flows and water temperatures during the egg incubation time period for CV spring-run Chinook salmon, the survival rate from eggs to juvenile fish would be expected to increase in general. However, as mentioned above, there are limited flow and water temperature management decisions that can be made by the SJRRP to improve egg incubation habitat from September through December. An assessment of current operational practices during the spawning and incubation period could be developed, and may show potential patterns or actions that could lead to better flows and water temperature management (SJRRP 2018).

3.6 Monitoring of Juvenile Chinook Salmon

3.6.1 Rotary Screw Traps

To assess the juvenile population of reintroduced CV spring-run Chinook salmon on an annual basis, the SJRRP typically deploys up to four rotary screw traps (RSTs) in Reach 1 and 2 from November through the subsequent June (Figure 8). Table 4 summarizes the number of juvenile Chinook salmon caught (and released) by RSTs. RSTs are commonly used to sample juvenile salmon populations for a particular area of a river at different points in time. The number of fish caught is extrapolated and used to estimate the total juvenile population in the river, which are available in annual reports produced by the SJRRP (SJRRP 2020, 2021, 2023).

Figure 8. A Rotary Screw Trap in Reach 1 of the Restoration Area that is used to capture juvenile Chinook salmon for population estimates as they migrate downstream in the San Joaquin River. Photo credit: U.S. Bureau of Reclamation.

Table 4. The number of naturally-produced juvenile Chinook salmon captured in the RST by field season. These numbers do not include the calculated overall estimate of juvenile production in the river per year, which are described in the annual reports produced by the SJRRP as they become available.

RST Season (Fall to Spring months)	Number of juvenile Chinook salmon captured[a]
2017-2018	757
2018-2019	412
2019-2020	10,808
2020-2021	1,460
2021-2022	1,440
2022-2023	No monitoring occurred[b]
2023-2024	522

[a] These are the observed numbers of juveniles found in the RSTs and are not the expanded population estimates; these results should be interpreted with caution.
[b] No rotary screw trap monitoring occurred during the 2022-2023 field season due to low adult returns in spring 2022 and low redd counts in fall 2022.

Several factors are taken into consideration when calculating the estimated juvenile population using RSTs, including the efficiency of the RST which can vary daily or weekly depending on flows and other riverine habitat characteristics (SJRRP 2023). Overall, the number of juvenile salmon captured in the RSTs varies annually based on the number of spawning adults, and the survival of eggs to the juvenile life stage. Environmental conditions like flows, water temperatures, and sediment transport, strongly influence the development and survival of incubating eggs and larval fish (Quinn 2007, Jensen et al. 2009). Once larval fish reach the juvenile life stage, then flow, water temperature, and access to adequate rearing habitat are the primary influencers for the survival of juvenile fish as they migrate downstream through the San Joaquin River and out to the Delta, San Francisco Bay estuary, and Pacific Ocean.

3.6.2 Annual Technical Memorandum

NMFS prepares an annual Technical Memorandum (Tech Memo) to fulfill the following three purposes:

1. Address one of the requirements of the Designation of a Nonessential Experimental Population of Central Valley Spring-run Chinook Salmon Below Friant Dam in the San Joquin River, California (70 FR 79622, December 31, 2013) to release an annual technical memorandum to:

   "Calculate and document the proportionate contribution of Central Valley (CV) spring-run Chinook salmon (*Oncorhynchus tshawytscha*) originating from the reintroduction to the San Joaquin River and deduct or otherwise adjust for share of CV spring-run Chinook salmon take when applying the operational triggers and incidental take statements associated with the NMFS 2009 Biological and Conference Opinion on the Long-term Operations of the Central Valley Project and State Water Project (CVP/SWP Opinion) or subsequent future biological opinions, or Section 10 permits."
2. Present (a) methods used in a given year to identify reintroduced, nonessential experimental population (NEP) CV spring-run Chinook salmon from the San Joaquin River when encountered outside the Restoration Area; and (b) outline the deduction, or adjustment, in the operations of the Central Valley Project (CVP) and State Water Project (SWP). The purpose of the deduction, or adjustment, is to ensure the reintroduced population will not impose more than *de minimis* water supply reductions, additional storage releases, or bypass flows on unwilling third parties as defined in P.L. 111-11, Title X, section 10011(c)(1).
3. Outline the NEP CV spring-run Chinook salmon release and monitoring plans for the subsequent year.

NMFS issued the first Tech Memo in 2014 and posts them online each year on NMFS's SJRRP webpage.[7] Since 2014, monitoring, scientific studies, and hatchery releases of CV spring-run Chinook salmon in the Restoration Area have grown into a multi-faceted and dynamic effort based on an adaptive management process. As the SJRRP continues into the future, NMFS will continue to re-visit the format, organization, and content of the Tech Memo to ensure readability and purpose fulfillment. Additional data and analyses are included in the annual Tech Memos, such as an analysis of environmental conditions that may influence juvenile outmigration travel times (NMFS 2022), and a conceptual juvenile production estimate (NMFS 2022, 2023, 2024).

[7] NMFS's SJRRP webpage: https://www.fisheries.noaa.gov/west-coast/habitat-conservation/san-joaquin-river-restoration.

3.7 Genetics Monitoring of CV Spring-run Chinook Salmon

Monitoring was conducted by the SJRRP to evaluate the genetic composition of reintroduced CV spring-run Chinook salmon. Genetic tissues from adult and juvenile Chinook salmon were consistently sampled from the various fisheries monitoring activities throughout the years. NMFS's Southwest Fisheries Science Center (SWFSC) in Santa Cruz, California, conducted the genetics analyses. In general, the SWFSC determined the reintroduced population of CV spring-run Chinook salmon is genetically "healthy", and would benefit from additional genetic diversity from other CV spring-run Chinook salmon populations outside of the Feather River Fish Hatchery (USFWS 2014-2023, CDFW 2023).

3.8 Other Fisheries Special Studies in the Restoration Area

Various fisheries special studies have been completed over the years by SJRRP Implementing Agencies or external partners. These special studies include juvenile outmigration survival studies (Hause et al. 2022), juvenile growth studies (Zeug et al. 2019), adult summer holding behavior studies, and disease and health studies. All of the special studies have helped fill in data gaps to inform the status and the limiting factors of the reintroduced population of CV spring-run Chinook salmon.

4 Evaluation of Reintroduction on the Greater CV Spring-run Chinook Salmon Population

Reintroduction is one of three foundational actions toward recovering the CV spring-run Chinook salmon ESU (refer to Figure 9; NMFS 2014). The efforts by the SJRRP have provided data that confirm reintroduction is a feasible action for salmon recovery in the Central Valley. All fish released from the iSCARF are marked using standard hatchery techniques of a clipped adipose fin and a coded wire tag (CWT) internally inserted into the snout of juvenile fish. The clipped adipose fin (last small fin on their back) externally identifies the fish as originating from a hatchery; while the CWT has a microscopically engraved number that can identify which hatchery produced an individual fish. CWTs are retrieved from deceased adult fish caught in the offshore ocean and river recreational fisheries, or fish observed as carcasses during surveys completed in the river. Since the salmon life cycle includes feeding in the coastal oceans for approximately two to four years, CWT retrieval provides valuable information on the status of the salmon fisheries, not only for California, but for all salmon ocean fisheries off the Pacific West coast.

Figure 9. The Recovery Triangle shows three crucial steps to recovering salmonids in the California Central Valley: resiliency, restoration, and reintroduction. Artwork credit: Stephanie Fogel.

The Regional Mark Processing Center[8] (RMPC) is an online public database that coordinates and contains CWT information for several different states, Native American tribes with fisheries programs, and U.S and Canadian federal agencies. This database is useful in determining where SJRRP adults are caught in the coastal ocean and in rivers throughout the Central Valley, provided the entity that retrieves the CWT sends the information to the RMPC. Based on the data in the RMPC, within the coastal oceans, SJRRP fish have been captured along the Pacific West Coast from Washington, Oregon, and northern to southern California coastal areas (Table 5). This indicates that not only are juvenile iSCARF fish surviving outmigration from the San Joaquin River, but they are thriving in the coastal waters as they feed and grow into adults.

[8] The Regional Mark Processing Center's coded wire tag database is publicly available at: https://www.rmpc.org/.

Table 5. Summary table of SJRRP fish captured in the coastal ocean fisheries, river fisheries, and observed in carcass surveys. Data are from the CWT database in the Regional Mark Processing Center, which is publicly available online. NA = Not Available.

Year Adult Captured	California Coast	Oregon Coast	Washington Coast	Sacramento River Basin	San Joaquin River Basin[a]
2017	1				
2018[b]	32	1	1	36	
2019	13	2	1	7	
2020	8			8	
2021	29		2	51	30
2022	9			22	6
2023[c]	NA	NA	NA	NA	NA

[a] Outside of the Restoration Area in the major tributaries to the San Joaquin River; abundance is likely underestimated since there are no monitoring programs that target CV spring-run Chinook salmon.
[b] Offshore coastal fisheries partially closed and limited with specific rules (83 FR 7650).
[c] Offshore fisheries for Chinook salmon completely closed for California, Oregon, and Washington (88 FR 30235, 88 FR 44737, 88 FR 51250).

Within the Central Valley rivers, fish that were released from the iSCARF and survived to adulthood to spawn have been documented within both the Sacramento River Basin and the San Joaquin River Basin outside of the Restoration Area (Table 5). In the Sacramento River Basin, CV spring-run Chinook salmon have been observed primarily on the spawning grounds in the Feather and American Rivers. In general, the rate that salmon migrate into a non-natal river to spawn (also known as “straying”) can depend on a variety of factors, such as hatchery practices, and natural environmental conditions compounded with water management decisions for a given year.

In the lower San Joaquin River Basin, SJRRP fish have been observed in all major tributaries, including the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers. It is important to note, however, that the Sacramento River Basin has salmon monitoring programs that target the life stages of CV spring-run Chinook salmon. Whereas *there are no monitoring programs within the San Joaquin River Basin*, outside of the Restoration Area, that target CV spring-run Chinook salmon. The salmon monitoring programs within the major tributaries of the San Joaquin River target the life history of CV fall-run Chinook salmon. Thus, it is likely that the population distribution and abundance of CV spring-run Chinook within the San Joaquin River Basin is underestimated (Gutierrez et al. 2024).

Nevertheless, CWT data indicate that fish from the SJRRP have started to contribute to the populations of CV spring-run Chinook salmon outside of the Restoration Area in both the Sacramento and San Joaquin River Basins. From a salmon recovery perspective, the SJRRP reintroduction activities are successful in providing proof of concept that reintroduction is a valuable recovery action. As the status of the greater population of CV spring-run Chinook salmon continues to decline throughout the Central Valley (Southwest Fisheries Science Center 2023), every fish that contributes to the population is valuable. The continuation of SJRRP reintroduction efforts, along with habitat and flow improvements, will become even more essential toward the conservation and recovery of Central Valley salmon.

5 Assessment of Challenges

Various challenges need to be addressed by the SJRRP for the Settlement to be fully implemented. For example, good faith efforts by the SJRRP to avoid, minimize, and mitigate for third-party concerns have contributed to unexpected expenditures and delays in the full implementation of the Settlement. These third-party delays and additional major unanticipated challenges have impeded the completion of fish passage and habitat improvement projects as required under the Settlement. A subset of major challenges being addressed by the SJRRP includes:

- Addressing groundwater seepage[9] impacts assessed on river-adjacent lands from restoring flows to the San Joaquin River channel.
- Increased costs and timing delays associated with land rights acquisition.
- Land subsidence and developing fish passage designs that can meet objectives in the future under subsided conditions.
- Channel capacities that limit the amount of river flows that can be released from Friant Dam into the San Joaquin River.

These challenges have impacted implementation of Restoration Flows, designs and costs for fish passage structures, and ultimately have limited the success of the reintroduction of CV spring-run Chinook salmon.

Compounded with the aforementioned challenges, salmon also face the impacts of a warming climate, which will continue to be a threat to the recovery of CV spring-run Chinook salmon (NMFS 2014). In general, more frequent and longer duration droughts could have a significant impact on water supply and reliability for both people and fish. Increased drought frequency, combined with an overall decrease in snow pack, decreases the quantity of cold water in some water years.

5.1 River Flows

5.1.1 Background

Flow releases from Friant Dam into the San Joaquin River with the intention of meeting the Restoration Goal of the Settlement are termed "Restoration Flows". Refer to the Report to Congress for a map of how Restoration Flows are routed through the Restoration Area. In general, Restoration Flows are routed through the San Joaquin River channel from Friant Dam through Reach 4A. Restoration Flows are then routed into the Eastside Bypass at the downstream end of Reach 4A, and routed back into the San Joaquin River at the upstream end of Reach 5. Restoration Flows are not routed through Reach 4B1 or 4B2 (refer to Figure 1 for Reach identifications).

[9] Groundwater seepage is the infiltration of surface water that goes subsurface and becomes the movement of groundwater through porous soil, often elevating shallow groundwater levels.

The Settlement provides default river flow hydrographs[10] based on water year type, that are used in the annual implementation of Restoration Flow releases. The water year begins in October and continues through the subsequent September. Water year types are defined by the total volume of water runoff from the watershed over the water year and are highly variable in California. The rain and snow season typically begins in the fall and continues through the winter and spring of the subsequent year. California Central Valley summers (June through September) are typically very warm and dry, with limited rainfall. This is why historically CV spring-run Chinook salmon migrated far upstream of present-day Friant Dam to hold over the summer in the high elevation southern Sierra Nevada mountains, where colder water is present due to an extended snow melt period.

The differences in geography and climate between the Sacramento and San Joaquin River basins of the Central Valley means there can be dry weather conditions in the Sacramento basin and wet weather conditions in the San Joaquin Basin in the same year. The opposite can be true as well, where there can be dry weather conditions in the southern Central Valley, and much wetter weather conditions in the northern Central Valley. Therefore, a drought can occur in one basin and not in the other, and likewise there can be extreme flooding in one basin and not in the other, all within the same water year. This information is important to understand Restoration Flow operational decisions in a given year, and why the San Joaquin River can still become disconnected in some years despite the best efforts of the SJRRP and the Restoration Administrator (RA).

5.1.2 Implementation of Restoration Flows

In accordance with the Settlement, in October 2009, Interim Flows began. These Interim Flows were intended to test flow conditions downstream of Friant Dam and were released only for specific periods of the year. In 2014, Restoration Flows began in accordance with the Settlement, which were intended to provide continuous flows downstream except during drier years. These Restoration Flows were released from Friant Dam to an amount that is within the current channel capacity constraints, including groundwater seepage limitations and the limitations of adjacent levees (Figure 10 and Figure 11). Due to seepage constraints, no more than 500 cubic feet per second (cfs) of Restoration Flows can currently be released past Sack Dam in Reach 3 of the Restoration Area. Full Restoration Flows as described in the Settlement cannot be achieved until flow constraints and the challenges listed above are addressed.

The RA coordinates with the SJRRP in various venues and recommends the schedule of Restoration Flows in accordance with the Settlement. The RA produces annual reports that provide valuable information regarding the implementation of Restoration Flows (Restoration Administrator 2007-2024). After implementing Interim Flows (2009-2013) and Restoration Flows per the Settlement under a variety of water year types and environmental conditions, the SJRRP has collected important data and learned new information. In general, the limited availability and quantity of water currently available for Restoration Flows due to flow constraints, such as seepage limitations, is challenging (Restoration Administrator 2007-2024).

[10] A hydrograph is a way of displaying water level information across time.

Figure 10. A dry San Joaquin River in Reach 2 of the Restoration Area in 2009, prior to the start of Interim Flows. Photo Credit: U.S. Bureau of Reclamation.

Figure 11. The San Joaquin River in Reach 2 of the Restoration Area, in the same general area as shown in Figure 10, after the implementation of Interim Flows in 2009. Photo credit: U.S. Bureau of Reclamation.

During drought conditions in the San Joaquin River basin that are classified as "Critical Low" water year types, there is zero water allocated for Restoration Flows (refer to the 2006 Settlement), which results in the river becoming dry and disconnected in Reach 2 and downstream of Reach 3. In 2022, which was a "Normal-Dry" water year type and had an adequate allocation for Restoration Flows, the river was disconnected in an attempt to preserve the limited cold-water pool in Millerton Reservoir[11] during summer months. This action was recommended by the RA and consistent with the flow recommendation approved by Reclamation. The preservation of the available cold-water pool was necessary in order to release the coldest available water in the early fall during the egg incubation time frame for CV spring-run Chinook salmon downstream of Friant Dam. The limited cold-water pool was not envisioned in the Settlement as a constraint, but it has become clear that egg incubation is the life stage most sensitive to warm water temperatures (SJRRP 2018). Although there is uncertainty about how to manage the cold-water pool in Millerton Reservoir, this will likely be an issue during some water year types in the future.

Another reason that river disconnection can occur is from water delivery requirements for third-party water users. These contractual deliveries to Mendota Pool can occur when Reclamation cannot deliver water from the Delta-Mendota Canal in conformance with requirements outlined in the December 6, 1967, *Second Amend Contract Exchange of Waters* (Exchange Contract) to the Exchange Contractors[12] (aka Contracting Entities). Due to drought conditions and regulations on Delta CVP and SWP[13] pumping, in recent years

[11] The capacity of Millerton Reservoir is 520,500 acre-feet; however the cold pool is estimated to be approximately 110,000 acre-feet (depending on water year type conditions).

[12] The Exchange Contractors are senior water rights holders located on the west side of the San Joaquin River basin and include the Central California Irrigation District, Columbia Canal Company, San Luis Canal Company, and Firebaugh Canal Company (as described in the Second Amended Contract for the Exchange of Water with Bureau of Reclamation).

[13] CVP refers to the Central Valley Project (https://www.usbr.gov/mp/cvp/) and SWP refers to the State Water Project (https://water.ca.gov/programs/state-water-project).

Reclamation has been unable to meet Exchange Contract without water supply from Friant Dam. Reclamation has fulfilled the contractual allocation by providing deliveries directly from Millerton Reservoir in 2014, 2015, 2016, and 2022. This action can leave parts of the river dry (downstream of Reach 3) because of other flow constraints and levee capacity. Particularly in 2022, these water deliveries resulted in no Restoration Flows being released. The water deliveries in 2022 also reduced the Millerton Reservoir cold pool because the amount of flows necessary for the water delivery was an order of magnitude larger than the allocated Restoration Flows for that time period. This prompted the RA to extend the hiatus in Restoration Flows until October 1, to avoid releasing warm water during the salmon egg incubation timeframe. Additional biological implications of these contractual water deliveries are further described in the 2023 Technical Memorandum to Account for Reintroduced San Joaquin River Spring-run Chinook salmon (NMFS 2023).

At the time of the Settlement and Settlement Act, there had been no implementation of this contractual obligation to release the reserved waters at Friant Dam, even during the critically dry years of 1976 and 1977, and the impacts of such an occurrence were not envisioned by the signatories to the Settlement. Careful management, coupled with improvements to temperature measurement and management methods of Millerton Reservoir's cold-water supply is critical for the success of the SJRRP. The SJRRP is developing operational guidance which can help minimize conflicts between fulfilling contracts and releasing Restoration Flows and help avoid potential future risks to fish.

5.2 Habitat Improvement and Fish Passage Projects

The Settlement identified the need for some significant habitat improvement projects throughout the Restoration Area. Beyond fish passage at barrier dams, habitat improvements generally needed to support a self-sustaining population of Chinook salmon include increased quantity and quality of: over-summer cold water adult holding habitat, spawning and egg incubation habitat, juvenile rearing habitat, and juvenile and adult migratory habitat through the Restoration Area. Each Reach within the Restoration Area has particular habitat improvement needs, as outlined in the Settlement, and in various SJRRP planning documents.

5.2.1 Reach 1

Reach 1 of the Restoration Area contains the primary spawning habitat for CV spring-run Chinook salmon, which is within the first seven miles downstream of Friant Dam (refer to Figure 12 and Figure 13 for pictures of some areas in Reach 1). Reach 1 is further divided into two sub-reaches, identified as Reach 1A and Reach 1B (Refer to Figure 1 in Section 1). As previously mentioned, spawning and egg incubation habitat improvements are needed to achieve the SJRRP population objectives and Settlement objectives of a self-sustaining salmon population, which include increased river flows and managed cold-water temperatures.

Figure 12. Picture of the San Joaquin River as seen from the top of Friant Dam (Reach 1 of Restoration Area). Photo credit: NOAA Fisheries.

Figure 13. Picture of Reach 1 of the Restoration Area, at the Lost Lake recreational area. Photo credit: NOAA Fisheries.

Downstream of the spawning grounds, various juvenile rearing habitat improvements are needed. These improvements include increased floodplain habitat and the isolation of legacy mining pits that can decrease the survival of juvenile salmon migrating downstream. The SJRRP, in partnership with the San Joaquin River Conservancy,[14] completed the Sycamore Island project in 2018, which isolated a major mine pit from the river and created some floodplain habitat. The Sycamore Island project is a prime example of how partnerships with non-governmental organizations and state agencies can accelerate habitat restoration projects outlined in the Settlement.

5.2.2 Reach 2

Reach 2 of the Restoration Area primarily contains juvenile rearing habitat and migratory habitat for both juvenile and adult salmon (Figure 14). Reach 2 is further divided into two sub-reaches, identified as Reach 2A and Reach 2B (refer to Figure 1 in Section 1). The goals of the Mendota Pool Bypass and Reach 2B Improvements Project (Reach 2B Project) as stated in Paragraphs 11(a)(1) and (2) of the Settlement are to: create a bypass channel around Mendota Pool; increase Reach 2B channel capacity to 4,500 cubic feet per second (cfs); and enhance and create floodplain and riparian habitat.

Figure 14. Picture of Reach 2 of the Restoration Area, several miles upstream of Mendota Dam. Photo credit: NOAA Fisheries.

The project design contains multiple components that will be built in phases based on funding availability. The different aspects of the project are expected to fulfill the needs and objectives of all the affected parties.

[14] More information about the San Joaquin River Conservancy is available on their website at: https://sjrc.ca.gov/.

Specific design components include:

- Compact Bypass channel around Mendota Dam.
- Mendota Pool Control Structure to allow water deliveries into Mendota Pool, and a fish ladder to allow adult salmon and steelhead passage during water deliveries.
- Two V-shaped fish screens able to deliver 2,000 cfs to Mendota Pool.
- Reverse Flows Facility able to deliver up to 500 cfs from Mendota Pool to the Compact Bypass for downstream water deliveries. The objective of the design is to discourage adults from migrating upstream toward Mendota Dam, and instead to encourage migrating adults to swim through the Bypass.
- Fish Sampling Facility after fish are screened from entering Mendota Pool. This facility will primarily be used to rescue and relocate fish during specific flow and water delivery scenarios that would require the use of the fish screens.
- Reach 2B floodplain habitat with 4,500 cfs capacity setback levees throughout the reach.
- South Canal and siphon to maintain water deliveries to Columbia Canal Company located on the north side of the river from Mendota Pool and a few other diverters.

A difficult aspect of this project is accommodating the gravity-fed diversions from Mendota Pool (which is fed by the Delta-Mendota Canal). The ability to gravity-feed these diversions needs to be maintained at all times and under all delivery conditions. The need to balance protecting sensitive fish and wildlife while prioritizing current methods of water deliveries and controlling flood flows creates a complex project. The required water delivery conditions, combined with budget constraints, have caused delays in the design of a feasible project.

The Settlement requires increased river channel capacity, which in turn requires numerous land right acquisitions for levee setbacks to accommodate increased flows and to establish accessible floodplain areas. Land acquisitions also need to occur for other aspects of the Reach 2B project. This, in combination with land subsidence concerns, has further contributed to the delays in the progress of the project.

More details on the design history and current progress can be found at: https://www.restoresjr.net/reach-2b-and-mendota-pool-bypass-documents/.

5.2.3 Reach 3

Reach 3 of the Restoration Area primarily contains juvenile rearing habitat and migratory habitat for adult and juvenile salmon (Figure 15). The goal of the Arroyo Canal Fish Screen and Sack Dam Fish Passage Project (Sack Dam Project) is to fulfill paragraphs 11(a)(6) and (7) of the Settlement. The main objectives of the project include:

- Screening the Arroyo Canal water diversion, which is located immediately upstream of Sack Dam, to prevent entrainment of anadromous fish.
- Modifications at Sack Dam to ensure volitional fish passage.

Sack Dam is owned and operated by the Henry Miller Reclamation District (HMRD) for the purpose of diverting water into Arroyo Canal. Water that is not diverted passes through Sack Dam when the dam gates are opened. During routine operations, HMRD diverts Central Valley Project water released from Mendota Dam upstream of Sack Dam into the Arroyo Canal. Construction of permanent infrastructure at Sack Dam was completed in 1946.[15]

Figure 15. Picture of Reach 3 of the Restoration Area near the town of Firebaugh, a few miles upstream of Sack Dam. Photo credit: NOAA Fisheries.

There has been regional ground subsidence[16] at both the Sack Dam site and the surrounding lands in recent decades. In the Central Valley, subsidence is generally caused by groundwater pumping for agricultural purposes. Typically, fish screening and passage projects are designed for a constant land-surface elevation. However, due to land subsidence at Sack Dam, geological survey points used to inform project design and construction clearly showed the land is sinking due to groundwater over-pumping.

In 2012 the 90% designs were developed for a project that would provide adequate fish passage past Sack Dam. However, once the degree of regional land subsidence was fully understood, the completed screen and passage designs were rendered unusable and a complete redesign has since ensued. Land subsidence has been the most significant and most difficult challenge contributing to delays for design progress on this project.

Generally, the current project designs and specific components include:

- New berm structure downstream of Sack Dam.
- Cross-channel flat plate fish screen for up to 700 cfs of water deliveries to Arroyo Canal.
- Vertical slot fish ladder to provide salmon and steelhead passage during certain flow conditions.
- Concrete river bypass to pass higher flows.
- Concrete and/or grouted cobble fish ramp to accommodate other native fish, including sturgeon.
- New river bypass and fish ramp headworks structure that can convey a maximum of 4,500 cfs but functions at a variety of flows and water surface elevations.
- Design elements to account for land subsidence for several decades after construction.

[15] Prior to permanent infrastructure being installed, Sack Dam was historically a seasonal dam made of burlap sacks filled with gravels and other materials.
[16] Land subsidence is the loss of land-surface elevation due to soil compaction as groundwater is removed at a faster rate than it is replaced.

The Sack Dam Project requires acquisition of three relatively small plots of land. In December 2021, a crucial piece of land was donated to the SJRRP for the project. The donated land allowed designs to progress to 100% completion, and the space necessary to build a fish passage ramp and technical ladder that fish can use to pass around Sack Dam.

More details on the design history and current progress can be found at: https://www.restoresjr.net/arroyo-canal-and-sack-dam-documents/.

More details on regional ground subsidence can be found at: https://www.restoresjr.net/science/subsidence-monitoring/.

5.2.4 Reach 4 and 5

Similar to the river reaches upstream, Reach 4 and 5 of the Restoration Area contain juvenile rearing habitat and migratory habitat for both adult and juvenile salmon (Figure 16). Reach 4 is further divided into three sub-reaches, identified as Reach 4A, Reach 4B1, and Reach 4B2 (refer to Figure 1 in Section 1). There are several paragraphs in the Settlement specific to passage improvement projects, river channel capacity, and flow routing in Reach 4 and 5. Within the 2009 Settlement Act, a Reach 4B study is also described that includes consideration of channel capacity and channel routing (Sec. 10009. Appropriations; Settlement Fund, paragraph (f)), which has yet to be completed due to funding constraints. A flow routing decision for Reach 4B also has not been finalized yet by the SJRRP. Restoration Flows are currently routed through Reach 4A, then routed into the Eastside Bypass, and into Reach 5. Restoration Flows are not currently routed through Reach 4B1 and 4B2.

Figure 16. Picture of Reach 5 of the Restoration Area, at the Fremont Ford recreational area. Photo credit: NOAA Fisheries.

Several projects have been completed or are in progress in the Eastside Bypass. The SJRRP improved approximately two miles of levees, within a three-mile reach of the existing east levee in the Eastside Bypass between Sand Slough and the Mariposa Bypass, to meet levee seepage and stability criteria. The improvement allows conveyance of up to 2,500 cfs. Additionally, the SJRRP implemented the removal of two existing weirs in the Eastside Bypass. The weirs were considered fish passage impediments. An existing non-operational well on the Merced National Wildlife Refuge was replaced with a new well to provide replacement water supply lost by removing the weirs.

The SJRRP has designs in progress to modify the Eastside Bypass Control Structure for fish passage. In general, the designs include a rock ramp downstream of the structure, and notching the sill and removing some baffles from the structure to allow fish to pass volitionally upstream and downstream.

Design history and current progress can be found at: https://www.restoresjr.net/reach-4b-and-eastside-bypass-documents/.

6 Additional Beneficial Effects

6.1 Community Environmental Benefits

There have been unexpected benefits to the communities within the San Joaquin River basin as a direct result of the SJRRP. For approximately 70 years, before the implementation of Interim Flows in 2009, over 60 river miles of the main-stem San Joaquin River remained dry for most of the year. Multiple generations of people in the communities around the San Joaquin River were denied the environmental benefits of living near or having access to a flowing healthy river. Rivers provide people with an opportunity to connect with nature and wildlife recreationally, spiritually, culturally, and can be used as an educational tool (Anderson et al. 2019).

The construction and operation of Friant Dam and subsequent dewatering of the San Joaquin River led to most of these communities losing connection with the river. Many of the communities surrounding the San Joaquin River within the Restoration Area could be described as underserved, minority, or impoverished (Huang et al. 2012, ATSDR 2024). NMFS recognizes that barriers to environmental equity have left many communities underserved, and they are often the most vulnerable to environmental issues, such as climate change and environmental degradation (NOAA Fisheries 2023). In the absence of year-round river flows within the river channel of the San Joaquin River between Friant Dam and the confluence of the Merced River, the communities in the surrounding areas would continue to be impacted and denied the environmental benefits of a healthy and vibrant river system. However, the continuation and full completion of the Restoration Goal under the Settlement would contribute towards re-balancing the environmental inequities within the San Joaquin Valley.

6.2 River Bank Habitat

Restoration Flows in the San Joaquin River provide a source of water for reestablishing riparian vegetation, a process known as riparian recruitment. Reclamation has been conducting a Vegetation Monitoring Study in the Restoration Area since 2011. Vegetation transects have been sampled within all Reaches along the San Joaquin River within the Restoration Area, including the Eastside Bypass. The purpose of the Vegetation Monitoring Study is to evaluate the establishment and development of riparian vegetation in response to Restoration Flows. This study collected data from 2011 to 2015, and in 2017, 2019, and 2022. In general, implementing Restoration Flows has been beneficial in restoring native plant communities (Reclamation 2022).

6.3 River Recreation

Restoration Flows implemented through the SJRRP provide recreational opportunities adjacent to and in the river that would not exist without the SJRRP. These recreational activities include swimming, wading, fishing, wildlife viewing, hiking, and boating. River recreation can provide an opportunity for people to connect to the natural environment, especially for those underserved communities that may not otherwise have access to nature. In the Central Valley, the land adjacent to rivers is dominated by private land ownership. Wetted river channels accessible to the public provide opportunities that would otherwise not be there to connect, recreate, and enjoy the benefits of a larger river system in their backyard.

6.4 Environmental Education

In addition to recreation, a flowing river provides a wide array of educational opportunities for school children and adults. Prime examples of organizations that have river or salmon related educational lessons are Fresno County's Superintendent of Schools' Scout Island[17] (Scout Island Outdoor Education Center; Figure 17), and the San Joaquin River Conservancy.[18] Public areas such as these provide on-the-ground education to the public and to students, both locally and throughout the state. Students and the public alike can see firsthand restoration projects, salmon returning to their ancestral home, and a revitalized river ecosystem. Additionally, facilities such as Scout Island Outdoor Education Center are able to provide these services to schools at no cost to the school, thus removing the fiscal barrier for students to learn through experience about their local ecosystems and natural history. Environmental education such as these would not be as effective if salmon disappeared again, and there were no river flows to maintain the connection between the river and people.

Figure 17. Picture of children creating salmon paintings with educators at the Scout Island Education Center in Fresno, CA. Video still is from "Valley PBS Community by You", a public television program that produced a video about the Scout Island Outdoor Education Center in 2019. Full video is publicly available at: https://www.pbs.org/video/cvhs-scout-island-dleznq/

6.5 Southern Resident Killer Whale Recovery

The recovery of CV spring-run Chinook salmon is beneficial to one of the most beloved marine mammal species, the orca whale (also known as the "killer whale"; Figure 18). The Southern Resident Killer Whale (SRKW) was listed as endangered under the ESA in 2005 (70 FR 69903). One of the main reasons for the decline of the species is the significant decrease in their primary food source, Chinook salmon (NMFS 2008). Accordingly, the

[17] https://www.scoutisland.org/
[18] https://sjrc.ca.gov/

recovery of multiple populations and runs of Chinook salmon is required throughout the NMFS West Coast Region to help recover the SRKW population.

Figure 18. Picture of a jumping orca whale. Photo credit: NOAA Fisheries

In 2018, NMFS identified and prioritized the Chinook salmon stocks that should be "rebuilt" or recovered that would have the highest impact toward helping to recover SRKW (NMFS and WDFW 2018). The highest-ranking California Chinook salmon stock on the priority prey list is CV spring-run Chinook salmon (NMFS and WDFW 2018). Other Central Valley Chinook salmon stocks also rank within the top 20 on the list. In general, during the late winter and early spring months in the California coast, Central Valley Chinook salmon in total can make up about 19% of SRKW diet (Hanson et al. 2021).

Adult Central Valley salmon gather offshore of the San Francisco Bay several weeks prior to their upstream migration timing. The mouth of the San Francisco Bay, which flows underneath the iconic Golden Gate Bridge, is the only way for salmon to swim into the Central Valley rivers where they spawn. For CV spring-run Chinook salmon in particular, adult fish gather off the coast near the mouth of the San Francisco Bay in the winter and early spring months. This timing means that CV spring-run Chinook salmon temporally and spatially overlap with when SRKW are residing off the California Central Coast and hunting for high-quality food.

The San Joaquin River Basin, and especially the Restoration Area, has potential to support a CV spring-run Chinook salmon population once again, but only if investments are made toward habitat restoration and salmon reintroduction. If the SJRRP continues to be prioritized in the recovery of CV spring-run Chinook salmon, then SRKW would benefit from increased prey availability. Increased prey availability during the winter months off the California coast could be highly effective towards the recovery of the whales. This connection exemplifies how ecologically important CV spring-run Chinook salmon are in the marine ecosystem.

7 Recommendations and Opportunities for Restoration Partners Working with the SJRRP

NMFS supports continuation of the SJRRP and recognizes that collaboration and coordination with a variety of restoration partners is the cornerstone for long-term success of the SJRRP. As the implementing agencies and partners continue to learn and adaptively implement the SJRRP, NMFS fully intends to continue to provide guidance and technical expertise to help ensure success.

To date, the SJRRP has only been partially completed and neither the Restoration Goal nor Water Management Goal has been fully realized. Despite this and with significant effort by the SJRRP Implementing Agencies, the Restoration Administrator, the Settling Parties, and other partners, CV spring-run Chinook salmon have begun to return to the San Joaquin River. NMFS believes this clearly proves it is possible for Chinook salmon to reestablish in the San Joaquin River.

Following are several recommendations and opportunities for partners working with the SJRRP to help in efforts to achieve the Settlement Goals:

- NMFS recommends to the California Fish and Wildlife Department that a dedicated long-term funding source be identified and directed for SCARF maintenance, staffing, and operations. The SCARF is significantly valuable in the future of salmon recovery in the Central Valley.
- Increased coordination and collaboration between the SJRRP and land conservancies and land trusts, non-profit environmental organizations, and interested tribal groups on the designs, implementation, and cost-sharing options for habitat improvement projects throughout the Restoration Area. We believe habitat restoration can be achieved on an accelerated timeline if partnerships with non-SJRRP entities were further developed and maintained. These partnerships could also be used to leverage external funding sources which could reduce current financial and staffing constraints to the implementing agencies.
- The reintroduction of CV fall-run Chinook salmon should be re-evaluated as a priority in the near future, and a summary report produced that outlines potential next steps regarding this issue. Given the declining status of the CV fall-run Chinook salmon ocean fisheries off the coast of California (83 FR 7650, 88 FR 30235, 88 FR 44737, 88 FR 51250, CDFW 2023b), reintroduction of CV fall-run Chinook salmon into the Restoration Area could provide an important opportunity to increase overall escapement and fishing opportunities in the future.
- Development and implementation of a governance document to facilitate collaboration and coordination. A clear and directed governance document could facilitate improved collaboration and communication both within the SJRRP and those partnering with the SJRRP. Examples from other restoration programs could be followed, such as the Trinity River Restoration Program.[19]

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[19] The Trinity River Restoration Program is another large-scale restoration program in California. More information is available at: https://www.trrp.net/.

- Options for improved water temperature measurement and management at Friant Dam and Millerton Reservoir should be investigated, and a summary report produced to document those options. A data gap for reintroduction and fisheries monitoring efforts is the current water temperature measurement procedures and management options in Millerton Reservoir.
- Development and implementation of a data management plan to organize and compile all the SJRRP documents and data collected thus far. A data management plan is essential for implementation and evaluating the success of the SJRRP.
- Compilation of a comprehensive report that includes a chronology, actions, and lessons learned from implementation of the SJRRP. The purpose of this comprehensive report would be for future reference by scientists, natural resource managers, and policy makers, and could provide more in-depth technical information than this paper.

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9 Glossary

A

Adipose fin clip: Standard salmon hatchery practice of clipping off the adipose fin from a juvenile hatchery fish. The adipose fin is the last small fin on a salmon's back and is not considered to affect a fish's swimming ability. A clipped adipose fin "marks" or visually identifies a salmon as hatchery origin.

Alevin: Larval salmon with a yolk sac still attached. Alevins typically reside inside the gravel nest (refer to the term "redd") until their yolk sac is fully absorbed and the juvenile fish begins to feed on macroinvertebrates (refer to term below).

Anadromous: Refers to fish born in freshwater that spend most of their lives in saltwater and return to freshwater to spawn, such as salmon, steelhead, and some species of sturgeon. NOAA Fisheries (also known as NMFS) has jurisdiction over most marine and anadromous fish listed under the ESA (refer to term below).

Ancillary: Supplemental or secondary.

B

Benthic: Associated or occurring on or with the bottom of a body of water.

Broodstock: A small population of an animal maintained as a source population replacement or for the establishment of new populations in suitable habitats.

Bypass: For this document, "Bypass" refers to an alterative route for the river to flow around a barrier dam or a pool behind a dam.

C

Channel capacity: In this document, refers to the capacity of the natural river channel to convey river flows without harming or flooding lands behind adjacent levees.

Coded wire tag (CWT): A tiny length of magnetized stainless steel wire (approximately 0.25 millimeter (mm) in diameter, and 1 mm in length) that is microscopically engraved with a unique number. CWTs are injected into the snout of a juvenile fish to identify the exact hatchery it originated from. CWTs are a standard salmon hatchery practice that has been in use since around the 1970s throughout the nation.

Cold-water pool: Refers to the quantity of cold water (generally less than 65 degrees Fahrenheit) available within a reservoir that can be used to help sustain cold-water fish populations downstream of a barrier dam. The cold-water pool is typically limited by the storage capacity of a reservoir, upstream weather conditions and topography, and is also influenced by operations of the reservoir for other water users.

Critical habitat:[20] For species listed under the federal Endangered Species Act (ESA; see term below), critical habitat consists of: (1) specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions section 4 of the ESA, on which are found those physical or biological features (constituent elements), (a) essential to the conservation of the species, and (b) which may require special management considerations or protections; and (2) specific areas outside the geographical area occupied by the species at the time it is

[20] Definition is from the "Endangered Species Consultation Handbook" by the USFWS and NMFS. Publicly available at: https://www.fws.gov/media/endangered-species-consultation-handbook.

listed in accordance with the provisions of section 4 of the ESA, upon a determination by the Secretary that such areas are essential for the conservation of the species [ESA section 3(5)(A)].

D

Delta: Refers to the Sacramento-San Joaquin River Delta, which consists of the confluence of the Sacramento and San Joaquin Rivers along with numerous other rivers and water bodies. The Delta flows out into the Pacific Ocean underneath the iconic Golden Gate Bridge in San Francisco, CA.

Distinct Population Segment (DPS): Under the ESA (see term below), a DPS is a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. NOAA Fisheries and the USFWS released a joint policy defining the criteria for identifying a population as a DPS.[21] The ESA provides for listing species, subspecies, or distinct population segments of vertebrate species.

Donor Stock: Refers to fish that are collected to create and maintain a broodstock (see term above) population.

E

Ecology: A branch of biology that incorporates the relationships of organisms to one another and to their physical environment.

Ecosystem: A biological community of interacting organisms and their physical environment.

Endangered Species Act (ESA): Congress passed the ESA in 1973, recognizing that the natural heritage of the United States was of "esthetic, ecological, educational, recreational, and scientific value to our nation and its people." It was understood that, without protection, many of our nation's native plants and animals would become extinct. The purpose of the ESA is to conserve endangered and threatened species and their ecosystems. More information is available at: https://www.fisheries.noaa.gov/topic/laws-policies/endangered-species-act.

Environmental Equity: The consistent and systemic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment.

Environmental Justice: The fair treatment and meaningful involvement of all people during the development, implementation, and enforcement of environmental laws regulations, policies, including but not limited to: equitable protection from environmental and health hazards; equitable access to healthy, sustainable, and resilient environment in which to live, play, work, learn and grow, and engage in cultural and subsistence practices; and equitable opportunity and access to decision-making processes for underserved communities.

Essential Fish Habitat (EFH): The MSA (see term below) established requirements for fishery management councils to identify and describe EFH, and to protect, conserve, and enhance EFH for the benefit of fisheries. Essentially, EFH is habitat that is necessary for fish and other marine species to survive and reproduce. More information available at: https://www.fisheries.noaa.gov/national/habitat-conservation/essential-fish-habitat.

Estuary: The tidal mouth of a river, where the tide meets the stream.

Extirpation: The local removal or extinction of a species or population of a species from a particular geographical area.

[21] Available at: https://www.federalregister.gov/documents/1996/02/07/96-2639/policy-regarding-the-recognition-of-distinct-vertebrate-population-segments-under-the-endangered.

Extinction: The complete removal, loss, or disappearance of a species from the Earth that is permanent and irreversible.

Evolutionarily Significant Unit (ESU): Under the ESA (see term above), an ESU is a population or group of populations that is substantially reproductively isolated from other conspecific populations and that represents an important component of the evolutionary legacy of the species. Under NMFS Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon (56 Fed. Reg. 58612, November 20, 1991), a salmon stock will be considered a distinct population segment and hence a "species" if it represents an ESU. More information available at: https://www.federalregister.gov/citation/56-FR-58612.

F

Federal Register (FR): The official daily journal of the United States Government that contains rules, proposed rules, and notices published by the various federal agencies. Publicly available at: https://www.federalregister.gov/.

Fish ladder: A structure that allow migrating fish to swim over or around a barrier in the river.

Fish screen: A metal screen specifically designed to prevent fish from swimming or being drawn into a water diversion.

Floodplain: Area of land adjacent to a river that floods at certain river flows. Floodplains are naturally occurring areas that provide important habitat to salmon and other aquatic wildlife and plants.

G

Groundwater seepage: For this document, groundwater seepage is the infiltration of surface water that goes subsurface and becomes the movement of groundwater through porous soil, often elevating shallow groundwater levels.

H

Habitat: The physical environment of an organism that provides the necessities to survive and reproduce.

Hydrograph: A graph that displays water level information over time.

I

Intra-gravel: For this document, refers to the spaces and physical environment between individual pieces of gravel, which is an important habitat for salmon eggs and alevins (see term above).

Iteroparous: Organism that can undergo more than one reproductive event throughout their lifetime.

J

None

K

None

L

Life cycle: The series of changes in the life of an organism.

Life history strategy: The age- and stage-specific patterns and timing of events that make up an individual organism's life.

M

Macroinvertebrate: Invertebrates (animals without a backbone, such as insects) that can be seen without the use of a microscope or magnifying glass.

Magnuson-Stevens Fishery Conservation and Management Act (MSA): The primary U.S. law that governs marine fisheries management in federal waters. The MSA fosters the long-term biological and economic sustainability of marine fisheries. More detailed information is available at: https://www.fisheries.noaa.gov/topic/laws-policies/magnuson-stevens-act.

N

Nonessential experimental population (NEP): Section 10(j) of the Endangered Species Act authorizes listed species to be released as experimental populations outside of their currently occupied range, but within probable historical habitat, to further species conservation. Before making a release, the Services [USFWS or NMFS] determine by rulemaking whether that population is "essential" or "nonessential". An "essential experimental population" is a reintroduced population whose loss would be likely to appreciably reduce the likelihood of survival of the species in the wild. A "nonessential experimental population" is a reintroduced population whose loss would not be likely to appreciably reduce the likelihood of survival of the species in the wild. More information is available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act.

O

Olfactory: Relating to the sense of smell.

P

Pacific Fishery Management Council (PFMC): The MSA (see term above) created eight regional fishery management councils responsible for the fisheries that require conservation and management in their region. More information is available at: https://www.fisheries.noaa.gov/topic/partners.

Production release: For this document, refers to juvenile fish released from a hatchery with the intention that these fish will contribute to the future spawning population.

Q

None

R

Recovery: The process of restoring endangered and threatened species to the point where they no longer require the safeguards of the ESA (see term above). More information available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/recovery-species-under-endangered-species-act.

Redd: Salmon nest made of gravel and dug by the female salmon using her tail fin. Chinook salmon redds are typically oblong in shape with a defined mound and pit area. The eggs are then laid within the gravel in the pit area. Chinook salmon redds can be quite large and get upwards of four feet in width and ten feet in length or more.

Reintroduction: The action of putting species back into their habitat.

Riparian: Related to or situated on the banks of a river.

Rotary Screw Trap (RST): A fish trap that consists of a large metal cone suspended between two floating pontoons. The river flows force the rotation of the cone, which contains an internal screw design and funnels fish into an underwater holding tank attached to the back of the trap.

S

Semelparous: Organisms that reproduce or breed only once in their lifetime and then die.

Sinuous: Having many curves or turns.

Smolt: A juvenile salmon that becomes silvery in color and migrates out to the ocean.

Smoltication: The physiological process by which juvenile salmon become ready to enter marine water, from freshwater.

Subsidence: For this document, land subsidence is the sinking of the ground because of underground geologic movement, caused by the overdrafting or pumping of groundwater.

T

Trap and Haul (or "Assisted Migration"): For this document, refers to the action of capturing salmon using specialized nets and traps, moving them into specialized trucks for transport, and then releasing fish into the river above barrier dams.

U

None

V

Volitional fish passage: For this document, refers to fish being able to swim around, through, or over a structure on their own and without needing human assistance.

W

None

X

None

Y

Yearling: Juvenile salmon that has reared in the river for approximately one year before migrating out to the ocean.

Young-of-Year (YOY): For this document, refers to juvenile fish that are less than a year old.

Z

None

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