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CENTRAL VALLEY SPRING-RUN CHINOOK SALMON IN THE SAN JOAQUIN RIVER BASIN

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Central Valley Spring-run Chinook Salmon in the San Joaquin River Basin

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Executive Summary

In 1998, Central Valley (CV) spring-run Chinook salmon were proposed for listing as an endangered species (63 FR 11482) under the federal Endangered Species Act (ESA) of 1973, as amended, but formally listed as threatened in 1999 (64 FR 50394). The historical range of the CV spring-run Chinook salmon Evolutionarily Significant Unit (ESU) encompassed most of the Central Valley and its rivers; from the upper Sacramento River south through the San Joaquin River, down to the Kings River (Lindley et al. 2004). The San Joaquin River and its tributaries historically supported the largest run of CV spring-run Chinook salmon (Yoshiyama et al. 1998), with an estimated 200,000 to 500,000 adults returning to the San Joaquin River annually before the completion of Friant Dam in 1942 (Yoshiyama et al. 2001). Friant Dam and other dams blocked access to nearly all CV spring-run Chinook salmon spawning habitat in the San Joaquin basin, causing severe population declines. Thus, at the time of listing, CV spring-run Chinook salmon in the San Joaquin basin were considered extirpated. As such, only CV spring-run Chinook salmon in the Sacramento River and its tributaries were formally listed under the ESA, excluding the San Joaquin River and its tributaries.

New data and information presented in this technical paper suggests passive reestablishment of CV spring-run Chinook salmon throughout the San Joaquin River basin. The National Marine Fisheries Service (NMFS) California Central Valley Office (CCVO) suggests that CV spring-run Chinook salmon no longer be considered extirpated in their historical watershed of the San Joaquin River, and downstream of major dams in the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers.

In this technical paper, NMFS describes how CV spring-run Chinook salmon may distribute and utilize different areas within the watershed as they reestablish themselves. NMFS believes that adult and juvenile life stages can be sustained within the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers, and the mainstem San Joaquin River downstream of Friant Dam. Additionally, the Cosumnes River, a major tributary to the Mokelumne River, provides quality rearing habitat that could support juvenile CV spring-run Chinook salmon. The Calaveras River, which flows into the San Joaquin River near the city of Stockton, may provide opportunistic spawning habitat during high water years below New Hogan Dam. The mainstem San Joaquin River, from the Merced River confluence through the Stanislaus River confluence, provides important migratory and rearing habitat for juvenile CV spring-run Chinook salmon. Lastly, this technical paper includes suggestions for fisheries monitoring and management to better assess the reestablishing population of CV spring-run Chinook salmon in the San Joaquin River basin.

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Section 1. Life-History of CV spring-run Chinook salmon

CV spring-run Chinook salmon (*Oncorhynchus tshawytscha*) evolved to take advantage of the geography and hydrology of California's Central Valley and surrounding mountain ranges, from Northern California's Cascade Range, through the Northern and Southern Sierra Nevada mountain range. The Southern Sierra Nevada mountains include some of the tallest mountains in the continental United States, such as Mount Whitney, and the iconic Yosemite National Park. The western slopes of the Southern Sierra Nevada mountain range flows into the San Joaquin River Valley floor. The high elevations of the Southern Sierra Nevada help to maintain the winter snowpack into the summer months, where the melting snow provides cold water for adult and juvenile salmon to survive and thrive during the hot California Central Valley summers (Fry 1961).

Adult CV spring-run Chinook salmon leave the Pacific Ocean to begin their upstream migration to natal streams in late January and early February (CDFG 1998) and enter the Sacramento and San Joaquin Rivers from March to September, with peak migration during the spring months (Moyle 2002; Yoshiyama et al. 1998). They enter rivers in a sexually immature state and hold in freshwater for several months to mature prior to spawning. Adults mature while holding in deep cold-water pools and then spawn from mid-August to early October, with peak spawning occuring in September (Moyle 2002). Access to cold water habitats during the summer and early fall months is a critical component of adult holding, spawning, egg incubation, and juvenile rearing life stages.

CV spring-run Chinook salmon have two distinct juvenile life-history strategies, which allows them to take advantage of California's variable climate. The sub-yearling life-history strategy applies to juveniles that rear and then migrate downstream to the ocean within a short time (3-8 months) of hatching, typically from December to June depending on river conditions. The river rearing, or "yearling," juvenile life-history strategy applies to juveniles that rear in the river over an extended time (usually 8-12 months) prior to migrating out to the ocean. The yearling life-history strategy helps ensure species' survival across a range of hydrological conditions and water year types (Cordoleani et al. 2021). Yearling juveniles are typically larger in size than sub-yearling juveniles, at the time of outmigration. Cordoleani et al. (2021) found CV spring-run Chinook salmon yearlings comprised roughly 10% of juveniles, but represented approximately 60% of returning adults when averaged across years in Mill and Deer Creeks in the Sacramento River basin. The number of returning adults with the yearling juvenile life-history strategy was even higher (77–100%) in drought years. Ensuring habitat conditions are suitable for the expression of the yearling life-history strategy in all water year types is critical for CV spring-run Chinook salmon survival and recovery, particularly in challenging conditions created by climate change and the varying water year types of the California Central Valley.

Section 2. Historical Distribution and Abundance

"The numbers of salmon that at one time existed in the San Joaquin River were, by some accounts, tremendous" and CV spring-run Chinook salmon were the most abundant salmonid in the San Joaquin "ascending and occupying the higher-elevation streams fed by snowmelt where they over-summered until fall spawning season" (Yoshiyama et al. 1996). The California Central Valley watershed as a whole is estimated to have supported CV spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported the majority of the CV spring-run Chinook salmon population, and was characterized to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 to 500,000 adults returning annually (CDFG 1990). Following the loss of access to historical holding, spawning, and rearing habitats

combined with subsequent water management practices, CV spring-run Chinook were believed to be extirpated from the San Joaquin River and its tributaries by the early 1950s (CDFG 1965; Campbell and Moyle 1991; NMFS 1997).

"The former San Joaquin River salmon runs were the most southerly, regularly occurring large populations of Chinook in North America, and were possibly distinctly adapted to the demanding environmental regime of the southern Central Valley" (Yoshiyama et al. 1996). San Joaquin River spring-run populations occupied the upper and middle reaches of the watershed from 450 meters (m) to 1,600 m in elevation (Stone 1872; Rutter 1908; Clark 1929; NMFS 1997). According to Yoshiyama et al. (1996), CV spring-run Chinook salmon ascended as far as the border of Yosemite National Park, and to where Mammoth Pool Reservoir is now on the upper San Joaquin River. Historically, the Stanislaus, Tuolumne, and Merced Rivers provided exceptional habitats for CV spring-run Chinook salmon (Yoshiyama et al. 1996). The Mokelumne River is unique among historical CV spring-run Chinook salmon rivers as it drains directly into the Sacramento-San Joaquin River Delta rather than into the Sacramento or San Joaquin Rivers. Yoshiyama et al. (1996) also documented that CV spring-run Chinook salmon were historically present in the mainstem. Lindley et al. (2004), in describing the historical population structure of Central Valley Chinook salmon, determined that the populations of the Mokelumne, Stanislaus, Tuolumne, Merced and San Joaquin were capable of persisting in isolation without depending on neighboring watersheds for their persistence (i.e., independent populations).

According to Yoshiyama et al. (1996), the historical upstream limits for CV spring-run Chinook salmon in the San Joaquin River basin have been described as:

- Latrobe Falls, about 0.5 miles below Latrobe Highway Bridge, on the Cosumnes River;
- Bald Rock Falls, seven miles upstream of Electra Powerhouse, on the Mokelumne River;
- Location of New Hogan Dam on the Calaveras River;
- The North Fork (several miles upstream of confluence with Middle Fork), and Middle Fork (near Beardsley Reservoir) of the Stanislaus River;
- Preston Falls (few miles downstream of Hetch Hetchy Reservoir) on the Tuolumne River;
- The vicinity of the community of El Portal on the Merced River;
- Midway (3 miles) up the length of what is now Mammoth Pool Reservoir on the upper San Joaquin River; and
- The confluence of North Fork (upstream of Pine Flat Reservoir) on the Kings River.

Access to these historical holding, spawning, and rearing habitats are presently blocked by Camanche and Pardee Dams (Mokelumne River); Goodwin, New Melones and Tulloch Dams (Stanislaus River); La Grange and New Don Pedro Dams (Tuolumne River); Crocker-Huffman, Merced Falls, McSwain, and New Exchequer Dams (Merced River); and Friant Dam (San Joaquin River)[1].

Construction of low elevation, high head dams in the foothills of the Sierra Nevada Mountains on the San Joaquin, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers block access to high elevation cold-water habitat that is essential for CV spring-run Chinook salmon. These dams, which do not allow for anadromous fish passage, in conjunction with past and present

[1] Upstream passage is currently blocked by Sack and Mendota Dams on the San Joaquin River, but the San Joaquin River Restoration Program is required to create volitional passage up to Friant Dam and construction is expected to be underway to provide volitional passage in the near future.

water management strategies, are the primary reasons for the extirpation of CV spring-run Chinook salmon from the San Joaquin River and its tributaries.

Section 3. Listed ESU Delineation and Central Valley Recovery Planning

Section 3.1 Listed ESU for Central Valley Spring-run Chinook salmon

In response to a series of petitions to list Chinook salmon under the ESA, in 1994, NMFS initiated an ESA status review for all populations of anadromous salmonids in the states of Washington, Idaho, Oregon, and California. A West Coast Chinook Salmon Biological Review Team was formed and their report was published December 17, 1997 (NMFS 1997). Based on this review, NMFS issued a proposed rule to include CV spring-run Chinook salmon on the list of Threatened and Endangered species. The 1998 Federal Register (FR) notice: (1) delineated the listed CV spring-run Chinook salmon ESU as "existing populations in the ESU spawning in the Sacramento River and its tributaries" (refer to Figure 1); and (2) concluded that CV spring-run Chinook salmon was in danger of extinction throughout all or a significant portion of its range (63 FR 11482). Native CV spring-run Chinook salmon had been extirpated from all tributaries in the San Joaquin River basin, which represented a large portion of the historical range and abundance of the ESU as a whole (63 FR 11482). While the 1998 FR notice proposed CV spring-run Chinook salmon be listed as an endangered species (63 FR 11482), the final FR notice (64 FR 50394) formally listed CV spring-run Chinook salmon as threatened. The shift from endangered to threatened was based on observations of large runs of CV spring-run Chinook salmon in Butte Creek, Butte County, California.

The CV spring-run Chinook salmon listed ESU boundary is currently delineated as all naturally spawned CV spring-run Chinook salmon originating from the Sacramento River and its tributaries downstream of barrier dams (70 FR 37160). The listed ESU also includes CV spring-run Chinook salmon from the Feather River Fish Hatchery (FRFH) spring-run Chinook salmon Program. The listed ESU boundary does not include the lower San Joaquin River or its tributaries because CV spring-run Chinook salmon were considered extirpated from the basin at the time of listing. Section 10(j) of the ESA, Non-Essential Experimental Population (NEP) designations for CV spring-run have been designated for: the San Joaquin River Restoration Program (SJRRP) in 2013 (78 FR 79622); in the upper Yuba River in 2022 (87 FR 79808); and upstream of Shasta Dam (88 FR 58511) in the upper Sacramento and McCloud Rivers[2] in 2023. Section 10(j) of the ESA provides for the release of an experimental population outside a species' current range to further the conservation of the listed species.

[2] To date, Sacramento River CV spring-run Chinook salmon have not been reintroduced to the upper Yuba River or upstream of Shasta Dam.

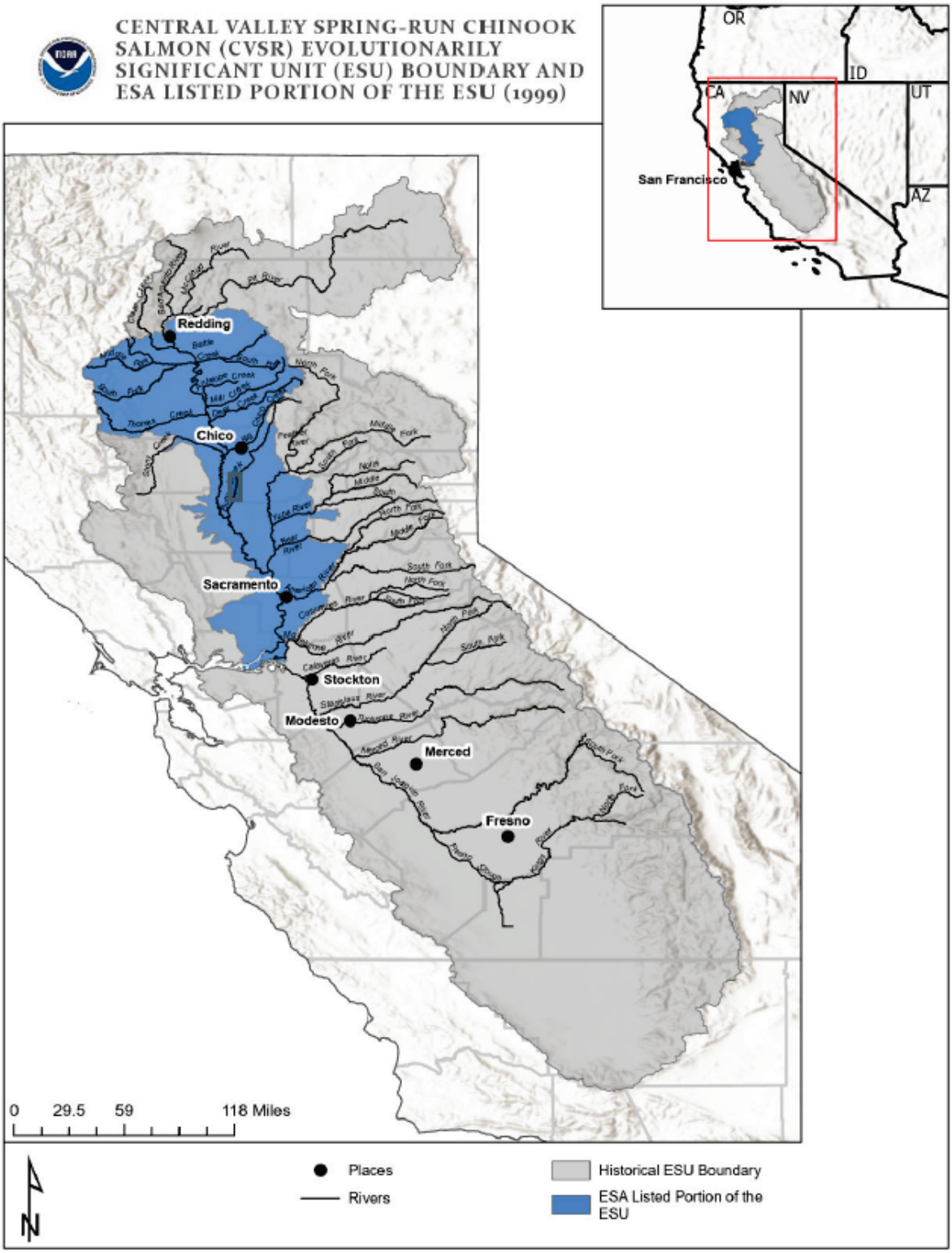

Figure 1. Map of Central Valley spring-run Chinook salmon ESU boundary (Lindley et al. 2004) and ESA listed portion of the ESU at the time of listing in 1999.

Section 3.2 Central Valley Recovery Planning

The ESA requires that recovery plans be developed for listed populations and that they have objective measurable criteria that define when a species can be removed from the list. Technical Recovery Teams (TRTs) were charged with developing a framework for assessing viability to be used in recovery planning. The historical population structure of CV spring-run Chinook salmon was defined by Lindley et al. (2004), and a framework for assessing viability is described in Lindley et al. (2007). The historical CV spring-run Chinook salmon ESU and its population groups (i.e., Diversity Groups) were delineated on the basis of geography as defined by mountain ranges (e.g., Northwestern, Basalt and Porous Lava, Northern Sierra, and Southern Sierra; Lindley et al. 2004, Figure 2, and Figure 3). The TRT historical structure and viability assessment described the Southern Sierra Nevada Diversity Group to include the San Joaquin River and its tributaries. Lindley et al. (2007) identified five independent populations within this Diversity Group (Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin Rivers), and one Dependent population (Kings River).

Drawing from the TRT framework, the NMFS CV Recovery Plan (NMFS 2014a) requires that for CV spring-run Chinook salmon to achieve recovery, at least nine populations must be found at low risk of extinction across the four Diversity Groups. The CV Recovery Plan (NMFS 2014a) also requires: (1) the restoration of viable populations in the historical habitats of the San Joaquin River basin (Figure 2 and Figure 3); and (2) that the San Joaquin River basin provide habitat components consistent with the primary constituent elements essential for the conservation of CV spring-run Chinook salmon. Viability for the Southern Sierra Nevada Diversity Group and San Joaquin River basin will rely on a minimum of two Independent populations (i.e., Core 1 populations) achieving a moderate extinction risk threshold and all Core 2 populations achieving a moderate extinction risk threshold (NMFS 2014a). The mainstem San Joaquin River downstream of Friant Dam has been identified by the CCVO as one of the two Independent populations necessary to meet recovery criteria. One population from the Mokelumne, Stanislaus, Tuolumne, or Merced River could be selected as the second Independent population to achieve low extinction risk criteria. Additional populations in the tributaries will be required to meet moderate extinction risk criteria.

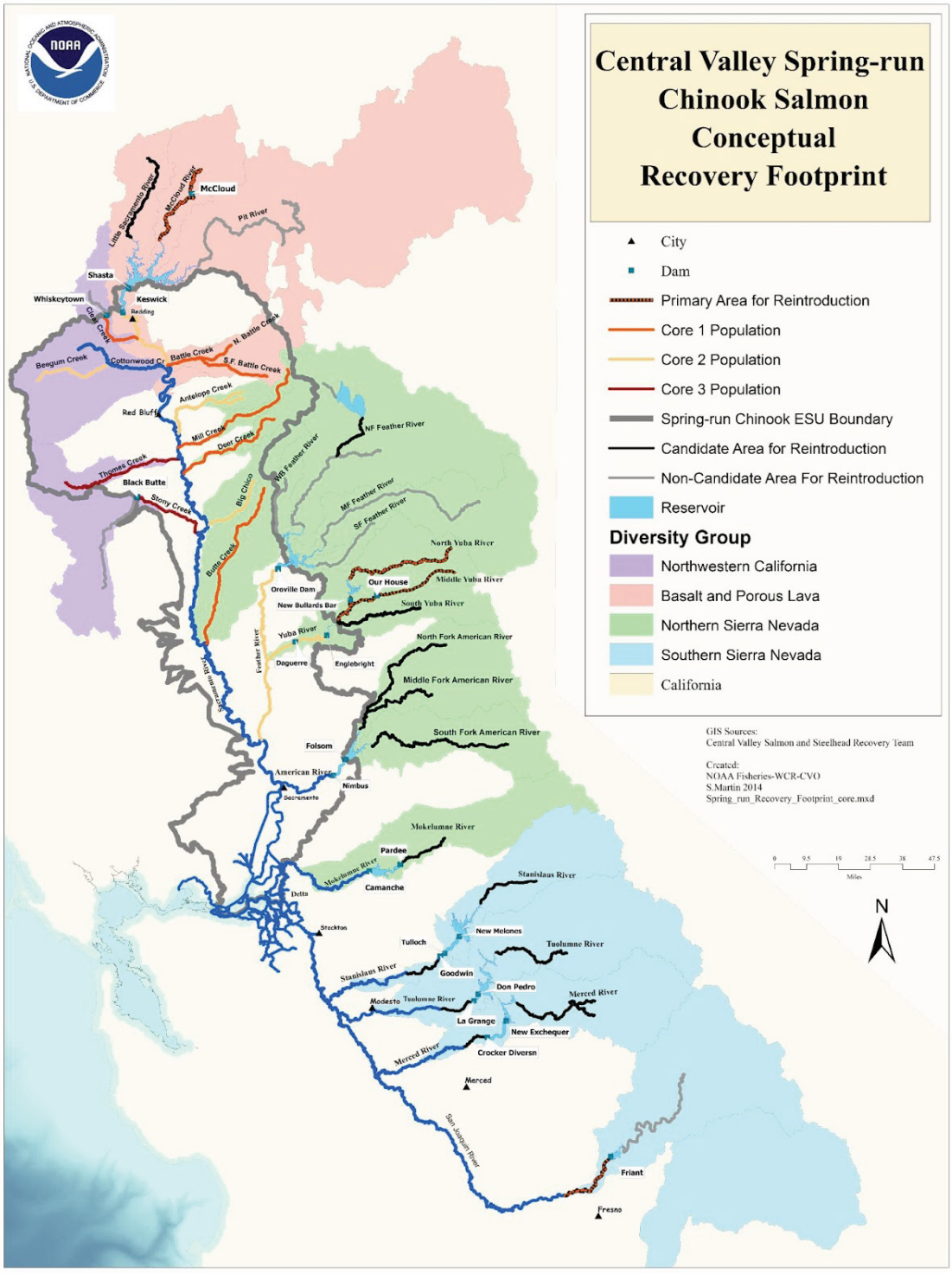

Figure 2. Map of the California Central Valley overlaid with an outline of the conceptual recovery footprint for CV spring-run Chinook salmon (NMFS 2014a). The map highlights the four diversity groups defined for CV spring-run Chinook salmon and the watersheds that historically supported populations of CV spring-run Chinook salmon.

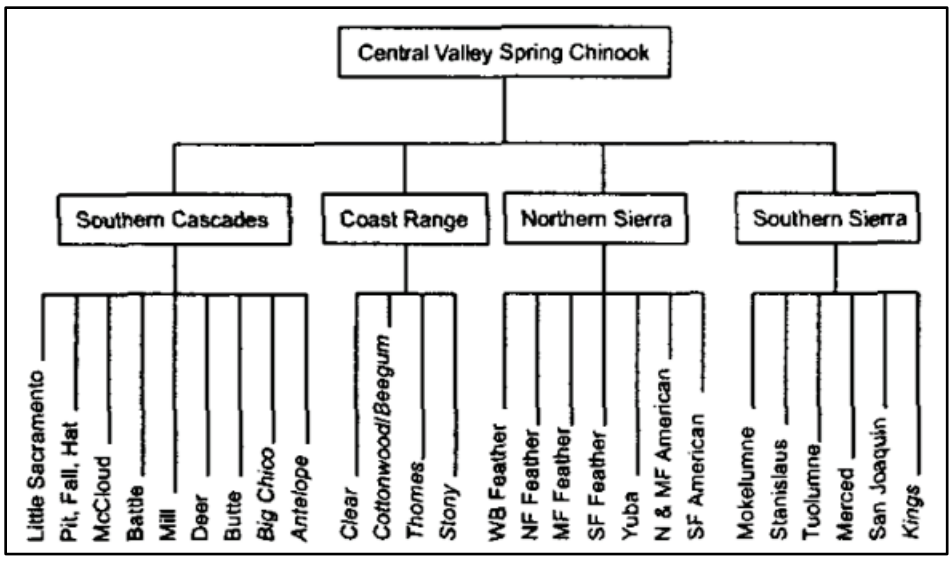

Figure 3. Historical structure of the Central Valley spring-run Chinook salmon ESU (Lindley et al. 2004). Independent populations are in regular type; dependent populations are in italics. In this figure, Mill and Deer Creek spring-run Chinook salmon populations are indicated as independent, although the CV Technical Recovery Team will also consider the possibility that spring-run Chinook salmon in these two streams form a single population (Lindley et al. 2004).

Section 4. Indigenous Knowledge (IK)

The NOAA Tribal Consultation Handbook (NOAA 2023a) defines Indigenous Knowledge (IK) as "a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment (Berkes et al. 2000)." NOAA recognizes the importance of indigenous peoples' traditional knowledge for understanding the environment, adapting to environmental change, and mitigating negative environmental impacts (NOAA 2019). To fully understand the environment for the purpose of adaptive and holistic decision-making, we need to bring together Indigenous Knowledge and western science (NOAA 2023b).

There are many salmon cultural practices that have been disrupted following European-American contact in California, including blockage of anadromous salmon migration following construction and ongoing operations of large dams throughout the Sierra Nevada and southern Cascade Mountain Ranges. For example, Merced Falls Dam, located upstream of Crocker-Huffman Dam on the Merced River, is a significant location for tribal salmon ceremonial uses for the Southern Sierra Miwuk Nation. However, the Southern Sierra Miwuk Nation have been denied these practices because salmon cannot reach these areas in the Merced River. These rituals help people remember the rules and appropriately interpret signals from ecosystem change (Berkes et al. 2000). In addition, many tribes historically and currently rely on subsistence fishing for salmon in California. Salmon have sustained indigenous Central Valley populations in the tens of thousands and indigenous peoples recognized their responsibility to protect and care for the salmon (NMFS 2022a).

The suggestions within this technical paper could benefit Native American communities in the San Joaquin River basin by allowing for: (1) increased funding opportunities for indigenous-led

fisheries and restoration projects and studies; and (2) reconnection, reinvigoration, or continued long-term practice of salmon-related IK for future generations within individual tribes.

Section 5. CV Spring-run Chinook salmon in the Southern Sierra Nevada Diversity Group within the San Joaquin River basin

At the time of final listing in 1999, CV spring-run Chinook salmon were deemed extirpated at the southern extent of their range (e.g., Southern Sierra Nevada Diversity Group). However, this technical paper presents evidence to suggest that through the decades, CV spring-run Chinook salmon persisted and continued to populate these watersheds, albeit in low numbers. New data indicate CV spring-run Chinook salmon are reoccupying their historical watersheds in the lower tributaries to the San Joaquin River (downstream of the major dams). All of these locations were identified as historically supporting "Independent Populations" within the Southern Sierra Nevada Diversity Group (i.e., in the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers) per Lindley et al. (2004). Recently (2019–2022), there have been observations of low numbers of "early migrating" adult Chinook salmon returning to major San Joaquin River tributaries that exhibit spring-run Chinook salmon life-history characteristics.

Franks (2014) was the first NMFS white paper to acknowledge the potential presence of CV spring-run Chinook salmon in the San Joaquin River basin. Franks (2014) summarized data opportunistically collected from ongoing salmonid monitoring efforts, and reported that populations of CV spring-run Chinook salmon occur in some of the San Joaquin River tributaries, most notably the Stanislaus and Tuolumne Rivers. Evidence presented in Franks (2014) describes several adult Chinook salmon observed during the spring months in both the Stanislaus and Tuolumne Rivers over several years. Additionally, in the early 2000s, juvenile Chinook salmon were observed during visual underwater surveys in December. Detections of juvenile Chinook salmon in December is outside the generally accepted juvenile CV fall-run Chinook salmon timing and is more indicative of CV spring-run Chinook salmon life-history. The SJRRP reintroduction efforts for CV spring-run Chinook salmon were initiated in 2014, after the above-mentioned observations. Thus, the observations reported by Franks (2014) could have been naturally produced CV spring-run Chinook salmon.

According to the SWFSC Viability Assessment Reports for Pacific Salmon and Steelhead (SWFSC Report; Williams et al. 2016; SWFSC 2023), information on the presence of fish exhibiting spring-run behavior in the San Joaquin River tributaries may represent reoccupation of CV spring-run Chinook salmon into the San Joaquin River basin. As such, the SWFSC Reports state that there is value in continuing to monitor these populations.

Section 5.1 SJRRP Reintroduction

In 1988, a coalition of environmental groups, led by the Natural Resources Defense Council (NRDC), filed a lawsuit, titled NRDC, et al., v. Kirk Rodgers, et al., challenging the renewal of long-term water service contracts between the United States and the Friant Division Contractors. NRDC sued the Federal government for a violation of California Fish and Game code 5937 which requires that "(t)he owner of any dam shall allow sufficient water at all times" …"allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam." NRDC noted that the lack of water in the San Joaquin River was not keeping fish populations below Friant Dam in "good condition." On September 13, 2006, after more than 18 years of litigation, the Settling Parties, including NRDC, Friant Water Users Authority, and the United States Department of the Interior, and the Department of Commerce, agreed to the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.*, (Settlement). The Settlement established two primary goals:

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 (the Restoration Area), including naturally reproducing and self-sustaining populations of salmon and other fish.

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.

To achieve the Restoration Goal, the Settlement specified a combination of channel and structural modifications along the San Joaquin River downstream of Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of Chinook salmon.

To facilitate reintroduction of CV spring-run Chinook salmon, NMFS established an experimental population designation under ESA section 10(j) and adopted limited take prohibitions under ESA section 4(d) on December 31, 2013 (78 FR 79622). The NEP designation signifies that the species (threatened CV spring-run Chinook salmon) will not be in jeopardy of extinction if the NEP is lost. The 10(j) rule also authorizes reintroduction of CV spring-run Chinook salmon within the SJRRP Area (Figure 4).

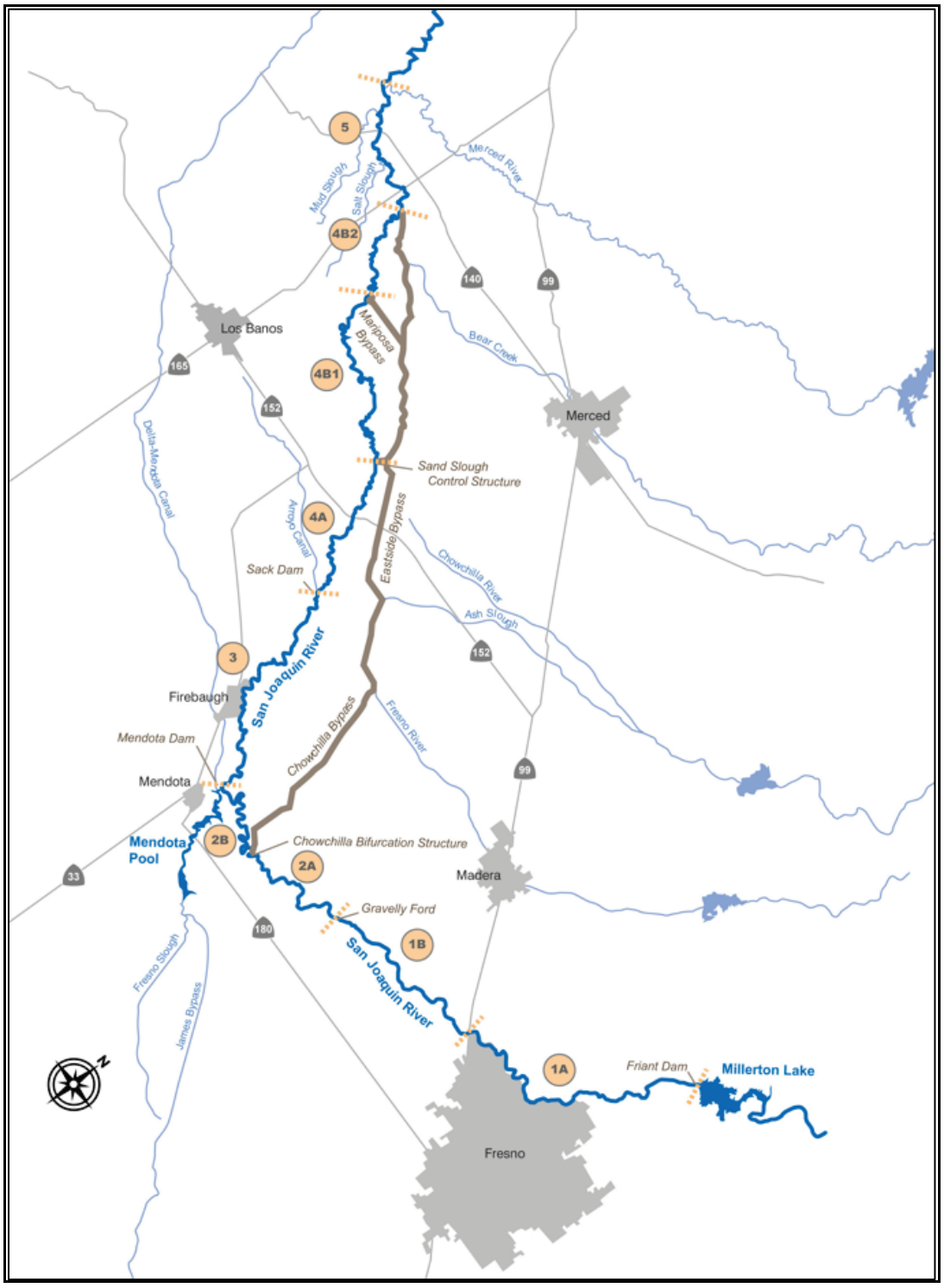

Figure 4. Map of the San Joaquin River Restoration Program Area in the San Joaquin Valley, California. The map shows the mainstem of the San Joaquin River from Friant Dam to the confluence of the Merced River. Map credit: San Joaquin River Restoration Program.

In 2014, the SJRRP began the reintroduction of CV spring-run Chinook salmon in the mainstem San Joaquin River within the SJRRP Area. From 2014–2016, the SJRRP released

juveniles originating from the FRFH into the SJRRP Area. Beginning in 2016 and through the present year (2024), juvenile Chinook salmon raised in the Salmon Conservation and Research Facility (SCARF), near the city of Fresno, California, have been released instead of, or with, FRFH juveniles (NMFS 2014b, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023). The reintroduction activities have been successful and adult CV spring-run Chinook salmon have been documented returning to the SJRRP Area since 2019, but may have returned starting in 2017 based on genetic data (NMFS 2014b, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023) (Figure 5).

The long-term goal of reintroduction is to aid in the recovery and resiliency of the CV spring-run Chinook salmon population throughout the greater Central Valley (Figure 6).

Figure 5. Image of an adult CV spring-run Chinook salmon captured near the confluence of the San Joaquin River and Merced River in 2022. The salmon had originated as a juvenile from the SCARF and was captured for transport to the spawning reach below Friant Dam. Credit: U.S. Bureau of Reclamation.

Figure 6. The recovery triangle illustrates the concepts outlined in the NMFS Central Valley Recovery Plan (NMFS 2014a) and shows the three crucial steps to recovering salmonids in the California Central Valley: resiliency, restoration, and reintroductions. Credit: Stephanie Fogel.

Section 5.2 San Joaquin River and Tributaries Downstream of the SJRRP Area

Outside of the SJRRP Area, there are no ongoing monitoring programs designed to target or detect CV spring-run Chinook salmon within the San Joaquin River or its tributaries. Therefore, all of the data presented in this technical paper was opportunistically collected during ongoing monitoring for CV fall-run Chinook salmon, which have different migration timing at the adult and juvenile life stages. Due to this discrepancy in monitoring and migration timing, it is highly likely that the available data significantly underestimates the distribution and abundance of CV spring-run Chinook salmon in the San Joaquin River basin.

Section 5.2.1 Stanislaus, Tuolumne, and Merced Rivers

In 2021, the California Central Valley entered a second consecutive year of drought[3]. This resulted in water management actions that left the mainstem San Joaquin River, upstream of the Merced River confluence, dewatered and disconnected. Under these conditions, adult CV spring-run Chinook salmon from the reintroduced population were unable to return to the SJRRP Area. Since they were unable to migrate to the SJRRP Area, many of these fish likely migrated into the major tributaries of the San Joaquin River. In fall of 2021, the California Department of Fish and Wildlife (CDFW) conducted annual spawning surveys for adult CV fall-run Chinook salmon in the Stanislaus, Tuolumne, and Merced Rivers. CDFW collected data that indicated CV spring-run Chinook salmon did indeed migrate and hold over for the summer in those tributaries. Coded-wire tag data from adult carcasses confirmed these fish were of SJRRP-SCARF origin (Table 1).

[3] Refer to www.drought.gov for more details regarding the drought in California during the past several years.

NMFS staff coordinated with CDFW to obtain fin-clip samples from carcasses of Chinook salmon (both ad-clipped of hatchery origin, and non-ad-clipped of unknown origin) from September through October 2021. Fin-clip samples were obtained because they can be used to generate genetic data, that can in turn inform whether individuals or populations, and population groups, originate from the CV spring-run ESU. This information informs strategies for conservation, reintroduction, and recovery. The short timeframe of adult fin-clip sample collection was to limit overlap with carcasses from CV fall-run Chinook salmon, which occur primarily from October through December. Unfortunately, in the fall of 2022, no adult fin-clip samples were collected due to limited monitoring opportunities for carcasses of Chinook salmon that could likely be CV spring-run fish.

Table 1. Summary of the number of adult San Joaquin River Restoration Program Central Valley spring-run Chinook salmon observed in the San Joaquin River tributaries. Coded wire tag data are available on the Regional Mark Processing Center website at: https://www.rmpc.org/. Passive integrated transponder (PIT) tag data was provided by Cramer Fish Sciences (personal communication) for the Stanislaus River.

Year	Mokelumne Hatchery	Stanislaus River	Tuolumne River	Merced Hatchery
2021	1	8	18	2
2022	0	4	4	0

In early 2022, NMFS staff coordinated with CDFW and FISHBIO, Inc., to obtain fin-clips for genetic testing from juvenile Chinook salmon captured in the Rotary Screw Traps (RSTs), near the town of Oakdale on the Stanislaus River, and near the community of Waterford on the Tuolumne River. The objective of collecting fin-clips from juveniles was to determine, using genetic data, if adult CV spring-run Chinook salmon successfully spawned and produced juveniles in those rivers. The RSTs in the Stanislaus and Tuolumne Rivers target CV fall-run Chinook salmon outmigration from January through June, which is a narrower period of time compared to the CV spring-run Chinook salmon juvenile outmigration window of November through June. Juvenile Chinook salmon fin-clip collections began in mid-February of 2022 (the delay was due to permitting logistics). Therefore, juvenile fin-clip collection did not span the entirety of the juvenile CV spring-run Chinook salmon outmigration period. Juvenile fin-clip samples were also collected from January through June in 2023, from the same RST locations. Monitoring for juvenile Chinook salmon does not occur in the Merced River and no fin-clips were collected from that watershed.

Adult and juvenile fin-clip samples were analyzed by NMFS' SWFSC. These genetic results provide direct evidence that CV spring-run Chinook salmon (e.g., both the homozygous and heterozygous genotypes[4]) are present in the Stanislaus, Tuolumne, and Merced Rivers (Clemento and Garza 2023). The genetics report by Clemento and Garza (2023) concluded that "Individuals with at least some spring-run ancestry were identified in all three rivers. The confirmed presence of spring-run [homozygote] and spring/fall-[run] heterozygote juveniles in

[4] An individual's genotype is the specific genetic material, or DNA, they possess. A gene is a section of DNA that encodes a trait, and can exist in different forms known as alleles. The combination of alleles that an individual possesses for a specific gene is their genotype. If an individual possesses two different alleles for a specific genetic trait, such as salmon run-type, then their genotype is classified as heterozygous. If an individual possesses two of the same alleles for a specific genetic trait, then their genotype is classified as homozygous.

the Stanislaus and Tuolumne Rivers confirms that adults with spring-run ancestry successfully spawned in these rivers and strongly suggests that spring-run [Chinook] salmon were the parents of some of these individuals."

From an ecological perspective, the heterozygote genotype provides resilience for the homozygote genotype. This is particularly relevant for a cold-water species in a warming Mediterranean climate at the southern extent of its North American range and therefore vulnerable to stochastic or dynamic events. In a stochastic event, such as a multi-year drought or large-scale wildfire that may result in local extirpations of fish with spring-run life-history (i.e., homozygote early-migrating genotypes), the heterozygote genotype preserves the genetic information for the potential long-term reemergence and persistence of the spring-run phenotype[5]. A diversity of genotypes associated with Chinook salmon migration timing is preferred when trying to conserve distinct run-timing phenotypes; however, this conservation strategy may present challenges for current management frameworks (Waples and Lindley 2018; Ford et al. 2020). The frequency of genotypes for migration-timing in Chinook salmon is influenced by environmental conditions that "select" for the phenotypic behavior associated with migration timing. In order to conserve a diverse array of genotypes that support the spring-run phenotype, it is necessary to conserve those habitats that allow for the spring-run phenotype to be expressed and to thrive (Thompson et al. 2018).

CV spring-run Chinook salmon historically inhabited the Stanislaus, Tuolumne, and Merced Rivers (Yoshiyama 2001; Lindley et al. 2004). The recent documentation of CV spring-run Chinook salmon reestablishing these rivers has likely been bolstered by the reintroduction efforts by the SJRRP.

Section 5.2.2 Detections of ESA-listed fish outside of the SJRRP Area

Detections of ESA-listed fish from the FRFH have been observed in the San Joaquin River tributaries from 2002 to 2016 (Table 2). Since 2016, observations of FRFH fish migrating into the San Joaquin River tributaries have not been recorded. However, this is likely an artifact of ongoing monitoring programs that are directed at sampling of CV fall-run Chinook salmon rather than targeting CV spring-run Chinook salmon presence.

While Table 2 provides coded wire tag confirmation of FRFH fish prior to 2016, video monitoring data collected from the Mokelumne (EBMUD 2024), Stanislaus (Tri-Dam Project and USBR 2024), and Tuolumne Rivers (TID and MID 2024), have also observed adult Chinook salmon during the spring months (Appendix A). Video monitoring data is summarized in Appendix A, and shows the monthly observed counts of adult Chinook salmon for each year monitoring occurred, and includes fish with an ad-fin clip or with no ad-fin clip (i.e., ad-fin present). It should be noted that video monitoring in the San Joaquin River Basin is also directed at sampling CV fall-run Chinook salmon and California CV steelhead (*O. mykiss*). Fish observed in January were included in the Appendix A table summaries because it is uncertain if they are late migrating CV fall-run Chinook salmon or early migrating CV spring-run Chinook salmon. Fish observed in the video monitoring data during the spring months prior to 2016 with an ad-fin clip are likely FRFH; while fish observed after 2016 with an ad-fin clip could be from either the FRFH or the SJRRP. Fish observed in all years during the spring months that have an adipose fin present, have an uncertain origin (refer to Appendix A). These fish should be considered ESA-listed CV spring-run Chinook salmon, unless they are genetically determined not to be. Tables

[5] An individual's phenotype is the combination of their observable characteristics or traits. While an organism's genotype (refer to footnote 4) is directly inherited from its parents, phenotype is merely influenced by genotype. Environmental factors can also affect an individual's phenotype.

A-1, A-2, and A-3 in Appendix A, also illustrate how the observed counts of CV spring-run Chinook salmon in all three tributaries, regardless of ad-fin status, declined drastically after the 2012-2016 drought that the Central Valley experienced (CNRA 2021).

Table 2. Summary of the number of adult CV spring-run Chinook salmon from the Feather River Fish Hatchery that were observed in the San Joaquin River tributaries. Coded wire tag data are publicly available on the Regional Mark Information System Database (RMIS) website at: https://www.rmpc.org/

Year	Mokelumne Hatchery	Mokelumne River	Stanislaus River	Tuolumne River	Merced Hatchery	Merced River
2002					1	
2003		4	1			
2004						1
2005	1			1	1	
2007		1				1
2010	18	3		3		
2011	15	9		1		
2012	1					
2015	2					
2016			1			

Section 5.2.3. Mokelumne River

The Mokelumne River, a tributary to the San Joaquin River in the northern Sacramento-San Joaquin River Delta, historically supported CV spring-run Chinook salmon (Yoshiyama 2001). Fisheries monitoring in the Mokelumne River for California CV steelhead and CV fall-run Chinook salmon is conducted by East Bay Municipal Utility District (EBMUD). However, non-hatchery origin, and hatchery origin CV spring-run Chinook salmon from the FRFH and the SJRRP, have been documented in the Mokelumne River (EBMUD 2024; RMIS 2024). Th occurrence of CV spring-run Chinook salmon is likely due to the proximity of the Mokelumne River to the Sacramento River basin. While there is no monitoring conducted for CV spring-run Chinook salmon in the Mokelumne River, anecdotal observations (EBMUD pers. comm. 2023) indicate that CV spring-run Chinook salmon are present in some years and possibly spawning in the Mokelumne River (refer to Appendix A for additional observations of adult Chinook salmon in the spring over several years).

Section 5.2.4 Cosumnes River

The Cosumnes River is a major tributary to the Mokelumne River, and is a low elevation watershed with a rain-driven hydrology rather than snow-melt driven hydrology. It is most notable for being the only large California Central Valley river without a major dam. Since the Cosumnes River is a rain-driven system, NMFS does not anticipate many adult CV spring-run Chinook salmon to migrate upstream and spawn. Historically, natural occurrence most likely occurred in wet years (Yoshiyama et al. 1996). The Cosumnes River historically supported

moderate size runs of Chinook salmon, with escapement ranging from several hundred to more than 4,000 fish between 1953 and 1973 (Snider and Reavis 2000). Spawning occurs from Highway 16 to Latrobe Falls, which is the upstream limit of anadromy (RBI 2006).

The lower Cosumnes River likely provides high-quality rearing habitats for juvenile Chinook salmon migrating downstream in the Mokelumne River. The Cosumnes River Preserve, just upstream of the confluence with the Mokelumne River, contains low elevation wetlands and floodplains, which are productive rearing habitats for juvenile salmonids (Sommer et al. 2001; Jeffres et al. 2008; Ogaz et al. 2022). In the scientific literature, non-natal rearing by juvenile Chinook salmon is a recognized important rearing strategy (Copeland et al. 2014; Sturrock et al. 2015; Phillis et al. 2018; Cordoleani et al. 2021). There is inconsistent salmon monitoring that occurs in the Cosumnes River and, in many years, no monitoring occurs.

Given the proximity and open access of the lower Cosumnes River to adults and juvenile salmon in the Mokelumne River, and how common it is for juvenile Chinook salmon to rear non-natally, NMFS assumes that adults have the ability to access the upper spawning reaches in wet years; and juvenile CV spring-run Chinook salmon are likely present in the Cosumnes River, especially during wet water years when floodplains are highly accessible.

Section 5.2.5 Calaveras River

The Calaveras River is a major tributary to the San Joaquin River, and is also a low-elevation watershed with a rain-driven hydrology. Similar to the Cosumnes River, NMFS does not anticipate many adult CV spring-run Chinook salmon to migrate upstream and spawn due to inadequate spring, summer, and fall flows and water temperatures in most water years. However, in water years with very high late winter and early spring flows, there is the potential for volitional passage to the spawning grounds downstream of New Hogan Dam. If there is volitional passage during the spring months, then there is the potential for adult CV spring-run Chinook salmon to migrate upstream into the Calaveras River and hold over the summer, and then spawn if water temperatures are adequate below New Hogan Dam. Salmonid monitoring in the Calaveras River targets California CV steelhead and CV fall-run Chinook salmon. Monitoring is conducted by FISHBIO through the Calaveras River Habitat Conservation Plan[6] (CHCP), and funded by Stockton East Water District. Given the numerous fish passage barriers to upstream rearing areas, NMFS does not anticipate juvenile non-natal rearing to occur in the Calaveras River.

Section 5.2.6 Mainstem San Joaquin River

The mainstem San Joaquin River, from the confluence with the Merced River through the confluence with the Stanislaus River, provides freshwater migratory and non-natal rearing habitat for juvenile salmon as they migrate downstream into the Sacramento-San Joaquin River Delta (Delta). The only data available that provides information on juvenile CV spring-run Chinook salmon migration and rearing times in the mainstem San Joaquin River are the SCARF production releases. As described in Section 5.1, the SJRRP has been releasing juvenile CV spring-run Chinook salmon raised at the SCARF from 2016 through the present year (2024). Juvenile Young-of Year (YOY) fish are usually released in the mainstem San Joaquin River just upstream of the confluence with the Merced River. YOY fish releases occur anytime between

[6] The Calaveras River Habitat Conservation Plan, and associated documents, are publicly available at: https://www.fisheries.noaa.gov/action/calaveras-river-habitat-conservation-plan-and-environmental-assessment

February and April each year. Juvenile yearling fish are usually released in November or December each year in the same general areas that YOY fish are released. Both YOY and yearling juvenile fish are typically observed, and identified with unique coded-wire tags, at the fish salvage facilities downstream that are part of the federal and state water projects in the Delta[7].

The time between SCARF fish release and the observation of individuals at the Delta fish facilities provides valuable information on how long juvenile CV spring-run Chinook salmon may rear and migrate through the mainstem San Joaquin River (Table 3 and Table 4). In many years, both YOY and yearling fish can spend upwards of three months rearing in the mainstem San Joaquin River (refer to Table 3 and Table 4). In spring 2022, there was one fish observed at the Delta fish facilities that had been released as a YOY in spring 2021 (refer to Table 3), which was confirmed by a unique acoustic tag that had been inserted into the fish as part of a study by the University of California, Davis. This fish reared for approximately 393 days in the mainstem San Joaquin River, and naturally adopted a yearling life-history strategy. Additionally, in March 2024, there were 18 fish observed at the Delta fish facilities that were released as YOY in February 2023. These fish reared in the mainstem San Joaquin River for a year and also naturally adopted a yearling life-history strategy. This unique long-term dataset provided by SCARF fish releases can provide insight into how tributary flows and mainstem water temperatures influence juvenile CV spring-run Chinook salmon migration through the mainstem San Joaquin River (NMFS 2022b).

This 9-year dataset (2016-2024) provides clear evidence that juvenile CV spring-run Chinook salmon can and will use the mainstem San Joaquin River as a freshwater migratory corridor and non-natal rearing habitat. Further exploration of this dataset, in combination with data on flows and other environmental attributes such as water temperatures, could provide information on how best to manage tributary flows (i.e., the Stanislaus, Tuolumne, and Merced Rivers) to benefit juvenile outmigration to the Delta.

[7] Data is publicly available on the “SacPAS: Central Valley Prediction & Assessment of Salmon” webpage at: https://www.cbr.washington.edu/sacramento/

Table 3. Summary of outmigration timing for SCARF Young-of-Young (YOY) in the mainstem San Joaquin River between the Merced River confluence to Delta Fish Facilities (downstream of confluence with Stanislaus River). Data is publicly available at the SacPASS webpage (refer to footnote 7).

	Number of Days migrating/rearing			
Year Observed at Delta Fish Facilities	**Minimum No. of Days**	**Median No. of Days**	**Maximum No. of Days**	**Approx. Number of Fish Observed**
2024[2]	7	25	63	741
2023	14	41	95	1,259
2022[1]	10	36	90	14
2021	10	44	92	232
2020	4	28	82	291
2019	4	46	81	525
2018	12	31	84	266
2017	6	33	94	387
2016	3	6	20	171

[1]Does not include the one "outlier" fish that reared for 393 days in the mainstem San Joaquin River (March 2021-March 2022).
[2] Does not include the 18 fish that reared for one year in the mainstem San Joaquin River from February 2023-March 2024.

Table 4. Summary of outmigration timing for SCARF Yearlings in the mainstem San Joaquin River between the Merced River confluence to Delta Fish Facilities (downstream of confluence with Stanislaus River). Data is publicly available at the SacPASS webpage (refer to footnote 7).

	Number of Days migrating/rearing				
Year Observed at Delta Fish Facilities	**Minimum No. of Days**	**Median No. of Days**	**Maximum No. of Days**	**Number of Fish Observed**	**Release Notes**
2024	36	27	65	6	Yearling release = Dec. 2023
2023	NA	NA	NA	NA	
2022	NA	NA	NA	NA	
2021	68	124	132	6	Yearling release = Dec. 2020
2020	NA	NA	NA	NA	
2019	4	8	17	68	Yearling release = Dec. 2019
2018- a	11	15	21	8	Yearling release = Dec. 2018
2018- b	21	82	96	7	Yearling release = Dec. 2017
2017	NA	46	NA	1	Yearling release = Nov. 2016
2016	28	NA	29	2	Yearling release = Nov. 2016

Section 6. Conclusion

Available information indicates CV spring run Chinook salmon are not extirpated from, and are passively reestablishing into, their historical habitats of the San Joaquin River basin. CV spring-run Chinook salmon adults can, and will, volitionally pass and migrate upstream in the San Joaquin River tributaries up to the first major dams during the spring months. In general, wetter water years provide better access to spawning and rearing habitats, and create better freshwater habitat conditions for all life stages when compared to drier water years (Michel et al. 2015; Cordoleani et al. 2017; Notch et al. 2020). CV spring-run Chinook salmon abundance and distribution would be expected to vary throughout the different tributaries within the San Joaquin River basin depending on the annual hydrological conditions. Due to these variations in water year conditions, different water management actions in individual tributaries, and differences in hydrology in each tributary watershed (i.e., more rain-driven versus snow-pack driven hydrology), it should be expected that the abundance and distribution of CV spring-run Chinook salmon would vary from year to year and from tributary to tributary within the San Joaquin River basin. CV spring-run Chinook salmon populations in the Sacramento River basin tributaries also experience wide fluctuations in abundance and in distribution from year to year (CDFW 2023), due in part to annual freshwater environmental conditions and water management actions implemented throughout the basin by various entities.

The current population of CV spring-run Chinook salmon in the San Joaquin River basin is believed to be small; however, every fish contributes to the overall basin-wide population. Similar to the Sacramento River and its tributaries, each tributary within the San Joaquin River basin provides value to the population in terms of overall habitat availability. Collectively, the San Joaquin River tributaries provide a variety of habitats that allow flexibility in life-history strategies that Chinook salmon depend on to survive the dynamic hydrology, varied geology and typology, and climate of the Central Valley. Ensuring habitat conditions are suitable for the expression of the yearling life-history strategy in all water year types is necessary for CV spring-run Chinook salmon survival, resiliency, and recovery, particularly in challenging conditions created by climate change and the varying water year types of the California Central Valley. The high elevation and snow pack of the southern Sierra Nevada Mountains will likely play a key role in the long-term conservation of CV spring-run Chinook salmon due the abundance of cold-water resources and available habitat that are critical for the long-term persistence of the ESU.

Section 7. Suggestions for Fisheries Monitoring and Management

Available information suggests passive reestablishment of CV spring-run Chinook salmon has occurred in the San Joaquin River tributaries. If long-term restoration actions to improve habitat conditions (e.g., the SJRRP, Fisheries Restoration Grant Program, and other programs) are implemented throughout the watershed, there is a significant potential for CV spring-run Chinook salmon to increase in distribution and abundance throughout the San Joaquin River basin and significantly contribute to the conservation and recovery of the CV spring-run Chinook salmon ESU.

The San Joaquin River basin has major potential for advancing the recovery and resiliency of CV spring-run Chinook salmon in the Central Valley. This is based on historical population data (refer to Section 2), and the sheer size of the currently accessible low elevation watershed area (over ~10 million acres) and river miles (~500 river miles) that are underutilized as habitat. Both historical and current data demonstrate that CV spring-run Chinook salmon can not only survive, but thrive in the watershed, particularly if beneficial restoration, reintroduction, and management actions continue.

To better assess the reestablishing population of CV spring-run Chinook salmon in the San Joaquin River Basin, suggestions for fisheries monitoring and management are as follows:

- Secure long-term funding for monitoring CV spring-run Chinook salmon populations in the Mokelumne, Stanislaus, Tuolumne, Merced Rivers, and main-stem San Joaquin River.

- Secure funding for consistent fin-clip collection and genetic analysis of adult and juvenile CV spring-run Chinook salmon.

- Develop a genetics-based, length-at-date table for CV spring-run and CV fall-run Chinook salmon, specifically for the San Joaquin River and each of the major tributaries: the Mokelumne, Stanislaus, Tuolumne, and Merced Rivers.

- Develop adult and juvenile CV spring-run Chinook salmon migration timing tables, recommended in-water work windows, and conservation strategies specific to the San Joaquin River basin for ESA and Magnuson-Stevens Fishery Conservation and Management Act consultations.

- Facilitate San Joaquin River Fisheries Advisory Technical Team efforts to coordinate flows between the tributaries to specifically benefit juvenile CV spring-run Chinook salmon out migration, and the upstream migration and spawning of CV spring-run Chinook salmon adults.

- Collect and synthesize information regarding the importance of CV spring-run Chinook salmon to the Native American tribes residing in the San Joaquin River basin, who have a rich cultural and ecological history with salmon.

- Continue evaluating options for fish passage projects that would allow for passive or managed segregation of CV spring and CV fall-run Chinook salmon, as well as options for CV spring-run to access high-elevation cold water habitats upstream of barrier dams.

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Appendix A - Video Monitoring Summaries

Table A-1. Video monitoring data summary from 2000-2024 for adult Chinook salmon observed in the Mokelumne River between February to July. Data was collected and provided by the East Bay Municipal Utility District. Note that monitoring efforts between months and years may have differed for various reasons, therefore these numbers should be considered an estimate.

Year	Month	Monthly total (no ad-fin clip/ad-fin present)	Monthly total (ad-fin clip)
2024	February	0	1
2024	May	0	1
2024	June	2	12
2024	July	1	1
2023	February	2	0
2022	May	0	2
2021	April	1	2
2021	May	1	4
2017	July	5	2
2015	February	2	0
2015	April	1	0
2015	June	4	16
2015	July	0	2
2014	May	0	2
2011	April	1	0
2011	May	2	1
2011	June	3	6
2011	July	37	26
2010	May	1	11
2010	June	4	17
2010	July	8	10
2009	March	1	0
2009	June	2	1
2007	May	2	1
2007	June	1	0
2006	July	52	6
2005	February	0	1
2005	July	13	0
2004	May	5	0
2004	June	18	5
2003	March	1	1
2003	May	5	4
2003	June	26	5
2003	July	46	12
2002	February	1	0
2002	May	11	0
2002	June	91	4
2002	July	10	0
2001	February	1	0
2000	February	2	0

Table A-2. Video monitoring data summary from 2009-2024 for adult Chinook salmon observed in the Stanislaus River between January to June. Monitoring was funded and provided by Tri-Dam Project for 2007-2020 (Oakdale and South San Joaquin Irrigation District), and U.S. Bureau of Reclamation for 2021-2024. Monitoring was contracted to and conducted by FISHBIO, Inc. Note that monitoring efforts between months and years may have differed for various reasons, therefore these numbers should be considered an estimate.

Year	Month	Monthly total (no ad-fin clip/ad-fin present)	Monthly total (ad-fin clip)
2024	January	6	7
2024	February	0	0
2024	March	0	0
2024	April	0	0
2023	January	0	0
2023	February	0	0
2023	March	No video monitoring	No video monitoring
2023	April	0	0
2023	May	0	0
2022	January	2	0
2022	February	1	5
2022	March	0	0
2022	April	0	2
2022	May	0	5
2021	January	2	1
2019	January	0	0
2019	February	0	0
2017	January	22	6
2017	February	0	0
2017	March	0	0
2016	January	42	22
2016	February	0	2
2015	January	5	7
2015	February	0	1
2014	January	14	3
2014	February	3	0
2014	March	2	0
2014	April	1	0
2013	January	2	1
2013	February	12	1
2013	March	11	0
2013	April	1	0
2013	May	18	1
2013	June	55	8
2012	January	7	3
2012	February	3	2
2012	March	0	1
2011	January	1	1
2010	January	16	0
2010	February	6	1

Year	Month	Monthly total (no ad-fin clip/ad-fin present)	Monthly total (ad-fin clip)
2010	March	2	0
2010	April	1	0
2010	May	3	1
2010	June	3	1
2009	January	0	0
2009	February	0	0
2009	March	0	0
2009	April	1	0
2009	May	6	0
2009	June	4	0

Table A-3. Video monitoring data summary from 2010-2024 for adult Chinook salmon observed in the Tuolumne River between January and May. Monitoring was funded and provided by Turlock Irrigation District and Modesto Irrigation District. Monitoring was contracted to and conducted by FISHBIO, Inc. Note that monitoring efforts between months and years may have differed for various reasons, therefore these numbers should be considered an estimate.

Year	Month	Monthly total (no ad-fin clip/ad-fin present)	Monthly total (ad-fin clip)
2024	January	13	10
2022	January	0	0
2022	February	1	0
2022	March	0	1
2022	April	0	0
2021	January	17	8
2021	February	0	0
2021	March	0	0
2020	January	7	6
2020	February	1	5
2019	No video monitoring		
2018	No video monitoring		
2017	January	3	1
2016	January	8	8
2016	February	1	1
2016	March	0	0
2016	April	1	0
2016	May	2	0
2015	January	26	4
2015	February	4	0
2015	March	1	0
2014	January	27	4
2014	February	12	0
2014	March	22	0
2014	April	4	0
2013	January	13	1
2013	February	1	3
2013	March	27	0
2013	April	25	2
2013	May	27	0
2012	January	27	12
2012	February	14	2
2012	March	17	0
2012	April	16	0
2012	May	8	0
2011	No video monitoring		
2010	January	7	13
2010	February	9	4
2010	March	2	0